A Biophysical Profile of the Tristan da Cunha Archipelago

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Biodiversity and ecology

The Tristan archipelago is situated in temperate South Atlantic waters, approximately half way between South Africa and South America, thousands of kilometers from the nearest land. The territory consists of three northern ('top') islands, Tristan, Inaccessible and Nightingale, about 25km apart, together with Gough situated on its own around 350km to the south southeast. The islands are the tops of volcanoes that arose from hotspots beneath the seafloor, and range in age from less than 200,000 years (Tristan) to 18 million years (Nightingale). They are all small, with Tristan the largest at 12km across, and an area of 96km^2. The Peak on Tristan rises to 2,060m above sea level, and slopes steeply to the seafloor at 2-3000m within a few km of the coast. The top islands have a warm temperate climate, while Gough is cool temperate. All the islands are exposed and windy, with no sheltered marine habitats.

Tristan claims to be the most isolated inhabited island in the world, and has a small community of around 270 islanders, in a single settlement on Tristan. The community is largely self-supporting, with the main sources of income being rock lobster (crayfish) fishing, and the sale of stamps and other souvenirs. Tourism also brings in revenue, but potentially lucrative trade from passing cruise and expedition ships is severely limited by the remote location and often difficult landing conditions; the small harbor is often unusable because of swell. Wildlife conservation and scientific research is increasingly bringing funded projects to the islands, employing both outside biologists and islanders.

There are no other islands in the temperate south Atlantic to act as stepping stones, so life that has colonized the islands is a collection of chance arrivals of spores and seeds borne on the wind, on ocean currents or carried by birds, while much of the shallow-water benthic marine life probably arrived on drifting kelp and other marine debris. In common with other small, isolated islands, biodiversity is generally low, but varies with group; sponges and seaweeds are relatively diverse, while echinoderms and mollusks are very impoverished. Subsequent evolution in isolation has resulted in a high proportion of endemics in some plant and animal groups.

The 'top' islands of Tristan, Inaccessible and Nightingale lie on the north edge of the Subtropical Convergence (STC), where the warm waters of the South Atlantic gyre meet colder waters to the south. Seawater temperatures at the top islands average 14°C in winter and 19°C in summer. Gough, some 350km to the south southeast, is around 3°C colder year-round than the top islands, and is consequently more subantarctic in nature. In shallow water down to at least 40m, forests of giant and pale kelp thrive, forming a highly productive habitat for smaller seaweeds, abundant fish and numerous invertebrates including the Tristan rock lobster, the basis for an MSC certified fishery. Little is known of life in deeper water around the islands.

While Tristan itself has been much changed over the years through clearing of natural vegetation, harvesting of mammals and birds, agriculture and introduction of alien species, the uninhabited islands still support an abundance of wildlife. They are of global importance for breeding seabirds, endemic land birds, and Subantarctic Fur Seals, and home to many endemic plants and invertebrates. Gough and Inaccessible islands together comprise a World Heritage Site, with boundaries out to the 12nm territorial limit. The islands are home to entire, or a large proportion of, the world breeding populations of Spectacled Petrels, Tristan Albatross, Atlantic Yellownosed Albatross and Northern Rockhopper Penguins, as well as seven endemic land birds. The islands also appear to be a stronghold for Shepherd's Beaked Whales, an otherwise little known whale species, and a nursery area for Southern Right Whales, although these are much reduced from former numbers by hunting. At least another nine cetacean species are regular visitors.

Sensitivity

As with many isolated islands, the Tristan islands are particularly vulnerable to the effects of invasive introduced species. House Mice on Gough are having a devastating effect on Tristan Albatross and Atlantic Petrel populations, by eating chicks and eggs, and their eradication is a priority. Rats on Tristan are similarly preventing the recovery of petrels, following the cessation of harvesting by humans. Inaccessible and Nightingale islands so far remain free of mice and rats, but are highly vulnerable to their introduction from Tristan, where both are present, and from shipwrecks. Invasive plants including New Zealand Flax and Procumbent Pearlwort are threatening natural vegetation, and introduced invertebrates have become agricultural pests on Tristan. In the marine environment, the South American Silver Bream (porgy), a fish introduced with a stranded oil rig in 2006, is now abundant around Tristan; its effect on native fish and rock lobster populations is as yet unknown.

As well as historical impacts and ongoing mortality from introduced rodents, foraging seabirds are at risk from activities a long way from the islands, and outside territorial waters. Longlining in particular still kills many albatrosses, though simple deterrents have greatly reduced the mortality in more responsible fisheries in recent years.

As evidenced by the stranding of an oil rig in 2006 and the wreck of the bulk carrier *Oliva* in 2011, the islands are at risk from marine incidents, and subsequent impacts from spilt oil and cargo, as well as introduced species. This risk has increased in recent years with more ships passing near the islands en route from South America to the Far East. Some means of flagging the islands as a sensitive area, and one to be avoided by commercial shipping, is required.

Climate change could cause profound changes in the Tristan marine environment. Giant kelp, a keystone species in shallow water around all the islands, is already at the upper limit of its temperature tolerance at the top islands. Even slight warming of seawater here could result in large-scale disappearance of giant kelp, with knock-on effects on the numerous organisms occupying the kelp forests, including the rock lobsters on which the Tristan economy depends.

IUU fishing is a real threat in a situation where policing such remote islands is difficult, and in a fishery with such a small total target area, any IUU fishing is significant. Reduction or collapse of the fishery could create pressure to exploit other marine resources. Other services provided by the fishing company, particularly transport of people and goods to and from Cape Town, is also very important to islanders.

Other issues

Tristan depends heavily on income from the rock lobster fishery, which at present is well-managed and has MSC certification. However little is known of major aspects of rock lobster biology, particularly of the fate of larvae, which spend a long time at sea, and of the survival of very young stages after settling on the seabed. Work is ongoing as part of a current project to try to shed light on some of these aspects. However this project is drawing to a close in June 2016 and much more research is required.

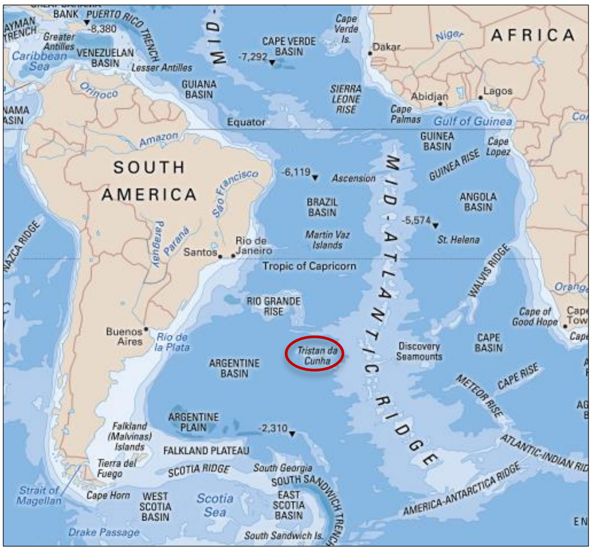
The knowledge of marine life in deeper water below 40m is still very scant. Depths from 40-200m are subject to the main lobster fishery effort, and from a few dredges and photos of the seabed it is known that life here is very different from that above 40m, yet information from these depths is severely limited. This makes any meaningful assessment of the impact of current and future fisheries difficult. Life in much deeper water from 300-3000m, which constitutes the major part of the waters within the WHS boundaries and within Tristan territorial and EEZ limits, is virtually unknown.

Very little is known about the functioning of the Tristan marine system, particularly the life histories, interactions, diets, food webs and other requirements of key species, which makes it difficult to assess the potential impacts of introduced species, marine incidents, effects of climate change, and decisions on current and future fisheries.

Infrastructure developments which impact on the marine environment are generally unlikely on Tristan because of the extremely exposed nature of the islands' coasts. However, islanders have long campaigned for a better harbor, which would facilitate more fishing days and tourist landings from cruise ships. Any substantial new construction should include looking at the potential to create new habitat for settlement and subsequent survival of juvenile lobsters.

1. Key information on Tristan da Cunha

- The Tristan archipelago consists of three 'top' (northern) islands, Tristan da Cunha, Nightingale and Inaccessible, and a fourth, Gough island, which lies isolated, 380km (235 miles) to the south southeast. The islands are the summits of much larger underwater volcanoes, formed over volcanic hotspots, with ages ranging from 200,000 years (Tristan) to around 18 million years (Nightingale).



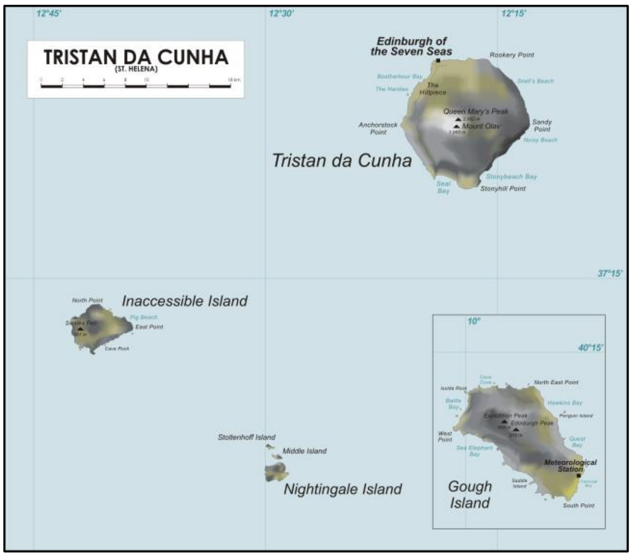


Figure 1: Geographic location of the Tristan archipelago. Gough (in box) lies on its own 380km to the south southeast of Tristan

- Tristan da Cunha is the most isolated island in the world inhabited by humans. It lies in the middle of the South Atlantic Ocean, east of the mid-Atlantic ridge, 2800 km (1750 miles) from the continental shores of South Africa and 3360 km (2088 miles) from South America. The nearest inhabited land is St Helena, some 2400km (1510 miles) to the north.

Figure 2: Tristan da Cunha, from the southwest. The Peak of the volcanic island is at 2060m.

Figure 3: The settlement of Edinburgh of the Seven Seas on Tristan, with the 1961 eruption a dark mound on the left of the buildings.

- Tristan is the only permanently inhabited island of the archipelago, and has a human population of around 270. The only habitation on Gough is a meteorological station, leased to South Africa, with a staff of 6-9 people replaced annually.

- The seabed slopes steeply into very deep water of over 3000m (9000 feet) within a few miles of the coast of the islands. There is no continental shelf, only a small erosion platform in places, which is most extensive off the west side of Inaccessible, where it extends out to 10km (6 miles).

- The Tristan islands are unique - they are the only isolated islands found in temperate waters in the South Atlantic - there is no other island 'stepping stones' for colonization by terrestrial or shallow-water marine species.

- The islands home many endemic species, both terrestrial and marine, that occur nowhere else in the world. The proportion of endemics varies with taxonomic group; around a quarter of seaweeds are endemic, but there is only one endemic fish.

- Among seabirds, the Spectacled Petrel is endemic to Inaccessible Island. Its population of some 15,000 breeding pairs is slowly recovering from near-extinction at the start of the 20th century due to predation of eggs and chicks by feral pigs. Its current IUCN Red List status is Vulnerable, owing to its very small breeding range and losses as bycatch in long-line fisheries.

- Slightly smaller than the Wandering Albatross, the Tristan Albatross is endemic to the Tristan islands and has a population of only 1800 breeding pairs on Gough and 1-2 pairs on Inaccessible. They formerly bred on Tristan, where they were killed historically for food, and went extinct by 1900. The population on Inaccessible was impacted by harvesting and pig predation and has failed to recover despite limited impacts since the 1950s and formal protection since the 1970s. Its IUCN conservation status is Critically Endangered, with the main threats being predation of its chicks by introduced mice on Gough Island, and low adult survival due to incidental mortality in long-line fisheries.

The Atlantic Petrel is also endemic to the islands, with almost the entire population now confined to Gough Island, following extensive harvesting for food on Tristan. It is listed as Endangered given the high level of mouse predation on its chicks.

Figure 4: Tristan albatross *Diomedea dabbenena* and chick, on Gough (Photo Trevor Glass)

- More than 90% of the world population of Northern Rockhopper Penguins breed at the Tristan islands, but numbers have been decreasing for unknown reasons, especially at Gough. 3,000 penguins were killed by an oil spill following the wreck of the bulk carrier *MS Oliva* at Nightingale in 2011.

Figure 5: Northern Rockhopper Penguins *Eudyptes moseleyii* amongst Tussock Grass on Nightingale.

- Seven endemic land birds are found on the islands, including a thrush, four 'buntings' and two flightless rails, the Inaccessible Rail being the world's smallest extant flightless bird. The buntings have undergone an adaptive radiation into small-billed and large-billed forms on the Tristan archipelago similar to Darwin's finches on the Galapagos, but the population on the main island of Tristan went extinct during the 19th century. The Gough Bunting is Critically Endangered due to predation by introduced House Mice.

- The Tristan top islands appear to be a stronghold for the rarely seen Shepherd's Beaked Whale, and also a small nursery area for Southern Right Whales, which were formerly much more numerous around Tristan but were hunted intensively.

- Eleven cetacean species have been recorded in Tristan waters within the 12nm territorial limits, and another two within the Exclusive Economic Zone to 200 nm.

Figure 6: Tristan Thrush *Nesocichla eremita* on Nightingale.

- The islands are surrounded by underwater forests of the giant kelp *Macrocystis pyrifera*, one of the fastest growing plants on the planet. Its fronds are known to grow up to 60cm (two feet) a day, and to over 50m (150 feet) in total length. The kelp forests are highly productive and support many other marine species.

- Diversity of marine life varies greatly with taxonomic group, but is generally very low. In common with other extremely isolated islands, many invertebrate groups including crustaceans and echinoderms are species-poor, while others, such as sponges and bryozoans, are more diverse. Seaweeds are particularly diverse for such a small area, with around 120 known species at the top islands.

- Marine invertebrates of the islands contain a large proportion of species that are very small, have no planktonic larval stage, brood their young or lay eggs from which adult forms hatch directly, and have a means of attachment to the substrate. These are all features consistent with transport to the islands over long distances on kelp or other floating marine debris.

Figure 7: Marine invertebrates on this rock face include Tristan rock lobsters *Jasus tristani*, starfish, whelks, and many sessile animals including sponges, bryozoans and hydroids.

- The Subtropical Convergence, the boundary between the warm Atlantic gyre and cold water to the south, lies approximately at the Tristan top islands, with residual currents from west and northwest. Gough lies south of this boundary, so that seawater temperatures at Gough are 3-4°C lower than at the top islands, and residual currents are from the west. This results in significant differences in the marine life at Gough, which is more subantarctic in nature than at the northern islands.

- Gough has its own version of a 'coral reef', a complex structure in shallow water at 0-4m, made up, not of animal coral, but of hard, leafy coralline seaweed, often overgrowing the shells of large barnacles. This complex carbonate structure is a refuge for many small animals, including lobsters.

Figure 8: A Tristan rock lobster *Jasus tristani* with endemic trumpet anemones *Parazoanthus hertwigi*.

Rock lobsters *Jasus tristani* support a productive, MSC-certified fishery on Tristan and Gough. *Jasus tristani* was thought to be endemic to Tristan and the Vema seamount, but has recently been shown to be conspecific with *Jasus paulensis* at the St Paul and Amsterdam islands.

- Gough is home to an estimated 80% of the world's population of Subantarctic Fur Seals, with around 300,000 animals. Around 60,000 pups are born on the boulder beaches each year. Southern Elephant Seals were once numerous at Gough, but have not recovered from hunting from the 18th century onwards; now only 15-20 pups are born at Gough each year.

- Around 50 species of flowering plants are native to the islands, with 27 of these found nowhere else. Ferns also constitute a large proportion of the vegetation at the islands, with 35 species, of which 14 are endemic.

- More than 140 flowering plants have been introduced to the islands by humans, mostly on Tristan, with only 8 at Nightingale, 27 at Inaccessible and 25 at Gough. Some of these introductions have become agricultural pests, or invasive in natural habitats.

2. Geophysical setting

2.1. Isolated islands

Tristan da Cunha is the world's most isolated inhabited island, lying in the middle of the South Atlantic at 37°04' S, 12° 18' W, approximately equidistant between South Africa, South America and the Antarctic, and just east of the Mid-Atlantic Ridge. Tristan is the largest of four islands that comprise the Tristan archipelago. It is roughly circular, 12km across with an area of 96km^2. Around 30km southwest of Tristan are the two smaller, uninhabited islands of Inaccessible (37°18' S, 12° 40' W) and Nightingale (37°25' S, 12° 29' W), which lie approximately 20 km apart. Inaccessible is roughly 5km long with an area of around 14 $km^{2,}$ while Nightingale is only 2.5km long and 4km^2 in area. Nightingale has two large islets of Alex (Middle) and Stoltenhoff. Tristan, Inaccessible and Nightingale form the 'top' (northern) islands of the archipelago, while Gough Island (65km^2 in area and 13km long) is on its own some 380km south southeast, at 40°19'S, 9°57'W.

Extreme isolation has profound implications for both terrestrial and marine ecology and biodiversity of all the islands. Gough has important differences from the top islands because of its position further south in colder water, and its marine life is further isolated from the top islands by oceanic fronts.

2.2. Geology and topography

Region (South Atlantic)

The South Atlantic Ocean is characterized by a deep abyssal plain, at depths of 3,000 to 5,000m, broken by the long undersea mountain chain of the Mid-Atlantic Ridge. This runs roughly north-south down the entire length of the Atlantic Ocean (a distance of some 16,000km), and north-west of Tristan its peaks rise to within 870m of the sea surface. In the South Atlantic, the ridge is formed by the divergence of the African and South American tectonic plates, creating a rift through which magma wells up from the Earth's mantle, cooling and solidifying as vertical basalt dykes and fields of pillow lava which form the ridge. The Tristan islands are located to the east of the ridge, on the African plate.

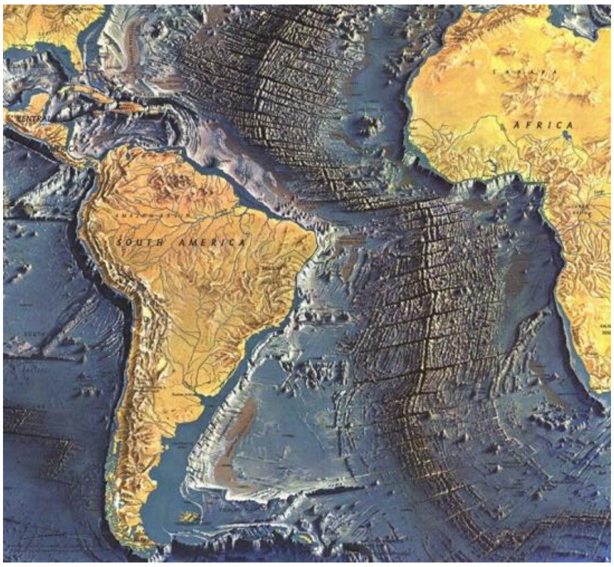


Figure 9: Fracture zones crossing the Mid-Atlantic Ridge

A series of transverse fracture zones cross the Mid-Atlantic Ridge at roughly right angles. Like the main ridge, these fracture zones are tectonically active. The Rio Grande Fracture Zone lies roughly 900km to the north of Tristan, while the Gough Fracture Zone lies south of Gough Island

The abyssal plain lying between the Mid-Atlantic Ridge and the continental shelf of southern South Africa to the east is known as the Cape Basin and reaches a maximum depth of 5,115m at a point around 2,000km east of Tristan. This is crossed by another subsea volcanic ridge called the Walvis Ridge, which runs south-westwards from off the coast of Namibia with the Tristan archipelago at its south-western end.

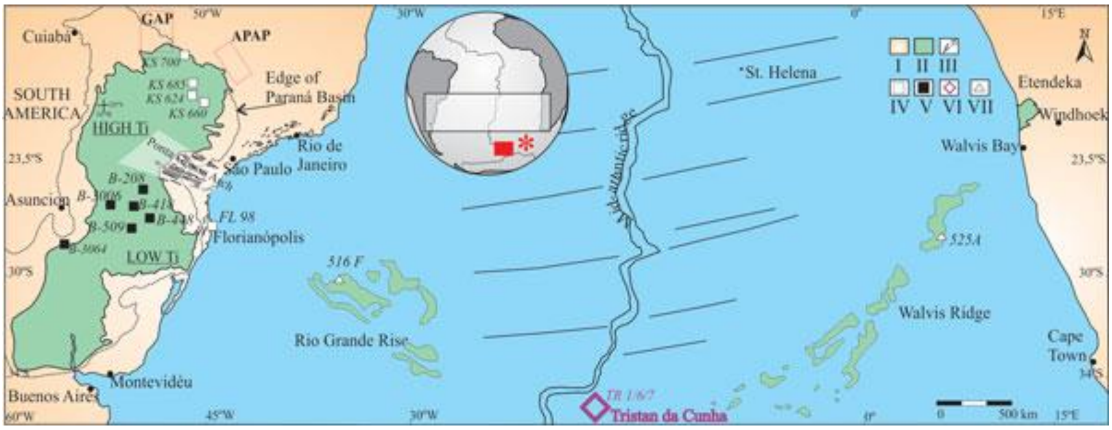


Figure 10: Map showing the Walvis Ridge running southwest from the African coast, and the position of Tristan de Cunha (Rocha Junior, 2013)

The Walvis Ridge is aseismic, characterized by the absence of earthquake activity. This feature distinguishes it from oceanic spreading centers, where there is much seismic activity. Most aseismic ridges are formed where a tectonic plate moves over a stationary upwelling of magma, also known as a plume or hot spot. Active volcanoes are usually found only at one end of the ridge, and the ages (and degree of erosion) of the ridge and any associated islands and seamounts increase with their distance from the site of volcanic activity. Tristan is the latest manifestation of the hotspot that created the seamounts that form the Walvis Ridge.

Interpretations of the geological origins of the Walvis Ridge are varied (Chevallier and Verwoerd, 1987). The eastern end of the ridge has been interpreted as a continental fragment that was originally in a marginal position to Africa. The western portion of the ridge (on which the Tristan Archipelago lies) is morphologically different, with a series of scattered seamounts and guyots. This conforms to the hypothesis that the Walvis Ridge was formed during successive periods of intense and abnormal volcanism over a volcanic hotspot.

The Walvis Ridge appears to be bounded by the same fracture zones as the Rio Grande Rise, and drilling data suggests that the ridge has subsided continuously since its creation (Kumar, 1979). O'Connor and Duncan (1990) estimated the ages of volcanic rocks dredged or drilled from the Walvis Ridge (10 sites) and Rio Grande Rise (one site). They concluded that the fundamentally age-progressive distribution of these rocks suggested that Tristan da Cunha, the Walvis Ridge and Rio Grande Rise all shared a common hotspot source of volcanism. The hotspot was located along a section of the South Atlantic spreading axis, as the African and South American plates separated, astride, or in close proximity to, an upwelling volcanic plume. Reconstructions of the spatial relationship between the spreading axis, the Tristan hotspot and the evolving volcanic features of the Walvis Ridge and Rio Grande Rise suggest that, around 70 million years ago (in the late Cretaceous), the spreading axis began to migrate westwards away from the hotspot. At the same time, there was a northwards migration of previously-formed seafloor of the African plate over the hotspot. Subsequent volcanism along the Walvis Ridge can therefore be interpreted as intraplate hotspot volcanism arising through the African plate. O'Connor & Jokat (2015) refine these ideas using more recent $^{40}Ar/^{39}Ar$ basement ages for Tristan (Hicks et al 2012), and conclude that the data implies a connection to a stable or constantly moving source in the mantle.

The Tristan Archipelago

The islands represent the summits of massive shield volcanoes arising from the abyssal depths of the Atlantic Ocean. Critically, for their marine and terrestrial biodiversity, the islands have never been linked to a continental land mass.

Figure 11: Tristan has a 'classic' volcano shape, with steep sides rising to a peak at 2060m, with a small crater. Here with the lobster fishing ship *MV Edinburgh*.

The Tristan top islands resulted from progressive eruptions over one volcanic hotspot, and form a series of peaks arising from the seabed. Geochronological studies reveal that the ages of the islands are quite diverse (Baker et al 1964, McDougall & Ollier 1982, Bjork et al 2011). Nightingale is the oldest of the islands, emerging subaerially around 18 million years ago, although the most recent eruption occurred around 24-36,000 years ago at Ned's Cave (Baker et al 1964, Bjork et al 2011). Submarine eruptions producing floating pumice have occurred near the island as recently as 2004. Inaccessible is much more recent, at 3–4 million years old, with its most recent eruption less than 50,000 years ago on the area known as Round Hill. Tristan itself is geologically immature, with its oldest rocks just 200,000 years old and its most recent eruption famously occurring in 1961. Compared to other volcanic island groups in the Atlantic, such as the Canary Islands or the Azores, the Tristan Archipelago is unusual in having three volcanic islands with such disparate ages so close together, suggesting that the tectonic plate has moved little over the hotspot for at least 18 million years.

Figure 12: Nightingale is the oldest of the islands, and is highly eroded. Beds of giant kelp (foreground) surround all the islands.

Tristan da Cunha forms a classical conical volcano, roughly circular in outline with a diameter of around 12km. The slopes of the cone are steep (30°), although in places there is a basal plain with gentler slopes (8°). Chevallier and Verwoerd (1987) interpret this morphology as being due to different volcanic products: the central cone is made of pyroclastic material, subject to quick erosion resulting in the formation of scree talus, while the slopes of the basal plain are predominantly made of lava flows. Around most of the island, coastal erosion has resulted in steep cliffs arising straight from the sea. The more detailed profile of the island above water is therefore of a girdle of extremely steep and often inaccessible cliffs rising to around 500m, with a less steep area above this (which islanders refer to as The Base). Beyond this area is a steady 30° slope to the summit of Queen Mary's Peak at 2,060m, with steep erosion gullies radiating downwards on all sides. There are numerous cinder cones across The Base, some crater lakes (The Ponds), and there is a central heart-shaped crater lake near the Peak.

Figure 13: The heart-shaped crater lake at The Peak on Tristan.

The history of eruptions at Tristan is complex and dynamic, with numerous scoria (cinder) cones punctuating the main large 'volcano' (note that islanders reserve the term 'volcano' for the recent lava flow resulting from the 1961 eruption near the Settlement). An extensive study by Hicks et al (2012) found that eruptions were much more frequent and recent than previously suspected.

It was previously thought that the last summit eruption happened more than 15,000 years ago (e.g. Dunkley 2002), but this new geochronology established that a recent lava flow erupted there only around 5,000 years ago. Several eruptions on the volcano flanks and in coastal areas have occurred during the last 16,000 years, confirming that eruptions from the summit and parasitic activity on the volcano's flanks overlapped in time. The oldest dated deposits are around 118,000 years old, from a parasitic cone in the southern sector, and 81,000 years from one of the lowest sub-aerial shield-forming lava flows in the northern sector.

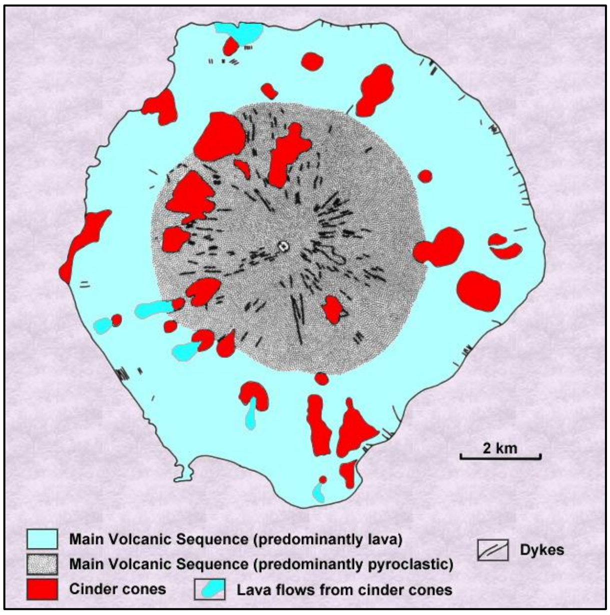


Figure 14: A simplified map of the geology of Tristan da Cunha. [After Baker et al (1964; source: http://mcee.ou.edu/bweaver/Ascension/tdc-geol.htm]

Large-scale sector collapse, resulting in the low-lying ground between the settlement and Anchorstock in the northwest of the island, is dated at between 34,000 and 26,000 years. Although magmatic flux has been inferred to be relatively low, Tristan is capable of relatively frequent eruptions from a wide variety of vent locations across a broad range of compositions. This makes it impossible to predict with any accuracy when the next eruption might occur. An initial hazard assessment was made in 2002 (Dunkley 2002); islanders recently upgraded their emergency action plan in response to the more recent studies.

There are only three areas of coastal lowland. The Settlement Plain in the northwest is the largest, and there is also a coastal strip between The Caves and Stony Hill in the south, and a small area at Sandy Point in the east. Access to the latter two areas is only possible by boat or by a steep climb up to The Base, a traverse of The Base, then an equally steep descent. The Settlement Plain, formed by lava flows which infilled a massive sector collapse (Hicks et al 2012), is approximately 6km from end to end and no more than 1km wide, and represents the entire area inhabited by humans, no more than about 5km^2 in extent, or 5.2% of the island map area. The most recent volcanic eruption of 1961 was on the north of this plain, just east of the Settlement itself. This destroyed the fish factory and necessitated evacuation of the island, but fortunately the lava flows stopped just short of the Settlement. One critical factor for the human community is the absence of any sheltered bays or inlets around the conical volcanic island; the only partially sheltered bay was engulfed by the 1961 eruption. Due to the volcanic origin of the island, shallow, shelf waters are generally no more than 2km wide. Below 250m, the slope becomes much steeper down to 1000m and more.

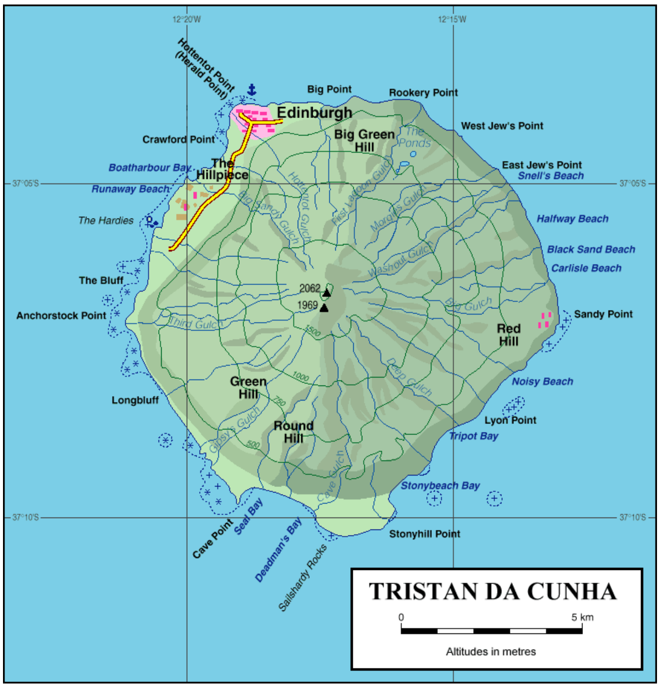


Figure 15: Left – map of Tristan da Cunha (pink area = settlement).

Figure 16: Above - The Settlement on Tristan, looking down from The Base at around 600m. The black cone and lava flows are from the 1961 eruption. Calshot Harbour is on the coast left of centre, appearing very small from this height.

Inaccessible Island, around 30km south west of Tristan, is believed to be the much-eroded remnant of a terrestrial volcanic peak similar to that of Tristan, which is estimated once to have been around 2,200m high and 16km across (Ryan, 2007). The outline of the original island remains as a shallow underwater shelf less than 100m deep, which extends out to 10km to the west of the current island. Because erosion by sea and wind is greatest from the west, the highest cliffs have been formed on the west of the island, with a plateau beyond these sloping down to the east. The highest point is Swale's Fell towards the southwest corner (561m), while the central Cairn Peak reaches 449m.

Figure 17: Dramatic features on the south coast: Michael's Massif, South Hill and Pyramid Rock

Figure 18: Steep slopes covered with tussock, and boulder beaches on the northeast coast of Inaccessible.

Nightingale Island, around 30km south southwest of Tristan and 20km southeast of Inaccessible, is the oldest of the islands at 18 million years, and the most eroded. To the north of the main island, two large islets, Alex (or Middle) Island, and Stoltenhoff, have become separated off by channels, and there is a range of smaller rocks and skerries around the coast. The main island of Nightingale is now just 4km^2 in extent and rises to no more than 400m on High Ridge. It is roughly square in shape, with a distance end to end of 2.5km. The remaining rocks are mainly trachyte (a grey fine-grained volcanic rock consisting largely of alkali feldspar), which form low cliffs with sea caves. Shallow depressions on the western plateau have filled to form boggy ponds.

Figure 19: Tussock-covered ground on Nightingale, looking across to the islets of Middle (Alex) Island and Stoltenhoff (left). Tristan is on the horizon, shrouded in cloud layers.

Gough Island (40°19'S, 09°56'W) lies approximately 380km south-southeast of Tristan and 2,700 km southwest of Cape Town. The island is around 13km long and 5km across, and 65km^2 in area. It represents a completely separate volcanic peak from the Tristan Group, rising to 910m above sea level at Edinburgh Peak from waters that rapidly drop to 3,500m around it.

Using Potassium-Argon dating, Maund *et al* (1998) estimated the oldest rocks on Gough to be 2–3 million years old (somewhat younger than previous estimates).

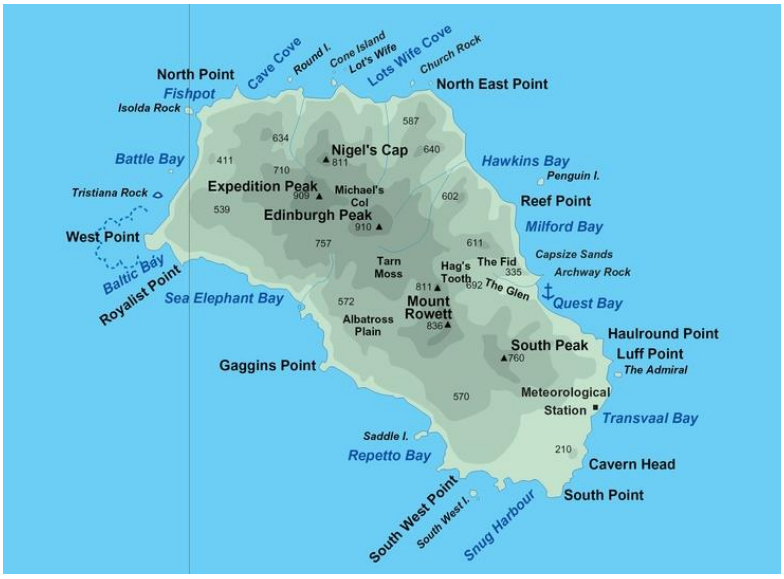


Figure 20: Left – Map of Gough Island. Above - The north east coast of Gough, at The Glen, with Archway Rock in the center and Hag's Tooth on the skyline.

Figure 21: Coastal cliffs and stacks on the north coast of Gough, at North East Point. Church Rock in the foreground, with Cone Island on its left and Lot's Wife on the right (above). Basalt column formations and waterfall on the northeast coast of Gough (below)

From the dating of rock samples, Maund *et al* (1998) concluded that there appeared to be four distinct events in the volcanic history of Gough. The first was a main basalt shield-building phase as the island emerged from below sea level, between 2.5 and 0.5 million years ago. This was followed by a minor phase of plug intrusions of trachyte injected into the basalt shield. Next, from about 300,000 years ago, came a major phase of extensive trachyte eruptions, with the production of volcanic features including lava flows, domes, plugs and pyroclastic beds. Finally, came a minor phase of renewed basalt eruption, which overlaid the trachyte around Edinburgh Peak and ended between 100,000 and 200,000 years ago (rather more recently than some earlier estimates).

Gough is the only emergent island in a group of stacks and seamounts, including the McNish Seamount, some 120km to its northeast (40°10'S 08°31'E), which rises to 143m below sea level, and the R.S.A. Seamount east of that (176m below sea level). These may be derived from the same volcanic hotspot; Long (1968) showed that the McNish Seamount and the Gough Island lavas have almost identical major and trace element geochemistry, and as a result concluded that Gough Island and McNish Seamount are derived from similar source materials. Between Gough and Tristan, the recently discovered Esk Guyot rises to less than 300m below sea level, and the Crawford Seamount to around 470m. The submarine profile of Gough broadly follows that of the island itself, typically dropping to 1,000m within 4.5km of the shore.

2.3. Climate

The climate of the islands is described as cool temperate (Ryan 2007), and temperatures are relatively stable, on both a daily and an annual basis, because of the moderating influence of the ocean. Mean seawater temperatures around the Tristan top islands vary only from 12–16°C in winter to 15–20°C in summer, with those around Gough varying between 10–13°C in winter and 12–15°C in summer. This relatively small range in seawater temperature greatly influences the terrestrial environment. The climate of the islands appears to have remained relatively stable during at least the last 20,000 years, and the islands were free of glaciation during the most recent ice age.

The climate of the Tristan top islands is warmer than Gough, although they are still cool, wet and windy. The average air temperature near sea-level at Tristan is 15°C, with a range of 2° to 25°C. Frost at low altitudes is extremely rare, although snow is regular on The Peak in winter and can fall sporadically through to December. Cold fronts occur most regularly in winter, so there is marginally more rainfall then, but nevertheless 40% of precipitation occurs in summer (see Table 1). On average, rain falls on 250 days a year at the Settlement and the annual average rainfall is 1,615mm. The Peak is frequently shrouded in cloud, as the mass of the island forces moist maritime air to rise and condense, and precipitation is much higher on the Peak than at the coast.

Gales occur on 2% of days in summer and 10% of days in winter, with an average wind speed of 36 km (22 miles) per hour. Significant residual sea swells occur on many days even when no gale is blowing, and this is a major problem for the islanders, in limiting the number of days on which the harbor can be used.

TRISTAN	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Temperature (°C)[1]	17	18	17	16	14	12	12	11	11	12	14	16	14
Average High Temperature (°C)[2]	20	20	20	19	17	15	14	14	14	15	17	18	16
Average Low Temperature (°C)[2]	14	14	14	13	11	10	9	8	8	9	11	12	11
Average Precipitation (mm)[1]	104	92	115	140	151	156	150	160	155	142	126	125	1615

Table 1: Monthly climate statistics for the settlement of Edinburgh, Tristan da Cunha (23m asl) (source: www.weatherbase.com; [1] based on 45-46 years records; [2] based on 27 years records)

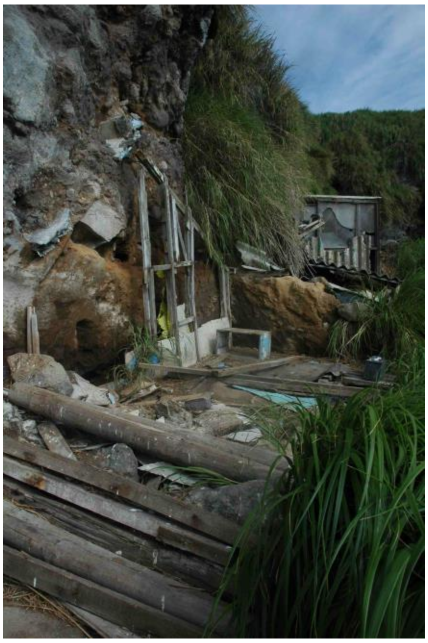


Figure 22: Above: Waves frequently break over the wall of the only harbor on Tristan, while swell in the shallow channel makes it unusable for boats. Left: Huts on Nightingale, well above the theoretical high tide mark, were destroyed by exceptional storm winds and waves in 2001.

The climate of Gough Island is best described as cold, wet and windy, due to its position on the edge of the 'roaring forties'. These are strong westerly winds, generally found between latitudes of 40°S and 50°S, caused by the combination of air being displaced from the high-pressure zone around the Equator towards the South Pole and the Earth's rotation, and exacerbated by the absence of any significant landmasses to serve as windbreaks. Average wind speeds on Gough frequently reach 44km (28 miles) per hour, and gales blow on 5% of days in summer and 15% of days in winter. The average daily air temperature near sea-level is 12°C (with a range from -3° to 31°C).

Rain falls throughout the year, linked to the passage of cold fronts. These can bring 180mm of precipitation in a few hours, causing flash floods and peat slippage (Ryan 1993). The mass of the island also forces moist maritime air to rise, creating more precipitation on the peaks. It rains on Gough on almost 300 days of the year, with an annual average of around 3,200 mm. Monthly climate statistics are shown in Table 2.

Figure 23: Above: the South African weather station on Gough, manned year-round to gather data to facilitate accurate weather forecasting for South Africa.

Left: High rainfall on Gough, together with high terrain and steep coastal cliffs, produces many spectacular waterfalls.

GOUGH ISLAND	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Temperature (°C)[1]	14	14	14	13	11	10	9	9	9	10	12	13	12
Average High Temperature (°C)[1]	16	16	16	14	12	11	11	10	10	12	14	15	13
Average Low Temperature (°C)[1]	12	12	12	11	10	8	7	7	7	8	10	11	10
Highest Recorded Temperature (°C)[1]	26	26	23	22	18	20	18	22	18	26	22	31	31
Lowest Recorded Temperature (°C)[1]	6	6	6	---	-1	2	---	-3	1	2	---	2	-3
Average Precipitation (mm)[1]	210	180	250	270	280	320	280	320	270	290	250	250	3220
Average Wind Speed (km/h)[2]	30	28	27	28	22	27	28	28	22	27	27	30	27

Table 2: Monthly climate statistics for Gough Island (53m asl) (source: www.weatherbase.com; ([1] based on 18 years data; [2] based on 11 years data).

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3. The ecology and biodiversity of the marine ecosystems of Tristan da Cunha

3.1. The pelagic ecosystem

3.1.1. Oceanography and ecosystem productivity

At approximately 37°S and 40°S respectively, Tristan and Gough occupy an interesting position in the South Atlantic in relation to ocean currents, being at the boundary between the Southern Ocean and the South Atlantic where waters of different characteristics meet. North of the islands, the huge anticlockwise gyre of the South Atlantic brings warm water towards the islands from the direction of Brazil and Argentina, while to the south of the archipelago, cold water of the Antarctic Circumpolar Current (ACC) runs west to east right around the globe, circling the Antarctic continent. The Tristan islands are located in the meeting zone between these two major circulatory features. Strong westerly and northwesterly winds drive these currents eastwards, in the broad zone known as the West Wind Drift, which continues right across the southern Indian Ocean to Australia and New Zealand.

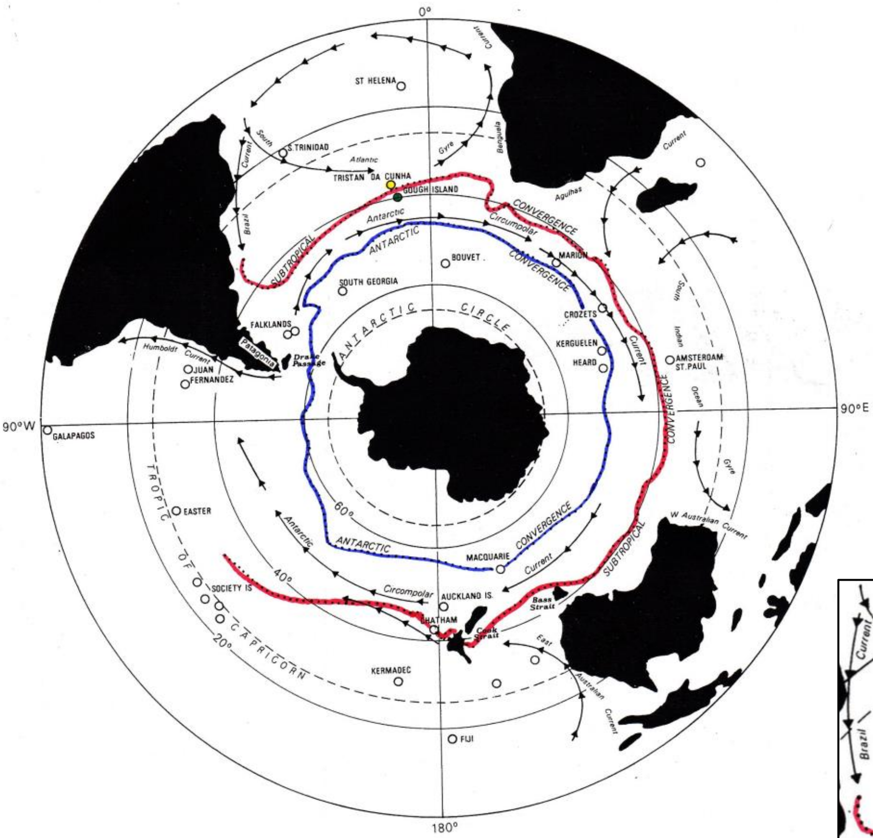
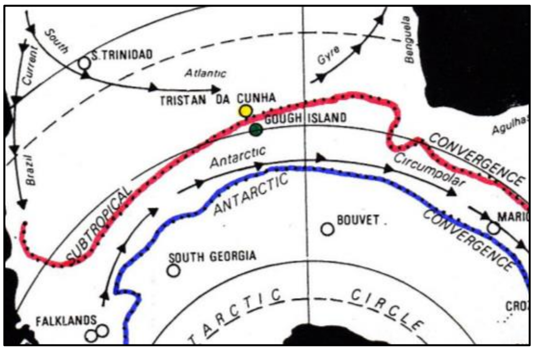


Figure 24: Location of Tristan and Gough in relation to continents, ocean currents and fronts in the southern hemisphere. Tristan is the yellow circle, Gough the green circle just below it. The red line represents the subtropical front (STC), the blue line is the Antarctic Polar Front (APF). Adapted from Chamberlain et al (1985).

Figure 25: Expanded portion of Figure 24, showing the location of Tristan and Gough with relation to continents, ocean currents and fronts in the South Atlantic.



The boundary between the subtropical gyre and the ACC has long been known as the subtropical convergence (STC). Deacon (1933) described it as being marked by a sudden change of surface temperature of at least 4°C, and a change in salinity of at least 0.5 psu. There is little change in density because the warm, saline water to the north has a similar density to cooler, fresher water to the south. South of South Africa, where most work on the characteristics of the STC has been undertaken, 70 crossings of the STC established that here, its width is more than 200k (125 miles), surface temperatures span 11°C to 18°C on average, and the mean temperature in the core of the front is 14.2°C (Lutjeharms & Valentine 1984). Dolittle et al (2008) noted the width of the STC between distinct southern and northern boundaries as spanning approximately 4 degrees of latitude, (approximately 440km (280 miles)).

Sharp boundaries between water masses with different characteristics are known as 'fronts', and more recently the term Subtropical Front (STF) has come into use, sometimes as a direct replacement for STC. However, fronts are normally sharply-defined features. Dolittle et al (2008) interpreted sudden temperature changes to south and north of Gough as the southern and northern edges respectively of the broader STC zone, and called these the southern STF (sSTF) and northern STF (nSTF). The term subtropical frontal zone (STFZ) is also used (e.g. Fouilland et al 1999) for the broader zone. Fronts are often areas of enhanced plankton productivity, because of an increased supply of nutrients, but are also barriers for dispersal of some planktonic animals, including larval stages.

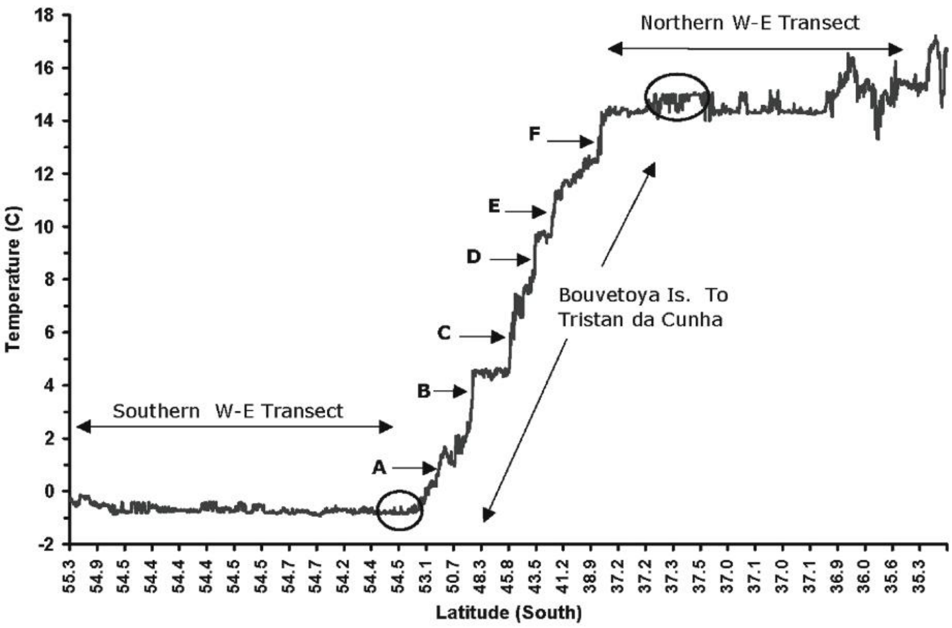


Figure 26: Fronts south of Tristan, as indicated by winter surface seawater temperatures along a south-north transect from Bouvetoya at 54.5°S to Tristan da Cunha at 37.2-37.5°S (center portion of graph). Sharp rises in temperature of between 1.2 and 1.5 degrees in less than 0.3 degrees latitude are interpreted as fronts, and indicated by lettered arrows. Compared to previously reported fronts, these correspond to: Front A (at approximately 52°S) is the Southern Antarctic Circumpolar Front; Front B (at approximately 49°S) is the Polar Front; Front C (at approximately 45°S) is the Subantarctic Front; Front E (at approximately 42°S) is the Southern Subtropical Front; Front F (at approximately 38°S) is the Northern Subtropical Front. The front at D is not identified with previous reports. On this data, Gough at 40°S lies between E and F, the Northern and Southern Subtropical Fronts, while Tristan (upper circle) is just north of the Northern Subtropical Front. From Dolittle et al (2008), results from the 2004 ICEFISH survey.

The position of the STC and associated fronts with respect to the Tristan islands has been the subject of some debate. This has possibly been confused by its consideration as a single feature, or as a broader zone delimited by two distinct fronts at northern and southern edges. Another reason for varying results is that it is probably not a static feature. Deacon (1937) considered that its position may vary as much as 6 degrees of latitude seasonally, (although temperature alone may not be a good indicator of its summer position; see below). Smythe-Wright et al (1998), using data from a number of crossings between subtropical and subpolar water in the region 15°W-5°E, found that the position of the northern subtropical front (nSTF) varies by only 1.5° of latitude, whereas the southern subtropical front (sSTF) (which they consider to be the STC as defined by Deacon 1937), migrates over 2.5° of latitude and remains south of Tristan da Cunha. They consider there is strong seasonality in the frontal structure between 30 and 45°S in the South Atlantic. However Andrew et al (1995) conclude that temperature profiles and salinity measurements at Tristan over 18 months in 1988-1990 do not clearly indicate any meridional movement of the STC there on a seasonal basis.

Andrew et al (1995) present a plot of the location of frontal expressions with respect to the Tristan da Cunha group from January to June 1988, from satellite thermal infrared imagery. These authors consider that the mean monthly seawater temperatures at Gough and the Tristan top islands are consistent with the islands being within the STC; in the warmer 6 months the surface seawater temperature at Tristan is 15-19°C, and in the colder six months between 13-15°C. Surface seawater temperatures around Gough are on average three degrees colder than those at Tristan. They conclude that the Tristan islands and Gough fall within the influence of the STC, including perhaps through cast-off eddies.

By Deacon's (1966) definition of the STC, these temperatures place the top islands at the northern edge of the STC and Gough at the southern edge, or entirely south of it. Dolittle et al (2008), reporting the results of the ICEFISH survey of 2004, which included a complete winter transect from Bouvetoya to Tristan crossing all the major frontal boundaries, place Gough in the center of the STC, with the Tristan top islands just north of it. Large monthly standard deviations in temperatures at Tristan and Gough (Andrew et al 1995), may reflect the movement of these frontal features, and also indicate that seasonal temperature cycles at the islands may vary considerably from year to year.

Andrew et al (1995) report the results of seawater temperature/depth profiles at approximately monthly intervals over an 18 month period, to depths between 200 and 400m, approximately 1km offshore at Tristan. These showed that while surface temperatures down to 50m varied with season, at 300m the temperature remained a relatively constant 11-12 °C. There was a distinct summer warming of the upper 50m, with the most extreme example being a February temperature of 21.0°C at the surface, but only 14.5°C at 50m at the same station. This surface heat is eventually transferred to deeper water by event-controlled (storm) vertical mixing of heat into the water column. The heat absorbed into the upper 50m in February was mixed to 100m by March, to 200m by August and to 300m by September.

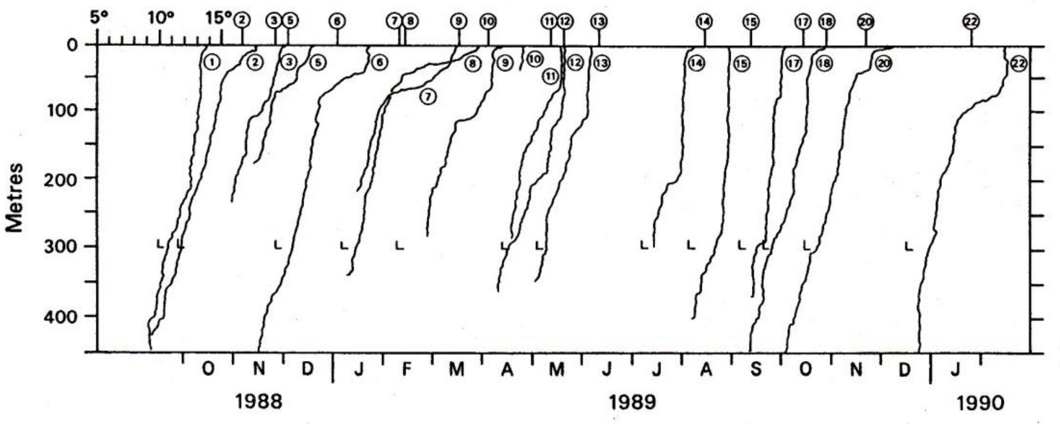


Figure 27: Profiles for ocean temperature to 400m in the vicinity of Tristan da Cunha. The date when each profile was measured can be read off by comparing the numbered location above the top axis with the months on the bottom axis. Each numbered location corresponds to the 15°C isotherm on the temperature scale. The location of the 10°C isotherm at 300m depth is shown as a step for each temperature trace that extended that deep. [From Andrew et al 1995].

More recently, information on seawater temperatures has come from elephant seals. These animals have a mainly subantarctic distribution, and spend long periods at sea on feeding trips, diving to depths of over 2000m, and often stay submerged for over an hour. To find out more about their habits, scientists fitted elephant seals with instruments that record temperature and salinity data during the seal's dive, data that can be received via satellites in near real-time from remote, relatively inaccessible parts of the ocean. This work has developed into a multinational collaborative project called SEaOS (Southern Elephant seals as Oceanographic Samplers, http://biology.st-andrews.ac.uk/seaos/), mainly aimed at increasing information on seawater characteristics south of 60°S, where the seals often forage but where ice cover for much of the year makes it difficult for ship-based work. One elephant seal called Bernt made two remarkable journeys, six months apart, between South Georgia and Gough. The resulting profiles (below) from his dives show the positions of the various fronts, as well as summer and winter temperature profiles from the surface to deep water along the length of his route. At the northern end of his route, near Gough, it shows relatively stable temperatures of the STC between 300-400m, but varying surface temperatures between summer and winter.

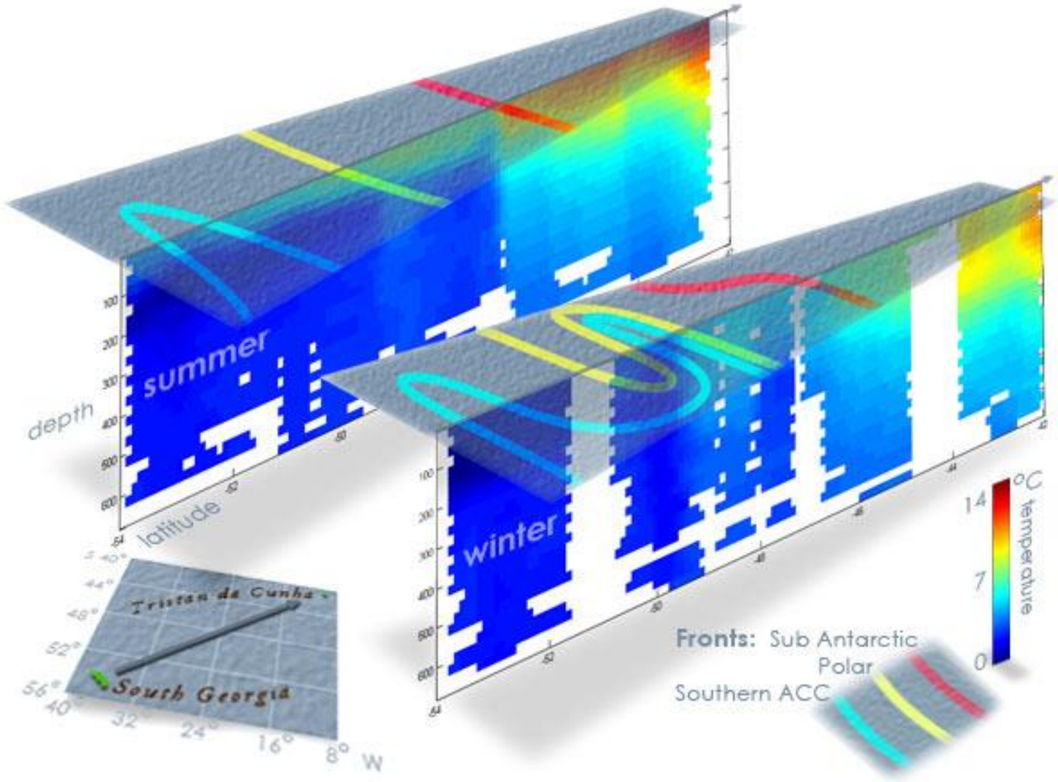


Figure 28: Journeys of Bernt the elephant seal between South Georgia (on left of diagrams) and Tristan da Cunha (on right of diagrams), in summer and winter. The colors indicate the temperature of the water at different depths as he dived, building up a composite picture of water masses. Fronts are indicated at relatively steep changes in temperature. [From http://biology.st-andrews.ac.uk/seaos/]

A strong current flows along the STC. Residual current speeds at the surface of the STF have been measured at around 20-26 cm per second (Hoffman 1985). Around the islands, the strong winds undoubtedly generate wind-driven surface currents.

McIntyre et al (1976) and Kennet (1982) proposed that a northward shift of 2-4 degrees of the STC may have occurred during recent glacial periods, together with an increase in velocity of the Antarctic Circumpolar Current (ACC). Pollock (1990) suggested that this would increase the chances of long-distance dispersal of long-lived lobster larvae into the Indian Ocean. Tristan shares some species only with St Paul & Amsterdam Islands, some 4680 km distant but directly downstream in the Westwind Drift, and with some Indian Ocean seamounts on the same route.

The waters surrounding the islands are essentially oceanic in character. Although the islands generate considerable local rain, the surrounding sea is only very locally affected by freshwater runoff and silt from the small land area of the islands. This is more pronounced at Gough, where divers have reported a surface peat-stained layer of freshwater near to the shore in Glen Bay (Hay 2008, Scott & Holt in prep).

3.1.2. Plankton and pelagic life

The series of fronts and water masses between the Tristan islands and the Antarctic have a profound effect on phytoplankton productivity. Fronts are well-known areas of enhanced productivity in the world's oceans. Dolittle et al (2008) analyzed the presence of picophytoplankton (tiny cells between 0.2 and 2.0μm diameter) in a winter ICEFISH cruise transect between Bouvetøya and Tristan da Cunha that spanned latitudes of 55°S to 34.8°S, seawater temperatures of -0.8 to 17°C, and crossed all the major frontal systems between the Antarctic and Tristan. They found a general pattern of increased picophytoplankton with increased seawater temperature, up to peak production at around 14°C, (at approximately 35°S). At temperatures above 16°C, productivity began to decline. This accords well with measurements of global phytoplankton productivity. However they also found that underlying this general increase with temperature was a change in community structure between picoplankton groups from south to north, with marked changes at frontal boundaries. Picoeukaryotes were found throughout, but were the only group found at the coldest, southernmost sampling stations. Other groups became more prominent in the water masses as the temperatures increased, with *Prochlorococcus* only observed in waters exceeding 10°C, but becoming dominant by the time temperatures exceeded 14°C. Their main conclusion is that picoplankton are a significant part of the ecological community in the southern Ocean and South Atlantic in winter, but also that the composition of this community is affected spatially by water masses and fronts.

Kim et al (1998) compared the plankton species and biomass in two areas of the STC, in the mid-Atlantic (in summer), where the authors say the STC is ephemeral and weak, and south of South Africa (in winter), where it is permanent and intense. They found higher biological diversity but weaker zonation patterns in the mid-Atlantic. In both sectors, species of Antarctic and subtropical origin were present, on both sides of the convergence, suggesting cross-frontal mixing. Higher phytoplankton, zooplankton and mesopelagic fish abundances were associated with the STC in both sectors, reflecting the importance of this region in the pelagic production of the South Atlantic.

Pakhomov et al (1994) found that species occurring at the two fronts were very different, with 115 species in the epipelagic zones of the STC, and 32 species in the APF. Three distinct plankton communities were distinguished; one in the STC, one to the north of the APF and one to the south of the APF. The authors comment that the figure of 115 species observed in the STC zone is much higher than the 56 species recorded by Miller (1982) in the Gough region, which lies just south of the STC. Community structure within a warm-water eddy of the STC was also different, with larvae of subtropical origin (Stomatopoda, Brachiura and Phyllosoma) common inside the eddy but completely absent outside it. The authors conclude that although the STC is a strong biogeographical front, eddy-shedding results in many tropical and subtropical species penetrating through the STC to the south, although they are not likely to be able to reproduce successfully here.

Miller (1985) compared macroplankton from Gough Island and Prince Edward Island, located further south near the Antarctic Convergence, and found a marked faunal dissimilarity. He attempted to identify 'indicator species' for each area, and found that 12 species were sufficiently dissimilar in abundance to warrant separation, with three species characterizing the Prince Edward Island region.

There are very few published studies of composition and variability of larger plankton in inshore waters around the Tristan islands or Gough. Wiborg & Bjorke (1969) reported on marine copepods collected by the Norwegian Expedition in the 1930s.

Mid-water trawls deployed at night at depths of 10m-200m near Gough and the Tristan top islands (BAS 2013) caught mainly small pelagic fish, pteropods, a variety of planktonic crustaceans, salps, siphonophores and chaetognaths (arrow worms). Less frequent were larval fish, lobster phyllosoma and puerulus larvae, squid, other ascidians, and other unidentified animals. These samples, together with benthic samples taken in the same area at the same time, are being analyzed for stable isotopes, with the aim of identifying possible bentho-pelagic coupling.

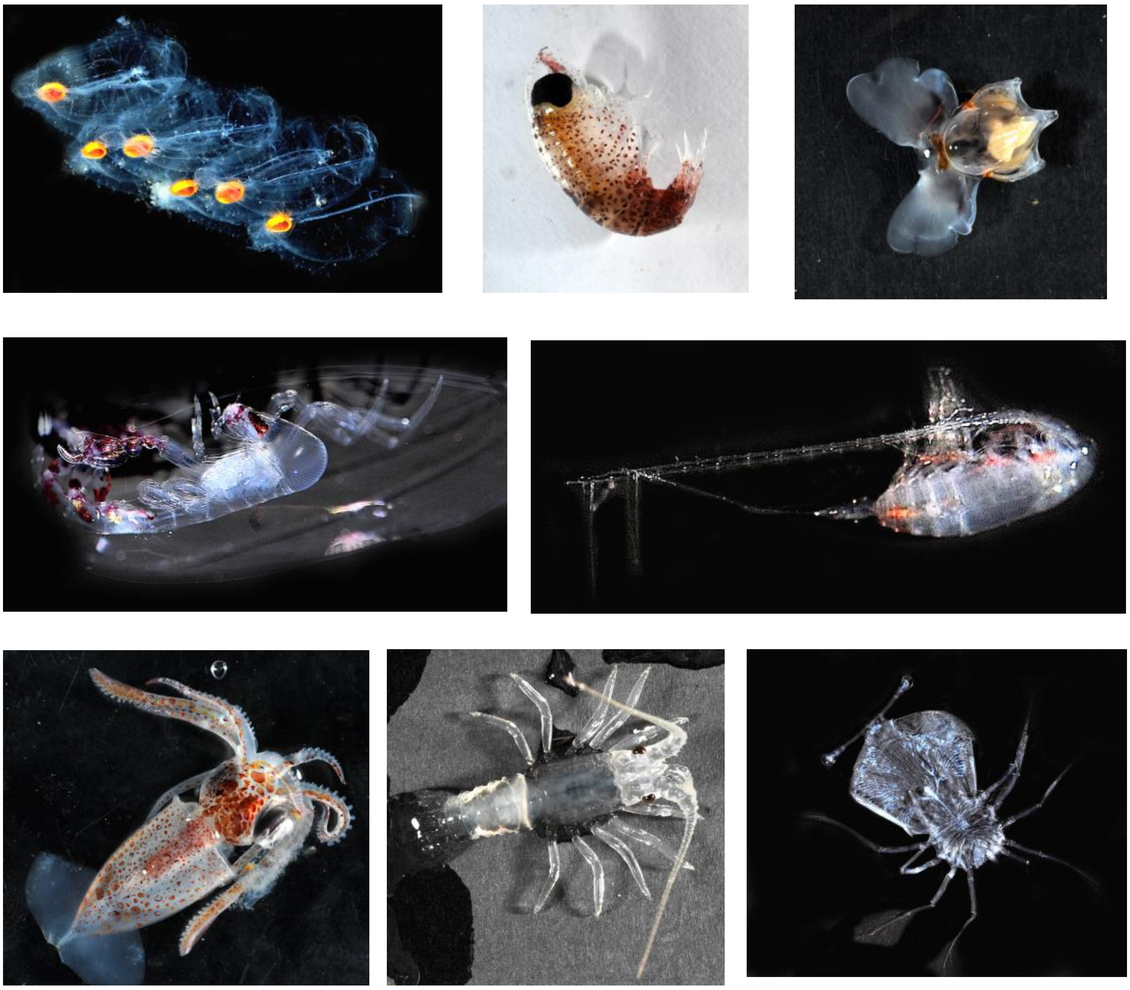


Figure 29: Some pelagic invertebrates from BAS survey mid-water trawls around Gough and the Tristan top islands. Clockwise from top left: salp chain; amphipod; pteropod; copepod; lobster phyllosoma larva; transparent lobster puerulus larva; cephalopod (squid). (Photos: BAS)

Diving surveys have rarely noted larger zooplankton, but on two occasions, plankton has been seen by divers at Stoltenhoff, an islet off the northwest of Nightingale, although records are five years apart (Scott & Tyler 2008, Scott 2010). Numerous salps were noted near the surface in March 2005, when the water temperature was 17°C. In March 2010, salps, medusae, phytoplankton 'balls' and other plankton were recorded as abundant in the top few metres at Stoltenhoff. On this occasion the seawater temperature at Stoltenhoff was 15°C, and noted as "4°C colder than at Tristan last week". This may indicate the position at that time of a front between Tristan and Nightingale, or of local upwelling of colder water from below. Salps and other larger zooplankton were also noted at Gough during diving surveys in February 2014 (Scott & Holt in prep.). Further work on plankton occurrence and composition in inshore waters around the islands is required.

Pelagic fish, crustaceans and squid are important food for seabirds, and much is known about the diets of seabirds nesting at Gough and Tristan from studies of their stomach contents (e.g. Klages & Cooper 1997). However, many of these birds range over huge distances while at sea, meaning that where they caught their prey is often unknown.

The Portuguese man-of-war, or bluebottle (*Physalia* sp.), is a distinctive planktonic siphonophore with a gas-filled float that keeps it at the sea surface. It is carried across oceans by winds and currents, and frequently washes ashore on the Tristan top islands. Its tentacles are highly toxic and can sting human skin, but this is no defense against the violet snail (*Janthina* sp.), which preys on the man-of-war, and is also washed ashore on Tristan.

Figure 30: Left: Portuguese man-of-war or bluebottle *Physalia* sp.; right: Violet snail *Janthina* sp. Both washed ashore on Runaway Beach, Tristan.

Rafting or Columbus crab *Planes (= Pachygrapsus) marinus* by LeMaitre (1999) have been identified on Tristan. Rafting crabs normally spend their entire lives at sea on floating debris, but when this debris washes ashore they perish. Another small grapsid crab with carapace around 25mm across was found on a buoy in the harbor on Tristan in 2011 by fish factory manager Erik Mackenzie. This has been identified as another rafting crab *Planes major* by the current author, using characteristics in Chace (1951).

Figure 31; Rafting crab *Planes major* found on a buoy in the harbor on Tristan in 2001.

3.1.3. Pelagic fishes

Andrew et al (1995) list the fishes reported from the Tristan islands. 23 of the 51 species recorded are oceanic and mesopelagic (see the table below). All were taken within a mile of the islands, but include species that range widely as adults in the pelagic zone of the oceans. Of the 15 epipelagic (upper or photic zone) species that have been recorded from Tristan and Gough, only four have been found at Gough, which the authors suggest indicates a strong isolating factor preventing certain species reaching Gough, only 200 miles to the south of Tristan. Water temperatures appear to be the primary factor, with the STC acting as a substantive biogeographic barrier. Oceanic species such as flying fish and great hammerhead sharks move into the Tristan area from the north during the warmer summer months, but do not reach Gough, where the water temperature is 3-4 degrees colder.

	Species	Distribution	Tristan top islands	Gough
1	*Hexanchus griseus* Sixgill shark	Gough. All oceans		x
2	*Etmopterus princeps* Great lanternshark	Inaccessible; caught in a crayfish trap at 220m. N Atlantic, W Pacific.	x	
3	*Prionace glauca* Blue shark	Caught all year round at all the islands. Worldwide in tropical and temperate waters.	x	x
4	*Isurus oxyrinchus* Shortfin mako	Said to be common at Tristan but seldom landed. Worldwide in tropical and temperate waters.	x	
5	*Sphyrna mokarran* Great hammerhead	Seen at Tristan only in summer. Wide ranging in tropical seas.	x	
6	*Vinciguerria poweriae* Small mesopelagic species with light organs	Only one specimen collected (dead) at Tristan. Circumglobal, subtropical	x	
7	*Maurolicus inventionis* Small silvery fishes with light organs	Found only at Tristan, Gough and nearby seamount	x	x
8	*Electrona paucirastra* Mesopelagic Myctophiid fish.	Collected off Gough by Miller (1982). Circumglobal between the STC and APF.		x
9	*Electrona subaspera* Mesopelagic Myctophiid fish.	Collected off Gough by Miller (1982). Circumglobal between the STC and APF.		x
10	*Lampadena dea* Mesopelagic Myctophiid lanternfish.	One specimen collected off Inaccessible (Andrew et al 1995). Circumglobal in the vicinity of the STC.	x	
11	*Symbolophorus barnardi* Mesopelagic Myctophiid fish	Reported by Sivertsen 12(1945), based on a specimen dropped by a tern feeding close to Tristan. Circumglobal between 30° and 40°S	x	
12	*Alepisaurus ferox* Lancetfish	Reported by Rowan & Rowan (1955) from Tristan, but no details given. Tropical & temperate waters of all oceans.	x	
13	*Cheilopogon pinnatibarbatus* Smallhead flyingfish	Common around Tristan in summer, at its furthest south Atlantic location. Associated with islands. Atlantic, avoiding tropics; St Paul & Amsterdam.	x	
14	*Hirundichthys rondeletti* Subtropical flyingfish	Single specimen collected at Gough in 1972 by G. Basson. Subtropical; Gough is at the southern limit of its range		x
15	*Scomberesox saurus* Saury	Specimens found in the guts of snoek, rockhopper penguin, yellownosed albatross and brown noddy. Circumglobal southern hemisphere.	x	
16	*Lophotus lacepede* Crestfish	One specimen caught on a line from the *MV Hekla* in 1977. Tropical & subtropical, all oceans	x	
17	*Trachipterus trachypterus* Peregrine ribbonfish	One specimen taken in midwater trawl close to Gough in 1980 (Miller 1982). Rare but widely distributed.		x
18	*Brama australis* Pomfret	One specimen collected at Tristan, stranded; some doubt over identification.	x	
19	*Naucrates ductor* Pilotfish	All oceans, tropical and temperate.	x	
20	*Remora remora* Shark remora	Two specimens collected in 1977 from lobster-fishing vessel. Worldwide except polar seas.	x	
21	*Lepidopus caudatus* Buttersnoek	Two specimens from Tristan and Nightingale. Wide anti-tropical distribution	x	
22	*Allothunnus fallai* Slender tuna	One juvenile collected in 1989. Worldwide distribution between 20°S and 50°S	x	
23	*Mola* sp Ocean sunfish	Several sightings around the top islands. Worldwide except polar seas	x	
24	*Ranzania laevis* Slender sunfish	Single specimen washed up near the harbour, Tristan in March 2015	x	

Table 3: Oceanic and mesopelagic fishes recorded from Tristan da Cunha and Gough (Andrew et al 1995)

Figure 32: Left: Smallhead Flyingfish *Cheliopogon pinnatibarbatus* are common around the Tristan top islands in summer. Right: Slender Sunfish *Ranzania laevis* washed up on Tristan in 2015 (Photo Rob Mrovicki).

3.2. Marine biological surveys

Other than short visits from passing expeditions en route to and from the Antarctic, which sampled opportunistically, there have been very few studies of marine life on the Tristan islands because of their extreme remoteness and the difficulty of getting to the islands and working there. Table 4 lists the main expeditions and other major marine projects, together with references to their results.

For the top islands, the most comprehensive survey of shallow water benthic marine life was the Norwegian Expedition in 1937-38, resulting in publications on the seaweeds and most of the main animal groups. Although the taxonomy now requires revision, and with a few major invertebrate groups not written up (sponges, gastropod mollusks), these papers still remain the most comprehensive reference to Tristan marine species. Crucially many of their specimens (including many type specimens) were deposited in museums and are still available for study.

The expedition was based on Tristan for four months from December 1937 through to March 1938, working both intertidally and using small dredges from a motor schooner to obtain specimens from deeper water. They sampled at Tristan, Nightingale and Inaccessible, but failed to reach Gough. One of their richest collecting sites, at Julia Point near the settlement on Tristan, was later destroyed by the volcanic eruption in 1961. Several of the species recorded at Julia Point have not been recorded at the top islands since, including the urchin *Pseudechinus magellanicus*, starfish *Allostichaster capensis (=inaequalis)*, and orange brittlestar *Ophiomyxa vivipara*

Figure 33: Scottish National Antarctic Expedition ship *Scotia* in the ice at Laurie Island, South Orkneys. The first scientific sampling at Gough was done from this ship on its way back to Scotland in 1904. Photos by expedition leader William Spiers Bruce. [Source: Wikipedia commons]

Ship or organization	Dates	Work done	Publications
Challenger	1872-76. On Tristan Sep 1873	Eight sampling stations at top islands. Took off Stoltenhoff brothers.	John Murray reports. Chart at www.19thcenturyscience.org/HMSC/HMSC-INDEX/Charts-150/242-Chart17.jpg
Scotia (previously a Norwegian whaler named *Hekla*) - Scottish National Antarctic Expedition	1902-04. 21st April 1904 on Gough, on way back to Scotland	1st visit to Gough by a scientific party. Shore collecting, baited traps and Montague trawl at 100 fathoms.	Wilton et al 1908 Appendix to Chamberlain et al 1985
Discovery	1926, 1927, 2 visits to Tristan top islands	Various sampling methods	Hardy 1967; this reference includes a guide to the many reports of the expedition
Quest - Shackleton-Rowett Expedition	1922, TdC 20th May. Gough	Soundings & surveys of the coastline	
William Scoresby	1927, 9-10 June. Gough	Small dredge collections from 40-60m near Penguin Is on east coast and 90-120m off west coast	Appendix to Chamberlain et al 1985; Hardy 1967; expedition reports
Discovery II	1930, 18th May, Gough	Trawl 102-141m one mile off Southwest Point	Appendix to Chamberlain et al 1985; Hardy 1967; expedition reports
Anatolia, Norwegian Scientific Expedition	1937-38 Tristan	Major expedition, set up camp on Tristan. Four months	Published on most marine groups (see References)
Gough Island Scientific Survey (GISS) (British)	Nov 1955-May 56 Gough	Camped for six months at The Glen; surveyed terrestrial life and seashores	Holdgate 1958, Chamberlain 1965, Chamberlain et al 1985
RSA. South Africa Division of Sea Fisheries	1967	Gough - three dives on the east side; one dive at Tristan	Heydorn 1969
University of Cape Town expedition	1981 Gough, top islands	17 dives around Gough, four at top islands. Camped at The Glen, worked from small inflatables	Hay, reports for Darwin Initiative
Tim Andrew, PhD project based on Tristan	1988-90 Tristan	Numerous dives, fish studies	PhD thesis; Andrew et al 1995
ICEFISH 2004	2004	Deep sampling for fish; trawls and grabs for invertebrates; ROV footage	Anderson et al 2005; Lessios et al 2012
Crid Fraser	2007 Oct Gough	Algal collections	Fraser et al 2008
MV Maria S Merian Cruise MSM 24	Dec 2012-Jan 2013	Walvis Bay - Cape Town, via Tristan. Geophysical data, from instruments left on the seabed & on the islands for a year; bathymetry & currents	Short cruise report. Chief Scientist Wolfram Geissler
RV Polarstern (AWI)	2012-13	Bathymetry	Alfred Wegener Institute
Darwin Initiative projects, based on Tristan & *MV Edinburgh*	2004-2014 all islands	Diving surveys to 30m at all the islands; some intertidal sampling	Scott & Tyler 2008, Scott 2010a,b, Scott and Holt in prep.
James Clark Ross, British Antarctic Survey JR287 cruise	May 2013 19-20 Gough; 21-Esk Guyot; 21-26 top islands	Benthic sampling in depths of 100-300m; camera lander, benthic trawls, mid-water trawls	BAS JR287 cruise report

Table 4: A list of the main expeditions to Tristan and Gough that have gathered information on marine life at the islands

Sampling in the shallow subtidal at the top islands has been sporadic, with early opportunistic dredging, and no direct observations possible until the advent of SCUBA diving. A thorough study of Tristan inshore fishes, partly by diving, was made by Tim Andrew (Andrew et al 1995). An expedition from University of Cape Town in 1981 dived at both Gough and the top islands (Hay 2008), with the aim of comparing the two locations. They dived at 17 locations in a good spread around Gough, but managed only four sites at the top islands, not enough for a detailed comparison. Early studies of the lobster populations included sampling by diving at very few sites, and made some general observations on subtidal communities and lobster habitats (Roscoe 1979, Pollock 1991). No comprehensive descriptions of shallow water habitats and species were made until the Darwin Initiative-funded subtidal surveys from 2004-2014. These trips completed diving surveys at 24 sites around Tristan, 11 at Nightingale, 15 at Inaccessible and 37 at Gough (Scott & Tyler 2008, Scott 2010a, 2010b, Scott & Holt in prep). These surveys recorded habitats and species using methods developed in the UK for the Marine Nature Conservation Review (and SEASEARCH, its amateur diver spinoff), and generated many specimens currently being identified by experts, including genetic studies.

The British Gough Island Scientific Survey (GISS), which stayed for six months on Gough at The Glen in 1955-56, made good collections of seashore animals and seaweeds, and notes on zonation, later published by Chamberlain (1965) and Chamberlain et al (1985). Heydorn (1969) gives a brief description of three dives on the east side of Gough in April 1967, and noted 'an astonishing lack of sessile life, other than *Macrocystis*, on the rocks'. A diving expedition from University of Cape Town in 1981 made 17 dives around Gough, with the main emphasis on seaweed collections, but also recorded habitats and animals. This work was never published, but notes by Cameron Hay were written up many years later as part of a Darwin Initiative project (Hay 2008). Specimens from this expedition are deposited in the South African Museum, Cape Town (animals), and the National Museum of New Zealand, Wellington (algae). A Darwin Plus project funded a diving survey of Gough in February 2014, when 26 sites were dived. However, these were all on the rather more sheltered north coasts as the west and south coasts were subject to heavy swells throughout the trip. A further 11 sites were surveyed, mostly on the south and west sides, in February 2015 (Scott and Holt in prep).

Figure 34: Dive surveys at Gough in 2014 were made possible by using the rock lobster fishing ship *MV Edinburgh* (left) as a mother ship, and diving daily from a rigid-hulled inflatable boat (RIB), while the *Edinburgh* was away fishing.

Deep waters below diving depths (30m) have been sampled in passing by dredging giving tantalizing glimpses of a seabed populated in places by small corals, soft corals, seafans and occasional black coral. However, there have been no comprehensive studies of life in deeper water. Most recently (2013), the British Antarctic Survey ship James Clark Ross spent two days at Gough and six days at Tristan, recording and sampling seabed life between 100-300m with camera lander and Agassiz trawl, and also completing midwater trawls (BAS 2013). Results from this trip are still to be worked up, and will undoubtedly generate new species records for the islands, but the steep and uneven terrain made the use of the seabed sampling equipment, which was largely designed for even, continental shelf seabeds, somewhat hazardous, and severely limited the types of habitat sampled. The camera lander system requires a flat seabed to land on and takes photos only of the small square of seabed directly below it within its frame, so also provided very limited information.

Figure 35: The BAS vessel *James Clark Ross* off Gough. The ship is equipped for sampling and photography at depths of 100-300m.

Much of the benthos in deep water between 300-3000m, which comprises the vast majority of marine area of the islands out to the conservation limits of 12 miles (19km) and fishing limits of 200nm (370km), remains completely unknown. Sampling at these great depths requires large, specially equipped ships, and is therefore much more time-consuming and expensive than inshore areas.

There is also a gap in knowledge between 30m, which is the lower limit of safe diving surveys, and 100m, which is the shallowest that larger ships can safely work with trawls and other towed equipment. Life at these two depths is very different, and there is obviously a transition zone between the two, which is so far unrecorded except for occasional dredges and incidental catches in lobster traps. This is an important depth range for lobster populations and fishing operations. Towed and remotely operated videos would gain much useful information from these depths, as evidenced by videos of the seabed off Nightingale (produced by the insurers after the wreck of the bulk carrier Oliva, but not made available for general use).

3.3. The coastal environment

3.3.1. The seabed

All the islands are small, with exposed rocky coastlines that drop steeply into deep water. The margins of these volcanic islands are constantly being eroded by waves and swell resulting from the frequent winds, resulting in mainly narrow erosion platforms in places. There are no sheltered inlets, and the shores and seabed are of volcanic bedrock, or of the products of rock erosion - boulders, cobbles and coarse sand, supplemented by material washed down from the interior by rainfall.

Figure 36: Boulder and cobble shores on the northeast coast of Gough, with steep backing cliffs and offshore stack of Penguin Island.

The intertidal zone is predominantly wave-exposed rock and boulders. There is no real shelter, though the northeast coasts are slightly less exposed. In many places the coastal zones are backed with sheer cliffs of various heights, dropping straight into the sea, or littered at the base with fallen rocks, which are rapidly eroded into rounded boulders, cobbles and pebbles, forming narrow beaches.

Beach 'boulders' can be as much as 10m across. More often they are 2m down to 30cm across, and mobile in storms. 'Floating stones', vesicular volcanic rocks full of holes and gas bubbles that make the rock light enough to float can sometimes be found washed up at the top of the shore on Tristan. Many lumps of pale, soft pumice floated ashore on Tristan in 2004 after an underwater eruption 24km southeast of the island, but these rapidly eroded away. Small patches of sand are fairly frequent on the seashores, but there are very few more extensive sandy beaches. The black sands at Runaway Beach and Sandy Point on Tristan are the two largest at the top islands, while on Gough the only sandy beach is a small area of golden sand at Capsize

Sands on the northeast coast. Offshore there are many dramatic stacks ('hardys') and islets, particularly at the more eroded older islands; Lot's Wife and Cone Island off the north coast of Gough are over 100m high. There are numerous lower-lying reefs and 'blinders' just below the surface.

Figure 37: Beach of black sand at Runaway Beach, Tristan

In a few places, lava flows at sea level have formed horizontal rock platforms, resulting in a more extensive intertidal zone. These lava flows are complex features with numerous rock pools, arches and deep channels, connecting the outer seashore pools to the open sea. Rock flats are particularly extensive at Runaway Beach on Tristan. On Gough, there are very few intertidal rock shelves and reefs with pools, notably at West Point and South Point (Chamberlain *et al.* 1985), and in Glen Bay and at Buttress Rock (Scott & Holt in prep).

Figure 38: 'Hardies' off the north coast of Gough. Church rock is in the foreground, with Lot's Wife to the right and Cone Island to the left.

Intertidal cliffs often continue steeply into the shallow subtidal, often descending rapidly to 30-50m, and usually ending in a tumble of boulders continuing into deep water or ending on a sand plain. Rugged rocky reefs and pinnacles interspersed with boulders, pebbles and sand are common at 15-30m, with features such as potholes, arches and caves in places.

There are some more extensive areas of coarse sand, especially around Tristan (off the Settlement, in Seal Bay and Deadman's Bay, and from Trypot to Sandy Point). There is also extensive sand at 25m and deeper off northeast Inaccessible, and off northeast Gough. The color of the sand reflects its geological origin. Black mineral sand is common around Tristan and Inaccessible, with varying amounts of white fragments of biological origin (mollusk shells, echinoderm tests and calcified algae).

Figure 39: Underwater, coastal cliffs often continue as steep, vertical or overhanging rock faces, covered with marine life (left). At the bases of rock slopes, and in bays, boulders of assorted sizes form less steep boulder slopes, often ending in sand at the seaward limit - both photos taken at Nightingale.

Little is known of the nature of the seabed below diving depths, but as it drops steeply into deep water of over 3000m a short distance offshore, seabed topography is likely to be rugged with a large proportion of hard material. There are few extensive horizontal areas, with the exception of Inaccessible, where there is a plateau or ridge at 50-90m deep extending out to about 10km to the west of the island. Information from sidescan sonar down to 500m suggests a rugged topography at all the islands, and downward-facing camera lander images (BAS 2013) show mixed sea beds of bedrock, cobbles, pebbles and coarse sediments at 100-300m. Video images taken at 120m off southeast Nightingale show fairly extensive areas of sediment containing a high proportion of broken bryozoan skeletons, between areas of rock and boulders.

3.3.2. Tides

The tidal range at all the islands is small, less than 40cm on neap tides and just over a meter on spring tides. The tidal range at Gough is slightly more than at the Tristan top islands. At spring tides (which occur twice a month, around new and full moon) at the top islands, one of the semi-diurnal (twice-daily) tides has a slightly smaller range than the other, with a higher low tide and a lower high tide, although the difference between the two low tides in a day is only around 8cm, and high tides are almost identical. On Gough, this effect is much more pronounced; at spring tides there can be as much as 25cm difference in height between the two low tides in a day. At neap tides (which occur at fortnightly intervals between spring tides, around half moon, waxing or waning), tides on Gough become even more asymmetric, with the two tides of the day having a vertical range of around 30cm and 80cm. At both islands, the lowest spring tides (the best for shore survey work) occur around 6am and 6pm, which is probably least stressful for intertidal organisms, as it minimizes exposure to sun and drying conditions.

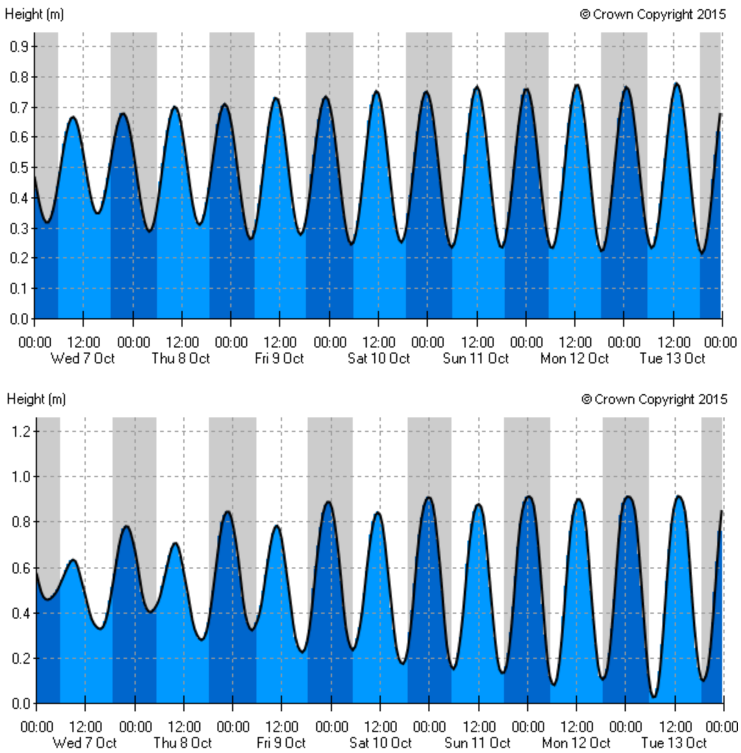


Figure 40: Predicted tidal range over a neap tide (left) to spring tide (right) period at Tristan (top graph) and Gough (bottom graph). There is a very small tidal range of less than a meter at spring tides, and less than 40cm at neap tides. Note the markedly asymmetrical neap tides at Gough, with one low and high tide each day different from the other, although this has little effect in practical terms on seashore life on such an exposed coast when swell is often more than a meter.

[Tidal information from www.ukho.gov.uk/easytide]

At all the islands, tidal height in relation to shore conditions and zonation of biota is often academic, because the swell height is often more than a metre and therefore greater than the tidal range, so that waves break across the entire shore, even at low water. There is also an extensive 'splash' zone above technical high water mark. However enough calm days occur for physical stresses to result in an obvious zonation of seashore seaweeds and animals relative to immersion, showing as horizontal bands of the most successful or visible organisms.

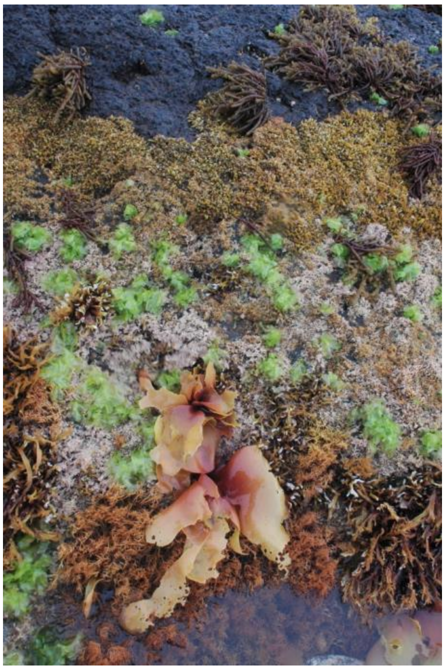


Figure 41: Compressed zonation of seashore life on rocky shores with small tidal range of less than a meter. Left: less exposed shore east of the Harbour, Tristan. Above: bands of dark red and pink coralline seaweeds on the northeast coast of Gough, with zones extending higher up the shore in a surge gully, where bull kelp *Durvillaea antarctica* is also growing on the lower shore.

3.3.3 Seashore

Due to the small tidal range, exposed coast and frequent swell, the intertidal is often not visible or accessible. A calm day and a low spring tide gives quite a different picture, revealing (on the mainly steep shores) a narrow intertidal band covered with pink and red seaweed crusts and turfs, with a distinct vertical zonation, albeit highly compressed.

Seaweeds are the most visible intertidal life. Very few intertidal grazers are present to keep the seaweeds in check, as the herbivorous limpets and gastropods familiar on most temperate continental shores of the world are largely absent. The dense bands of mussels and barnacles that often take up much space on temperate shores are absent from Tristan and Gough. There are no large mussels, and barnacles grow only on vertical rock in the subtidal, at the most wave-surged sites. These species that we think of as 'typical' seashore animals have simply been unable to reach Tristan, as their larvae are short-lived and could not survive dispersal over the huge distances to get there, and, even if they manage to reach Tristan, may be unable to cope with the rigorous conditions.

Although large invertebrates are few on Tristan shores, there are huge numbers of tiny crustaceans, bivalves, worms and other animals living amongst the seaweed turfs. There are significant differences between the inshore marine life at Gough and at the Tristan top islands, so the two areas are described separately below.

3.3.4. Intertidal bedrock and stable boulders

Tristan top islands

The 'splash' zone or supralittoral, above the technical high water mark of tides, is difficult to define on such exposed coasts, as the influence of waves and swell extends for many meters above high tide mark, and salt spray carries far inland. There appear to be no comprehensive descriptions of this zone on Tristan. Rocks and small rock pools in the splash zone often have a slippery film of blue-green algae (Cyanophyceae), a few small gastropods (*Marinula tristanensis*), and the larvae of kelp flies are often present in small tubes attached to open rock (Scott & Tyler 2008). Amphipods and small flatworms live under stones. Baardseth (1941) reports the thin (polythene-like) purple seaweed *Porphyra tristanensis* as occurring as high as 3m above mid-tide level. Siphonariid limpets also occur in the splash zone, although on Tristan they were seen mainly on the highest part of rock flats where they were frequently inundated by swells.

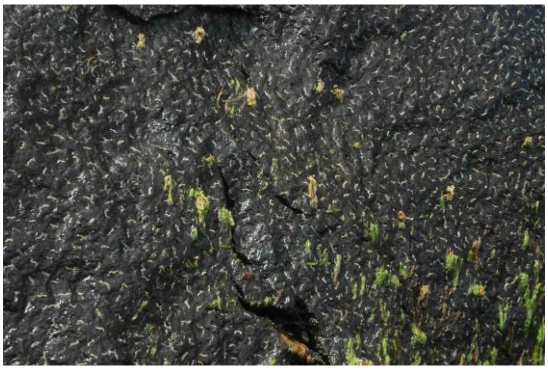
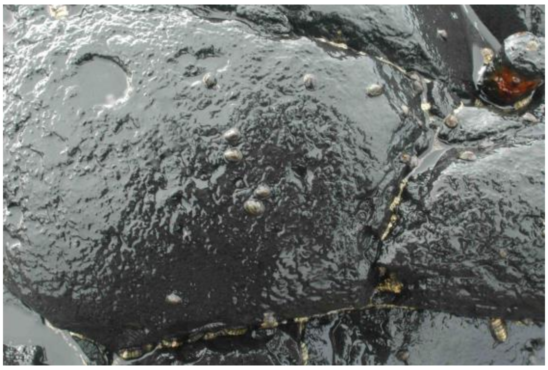



Figure 42: 'Splash' zone at Tristan. Left: tubes of kelp fly larvae, small specimens of red seaweed (*Porphyra* sp) and green seaweed on the side of a large boulder. Right: siphonariid limpets and chitons on higher-level rock on more extensive rock flats. The wet rock surface is covered with a slippery film of blue-green algae (cyanophyceae).

On steep rocky shores at the top islands the uppermost red seaweed is laver *Porphyra tristanensis*. Below this, at or just above high water mark, dense short turfs of the red seaweeds *Bostrichia mixta* and *Gelidium* sp develop in crevices and on more sheltered faces. A little lower, turfs of dark red seaweeds only 1-3cm long commonly include *Centroceras clavulatum*, *Gelidium* sp, *Dipterosiphonia heterocladia, Rhodoglossum revolutum*, and *Schizoseris* spp. Patches of dark green spongy encrusting *Codium adhaerens* grow on vertical rock and in more shady places. Scattered larger seaweeds on the mid-shore include dark red *Gigartina stiriata* and *Iridaea cordata*, and tufted green *Ulva* and *Cladophora* species are also frequent on upper and middle shores. Often the smaller algae are attached to coralline seaweeds beneath. The cell walls of coralline seaweeds contain calcium carbonate, giving them a hard skeleton and a distinctive chalky-pink color.

Encrusting coralline seaweeds are ubiquitous on mid and lower shore and into the subtidal, while on the lower shore tufts of jointed coralline seaweeds (including *Corallina officinalis*, *Jania* sp) often form a dense turf, overgrown by small tufts of dark reds including *Centroceras clavulatum*, *Heterosiphonia arbuscula*, *Dipterosiphonia heterocladia* and *Schizoseris* spp. Scattered larger plants of *Iridaea cordata*, *Streblocladia atrata*, *Gigartina stiriata* and other dark reds often grow amongst the jointed corallines, with the variety of seaweeds increasing towards the subtidal fringe. On these steep shores, the whole mid and lower shore is kept constantly wetted by swells, even on relatively calm days, and the small tufted algae also retain water, providing a home for huge numbers of small marine animals.

Figure 43: Steep rock in the intertidal at Nightingale, with dense turfs of dark red seaweeds. The pink is jointed and encrusting coralline red seaweeds and the dark blackish-green patch on the upper mid-shore is encrusting green seaweed *Codium* sp.

At Pyramid Rock, an extremely exposed offshore rock off the southern point of Inaccessible, most of the mid and lower shore was covered with large barnacles, with small filamentous red seaweeds and small orange ascidians growing on the shells (Scott 2008).

At the top islands this community appears to be confined to relatively few places with extremely exposed, vertical rock; a similar barnacle-dominated community is more widespread at Gough (see below).

On more extensive rock flats, particularly at Runaway Beach, the harbor and the Caves on Tristan, much more luxuriant seaweed turfs up to 5-10cm long develop on upward-facing rock on the mid and lower shore. Typically these include dense patches of the red seaweeds (often bleached brown or yellow) *Gymnogongrus* sp, *Streblocladia atrata,* and *Gigartina stiriata,* and the brown *Splachnidium rugosum*. The green *Ulva* may be more abundant on flatter shores. The large flat fronds of *Iridaea cordata* are often conspicuous or even zone-forming, especially where rock surfaces drop into surge channels or rock pools. On outer rocks, these larger seaweeds grade into the shorter coralline and filamentous red turfs described for the more exposed and steeper faces above, and often include the brown *Dictyota liturata* and filamentous brown *Halopteris funicularis,* the latter with many small algal epiphytes. Baardseth (1941) elaborates on algal species and zonation, although sadly one of the Norwegian expedition's main study sites on Tristan, Julia Point, was destroyed in the 1961 eruption.

Figure 44: Rock ridges with dense turf of red seaweed *Gigartina stiriata* near the Harbour, Tristan. The brown seaweed *Splachnidium rugosum* (above) also forms dense turfs in places; both species are absent from Gough shores.

Invertebrate animals are not conspicuous on open rock on Tristan shores, and there are no obvious zone-forming animals like barnacles and mussels, or large limpet and gastropod grazers so familiar on continental shores. Small siphonariid limpets *Siphonaria tristensis*, chitons *Ischnochiton bergoti* and gastropods *Marinula tristanensis* are locally common at high water or just above, and small anemones live in crevices. A few much larger chitons *Plaxiphora aurata*, up to around 40mm long, cling firmly to the rocks around low water, where the antennae of juvenile lobsters may also be seen sticking out from the seaweeds. The whelk *Argobuccinum tristanense* is occasional from midshore downwards.

Figure 45: Larger seashore animals. Left: chitons *Plaxiphora aurata*. Right: whelk *Argobuccinum tristanense.*

Most littoral animals are extremely small, less than 5mm long, and live hidden inside the permanently damp seaweed turfs. These include bivalve and gastropod mollusks, crustaceans (amphipods, isopods, tanaids, copepods) and polychaete worms. The tiny bivalve mussel *Lasaea rubra*, for example, is particularly abundant in upper shore algal turfs in places. Although small and inconspicuous, these animals are often present in huge numbers, collectively forming a significant biomass. Many of them will be grazers on microscopic and macroscopic algae, or accumulate filtered material from local sources, and probably form a very important link in local food webs. We know little of these turf animal communities, or their significance as food for fish and the commercially important lobster populations.

Gough

Intertidal rock on Gough is mostly steeply sloping or vertical, and intertidal platforms are rare and very small. There is no equivalent of the extensive lava flow platforms on Tristan. Chamberlain et al (1985) give a detailed description of Gough seashores from information collected by the Gough Island Scientific Survey (GISS) of 1955-56, particularly around Glen Bay, where they were based. They provided a good description of the 'splash zone' (supralittoral), which they considered to be from the lower limit of land vegetation at around 3m above mean sea level (MSL), down to about 75cm above MSL. The vegetation of the upper part of this zone was chiefly of lichens (*Lichina* sp, *Placodium* sp), while the most characteristic animals were two black oribatid mites, and the amphipods *Orchestia platensis* and *O. scutigerula*. There were also typical terrestrial invertebrates (flies, moths), most abundant amongst driftwood, dead kelp and other strandline debris, together with the isopod *Pocellio scaber* and diplopod (millipede) *Cylindroiulus latestriatus*.

The lower splash zone was characterized by locally abundant laver *Porphyra tristanensis*, with black encrusting lichens *Verrucaria* sp, and the ellobiid gastropod *Marinula tristanensis* in crevices. Other crevice-dwellers included the amphipod *Hyale hirtipalma*, the isopod *Isocladus tristanensis* and the flatworm *Procerodes variabilis*. In the lowermost 50cm siphonariid limpets were abundant in places (identified as *Kerguelenella lateralis* in Chamberlain et al (1985), though superficially similar siphonariid limpets from Tristan have been recently identified as *Siphonaria tristensis*). The small bivalve *Lasaea rubra* was numerous in wet hollows.

In the upper littoral, patches of the green algae *Blidingia minima* and *Enteromorpha bulbosa* typically occur in moist and shady places, progressively replaced by the red (bleached yellow) *Mazaella (=Iridaea) laminarioides* with increasing exposure, and lower into the mid-littoral. This seaweed forms large clumps and often a conspicuous zone on the upper shore at Gough, and has a wide distribution in colder water in the South Atlantic, but is not present at the Tristan top islands. The red *Rhodoglossum revolutum,* endemic to Tristan and Gough, often grows with *Mazaella laminarioides* in the lower part of its zone. Siphonariid limpets are abundant, as is *Lasaea rubra* and the amphipods *Hyale hirtipalma* and *H. grandicornis* amongst the seaweed turfs, while the gastropod *Marinula tristanensis* is much less common than in the supralittoral. Chitons are common in the mid-littoral, and, according to Chamberlain et al (1985), *Plaxiphora simplex* is abundant at this level while *Ischnochiton bergoti* is relatively rare. However shore surveys on Gough in 2014 (Scott & Holt, in prep) and on Tristan (Scott & Tyler 2005) recorded the opposite, with *Ischnochiton* more abundant at the upper levels.

Mid to lower shores at Gough are covered with a short turf of red seaweeds, including the coralline *Corallina officinalis*, with dark red *Centroceras clavulatum* and *Herposiphonia paniculata*. However the jointed coralline *Jania* sp, abundant on Tristan, is absent from Gough shores, while the small filamentous red *Polysiphonia howei* is frequent at Gough. Many of the conspicuous medium-sized (5-10cm) seaweed species at the top islands are absent from Gough, including the red *Streblocladia atrata*, *Gigartina stiriata*, *Iridaea ciliata,* and brown *Splachnidium rugosum,* and *Ulva* is rare on open rock. The bull kelp *Durvillaea antarctica* is very conspicuous in surged places on the lower shore at Gough, but is absent from Tristan. Chamberlain et al (1985) note that the chitons *Ischnochiton bergoti* become more abundant on the lower shore while *Plaxiphora simplex* becomes rarer; again, shore surveys in 2014 (Scott & Holt, in prep) and on Tristan (Scott & Tyler 2005) recorded the opposite, with the larger *Plaxophora* more abundant at the lower levels. As well as amphipods and isopods recorded at higher levels, fauna on mid and lower shores included spirorbid tubeworms, other polychaetes, nemertean worms, anemones and nudibranchs.

Figure 46: Seashores at Gough. Left: steep rock with dark patches of the red (yellow-brown) seaweed *Mazaella laminariodes* at the top of the intertidal, and bull kelp *Durvillaea antarctica* below. Neither seaweed is present at the Tristan top islands. The bull kelp patch is subject to local swell. Right: midshore of sloping rock with dense turf of pink coralline seaweeds.

A different zonation occurs on Gough shores in places on vertical rock, with larger algae generally absent from the mid-shore. At Church Rock, Chamberlain et al (1985) described a band of *Codium adhaerens* around mid-tide level, overlapping downwards into a band of *Cladophora radiosa* and corallines which continues into the subtidal; this type of zonation was also noted at several sites on recent dive surveys (Scott & Holt in prep). At Penguin Island and a few other sites, a hard leafy coralline (*Mesophyllum* sp) forms large patches on the steep and vertical lower shore, continuing into the subtidal (see below). This distinctive seaweed, together with the shells of large barnacles, provides a refuge for many small animals including young lobsters *Jasus tristani*, but has not been recorded at the Tristan top islands.

Figure 47: Vertical rock in the intertidal at Penguin Island, with clumps of the pink leafy coralline seaweed *Mesophyllum* sp. and other red seaweeds, with a band of green *Cladophora* sp.

3.3.5. Rock pools and channels

Tristan top islands

The lava flow shores at the harbor, Runaway Beach and the Caves on Tristan are complex structures, containing many rock pools of various areas and depths, as well as deep 'pools' and channels that connect either directly to the open sea, or via underwater archways.

The highest level pools, that experience temperature and salinity changes, are lined with green algae *Chaetomorpha* and *Ulva (Enteromorpha)* sp, together with other green and brown algae (*Ulva, Cladophora, Sphacelaria*, Ectocarpaceae). Deeper pools also contain *Ulva* and stunted *Corallina*. Crevices are lined with orange and grey anemones, and algal tufts contain many tiny amphipods.

Figure 48: Small anemones are common in crevices in some upper shore pools.

Shallow mid-shore pools are lined with jointed and encrusting corallines, with a few other filamentous red and brown algae. Deeper pools have a much wider range of filamentous and larger foliose seaweeds, with the red *Iridaea ciliata* and green *Ulva* often visually dominant, but also with seaweeds more typical of the subtidal including species of *Plocamium*, *Epymenia*, *Gelidium*, *Pterosiphonia, Dictyota* and occasional small giant kelp or pale kelp plants. Giant kelp is often dense in the channels where it is kept constantly moving by swells. The walls of a deep rock pool at the east Landing on Nightingale have abundant brown 'brackets' of the seaweed *Zonaria tournefourtii*, a species seen rarely elsewhere at the top islands, growing amongst dense coralline turf. The sides and bases of deeper pools are often heavily grazed by urchins *Arbacia dufresnii,* and are bare of algae except for hard encrusting corallines.

Many of the deeper pools and channels have highly scoured bases of mobile cobbles and pebbles. Some interesting algae are occasionally found growing on scoured and sand-influenced rock tops, including probable species of *Tsengia, Schizymenia* and other flat reds, *Helminthocladia,* and more characteristically, *Iridaea ciliata* and a narrow-branched species of *Gymnogongrus/Ahnfeltiopsis*.

Figure 49: Cobble-filled channels with constant surge from connections to the open sea carry a luxuriant seaweed flora in summer, provided cobbles are not too mobile in bad weather. The large pink leafy seaweed is *Iridaea ciliata*.

A much wider variety of larger invertebrate animals lives in rock pools and channels than on open rock. Urchins *Arbacia dufresnii* are common in the deeper pools, grazing the bases bare of seaweeds and sessile animals.

White anemones *Anthothoe chilensis* are common, even abundant in the shady parts of some pools, and orange and pink anemones (*Bunodactis* sp) are locally common in the crevices of shallower pools, often with coarse sand or gravel attached to their columns.

Octopus (probably *Octopus vulgaris*) are found under overhangs and in deep crevices, and can be very large with tentacles up to a meter long in some of the deeper pools at Runaway Beach. Their normal diet is crustaceans, and on Tristan they are well-fed on the numerous rock lobsters *Jasus tristani*. Young rock lobsters, from puerulus stage to 3-4 years old, are particularly abundant in rock pools, hiding in crevices and amongst the seaweeds during the day, and emerging at dusk to climb up the kelp.

Figure 50: Animals common in rock pools on Tristan. Clockwise from top left: seaslug *Tyrinna nobilis*; endemic klipfish *Bovichthys diacanthus*; large octopus, hunting for rock lobsters; juvenile rock lobster *Jasus tristani* hiding in seaweed.

Sponges, bushy bryozoans and clumps of spionid worms grow in shady places, preyed on by pink starfish *Henricia* sp and several species of seaslug (*Tyrinna nobilis*, *Archidoris fontainei*, and other unidentified species). Large sea hares *Aplysia* sp. have been reported from Runaway beach on two widely separated occasions, once in 1952 by Mr H.F.I. Elliot, the Administrator at the time (Eales 1960, described as a new species *Aplysia dura,* occurring at Tristan and Cook Strait, New Zealand), and again by islanders in 2010 (Trevor Glass pers.comm.). Tristan whelks *Argobuccinum tristanense*, the only large gastropod on the islands, are frequent in rock pools.

Endemic klipfish *Bovichtus diacanthus* are common in rock pools, and rocklings *Gaidropsarus novaezealandiae* emerge from crevices at night. Deeper pools are inhabited by Tristan wrasse *Nelabrichthys ornatus* and young fivefinger *Acantholatris monodactylus*, and more recently on Tristan by an alien fish, the South American silver porgy *Diplodus argenteus argenteus*, introduced with a stranded oil rig in 2006 and now well-established around Tristan.

Gough

Apart from one large sheltered pool near The Admiral used by seals and highly enriched by their droppings, and a large pool about 4m across at the Glen, rock pools on Gough's north and east coasts are generally small and shallow, and there are no extensive deep rock pool and channel systems on rock flats equivalent to those on Tristan.

In the supralittoral, the GISS in 1955-56 found pools at The Midshipman (a relatively sheltered site) containing the algae *Scytosiphon lomentaria*, *Herposiphonia paniculata*, *Centroceras clavulatum* , *Ulva lactuca* and blue-green algae (Chamberlain et al 1985). A high-level pool near the seal pool near The Admiral was filled with tubular *Ulva* (*Enteromorpha)*, with kelp flies on the surface (Scott & Holt in prep). At the more exposed West Point reefs, the GISS reported white encrusting coralline algae, the knobbly coralline *Dermatolithon nodulosum* and green *Ulva* fringing pools in the lower supralittoral, plus the red seaweeds *Rhodoglossum revolutum* and *Polysiphonia boergesenii*, and green *Codium fragile* in the pools.

Midshore pools at Dell Rocks, near the Glen, were thoroughly examined by the GISS. (Chamberlain et al 1985). The largest, in the lee of Window Rock, was around 4m across, from which the authors report an 'extremely rich' fauna. There were numerous smaller and more exposed pools nearby, and they publish a collective list of some 50 animal species, including sponges, anemones, polychaete and nemertean worms, amphipods, isopods, tanaids, rock lobsters *Jasus tristani*, pycnogonids, chitons, gastropods, nudibranchs, the urchin *Pseudechinus magellanicus* (as *P. novaeamsterdamiae*), ophiuroids, colonial tunicates, the klipfish *Bovichtus diacanthus* and wrasse *Nelabrichthys ornatus*. Many of these are essentially subtidal species, more common below low water. Algal species were much less diverse, and included *Rhodoglossum revolutum*, *Blidingia minima*, *Codium fragile*, *Iridaea undulosa* and coralline algae in the big pool, while the brown *Scytosiphon lomentaria* and *Giffordia mitchelli,* and green *Ulva* sp. grew in the smaller, more exposed pools. Chamberlain (1965) also notes *Corallina officinalis*, *Dermatolithon undulosum* and *Iridaea undulosa* as among the most common seaweeds occurring in littoral rock pools.

Slaughtered Seal Bay on the east coast had abundant midshore pools in vesicular trachyte lava, with a variety of small algae, and animals including siphonariid limpets, chitons, the bivalvae *Lasaea rubra*, amphipods, polychaete worms and klipfish. Small, shallow midshore rock pools at Buttress Rock examined briefly in 2014 (Scott & Holt in prep) contained a variety of small green, red and brown algae (still to be examined), and a few small barnacles and anemones.

3.3.6. Boulder beaches

Tristan top islands

Biota on boulders at the top islands was studied at Sandy Point and Seal Bay on Tristan, and at Blenden Hall on Inaccessible, by Baardseth (1941), who noted that algae grew mainly on the seaward side, and that encrusting corallines were almost entirely lacking. However Scott (2008) found luxuriant algae on the leeward sides of boulders, for example dense *Halopteris* with epiphytic *Schizoseris* and *Heterosiphonia*, and jointed corallines, at the slightly more sheltered Salt Beach, Inaccessible.

Boulders in the splash zone have abundant kelp fly larvae, together with blue-green algae. A little further down grow the red *Bangia fuscopurpurea* and *Porphyra tristanensis*, green *Ulva lactuca*, tubular *Ulva* (*Enteromorpha)* and other green algae, and brown *Splachnidium rugosum*. Lower on the shore the velvety patches of the fine filamentous reds *Callithamniella flexilis* are characteristic, and *Polysiphonia boergesenii*, the flat red *Iridaea membranacea*, and browns *Petalonia fascia*, *Giffordia mitchellae* and encrusting *Ralfsia* sp may also be present. The endemic red *Schimmelmannia elegans*, which seems to require particularly turbulent conditions, is also occasional on lower littoral boulders. Apart from the occasional whelk and chiton, larger animals are not obvious on boulders, but as on bedrock shores, algal tufts contain numerous small amphipods and other animals.

Gough

At Gough, some of the algae that grow on bedrock shores also grow on larger boulders, including *Porphyra*, *Mazzaella laminarioides*, *Rhodoglossum revolutum* and jointed and encrusting corallines. More characteristic of stable boulders are a bright red *Gymnogongrus* sp., which grows on larger boulder tops at a slightly lower level than *Mazzaella*, and the brown *Petalonia fascia*, which grew on the sides of some boulders, together with smaller filamentous brown and green algae. *Gymnogongrus* at all the islands requires more taxonomic work.

Boulder beaches on the uninhabited and remoter islands, particularly Inaccessible and Gough, are haul-outs and breeding territories for Subantarctic Fur Seals, Southern Elephant Seals, and Northern Rockhopper Penguins, accompanied by scavenging seabirds, particularly skuas.

3.4. Shallow subtidal to 40m depth

Subtidal fringe and shallow subtidal

From the lower shore down to 4-8m depth is a particularly diverse and productive zone. High light levels and constant water movement provide excellent conditions for seaweed growth, while the frequent waves and swell discourage grazing urchins and predatory whelks and fish. The dense seaweeds provide cover and food for a host of small invertebrates, particularly crustaceans, living amongst the fronds or attached to them. Jointed coralline seaweeds are abundant around low water and in the top few meters of the subtidal, especially on less steep rock at the top islands, forming a dense turf.

The transparent 'glass' puerulus stage of rock lobsters, and very small juveniles, have so far only been seen by divers in the top two meters of the subtidal, although this may reflect the difficulty of spotting these tiny creatures in underwater habitats. The dead shells of the large barnacles *Austromegabalanus isolde,* which can grow to 8cm or more high, appear to be a particularly favored refuge for newly-settled lobster pueruli. These barnacles form a distinct zone in shallow water from around low water to 2-8m, depending on site. At the top islands, this band of barnacles appears to be present in only a few sites in the most wave-exposed locations, usually on vertical bedrock with relatively deep water below. At Gough, dense barnacles are a more common feature, present at many sites, at least on the northern coasts. The slipper limpet *Crepipatella dilatata* often occurs in dense patches at the lower limits of the barnacle zone at 4-8m, and is also much more abundant at Gough than at the top islands.

In both areas the attached shells of barnacles, dead and alive, provide good surfaces for a host of other sessile marine life, including hydroids, ascidians, anemones, seaweeds, bryozoans and sponges, while polychaete worms, small mollusks and crustaceans (including tiny lobsters) live inside the dead shells and amongst the bases. Although urchins are often found amongst the barnacles, the physical complexity of the barnacle shells probably limits intensive urchin grazing, and frequent heavy surf in shallow water discourages or dislodges them and other predators including whelks and fish. The result is a rich habitat worthy of further investigation. It may play a particularly important part in the recruitment of rock lobsters into benthic life and ultimately into the fishery.

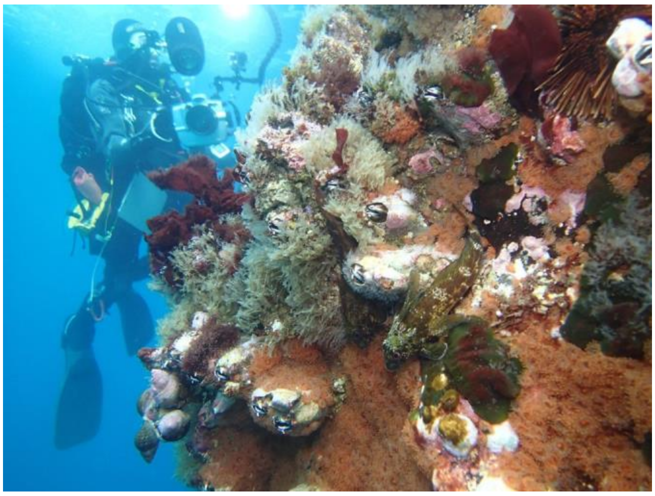


Figure 51: Dense large barnacles *Austromegabalanus isolde* at 0-4m, with orange jewel anemones, whelks, urchin and klipfish. Hydroids, seaweeds and orange ascidians are growing on the barnacle shells.

At all the islands, dense seaweed turfs and meadows cover upward facing rocks, and even vertical rock at exposed sites, from the lower shore down to 6-8m. At both Gough and the top islands, coralline algae, *Iridaea* spp, *Cladophora* sp, *Halopteris funicularis*, *Epymenia* sp., *Gelidium* sp., *Pseudophycodrys pulcherrima* and *Schizoseris* sp are major components of these algal beds.

However there are also major differences in seaweed species composition between Gough and the top islands. At Gough, mini-forests of the green *Codium fragile* and stands of the bull kelp *Durvillaea antarctica* are a characteristic inshore feature. Both are absent from the top islands. At the top islands, *Streblocladia atrata*, *Gigartina stiriata*, species of *Gymnogongrus*, and *Ulva* sp are all abundant in the shallow subtidal, but are absent or rare at Gough.

Figure 52: Subantarctic seaweeds common at Gough but absent from the top islands. Left: green seaweed *Codium fragile*. Right: Bull kelp *Durvillaea antarctica*.

At the top islands, areas of boulders and cobbles at 6-10m off the south west coast of Inaccessible support particularly luxuriant meadows of foliose and filamentous algae in summer. This is the only recorded location at the top islands for the large brown seaweed *Desmarestia ligulata*, which prefers colder water and is more common on Gough.

On Tristan, the harbor provides some protection on an otherwise extremely exposed coastline, even though surge. It may well be the place where accidental introductions have been able to get a foothold on Tristan (Scott, in prep) before spreading to adjacent areas. For example in 2014, the red seaweed *Bonnemaisonia hamifera* was found for the first time on Tristan in large masses in the center of the harbor.

Larger invertebrates are not conspicuous on upward-facing rock in this shallow, seaweed-dominated zone, but whelks, nudibranchs, chitons and sponges can all be found on searching through the algae, and vast numbers of smaller animals (crustaceans, bivalve mollusks, worms, sponges, hydroids, bryozoans and stalked jellyfish), live on and among the seaweeds.

Fivefinger and klipfish are also frequent in the shallows, and on Tristan, the recently introduced porgy or South American silver bream *Diplodus argenteus* is now common in shallow water. Overhanging rock, archways and caves, where algae cannot grow, have more sessile animals, similar to that described for deeper water. Rock lobsters inhabit holes and crevices. The large grapsid crab or red rock crab *Guinusia* (=*Plagusia*) *chabrus* has been seen rarely at all the top islands, usually on steep rocks in shallow water, but has not been recorded at Gough.

Figure 53: Typical small crustaceans found in seaweed samples. Top left, amphipods; top right, caprellids (ghost shrimps); bottom right, a pycnogonid (sea spider); bottom centre, tanaids; bottom left, isopods.

3.5. Deeper subtidal

Kelp forests

Below 8-12m deep, kelp forests are the major feature of the subtidal all around the islands, growing on rocks to at least 35m depth. Two species of kelp form subtidal forests at the islands. Giant kelp *Macrocystis pyrifera* is a spectacular brown seaweed, reaching up to at least 60m long, with one of the highest growth rates of any plant on the planet. In some locations its fronds increase by as much as a meter a day when conditions are optimal, though growth rates have not been established at Tristan and Gough. Its stipes and fronds, each buoyed by a small air bladder, continue to grow on reaching the sea surface, forming dense floating masses that surround the islands, and are conspicuous from the air and visible in satellite images. Pale kelp *Laminaria pallida* is a smaller kelp 1-2m high, with a single palm-shaped frond and no buoyancy bladders. It grows densely at more exposed sites and on steeper rock faces than giant kelp, and beneath giant kelp in mixed forests.

Figure 54: Left: Forest of giant kelp *Macrocystis pyrifera* and pale kelp *Laminaria pallida* (bottom left of photo), with fivefinger fish *Acantholatris monodactylus* and a male Tristan wrasse *Nelabrichthys ornatus* (Nightingale). Right: Subantarctic Fur Seals swimming over pale kelp at Gough (photo: Rohan Holt).

The fronds of giant kelp, buoyed up by gas-filled bladders, form a habitat above the seabed, safe from predatory urchins and starfish, for those animals that can settle on the slippery fronds. Although kelp has effective antifouling methods, a few animals have managed to colonize the fronds, including small hydroids, the encrusting white bryozoan *Membranipora membranacea*, spirorbid tubeworms and stalked barnacles. The floating canopy also provides shelter for small and juvenile fish. Pale kelp generally has few animal settlers, with clean fronds and stipes, although older stipes may become colonized by seaweeds and sessile animals. The holdfasts of both species may contain many small animals. The fauna of kelp holdfasts is being examined as part of the Darwin DPLUS 005 project.

Kelp forest canopies reduce the light reaching the rocks below, so smaller algae become noticeably less abundant beneath kelp, as well as with increasing depth. Urchins *Arbacia dufresnii* also become very numerous in the shelter of kelp forests, and in deeper water where water movement from waves and swell is less destructive, so rocks below 10-12m are usually heavily grazed. The predominant organisms here are those resistant to urchin grazing, particularly encrusting pink coralline seaweeds, jewel anemones *Corynactis annulata*, and hard-shelled animals such as serpulid tubeworms and encrusting bryozoans. A few foliose seaweeds also appear distasteful to urchins, including the red *Pseudophycodrys pulcherrima* and brown *Dictyota liturata*. At Gough, rocks also have extensive patches of the encrusting spongy green seaweed *Codium adhaerens*, which does not occur in the subtidal at the top islands, and also appears to survive urchin grazing.

Figure 55: Left: beneath the bare stipes of pale kelp, an urchin grazes sparse undergrowth of hydroids and bryozoans. Centre: below about 15m, urchins are abundant in many places, reducing the biota to urchin-resistant organisms including encrusting pink coralline seaweeds, and the red seaweed *Pseudophycodrys pulcherrima*. (Nightingale). Right: Urchin-grazed rocks at Gough, with extensive patches of the spongy green seaweed *Codium* sp.

The kelp forests shelter many fish, although of very few species. Fivefinger *Acantholatris monodactylus* are common at all the islands. Tristan wrasse *Nelabrichthys ornatus*, klipfish *Bovichtus diacanthus*, false jacopever (soldiers) *Sebastes capensis* and telescope fish *Mendosoma lineatum* also occur at all the islands, but in very different abundances at Gough and at the top islands. Tristan wrasse are very common in the kelp forest and amongst smaller seaweeds at the top islands, but are relatively rare at Gough, while telescope fish, false jacopever and klipfish are all more abundant at Gough.

The southern horse mackerel *Trachurus longimanus* is also common amongst kelp at both islands, but is difficult to distinguish underwater from young telescope fish with which it often shoals, so its relative abundance is not easy to determine. The yellowtail amberjack *Seriola lalandi,* rare at the top islands in 1989*,* is now common there and seen on most dives. It was not positively identified at Gough on dive surveys in 2014 (Scott & Holt in prep), but was reported from there in 2014. Broadnosed sevengilled sharks *Notorynchus cepedianus* are seen sporadically by divers above the pale kelp forests. Jacopever *Helicolenus mouchesi* are more common in deeper water; they are occasionally seen by divers but frequently brought up in lobster traps set below 30m.

Figure 56: Some fish of the shallow subtidal at the Tristan top islands and Gough. Clockwise from top left: false jacopever (soldier) *Sebastes capensis*; broadnosed seven-gilled shark *Notorynchus cepedianus*; jacopever (soldier) *Helicolenus mouchesi*; shoal of juvenile telescope fish *Mendosoma lineatum* at Gough.

Other rocky habitats

Vertical rock in deeper water is often covered with huge numbers of jewel anemones in large patches, together with sponges and other sessile life. On Gough the large brown sponge *Tedania* sp is common on vertical walls, and the tubeworm *Salmacina* can form large clumps.   Overhanging rock, the sides of boulders, roofs and walls of caves, and crevices, all places where urchins find it harder to reach, and where there is not enough light for seaweeds, are much richer in sessile animals.

Rock surfaces here are often covered with a colourful patchwork of sponges, hydroids, bryozoans, anemones, tubeworms, and ascidians, with seaslugs, starfish and whelks preying on them. Jewel anemones are abundant at all the islands, rock lobsters hide under overhangs during the day, and rocklings and juveniles of other fish species inhabit rock crevices.

Species at Gough that have not been found at the top islands include many different sponges, bryozoans and colonial ascidians, the urchin *Pseudechinus magellanicus*, the orange brittlestar *Ophiomyxa vivipara*, the batstar *Odontaster penicillatus*, starfish *Cosmasterias lurida*, orange starfish *Henricia* sp, and small prawns. The pink sponge *Aplysilla* sp and blue *Dysidea* sp, and bushy orange bryozoan *Catenicella elegans* are all abundant at Tristan, but rare at Gough, giving overhangs a quite different appearance. Another characteristic animal of steep rock and overhangs at the top islands, the colonial trumpet anemone *Parazoanthus hertwigi*, endemic to Tristan, is absent from Gough. Rarer finds at Gough include the curious stalked jellyfish (scyphozoan) *Lipkea* sp, and a single sighting of a small holothurian (sea cucumber) Holothurians have otherwise been recorded only from deep water at 100-300m around the islands, and only a single species (BAS 2013).

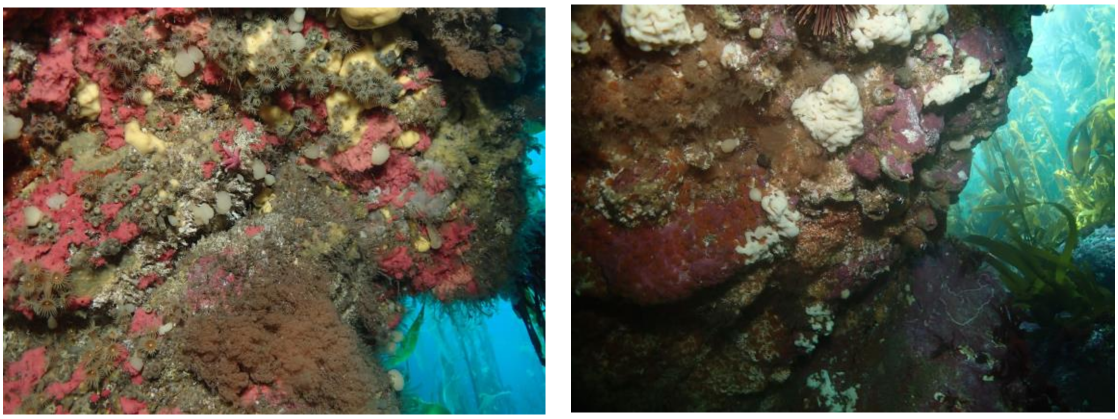


Figure 57: Overhanging rock in a similar situation at Tristan (left) and Gough (right). At both places rock surfaces are covered with sessile animals - sponges, hydroids, ascidians, anemones, bryozoans, but the dominant species are different at each site. The pink sponges, bushy orange bryozoans and sandy-colored trumpet anemones common at the Tristan top islands are rare or absent at Gough, resulting in a very different appearance to the overhangs.

Some animals more characteristic of deeper water below 40m have been seen occasionally by divers in deep crevices or at the back of caves (Scott 2008, Scott & Holt, in prep). These habitats mimic some of the conditions in deeper water, in particular low light and slight water movement. At Gough, small cup corals, known to be very common at 100-300m, were seen under deep overhangs at one site, together with a single much larger cup coral, around 6cm across. Brachiopods were also found in deep crevices at several Gough sites. At the top islands, a single cup coral was seen in a deep crevice off Stoltenhoff (Nightingale). From a few diving observations at Tristan, animal communities appear to change below 40m, where the sea fan *Callogorgia verticillata* appears; sea fans are locally abundant in deeper water. Tanaid crustaceans were particularly abundant in bryozoan turfs in deep water at Tristan. One specimen of the rarely-recorded bright orange bat star *Sphaeriodiscus mirabilis*, apparently endemic to deep water around the Tristan top islands, was also found at around 35m off the east coast of Tristan.

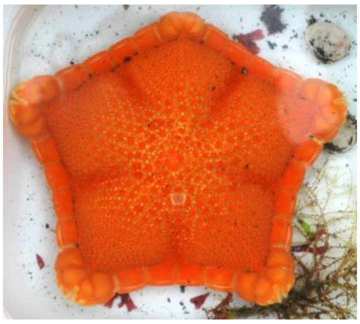


Figure 58: Below 35-40m, animals not found in shallower water begin to appear. Left: seafan *Callogorgia verticillata* on vertical rock. Right bat star *Sphaeriodiscus mirabilis*. (Tristan)

3.6. Deep sea

Very little is known about benthic marine life below 30-40m around the islands, and especially in the depth range 30-100m, where there is a gap in knowledge between the deepest diving surveys and the shallowest remote survey work from ships. Diving is generally limited to 30m for safety reasons, but on two dives to 40m on Tristan, the sea fan *Callogorgia verticillata* was found growing on vertical rock, and has never been recorded shallower than this. From the little information available, it appears to be common in deeper water below 100m (BAS 2013). One of these deep dives also found a specimen of the orange bat star *Sphaeriodiscus mirabilis*, apparently endemic to the Tristan top islands, and otherwise only recorded from a few dredge samples in deep water. Bushy bryozoans, a small zooanthid anemone, larger hydroids and the brown seaweed *Desmarestia sivertsenii* were also noted only on deep dives at the top islands. No dives deeper than 30m have been undertaken on Gough surveys. The large starfish *Cosmasterias lurida* was seen at around 30m on one dive only at Gough, and is apparently more frequent in deeper water as it is sometimes brought up in lobster traps.

The scientific voyage of *HMS Challenger* in 1873 was the first to sample the deepwater benthos around the top islands and to publish comprehensive results. From 8 benthic sites at the Tristan top islands (collectively site 135), using trawls and dredges, they recorded an impressive 135 animal species at depths from 60 fathoms (110m) to 1100 fathoms (2010m), plus a few samples from the shore (see table below). 70 of their species were new to science, and included eight new genera. Most of these were captured above 150 fathoms (275m). Sir Alister Hardy, in his book 'Great Waters' (Hardy 1967), which documents the 1925-27 voyage of *Discovery II,* graphically describes a dredge haul from 100 fathoms (180m) off Tristan as a "truly magnificent haul".

Recent sampling of the benthos between 150 and 300m at Tristan and Gough, using Agassiz trawl and camera lander (BAS 2013), has revealed a very different biota to that above 50m. Macroscopic seaweeds are absent at these depths, and without the coating of pink coralline algae that is ubiquitous in shallow water, the black volcanic rocks look very different, and the grazing urchins *Arbacia dufresnii* so abundant in shallow water are rare. Of 49 recognisable species/entities, only 12 (24.5%) also occur in shallow water above 30m, and two of those (brachiopods and cup corals), have only been seen in sheltered crevices or caves and deep overhangs, places where conditions resemble those in deep water.

Species	Found above 40m	Gough	Top islands
PORIFERA			
White, yellow, cream, orange encrusting		x (all 4)	
Large erect branched on stone		x	
Large dirty white thick cup			x
Encrusting white spiky			x
Off-white slimy lumpy			x
Brown/green *Latrunculia brevis*	N	x	x
Yellow granular			x
Greeny-yellow thin crust			x
Big grey			x
Pink			x
Stalked sponges			x
ANTHOZOA			
Hydroids - small thecate on other biota		x	x
Sertularella			x
Athecate (*Hydractinia*-like) on hermit shell		x	
Amphianthus - like anemone on octocorals	N	x	x
Anemone on hermit shell	N	x	
Tiny anemone, gravel attached, on *Epymenia*			x
Zooanthids - pale grey (white, black minerals)	N		x
Zooanthids - dark grey	N		x
Cup corals - small, round		x	
Cup corals - various shapes	Y (crev)		x
Callogorgia verticillata	N	x	x
Swiftia-like octocoral	N	x	x
Knobbly white octocoral	N		x
Rhodelinda gardneri	Y	x	x
White *Rhodelinda*	N		x
Leiopathes sp - black coral (Site N2)	N		x
CRUSTACEA			
Stalked barnacles on octocorals		x	x
Isopod (Site N2)			x
Amphipod (Site N2)			x
Hermit crabs	N	x	x
Spider crabs (tiny decorator - sponges)	N	x	x
Small true crabs, black-tipped claws	N	x	x
Small true crabs, no black tip, more prickly	N		x
Prawn (Site N1)			x
BRACHIOPODA			
Large white, 3 broad ribs	Y (crev)	x	
MOLLUSCA			
Small chiton			x
Small whelks (Argobuccinum) (shells + hermits)		x	
Small whelks - not Argobuccinum, fine sculpturing			x
Small pearly ribbed topshell, orange foot (check SA)	N	x	
Small smooth necklace shell (shell + hermit)	N		x
Scaphopoda shells	N	x	x
Nudibranchs - several tritoniids, at least 3	N	x	
Nudibranch - large speckled	N	x	
Cadlina			x
Scallop	N	x	
Saddle oysters (Site IN1)	N		x

Bivalve shells (dead) including *Tawera philomela*	Y		x
BRYOZOA			
Encrusting misc		x	
Large erect branched white (could be hydroid)	N	x	x
Small bushy, flat branches		x	
Fine, fluffy (Site IN1)			x
Probably many more preserved			
ECHINODERMATA			
Crinoid	N	x	x
Starfish - Henricia, pale pink		x	
Henricia, orange		x	
Starfish - unidentified, pale pink prickly	N	x	
Starfish (*Stichastrella*-like; *Allostichaster inequalis)*	N	x	
Starfish - *Astropecten mesactus*	N	x	x
Starfish - *Cosmasterias*			x
Starfish - little 6-armed, pale with 2 or 3 darker orange arm bands	N		x
Small 'sunstar' (SUCS pics)	N	x	
Starfish, tiny, fat arms, v knobbly			x
Bat star - *Odontaster penicillatus*	Y	x	
Small bat star sp	N	x	
Orange biscuit star (like *Sphaeriodiscus*) Site N2	N		x
Brittlestar - brown granular disc, patchy buff/reddish arms, shaggy long spines		x	x
Brittlestar - pale orange arms, pale knobbly disc, 2 brown/yellow marks at base of each arm, off octocorals	N	x	
Small orange, smooth disc (possibly same as above)			x
Ophiura-type, 'comb' spines	N		x
Tiny 'pincushion' urchin	N		x
Small urchin with various sizes of fine spines, shades of pink *Pseudechinus magellanicus*. Possibly 2 different spp	Y	x	x
Arbacia dufresnii	Y		x
Holothurian - small, hard plates. *Psolus*	N	x	x
POLYCHAETES			
Small *Lanice*-like tube	Y	x	
Leathery tubes (SUCS photos)		x	
Errant polychaete (scale worm)		x	
Small Serpulid		x	
Spirorbids	Y	x	x
Hydroides/Salmacina/Filograna	Y	x	x
OTHER WORMS			
Nemertean	N	x	
PISCES			
Lepidoperca coatsii	N	x	x
Helicolenus mouchesi (small specimens).	Y	x	x
Dragonet *Synchiropus valdiviae*	N	x	x
Sole *Arnoglossus capensis*	N		x
	Y = 12 (10) N = 37	53	58

Table 5: Animals found in bottom trawls and recorded by camera at 150-300m depth around the islands by BAS cruise JR287 in February 2013. Many of these (75%) have not been seen in water shallower than 30-40m around the islands. Many specimens still await identification. N = not found above 40m; Y = occurs above 40m; crev = found above 40m but only in deep sheltered crevice.

Animals not recorded from shallow water include several octocorals (together with a possibly symbiotic anemone), black coral (antipatharian) *Leiopathes* sp., zooanthid anemones, several gastropod, nudibranch and bivalve molluscs, crabs and hermit crabs, and large erect bryozoans. Of the 11 sponges identified to genus or species that were collected from 150-300m by the BAS survey in 2013, none have been found in shallow water. A notable number of echinoderms appear to be confined to deeper water, especially asteroids and ophiuroids, small urchins, a holothurian (the first report of a holothurian from the Tristan islands; probably a species of *Psolus*), and a crinoid (featherstar). In common with shallow water echinoderms, a different set of species was recorded from deep water at Gough and at the top islands. The fish *Lepidoperca coatsii*, and the dragonet *Synchiropus valdiviae* are also only recorded from deeper water.

Figure 59: Camera lander image from southeast Nightingale, at ca 120m, on upward-facing rock with patches of bryozoan gravel. The image is rather indistinct but includes numerous small cup corals, a white soft coral, pink soft coral *Rhodelinda gardneri,* small encrusting sponges and a possible spionid worm clump bottom center. [From BAS JCR287 survey]

Camera images from the BAS surveys show that small cup corals are abundant at depths of 150-300m, both attached to rock and loose-lying on sediments. Sea fans (probably *Callogorgia verticillata* and/or *Thourarella* sp) are also conspicuous, and were abundant on some steeper rock faces, a habitat only recorded incidentally on hauling or lowering the camera. The soft coral *Rhodelinda gardneri* (also present in shallow water) and two other octocorals were frequent in trawls. Sea fans and other octocorals carried many other small animals on their branches, including brittlestars, stalked barnacles, hydroids, anemones, tubeworms and (rarely) featherstars. Sponges, bryozoans and hydroids appeared patchily common, though little can be deduced about relative abundance of sessile organisms because the sampling gear was designed for work on even terrain rather than rugged seabed topography, the latter being particularly common around these steeply sloping islands.

Figure 60: Some animals from depths of 100-300m that have not been seen in shallow water by diving surveys. From left: hermit crab with tubeworms, anemone and bryozoans on its shell; a crinoid (featherstar) attached to a sea fan; starfish; spider crab. [From BAS JCR287 survey]

One of the richest trawls of the BAS survey was from north of Nightingale at 200m, the only site that yielded black coral (*Leiopathes* sp) and an orange biscuit star (similar to *Sphaeriodiscus mirabilis*, a deep-water biscuit star apparently endemic to this area), together with a variety of starfish and brittlestars, octocorals, cup corals, sponges, crabs, hermit crabs and small urchins. The rarely-recorded dragonet *Synchiropus valdiviae* was also caught in this trawl. Apart from *Lepidoperca coatsii* and the jacopever *Helicolenus mouchesi*, the only other benthic fish captured on the BAS survey was a small flatfish at 132m off Inaccessible, possibly the Cape flounder *Arnoglossus capensis*, previously recorded rarely from Nightingale and Gough (Andrew et al 1995).

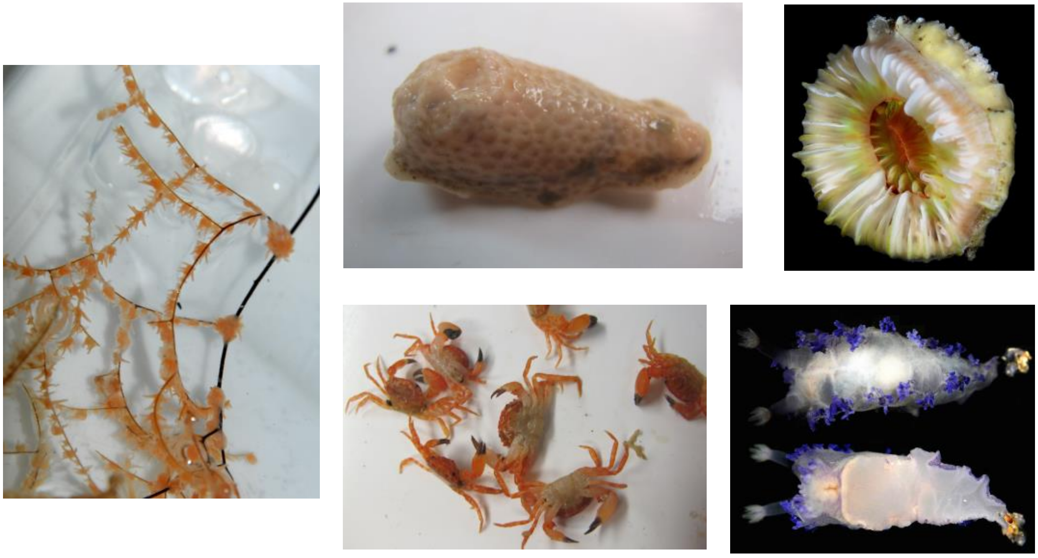


Figure 61: Deepwater animals not found in the shallows. Left: black coral *Leiopathes* sp from 200m north of Nightingale. Centre top: cup coral. Top right: holothurian, probably *Psolus* sp. Centre bottom: small crabs. Bottom right: beautiful tritoniid seaslug.

The BAS surveys give an intriguing glimpse of life between 100-300m around the islands, and specimens retrieved show that this is very different to life in shallow water. However it is a very incomplete picture; sampling was possible only in the 'flattest' areas that could be located, while much of the seabed in rugged habitats like vertical and steep rock, gullies and overhangs was not sampled at all. One occasion where the camera frame accidentally toppled over revealed a rock wall covered with seafans, a completely different community to that on upward-facing rock or sediments. The biota at depths between the lower limits of diving at 30-40m and the upper limits of the BAS survey at 100m is completely unknown apart from a few remote samples from older surveys, despite these depths being the most important fishing grounds for rock lobsters, so information from here is urgently required. High resolution video surveys at these depths would do much to fill this gap. Video between 100-300m would also help to evaluate and interpret the results from remote sampling.

The seabed around both Gough and the northern islands falls rapidly to depths of 2000-3000m within a few kilometers of the coast. This means that the majority of the seabed within the 12 nautical mile territorial and 200 nautical mile EEZ limits around the islands is well below 300m. Very little is known of life at these depths, which will probably include a number of biological zones and habitats. The area also includes several seamounts that rise to within 200m of the surface. The Challenger sampled at depths between 300m and 2012m at several locations between Nightingale and the south side of Tristan. Specimens obtained included a sponge, two alcyonarians, a hard coral, a crinoid, six species of brittlestars, an urchin, a euphausiid (krill), a bivalve and four bryozoan species. 'Numerous specimens' of the coral *Solenosmila variabilis* were obtained from 1000 fathoms (1829m), and all of the six species of ophiuroid (brittlestar) collected were present only in deep water below 914m; five of them occurred below 1829m. 'Pumice' was found in a dredge haul taken a few miles south-west of Tristan.

3.7. Diversity and biogeography of benthic biota

3.7.1. Diversity and biogeography of fish communities

Andrew et al (1995) reviewed previous information on Tristan fishes, and added 25 new species records. A total of 93 species of fish have been reported from Gough and Tristan waters. Andrew et al (1995) discuss the biogeography of the 51 species recorded from within one mile of the islands. This list was updated in 2010 to 47 species (unpublished data for Gough and Inaccessible management plan), to exclude three 'probable' and two 'doubtful' species, and to include the South American silver porgy (*Diplodus argenteus argenteus*), a fish that was introduced to Tristan with a stranded oil rig in 2006 and is now well established. Two more fish species were found in deeper water by the 2004 ICEFISH survey: the dragonet *Synchiropus valdiviae*, previously known from a single specimen from the Walvis Ridge, and a new species of pearlfish *Echiodon atopus* (Anderson et al 2005). The dragonet was subsequently found at all four islands at depths of 100-300m in 2013 (BAS 2013), extending its known range considerably.

In shallow inshore waters, very few fish species are seen by divers, but these are often present in large numbers. At the top islands, fivefinger *Acantholatris monodactylus* and Tristan wrasse *Nelabrichthys ornatus* are particularly common in and around the kelp forests, while soldiers *Sebastes capensis* and *Helicolenus mouchezi* are often seen lurking around boulder holes. *H. mouchezi* is more common in deeper water. The endemic klipfish *Bovictus diacanthus* is common mainly in shallow water, and also in rock pools at the top islands. Small shoals of southern horse mackerel *Trachurus longimanus*, and telescope fish *Mendosoma lineatum* are often seen, and the yellowtail *Seriola lalandi* is now very common around the top islands (though only recently recorded at Gough). Broadnosed sevengilled sharks (rock sharks, *Notorynchus cepedianus*) regularly investigate divers. Andrew et al (1995) comment that the local population of rock sharks is probably self-sustaining, as all size ranges are found in the region. Klipfish, soldiers *Sebastes capensis* and telescope fish are more common at Gough than at the top islands, while Tristan wrasse are rarer at Gough.

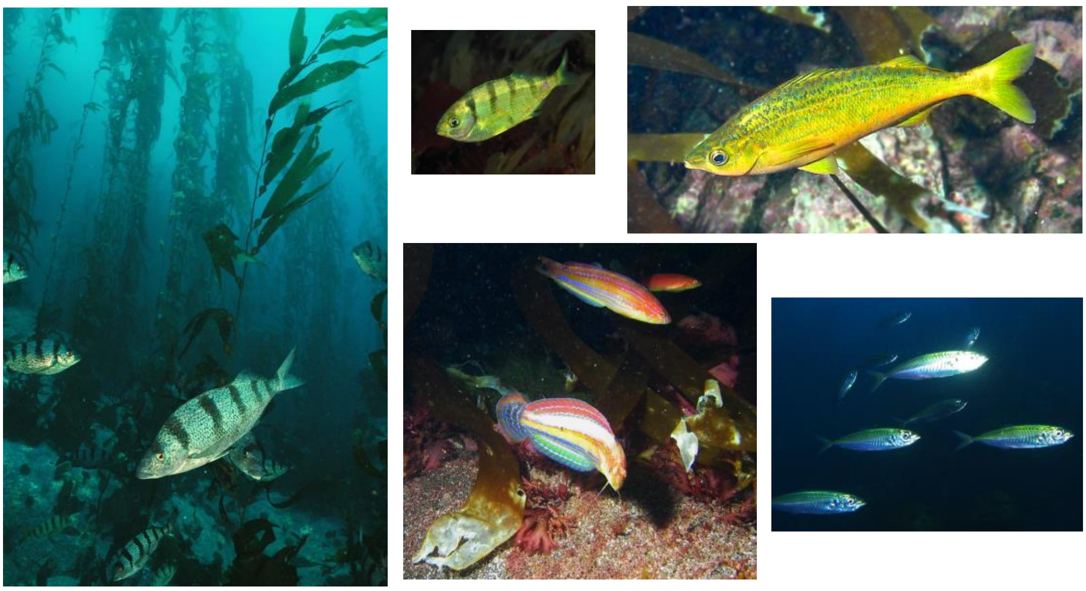


Figure 62: Common fishes of the shallow subtidal, particularly in and around the kelp forests. Left: Shoal of fivefinger *Acantholatris monodactylus*, with small post-larval fish (inset). Top right: Telescope fish *Mendosoma lineatum*. Centre: Tristan wrasse (conca), two males with female behind. The males are territorial; the lower fish is displaying by blanching the upper part of his body in a white stripe. Bottom right: Southern horse mackerel *Trachurus longimanus*.


Figure 63: The klipfish (black devil) *Bovichtus diacanthus* is endemic to Gough and the Tristan top islands. The usual color is dark olive brown (left), but red specimens are not uncommon.

Many of the fish not seen by divers are either nocturnal or cryptic, for example the rockling *Gaidropsaurus novaezealandiae*, or live mainly in deeper water, or both. Some are caught regularly by fishermen, including southern butterfish (bluefish) *Hyperoglyphe antarctica*, snoek *Thyrsites atun*, and oval driftfish (stumpnose) *Schedophilus velaini,* or more rarely wreckfish or steembras *Polyprion oxygeneos*, and blue shark *Isurus oxyrinchus* (formerly caught for bait). Some are rarely caught on line, but are attracted by the bait in crayfish traps, including round bellowsfish *Notopogon lillei*, *Physiculus karrerae*, hairy conger *Bassanago nielseni*, and even a great white shark *Carcharodon carcharias* caught at 51m at Gough, its stomach containing seals and seven bluefish.

Other records are of rare captures, often of single specimens, and include sixgill shark *Hexanchus griseus*, great lanternshark *Etmopterus* cf *princeps*, electric ray *Torpedo nobiliana* (also seen once while diving in 25m off Inaccessible (Scott 2008)), conger *Conger wilsoni*, southern conger *Gnatholepis capensis*, banded snipefish *Centriscops obliquus*, pelagic armourhead *Pseudopentaceros richardsonii*, pomfret *Brama australis*, southern rover *Emmelichthys nitidus*, and striped trumpeter *Latris lineata*.



Figure 64: Left: The curious round bellowsfish (piper) *Notopogon lillei* is regularly caught in lobster traps set between 40-200m (Andrew et al 1995). Centre: Atlantic electric ray, torpedo ray *Torpedo nobiliana*, rarely recorded at Tristan. This individual was photographed by the author at approximately 25m depth off Inaccessible. Right: The rockling *Gaidropsaurus novaezealandiae* is common but rarely seen, as it is nocturnal and hides in crevices during the day.

Apart from the records from lobster traps at 40-200m noted above, little is known of the benthic fish of deeper water around the islands. The orange serranid *Lepidoperca coatsii* was originally described from specimens collected from Gough in 100 fathoms (about 200m) by the *Scotia* survey (Regan 1913). It was noted as 'rare' by Andrew et al (1995), who obtained only six specimens from Gough and Nightingale in lobster traps at around 50m. However *Lepidoperca coatsii* was captured often in trawls at around 200m at both Gough and Tristan top islands by the BAS James Clark Ross survey in 2013 (BAS 2013), and is evidently more common in deeper water. The BAS survey also captured specimens and images of the dragonet *Synchiropus valdiviae* from all the Tristan islands. This little fish was described recently from two specimens from the Walvis Ridge (Trunov 1981), and is otherwise only known from five further specimens collected north of Nightingale between 180-230m by the ICEFISH research cruise in 2004 (Anderson et al 2005). Its discovery at Gough considerably extends its known range of the Walvis Ridge and Tristan top islands. Anderson (2005) also describes a new species of pearlfish, *Echiodon atopus*, from a single specimen collected off Inaccessible Island by the 2004 ICEFISH survey.

Species	**Common name**	**Tristan name**	**Distribution (T=Tristan top islands, G=Gough)**
Notorynchus cepedianus	Broadnosed Sevengilled Shark	Rock shark	T, G, Worldwide in temperate waters, except N Atlantic.
Carcharodon carcharias	Great White Shark		G, Worldwide in tropical and temperate seas
Torpedo nobiliana	Atlantic Electric Ray		T, Mediterranean and Atlantic
Bassanago neilseni	Hairy Conger	Eel	T, Nazca Ridge (SE Pacific), probably Amsterdam Is.
Conger wilsoni	Conger Eel		G, S Africa, Australasia, New Zealand
Gnathophis capensis	Southern Conger	Eel	T, S Africa, St Paul & Amsterdam
Gaidropsaurus navaezealandiae	Comb Rockling		T, G, S Africa, St Paul & Amsterdam, Australia, New Zealand, Nazca Ridge, Bromley Plateau
Physiculus karrerae			T, Anti-tropical Atlantic
Beryx decadactylus	Beryx		T, Subtropical and temperate waters, all oceans
Centriscops obliquus	Banded Snipefish	Piper	T, G, S Africa, St Paul & Amstrdam, Australia, New Zealand, Chile, Argentina
Notopogon lillei	Round Bellowsfish	Piper	T, G, S Africa, New Zealand, S Australia
Helicolenus mouchezi		Soldier	Endemic to Westward Drift Islands Province - T, G, St Paul & Amsterdam, Austral & Sapmer Seamounts
Sebastes capensis	False jacopever	Soldier	T, G, S America & S Africa, but taxonomic relations require more clarification.
Polyprion oxygeneios	Wreckfish	Steambras	T, G, subtropical and temperate southern hemisphere
Lepidoperca coatsii			T, G, St Paul & Amsterdam, Austral Seamount
Pseudopentaceros richardsoni	Pelagic Armourhead		T, S Africa, Indian Ocean seamounts, Australia, New Zealand, S America
Emmelichthys nitidus	Southern Rover		T, S Africa, St Paul & Amsterdam, Australia, New Zealand
Seriola lalandi	Giant Yellowtail, Yellowtail Amberjack, Great Amberjack	Yellowtail, Cape mackerel	T, G, circumglobal subtropical
Trachurus longimanus	Southern Horse Mackerel	Mackerel	T, G, Vema Seamount, St Paul & Austral Seamount, Walters Shoal
Acantholatris monodactylus		Fivefinger	T, G, Vema Seamount, St Paul & Amsterdam, Austral Seamount, Walters Shoal
Latris lineata	Striped Trumpeter	Funnyfish	T, G, Amsterdam Is, Australia, New Zealand, Auckland Islands (subantarctic)
Mendosoma lineatum	Telescope Fish		T, G, Chile, New Zealand, Tasmania, St Paul & Amsterdam, Auckland Islands (subantarctic)
Nelabrichthys ornatus	Tristan wrasse	Conca	T, G, Vema Seamount, St Paul & Amsterdam. Some taxonomic doubt.
Bovichtus diacanthus	Klipfish	Black devil	Endemic to Tristan and Gough
Thyrsites atun	Snoek		T, G, temperate southern hemisphere
Hyperoglyphe antarctica	Southern Butterfish	Bluefish	T, G, wide southern hemisphere
Schedophilus velaini	Oval Driftfish	Stumpnose	T, St Helena, Vema Seamount, S Africa, St Paul & Amsterdam, Austrailia, Lord Howe, New Zealand, Rapa Island, Juan Fernandez Islands, Chile
Arnoglossus capensis	Cape Flounder	Sole	T, S Africa, St Helena, Ascension.
Synchiropus valdiviae	Dragonet		T, G, Walvis Ridge
Echiodon atopus	Pearlfish		T; known from a single specimen collected off Inaccessible

Table 6: Nearshore benthic fish species recorded from Tristan and Gough, and their known distribution. Mainly shallow water (neritic) species, but records down to 300m are included. [Most information from Andrew et al 1995].

Most of the 51 species (benthic and pelagic) listed by Andrew et al (1995) are widely-distributed, known from several continental and insular locations in the warm-temperate waters of the southern hemisphere. The authors comment that, situated in the SCZ, the Tristan islands are the most southerly 'way-station' for many wide-ranging and eurythermic subtropical species, with many more at the Tristan top islands - 26 of the 28 neritic (shallow water) species recorded from the islands occur at the top islands, but only 19 at Gough. Examples of neritic fishes resident at Tristan but not recorded at Gough are the stumpnose *Schedophilus velaini* and the cod-like *Physiculus karrerae*. The difference in fish faunas between Tristan and Gough is also evident in the oceanic species that move southward into Tristan waters in summer, but do not reach Gough.

The normally tropical and subtropical yellowtail amberjack *Seriola lalandi* has apparently undergone a recent expansion in Tristan waters. This fish was noted as 'extremely rare' at the Tristan islands in 1989, when Andrew (Andrew et al 1995) saw only two specimens, one caught by a fisherman, and only one underwater during many dives through all seasons. However the fish is now (since at least 2004) relatively common around the top islands, and seen on most dives, in shoals of up to 20 fish (Scott & Tyler 2008, Scott 2010a, 2010b, Scott & Holt in prep.). It is often caught by local fishermen, and is now an important food fish for islanders.

Figure 65: The Yellowtail amberjack, rare at the islands in the 1980s, is now common at the top islands and has been recently caught at Gough.

The significance of this increase is unclear; *S. lalandi* is a circumglobal, tropical species. Andrew et al (1995) comment that Tristan is possibly a fringe area of its range, and that it probably enters Tristan waters during the warmer summer months. It prefers water temperatures of 18-24°C, so a slight shift towards higher seawater temperatures would be the most obvious implication for its increase in abundance around Tristan.

21 of the 51 fish species known from Tristan and Gough are found only within or north of the STC, again indicating this frontal zone as an effective barrier to the north-south dispersal of animals in the Southern Ocean. Water temperatures appear to be the primary factor. Andrew et al (1995) compiled a list of fish species they considered characterized a shallow-water Subtropical Convergence ichthyofauna, together with their affinities with other areas close to the STC. They found that the closest affinity is with the St Paul and Amsterdam islands in the Indian Ocean, where 18 fish species (64% of the St Paul and Amsterdam total of 29 species) are found at both places, despite their long distance apart (see table below). Tristan and Gough, St Paul and Amsterdam, and the Austral Seamount comprise the Westwind Drift Islands province. More than half of the neritic species at these three locations is shared with the other two, and two species (*Helicolenus mouchesi* and *Lepidoperca coatsii*) are endemic to this province. Three species (*Trachurus longimanus*, *Acantholatris monodactylus* and *Nelabrichthys ornatus*) are known only from the West Wind Drift province, and the two subtropical seamounts, Vema and Walters Shoal. The recently-discovered dragonet *Synchiropus valdiviae* appears to be endemic to the Walvis Ridge and the Tristan islands, but as it is inconspicuous and inhabits deeper water it may yet be found in other places. 18 Tristan fish species also occur at South Africa.

	T-G	V	AF	P-A	ANZ	SA
T-G/Total	28	6/17	18/500+	18/29	16/600+	14/300+
%T-G species/% total		21/35	64/4	64/62	57/3	50/5
		27	77	67	79	80

Table 7: The number of species, and the percentage of species and genera of Tristan and Gough neritic fishes at other areas close to the STC. T-G = Tristan and Gough; V = Vema Seamount; AF = Southern Africa; P-A = St Paul & Amsterdam Islands; ANZ = Australia and New Zealand; SA = South America. [Reproduced from Andrew et al 1995]

The circumpolar distribution of many Tristan-Gough fish species, without obvious 'stepping-stones' to other distant areas, is indicative of complex dispersal mechanisms. Some aspects of the reproductive biology of many of the benthic shallow-water Tristan fishes, where known, are summarized by Andrew et al (1995). Eggs and/or larvae and juveniles must be able to survive in the plankton for long periods before taking up a benthic lifestyle. This has been demonstrated or is likely for congrid eels, *Beryx* spp, the scorpaenids *Sebastes capensis* & *Helicolenus mouchesi,* wreckfish *Polyprion oxygeneios,* bluefish *Hyperoglyphe antarctica* and stumpnose *Schedophilus velaini.*

Relatively large young pelagic stages of *Acantholatris monodactylus* (6cm), *Mendosoma lineatum* (9cm) and *Gaidropsaurus novaezealandiae* (3cm) are also seen on Tristan. Adults of all these species occur at widely separated areas of shallow water in the Southern Ocean close to the STC. The klipfish *Bovichtus diacanthus* has a pelagic juvenile stage that is terminated at approximately 6cm; although it is apparently endemic to Tristan and Gough, it has conspecifics elsewhere.

Andrew et al (1995) note that at least 65% of fish species at the islands have extended pelagic larval stages, and all these had high fecundity and small egg size, features which 80% of all the species had. However the authors consider that it is unlikely that the life-cycles of these fishes involve a complete circumpolar cycle, ending back at Tristan before beginning adult life, or that the larvae travel a large gyre in either the South Atlantic or Indian Oceans. In theory, with surface current speeds of around 26cm/sec, drifting larvae could be moved passively up to 4088km in 6 months, and dispersal over large distances (e.g. 4023km from South America to Tristan, or 4680km from Tristan to St Paul) is possible. However a number of authors consider that there is more likely some feature of local currents, eddies and upwellings that encourages retention of larvae near the source area, and that only small numbers of larvae are carried far afield (this may well be the case for lobster larvae also).

Andrew et al (1995) concluded that to understand the zoogeography of the fish fauna at Tristan and Gough, a holistic approach is necessary that considers endemism, the geological history of the islands, the proximity of other neritic fish communities, the hydrography of the South Atlantic and southern Indian Oceans, the ecology of the marine communities at these islands, the possibilities for dispersal, and the cladistic relationships of the Tristan and Gough fishes with regard to their sister species at other locations.

3.7.2. Diversity and biogeography of invertebrates

The diversity of shallow-water marine invertebrates at Tristan and Gough is generally very low, compared with coasts adjacent to continental shelf with equivalent seawater temperatures. Animal species at all islands totalled 158. At the top islands, 104 species were recorded, while animals were more diverse at Gough with 131 species. Results are partly influenced by the individual expertise of surveyors, but some trends appear to be independent of surveyor, with echinoderms, nudibranch mollusks and ascidians being noticeably richer at Gough. Although the dive surveys are limited in scope, and the above figures do not include very small species, it is obvious that Tristan nearshore marine life is generally very impoverished in terms of species numbers. For many groups of animals only one or two species were recorded. For example, at the top islands, only a single species of soft coral, sea urchin, barnacle, siphonariid limpet, two starfish, two gastropod mollusks, and three decapod crustaceans. Apart from the endemic whelk *Argobuccinum tristanense*, and the blue bubble snail *Ianthina*, which is common throughout the Atlantic, no seashells are found washed up on Tristan beaches, indicating an astonishingly sparse shelled mollusk fauna.

Species diversity also varies according to taxonomic group; sponges, bryozoans, small crustaceans (amphipods, isopods), and seaweeds are relatively diverse, while echinoderms, decapod crustaceans and ascidians are extremely impoverished, especially at the top islands. Most other groups have relatively small numbers of species. Endemism also varies widely with group. Species numbers (endemics in brackets) for the top islands from Norwegian expedition publications are: Ascidians 6 (3); Bryozoans 13 (0), Pycnogonids 5 (2), Copepods 53 (25%), Barnacles 2 (1). More work is needed on both Tristan and on related species on continental coasts either side of the Atlantic, to establish the true degree of endemicity amongst the marine flora and fauna, especially in the lesser known groups, and some 'endemics' will undoubtedly turn out to be more widely distributed. Molecular sequencing work is also challenging some of the conclusions reached by taxonomy based on morphology. For example, recent genetic work has concluded that the common urchins on Tristan and Gough, originally described by Mortensen (1941) as *Arbacia crassispina*, endemic to the Tristan islands, are conspecific with *A. dufresnii*, widely distributed in South America and the Falklands (Lessios et al 2012).

Figure 66: Tristan 'endemic' no longer. Genetic work has indicated that urchins *Arbacia crassispina* from Tristan (left) and *Arbacia dufresnii* from South America (right, from Chile) are the same species. As the South American urchins were named first, urchins at Tristan should correctly be called *A. dufresnii*.

Animal Species	Gough	Tristan	S Africa	West Wind Drift	S America	Falkland Islands	Subantarctic Islands	Antarctica	Australia & New Zealand	Cosmopolitan
Parazoanthus hertwigi		x								
Austromegabalanus ?isolde	x	x								
Argobuccinum tristanense	x	x								
Tawera philomela	x	x								
Bovichtus diacanthus	x	x								
Jasus tristani	x	x		x						
Nemadactylus monodactylus	x	x		x						
Nelabrichthys ornatus	x	x		x						
Helicolenus mouchesi	x	x		x						
Trachurus longimanus	x	x		x						
Doris fontainei	x	x			x					
Holoplocamus papposus	x				x					
Diaulula hispida	x				x	x				
Tyrinna nobilis	x	x			x	x				
Crepipatella dilatata	x	x			x	x				
Pseudechinus magellanicus	x	(x)			x	x				
Odontaster penicillatus	x				x	x	x			
Anasterias antarctica	x	?			x	x	?	x		
Cosmasterias lurida	x				x	x	x			
Arbacia dufresnii	x	x			x	x		x		
Rhodelinda gardneri	x	x			x		x			
Mendosoma lineatum	x	x		x			x		x	
Silicularia rosea	x	x					x	x		x cold
Antenella quadriaurita	x	x	x						x	
Gaidropsarus novaezealandiae	x	x	x	x	x				x	
Guinusia (=Plagusia) chabrus		x	x		x				x	
Anthothoe chilensis	x	x	x		x					
Ovalipes trimaculatus	x	x	x		?				?	x
Aglaophenia parvula	x	x								x
Plumularia setacea	x	x								x
Octopus vulgaris	x	x								x
Notorynchus cepedianus	x	x								x temp
Seriola lalandi	?	x								x-subt

Table 8: Wider distribution in the southern hemisphere of some animal species at Gough and Tristan. 'Cosmopolitan' may include some of the other specified areas. Animal distribution information from WORMS and other sources.

Currently, the shallow water invertebrate fauna of Gough contains several cold-water and subantarctic faunal elements that are not present, or are very scarce, at the top islands including a notable number of echinoderms (the batstar *Odontaster penicillatus*, starfish *Anasterias antarctica*, *Henrica studeri* and *Cosmasterias lurida*, the urchin *Pseudechinus magellanicus* and brittlestar *Ophiomyxa vivipara*). The seaslugs *Diaulula hispida* and *Holoplocamus papposus* also have a subantarctic or Magellanic distribution.

Figure 67: Some invertebrates with subAntarctic or Magellanic distribution occurring at Gough but not at the Tristan top islands. Top row from left: starfish *Odontaster penicillatus*, *Anasterias antarctica* and *Cosmasterias lurida*; bottom row from left: urchin *Pseudechinus magellanicus*, seaslugs *Diaulula hispida* and *Holoplocamus papposus*.

Kelp, particularly the giant kelp *Macrocystis* which has a wide distribution in temperate and colder waters of South America, and which has bladders which keep it floating at the surface, is often seen floating hundreds of miles from the nearest coast, and is the probable vector for many species to have arrived at the islands over the years, either attached to its fronds or hidden amongst the much-branched holdfast. However nowadays increasing amounts of plastic and other persistent, man-made debris reaches Tristan shores and is a likely vector for introductions.

Ocean currents and temperatures were almost certainly not the same in the past as they are today. Considering the dispersal of rock lobsters, which have widely separated populations at islands and seamounts, and a long-lived larval stage of up to a year, Pollock (1990) suggested that a northward shift in latitude of 2-4° in the STC, combined with an increase in velocity of the ACC during recent glacial periods as proposed by McIntyre et al (1976) and Kennett (1982), would increase the chances of larval dispersal eastwards from the Tristan islands.

At 18 million years old, the Tristan group is much older than St Paul and Amsterdam (700,000 years old), so colonization of St Paul and Amsterdam is likely to have been from the Atlantic islands and South Africa. The last glacial period ended only 15,000 years ago, so the last long-distance colonization could have been relatively recent, but now recruitment to maintain populations may be local rather than long-distance. St Paul and Amsterdam Islands, although in the Indian Ocean 6400km (4000miles) from Tristan, have a remarkably similar shallow-water marine environment to Tristan, with similar sea temperatures, forests of giant kelp *Macrocystis pyrifera*, closely related rock lobsters, fish and other species in common.

3.7.3. Diversity and biogeography of macroalgae

Baardseth (1941) reported a marine flora of around 120 species from the top islands, including an estimate of 10 species for the Corallinaceae. This is a relatively rich flora for such small islands with almost no sheltered habitats. Continental coasts generally have much richer seaweed floras than islands. For example, the temperate coast of western South Africa has almost 800 species, though this is for a much longer coastline. Stegenga et al (1997) comment that detailed collections within localized areas of temperate southern Africa produce lists of 120-200 species, depending on intensity of collection and variability of habitat, and this is perhaps a better comparison.

Taking the floras of both Tristan (Baardseth 1941) and Gough (Chamberlain 1965), and including preliminary results from recent surveys (Hay 1980, Scott & Holt, in prep.), a total of 145 species has been recorded, and this is expected to rise to at least 160 after specimens (particularly corallines) are worked up. Diversity at Gough appears to be lower than at the Tristan top islands, with only 33 species (plus seven Cyanophyceae) recorded by Chamberlain (1965), although this was from limited and predominantly intertidal collections. For macroscopic species, a more direct comparison can be made from recent dive surveys, which found a total of 78 macroscopic algal species at all islands, with a richer flora of 66 species recorded at Tristan compared with 58 at Gough. This difference is likely to be greater in reality, as there are a considerable number of small filamentous and crustose algae not included in these figures, and these are likely to be more diverse at the top islands.

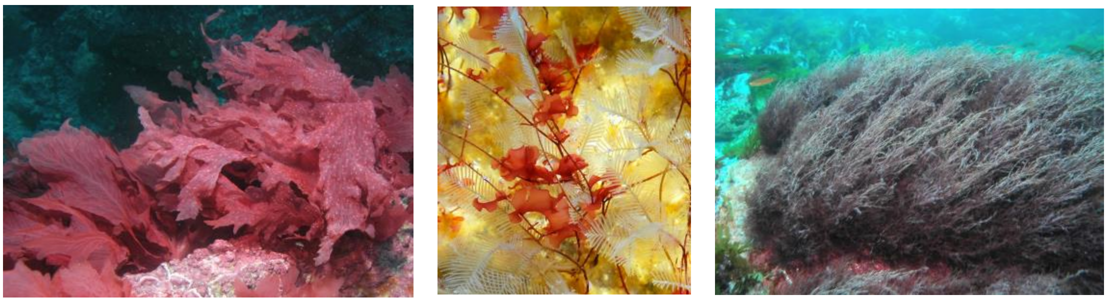


Figure 68: Some red seaweeds endemic to the Tristan islands. Left to right: *Pseudophycodrys pulcherrima*; *Pugetia kylinii* on hydroid stalks; *Streblocladia atrata* on boulder top.

Of the 120 species from the top islands, Baardseth (1941) considered 49 species, or around 40%, to be endemic to the islands. Recent updating of his checklist taking into account changes in taxonomy and increased knowledge of other floras in the South Atlantic and elsewhere has reduced the estimated percentage of endemics to around 33% for the Tristan top islands (Scott in prep.), but this is still a large proportion of the flora. However endemism is even higher on the South African coast, where 58% of red algae, 33% of browns and 28% of greens are endemic. Of the 33 species reported from Gough, Chamberlain (1965) considered two species endemic to Gough, and a further six endemic to the Tristan group (Gough and the top islands), making 24% of the Gough species endemic to the Tristan group. The floras of both Tristan (Baardseth 1941) and Gough (Chamberlain 1965), including preliminary results from recent surveys (Hay 1980, Scott & Holt, in prep.), currently total around 145 species. Of these, 42 are thought to be endemic, a total of around 30% for the whole island group. This breaks down as green seaweeds 23 species (one endemic); brown seaweeds 26 species (two endemic) and red seaweeds 96 species (39 endemic). Thus a much higher proportion of red seaweeds (ca 40%) appear to be endemic than for other groups. Further work on the Gough flora, especially the coralline algae, will shed further light on the true degree of endemism.

Species	**Gough**	**Tristan**	**S Africa**	**West Wind Drift**	**S America**	**Falkland Islands**	**Subantarctic Islands**	**Antarctica**	**Australia & New Zealand**	**Cosmopolitan**
ALGAE										
Heterosiphonia obscura		x								
Streblocladia atrata		x								
Pterosiphonia concinna		x								
Pugetia kylinii	x	x								
Herposiphonia paniculata	x	x								
Polysiphonia boergesenii	x	x								
Rhodoglossum revolutum	x	x								
Pseudophycodrys pulcherrima	x	x								
?Delesseria minor	?	x								
Gigartina stiriata		x	x							
Nothogenia ovalis	x	x	x							
Laminaria pallida	x	x	x	x						
Schimmelmannia elegans	x	x	x intro		x					
Splachnidium rugosum		x	x	x	x				x	
Scinaia		x			x Bra					
Durvillaea antarctica	x				x	x	x			
Desmarestia ?confervoides	x				x	x	x	x	x	
Mazzaella laminarioides	x				x		x	x	x	
Iridaea undulosa	x	?			x	x	x	x	x	
Desmarestia ligulata	x	x			x		x	x	x	
Iridaea ciliata		x			x		x			
Sporochnus stylosus	x	x							x	
Codium fragile	x		x		x		x	x	x	?
Halopteris funicularis	x	x	x		x		x	x	x	x
Callophyllis variegata (=corollata)	x	x	x	x	x	x	x	x	x	
Macrocystis pyrifera	x	x	x	x	x	x	x	?	x	
Centroceras clavulatum	x	x	x	x	x				x	x
Polysiphonia howei	x	?x								? warm
Zonaria tournefourtii		x	x		x (Atl)					warm Atlant

Table 9: Wider distribution in the southern hemisphere of some seaweed species at Gough and Tristan. 'Cosmopolitan' may include some of the other specified areas. Algal distribution information mainly from Algaebase.com.

Figure 69: Seaweeds occurring on the Tristan islands, and in South America, Magellanic and/or subantarctic regions. Left: *Iridaea ciliata* (Tristan top islands; the similar *I. undulosa* occurs at Gough); Centre: red seaweed *Mazaella laminarioides* (Gough); Right brown seaweed *Desmarestia confervoides* (Gough).

During the ice ages in the southern hemisphere, conditions were not hospitable for seaweeds, and cool temperate and sub-antarctic islands have probably served as refugia (Weinke and Amsler 2012). A study of samples of bull kelp *Durvillaea antarctica*, over a wide area of its distribution including Gough, showed striking genetic homogeneity over vast distances of the southern ocean, indicating recent recolonisation of the subantarctic (Fraser et al 2008). Bull kelp does not survive ice scour, and populations would have been extinguished around the Southern Oceans in regions affected by ice. However buoyant, drifting bull kelp could quickly recolonise available coasts from remaining populations as sea temperatures warmed and the ice retreated south at the end of the glacial period. The authors suggest that this rapid recent recolonisation indicates that the extent of sea ice during the last glacial maximum was much greater than previously thought.

Figure 70: Bull kelp *Durvillaea antarctica* on the lower mid-shore at Gough. A typically subantarctic brown seaweed, it does not survive ice scour. It is common at Gough but does not occur at the top

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4. Marine mammals of Tristan da Cunha

4.1. Introduction

Gough Island is of global importance for one species of seal, the Subantarctic Fur Seal *Arctocephalus tropicalis*, which also breeds in small numbers at the Tristan top islands. Southern Elephant Seals *Mirounga leonina* also occur in small numbers and are decreasing. They may represent the remains of an isolated population severely depleted by past hunting. Both species are important indicators of the health of the marine environment around the islands.

Figure 71: Young Subantarctic Fur Seal snoozing on a pile of washed-up fishing rope at The Caves, Tristan

The significance of the cetaceans recorded from the seas around the islands is difficult to assess, because of the paucity of data both locally and internationally (Best *et al.* 2009). However, there is a high diversity of cetaceans recorded within this area of the South Atlantic. In total, 11 species have been recorded within the territorial waters (12 mile limit) of Tristan da Cunha:

1. Southern Right Whale
2. Fin Whale
3. Humpback Whale
4. Long-finned Pilot Whale
5. Shepherd's Beaked Whale,
6. Antarctic Minke
7. Pygmy or Dwarf Sperm Whale (*Kogia* sp)
8. Killer Whale
9. Common Dolphin
10. Dusky Dolphin
11. Southern Right Whale Dolphin

Another two species have been identified within the Exclusive Economic Zone out to 200 nautical miles (Sperm Whale, Sei Whale)

It is impossible to assess the significance of any of these sightings in a global context, but the range of species recorded suggests that the islands might provide a focal point of rich feeding for a significant variety of cetacean species. The seas around the Tristan islands are clearly important as a nursery area for the Southern Right Whale. They appear once to have been an important feeding ground for the Sperm Whale before this species was over-exploited, and there is a potential for slow recovery of this species. An unusually large number of strandings or sightings of Shepherd’s Beaked Whales suggest that the islands may be an important part of the range for this highly oceanic species (this requires further study).

4.2. Seals (order Carnivora)

4.2.1. Eared Seals (family Otariidae)

Subantarctic Fur Seal *Arctocephalus tropicalis*

IUCN Red List Status: Least Concern

Population and trends

Subantarctic Fur Seals are widely distributed in the southern Hemisphere. They breed on subantarctic islands north of the Antarctic Polar Front (their rather anomalous specific name of *tropicalis* apparently is because the first specimen named was found on the tropical north coast of Australia!). As well as Gough and the Tristan Islands, their breeding sites include Amsterdam & St Paul Islands, the Crozets, Macquarie, and the (subantarctic) Prince Edward Islands. There are also breeding records from Heard Island. Vagrants have been recorded on the coasts of Antarctica, southern South America, southern Africa, Madagascar, Australia and New Zealand, and on Bouvetøya, the Comores, the Juan Fernandez Islands, the Kerguelen Islands, Mauritius and South Georgia (Hofmeyr 2015a).

The global population of Subantarctic Fur Seals was estimated as >400,000 individuals in the early 2000s (SCAR EGS 2008). They breed at numerous sites on eight islands or island groups. However, around 99% of Subantarctic Fur Seals breed at just three of these sites: approximately 63% of global pup production is estimated at Gough Island (Bester *et al.* 2006), 25% at the Prince Edward Islands (Hofmeyr *et al.* 2006, Bester *et al.* 2009) and 11% at Amsterdam Island (Guinet *et al.* 1994). Bonner (1994) also notes that this species is a great wanderer, and that further colonisations might therefore be expected.

Figure 72: Male (left) and female Subantarctic Fur Seals *Arctocephalus tropicalis* on Nightingale. Their dense, soft fur was coveted by humans and numbers were decimated by sealers in the 18th and 19th centuries.

Bester and Ryan (2007) estimated the total numbers on Gough Island to be some 300,000, with around 60,000 pups born each year. From counts at selected sites, numbers at Gough were thought to be stable or increasing slightly between 1975 and 2005 (Bester *et al.* 2006); beaches on the west of the island may be at carrying capacity, with other beaches approaching carrying capacity which may limit future increases there. Small numbers breed at The Caves on Tristan, and on Nightingale and Inaccessible.

Subantarctic Fur Seals were over-exploited by sealers in the 18th and 19th century and were reduced to the brink of extinction at the beginning of the 20th century. Since then their population has increased rapidly and they have reoccupied much of their former range (Bester 1987). This population bottleneck reduced their genetic variation, and it has been suggested that this may make the species particularly vulnerable to mass mortality from infectious diseases (Lavigne and Schmitz 1990, Wynen *et al.* 2000). The isolation of their breeding islands probably affords some degree of protection from disease, but adds to the importance of biosecurity measures on the Tristan and Gough islands.

The impact of climate change on fur seals is potentially detrimental through impacts on the abundance and distribution of prey species and changes in environmental conditions (Hofmeyr 2015a). Subantarctic Fur Seals are currently protected on both Gough and Inaccessible, and efforts are made to minimize disturbance at The Caves on Tristan. They are seen rarely on beaches around the Settlement Plain on Tristan, but numbers on the less disturbed beaches of the island are increasing.

Life history

Subantarctic Fur Seals are sexually dimorphic, with adult males reaching a length of 1.8m and weighing 70-165 kg, while adult females are 1.19-1.52 m long and weigh 25-67 kg, with a mean of around 50 kg (Hofmeyr 2015a). Females attain sexual maturity between four and six years of age at Gough Island (Bester 1995). Longevity is unknown (Hofmeyr 2015a) although counts of incremental lines in the dentine of tooth sections suggest that longevity of males and females is 18+ and 23+ years respectively (Bester 1987).

On the Tristan islands Bester and Ryan (2007) report that fur seals breed in crowded coastal colonies, mainly on beaches with a jumble of boulders, but also amongst dense Tussock Grass and other coastal vegetation. Juveniles and females come ashore on these beaches throughout the year, but males are strongly seasonal, returning between October and December. They then compete with other males to establish their breeding territories, which have an average size of around 20sq.m. Females are gathered in harems of around seven per territorial male and give birth to their single pup (which weights 4.0–4.5kg) between late November and early January, usually within about six days of arriving at the colony. Males guard the females, which come into oestrus briefly around a week or so after giving birth, at which point the dominant male mates with them. Gestation lasts 51 weeks to ensure pupping at the same time the following year.

Males cease vigorous defense of their harems from late December, and depart to sea soon after. Pups remain on the islands for 10–11 months, fed by the females which make trips to sea to feed, averaging around seven days, before returning ashore for a couple of days to suckle the pups. Feeding trips become longer during the winter months.

Foraging ecology

Figure 73: Subantarctic Fur Seal underwater at Gough. Fur seals are excellent swimmers and eat mainly small fish and squid

Subantarctic Fur Seals are opportunistic and pelagic foragers. Their diet around Tristan and Gough is mainly myctophid fish (lanternfish), cephalopods and small numbers of crustaceans (Bester and Laycock 1985). It has been suggested that the recent decline in the numbers of Northern Rockhopper Penguins on Gough Island may be explained by the burgeoning population of Subantarctic Fur Seals, either as a result of competition for food or through predation by the fur seals on penguins.

4.2.2 True Seals (family Phocidae)

Southern Elephant Seal *Mirounga leonine*

IUCN Red List Status: Least Concern

Population and trends

15–20 Southern Elephant Seal pups are born each year at breeding sites on narrow sandy and pebbly beaches on the east coast of Gough Island (Bester and Ryan 2007). Immatures regularly haul out at Tristan and Inaccessible, and occasionally on Nightingale, and pups are sometimes born on Tristan. There is no recent integrated population estimate throughout the species' entire range (Hofmeyr 2015b). However, the worldwide population in the mid-1990s was estimated to be 650,000 (SCAR EGS 2008). The islands are therefore unimportant to the species in global population terms, but maintenance of the species range is important.

Southern Elephant Seals have a nearly circumpolar distribution in the southern hemisphere. Although they reach the Antarctic continent and even very high latitude locations such as Ross Island, they are most common north of the seasonally shifting pack ice, especially in sub-Antarctic waters where most rookeries and haul-outs are located. Notable exceptions include the northern breeding colonies at Peninsula Valdés in Argentina and on the Falkland Islands.

Southern Elephant Seals occur in four distinct groups: in Argentina and the Falklands; the Atlantic sector (South Georgia, the South Shetland Islands, the Antarctic Peninsula and Gough); the Indian sector (Kerguelen Archipelago, Heard Island, the Prince Edward Islands and Crozet Island); and the Pacific sector (Macquarie Island and Campbell Island) (Gales *et al.* 1989, Hoelzel *et al.* 1993, Slade *et al.* 1998).

Colonies in the South Atlantic, which include the largest breeding aggregation located at South Georgia (more than 50% of global pup production) and also the breeding population on Peninsula Valdés, are stable or growing, while some in the Southern Indian and Pacific Oceans have decreased. Causes of decline are not completely understood (Hofmeyr 2015).

The species was subjected to intensive commercial killing starting in the early 19th century and not ending until 1964 at South Georgia. They were prized for their large quantity of blubber that could be rendered to fine, valuable oil. As a result, their numbers and range were greatly reduced in all populations. However, in the last 30 years some populations have stopped declining and others are increasing, which is why the species is rated as 'Least Concern' under IUCN criteria.

Figure 74: Southern Elephant Seals hauled out at Capsize Sands, the only sandy beach on Gough.

Bester and Ryan (2007) suggested that numbers have continued a slow decline on Gough over the last 25 years, although they have full legal protection on all the Tristan da Cunha islands. Today, there are few recorded threats and conflicts, as most Southern Elephant Seals live far from human population centers and have minimal interactions with commercial fisheries (Hofmeyr 2015b). However, intensive fishing could deplete important stocks of elephant seal prey (Hanchet *et al.* 2003). The effects of global climate change are unknown, although possible adverse effects could include impact on prey populations, change of marine habitat, and exposure to diseases (Lavigne and Schmitz 1990). It has also been suggested that a reduction in sea ice due to climate change might benefit elephant seals (van den Hoff *et al.* 2014)

Life history

Adult males typically reach 4.5m long (maximum 5.8m), and weigh 1,500–3,000kg (maximum 3,700kg). Adult females are somewhat smaller and much lighter, weighing 350–600 kg with exceptionally large females reaching 800 kg.

On Gough, adult males return to their breeding 'rookeries' in September–October (Bester and Ryan, 2007). Males set up beach territories, using loud roars and aggressive displays to chase off competitors. Females return shortly after (with peak numbers arriving in mid-October) and are gathered by males into harems with a maximum of 16 females per 'beachmaster' on Gough, but can be much larger at other breeding colonies. Females give birth to a single pup, which is about 1.3m long and weighs 40–50 kg, at the end of October. Males mate with the females shortly before the pups are weaned at about three weeks. Females then depart for a two-month foraging trip, before returning to moult in December–February. Males head back to sea once most of the females have left the beaches, and they then return to moult in February–April. Pups leave the rookeries in December, although they sometimes return for winter shelter in March–April. According to Hofmeyr (2015), females first pup at between three and five years old and males typically breed for the first time at 6-10 years. At Marion Island, less than 5% of males survive to 10 years old, while less than 5% of females survive beyond 14 years (de Bruyn 2009). Adult females have been recorded as old as 23 years at Macquarie Island (Hindell and Little 1988).

Figure 75: Male elephant seal at Seal Beach, Gough. [Photo Peter Ryan]

Foraging ecology

Southern Elephant Seals spend a large percentage of their lives at sea and only return to land to give birth, breed and moult. At sea, they range far from their rookeries and predominantly feed between the Sub-Antarctic Convergence and the northern edge of the pack ice, south of the Antarctic Convergence, in areas with frontal systems, currents and shifting marginal ice-edge zones (Hofmeyr 2015).

Adult males typically venture further south than females, and are known to forage at the seaward edge of the Antarctic continental shelf. Wandering and vagrant Southern Elephant Seals reach southern Africa, southern Australia, New Zealand and Brazil.

Foraging Elephant Seals combine exceptionally deep diving with long-distance traveling. They cover millions of square kilometres while traversing a wide range of oceanographic regions during periods of up to seven months at sea. Foraging grounds may be located over 5000km from haulout sites (Bester and Pansegrouw 1992, Jonker and Bester 1998). Both sexes are reported to spend over 65% of their lives below

100m (Hofmeyr 2015). Research at Marion Island (Jonker and Bester 1994, McIntyre *et al.* 2010), found that prey is caught on deep dives, typically to around 500m and lasting for 20–40 minutes. Foraging dives occur both day and night, although night dives tend to be shallower. Adult males often performed benthic dives in excess of 2,000 m, including the deepest known recorded dive of any seal, to 2,133 m (McIntyre *et al.* 2010). The longest recorded breath hold for an adult southern elephant seal female was 113 min (Jonker and Bester 1994).

Prey varies between populations and seasons, but consists primarily of myctophid and notothenid fish and squid (e.g. Cherel *et al.* 2008, Newland *et al.* 2011). Most feeding by females occurs in deep ocean areas at mid-water depths. Adult males pass through female feeding areas on their way south to Antarctic continental slope and shelf waters, where their diving activity suggests they pursue more benthic prey.

4.2.3. Rare vagrant seals

Antarctic Fur Seals *Arctocephalus gazella* are rare vagrants to the islands, with records from Gough 2005, 2009 and 2013, and a first record from Tristan da Cunha in 2013 (Bester *et al.* 2014). In 2005, a total of 18 individuals were observed at Gough over a 7-week period in October/November. Most were immature males, with one mature male and six putative females. All had departed by November 23rd, before the onset of the breeding season of Subantarctic Fur Seals (Wilson *et al.* 2006).

Leopard Seals *Hydrurga leptonyx* are also very rare visitors, recorded twice at Gough (Wilson *et al.* 2006).

4.3. Cetaceans

It is very difficult to assess the significance of the Tristan and Gough islands for cetaceans. Occurrences around the islands have never been monitored in any systematic way, and our knowledge of the distribution and movements of many of the species on the global scale for comparison is very limited. The information below is based largely on Best *et al.* (2009), which reports cetacean sightings in the waters around the Tristan top islands between 1983 and 2000, and strandings on shores of the islands between 1983 and 1995. It also includes a review of published material and commercial catches from the region. Additional information comes from Ryan (2007), and the IUCN Red List database (Reilly *et al.* 2013). The Tristan website (www.tristandc.com) has a dedicated page reporting strandings and sightings.

The only systematic effort to record cetaceans around the Tristan islands occurred in September–October in six years between 1983 and 1989 (except 1984), when cetacean observers joined the South African vessel *SA Agulhas* during her annual trip to relieve the scientific team stationed on Gough Island. The ship's helicopter was used in this study. Incidental sightings of right whales were kept by vessels engaged in the rock lobster fishery around the islands from 1986-1991 (Best *et al.* 2009).

Evans (1987) noted that the waters around Tristan were amongst the most important historical whaling grounds, especially for Sperm Whales, in the South Atlantic, along with the south-western tip of South Africa, the seas off Angola in West Africa, and the coast of eastern South America from Brazil to near the Falkland Islands. Sperm Whales and other species are still recovering from the depredations of the whalers, but in many cases their numbers were so reduced that their recovery is slow and protracted. Best *et al.* (2009) extracted positions from the International Whaling Commission database of 1,040 whales taken by Antarctic whaling expeditions in the area around Tristan, mainly between 1961 and 1967, with a few records dating back to 1934. Most of the whales were taken in November–December as ships headed south for the Antarctic whaling season and February–April as they returned north.

4.3.1. Baleen Whales (suborder Mysticeti)

Baleen whales feed primarily on plankton, filtered from the water through their baleen plates. They therefore gather to feed in areas of nutrient-rich water, which supports high concentrations of phyto and zooplankton.

Southern Right Whale *Eubalaena australis*

IUCN Red List Status: Least Concern

Of all the cetaceans, the Southern Right Whale is probably the species for which the Tristan islands are most important, with strong evidence that the seas around the islands are a nursery area. Tristan waters once supported such large numbers of this species that 19th Century whalers referred to the area as the 'Tristan Ground'. Best (1988) suggested that exploitation began here about 1819/20, and estimated that 2,500 animals were taken by French and American whalers between 1830/31 to 1834/35. Although numbers were strongly depleted as a result, catches continued to be taken from this stock throughout the remainder of the 19th century. The whales began to reappear at the islands in the 1890s, and by the 1940s and 1950s they were numerous enough to be regarded as a nuisance (in the sense that islanders considered them a hazard to fishermen). This apparent recovery seems to have been possible because, unlike nearly all other southern hemisphere stocks, the whales around Tristan were not subjected either to a shore-based fishery in the late 19th century or to a phase of modern coastal whaling in the early 20th century. However, this increased population attracted illegal exploitation by Soviet whaling fleets, in the period when the island was unoccupied following the 1961 volcanic eruption (Ryan 2007).

Between 1983 and 1991, Best *et al.* (2009) reported 75 sightings, totaling 116 Southern Right Whales, off the Tristan islands, all but one of which were seen from Tristan itself. This may partly reflect the lack of habitation on the other islands, but does accord with the fact that 14 helicopter flights in the 1980s only recorded Southern Right Whales off Tristan, and not the other islands. The peak months for sightings were September and October. When the population was larger, before the Soviet exploitation, it was said that the whales arrived from July, with a peak in October, and departed by December (Elliott 1953).

Twenty of the 75 recorded sightings involved cow-calf pairs, but this is probably an under-representation, given the difficulty of spotting calves from the shore (Best *et al.* 2009). The majority of the cow-calf sightings are in the south-east quadrant of the island, between Sandy Point and Stoneyhill Point, centred on Trypot and Stoneybeach Bays, suggesting that the whales use these somewhat more shallow and sheltered waters with a sandy seabed as a nursery ground (it is typical in this species for nursing cows and calves to be segregated from others of their species in winter nursery areas).

Southern Right Whales have a circumpolar distribution in the Southern Hemisphere. Beyond the small nursery area at Tristan, their major current breeding areas are near-shore off southern Australia, New Zealand (particularly the Auckland and Campbell Islands), the Atlantic coast of Argentina and Brazil, and southern Africa (Reilly *et al.* 2013). Small numbers are also seen off central Chile, Peru, and the east coast of Madagascar. In summer, Right Whales are found mainly in latitudes 40–50°S, but they have been seen, especially in recent years, around South Georgia and in the Antarctic as far south as 65°S.

Following severe depletion by commercial whaling, the total estimated population in 1997 was 7,500 animals, of which 1,600 were mature females (IWC 2001). The hemispheric population in 1770 was estimated at 55,000-70,000, and was thought to have been reduced to a low of about 300 animals by the 1920s (IWC 2001). Several breeding populations (Argentina/Brazil, South Africa, and Australia) have shown evidence of strong recovery following the cessation of whaling, with a population doubling time of 10–12 years (Bannister 2001, Best *et al.* 2001, Cooke *et al.* 2001). This increasing population trend has led to its IUCN listing in 2008 of Least Concern (Reilly *et al.* 2013a). Other breeding populations, including the Tristan population, are still very small, and data are insufficient to determine whether they are recovering.

Other Baleen Whales

Humpback Whales *Megaptera novaeangliae* are occasional visitors to Tristan waters, mainly as they move south in summer to feed around the Antarctic pack ice. Best *et al.* (2009) report one female taken by a Soviet whaler in December 1965 around 40km south-west of Tristan. One was seen in November 1985 about 2nm north of Nightingale, and in January 1990 two were seen off Inaccessible. In 2009, Brad Robson of the RSPB photographed a female Humpback Whale with calf off Calshot Harbour on Tristan (Robson 2009). In November 2012, a Humpback Whale was spotted close to Calshot Harbour on Tristan. Previously listed as Endangered, the IUCN Red List status of the Humpback Whale was downgraded to Vulnerable in 1990 because of continued increases in populations following protection from whaling (Reilly *et al.* 2008a).

Fin Whales *Balaenoptera physalus* are recorded as fairly common around Tristan in October–December. They are mainly seen in loose groups of up to 5–10 animals, before moving south to the Antarctic to feed during the austral summer (Bester and Ryan 2007). However these are mainly records from well offshore (400-600nm), and Fin Whales are only occasionally seen within 200nm. There are only four records of Fin Whales being taken by modern whaling in the Tristan Square (Best *et al.* 2009), the closest being about 175km east of Tristan. Fin Whales are classified as Endangered on the IUCN Red List, because of a global decline of more than 70% over the last 3 generations (1992-2007), although it is probably now increasing because of reduction in whaling (Reilly *et al.* 2013b).

Figure 76: Fin whale, showing distinctive white lower jaw on right side, and remains of tall blow. [Photo: Peter Ryan].

Sei Whales *Balaenoptera borealis* were taken by Antarctic whaling fleets in Tristan waters; 58 were recorded as taken mostly to the east of the islands (Best *et al.* 2009). Three Sei Whales were tagged 94-105km north-west of Tristan in November 1965; two were recovered 2–3 months later, south and west of Tristan at latitudes of 44–46°S, and the third a year later, about 2,700km east of Tristan (Brown 1977), indicating the high mobility of the species. No recent sightings in the region have been attributed to this species (Best *et al.* 2009). Sei Whales are classified as Endangered by IUCN (Reilly *et al.* 2008b).

Minke Whales have been reported occasionally around Tristan, but few have been positively identified and it is not clear whether historic records are of the recently separated Antarctic Minke Whale *Balaenoptera bonaerensis* or Dwarf Minke Whale *B. acutorostrata*. (Best *et al.* 2009). A juvenile Antarctic Minke Whale was found stranded in November 2014 at the east end of Deadman's Bay on the south side of Tristan, identified by Peter Best from photographs. It was alive when first seen, but dead by the following day. This was the first record of a stranding of this species on Tristan (www.tristandc.com/wildwhales.php). Antarctic Minke may be declining, but this is based on insufficient data for IUCN to assign a Red List classification, and the species is currently listed as Data Deficient. (Reilly *et al.* 2008c).

4.3.2 Toothed Whales (suborder Odontoceti)

Toothed whales feed largely on cephalopods and fish, and as 'top predators' are especially susceptible to the impacts of chemical pollution in the food chain.

Sperm Whale *Physeter microcephalus*

IUCN Red List Status: Vulnerable

In the 19th Century, whalers took significant numbers of Sperm Whales from the waters around Tristan, mainly between October and January. The records collected by Best *et al* (2009) from the IWC database show that 648 Sperm Whales were taken by modern whaling in the 'Tristan Square', mainly in the period 1962–1967. 243 of these were males and 186 females (the remainder of the records contained no information on sex or length). Most records of females and small males were from the west of the archipelago, but larger males (more than 11m long) were more widely distributed, particularly farther south and east.

Although numbers were severely depleted by the whaling fleets, Bester and Ryan (2007) still regarded Sperm Whales as 'fairly common' in Tristan waters. One was found stranded on Inaccessible Island in 1982. The closest sighting was of three whales seen in November 1985 from the MV *SA Agulhas* about 105km north-west from the top islands.

The Sperm Whale has a large geographic range. It can be seen in nearly all marine regions, from the equator to high latitudes, but is generally found over the continental slope or in deeper water. Within that huge range, the species' global population size is estimated in the hundred thousands, although with considerable levels of uncertainty (Taylor *et al*, 2008a). Although large-scale whaling for this species has largely stopped and the IWC is currently maintaining an annual quota size of zero, the species may well still be hunted in parts of its range where states are not members of the IWC.

Even where whaling has ceased, modelling suggests the species is not well adapted to recover from population depletion, with a maximum rate of increase of around 1% per year. The species may also be suffering from the impacts of chemical contaminants, increasing ocean noise, interactions with fisheries which can result in Sperm Whale deaths, and the lingering, socially disruptive effects of whaling which may be inhibiting recovery of this highly social species. It is classified in the IUCN Red List as Vulnerable (Taylor *et al.* 2008a).

Figure 77: Sperm whales have a blowhole on the left side of the head, resulting in a distinctive sideways blow when seen from the right angle. [Photo: Peter Ryan].

Short-headed Sperm Whale *Kogia sp.*

IUCN Red List Status: Data Deficient

In January 2011, a small whale was sighted in Calshot Harbour on Tristan da Cunha, which immediately raised interest as the harbor is less than 2m deep in places. A French contractor working on the island at the time entered the water in a wetsuit, and was able to shepherd the whale (which was badly injured) out to sea through the 50ft entrance of the harbour. The whale stranded itself again, to the west of the 1961 volcano, but managed to refloat itself, swam off and was not seen again.

The conclusion of experts from photographs was that the animal was either a Pygmy Sperm Whale *Kogia breviceps* or Dwarf Sperm Whale *Kogia sima*, neither of which had been recorded on the island before. Separation of these species is extremely difficult without detailed measurements. Neither species is well-known, nor are there any estimates of global populations, although both are thought to be widely distributed through temperate and tropical oceans.

Shepherd's Beaked Whale *Tasmacetus shepherdi*

IUCN Red List Status: Data Deficient

Tristan, for its size, has an unusually high number of records of Shepherd's Beaked Whale, regarded as a circumpolar species of cold-temperate waters in the Southern Hemisphere south of about 30°N. All the 21 species of Beaked Whales (Family Ziphiidae) are poorly known, because they are strictly oceanic, deep-diving species with inconspicuous surfacing behavior. Some species have never been identified at sea, and most are best known from strandings (Shirihai & Jarrett, 2006). There is still uncertainty on the identification and taxonomy of some of the species.

Best *et al.* (2009) summarized sightings of Shepherd's Beaked Whale. In April 1983, two dead beaked whales were found on the beach south of Anchorstock Point on Tristan. Both were measured and one was photographed (tristandc.com). Although no skeletal or other material was collected, the full set of upper and lower teeth visible in the photographs and noted in the description indicates that the animals must have been *T. shepherdi* (other Beaked Whale species have much reduced dentition). In October 1984, a dead Beaked Whale was found at Deadman's Beach, Stony Hill Point on Tristan. In March 1985, islander James Glass visited the site, measured the specimen at 6.7m long, and prepared its skeleton, which was subsequently retrieved and accessioned by IZIKO, the South African Museum. From the description and some teeth collected, this animal was also identified as *T. shepherdi*. Further strandings occurred in December 1987 at Runaway Beach and in October 1995 at Noisy Beach.

In November 1985, two sightings of Beaked Whales were made from the air near the island, one of four whales and the other of six whales. Photographs were taken of both groups, and, from their size and pigmentation patterns, these were subsequently also identified as *T. shepherdi* (Pitman et al 2006). An earlier sighting of two whales off the southwest corner of Inaccessible Island may also have been of this species.

In 2008, 2009 and 2012 additional sightings of Shepherd's Beaked Whales were also recorded. Beyond these Tristan records, the only other records of Shepherd's Beaked Whale from the South Atlantic are a sighting near Gough Island and seven records from Tierra del Fuego and Peninsula Valdez in central Argentina. Otherwise, the species is primarily known from a few dozen strandings, all south of 30°S, around New Zealand, southern Australia, southern South America and the Juan Fernandez Islands (Taylor *et* al, 2008b). There have been only a few sightings reported in the literature and the validity of most of those is suspect (or clearly erroneous). The confirmed sightings have been from south of Tasmania and in oceanic waters of the South Atlantic. From these records it has been presumed that this species has a circumpolar distribution in the colder waters of the Southern Hemisphere, but the records are sufficiently sparse that this is probably best regarded as unconfirmed.

Shepherd's Beaked Whales appear to be relatively rare, but there are no available estimates of abundance. They are known to feed on several species of fish (primarily eelpouts), as well as squid and crabs, possibly near the bottom in deep waters. This seems somewhat unusual, as most Beaked Whales are thought to feed almost exclusively on cephalopods.

Other Toothed Whales (including dolphins)

Andrew's Beaked Whales *Mesoplodon bowdoini*, were identified by mitochondrial DNA sequences (Dalebout *et al.* 2007) from two individuals washed ashore at Cave Gulch on Tristan in March 1988 (Best *et al.* 2009). This species is listed as Data Deficient by IUCN.

A single female **True's Beaked Whale**, *M. mirus*, was found dead and decomposing at Deadman's Bay, Stoney Beach on Tristan in June 1993 (Best *et al.* 2009). The body was dissected by James Glass and subsequently identified from its skull. This record extended the known distribution of True's Beaked Whale in the South Atlantic, where it was previously known only from strandings on the south and west coasts of South Africa, and a single record from Brazil. This species is listed as Data Deficient by IUCN.

Given the uncertainty of identifying Beaked Whales, Ryan (2007) suggests that **Gray's Beaked Whale** *M. grayi*, **Strap-toothed Beaked Whale** *M. layardii*, **Arnoux's Beaked Whale** *Berardius aruxii* and **Cuvier's Beaked Whale** *Ziphius cavirostris* might also be found in Tristan waters.

A juvenile **Pilot Whale** *Globicephala* sp. was found in an advanced state of decay at Blenden Hall Bay on Inaccessible Island In February 1990. In October of the same year, a 1.98m long pilot whale was found dead and partly decomposing at Big Point on Tristan, and was identified from its skull as a **Long-finned Pilot Whale** *G. melas*. Best *et al.* (2009) also reported a number of sightings from the shore of what were probably Pilot Whales in 1990, and of a small pod seen at sea four miles off Tristan in February 2000. They note that there is no evidence that any of these sightings were of the Short-finned Pilot Whale, although the distribution of this species in the South Atlantic is poorly known. A small pod of at least four pilot whales was seen by Sue Scott in October 2007 at sea on approaching Tristan from the east. Robson (2009) reports a group of 15 or more Long-finned Pilot Whales off the Tristan Settlement in January 2009. This species is assessed as Data Deficient by IUCN.

Figure 78: A small pod of Pilot Whales east of Tristan in October 2007

Four **Killer Whales** *Orcinus orca* were recorded from the MV *SA Agulhas* about 10 nautical miles off the east coast of Tristan in September 1987, and a day later a group of 5 Killer Whales was seen from the air just offshore from Sandy Point. In 1989, two Killer Whales were recorded off Calshot Harbour.

Common Dolphins have been recorded occasionally in Tristan waters, usually some distance offshore. A pod of 90 about 315km east-north-east of Tristan was reported by Best *et al.* (2009). Given the oceanic habitat, these were most probably **Short-beaked Common Dolphins** *Delphinus delphis*), although the sighting pre-dated publication of a paper documenting the morphological differences between this species and the more coastal Long-beaked species *D. capensis*. Common Dolphins were photographed by Sue Scott south of Inaccessible in December 2011, and between Gough and Tristan in February 2014. They are regularly seen on the ship route between Tristan and Cape Town.

Short-beaked Common Dolphins are listed by IUCN as of Least Concern, as they are widespread and very abundant, with a global population estimate in excess of 4 million (Hammond *et al.* 2008).

Figure 79: Common Dolphins east of Tristan, 2010.

A single **Southern Right Whale Dolphin** *Lissodelphis peronii* was captured by whalers some 60km east of Tristan in December 1847 (Best *et al.* 2009). These curious dolphins are so-named because, like Southern Right Whales, they have no dorsal fin. In September 2014, Peter Ryan observed a pod of around 70 Southern Right Whale Dolphins from the deck of the *SA Agulhas II*, between Tristan and Nightingale (Ryan 2015; tristandc.com/wildwhales.php). In these articles Ryan noted a previous record from Tristan waters in 1989, of a pod of at least 100 animals seen by Barrie Rose aboard the South African fisheries research vessel *Africana II*, approximately 300km south of Tristan and 260km west northwest of Gough. The dolphins were associated with **Bottlenosed Dolphins** *Tursiops truncates*. Ryan notes that this also appears to be the first record of Bottlenosed Dolphins from Tristan waters.

The distribution of Southern Right Whale Dolphins is poorly known, but appears to be circumpolar in the southern hemisphere, and restricted to cool temperate to subantarctic waters of the southern hemisphere, mostly between about 30°S and 65°S, with the southern limit generally bounded by the Antarctic convergence. It is listed by IUCN as Data Deficient.

Figure 80: Dusky dolphins, mother and calf [Photo: Peter Ryan]

Best *et al*. (2009) quoted substantiated records of the **Dusky Dolphin** *Lagenorhynchus obscurus* at Gough Island, but reports that sightings at Tristan are much rarer, and none of these have been confirmed by photographs or a stranding. Robson (2009) reported an impressive pod of 500 or more Dusky Dolphins moving down the east side of Gough Island on several afternoons during early January 2009, and observed these somersaulting, back-flipping and splashing as they passed. Ryan (2007) also noted that the **Hourglass Dolphin** *Lagenorhynchus cruciger* may occur south of Gough.

Dusky Dolphins are widespread in the southern hemisphere, but occur in apparently disjunct subpopulations. Some subpopulations, including those of Chile and Peru, have been seriously depleted by human activities, for direct human consumption, and as bycatch in fisheries. However IUCN lists them as Data Deficient, as there are few abundance estimates available (Hammond *et al.* 2008).

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5. Seabirds of Tristan da Cunha

5.1. Introduction

The Tristan archipelago is of major importance for its variety and numbers of seabirds. 25 species breed on the Tristan top islands and Gough (see table below), four of which breed nowhere else. The seas around the islands are used throughout the year by breeding and non-breeding foraging seabirds.

Due to their large seabird populations and endemic breeding species, all four islands are listed as Important Bird Areas (IBAs) by BirdLife International: Tristan (code SH005; area 9,600ha); Inaccessible (SH006; 1,400ha); the Nightingale Island Group, including Middle (or Alex) and Stoltenhoff Islands (SH007; 390ha); and Gough Island (SH008; 6,500ha). Both the Tristan top islands and Gough are listed by BirdLife International as Endemic Bird Areas, but this is for their terrestrial bird species, some of which also show some dependence on the marine environment. Gough, Inaccessible and much larger surrounding sea areas are gazetted as a Ramsar Wetland of International Importance (229,811ha & 126,524ha respectively), while an even larger area around Gough and Inaccessible Islands is designated as a natural World Heritage Site (397,900ha) with boundaries out to 12 nautical miles.

As with seashore and subtidal life, the first comprehensive studies of birds at the Tristan top islands were published following the Norwegian Scientific Expedition from December 1937 to March 1938 (Hagen 1952). Hagen's 248 page report contains details of bird and egg morphometrics, breeding habits, diet, habitat and populations, together with ornithological information from previous island visits, and forms the foundation of bird studies at the islands since.

At Gough, the first extended period of scientific work, including birds, was the Gough Island Scientific Survey from November 1955 to May 1956 (Holdgate 1958, Swales 1965), which led to the establishment of the now much-expanded meteorological base, now also the base for current bird research. The annual changeover of staff at the base allows a research trip of 3-4 weeks, supported by the *SA Agulhas*. Recently two research biologists have been employed on year-long contracts, allowing longer research projects and studies during the winter months.

The following seabird profiles are based largely on Ryan (2007) and BirdLife International factsheets on the species concerned (Birdlife International 2016), with additional information from the online publications and press releases of ACAP, the Agreement on the Conservation of Albatrosses and Petrels (www.acap.aq). The figures for population size quoted in the Table below and in the bullet points for each species are based on information compiled for the Gough and Inaccessible WHS Management Plan (Tristan da Cunha Government and RSPB 2015), which also contains an extensive bibliography of bird research at the islands. The other bullet points and the text sections on life history and foraging ecology are derived mainly from Ryan (2007) and more recent published papers. The names in brackets after the species' common name are those used by Tristan islanders.

The taxonomy of albatrosses and petrels has been in a state of flux in recent years, particularly taking account of genetic studies, but the identification of species and scientific names for all non-passerines in the text follows www.worldbirdnames.org as an up-to date source. There appears to be some inconsistency in the taxonomic treatment of seabirds, with the Wandering Albatross group for example, separated into four separate species (at least partly on conservation grounds), but with considerable 'lumping' of forms within other species, most notably the Little Shearwater group.

Species * = endemic to Tristan group	**Tristan**	**Inaccessible**	**Nightingale Group**	**Gough**	**IUCN status**
Northern Rockhopper Penguin *Eudyptes moseleyi*	6,700	54,000	108,000	32,000-65,000	EN
*Tristan Albatross - *Diomedea dabbenena*	Extirpated	?2	---	1,800	CR
Sooty Albatross - *Phoebetria fusca*	2,000-3,000	500	100-200	2,500-5,000 (3,500)	EN
*Atlantic Yellow-nosed Albatross *Thalassarche chlororhynchos*	16,000-30,000	2,000	4,000	4,600-6,000 (5,300)	EN
Southern Giant Petrel *Macronectes giganteus*	extirpated	---	---	225-255 (240)	LC
Blue Petrel - *Halobaena caerulea*	---	---	---	100s	LC
Broad-billed Prion *Pachyptila vittata*	1,000-10,000	50,000-500,000	10,000-100,000	ca 1 million	LC
MacGillivray's Prion *Pachyptila macgillivrayi*	?	?	?	>100,000	Not assessed;
Kerguelen Petrel *Aphrodroma brevirostris*	Unknown	---	50-500	>50,000	LC
Soft-plumaged Petrel *Pterodroma mollis*	100-500	10,000-100,000	100-1,000	400,000	LC
*Atlantic Petrel - *Pterodroma incerta*	100-200	Probably breeds	---	900,000	EN
Great-winged Petrel *Pterodroma macroptera*	1,000-3,000	May breed	---	>10,000	LC
*Spectacled Petrel *Procellaria conspicillata*	---	15,000	---	---	VU
Grey Petrel - *Procellaria cinerea*	50-100	Probably breeds	---	ca 5,000	NT
Great Shearwater - *Ardenna gravis*	<10	2.0 million	3 million	980,000	LC
Sooty Shearwater - *Ardenna grisea*	<10	May breed	---	---	NT
Subantarctic Shearwater *Puffinus elegans*	Possibly breeds	5,000-50,000	100-1,000	>5,000	LC
Grey-backed Storm-petrel *Garrodia nereis*	---	---	---	1,000-10,000	LC
White-faced Storm-petrel *Pelagodroma marina*	---	5,000-50,000	1,000 -10,000	>10,000	LC
White-bellied Storm-petrel *Fregetta grallaria*	---	10,000-50,000	100-1,000	?	LC
Black-bellied Storm-petrel *Fregetta tropica*	---	20,000-100,000	100-1,000	<5,000	LC
Common Diving Petrel *Pelecanoides urinatrix*	?	5,000-50,000	10,000-100,000	>20,000	LC
Antarctic Tern *Sterna vittata tristanensis*	50-70	100	100-300	500	LC
Brown Noddy - *Anous stolidus*	30-50	50-100	200-500	200	LC
Brown/Subantarctic (Tristan) Skua *Stercorarius antarcticus hamiltoni*	5-10	100	100-500	1000	LC

Table 10: Population counts on the Tristan and Gough islands for breeding seabirds; some of these are crude estimates that have not been updated since the 1970s (Richardson 1984). Counts are of breeding pairs; species marked --- are not recorded as breeding on that island. IUCN categories: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern. [Sources: Gough and Inaccessible WHS Management Plan (Tristan da Cunha Government and RSPB 2015); Important Bird Area factsheets (Birdlife International 2016); Prof. Peter Ryan pers. comm.].

5.2. Population size, ecology and distribution of the seabirds of Tristan and Gough

5.2.1 Penguins (family Spheniscidae)

Only the Northern Rockhopper Penguin *Eudyptes moseleyi* breeds on the Tristan archipelago. King Penguins *Aptenodytes patagonicus*, Gentoo Penguins *Pygoscelis papua* and Macaroni Penguins *Eudyptes chrysolophus* are recorded as very scarce visitors, and there is a single record of a Magellanic Penguin *Spheniscus magellanicus*.

Northern Rockhopper Penguin (Pinnamin) *Eudyptes moseleyi*

- Location: Tristan, Inaccessible, Nightingale group and Gough.
- IUCN Red List Status: Endangered.
- Population Size: 168,000 - 170,000 pairs (Tristan top islands); 32,000-65,500 pairs (Gough).
- Population Trend: Recent increase on Tristan following protection after major decline; serious decline on Gough and possibly declining on other islands.
- Diet: Mainly crustaceans, with some small squid and fish.
- Foraging range: Seldom observed at sea, so distribution poorly known.
- Breeding: Adults arrive in late July and August; two eggs laid in September, hatching mid-October to early November; single remaining chick fledges in late December or January.

Figure 81: Northern Rockhopper Penguins *Eudyptes moseleyi* at Gough. [left Photo: Trevor Glass]

Population and trends

The Northern Rockhopper has two separate breeding areas. Around 85% of the world population breeds on the Tristan archipelago, but it also breeds in the southern Indian Ocean, with 24,900 breeding pairs counted on Amsterdam Island and 9,000 pairs on St Paul Island in 1993.

This represented a decline from 58,000 on Amsterdam Island in 1971, but an increase from 4,000 on St. Paul Island, possibly as a result of long-term recovery from exploitation in the 1930s (Guinard *et al.*, 1998). The West Wind Drift provides an oceanographic link between these Indian Ocean islands and the Tristan and Gough Islands. Population estimates for the islands vary widely, and older counts do not account for factors including survey timing. More recent population counts on the Tristan islands were made in 2009, when the count for Tristan was 6,500-7,000 pairs (Cuthbert *et al.* 2009, Robson *et al.* 2011). These authors presented population trend data and suggestions for IUCN status of Endangered under criterion A2.

Counts have been carried out annually from 2009 on Tristan, Nightingale and Alex Islands, and a small subset of the population on Gough has been monitored regularly since 2001.

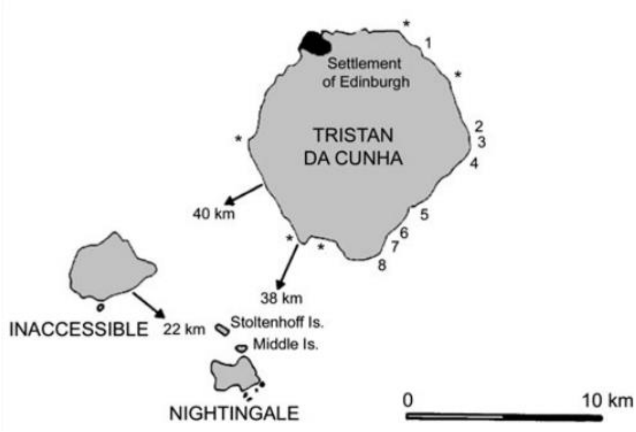


Figure 82: Map of the Tristan Group (inter-island distances not to scale), showing the position of extant penguin colonies on Tristan: West Jew's Point (1), Big Gulch (2), Phoenix Beach (3), East End of Sandy Point (4), Trypot (5), Goat Road Gulch (6), Stony Beach (7), and Stony Hill (8). Asterisks indicate the position of colonies that are known to have become extinct (from Cuthbert *et al.*, 2009). Early literature also mentions penguins at the Settlement.

Tristan is thought to have held hundreds of thousands of pairs of rockhopper penguins in the 1870s, with a rapid decline from 1817 onwards following human colonization of the island, largely as a result of egg collection, perhaps exacerbated by the impact of feral pigs (these were eradicated from the island in 1873). The penguins were also killed for food, as bait for crayfish pots and for their decorative head plumes. However, the species was eventually given a measure of protection on Tristan under the Tristan da Cunha Conservation Ordinance 1976, which allowed the species or its eggs to be taken without a permit by Tristan residents only on Inaccessible, Nightingale, Middle and Stoltenhoff Islands. Subsequently, the updated 2006 Ordinance declared all breeding colonies of penguins on Tristan as Nature Reserves. With protection and much stronger conservation awareness on Tristan, Northern Rockhopper Penguin numbers seem to be increasing on the island; 6,700 pairs were estimated in 2009 (Cuthbert *et al.* 2009), and more recent counts indicated a continuing increase with 7,000 breeding pairs in 2010 and 7,250 breeding pairs in 2011. However this was before the wreck of the *MS Oliva* at Nightingale in 2011, since when there has been a significant decline.

On Nightingale, Middle and Inaccessible Islands, the penguin colonies are located under dense stands of Tussock Grass *Spartina arundinacea*, up to 2m high, making precise counting challenging. Counts are therefore usually based on counts of the density of birds multiplied by the estimated area covered by the colony, with the inherent error this inevitably introduces. Surveys (Cuthbert *et al.* 2009) estimated 22,000–28,000 pairs on Nightingale, and 80,000–85,000 pairs at Middle (Alex) Island. For Middle Island, Richardson (1984) estimated up to 100,000 pairs in 1973, and Ryan (2007) suggested (based on comments from islanders) that numbers may be decreasing due to displacement by fur seals. However Robson *et al.* (2011) advised caution comparing these two estimates, because of differences in methods, and suggests that numbers have remained broadly constant over the previous 36 years.

Both Nightingale and Middle islands were impacted by the oilspill from the bulk carrier, *MS Oliva*, which ran aground on Nightingale in March 2011, spilling 1,500 tonnes of fuel oil into the sea just as adult penguins were beginning to moult. A major rescue effort was launched, and over 3,700 oiled penguins were taken to Tristan for rehabilitation. However, the impact of the oil on the penguins, weakened by breeding and moulting, was so severe that almost 90% of them died and only 381 were successfully returned to the sea. In the 2011-12 breeding season immediately following the spill, approximately 116,500 penguins were counted on Nightingale and Middle Islands, compared to counts on the two islands before the spill of 107,000 in 2009 and 114,000 in 2010). Herian (2012a) commented: "While the results of the [2011] penguin counts initially look more promising than at first anticipated, there are still gaps in our knowledge about the breeding ecology of Northern Rockhopper Penguins. In particular, the proportion of the penguin population that breeds every year is unknown, and it is unlikely that all adults breed every year. If the proportion not breeding annually is quite high, then we will need to monitor for the next three seasons at least, ideally for several more years, to establish the true impact on the oil spill on birds."

The 2012 count for Nightingale Island alone was an estimated 18,500 breeding pairs, lower than the preceding three years and a dramatic decline from 2011. This may suggest a delayed impact of the *Oliva* wreck. However, counts were also down on Tristan and Gough, and so may have reflected the condition of the penguins prior to breeding (Herian, 2013). Steinfurth (2013) found that, of 102 nests studied in late 2012, only 29 nests (28.4%) successfully raised chicks, but says the reasons for this poor performance are still unknown.

Steinfurth & Johaadien (2014) noted that, despite the belief of a stable population in the Tristan archipelago, observations over five breeding seasons are confirming a decrease in numbers, particularly and most noticeably on Middle Island, where numbers dropped by 55% between 2009 and 2013 (see Figure below). They also noted that on Nightingale, the Northern Rockhopper Penguin breeds in six rookeries, with the major colony being on the plateau at the site called Sergeant Major, which supports roughly 16,000 breeding pairs. Four smaller colonies, A-D, each support between 500 and 880 penguins, and a sixth colony is located at a hard-to-access stretch of the east coast where no census has been carried out. They suggested that, at some point in the past, the smaller colonies A-D probably formed part of the main Sergeant Major colony. However human activity on the island (including cutting paths through the tussock vegetation) presumably resulted in fragmentation of the colony. While the main colony has been subjected to guano and egg harvesting over several decades, these smaller colonies have been largely undisturbed. However, studies in 2013 showed that chick mortality was significantly higher in at least one of these smaller colonies, with birds in the main Sergeant Major colony much more likely to produce fledged chicks. 19 out of 26 chicks killed in this smaller colony were predated by Tristan Thrushes (*Nesocichla eremita*).

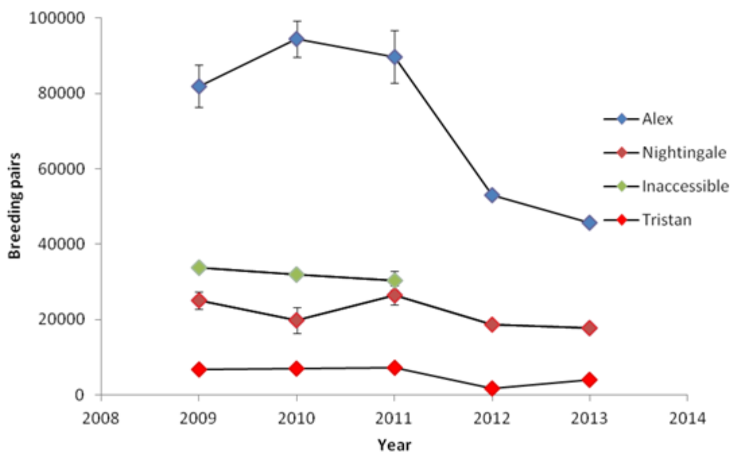


Figure 83: Breeding numbers of Northern Rockhopper Penguins in the Tristan archipelago, 2009-2013. (Data courtesy of the Tristan Conservation Department and RSPB; reproduced from Steinfurth & Johaadien, 2014).

Northern Giant Petrels have been observed attacking and killing young penguins at Nightingale (Ryan *et al.* 2008b), and fledglings are also predated by fur seals (Ryan and Kerr 2011). Penguin eggs are still legally harvested from the colonies on Nightingale and Middle Islands. This practice halted following the Oliva oil spill in 2011, but resumed in 2015. In the 1970s, between 25,000 and 40,000 eggs were taken annually for food, although consumption has declined in recent years as the islanders have not had to rely so much on a subsistence diet. Ryan (2007) considers that this level of harvest is sustainable, provided that only the smaller, first-laid eggs are collected (see 'Life History' below) and disturbance is minimized.

On Inaccessible, 50,000–55,000 pairs were estimated in 2009 (Cuthbert *et al.* 2009). This was higher than in previous years, but Robson *et al.* (2011) suggested that this difference in numbers could be partly accounted for by a different statistical treatment of birds in beach parties in assessing the total breeding population. When earlier counts were reassessed using this methodology, it was concluded that the population on Inaccessible had remained broadly steady over these years, although still lowest in 2004.

Bringing these revised counts together, Robson *et al.* (2011) suggested a total count for the Tristan Archipelago of 160,000–175,000 pairs (representing 65% of the world population). They concluded: "Comparison of population trends at the four main islands of the Tristan da Cunha group for the 36-year period from 1973 to 2009 for Tristan, Nightingale and Middle islands and for the 20-year period from 1989 to 2009 for Inaccessible indicate no significant trend in breeding numbers and stable populations at all islands, although with relatively high inter-annual variability in breeding numbers". However historically there have been massive declines, with probably hundreds of thousands of pairs on Tristan in the 1870s reduced to around 5,000 pairs by 1955 (Cuthbert *et al.* 2009).

On Gough Island, the only breeding site for the species south of the Subtropical Front – most breeding colonies are located on rocky boulder slopes below coastal cliffs and population estimates are generally based on scans of the colonies from the shore or from boats, with some potential for error. Perhaps as a result, BirdLife (2010) shows widely varying counts for breeding pairs of 78,300 (1979), 142,800 (1984), 32,400 (2004) and 64,700 (2006). Ryan (2007) therefore estimated the population to be 30,000–80,000 pairs, which he noted is down from the 142,800 pairs estimated in 1984, although the reason for this decline is unknown. Cuthbert *et al.* (2009) used an average from the 2004 and 2006 counts to produce an estimate of 48,500 pairs. Robson *et al.* (2011) calculated that this represents a decline of 3-4% a year from an estimated 110,000 pairs on the island in the early 1980s.

The 1980s figure of 110,000 pairs contrasts very sharply with an estimate of around two million pairs of Northern Rockhopper Penguins on Gough in the 1950s (Swales 1965). If this estimate is accurate (Swales did not detail methods), then Cuthbert *et al.* (2009) noted that the decline over the 26-year period from 1956 to 1979/84 was greater than 90%, or a mean decline of 11% per year (assuming a constant decrease). Although the 1950s population figure has been questioned, Cuthbert *et al.* (2009) noted Swales' estimate of about 200,000 pairs in the largest single colony at Rockhopper Point, occupying almost the whole of the point. By 2004 and 2006, only a small proportion of this area was still occupied by penguins and the colony size was estimated at 1,180 and 4,030 pairs in the respective years – a decline of 98%. This broadly corresponded with the calculated whole-island decline of 90% and suggested that the 1956 estimate of two million pairs is plausible.

Ryan and Kerr (2011) discussed the possible reasons for this decline on Gough: "The population collapse at Gough Island occurred after the end of the commercial sealing era. Possible factors include landslips, oil pollution, capture for zoos, use as fishing bait, incidental by-catch on fishing gear and entanglement in marine litter… However, even taken together, these factors are unlikely to have been sufficient to account for the rapid decrease observed at Gough Island… There is little evidence of competition with fisheries; the penguins' diet is dominated by small crustaceans, which are not exploited by fisheries. Cuthbert *et al.* (2009) suggested that the penguins' decrease is most plausibly explained by the burgeoning population of Subantarctic Fur Seals *Arctocephalus tropicalis*, either as a result of competition for food or through predation of penguins by fur seals." Ryan and Kerr (2011) recorded limited observations at sea between Tristan and Gough of penguin carcasses whose injuries were consistent with having been killed by fur seals. They suggested this may be due to individual seals targeting penguins, although they could not say whether this is a regular occurrence. They noted that Gough Island supports some 300,000 fur seals, compared to less than 10,000 at the Tristan top islands, and suggested that this difference in seal population size provided a possible explanation for the different trends in Northern Rockhopper Penguin numbers on Gough and at the Tristan top islands.

The BirdLife factsheet on the Northern Rockhopper Penguin (BirdLife 2012) concludes that population modelling, based on those breeding sites that have been accurately surveyed, indicates that over the past 37 years (three generations), the world population has declined by 57%, and therefore assessed the population as Endangered. However, following their 2011 assessment of the population on the Tristan Archipelago, Robson *et al* (2011), stated: "If numbers of breeding pairs have remained similar at Amsterdam and St Paul in the Indian Ocean where 25,000 and 9,000 pairs, respectively, were recorded in 1993…, and with 48,500 pairs at Gough Island [see above]…, then the total population of Northern Rockhopper Penguins is estimated to be around 250,000 pairs... Given a relatively stable population of around 168,000–170,000 pairs at Tristan da Cunha, the total population is estimated to have declined by around 33% over the last 30 years. Based on this rate of decrease the population of Northern Rockhopper Penguins should be classified as globally 'Vulnerable' instead of its current status of 'Endangered', on the basis of the decreases exceeding 30% in three generations (30 years for a *Eudyptes* penguin)." However, this relatively optimistic scenario has to be balanced against the much larger historical decline on the Tristan and Gough islands and it in no way reduces the impetus for measures to protect the marine environment around the islands.

Life history

Northern Rockhopper Penguins breed in coastal colonies, under dense tussock grass on Inaccessible, Nightingale and Middle islands, but in more open situations on Tristan and Gough. On the Tristan top islands, the adults return to breeding colonies in late July and August. In September, the birds lay two eggs, the first of which is about 10% smaller than the second. The female takes the first incubation shift, while the male goes to sea for 10–20 days, then the male takes over incubation for the remainder of the 32-34 days it takes for the eggs to hatch. When the chicks hatch, they are initially brooded by the male for 20-26 days, fed by the female (the 'guard phase' in chick development), then chicks gather in loose crèches (the 'crèche phase'), fed initially by the female while the male recovers from his guard duties, then by both adults.

Figure 84: Left - Northern Rockhopper Penguins returning to their nests in dense tussock inland at Nightingale. Right - Northern Rockhopper Penguin adults with chicks under tussock (Nightingale), where they get some protection from predatory skuas.

The chick from the second, larger egg usually hatches first and then monopolises food, almost invariably leading to starvation and death of the chick from the first, smaller egg (which is why these smaller eggs could potentially be harvested sustainably without impacting the overall population). Laying two eggs may be an insurance policy; should the larger second egg get lost, due to predation, weather or accidental damage during fights between penguins, the chick from the first, smaller egg stands a reasonable chance of survival. However, as in most circumstances the chick from the first egg is not reared, there may be a survival benefit in investing less energy in a smaller first egg.

The surviving chick fledges after about 10 weeks in late December or January. Adults then head out to sea to fatten up, returning in February or March to moult. Non-breeding adults and yearlings moult earlier, in December. Breeding and moulting on Gough is 3-4 weeks later than on Tristan. The adults then disperse to sea for the winter season, before returning to breed, normally in the following year.

Foraging ecology

Penguins from the Tristan and Gough islands feed mainly on crustaceans (particularly euphausiids, shrimps, amphipods and isopods), but also take some small squid and fish (Ryan, 2007). Using stable isotope analysis and stomach content analysis, Booth and McQuaid (2013) found that the diet of adult female penguins at Tristan and Nightingale was dominated by zooplankton during the guard stage (when the male guards the chicks and only the female forages), and in both sexes by fish in the crèche stage (when both parents forage). Penguins were opportunistic foragers, hunting in different areas during breeding and non-breeding periods, with different premoult foraging patterns observed in the colonies from the two islands, only 38km apart. Generally, the foraging range of Northern Rockhopper Penguins is poorly known because they are only very occasionally seen at sea, either singly or in small flocks (and discrimination between the two rockhopper penguin species would be almost impossible at sea). Tracking technology has improved greatly in recent years, and work is in progress on GPS and GLS tracking of birds from Nightingale and Gough.

A study of diving behavior of female Northern Rockhopper Penguins at Amsterdam Island provided compelling evidence for cooperative hunting behavior in this species (Tremblay & Cherel 1999). Two females were observed diving synchronously over a period of seven hours, including 286 dives, around 92% of which were synchronous. The two birds apparently met at sea and did not leave or return to the colony together, and they did not dive in synchrony on several other days studied.

Using Temperature Depth Recorders (TDRs), the frequency and depth of dives can be established. At Amsterdam Island, diving of Northern Rockhopper Penguins was studied during the guard phase in 1995 (Cherel *et al.* 1999) and during the crèche phase in 1994 (Tremblay *et al.* 1997). The figures from the two studies are not entirely comparable due to variations between the two years. During the guard phase, females left the colony at dawn, returning about 12 hours later. Transit speed to the foraging areas was estimated at approximately 7.4km/h (based on earlier studies, Brown 1987) and transit time was about 45 minutes either way. Most birds stayed within 6 km of the coast and performed about 550 dives. Mean dive depth was 18.4m, but dives up to a depth of 109m were recorded. Average dives lasted for 57 sec, with a maximum of 168 seconds, and the mean surface time between dives was 21 seconds. This means that birds spent nearly 70% of time at sea under water. The returning birds had average stomach contents of 123.6g (58% of which was crustaceans by mass). As the brood phase progressed, a trend towards more numerous shallow dives was noted. During the crèche phase, birds were observed diving deeper and shifting from a squid- to fish-dominated diet between the early and late crèche phases. Males and females dived to comparable depths.

Figure 85: Northern Rockhopper Penguins are excellent swimmers, using their wings as flippers to propel them, and to change direction rapidly. (Seal Pool, East Landing, Nightingale).

Northern Rockhopper Penguins on Tristan fitted with TDRs (36 females and seven males) were generally diurnal, daily foragers with foraging trips lasting 12-16 hours, with occasional extended trips and nocturnal diving recorded in a few individuals during guard and crèche stages (Booth 2011). The birds dived predominantly in the upper 20m of the water column but used longer, deeper (30-40m), energy-costly dives to target energy-rich prey (fish) and more frequent shallow (5-20m), energy-efficient dives when foraging for zooplankton. Estimates of the distance travelled to the foraging ground indicated that the average distance travelled was 8.26 ± 1.02km in guard-stage birds and 8.77 ± 2.6km in crèche-stage birds (the difference between the stages is not statistically significant). While most foraging trips were 12-16 hours in duration, two birds made trips longer than 24 hours; one guard bird of 27.4 hours and one crèche bird of 35.5 hours (Booth 2011), though whether this was mostly spent in transit or in feeding remains unknown.

From September to December 2012, TDRs that also contained a GPS unit to record the penguin's position were used on penguins at Nightingale (Steinfurth 2013). 34 of these GPS-TDRs were deployed on penguins during the incubation, guard and crèche phases and results showed that birds can move quickly over substantial distances from their breeding islands. Some of the birds that failed during incubation on Nightingale remained away from the colony for up to 10 weeks, with some penguins foraging more than 600km from Nightingale in the vicinity of the Walvis Ridge to the north-east, while others travelled south-east to feed around Gough. Birds with small chicks foraged within 95km of Nightingale. The tracked penguins dived to a maximum of 66-96m.

Figure 86: Northern Rockhopper Penguin molting at Gough before heading out to sea.

Once adults have finished breeding and molting, virtually nothing is known about their dispersal over the winter. Northern Rockhopper Penguins have been recorded in South Africa, and rockhoppers (of unspecified species, but likely to be Southern Rockhopper Penguins based on range) are also recorded as vagrants in New Zealand, Australia and Antarctica. A single Northern Rockhopper Penguin was first recorded in the Falkland Islands in 2009, at a colony of Southern Rockhopper Penguins in East Falkland, and has returned there every year since (post by Sarah Crofts on 11 April 2014, falklandsconservation.com). In 2014 the bird paired up with a Southern Rockhopper Penguin and in November was seen sitting on an egg; in December this hatched to produce the first recorded case between these species of a hybrid chick.

5.2.2. Albatrosses (Family Diomedeidae)

Three species of albatross breed on the Tristan and Gough islands, the Tristan Albatross *Diomedea dabbenena*, Atlantic Yellow-nosed Albatross *Thalassarche chlororynchus* and Sooty Albatross *Phoebetria fusca*. In addition, the Wandering (Snowy) Albatross *Diomedea exulans* and Black-browed Albatross *Thalassarche melanophrys* are relatively common non-breeding visitors, and the Northern Royal Albatross *D. sanfordi*, Southern Royal Albatross *D. epomophora*, Grey-headed Albatross *T. chrysostoma,* Salvin's Albatross *T. salvini,* Shy Albatross *T. cauta*, (southern form *T.C. steadi*, also known as White-capped Albatross) and Light-mantled Albatross *P. palpebrata* are scarce non-breeding visitors.

Tristan Albatross (Gony) *Diomedea dabbenena*

- Location: Primarily Gough, also Inaccessible and formerly Tristan (still occasionally visits).
- IUCN Red List Status: Critically Endangered.
- Population Size: 1,800 annual breeding pairs (Gough) (biennial breeder, so population certainly more than this); at most two pairs (Inaccessible).
- Population trend: Serious decline.
- Diet: Mainly squid and fish, with some crustaceans and offal.
- Foraging range: Widely in the South Atlantic, from Brazilian to South African waters.
- Breeding: Adults return November-December; single egg laid in January; chicks hatch March and fledge November-December; most adults that raise a chick only breed every second year; birds that fail late in their attempt also tend to defer for a year.

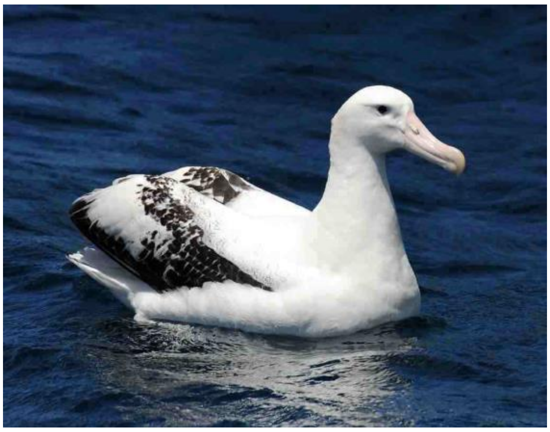


Figure 87: Tristan Albatross *Diomedea dabbenena,* adult male.

Population and trends

The Tristan Albatross is the most genetically distinct member of the Wandering Albatross group (Wandering (Snowy) Albatross *Diomedea exulans*, Tristan Albatross *D. dabbenena*, Antipodean Albatross *D. antipodensis*, Amsterdam Albatross *D. amsterdamensis*) (Nunn and Stanley 1998). It differs from other species in the 'wandering' group in size and rate of plumage maturation, but identification of the Tristan Albatross from others at sea is virtually impossible, which makes it difficult to assess the species' distribution away from its breeding sites.

With this in mind, Cuthbert *et al.* (2003a) presented the first detailed morphometrics of Tristan Albatrosses, which can be used to separate this species from the more common Wandering Albatross (*D. exulans*) from South Georgia, allowing fisheries observers to correctly identify albatrosses killed on long-lines in the Atlantic Ocean. Tristan Albatrosses are smaller than the Wandering Albatross in all measurements, with males larger than females in both species. A combination of bill measurements discriminated 97-98% of individuals of the two species, and tarsus and bill measurements allowed the sex of birds from both species to be determined. The authors concluded that, if the sex of the bird is known, then bill length should identify all individuals to species (although clearly this is only possible for a bird in the hand). They advised care using this treatment outside the South Atlantic region, because the Tristan Albatross is very similar in size to published measurements for the two subspecies of the Antipodes Albatross *D. antipodensis*, which breed off New Zealand and are thought to range across the South Pacific Ocean.

At breeding colonies, however, identification is not problematic because it is endemic to the Tristan and Gough islands. The Tristan Albatross was extirpated from Tristan between 1873 and 1907; Moseley (1879) mentions it in his account from the HMS Challenger visit in 1873, but it was absent by 1907 (Hagen 1952, Watkins 1987). Its demise was largely as a result of human exploitation, perhaps exacerbated by rat predation, although birds were seen prospecting at Tristan in 1999 (Ryan *et al.* 2001). Small numbers (no more than one or two pairs) have been recorded breeding on Inaccessible since the 1980s (Ryan *et al.* 2001, Ryan 2006). This compares to several hundred pairs there in 1871-72. The decline at Inaccessible is primarily the result of predation by feral pigs, which ate the chicks; birds have also been harvested by islanders in the past. Although the pigs died out on the island in the 1930s, albatross numbers have failed to recover, possibly due to their very small population size (Ryan, 2007).

Today, therefore, the species' breeding range is virtually restricted to Gough. The population has been estimated at around 1,800 breeding pairs (Cuthbert *et al.* 2013). This roughly equates to 4,700 mature individuals of this species (which normally breeds every second year), of a total world population for the species of around 7,100 birds. Recent counts suggest that the population has declined by 28% over 46 years, and at 3% annually between 2000 and 2011 (Cuthbert *et al.* 2014), equivalent to declines of >96% in three generations. Together with its extremely small breeding range, this is the justification for its IUCN rating of Critically Endangered.

Currently, a major threat is from the introduced House Mouse *Mus musculus,* which kills downy chicks, even while they are still being brooded by the parents (Cuthbert & Hilton 2004, Wanless *et al.* 2007, Wanless *et al.* 2009). Fledging success between 2000 and 2011 averaged just 23%, less than half that of other studied *Diomedea* colonies (Cuthbert *et al.* 2003b, Cuthbert and Hilton 2004, Wanless *et al.* 2007, R. Wanless *in litt.* 2007, Cuthbert *et al.* 2014). In January 2008, 1,764 adults were incubating eggs on Gough, but only 246 chicks survived to fledging – a success rate of just 14%. Recent figures are very bleak. In January 2013, 1,748 incubating Tristan Albatrosses were counted on Gough (Davies *et al.* 2015). This total is higher than the 1,421 nests recorded during the 2012 season and suggested no overall decline since 2008. However, by September 2013, just 578 large chicks were counted, giving a maximum breeding success of 33.1% which Cooper & Ryan (2014) noted is "far too low to sustain a population of great albatrosses". Results were even worse in 2014, when only 163 chicks were found in September, out of 1700 nests counted in January. This equates to a breeding success of just 9.6%, the lowest recorded since records began in 2001 (Davies *et al.* 2015). Ryan (2007) pointed out that numbers of adult birds are inflated on Gough by their low breeding success, because a proportion of failed breeders return to breed every year.

Figure 88: Female Tristan Albatross unaware of the danger to her chick, which is being attacked at night by two House Mice. The chick died 3.3 days after the first attack. [Photo: Ben Dilley]

Like other albatrosses, the Tristan Albatross is also threatened by long-line fishing, with an estimated 250 Tristan Albatrosses killed each year (Wanless *et al.* 2009). Breeding adults are also occasionally killed by peat slips, although this is probably rare. Recent population modelling suggests an annual rate of decline of 2.9-5.3% (Ryan *et al.* 2001, Wanless *et al.* 2009). This would give a decline over three generations (around 87 years for this long-lived species) of >96%, on which basis the species is listed as Critically Endangered. The worst-case scenario is of extinction in around 30 years because of the combined impact of mice and long-lining (Wanless *et al.* 2009).

A feasibility study for the eradication of House Mice on Gough by aerial broadcast of rodenticide has been completed (Parkes 2008, Torr *et al.* 2010), and the project is expected to go ahead in winter 2019. There are many challenges, to be addressed by the Operational Plan and Environmental Impact Assessment. For example, endemic Gough Moorhens are attracted to the same bait, so maintaining captive populations of these birds for reintroduction later may be necessary; similarly with Gough Finches.

Life history

The Tristan Albatross nests in loose colonies, usually on wet heath at an altitude of 400-700m, provided there are open areas to allow take-off and landing. Adults return to the islands in November-December, laying a single egg on a nest mound of vegetation in January. Pairs usually remain together for successive breeding attempts. Incubation is by both adults for 70-78 days, with shifts lasting 10-12 days while the other parent is at sea. Chicks are fed by both parents, and continue to be brooded for several weeks until they are large enough to protect themselves from Southern Giant Petrels and Skuas. The chicks fledge in late November and December. The breeding season is so long that successful adults need to remain at sea for a year before returning to breed every second year. Although immature birds return to land after 4-5 years, they do not start breeding until the age of 10-12. The species can live to at least 35 years, but current mortality is so high that most die before even breeding once.

Figure 89: Tristan Albatrosses cover vast distances at sea in search of squid and fish.

Foraging ecology

Tristan Albatrosses feed mainly on squid and fish, with some crustaceans and offal from fishing boats, caught at the sea surface, or on dives that rarely exceed 1m. The squid caught usually weigh less than 400g, although squid of up to 4.4kg have been recorded. The prevalence of bioluminescent squid in one study suggests they may feed at night (ACAP 2009). The birds are usually seen singly at sea, but gather in loose flocks where prey is abundant near fishing boats or around a dead whale. They habitually follow ships.

At sea, they spend most of the day flying, using thermals and wind currents to minimize the energy they expend in flight, and often sit on the water at night. They can travel at speeds of up to 100km/h.

Outside the breeding season, the Tristan Albatross disperses to South Atlantic and South African waters (Goren and Ryan 2010), with numerous recent records from Brazilian waters (Neves *et al.* 2000, Olmos *et al.* 2000) and regular records from Australia (Reid *et al.* 2013). 14 non-breeding Tristan albatrosses tracked from Gough between 2004-2006 remained within the South Atlantic or southern Indian Oceans, and showed distributions centered on the Subtropical Convergence (Reid *et al.* 2013). They used the southwestern Atlantic Ocean during the austral summer and the southeastern Atlantic and Indian Oceans as far east as Australia during the Austral winter, with foraging effort concentrated in areas of upwelling and increased productivity.

In December 2016, six fledgling Tristan Albatrosses on Gough were fitted with satellite transmitters (Birdlife Seabirds Facebook Page, 12th February 2016). Two of the birds came into South African waters; the recorded track of one of these showed that this young bird had travelled over 10,000km in the three months since it left Gough.

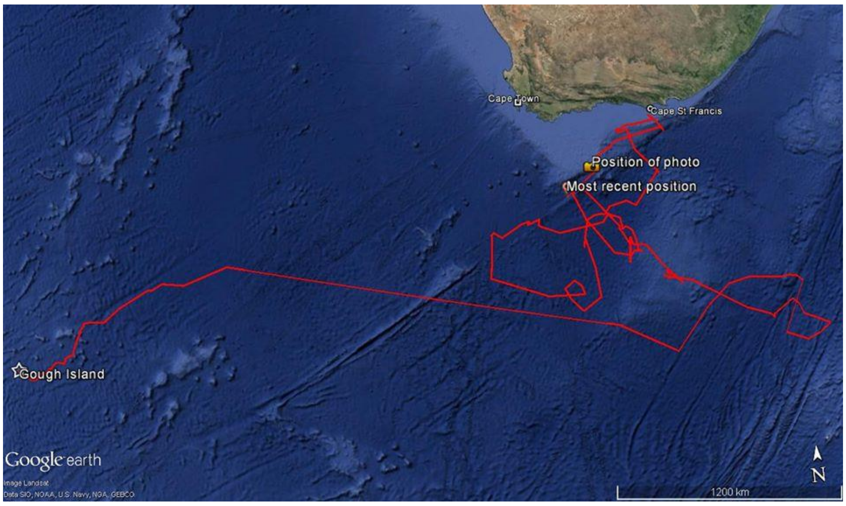


Figure 90: Track of a young Tristan Albatross fitted with a satellite tracker while it was a fledgling on Gough. The bird travelled over 10,000km in 3 months. [Birdlife Seabirds Facebook Page 12th February 2016]

Atlantic Yellow-nosed Albatross (Molly) *Thalassarche chlororhynchus*

- Location: Tristan, Inaccessible, Nightingale Group and Gough
- IUCN Red List Status: Endangered
- Population Size: c. 27,300-41,300 pairs on the islands; 16,000-30,000 (Tristan); 2,000 (Inaccessible); 4,000-4,500 (Nightingale); 4600-6000 (Gough).
- Population trend: Decreasing
- Diet: Fish and squid with some crustaceans and offal
- Foraging range: Throughout temperate South Atlantic, rarely to Australia and New Zealand
- Breeding: Adults return ashore August–September; usually single egg laid mid-September to early October; chicks hatch late November to December and fledge March–April.

Population and trends

The Atlantic Yellow-nosed Albatross is now separated from the Indian Yellow-nosed Albatross *Thalassarche carteri*. The two species have little overlap in range (only in waters around South Africa), and are morphologically and behaviorally distinct.

An estimated 16,000-30,000 pairs were present on Tristan in 1972-74 (Richardson 1984), and a recent aerial survey of part of Tristan estimated about 18,000 pairs, although not all the island was covered, with approximately 20% missed (Peter Ryan pers. comm.). On Nightingale, 4,500 were estimated in 1972-74 (Richardson 1984), while 4,000 were estimated in 2007 (ACAP 2009). Counts by The Tristan Conservation Department in the 2011-12 breeding season suggest a population of some 3,000-4,000 breeding pairs across the whole of Nightingale Island, remaining relatively stable in recent years (Herian 2012b). 40 pairs were estimated on Middle Island and 210 on Stoltenhoff Island in 2010 (Ryan *et al.* 2011), less than half the only previous estimates made in 1973 (Richardson 1984). On Inaccessible, 1,100 pairs were ringed on part of the island in 1983 (Fraser *et al.* 1988), giving a probably breeding population of >2000 pairs. There were an estimated 2000 pairs in 2004 (Ryan 2006).

In 2000-2001, the Gough population of this species was estimated at c. 5,300 breeding pairs (Cuthbert and Sommer 2004, Cuthbert *et al.* 2013), with a range of 4,600-6,000 pairs. However Cooper & Ryan (2014) commented: "No full-island survey of Atlantic Yellow-nosed Albatrosses… has ever been conducted on Gough. It would be a huge, if not impossible, task to undertake with any accuracy, given the island's rugged topography [an aerial survey was attempted in 2014; Cooper 2014]. However, a long-term demographic study (now going into its 32nd year), along with more recent counts in the island's south around Transvaal Bay, suggests a reasonably stable population, despite the mortality caused by longline fishing vessels off the

Atlantic coast of South America. Predation by mice on chicks has been reported but currently seems rare, so may not be having a deleterious effect on the population level."

Figure 91: Clockwise from top left - Atlantic Yellow-nosed Albatross *Thalassarche chlororhynchus*. Courting Atlantic Yellow-nosed Albatrosses at Nightingale. Atlantic Yellow-nosed Albatross chick on nest at Gough [Photo: Trevor Glass]. Outside the breeding season, Atlantic Yellow-nosed Albatross in flight

Combining these data gives a total of 27,500-41,600 breeding pairs per year on all the islands, equating to 55,000-83,200 mature individuals (as the species breeds annually). However, there is considerable uncertainty around the overall population estimate. The last (and only) reliable estimate of this species on Tristan was 16,000-30,000 pairs in 1972-74 (Richardson 1984). Aerial surveys in 2015 were incomplete but suggest that Tristan is still the stronghold for this species. Trend data from study colonies on Tristan was used to produce an estimate of a reduction in 2001 of 80-89% from 1974 levels (Cuthbert and Sommer 2004). Population modelling with 20 years of demographic data (1982-2001) predicted annual rates of decrease of 5.5% on Tristan da Cunha (Cuthbert *et al.* 2003b).

At Gough, population modelling with demographic data from 1982-2001 predicted annual rates of decrease of between 1.5 and 2.8% (Cuthbert *et al.* 2003b). Overall declines were estimated to exceed 70% over 72 years (three generations), which is why the species is assessed as Endangered. However population counts from 11 representative areas of Gough Island (representing some 5% of the species' breeding habitat) indicate a stable population for the period 2000 to 2005 (R. Cuthbert *in litt* 2008, from Birdlife International factsheet). Cuthbert *et al.* (2014) did not detect any significant decline at Gough, although they cautioned that further information is required before determining accurate island-wide population trends. Latest unpublished population modelling suggests populations are probably stable (Peter Ryan pers.comm.).

The 'Molly' was historically killed for food on Tristan, Nightingale and Inaccessible, with up to 2,000 eggs and 1,500 chicks killed per year in the 1950s (Elliot 1957, Richardson 1984). It is now protected at all its breeding sites, and the main threat is from drowning on long-lines. At least 900 birds per annum were thought to be killed off the coast of south-east Brazil, where it is one of the commonest species attending longline vessels (Olmos *et al.* 2000), although numbers killed in this fishery are thought to be less now. It also follows trawlers and longlining vessels off the west coast of southern Africa (Harrison 1983, Olmos 1997, Croxall and Gales 1998), where mortality has been recorded (Ryan *et al.* 2002). It is one of the most frequently killed species in pelagic and longlining fisheries off Namibia (Petersen *et al.* 2008). Deliberate killing for food off Angola is also a concern (Peter Ryan pers.comm.)

Life history

The Atlantic Yellow-nosed Albatross breeds in loose colonies amongst fern bush, bogs and meadows with bog grasses *Scirpus* spp., and locally under tussock grasses (Ryan 2007). Adults return ashore in late August–September and females lay a single egg from mid-September to early October, in pedestal nests of mud, peat, feathers and vegetation. Incubation by both adults lasts 64–70 days, with the adults replacing each other in incubation and feeding shifts lasting 10–12 days. The chicks, which hatch in late November to December, are fed by both parents, and brooded for the first three weeks until they are able to protect themselves from Southern Giant Petrels and Brown Skuas. They fledge in March–April, allowing plenty of time for the adults to feed up before the next breeding season, and enabling most adults to breed annually. Immature individuals return to the island at the age of 5–12, but they do not start breeding until 6–13 years old. They live at least 31 years, and pairs generally stay together over successive breeding seasons, but may 'divorce', or mate opportunistically with another bird, if their mate fails to arrive. Breeding success ranges from 62-72% for Gough and 62-76% for Tristan (ACAP 2009).

Foraging ecology

Atlantic Yellow-nosed Albatrosses are recorded offshore around the islands all through the year (Ryan 2007). They are usually seen singly or in small groups at sea, although rafts of 10–50 birds roost in the water near to colonies during the breeding season. They occasionally follow ships, partly for the aerodynamic benefits of flying in the ship's slipstream, but also for any scraps thrown overboard, which they generally snatch then fly away to consume. They feed mostly on fish and squid, with some crustaceans and offal, which they obtain by surface seizing, surface plunging and occasional plunge dives, usually to no more than 1m deep. Squid caught are generally <200g. In one study, cephalopods made up 73% of the diet by mass of birds caught by longlines (Colabuono and Vooren 2007). They often feed in association with other marine predators, including tuna, which bring baitfish to the surface.

During the incubation period, most adults commute to the edge of the African continental shelf; birds from Gough forage further south on average than those from Nightingale. A few head west towards the Patagonian shelf. During the brood/guard phase they remain closer to Tristan and Gough. Outside the breeding season, Atlantic Yellow-nosed Albatrosses disperse throughout the South Atlantic Ocean, mainly between 25°S and 50°S, and have been recorded off the coast of Argentina, Brazil and the west coast of southern Africa (Harrison 1983).

Sooty Albatross (Peeoo) *Phoebetria fusca*

- Location: Tristan, Inaccessible, Nightingale Group and Gough
- IUCN Red List Status: Endangered
- Population Size: 2,000-3,000 pairs (Tristan); 500 pairs (Inaccessible); 100-200 pairs (Nightingale); c 3,500 pairs (Gough). Total all islands 5,100-8,700 pairs
- Population trend: Rapid decline
- Diet: Mainly squid; also fish, crustaceans, carrion and even other birds
- Foraging range: Throughout temperate South Atlantic and southern Indian Ocean
- Breeding: Adults return to land early September; single egg laid early October; chicks hatch mid-December and fledge mid-May.

Population and trends

The Sooty Albatross is known as the 'Peeoo' on Tristan, from the distinctive *peee-aaarh* call of birds on land. The species also breeds on Prince Edward, Marion, Crozet, Kerguelen (a few), and Amsterdam and St Paul islands in the southern Indian Ocean. In 1998, the global annual breeding population estimate of 15,665 pairs on 15 islands, equivalent to a global population of around 100,000 individuals (ACAP 2010), as the species is almost wholly biennial (breeds every other year). On the Tristan islands, numbers are poorly known because their nest sites on the vegetated ledges of steep gulches and cliffs are difficult to survey. Less than 5,000 pairs bred annually (c 36% of the world population) at Gough (Cuthbert and Sommer 2004, Cuthbert *et al.* 2013), and around 2,625-3,750 at the Tristan top islands (Richardson 1984, Ryan 2006). Numbers at Gough appear to have dropped by over 50% from the period 1972-2000, although the 1972 figure was a very crude estimate. Counts of breeding birds on Gough in 2000, 2003 and 2005 indicated no change in breeding numbers (Cuthbert *et al.* 2014), although the authors stress that caution should be applied to the results because of the small proportion of the population monitored.

ACAP (2010) quoted a range of 2,625-3,750 pairs (neither from actual survey) for the top islands. Ryan (2007) quotes a "crude estimate" of 2,000 pairs on Tristan, 200 on Nightingale and 500 on Inaccessible. The Sooty Albatross was historically killed for food on Tristan and the other top islands, but is now protected. However the overall population trend is unknown because of the lack of reliable data.

The main threat to the Sooty Albatross is mortality from longlining. The population of around 3,500 pairs on Gough was deemed to be stable, based on monitoring over the last decade (Cuthbert *et al.* 2014). A small-scale demographic study, begun in 1982, was resuscitated in 2012, when 23 nests with eggs were followed through the breeding season, from which only eight chicks successfully fledged. This apparently poor breeding success may be caused, at least in part, by House Mouse predation, first observed in 2008 (Cuthbert *et al.* 2013).
Overall, BirdLife International (2016) assesses that the species has declined by 60% internationally over three generations (90 years), with a trend start date of 1960, and that the species is therefore Endangered. However, as a biennial breeder, its breeding population is highly variable between years, and better data on populations are required for a full assessment.

Figure 92: Sooty Albatross incubating its egg on a cliff site nest at Gough [Photo: Trevor Glass]

Life history

The species is found at sea throughout the year, but adults return to their breeding sites in early September. They breed singly or in small colonies of up to 15 pairs, on vegetated cliff ledges and ridges where they can land and take off right next to the nest (Marchant and Higgins 1990). They nest on bowl-shaped mounds of mud, where they lay a single egg in early October (with no replacement laying if this fails).

Incubation is by both adults for 68–73 days, with brooding shifts of up to 10–12 days (Ryan 2007). The chicks hatch in mid-December and are fed by both adults which brood the chicks for 2–3 weeks, then leave the chick (which can defend itself by spitting oil at potential predators) so that both adults can forage for enough food to sustain the chick. After five months, the chicks fledge in mid-May. Breeding success on the islands is estimated at 54–58% and few pairs that have bred successfully will breed again the following summer (Ryan 2007). Immature birds return to the islands after 5–14 years, but do not start breeding until they are 9–15 years old. Their longevity is unknown, but two birds observed in 2012 were survivors from a 1980s study (Cuthbert *et al.* 2013). One of these was still alive in 2015, and was banded as an adult, so was at least 40 years old (Peter Ryan pers. comm.).

Foraging ecology

Sooty Albatrosses have been tracked year round from Gough (GLS), by PTT (platform transmitter terminal) from Inaccessible, and breeding birds from Gough and Tristan have been tracked by GPS (Peter Ryan pers. comm.). At sea, the Sooty Albatross is found mainly between 30°S and 60°S in the southern Indian and Atlantic Oceans, with a southern limit of c. 65°S near Antarctica and a northern limit of c. 20°S (ACAP 2010). Adults move north in winter from subantarctic to subtropical seas, while immature birds tend to remain in subtropical seas year round. Like other albatrosses, they feed mainly by surface-seizing and occasional plunge dives (Ryan 2007). Their diet is mainly squid; also birds, carrion, fish and crustaceans. They feed on seabird carrion more than other albatross species do, including dead penguins and small petrels; prions and small petrels are possibly killed at sea (Ryan 2007). They follow fishing boats to scavenge offal at least occasionally. It has been suggested that their dark plumage evolved to allow them to feed at night (Weimerskirch *et al.* 1986), but data from leg-mounted temperature loggers showed that they land and take off frequently during the day, which probably represents foraging activity (Weimerskirch and Guionnet 2002). They usually feed alone, but sometimes join other seabirds and cetaceans.

5.2.3. Petrels and Shearwaters (family Procellariidae)

18 species from this family breed on the Tristan and Gough islands, and another eight species are non-breeding visitors. The Northern Giant Petrel *Macronectes halli*, Pintado or Cape Petrel *Daption capense* and White-chinned Petrel *Procellaria cinerea* are fairly common non-breeding visitors, and the Southern Fulmar *Fulmarus glacialoides*, Cory's Shearwater *Calonectris diomedea*, Manx Shearwater *P. puffinus* and White-headed Petrel *Pterodroma lessonii* are uncommon or rare non-breeding visitors. The Antarctic Prion *Pachyptila desolata* is probably fairly common offshore from the islands in winter, but its status is uncertain due to confusion with the two breeding prions. Up to 10 pairs of Sooty Shearwaters *Puffinus griseus* bred at Big Green Hill on Tristan in the 1980s (Ryan *et al.* 1990), and it is possible the species breeds on more of the islands.

Southern Giant Petrel (Stinker, Nellie or Boneshaker) *Macronectes giganteus*

- Location: Gough; extirpated from Tristan
- IUCN Red List Status: Least Concern
- Population Size: 225-255 pairs (Gough)
- Population trend: Stable
- Diet: Mainly carrion, squid, fish, crustaceans and other birds
- Foraging range: Widely throughout the Southern Ocean
- Breeding: Adults return to colonies August, eggs laid September, chicks hatch November and fledge April.

Population and trends

As well as on Gough, the Southern Giant Petrel breeds on the Falkland Islands, Staten Island and islands off Chubut Province (Argentina), South Georgia, the South Orkney and South Shetland Islands, islands near the Antarctic Continent and Peninsula, Prince Edward Islands, Crozet Islands, Heard Island and

Macquarie Island, with smaller populations on Diego Ramirez and Isla Noir (Chile), the Kerguelen Islands and four localities on the Antarctic Continent including Terre Adélie.

The global population was estimated at around 38,000 pairs in the 1980s (Hunter 1985), declining by 18% to 31,000 pairs in the late 1990s (Rootes 1988). However, more recent comprehensive surveys have increased the global population estimate to 46,000 pairs and approaching 100,000 mature individuals (roughly equating to 150,000 total individuals) (Birdlife International 2016). Chown *et al.* 2008 (unpublished report to SCAR) estimated a global population of 54,000 breeding pairs. Recent analyses of trend data for the global population are variable, with some populations declining, some stable and some showing increases. Over the past three generations (64 years) combining trend data gave a best-case estimate of a 17% increase and a worst-case scenario of a 7.2 % decline (Chown *et al.* 2008, unpublished report to SCAR), which is why the species is placed in the IUCN category of Least Concern.

Figure 93: Southern Giant Petrel *Macronectes giganteus*

For Gough, Cuthbert and Sommer (2004) quoted a 2002 count of 225–245 breeding pairs, which would represent just 0.5% of the world population, but noted that the Gough population is thought to be increasing. In September 2013, 222 incubating birds were counted at four widely-separated breeding sites on Gough, compared to 253 birds in the previous year (Cuthbert *et al.* 2014). Overall, the authors considered the Gough population to be stable.

The species ceased breeding on Tristan prior to 1900 (Ryan, 2007), due to the killing of their chicks by Tristanians and the local extinction of seals (whose carcasses and afterbirths are an important food for the petrels). Recent reports from islanders suggest they are being seen more regularly on Nightingale, and may be involved in recent deaths there of Northern Rockhopper Penguins. Small numbers of giant petrels are killed in illegal or unregulated Southern Ocean long-line fisheries for Patagonian Toothfish, and in trawl fisheries in the Falkland Islands, but improved mitigation in many long-line fisheries appears to have reduced by-catch levels of this species around some breeding colonies (Quintana *et al.* 2006).

Life history

Giant petrels are seen offshore around the islands year-round, but adult Southerns return to their colonies in August. On Gough, their loose colonies are typically found in open grassy areas, or under the shelter of Bog Ferns or small Island Trees *Phylica arborea*. There are three breeding sites on Gough in wet heath between Low Hump and Triple Peak at 340-450m, with a few pairs at sea level on Long Beach (Cuthbert & Sommer 2004; Cuthbert et *al.* 2014). A single egg is laid in September on a low mound of vegetation and incubated by both adults for 55–66 days, in shifts of 8–10 days (Ryan 2007). After the chicks hatch in November, they are fed by both adults, which brood the chicks for the first few weeks. The chicks fledge in April after 108–130 days, with the larger male chicks remaining on the nest an average of six days longer than females. Immatures do not return to land until they are 3–5 years old, and start breeding at 4–12 years. Longevity is at least 40 years.

Figure 94: Southern Giant Petrels gathering around powerboat off a fishing ship at dawn, Gough

Foraging ecology

The birds usually move singly at sea, but gather in loose flocks of 50–100 at food sources such as dead whales or behind fishing boats. They feed mainly on carrion, but also take squid, fish, crustaceans and other seabirds, including diving petrels, prions and other small petrels which are caught on the wing at sea, as well as penguin chicks, fledglings and adults on land and at sea. They will take discarded fish and refuse from ships, often feeding near trawlers and longliners (Hunter and Brooke 1982, Hunter 1983). Males (weighing 4.2-5.5kg, up to 15% bigger than females) gather at penguin and seal colonies, where they use their large size to compete for access to carrion (Ryan 2007). The smaller females (3.3-4.7kg) spend more time at sea, taking prey by surface seizing and shallow dives to 1-2m. Access to food is often contested fiercely between birds, both on land and at sea. Males and females have distinct foraging ranges during the breeding season (Gonzalez-Solis and Croxall 2005). In spring, ringed females known to be breeding on Gough are regularly seen attending vessels at the northern islands, almost 400km away, but males have not been seen away from Gough (Peter Ryan pers. comm.)

Non-breeding Southern Giant petrels disperse widely throughout the Southern Ocean (Ryan 2007), but GLS tracking of birds from Gough suggests that they remain in the central South Atlantic year round (Peter Ryan pers. comm.).

Great-winged Petrel (Black Haglet) *Pterodroma macroptera*

- Location: Tristan and Gough, perhaps Inaccessible
- IUCN Red List Status: Least Concern
- Population Size: >10,000 pairs (Gough); 1,000-3,000 pairs (Tristan); may breed on Inaccessible
- Population trend: Decreasing on Gough and Tristan
- Diet: Mainly squid; also fish, crustaceans and fishery discards.
- Foraging range: Widely in southern oceans.
- Breeding: Adults return mid-March; eggs laid late May to mid-June; hatch late July to early August; checks fledge November.

Figure 94: Great-winged Petrel *Pterodroma macroptera* [Photo: Peter Ryan]

Population and trends

This species, known on Tristan as the Black Haglet (a corruption of Eaglet), appears to be surprisingly little studied, compared to many other seabirds. It breeds in the Southern Hemisphere between 30°S and 50°S. As well as Tristan and Gough, there are colonies on Prince Edward and Marion Islands, the Crozet Islands and Kerguelen Islands, Amsterdam Island, and on the coasts of southern Australia (del Hoyo *et al.* 1992). The New Zealand population is now generally split as Grey-faced Petrel *P.M. gouldi*.

Globally the population is estimated at 1.5 million individuals (Brooke 2004). Although it is thought this may be declining, mainly because of introduced predators on several breeding islands, the population and range of the species is so large that it is regarded as a species of Least Concern.

More than 10,000 pairs were estimated on Gough (Cuthbert and Sommer 2004), but Cooper *et al.* (2011) noted that numbers are thought to be lower than this, based on night-time observations made since the 1980s. Despite searches in areas where it was reasonably common in 2000, there were no records from 2009 to 2015 (Peter Ryan pers. comm.) Ryan (2007) regarded the species as almost extinct on Tristan. 1,000-3000 pairs were estimated there in the 1970s (Richardson 1984), but the species has declined due to historic collection for food and predation mainly of chicks by introduced predators. Thousands of chicks were collected on Tristan each October in the 1950s, but it is now protected there. As it nests in burrows, it may suffer depredation from introduced rats (and from House Mice on Gough), but there has been no study of breeding success at either Gough or Tristan. Adults and fledglings are also killed by skuas. However, there are Great-winged Petrel burrows in several locations on the edge of the Base on Tristan (Alex Bond, pers.comm), and a small breeding colony on Tommy's Hill has been monitored since 2009 (Herian 2013). Of the 30 burrows monitored, in July 2012 15 contained incubating adults, and in early November six chicks were definitely surviving, with perhaps two more chicks that could not be confirmed. This compared to eight confirmed chicks in October 2009 and five in November 2011.

Life history

The Great-winged Petrel is a winter breeder, returning to its colonies from mid-March. Birds gather off the colonies at dusk and come ashore after dark. They nest in burrows 0.6m to 3m long dug in the peat, in fern bush and wet heath at altitudes of up to 1,400m on Tristan and 500m on Gough, and perhaps at Inaccessible (Ryan 2007). They lay a single egg in late May or early June, which both adults incubate for 52–58 days in brooding shifts of around 17 days. The chicks hatch in late July or early August, and are fed by both adults, which only brood their chick for a few days. The chick fledges after 100–120 days, in November. They start breeding at six years, with most pairs breeding annually, and have an adult life expectancy of >18 years (del Hoyo *et al.* 1992)

Foraging ecology

Great-winged Petrels feed mainly at night, mostly on squid (some of which they may find by bioluminescence), as well as fish and crustaceans (Ryan 2007). They feed mainly by dipping and surface feeding. They will mix with other petrels in feeding flocks and occasionally follow cetaceans and fishing boats for discards. Outside of the breeding season, they are highly pelagic and disperse widely in subtropical waters of the Atlantic, Indian and western Pacific Oceans, mainly between 25°S and 50°S, although some birds stay near their breeding islands throughout the year. They are also recorded occasionally in subantarctic and Antarctic waters (del Hoyo *et al.* 1992).

Atlantic Petrel (White-breasted Black Haglet or Biggest Whitebreast) *Pterodroma incerta*

- Location: Endemic as a breeding species to Tristan and Gough, possibly also Inaccessible
- IUCN Red List Status: Endangered
- Population Size: c. 900,000 pairs (Gough); 100-200 pairs on Tristan
- Population trend: Declining; almost extinct on Tristan
- Diet: Mainly squid; also some fish, crustaceans and fishery discards
- Foraging range: Widely dispersed in S. Atlantic, occasionally rounding S. Africa into Indian Ocean
- Breeding: Adults return to colonies in late March to April; single egg laid mid-June to late July; hatch August to early September; chicks fledge December–January.

Figure 95: Atlantic Petrel *Pterodroma incerta* [Photo: Peter Ryan]

Population and trends

The Atlantic Petrel is endemic as a breeding species to the Tristan and Gough islands, with most of the population on Gough. Small numbers may breed on Inaccessible (Fraser et al 1988, Ryan 2007). Petrel chicks found on the eastern plateau of Inaccessible in September-October belong either to this species or Great-winged Petrel (Peter Ryan pers.comm.), but there have been no surveys there during its winter breeding season.

On Tristan, the Atlantic Petrel has declined due to past collection for food. It was once of major importance to islanders as one of the few food sources in winter, but had become scarce by the 1940s (Richardson 1984). Ryan 2007 notes thousands of chicks were collected in the 1950s, and that latterly most chicks were killed by rats. The species is now fully protected on Tristan. The population was estimated at 100–200 pairs in 1972–1974 (Richardson 1984). With no breeding recorded at Tristan for over 35 years, it is regarded as probably extinct (Birdlife International 2016).

On Gough, the first quantitative population estimate indicated a total of around 1.8 million pairs (Cuthbert 2004), considerably larger than previous estimates, and suggested a world population of around five million birds (BirdLife International 2016). A more recent estimate by Rexer-Huber *et al.* (2014) re-estimated the Gough population as 900,000 pairs, although confidence in this estimate was low. The main threat at Gough is from introduced House Mice (Cuthbert and Hilton 2004, Wanless *et al.* 2007, 2012), which is likely to be driving a long-term decline, although adults and fledglings are also killed by skuas. Evidence suggests very low fledging success of less than 20%. In 2007, of 58 nests studied from laying to fledging, only one chick (1.7%) fledged (Wanless *et al.* 2012). In 2014, all seven Atlantic Petrel chicks monitored in their burrow nests using infra-red video cameras were killed by mice within hours of hatching, and 87% of 83 chicks monitored by various methods died (Dilley *et al.* 2015). Due to this threat and its extremely small breeding range, the species is assessed as Endangered. However if it were to be confirmed as extinct on Tristan, the species may qualify for upgrading to Critically Endangered.

After Hurricane Catarina, the South Atlantic tropical cyclone which reached south-eastern Brazil in late March 2004, 340 birds were recorded blown inland, all in heavy moult and near starvation (Bugoni *et al.*

2007). The authors noted that mortality associated with the hurricane points to a potential threat from hurricane activity in the South Atlantic, postulated to increase in frequency with global warming.

Life history

This species is a winter breeder, with adults returning to their breeding colonies from late March to early April (Ryan 2007). They gather off the colonies at dusk and come ashore after dark. They nest in burrows up to 2.5m long dug in the peat, in fern bush and coastal tussock at altitudes of up to 400m on Gough and formerly up to 600m on Tristan (where they were confined to the south-east of the island). The birds lay a single egg in mid-June to late July, which both adults incubate for 50–60 days. The chick hatches in August–September, and is fed by both adults, which brood it for just a few days. The chick has an unusually long fledging period of 135–140 days, and fledges in December–January. Its breeding frequency is unknown, but possibly biennial given the protracted breeding season (Ryan 2007).

Foraging ecology

The species is mostly pelagic, occurring singly or in small groups at sea, and rarely following fishing boats. The birds feed mainly on squid, with some fish and crustaceans (Klages and Cooper 1997) and occasional fishery discards, taking their prey by surface-seizing (Ryan 2007). The species is essentially confined to the southern Atlantic Ocean, from the east coast of South America across to the west coast of Africa (Enticott 1991), although a few occur round the Cape of Good Hope into the south of the Indian Ocean (Birdlife International 2016).

Soft-plumaged Petrel (Littlest Whitebreast, Whistler) Pterodroma mollis

- Location: Tristan, Inaccessible, Nightingale and Gough
- IUCN Red List Status: Least Concern
- Population Size: c. 400,000 pairs (Gough); 10,000-100,000 pairs (Inaccessible), 100-1,000 (Nightingale); 100-500 (Tristan)
- Population Trend: Stable (but almost extinct on Tristan)
- Diet: Mainly squid; some fish and crustaceans
- Foraging range: Wide-ranging in South Atlantic, Indian and south-west Pacific Oceans
- Breeding: Adults return August–September; single egg laid November–December; chicks hatch late January or February and fledge April–May

Figure 96: Soft-plumaged Petrel *Pterodroma mollis*

Population and trends

The Soft-plumaged Petrel is one of the world's most numerous petrel species with an estimated population of at least five million individuals (Brooke 2004) and an extremely large range. In the absence of any evidence to the contrary, its world population is assessed as stable, and so it is listed as being of Least Concern by the IUCN.

Beyond the Tristan and Gough islands, it nests on Prince Edward Island (1,000 pairs), Marion Island (numbers slumped from over 400,000 birds, with cats killing c. 38,000 (del Hoyo *et al.*, 1992) to perhaps 5,000 pairs (Ryan and Bester 2008)), Crozet Islands ("tens of thousands" of pairs), Kerguelen Islands (1,000 pairs), and on the Antipodes Islands, south east of the South Island of New Zealand.

The Gough population is the largest colony in the world, estimated at some 400,000 pairs (Cuthbert 2004), with at least 10,000 pairs (up to 100,000) on Inaccessible (Ryan and Moloney 2000), 100-1,000 pairs on Nightingale (Richardson 1984), and formerly 100-500 pairs on Tristan (Richardson 1984), where the species may have been extirpated because of past collection for food and introduced predators (Ryan, 2007). On Gough, video surveillance in 2014 of nine Soft-plumaged Petrel nests revealed two fatal attacks by House Mice (Dilley *et al.* 2015). House Mice are also known to kill chicks on the Antipodes Islands, where a mouse eradication project is planned. The species comprises over 40% of the birds taken by skuas on Gough (del Hoyo *et al.* 1992).

Life history

Adults return to their breeding colonies in August–September. They gather off the colonies at dusk and come ashore after dark. They nest in burrows 1- 2m long dug in the peat, in fern bush and coastal tussock and may occasionally breed on the ground beneath dense tussock (Ryan 2007). They lay a single egg in November–December, which both adults incubate for around 50 days. The chick hatches in late January or February, but occasionally as late as April. It is fed by both adults, and brooded for the first week or so, fledging after 90 days in late January or February. They are thought to be annual breeders.

Foraging ecology

The Soft-plumaged Petrel is highly pelagic, rarely approaching land except at colonies. At sea, it is usually seen singly or in small groups, and seldom follows ships. It feeds mostly on squid but will also take crustaceans and fish, mainly by surface-seizing (Ryan 2007). The species ranges widely outside the breeding season, reaching eastern South America north to Brazil, South Africa, Australia and New Zealand. Young birds may disperse more widely than adults (del Hoyo *et al.* 1992).

Kerguelen Petrel (Blue Nighthawk) *Aphrodroma brevirostris*

- Location: Gough, Inaccessible and possibly Nightingale
- IUCN Red List Status: Least Concern
- Population Size: >50,000 pairs (Gough); 50-500 pairs Inaccessible
- Population Trend: Stable
- Diet: Mainly squid; also some fish and crustaceans
- Foraging range: Widely across the Southern Ocean
- Breeding: Adults return to colonies in August; single egg laid October; chicks hatch late November to December

Figure 97: Kerguelen Petrel *Aphrodroma brevirostris* [Photo: Peter Ryan]

Population and trends

This species is also known by the scientific name *Lugensa brevirostris*. However, del Hoyo & Collar (2014) state that the type species of *Lugensa* is considered indeterminable, so it should be referred to instead as *Aphrodroma brevirostris*. For consistency, that name is applied here.

As well as their colonies on the Tristan and Gough islands, Kerguelen Petrels also breed on Marion Island, Prince Edward Island (20,000 pairs), the Crozet Islands (240,000–108,000 pairs) and the Kerguelen Islands. (Birdlife International 2016). Overall their total population is estimated at around 1 million birds (Brooke 2004), with a very large range. In the absence of any evidence of declines or substantial threats, the global population is assessed as stable. There are more than 50,000 pairs on Gough (Cuthbert and Sommer 2004) and 50-500 pairs at Inaccessible (Fraser et al 1988). It is probably extinct on Tristan because of past collection for food and rat predation, and some chicks are likely killed by mice on Gough (Ryan 2007).

Life history

Adults return to their breeding colonies in August, gathering off the colonies at dusk and coming ashore after dark. They nest in burrows up to 2m long dug in the peat, often on steep slopes and gullies, in short vegetation at altitudes above 200m on Gough (Ryan 2007). They probably breed annually, laying a single egg in October, which both adults incubate for 46–51 days. The chick hatches in late November or December. It is brooded for no more than two days, and fed by both adults, fledging after 59–62 days in late January or February.

Foraging ecology

When not at their breeding colonies, birds are found singly or in small flocks at sea, where they forage mainly at the surface for squid, but also fish and krill. They only rarely make shallow dives or surface plunges. They are highly pelagic, circumpolar in cold subantarctic and Antarctic waters south as far as the pack ice, occasionally irrupting north to about 30°S in winter (Del Hoyo *et al.* 1992).

Broad-billed Prion (Nightbird, Whalebird) *Pachyptila vittata*

- Location: Tristan, Inaccessible, Nightingale and Gough.
- IUCN Red List Status: Least Concern.
- Population Size: 1,750,000 pairs at Gough (but note 'morphs', see below); 50,000-500,000 pairs (Inaccessible); 10,000-100,000 (Nightingale); (1,000-10,000 Tristan).
- Population Trend: Declining on Tristan and Gough; probably stable on other islands.
- Diet: Mainly small copepods; also other crustaceans, small squid and fish.
- Foraging range: Tristan and Gough birds disperse widely in South Atlantic.
- Breeding: Adults return to colonies early July; single egg laid August; chicks hatch from late September and fledge late November to early December

Population and trends

Re-estimates of the numbers of Broad-billed Prions at the Tristan archipelago are required following the recent discovery of two species of prion at Gough (Ryan *et al.* 2014; see MacGillivray's Prion *P. macgillivrayi* below). This intriguing research found that narrow-billed birds bred three months later than the wide-billed, strongly suggesting that they are a separate species, not just an example of bill polymorphism. The small-billed birds also differed from typical Broad-billed Prions in having blue coloration on the sides and a grey tip to the upper mandible. Genetic evidence confirms that the smaller Gough birds are closely related to the relict population of MacGillivray's Prions on St Paul Island, and the extinct population of prions on Amsterdam Island (Ryan *et al.* in press).

Figure 98: Broad-billed Prion *Pachyptila vittata* at Nightingale

The Broad-billed Prion has two disjunct populations. Birds from the Gough and Tristan islands disperse across the south Atlantic, while a second population inhabits the seas around breeding sites in New Zealand (south of South Island, Chatham Island, Snares Island and islands off Stewart Island) (Miskelly 2013). Young birds disperse more widely and may allow some genetic exchange between these populations.

The global population of Broad-billed Prions is estimated at 15 million birds (Brooke 2004). Due to this population size, the species is evaluated as of Least Conservation Concern, despite the fact that populations at a number of sites are believed to be declining due to predation by invasive species (mice, rats and cats). The species also suffers heavy predation by skuas, although this is thought unlikely to cause long-term population reductions.

Swales (1965) estimated at least 10 million pairs of prions bred on Gough in the 1950s, although their numbers have decreased since then due to predation by introduced House Mice *Mus musculus* (Cuthbert *et al.* 2013, Dilley *et al.* 2015). Cuthbert (2004) estimated roughly 1.5–2.0 million pairs of prions at the island in 2000/2001 (making it the most abundant species there, and its most important breeding site worldwide (Brooke 2004), but figures include unknown numbers of MacGillivray's Prion).

50,000-500,000 breeding pairs were estimated on Inaccessible 1982-87 (Fraser *et al.* 1988), 10,000 pairs on the Nightingale group 1972-74 (Richardson 1988), and 1,000-10,000 breeding pairs on Tristan 1972-74 (Richardson 1984). Ryan (2007) quoted at least 100,000 birds on Nightingale and Inaccessible, but less than 5,000 birds on Tristan, where the breeding population is severely impacted by rats and now breeds mainly in rat-free refugia. Little is known about how the introduced House Mice affect this species on Gough, adding importance to ongoing work to follow its breeding success (Cooper *et al.*, 2011). At 18 nests monitored in 2014, Dilley *et al.* (2015) reported a 0% breeding success, with 100% mortality from mouse predation of eggs and chicks.

Life history

Adults return to their breeding colonies in early July. They gather off the colonies at dusk and come ashore mainly after dark, although they may occasionally be seen flying over coastal cliffs by daylight. They nest in burrows up to 1.5m long dug in the peat, in all habitats up to altitudes of 500m, but also in rocky crevices, caves, lava tunnels, and in the walls of the huts used by visiting islanders and researchers on Nightingale and Inaccessible (Ryan 2007).

Their single egg is laid in August-September, and is incubated by both adults for 45–50 days. The chick hatches in late September or October, and is brooded for the first week or so and fed by both adults. It fledges after about 50 days in late November or early December. Adults then disperse to sea, but return in March–May to clean out their burrows and display to find a mate. They are thought to breed annually.

Foraging ecology

At sea the birds are gregarious, sometimes occurring in large flocks. They are rarely attracted to fishing boats or follow ships for food, although they sometimes play above the bow wake of large ships. However, they are attracted to ship lights at night (Ryan 1991, Glass and Ryan 2013), which is a particular problem when cruise ships visit Tristan, and ship's operators should be required to switch off all unnecessary lights at night. Klages and Cooper (1992) found that during the breeding season birds at Gough and Tristan fed almost exclusively on copepods 0.7-4.1mm in size. Del Hoyo *et al.* (1992) noted that they take more crustaceans in summer and small squid in winter. They catch their food by 'hydroplaning', a technique in which the bird sits on, or patters over, the water, using its feet to propel it across the surface, with its wings raised. It then dips its bill, or sometimes its whole head, under the water and uses its tongue and muscular throat pouch to filter water through the comb-like lamellae fringing its upper mandible of the distinctive large, broad-based bill, hence the Tristan name of 'whalebird', because it filters food from the water like a baleen whale. It also seizes suitable small prey off the surface. Average ingested plastic loads in birds killed by skuas at Inaccessible Island increased from 1.7 items per bird in the late 1980s to 2.6-2.9 items per bird in 1999 and 2004 (Ryan 2008a). Over the same period, the proportion of industrial ('virgin') pellets decreased from 44-15%.

Onley and Scofield (2007) noted that dispersal of the species from their breeding colonies is poorly understood. Some birds in the south-east Atlantic population, breeding on the Tristan and Gough islands, are thought to remain in the area all year round, while others disperse as far as 10°S off the coast of Angola and into the Indian Ocean. Vagrants have also been recorded off the Falkland Islands. Del Hoyo *et al.* (1992) suggested that adults remain in waters adjacent to breeding colonies, and go ashore there intermittently during the winter, and it is young birds that disperse more widely.

MacGillvray's Prion *Pachyptila (salvini) macgillivrayi*

- Location: Gough.
- IUCN Red List Status: not assessed, but if recognized as a distinct species it qualifies as Endangered.
- Population Size: Unknown, but probably >100,000 pairs
- Population Trend: Unknown, but probably declining.
- Breeding: Eggs laid late November

Figure 99: MacGillivray's Prion *Pachyptila macgillivrayi* [Photo: Peter Ryan]

Population and trends

In 2012 and 2013, researchers on Gough made an extraordinary discovery, of what is almost certainly a new species (for Gough) of prion, breeding in vast numbers on the island (Ryan *et al.* 2014a). Previously, the prions on the island were assumed to be all Broad-billed Prions *Pachyptila vittata*, which is abundant there and for which Gough is the most important breeding site globally.

However detailed measurements of various parameters of bird carcasses revealed that two distinct morphs were present, one with typical Broad-billed Prion characteristics of wide bill and uniform dark grey upper mandible, and another with narrower bill, and with bluish sides and a grey tip to the upper mandible (Ryan *et al.* 2014a, Ryan 2014a). Most significantly, the narrow-billed birds bred three months later than the wide-billed. This marked difference in breeding season argues strongly that the narrow-billed birds are a separate species of prion, rather than just an example of bill polymorphism. The two morphs also occupied different sites on the island, and had largely non-overlapping ranges. The sites of the narrow-billed morph were at elevations from near sea level to at least 450m; a possible third morph, with even smaller bill, may occur at higher elevations. Ryan *et al.* (2014) commented that further study is needed to better understand the distribution, breeding habitat preferences and mate selection criteria of the morphs at Gough.

The characteristics of the narrow-billed morph fitted closely with MacGillivray's Prion *P. (salvini) macgillivrayi*, a large-billed prion variously allied to Salvin's Prion *P. salvini* and Broad-billed Prion. MacGillivray's Prion was formerly abundant at St Paul and Amsterdam Islands in the Southern Indian Ocean, but following the introduction of rats it became extinct on Amsterdam Island, and only a small number of birds survive at St Paul Island, breeding on an offshore stack (Ryan 2014a). There are biogeographic affinities between the Tristan islands and the St Paul & Amsterdam Islands in other groups of organisms, including plants and marine life. Ryan *et al.* (2014a) noted that the current consensus was to treat *macgillivrayi* as a subspecies of Salvin's Prion *P. salvini* based on its bill color and November laying date (Roux *et al.* 1986), or perhaps as a separate species (Bretagnolle *et al.* 1990; Shirihai 2007). However recent genetic evidence (Ryan *et al.* in press) indicates that *macgillivrayi* is sister to *vittata*, not *salvini*. It also indicates that Gough birds are similar, but not identical to St Paul birds, and the authors suggest they be treated as a separate subspecies *P.m. goughensis*.

Due to the very recent discovery of these narrow-billed morphs, no estimates of population size at Gough are yet available. However, an estimate of at least 100,000 pairs is based on the narrow-billed morphs making up 20-30% of carcasses (Peter Ryan pers. comm.). As with other petrels at Gough, House Mice are likely to be taking a toll. Dilley et al. (2015) monitored 60 nests at Prion Cave, and despite hatching success of 85% in 2013/14, only 18% of chicks survived to fledging because mice killed the young chicks, resulting in 82% mortality. In 2014/15 results were even worse, with no chicks at all surviving at the 60 monitored nests, giving an average breeding success over the two years of only 7%.

There is no evidence that a small-billed morph breeds at the Tristan top islands. Measurements taken from small numbers of birds at Inaccessible and Nightingale were all consistent with these being Broad-billed Prions, as was time of breeding (Ryan et al. 2014), although at least two birds photographed at Inaccessible in 2009 had blue sides to the upper mandible.

Life history

So far indications are that the narrow-billed prions breed mainly in caves, but one breeding pair, and a chick, have been found in (separate) burrows (Ryan *et al.* 2014a). Breeding sites range in elevation from near sea level to >450m, and tend to be more common at higher elevations. In Prion Cave (a site on the south east coast at 50m elevation, accessible to researchers), the prions do not breed during the September–October annual visit by researchers to Gough, but some birds sit together in apparent pairs, calling together and often allopreening (Ryan *et al.* 2014a). Eggs are laid in Late November and early December, three months later than Broad-billed Prions. Chicks hatch in January and fledge in March (Cuthbert *et al.* 2013b).

Foraging ecology

Foraging ecology is unknown, due to confusion with other prions, and difficulty of separation at sea. Prions feed mainly on zooplankton, particularly copepods, by filtering water through palatal lamellae along the sides of their upper mandibles. Bill width is closely linked to foraging behavior and diet (Warham 1990), and is correlated with the number and size of palatal lamellae (Klages and Cooper 1992). Ryan et al. (2014a) note that, as there is a general trend among filter-feeding prions for bill width to increase towards lower latitudes, the smaller-billed birds might be expected to forage further south [than Broad-billed Prions].

Blue Petrel *Halobaena caerulea*

- Location: Gough
- IUCN Red List Status: Least Concern
- Population Size: 100s(Gough)
- Population Trend: not known at Gough but probably threatened by mice; globally appears to be stable.
- Diet: crustaceans, fish, squid, salps, fishery waste, carrion.
- Foraging range: Wide throughout Southern Ocean, generally south of the Subtropical Front
- Breeding: Adults at Gough colony in September; brief exodus October, eggs laid November-December; chick hatching and fledging not yet known.

Figure 100: Blue Petrel *Halobaena caerulea* [Photo: Peter Ryan]

Population and trends

Previously thought to be uncommon, non-breeding visitors to the Tristan islands (Ryan 2007), Blue Petrels were recognised from their calls in burrows on the western slopes of Low Hump, Gough in September 2014 (Ryan *et al.* 2015). Later in the year (December), birds were found to be incubating eggs.

This was the first record of Blue Petrels breeding on Gough, and represented an extension of their breeding range northwards by >700km.

Numbers at the only known locality are in the low hundreds of pairs. The authors commented that, despite the fact that the colony is located at a breeding colony of Southern Giant Petrels that has been studied intensively since 2009, the recent discovery of Blue Petrels does not necessarily indicate a recent colonization event. Small numbers of birds would be easy to overlook, especially as the area also supports large numbers of Broad-billed Prions, with superficially similar burrow entrances. Subsequent checks in other locations with similar habitat failed to find further calling birds, but other colonies may exist elsewhere on the island.

Elsewhere, Blue Petrels breed at subantarctic islands including Diego Ramirez off Cape Horn, Crozet, Kerguelen, Marion, Prince Edward, Macquarie and South Georgia.

Globally, the population is estimated at least 3 million individuals (Brooke 2004), and the population is suspected to be stable in the absence of evidence for declines or substantial threats (Birdlife International 2016). However, they are highly vulnerable to predation by cats and rats, leading to extirpation of the species from several breeding islands (del Hoyo *et al.* 1992). The Gough population is likely threatened by predation of chicks by introduced House Mice, because other similar sized prions breeding at the same time of year at Gough suffer low breeding success (Cuthbert *et al.* 2013).

Life history

Most Blue Petrel burrows on Gough were found in short *Scirpus bicolor-Acaena sarmentosa* vegetation, but some occurred under sparse Tussock Grass *Spartina arundinacea* and a few in taller wet heath vegetation. Birds were found calling from at least 20 burrows over an area of more than one hectare in September 2014, but two pairs examined lacked eggs or brood pouches, and were assumed to be cleaning out burrows prior to laying (Ryan *et al.* 2015). Searches in October failed to elicit any response to playback of calls, suggesting the birds were absent on their pre-laying exodus. In early November, two burrows were occupied but neither contained eggs. On 7th December, four burrows excavated contained birds incubating eggs, which were not yet stained with mud, suggesting that egg-laying took place at the end of November or early December, about a month earlier than at colonies farther south (Marchant and Higgins 1990, Brooke 2004). There is no information on hatching and fledging at Gough, but elsewhere incubation is 45-52 days, with stints of 1-16 days, chicks are brooded for about three days, and fledging takes 43-60 days (del Hoyo *et al.* 1992).

Foraging ecology

Blue Petrels forage by surface seizing, dipping and shallow dives to 3-5m (Ryan 2007). Their diet is largely crustaceans (especially krill and amphipods), fish, generally few cephalopods, salps, fishery wastes and carrion (Ryan 2007, del Hoyo *et al.* 1992). Outside of the breeding season they disperse widely throughout the Southern Ocean, mainly south of the Subtropical Front (Ryan 2007). However del Hoyo *et al.* (1992) indicate that adult birds may be mainly sedentary, visiting colonies intermittently in winter and probably remaining in the surrounding area, while young birds are more dispersive, ranging north to 20°S off Peru, and to 40°S in the Atlantic and Indian Oceans. This would mean that the Gough birds may be breeding at the northern limit of their Atlantic foraging range. They also range south to the zone of pack ice. Despite this southerly breeding distribution, almost all individuals contain some ingested plastic (Ryan 1987a).

Grey Petrel (Pediunker) *Procellaria cinerea*

- Location: Gough, Tristan and possibly Inaccessible
- IUCN Red List Status: Near Threatened
- Population Size: ca. 5,000 pairs (Gough); <50 pairs (Tristan); possibly breeds on Inaccessible
- Population Trend: Decreasing, perhaps rapidly
- Diet: Mainly squid and fish
- Foraging range: Wide-ranging in Southern Ocean
- Breeding: Adults return late February; single egg laid April–June; chick hatches June–August and fledges September–October.

Figure 101: Grey Petrel *Procellaria cinerea* [Photo: Peter Ryan]

Population and trends

The Grey Petrel is the largest of Gough's burrowing petrels. It has an austral circumpolar distribution, breeding on many islands across this region, but its population is poorly known. Figures suggest a very tentative world population around 400,000 individuals, but this could be incorrect by a factor of 2-3 either way (Brooke 2004). A tally of recent figures points to at least 80,000 pairs worldwide, but this figure is thought to be only a rough estimate (Birdlife International 2016).

The largest population is likely to be on the Antipodes Islands, with 53,000 pairs estimated in 2001 (Bell 2002). In addition, several thousand pairs are estimated on the Marion and Prince Edward, Crozet and Kerguelen islands. Only c.10 pairs breed on Amsterdam Island (Birdlife International 2016), although the fossil record indicates that one of the world's largest colonies probably occurred there (Worthy and Jouventin 1999).

At one time it was thought that the Tristan and Gough islands hosted the largest breeding populations: in the early 1970s, hundreds of thousands were guessed to breed at Gough Island (Richardson 1984). However, the most recent estimate for Gough suggests a population of around 5,000 pairs (Cuthbert and Sommer 2004, B.J. Dilley unpublished data). A small number of pairs also breed on Tristan da Cunha itself, with 50-100 pairs estimated in 1972-1974 (Richardson 1984); however there have been no recent breeding records and it may be extinct at Tristan (Peter Ryan pers.comm.). It was probably also breeding on Inaccessible in the 1980s (Fraser *et al.* 1988).

Introduced predators on breeding islands are a serious threat to Grey Petrels - for example, cats and the Black Rat *Rattus rattus* on the Crozet and Kerguelen islands, and, until their eradication, cats on Marion Island. On Gough, a review of the impacts of House Mice concluded that Grey Petrels are probably predated by mice (Angel and Cooper, 2006), and this was confirmed by Dilley *et al.* (2015) who found several chicks in 2014 with wounds inflicted by mice, and of 35 chicks monitored, 60% failed. If predation rates are similar to other winter-breeding albatrosses and petrels on Gough then the population is likely to be declining. Substantial incidental mortality from fisheries has been recorded in other parts of its range, particularly in New Zealand (where it is the most frequently killed species by the long-line fishery for tuna) (Bell 2013), and off Kerguelen (Barbraud *et al.* 2009). Adults, and especially fledglings, are also killed by skuas. As with other petrels, the species historically was killed for food on Tristan, but it is now protected. On the basis of population modelling and data from fisheries, BirdLife International (2016) suggested that a moderate to rapid decline is suspected, but further data are urgently required to more accurately assess its population numbers and trends.

Life history

Adult birds return to their breeding colonies in late February, digging or re-using shallow burrows, often on stream banks or next to rock faces and boulders, and burrow entrances are sometimes flooded (Ryan 2007). They are largely nocturnal at their colonies, which are found at altitudes between 300m and 600m, but, unusually amongst petrels, they can often be seen arriving and departing their burrows in the early morning or afternoon. Their single egg is laid over a dispersed breeding period between April and June, and incubated by both adults for 55–65 days. The chick hatches in June–August. It is brooded for the first 2–3 days and fed by both adults. Its fledging period is very variable, from 87 to 165 days.

Foraging ecology

Grey Petrels occur offshore around the islands throughout the year, but most abundantly in winter. GPS and GLS tracking of incubating birds from Gough shows that they forage SW of the island, most of the way to South Georgia (Peter Ryan pers. comm.). Birds are usually seen singly at sea or in groups of three or four, and are often noted to associate with whales (Ryan 2007). They will sometimes follow ships. They feed mainly on squid and fish, which they catch by surface feeding, by plunge-diving from heights of up to 8m, or by diving, using their wings and feet for propulsion, for periods of several minutes. They also take some crustaceans and offal. This species has a full circumpolar distribution between 25°S and 60°S, but in the South Atlantic is scarce north of the Subtropical Front.

Spectacled Petrel (Ringeye) *Procellaria conspicillata*

- Location: Endemic breeder on Inaccessible Island
- IUCN Red List Status: Vulnerable
- Population Size: c. 14,400 breeding pairs (Inaccessible)
- Population Trend: Increasing
- Diet: Squid, fish, crustaceans, fishery discards and offal
- Foraging range: Confined to South Atlantic Ocean

- Breeding: Adults return September; single egg laid late October; chick hatches late December and fledges March.

Population and trends

Figure 102: Spectacled Petrel on bogfern at Inaccessible [Photo: Paul Tyler]

Both the name Spectacled Petrel and the evocative Tristan name of Ringeye refer to the distinctive white marking which extends from the back of the head under the eye and joins across the forehead. Birds showing this marking are very distinctive, but not all do: in some, the spectacle marking is narrow and broken and others have just a small white forehead marking. Some of these birds with small white markings can be difficult to tell from the White-chinned Petrel *P. aequinoctialis* (although this tends to have a pale, rather than dark, tip to its bill). Spectacled and White-chinned Petrels were formerly regarded as two subspecies of *P. aequinoctialis* (Ryan 1998).

The range of the Spectacled Petrel in the 19th Century is uncertain. It may have occurred throughout the Indian Ocean and may have bred on Amsterdam Island, where bones of *Procellaria* petrels, possibly this species, have been found (Enticott and O'Connell 1985, Ryan 1998). However it is now confined as a breeding species only to the high plateau of Inaccessible Island. This is almost 10° farther north than any breeding site of the White-chinned Petrel, which has a circumpolar distribution through the Southern Ocean.

As Ryan (1998) noted, Inaccessible Island was seldom visited by biologists (or islanders) until recently, and those who were able to land mostly remained at the coast because of the sheer cliffs that encircle the island. Spectacled Petrels nest on the plateau, so burrows are difficult to access and count. Hagan (1952) reported a group of burrows containing two females and five juveniles in 1937/38. In 1949-50, the population was estimated to be at least 100 pairs, probably considerably more (Rowan *et al.* 1951). In 1982-1983, it was estimated that some 1,000 pairs bred on the island (Fraser *et al.* 1988, Ryan 1998). In 1999, 6,000–7,500 burrows were counted (c.60% occupied), but it was difficult to extrapolate from this to an accurate population estimate, because failures prior to this stage and the presence of non-breeders confound an accurate population estimate (Ryan and Moloney 2000). However a repeat survey in 2004, using the same counting methods as in 1999 counted 11,000–12,000 burrows, indicating an increase of approximately 7% per year (Ryan *et al.* 2006). A count in 2009 of 14,400 breeding pairs (Ryan and Ronconi 2011) confirmed that this increase was continuing at a similar rate. Assuming burrow occupancy of 91%, this suggested a breeding population of around 30,000 individuals. An extrapolation from snapshot censuses conducted in waters off Brazil in 1997-1999 suggested a total population of 38,000 ± 7,000 (Birdlife International 2016).

The recovery since the 1930s from probable near-extinction is because of former predation by feral pigs. Introduced in the 19th century, by 1873 pigs were abundant on the island, and ate the petrels' eggs and chicks. As a result, numbers of the Spectacled Petrel were so low that islanders did not realize they bred there until about 1930, and only six nests were counted in 1938 (Ryan, 1998). The species therefore may well have gone extinct had the pigs not died out sometime in the late 19th or early 20th centuries. Substantial numbers of spectacled petrels were also killed by longline fishing gear mainly off the east coast of South America during the 1990s, resulting in the species being listed as Critically Endangered (Ryan 1998, Reid *et al.* 2013). However, as the breeding population has continued to increase, their conservation status has been changed to Vulnerable.

Life history

Breeding is confined to stream banks and boggy areas on the high plateau of Inaccessible, mainly above 400m (Ryan 2007). The species is largely nocturnal at breeding colonies, but some are active throughout the day. Adults return to the colonies in September. They breed in burrows 1–3 m long, dug in the peat, and reused year after year. Burrows usually slope uphill, and have an entrance moat. There may be 10–100 burrows in any one colony, with multiple burrows sharing the same moat pool. The birds lay a single egg in late October, which is incubated by both adults for 56–60 days, hatching in late December. The chick is brooded for the first week or so, and fed by both parents. It fledges, after about 95 days, in March. Adults disperse to moult after breeding, but some return to the colonies in early winter to display and clean out burrows. Like White-chinned Petrels, they are thought to breed annually from 5-8 years old.

Foraging ecology

The Spectacled Petrel forages by day and night, feeding on squid, fish, crustaceans, fishery discards and offal, which it acquires by surface seizing, shallow plunging and diving to depths of at least 12m, propelled by its wings and feet (Ryan 2007). It occurs singly or in small groups at sea, often following ships and sometimes apparently staying with them for several days. Flocks of up to 200 will occasionally gather in the wake of longline fishing vessels (Bugoni *et al.* 2008, Jiminez *et al.* 2011). It is essentially confined to the South Atlantic Ocean north of the South Polar Front, predominantly between 25°S and 41°S, as far north as central Brazil and the Benguela Current off Namibia. Of eight birds tracked for six months in summer from their breeding grounds at Inaccessible, breeding birds mainly foraged in oceanic waters, while failed breeders or non- breeders concentrated foraging activity over the Rio Grande Rise, the Walvis Ridge and along the shelf break of the east coast of South America (Reid *et al.* 2013). Of five birds tracked in winter (caught during fishing operations off Brazil), four remained within the Brazilian EEZ while one moved to Inaccessible then returned almost to Brazil before its transmitter failed (Bugoni *et al.* 2009). It is recorded as a vagrant in the Indian Ocean as far as Australia.

Great Shearwater (Petrel) *Ardenna gravis*

- Location: Near-endemic to Inaccessible, Nightingale and Gough
- IUCN Red List Status: Least Concern
- Population Size: 3 million pairs (Nightingale); >2 million pairs (Inaccessible); 980,000 pairs (Gough); <10 pairs, no evidence of breeding in recent years (Tristan)
- Population Trend: Stable, possibly increasing on Inaccessible
- Diet: Mainly fish, with some squid, crustaceans and fishery discards
- Foraging range: Trans-equatorial migrant found throughout the Atlantic Ocean
- Breeding: Adults return to colony late August; single egg laid early November; chick hatches early January and fledges late-April to May.

Figure 103: Great Shearwater *Ardenna gravis*

Population and trends

Like all species in the genus *Ardenna*, the Great Shearwater was previously included in the genus *Puffinus,* but recent genetic work suggests that these species represent a lineage distinct from both *Puffinus* and *Calonectris* shearwaters, so del Hoyo and Collar (2014) accept the name of *Ardenna gravis* used here.

The Great Shearwater is possibly the most evocative of all Tristanian birds as a 'global ambassador' for the islands. Birds are commonly seen around the coasts of Canada and Greenland in July and August and later down the coasts of western Europe, yet it is virtually certain that these birds bred on the Tristan and Gough islands at the other end of the Atlantic. Less than 20 pairs breed on the Falkland Islands, where breeding was first proven in 1961 (Woods and Woods 2006) in burrows adjacent to Sooty Shearwaters *Ardenna griseus* on Kidney Island. As a result, the bird can be regarded as a virtual breeding endemic on the Tristan and Gough Islands.

Ryan *et al.* (1990) estimated 2–3 million pairs on the Nightingale islands, which they believed are at full capacity for the species, and 2 million pairs on Inaccessible, possibly increasing (Ryan and Moloney 2000). Cuthbert (2004) estimated around 980,000 pairs on Gough. Brooke (2004) gives a total world population estimation of around 15 million individuals. Ryan (2007) suggested the species is virtually extinct as a breeder on Tristan, as a result of historical collection for food, habitat destruction and introduced predators, although a few pairs may still breed. The species is now protected on all the Tristan and Gough islands except for Nightingale, where up to 15,000 eggs, 50,000 chicks and several thousand adults were collected annually in the 1970s. Although numbers collected are now much lower and are no longer an essential part of a subsistence diet for the islanders, their collection is still an important cultural tradition and there is no evidence that it is unsustainable at current levels.

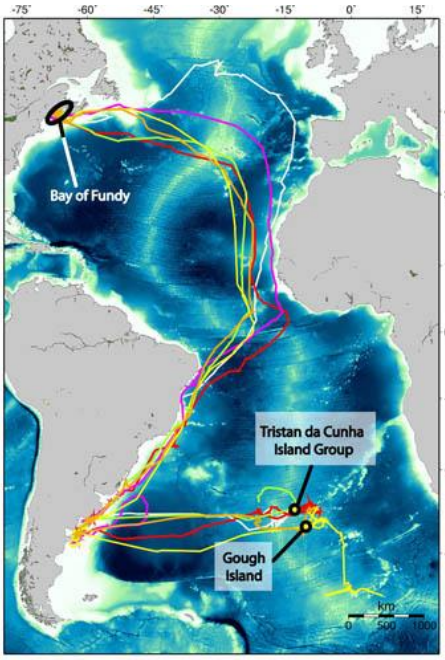
Historically the Great Shearwater was the bird most frequently killed by long-lines in Tristan waters, so it is important to continue monitoring populations. Licenses for pelagic longline vessels targeting either tropical tunas or Southern Bluefin Tuna *Thunnus maccoyi* have been issued sporadically by the Tristan Fisheries Department. Cooper *et al.* (2011) reported that limited research on the species on Gough has confirmed predation by mice, but at levels probably lower than on winter-breeding petrels. Dilley *et al.* (2015) reported one fatal attack by House Mice on a Great Shearwater chick, out of seven burrows covered by video cameras. Adults and chicks are also occasionally killed by skuas. Almost all Great Shearwaters collected have plastic litter, eaten at sea, in their stomachs (Ryan 1987a, 1987b, Moser and Lee 1992), although the potential impact of this is unknown. The amount of plastic ingested has changed little since the 1980s, but the proportion of industrial ('virgin') pellets has decreased from 64% of ingested plastic in 1983-85 to 11% in 2004/5 (Ryan 2008a). Overall, in the absence of any evidence of declines or substantial threats, the species' status is assessed as stable.

Life history

Adults return to their breeding colonies from late August, with most arriving in mid-September (Ryan 2007). They gather in huge rafts off their breeding islands before returning to their colonies at dusk, although the adults can be active throughout the day once they have chicks to feed. There they court and prepare their burrows, which are up to 1.5m long and dug into peat, in virtually any available habitat on Nightingale and Inaccessible, often under the roots of tussock grasses or island trees *Phylica arborea*. On Gough they are largely confined to coastal tussock grassland. Adults briefly leave the colonies in mid-October to find food, some moving as far as the Cape coast of South Africa or the Patagonian Shelf, before returning in early November to lay their single eggs. The egg is incubated by both adults for 55 days, so the chicks hatch in early January. The chicks are brooded for the first week or so, and fed by both parents until about mid-April, when they abandon the well-fed chick. The chick may not fledge until two to three weeks later, after 105–100 days, in late April to May. The species is thought to breed annually.

Foraging ecology

Great Shearwaters occur singly or in small to large groups at sea, and sometimes follow ships. They forage by surface feeding, shallow plunging (occasionally from heights of up to 10m) and diving, to depths of up to 19m (Ronconi *et al.* 2010a), propelled by their wings and feet, mainly in search of fish, although they also take some squid, crustaceans and fishery discards (Ryan 2007). A study of Great Shearwater diets from stable isotope analysis showed that while on migration in the northwest Atlantic outside the breeding season, Great Shearwaters eat herring, squid, euphausiids (krill) and in some years, mackerel (Ronconi *et al.* 2010b). The study, with sampling over five years, also indicated that there was considerable difference in diet from year to year, reflecting the shearwater's generalist foraging behavior.



After they finish breeding, a few remain in the southern hemisphere, but most migrate north-westwards across the Equator to reach the waters off Newfoundland and Greenland from late May to early August, where they rapidly moult. Most then move eastwards, turning south down past Britain and Iberia, then typically crossing the Atlantic and travelling down the Brazilian coast to return to their breeding colonies – a remarkable annual migration, which has been tracked using loggers. Ryan (2007) noted that a few also range into the south-western Indian Ocean, and occasional birds even reach Australia and California.

Figure 104: Tracks of Great Shearwaters on their vast migration from the Bay of Fundy in the North Atlantic to the Tristan islands, recorded in 2008. The eight birds were named after the seven island surnames, plus Lambert, another early American settler. [Image by Rob Ronconi]

<u>Sooty Shearwater *Puffinus griseus*</u>

- Location: Tristan; possibly other islands
- IUCN Red List Status: Near Threatened
- Population Size: <10 pairs at Tristan in 1980s.
- Population Trend: Moderately rapid decline globally
- Diet: Fish, crustaceans, squid and fishery discards
- Foraging range: Throughout the Southern Ocean; outside the breeding season birds migrate to North Atlantic and North Pacific.
- Breeding: Begins October; 1 egg laid November-December; incubation 53-56 days; fledging late April to early June.

Population and trends

The Sooty Shearwater is one of the most widely distributed seabirds in the world, breeding in colonies on islands off New Zealand, Australia, Chile, and the Falkland Islands. Brooke (2004) gives a global estimate of around 20 million individuals (Brooke 2004). Sagar (2013) says there are no accurate estimates for New Zealand, but gave an estimate of around 21 million birds based on detailed work on the Snares and islands off Stewart Island. Despite these large figures, there are persistent signs of decline in the global population, for example in New Zealand the numbers of burrows in the largest colony (in the Snares Islands) declined by 37% between 1969-1971, and 1996-2000, and burrow occupancy may also have declined, indicating that an overall population decline may have occurred (Warham and Wilson 1982; Scofield and Christie 2002).

Most colonies in mainland New Zealand have been extirpated by introduced mammals (feral cats, rats, mustelids, feral pigs and dogs) (Sagar 2013) and some offshore colonies have not responded to predator control (Gaze 2000; Jones 2000). The Sooty Shearwater was one of the seabird species most frequently observed killed in the New Zealand fisheries during 1996-2004, with demersal longliners and trawlers responsible for the majority of mortalities.

The species is legally harvested in New Zealand, with an estimated 400,000 young ('mutton birds') taken yearly from the Stewart Island region by local Maoris (Sagar 2013), although this is considered unlikely to account for the general scale of decline (Birdlife International 2016). Climate change resulting in shifts in foraging distribution during the boreal summer (Jones *et al.* 2008) may be another threat to the species. The population in North America is also in decline; in the California Current numbers fell by 90% in 20 years (Veit *et al.* 1996). However it remains uncertain whether this has resulted from population decline or distributional shifts.

On Tristan, <10 pairs were reported as breeding at Big Green Hill in the 1980s (Ryan *et al.* 1990). It may also breed on Inaccessible (Fraser *et al.* 1998). Given the huge populations elsewhere, this very small number is insignificant in global conservation terms.

Life history

Sooty Shearwaters nest on islands and headlands in large, dense colonies, and tend to return to the same area year after year, but not necessarily to the same burrow (Sagar 2013). They congregate offshore during early evening and come ashore after sunset. Birds dig burrows under tussock, low scrub or trees, and line a chamber at the end with leaf litter; burrows may be complex with several pairs sharing the same entrance. Breeding stars in October, and birds lay one egg from late November to mid-December to which is incubated for 53-56 days; chicks are brooded 2-3 days; fledging 86-106 days, in late April to early June.

Foraging ecology

Sooty Shearwaters feed on fish, crustaceans, cephalopods and offal from fishing vessels, taken on the surface or while diving. They frequently dive for food to depths averaging 16m, and occasionally as deep as >60m. Birds may congregate in large flocks to feed on concentrations of food, and may form extensive rafts on the sea after feeding (Sagar 2013). Short (1-3days) and long (5-15 day) provisioning trips are made by parents; longer trips allow foraging along the Antarctic Polar Front, reducing competition close to breeding grounds (Birdlife International). After breeding most birds migrate to the North Atlantic or North Pacific oceans, with some remaining in the Southern Ocean.

Subantarctic Shearwater (Whistler, Nighthawk) *Puffinus elegans*

- Location: Inaccessible, Gough and Nightingale
- IUCN Red List Status: Least Concern
- Population Size: >5,000 pairs (Gough); 5,000-50,000 pairs (Inaccessible); 100-1000 (Nightingale); possibly breeds on Tristan
- Population Trend: Possibly declining globally
- Diet: Fish, squid and crustaceans
- Foraging range: Wide-ranging in Southern Ocean
- Breeding: Adults return February-July; single egg laid August-September; chick hatches October-November and fledges December-January.

Figure 105: Subantarctic Shearwater *Puffinus elegans* [Photo: Peter Ryan]

Population and trends

This bird belongs to the Little/Audubon's Shearwater complex, which Onley and Scofield (2007) regarded as "one of the great problems in petrel and shearwater taxonomy". They split the Little and Audubon's Shearwater group into 11 species, on the basis of molecular phylogeny, and this forms the basis of the taxonomy used by del Hoyo and Collar (2014). The birds on the Tristan islands were previously regarded as a form of the Little Shearwater *P. assimilis* or possibly a distinct subspecies *P. assimilis elegans*, but *P. assimilis* is now regarded as breeding only around Australia and New Zealand. However, this leads to considerable confusion over the range of the different forms, now regarded as separate species, outside the breeding season.

The Subantarctic Shearwater is regarded as a bird of the subantarctic Southern Ocean (del Hoyo and Collar 2014), breeding on the Tristan and Gough islands in the Atlantic, and Chatham Island and Antipodes Island (tens of thousands of pairs, Southey 2013b) in the Pacific. Birds breeding on St Paul Island in the southern Indian Ocean may also belong to this species. It is unclear whether birds present off Chile represent an unknown breeding population of this species. A review of available data by Brooke (2004) suggested a global population of several hundred thousand pairs. Despite a slow suspected decline, given the very large range and breeding populations, it is regarded by the IUCN as being of Least Concern.

Ryan (2007) noted that the Tristan and Gough populations are poorly known. There are estimates of 5000-50,000 pairs for Inaccessible 1982-87 (Fraser *et al.* 1988) and >5,000 for Gough in 2000-01 (Cuthbert and Sommer 2004), with much smaller numbers of 100-1000 on Nightingale in 1972-74 (Richardson 1984). Cooper *et* al (2011) described the species as completely unstudied on Gough, but noted the suspicion that numbers have declined noticeably since the 1980s, as they are now rarely heard on the island or seen when spotlighting at night from the South African weather station at Transvaal Bay. The birds are probably extinct on Tristan, due to historical collection for food and introduced predators, and it is likely that chicks are killed by House Mice on Gough (Ryan 2007). BirdLife International 2016 states that the global population is suspected to be in decline, owing to predation by invasive species. In New Zealand, on both the Chatham and Antipodes island groups, subantarctic shearwaters breed only on islands that have no exotic predators (mice, cats, rats and weka (a large flightless rail)) (Southey 2013b).

Life history

Subantarctic Shearwaters are present at sea year round around the Tristan islands, with adults returning intermittently to their colonies amongst coastal tussock or adjacent fern bush, anytime from February through to July (Ryan 2007). They then leave the colonies to feed up before returning to lay their single egg in August–September. The egg is laid at the end of a burrow, 0.5-1m long, dug into the peat under dense tussock grasses. The egg is incubated by both adults for 52–58 days, hatching in October–November. It is brooded for the first week or so, and fed by both parents, fledging after 70–76 days in December–January. The species probably breeds annually.

Foraging ecology

Subantarctic Shearwaters are seen near the breeding colonies throughout the year, although immature individuals and post-breeding adults may disperse more widely through subantarctic waters (Southey 2013b). They are seen singly or in small groups at sea and often fly alongside ships (Ryan 2007). They forage for fish, squid and crustaceans by surface-seizing, shallow plunging or diving, using their wings and feet to propel them down, probably to depths of at least 20m. They seldom ingest plastic debris (Ryan 1987).

Common Diving-petrel (Flying Pinnamin) *Pelecanoides urinatrix*

- Location: Inaccessible, Nightingale and Gough; possibly on Tristan
- IUCN Red List Status: Least Concern
- Population Size: >20,000 pairs (Gough), 10,000-100,000 pairs (Nightingale), 5,000-50,000 pairs (Inaccessible), probably extinct on Tristan.
- Population Trend: Possibly declining
- Diet: Mainly small crustaceans.
- Foraging range: Generally remain close to breeding colonies year-round, with local range of up to 1,000km from colonies
- Breeding: Adults return to Tristan colonies mid-July; single egg laid August–September; chick hatches October–November and fledges December–January. Breeding cycle 3–4 weeks later on Gough.

Figure 106: Common Diving-petrel *Pelecanoides urinatrix* [Photo Peter Ryan]

Population and trends

The taxonomy of diving-petrels is a matter of some debate. Some authorities place them within a separate family, the Pelecanoididae, because their tubular nostrils open upwards, as opposed to forwards in other petrels. Del Hoyo and Collar (2014) maintained them within the petrel family Procellariidae in the genus *Pelecanoides*. That basis is followed here.

Only one of the four species in the genus is recorded in Tristan and Gough waters. The Common Diving-petrel is mainly found in discrete ranges around the oceanic islands on which it breeds. As well as the Tristan and Gough islands, in the South Atlantic these sites include South Georgia (c. 3.8 million breeding birds) and the Falkland Islands (perhaps 10,000 pairs). In the southern Pacific Ocean, somewhere between 100,000 and over a million pairs are recorded around the south and east of New Zealand (e.g. Antipodes Islands) and North Island. Millions of pairs are estimated for the Crozet islands, and the species is also abundant on the Kerguelen Islands, with over 1,000 pairs on Heard Island and 500+ pairs around Tasmania. Breeding colonies are also recorded on Prince Edward, Marion, St Paul and Amsterdam Islands (all data from del Hoyo *et al.*, 1992). Brooke (2004) estimated the total world population to exceed 16 million individuals. Del Hoyo & Collar (2014) recorded that birds breeding on the Tristan and Gough islands belong to an endemic subspecies *Pelecanoides urinatrix dacunhae*.

10,000-100,000 pairs were estimated on Nightingale in 1972-74, (Richardson 1984), 5,000-50,000 pairs on Inaccessible in 1999 (Ryan and Moloney 2000) and >20,000 pairs on Gough in the 1980s (Ryan 2007); however there may be many more at Nightingale and Inaccessible (Katrine Herian pers. comm.). Ryan (2007) reported that the species is extinct as a breeding species on Tristan, because of habitat loss and introduced predators. However their burrows are likely to be small and at higher levels, and they are one of the most common birds seen from boats just off Tristan (Trevor Glass and Alex Bond, pers. comm.), and as there has been so systematic search for them, it is possible that they breed there. Cooper *et al.* (2011) noted that night-time spotlighting and casual observations of remains in skua middens around the Gough weather station over the years suggest a decline since the 1980s, and it may be another species whose chicks are killed by mice there. Globally, the species is suspected to be in decline because of the impact of introduced predators at many breeding sites.

Life history

The Common Diving-petrel breeds in shallow burrows, 0.2–1.5m long, often in banks or under rocks amongst fern bush and coastal tussock grass. On the Tristan islands, adults begin returning to their colonies in mid-July (Ryan 2007). They lay a single egg in August–September, which is incubated by both adults for about 55 days. The species is one of the few petrel species that can lay a replacement egg if the first egg fails early in incubation (Miskelly 2013). The chick hatches in October–November and is fed by both parents through to fledging after 49–59 days in December–January. This breeding cycle is about 3–4 weeks later on Gough. Ryan (2007) reported that the species probably breeds annually. It returns to colonies from one year old but generally does not start to breed until it is 2–3 years old; however exceptionally they can breed at one year old (Miskelly and Taylor 2007). Annual survival is estimated at 75%, which is much lower than for other petrels and albatrosses. Del Hoyo *et al.* (1992) quoted success to fledging as 87%, but there are high losses associated with fledging. These authors also stated that the average life expectancy of a breeder is not more than 3.5 years. Miskelly (2013) noted that monogamous pairs can remain together over 'many seasons'. However, the average reproduction rate per bird is probably low and populations may be highly sensitive to small changes in breeding success.

Foraging ecology

Diving-petrels occur singly or in small groups at sea, but do not follow ships. Very little is known about the dispersal of the species. It is presumed to be a relatively sedentary species which remains throughout the year in waters adjacent to its breeding colonies, although Ryan (2007) suggests it can range up to 1,000km from colonies, mainly in winter. Its diet consists mainly of planktonic crustaceans, which are mostly caught underwater by pursuit-diving to depths of 60m (Ryan 2007), using its small wings for propulsion and its legs for maneuvering.

5.2.4 Southern storm-petrels (Family Oceanitidae)

Storm petrels have been split into two families – southern and northern – because they are not sister taxa. All four Tristan breeders are southern storm petrels Oceanitidae. In addition, Wilson's Storm-petrel *Oceanites oceanicus* is a fairly common non-breeding visitor, and Leach's Storm-petrel *Oceanodroma leucorhoa* is a rare non-breeding visitor.

Grey-backed Storm-petrel *Garrodia nereis*

- Location: Gough Island only
- IUCN Red List Status: Least Concern
- Population Size: Estimated 1000-10,000 pairs (Gough)
- Population Trend: Suspected declining

- Diet: Mainly barnacle larvae, other small crustaceans and small squid
- Foraging range: Circumpolar in subantarctic waters
- Breeding: Adults ashore August–April; breeding phenology poorly known.

Figure 107: Left - Grey-backed Storm Petrel *Garrodia nereis* [Photo: Peter Ryan]. Right - Grey-backed Storm Petrel in the hand, showing how small these seabirds are.

Population and trends

The Grey-backed Storm-petrel is a marine species of cool waters in the subantarctic zone. It is generally found over the edge of the continental shelf and is apparently pelagic only during post-breeding dispersal, although its dispersal pattern is poorly known. Ryan (2007) noted two possible reasons for this lack of knowledge: it rarely follows ships, and is easily overlooked at sea because of its small size and its grey color often merges into the grey sea. It breeds in the Falkland Islands (population size unknown), South Georgia and other subantarctic islands, Prince Edward Island, Crozet Islands, Kerguelen Islands (3,000–5,000 pairs) (del Hoyo *et al.*, 1992), Chatham Island (10,000–12,000 birds), Antipodes islands (tens of thousands of pairs) and other islands off New Zealand (New Zealand figures from Southey 2013a). The population on Gough was roughly estimated as 1,000-10,000 pairs in 1972-74 (Richardson 1984), but has greatly reduced in abundance at least around the weather station since the 1980s (Ryan 2010). The world population is believed to be of the order of 10,000–50,000 breeding pairs; Brooke (2004) estimated the global population as potentially >200,000 individuals.

Figure 108: Away from their nesting sites, Grey-backed Storm Petrels forage in cool, deep waters [Photo: Peter Ryan]

Del Hoyo *et al* (1992) stated that the species may be declining, as it suffers predation, mainly by cats and rats, exacerbated by its tendency to breed in fairly accessible sites, but noted that monitoring and more ecological study were required. Southey (2013a) noted that the birds are small and vulnerable on land, are killed by skuas, and nests, eggs and chicks may be inadvertently damaged by larger petrels and penguins, especially when seeking nest sites.

Numbers around the base on Gough have declined since at least the 1980s, probably due to House Mice attacking chicks (Ryan 2010), although no quantitative surveys have been done on Gough. At New Zealand breeding sites, they have been extirpated from islands with rats and cats, but survive on the Antipodes Islands in the presence of mice (Southey 2013a).

Life history

The species is recorded around Gough throughout the year, but is scarce at sea around the Tristan top islands (Ryan 2007). Adults begin coming ashore after dark from August, laying a single egg in a shallow burrow, up to 0.5m long, in dense coastal tussock, fern bush and wet heath vegetation (Ryan 2007).

Breeding phenology is poorly known, especially at Gough, where very few nests have been found. Elsewhere the egg is incubated by both adults for around 45 days, in stints of 1–3 days, with the egg sometimes abandoned for up to five days at a time. The chicks are fed by both adults, but their fledging period is unknown (although del Hoyo *et al* 1992 stated that chicks fledge mainly in March–April). The breeding sites are generally abandoned by April.

Foraging ecology

At sea, Grey-backed Storm-petrels are usually seen singly or in loose groups of up to five birds. They feed by pattering over the surface while in flight, often in association with drifting kelp and other debris, but sometimes make shallow plunges, and are seen hovering in search of food. Del Hoyo et al (1992) quoted their food as mainly immature stalked barnacles (*Lepas australis*) in the size range 1.7–5.4mm. However, Ryan (2007) and Southey (2013a) stated their diet is mostly barnacle larvae. The birds also snatch other small crustaceans, small squid and occasionally small fish. They attend trawlers and occasionally follow ships (del Hoyo *et al.* 1992). After breeding, most birds probably remain in waters near their colonies, but some also disperse to spend the winter close to continents (del Hoyo *et al.* 1992). At sea, they forage over deep water near the shelf edge and beyond in subantarctic waters as far north as the subtropical convergence (Southey 2013a). This is a pelagic, West Wind Drift species, which, off the Chilean coast at least, appears to be restricted to waters with surface temperature <18°C (Hinojosa *et al.* 2006).

<u>White-faced Storm-petrel (Skipjack) *Pelagodroma marina*</u>

- Location: Inaccessible, Nightingale Group and Gough
- IUCN Red List Status: Least Concern
- Population Size: Estimated >10,000 pairs (Gough), 5,000-50,000 pairs (Inaccessible), and 10,000 pairs (Nightingale)
- Population Trend: Probably declining
- Diet: Small crustaceans, fish and squid
- Foraging range: Pelagic waters across the southern oceans
- Breeding: Adults return to colonies July–August; single egg laid August–September; chick hatches mid-October to November and fledges late December to January

Figure 109: White-faced Storm Petrel *Pelagodroma marina* [Photo: Peter Ryan]

Population and trends

The global population is large, with Brooke (2004) estimating at least four million birds. Well over a million breeding pairs are recorded around New Zealand. They are numerous along the south coast of Australia and are also recorded in the north Atlantic, with an estimated half-million breeding birds on the Selvagem islands (between Madeira and the Canary Islands) and several breeding sites also on the Cape Verde islands off west Africa (del Hoyo *et al.*, 1992).

The birds in the South Atlantic are recognized as the type subspecies *Pelagodroma marina marina*, breeding on the Tristan islands and Gough and also recorded as breeding on St Helena (del Hoyo and Collar, 2014). A recent genetic study on White-faced Storm Petrels across their range (Silva *et al.* 2015) indicated that, despite the potential for long-distance dispersal, anti-tropical (i.e. North and South Atlantic) groups have been evolving as separate lineages, probably maintained by philopatry coupled with asynchronous reproductive phenology and local adaptation. However a fledgling sampled in St Helena indicated recent colonization from the northern hemisphere, rather than being affiliated to the southern hemisphere (Tristan and Gough) group. Sampling of subspecies across its range also showed groups to be all highly differentiated.

More than 10,000 pairs were estimated on Gough in the 1980s (Ryan 2007), 5,000-50,000 on Inaccessible in the 1980s (Fraser *et al.* 1988) and 1,000-10,000 on Nightingale 1972-74 (Richardson 1984). It is extinct as a breeding species on Tristan, and the Gough population is now thought to have declined because of mouse predation (Cooper *et al.* 2011), but it is still the commonest storm petrel around the weather station.

White-faced Storm Petrels are highly susceptible to human disturbance (del Hoyo *et al.* 1992) and predation by introduced species. As with other burrow-nesting birds, chicks are probably taken by mice on Gough; no nests have been found to confirm this impact. Many birds contain ingested plastic, with 2.5-4 items per bird on average among birds on Inaccessible Island (Ryan 2008). In 1970, on the South-east Island of the Chatham group, around 200,000 birds were found dead entangled in vegetation because their legs were shackled and impeded by filaments of the larval trematode worm, *Distomum filiferum*, picked up during foraging (del Hoyo *et al.* 1992). The same trematode has been noted on birds on Gough, but it seldom links both legs, so the risk of entanglement is greatly reduced (Ryan 1986). Adults are regularly killed by skuas, especially at Inaccessible where they form a large proportion of the diet of especially non-breeding 'club' birds (Ryan and Moloney 1991a). They are also killed by Tristan Thrushes at Inaccessible (Ryan and Moloney 1991b).

Life history

Adult White-faced Storm-petrels return to their breeding colonies in July–August. They come ashore under cover of darkness, and breed in coastal tussock and fern bush in shallow burrows 30–80cm long that are sometimes little more than runways through dense vegetation (Ryan 2007). They lay a single egg in August–September, which is incubated by both adults for about 50 days but frequently abandoned for 1-3 days at a time while they feed offshore. The chicks hatch from mid-October to November and are fed by both adults, which then mainly gather food in kelp beds close inshore around the islands. The chick fledges after 55–65 days in late December or January. It takes at least three years for the birds to reach sexual maturity, but they can live for >10 years (del Hoyo *et al.* 1992).

Foraging ecology

At sea, the White-faced Storm-petrel is generally solitary, but may form larger flocks (with numbers occasionally in hundreds) near breeding islands. It rarely follows ships, but is known to follow cetaceans (del Hoyo *et al.* 1992). Adults are seldom observed at sea around the Tristan and Gough islands until the chicks hatch in November and they begin inshore feeding (Cooper *et al.* 2011). Ryan (2007) described its flight behaviour as dancing and jumping low over the water, with legs trailing. It feeds by surface pattering, and feeds on planktonic crustaceans, small fish and squid. Outside the breeding season, birds from the South Atlantic range westwards to South America and eastwards to Africa.

White-bellied Storm-petrel (Storm Pigeon) *Fregetta grallaria*

- Location: Inaccessible and Nightingale; probably formerly on Tristan
- IUCN Red List Status: Least Concern
- Population Size: 10,000-100,000 pairs on (Inaccessible), 100-1,000 pairs on (Nightingale); not known to breed on Gough
- Population Trend: Probably stable
- Diet: Small crustaceans, fish and squid
- Foraging range: Wide-ranging over most oceans in S. hemisphere

- Breeding: Adults return to colonies late September. Single egg laid January; chick hatches mid-February and fledges April–May.

Figure 110: White-bellied Storm Petrel *Fregetta grallaria* at Nightingale

Population and trends

Recent genetic work has shed light on the identity of the *Fregetta* storm petrels at the Tristan islands. This indicated that White-bellied Storm-petrels *Fregetta grallaria,* together with another form of this species *F.g.leucogaster,* and a white-bellied form of the Black-bellied Storm-petrel *F. tropica, F. tropica melanoleuca*, were all present at the islands (Robertson *et al.* 2016).

Gene sequences indicated that *F. t. melanoleuca* was present during the breeding season at Gough and at the Tristan top islands (and showed limited divergence from *F. t. tropica,* the nominate form of *F. tropica,* which occurs at islands other than the Tristan top islands and Gough). There was greater diversity amongst global *F.grallaria* populations, with those at the Tristan archipelago being closely allied to the nominate form, as well as a distinct form identified as *F.g.leucogaster*. The authors commented that further research is needed to assess how White-bellied and Black-bellied Storm-petrels segregate in sympatry at Tristan and Gough, and why this is the only location where both species have white bellies. According to del Hoyo *et al.* (1992), *F. g. leucogaster* also occurs at St Paul Island. Samples of carcasses from skua middens on Gough have been all *F. tropica*, and both species have been caught at Nightingale (P.G. Ryan, pers. comm.).

White-bellied Storm-petrels range widely over most oceans in the southern hemisphere, including tropical waters with high salinity, north almost to the Equator (del Hoyo *et al.* 1992). They breed on Lord Howe Island, the Kermadec Islands, the Austral Islands in French Polynesia, and the Juan Fernández Islands in the Pacific Ocean, St Paul Island in the Indian Ocean, and the Tristan and Gough islands in the south Atlantic. Brooke (2004) estimated the global population at around 300,000 individuals.

Figures for the Tristan islands require revision following recent genetic work (noted above), but the estimate of 10,000-100,000 on Inaccessible (Ryan and Moloney 2000) ('at least 50,000 pairs', Ryan 2007) indicates that the island is very important for the species. Another 100-1,000 birds were estimated for the Nightingale islands in 1972-74 (Richardson 1984) and an estimated <5,000 pairs at Gough in the 1980s (Ryan 2007).

The species probably also bred on Tristan, but is now extinct, likely because of introduced predators. Colonies elsewhere are also declining because of introduced cats, rats and mice, and some have shifted breeding to offshore islands and stacks to avoid predators (del Hoyo *et al.* 1992). Adults are also taken by skuas (they are the main prey of non-breeding skuas on Inaccessible - Ryan and Moloney 1991a) and even by Tristan Thrushes (Ryan and Moloney 1991b). Overall, the species is suspected to be in decline because of the impact of invasive predators.

Life history

Adults begin coming ashore, at night, from late September but the timing of breeding is not known. They nest in shallow burrows, up to 1m long, amongst dense vegetation in coastal tussock or fern bush, or in rock crevices. Both adults incubate the egg for 35–40 days, so the chick typically hatches in mid-February. The chick is fed by both adults and fledges after about 70 days.

Foraging ecology

The White-bellied Storm-petrel is marine and highly pelagic, rarely approaching land except near breeding colonies. However, its movements are rather poorly known, partly due to confusion with the Black-belled Storm-petrel *F. tropica,* as differentiation between these two species is very difficult at sea, especially between *F. grallaria* and *F. t. melanoleuca* which both have white bellies. Ryan (2007) describes it as characteristically flying low over the water, rocking from side to side and often dragging its feet or belly. It feeds mostly on squid, with some crustaceans and fish, which it catches by surface seizing. It has been recorded feeding in the company of other seabirds and following ships.

Black-bellied Storm-petrel (Storm Pigeon) *Fregetta tropica*

- Location: Inaccessible, Nightingale Group and Gough
- IUCN Red List Status: Least Concern
- Population Size: 20,000-100,000 pairs on Inaccessible, 100-1,000 birds on Nightingale and <5,000 pairs Gough.
- Population Trend: Suspected decline.
- Diet: Probably squid and small fish.
- Foraging range: Wide-ranging over most oceans in S. hemisphere.
- Breeding: Adults return to colonies late September. Single egg laid January; chick hatches mid-February and fledges April–May.

Figure 111: Black-bellied Storm Petrel *Fregetta tropica* (nominate form). A white-bellied form *F. t. melanoleuca* occurs at the Tristan top islands. [Photo: Peter Ryan]

Ryan (2007) notes that the nominate form of Black-bellied Storm-petrel *F. t. tropica* is a rare vagrant to the Tristan islands. As noted above, recent genetic work (Robertson *et al.* 2016) has indicated that a white-bellied form of the Black-bellied Storm-petrel, *F. tropica melanoleuca*, is present during the breeding season at the Tristan top islands. In the past this has led to confusion as this white-bellied form is very similar to the White-bellied Storm-petrel *F. grallaria* (see above).

Robertson *et al.* (2016) commented that further research is needed to assess how White-bellied and Black-bellied Storm-petrels segregate in sympatry at Tristan, and why this is the only location where both species have white bellies. The white-bellied form of the Black-bellied Storm-petrel is endemic to Tristan and Gough but it shows limited genetic divergence from the nominate form *F. t. tropica,* which has a circumpolar distribution, breeding at subantarctic and periantarctic islands.

Population and trends

Brooke (2004) estimated the global population of Black-bellied Storm-petrels at around 500,000 individuals. The figures for the Tristan islands of 20,000-100,000 pairs on Inaccessible (Ryan and Moloney 2000), 100-1,000 birds on Nightingale (Richardson 1984) and <5,000 pairs on Gough (Ryan 2007) are very tentative due to past confusion with White-bellied Storm-petrels *F. grallaria.* It appears to be more common than *F. grallaria* at Inaccessible, and is the only species definitely known to occur at Gough Island. However, numbers at Gough have decreased greatly in recent years, presumably due to mouse predation of their chicks (P.G. Ryan pers.comm.). Globally the population is suspected to be in decline because of predation by invasive species (Birdlife International). Del Hoyo et al (1992) noted that globally, many colonies have moved to inaccessible offshore stacks to avoid predation.

Life history

Generally, Black-bellied Storm-petrels breed in loose colonies on rocky slopes, in rock crevices, or in thick vegetation or peat (del Hoyo *et al.* 1992). Breeding starts in November, and birds lay one egg that is incubated for 38-44 days. Chicks are not brooded and fledge in 65-71 days. Detailed information on breeding is not yet available from the Tristan islands.

Foraging ecology

This species is highly pelagic, ranging into subtropical and tropical zones as far north as the equator, although there is some confusion due to difficulty of separation from the White-bellied Storm-petrel at sea. Little is known of its diet, although fish and squid have been recorded (del Hoyo *et al.* 1992). It feeds mainly on the wing, by pattering; also dips and makes plunges from the air.

5.2.5. Skuas (family Stercorariidae)

The taxonomy of skuas has undergone some flux in recent years. In the past, all four large skuas were sometimes lumped as races or subspecies of the Great Skua, but del Hoyo *et al.* (1996) cited molecular data that showed that the Great Skua of the northern hemisphere (*Catharacta skua*) diverged from the southern hemisphere *Catharacta* spp. skuas before the latter diverged into three separate species. They noted that these southern forms – the Chilean (*C. chilensis*), South Polar (*C. maccormacki*) and Brown (*C. antarctica*) Skuas – differed only by a few base pairs per thousand in mitochondrial sequences, which might suggest that they could be viewed as subspecies rather than full species. However, they pointed out that the separation into three full species has been based on a careful and thorough analysis, particularly of their tendency not to hybridize extensively in areas where their breeding range overlaps, suggesting both behavioral avoidance of hybridization and reduced hybrid viability and fertility. The three species also differ in behavior, plumage and size measurements. The treatment in del Hoyo *et al.* (1996) and del Hoya and Collar (2014) of recognizing *C. antarctica* as a valid species is therefore followed here; however this is not recognized by Plantlife International (2016).

Only the Tristan Skua *Catharacta antarctica hamiltoni* (a sub-species of the Brown Skua, also called the Subantarctic Skua (Hemmings 2013, Del Hoyo and Collar 2014)) breeds on the Tristan and Gough Islands. However studies by Ritz et al (2008) concluded that there was little evidence for subspecific variation amongst Subantarctic (Brown) Skuas. The Long-tailed Jaeger (Skua) *Stercorarius longicaudus* is an uncommon non-breeding visitor, mainly to offshore waters, and two other arctic-breeding species are recorded as rare vagrants: the Arctic Jaeger (Skua) *S. parasiticus* and the Pomarine Jaeger (Skua) *S. pomarinus*. The South Polar Skua is also recorded as a rare vagrant.

Tristan Skua (Seahen) *Catharacta antarctica hamiltoni*

- Location: Tristan, Inaccessible, Nightingale Group and Gough
- IUCN Red List Status: Least Concern (Brown Skua)
- Population Size: 120 pairs at Inaccessible, 100-510 (nearer 100, Peter Ryan pers.comm.) pairs at Nightingale; 500 pairs at Gough
- Population Trend: Stable, although numbers on Tristan greatly reduced by humans.
- Diet: Mainly other seabirds, their eggs and chicks; also carrion, fish, offal etc.
- Foraging range: The species *C. antarctica* disperses in winter across southern oceans between the southern tip of South America and the south of New Zealand. There is unpublished GLS data on the range of the Tristan subspecies.
- Breeding: Protracted breeding, with eggs laid from September to early January, and chicks fledging in December–March.

Figure 112: Tristan Skua *Catharacta antarctica hamiltoni* on bogfern at Nightingale

Population and trends

The skuas that breed on Tristan (called Tristan Skuas here) are regarded as subspecies *hamiltoni* of the Brown Skua *Catharacta antarctica*. The nominate *antarctica* subspecies breeds on the Falkland Islands and south-east Argentina, and subspecies *lonnbergi* on other subantarctic islands and the Antarctic Peninsula.

Del Hoyo *et al* (1996) quotes 3,000–5,000 breeding pairs of the nominate subspecies *C. a. antarctica* on the Falkland Islands and Argentina, and 7,000 pairs of subspecies *C. a. lonnbergi*, with the largest population (1,000–2,000 pairs) on the Kerguelen Islands, 1,000 pairs on South Georgia, and smaller numbers on Macquarie Island, Marion and Prince Edward Islands, the Crozet Islands, South Shetlands, South Orkneys, Elephant Island, South Sandwich Islands, Heard Island, Antarctic Peninsula, Chatham Island, Auckland Island, and small populations on a few other islands. It hybridises locally with South Polar Skuas where the two species' ranges overlap. The total global population of the species is assessed at 13,000–14,000 pairs and BirdLife International regards the global population as probably stable, in the absence of any evidence of declines or substantial threats.

For the Tristan *C. a. hamiltonii*, some 1,000 pairs were estimated on Gough in 2000-1 (Cuthbert and Sommer 2004), 100 pairs at Inaccessible in 1999 (Ryan and Moloney 2000), and 100-500 pairs on the Nightingale islands and <10 pairs on Tristan in 1972-74 (Richardson 1984). There are also large numbers of non-breeding birds in addition to breeding pairs: at least 200 individuals on Inaccessible, 500 at Gough and 100 at Nightingale. Therefore, in addition to being the only breeding site for subspecies *hamiltoni*, the Tristan and Gough islands host >9% of the global breeding population of the species. Numbers were greatly reduced on Tristan by human persecution in the past, and killing skuas is still permitted under section 4(2)(e) of the Conservation of Native Organisms and Natural Habitats (Tristan da Cunha) Ordinance 2006, if they are "known to be, or are reasonably believed to be, killing or attacking domestic animals, including sheep and poultry".

Life history

Ryan (2007) provided a detailed biology of the Tristan Skua. The birds are present year-round on the islands because of the availability of food, but are scarcer in winter. Pairs breed singly or in loose groups in open grassy areas on the islands, at altitudes to 1,200m. The nest is no more than a shallow scrape. They are strongly territorial, chasing off other skuas that invade their breeding area. They have a very protracted breeding season, with the birds laying 1–2 eggs anytime from September to early January (occasional 3-egg broods were probably laid by two females). Both adults share incubating duties, resting the eggs on their feet as they incubate. The chicks hatch after 28–32 days, between October and February. Both adults feed the chicks, and brood them for the first week or so. They guard the chicks throughout their time around the nest, diving at any intruders; small chicks initially crouch to avoid attack, but larger ones run off to hide. The chicks fledge after 55–60 days, from December to March. They then remain around the nesting territory for 3–4 more weeks, before gathering in 'clubs' of juveniles.

They probably do not start breeding until they are 5–6 years old, although this may be delayed if breeding territories are in short supply. Non-breeders gather in large 'clubs', often along the coast or near bathing pools, waiting for breeding opportunities to open up. Pairs generally remain together from year to year and breed annually.

Foraging ecology

Brown Skuas are amongst the most predatory of all skua species, at least while breeding. Tristan Skuas feed mainly on seabirds, although they also take land birds, carrion, fish, offal, rats and goose barnacles off the shore. They also seek the afterbirth and carcasses of seals, and scavenge bait from the lobster fishing ship. Their seabird prey varies between localities; Ryan (2007) stated that the main prey species for most breeding birds are Broad-billed Prions, Soft-plumaged Petrels and Great Shearwaters, with Atlantic Petrels also important on Gough Island. On some of the islands, including Nightingale, they take penguin eggs and chicks, while non-breeders on Inaccessible mostly eat storm-petrels (Ryan and Moloney 1991a). They mainly kill seabirds on the ground at night, walking around their breeding colonies listening for movement and attacking only with their bill. During the day, they also catch birds in flight, and dig up burrows to reach adults and chicks. Breeding pairs store carcasses in larders. Non-breeders move between the islands to feed; the remains of rats caught on Tristan have been found in skua pellets on Inaccessible (Ryan 2007). After breeding, the birds disperse to sea, although most remain close to the Tristan and Gough islands. They are usually seen singly at sea, although groups of up to 50 will sometimes gather at fishing boats, attracted by discards and offal.

Figure 113: Tristan Skuas jostling for position on the crayfish fishing ship MV Edinburgh at Gough. The birds scavenge bait and other offal on the ship.

5.2.6. Gulls, Terns and Noddies (family Laridae)

Terns and Noddies are sometimes referred to a separate family, Sternidae, but del Hoyo and Collar (2014) regarded them as belonging to the subfamily Sterninae, within the larger family Laridae encompassing gulls, terns and noddies. Two species breed on the islands: the Antarctic Tern and Brown Noddy. Del Hoyo *et al.* (1996) noted the Black Noddy *Anous minutus* as a former breeder on Inaccessible, apparently based on a single record from the Challenger expedition (Moseley 1897, Elliott 1957), but this was in error for Brown Noddies breeding in trees. The Arctic Tern *Sterna paradisea* is an uncommon, non-breeding visitor. No gulls breed on the islands and only the Kelp Gull *Larus dominicanus* occurs as a scarce vagrant from South America.

<u>Antarctic Tern (Kingbird) *Sterna vittata tristanensis*</u>

- Location: Tristan, Inaccessible, Nightingale Group and Gough
- IUCN Red List Status: Least Concern
- Population Size: Up to 1000 pairs on the islands; 50-70 (Tristan); 100 (Inaccessible); 100-300 (Nightingale); 500 (Gough)
- Population Trend: Probably stable, although historic decline on Tristan
- Diet: Small fish and crustaceans
- Foraging range: Birds of the Tristan race probably winter mainly around the south coast of South Africa

- Breeding: Adults at breeding colonies September–May. 1–2 eggs laid November–February; chicks fledge mid-January to April.

Figure 114: Antarctic Terns *Sterna vittata tristanensis* at the harbour, Tristan.

Left: adult; below: juvenile.

Population and trends

The Antarctic Tern is divided into 6 subspecies on the basis of size and plumage, as listed in del Hoyo *et al* (1996). *S. v. tristanensis* is endemic as a breeding subspecies to Tristan, Inaccessible, Nightingale and Gough, and some authorities consider it a separate species. The global population of the species is unknown, but estimated to be at least 50,000 pairs (Ryan 2007).

The endemic subspecies on the Tristan and Gough islands is not numerous. Cuthbert and Sommer (2003) estimated 500 pairs on Goughin 2000-1, and Ryan and Moloney (2000) around 100 pairs on Inaccessible in 1999. Richardson (1984) estimated 30-50 pairs on Tristan (mostly on the Hardies and other offshore stacks), and 200-500 pairs on Nightingale in 1972-74. BirdLife (2016) suggested that the overall species population trend is downwards, as a result of human disturbance and feral cats and rats on some islands. The Macquarie subspecies, with just 40 pairs, is regarded as endangered as a result of these pressures; only a year following an eradication programme to rid the island of rats, rabbits and mice, Antarctic Terns in were breeding in greatly increased numbers on the island's cobblestone beaches (www.antarctica.gov.au). Ryan (2007) reported that the species was formerly more common on Tristan but was probably displaced from its breeding beaches by rats and cats.

The BirdLife factsheet on the species notes that phylogenetic analyses have been published which suggest rearrangements may be required of tern genera which may affect this species, but the organization's Taxonomic Working Group is waiting until work by other taxonomists reveals how these changes affect the entire groups involved. This may have some impact on the global significance of the *S. v. tristanensis* birds.

Life history

The Antarctic Tern breeds singly or in loose colonies on the ledges of coastal cliffs and stacks, and, more rarely, at the landward side of boulder beaches (Ryan 2007). The nest is a depression or scrape in rock, cliff ledge, soil, sand or vegetation. Although a few terns remain around the islands throughout the year, most return from September onwards to breed. Their breeding is protracted, and eggs are laid in the period November–February, with 1–2 eggs incubated by both adults for 23–25 days. Both adults feed the chicks, which fledge after 28–32 days in mid-January to April, but adults continue to feed the chicks for several weeks after fledging. By May, the breeding colonies are empty. There is no information on their longevity or typical productivity. Adults occasionally fall prey to skuas, despite their aggressive defense.

Feeding ecology

Outside of the breeding season the species moves to the nearest area of open water or to pelagic zones far from land, and communal roosts are sometimes recorded on ice-floes and icebergs (Higgins and Davies 1996). Around the Tristan and Gough islands, they roost communally on land when not breeding, and it is known that some birds from the *tristanensis* subspecies migrate to spend the winter off the coast of South Africa, frequenting rocky headlands and beaches with cold water currents offshore (del Hoyo *et al.* 1996). At sea they are seen singly or in pairs or small groups, usually within sight of the islands. They feed on small fish and crustaceans, such as amphipods or isopods, which they pick off the surface or plunge-dive to catch (Ryan 2007). A few birds also gather around Calshott Harbour on Tristan when islanders are sorting and gutting fish, and will feed on the discarded offal.

Brown Noddy (Woodpigeon) *Anous stolidus*

- Location: Tristan, Inaccessible, Nightingale Group and Gough
- IUCN Red List Status: Least Concern
- Population Size: c. 800 pairs across the islands. 200-500 (Nightingale); 50-100 (Inaccessible); 30-50 (Tristan); 200 (Gough)
- Population Trend: Probably stable
- Diet: Mainly fish from the upper layer of the open ocean
- Foraging range: Usually close inshore during breeding season; winter range unknown
- Breeding: Adults ashore September–March; single eggs laid mid-October to early January; chicks fledge January–March.

Figure 115: Brown Noddy *Anous stolidus* at Gough

Population and trends

The Brown Noddy is generally regarded as a tropical seabird with a worldwide distribution. Some colonies are also present in the sub-tropics with individuals from these colonies wintering in the tropics (del Hoyo *et al.* 1996). The global population is estimated to number anywhere between 180,000 and 1.1 million individuals (Delany and Scott 2006).

The Tristan and Gough colonies are therefore unusual in that the prevailing climate is cool temperate, and the islands are the southernmost breeding sites for the species. Five races or subspecies are recorded. The Tristan and Gough birds belong to the nominate race *A. s. stolidus* which is also found in the Caribbean, on the African coast from the Gulf of Guinea to Cameroon, and on Trinidade Island, Ascension and St Helena. The Ascension colony, with just 500 pairs, has been decimated by introduced rats and cats (feral cats have now been removed from the island).

Richardson (1984) estimated 30-50 pairs on Tristan and 200-500 pairs at Nightingale in 1972-74. 50-100 pairs were estimated on Inaccessible in 1999 (Ryan and Moloney 2000) and 200 pairs on Gough in 2000-01 (Cuthbert and Sommer 2004). These numbers are not significant on a global scale, but, as southern outliers of the species' range, the colonies could be sensitive indicators of population trends.

Life history

Adults are present around the islands from September to March, rarely to May (Ryan 2007). They breed singly or in loose colonies on ledges on coastal cliffs, where they build a flimsy nest of tussock grass or other vegetation; they also build substantial twig nests in the branches of Island Trees *Phylica arborea* and other trees, which are reused from year to year. On the plateau of Inaccessible, these tree nests can be up to 1km inland. A single egg is laid in the nest anytime from mid-October to early January and incubated by both adults for 32–36 days. The chick is fed by both adults, and fledges after 55–60 days in January–March, although the parents continue to feed it for several weeks thereafter. Some adults and chicks will have left the Tristan islands by mid-February; others occasionally remain as late as May. Birds can live to 25 years.

Feeding ecology

Birds are usually seen singly or in small groups, usually close inshore, although the species has been recorded feeding up to 50km from breeding colonies. Where birds from the Tristan and Gough islands go after breeding is unknown (Ryan 2007), and generally the migratory movements of the species are poorly known. At tropical colonies birds tend to remain all year round, but they leave subtropical colonies after breeding (as on the Tristan and Gough islands), and are known to disperse to the open ocean (del Hoyo *et al.* 1996).

Around the Tristan and Gough Islands, Ryan (2007) reported their main food as epipelagic fish (species that live in the upper zone of deep, open ocean waters), such as the Saury *Scomberesox saurus*. These are caught by surface picking or shallow surface dives. Elsewhere, squid are included in their diet, as well as pelagic molluscs, medusae and insects (Higgins and Davies 1996, BirdLife International 2016). They have been observed catching flying-fish (which occur around the Tristan top islands in summer) in mid-air (del Hoyo *et al.* 1996). They are also recorded foraging on moonlit nights.

5.2.7. Terrestrial birds

While the focus of this report is the marine environment, the conservation significance of the Tristan and Gough islands is considerably enhanced by its endemic land bird species. Several of these birds have links to the marine environment in their feeding habits, and, given the exposed, maritime environment of the islands, any marine pollution incident could conceivably have a very significant impact on terrestrial species over large areas of the islands. The information on these is largely drawn from Ryan (2007).

Of the seven endemic terrestrial birds, the one which is most significantly dependent on the marine environment for food is the **Tristan Thrush *Nesocichla eremita***, locally known as the Starchy, which has a widely varied diet, including invertebrates, seeds, berries and carrion from kills of the Tristan Skua. It can also break open eggs of penguins and other species with its bill, and even catches and kills adult White-bellied Storm Petrels on Inaccessible Island (Ryan and Moloney 1991, Ryan and Ronconi 2010). In a study at one of the small Northern Rockhopper Penguin colonies on Nightingale Island, the thrushes were responsible for 19 out of 26 known predation incidents on penguin chicks (Steinfurth and Johaadien 2014).

Figure 116: Tristan Thrush *Nesocichla eremita*.

The Tristan Thrush is listed as Near Threatened, with 50-80 pairs on Tristan (A. Rothwell unpublished data), around 300-500 pairs on Nightingale (Richardson 1984) and 850 pairs on Inaccessible (Fraser *et al.* 1994), and should therefore be considered as another species at least partially dependent on the management of the marine environment.

The **Tristan Moorhen *Gallinula nesiotis*** is extinct. It was believed still to be extant at the time of the *Challenger* Expedition in 1873, but islanders contacted by the *Valhalla* expedition in 1906 stated that it was no longer present (del Hoyo and Collar, 2014). Around 3,500-4250 pairs of the **Gough Moorhen *G. comeri*** ('Island Cock') breed on Gough (Cuthbert and Sommer 2004), and are listed as Vulnerable. In 1956, eight were released at Sandy Point on Tristan, and around 2,000 are now estimated to be present on Tristan. These birds also have links to the marine environment, in that they sometimes scavenge skua kills and feed on seabird eggs. The flightless **Inaccessible Rail *Atlantisia rogersi*** ('Little Island Cock'), which is endemic to Inaccessible with around 8,000 pairs and listed as Vulnerable, has minimal connection to the marine environment, although it is occasionally eaten by skuas.

Figure 117: Right: Inaccessible Rail *Atlantisia rogersi* [Photo: Peter Ryan]. Left: Gough Moorhen *Gallinula comeri*

One other group of endemic terrestrial birds is particularly intriguing from an evolutionary perspective. They are traditionally called 'buntings', given their similarity to the buntings familiar to the first European settlers of Tristan (Ryan 2014b).

However, they are now known to be related to the finch-tanagers (Thraupidae) of South America, with genetic sequencing indicating the Patagonian bridled finches of the Genus *Melanodera* as their closest relatives (Ryan *et al.* 2013). There was no evidence that the Gough finches are closely related to those of the top islands, which suggests they arose from separate colonisation events. They were presumably carried to the islands by the prevailing westerly winds. Their names have therefore been revised to **Tristan da Cunha Island Finches** (Ryan 2014b).

The finch found on Gough Island is more closely related to the two species of *Melanodera* finches from Patagonia and the Falkland Islands than it is to the finches at the Tristan top islands (Ryan *et al.* 2013), and is therefore retained within an endemic and monotypic genus as the **Gough Finch *Rowettia goughensis.*** It has evolved a larger body and long, slender bill which has allowed it to exploit a wide range of ecological roles (Ryan 2014b). It mainly feeds on fruits and seeds, but also scavenges from skua kills, so has some association with the marine environment. Its population was estimated at only 400-500 pairs in 2007, with a total population of 1,050-1,350 individuals (Ryan and Cuthbert 2008). Numbers have declined greatly since at least the mid-20th Century. The density of territorial pairs roughly halved between 1990-2007 and the proportion of juveniles in the population decreased from 50% to 20% over 15 years, suggesting that recruitment is too low to sustain the population (Ryan and Cuthbert 2008). The greatest threat is from predation at nests by House Mice, which has driven this species away from coastal areas, where mice are abundant, into suboptimal upland habitat and sheer coastal cliffs. The species' status is therefore assessed as Critically Endangered.

Tristan finches at the top islands are placed in the genus *Nesospiza*, which is confined to the Tristan group (Ryan 2008). On Nightingale Island, two species have evolved, presumably from a common ancestor. The medium-sized, smaller-billed species is known as the **Nightingale Finch *Neospiza questi*** ('Nightingale Canary') with around 4,000 pairs on Nightingale, Middle and Stoltenhoff Islands (Ryan 2007). It typically weighs 24-29g, and feeds mainly on seeds and berries, although it feeds its chicks on invertebrates. On

Nightingale Island only, a much larger, heavier-billed species, weighing 41-53g, is identified as the **Wilkin's Finch *N. wilkinsi*** ('Big Canary'). Its massive bill is specialized to crack open the fruits of *Phylica arborea* trees. It is Critically Endangered, with a population estimated at only approximately 80 pairs (Ortmann 2012).

Inaccessible Finches *N. acunhae* ('Inaccessible Canaries'), confined to Inaccessible Island, have also evolved into large- and small-billed forms. These remain largely discrete in coastal habitats but hybridize extensively on the island plateau, and so are treated as a single species with multiple subspecies. The large-billed **Dunn's Finch *N. acunhae dunnei*** feeds mainly on *Phylica* fruit, while the small-billed **Lowland Finch *N. a. acunhae*** lives and feeds mainly in *Spartina* grass tussocks. The bright yellow **Upland Finch *N. a. fraseri*** is mainly found on the plateau, although immature birds feed along the coast in winter and spring. Of the 10,000 or so finches on Inaccessible, around 1,500 are the subspecies *dunnei*, 3,500 *fraseri* and 5,000 *acunhae* (Ryan 2007).

Figure 118: A beautiful set of stamps celebrates the Tristan islands' endemic finches. Clockwise from top left: Gough Finch *Rowettia goughensis*; Dunn's Finch *Nesospiza acunhae dunnei* (Inaccessible); Wilkin's Finch *N. wilkinsi* (Nightingale); Nightingale Finch *N. questi*.

A small-billed finch from Tristan was extinct on the main island of Tristan by 1860, probably as a result of predation by House Mice and feral cats, and is known only from one museum specimen in Berlin. The populations of these finch species, all with very small ranges and populations, would be highly susceptible to the accidental introduction of predators, and so are dependent on the same measures to protect populations as seabirds. Measures to eradicate House Mice from Gough Island to protect seabirds would also greatly benefit the Gough Finch.

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6. Exploitation of the marine resources of Tristan da Cunha

6.1. Historical exploitation of seals, whales and seabirds

Seals

Wace and Holdgate (1976) outline the early exploitation of wildlife around the Tristan islands. The authors quote Oliver (1891), reporting a visitor off Tristan in 1690 as commenting: "the sea was almost cover'd with Whales and Sea-wolfs which swam to the very Shoar of the isle playing with the water and some of them ran against our Frigat'. How things have changed. There are still 'sea-wolfs' (presumably fur seals) particularly at Gough and Inaccessible, but numbers are much reduced, and a visitor now would be lucky to see a whale.

The abundance of seals around the islands soon became the target of sealers, who killed Subantarctic Fur Seals for their pelts and Southern Elephant Seals for their blubber, which was rendered down for oil. American sealers were among the first to exploit fur seals of the southern Atlantic and southern Indian Oceans, and they planned to use Tristan as a base for collecting pelts and oil and shipping onwards to markets in China, Mauritius and America. John Patton of the ship *Industry* spent nine months on Tristan in 1790. He gathered 5600 fur seal pelts, and also noted the abundance of elephant seals, the latter now rare at the Tristan islands. Sealing gangs also lived on Gough; 10 men found by *HMS Nereus* in 1811 had been there for 18 months, living on fish, penguins, other seabirds and their eggs, and eating island celery for vitamins. The sealers cultivated potatoes, which still grow wild on Gough and Inaccessible, and probably introduced mice to Gough, where they have since done untold damage to breeding seabirds and invertebrate populations.

Figure 119: A Tristan da Cunha stamp from the 'Ships and Explorers' issue (2014), depicting the sealer James Weddell and his brig *Jane*. Weddell made several sealing trips to the Southern Ocean, reaching the farthest south of any ship at the time, now known as the Weddell Sea. He called in at Tristan in 1822.

Seal populations soon became over-exploited, and industrial sealing for fur seals declined after 1820. Elephant sealing was still possible, but islanders are reported as complaining that the sealers shot more elephant seals than they could take, just to deny the oil to the Tristan settlers (Gane 1933). A short-lived resurgence of sealing took place between 1860-1890, but a sealing party who spent 18 months on Gough in 1888-1890 managed to kill only 311 fur seals and one elephant seal, and a second party there in 1891-1892 found that the seals were so reduced in numbers that the industry ended (Wace & Holdgate 1976). There are no records of total numbers killed, but logbooks show that fur seals were taken from all the islands, and elephant seals from all except Nightingale (where there are few suitable haulouts). They were extinct at the top islands in the 19th century because of hunting, and reduced to the brink of extinction elsewhere in their range (www.iucnredlist.org). Fur seal numbers have bounced back and they have reoccupied much of their former range, although Wynen et al (2000) note that this population bottleneck has reduced their genetic variation and may render them more vulnerable to disease or climate change. Elephant seals have recovered in the southern part of their range, but not at Tristan and Gough. The small numbers at Gough have actually decreased over the past 25 years (Ryan 2007).

Figure 120: Above: Fur seals were killed for their dense, soft fur. Right: Elephant seals at Gough were decimated, and have not recovered. This mother seal was guarding her long-dead pup.

More recently, seal meat was used for bait in rock lobster traps (Ryan 2007), but this is no longer a practice in the fishery. The Tristan da Cunha Conservation Ordinance 1976 now protects Southern Elephant Seals at all the Tristan islands, while Subantarctic Fur Seals are protected at Gough and Inaccessible, and their disturbance minimized on Tristan.

Whales

American whalers began to visit Tristan in numbers in the 1830s. The location of the islands meant that vessels sailing eastwards on the edge of the westerly wind belt passed by the summer Southern Right Whale and Sperm Whale grounds, and Tristan soon became a provisioning station for whalers voyaging to the Indian and Pacific oceans (Wace and Holdgate 1976). Both Southern Right and Sperm Whales were hunted intensively near the islands between 1830 and 1870, mostly by American whalers. The limits of the Tristan Grounds were roughly between 28-42°S and 0-20°W, though there was also some discrimination between the Pigeon Ground to the west of Tristan (31-39°S, 16-28°W) and the Tristan Ground (approximately 33-39°S, 9-14°W) (Best et al 2009). No shore-based whaling has ever taken place at the islands.

An estimated 2500 Southern Right Whales were taken from Tristan da Cunha waters in 1830-1834 (Best 1988), and catches continued for the remainder of the 19th century. Stocks recovered in the first half of the 20th century, and by the 1940s and 1950s were numerous enough to be considered a nuisance by locals. However illegal hunting by Russian fleets, while the islanders were absent from Tristan following the volcanic eruption in 1961, greatly reduced the local population to around a dozen adults and their young (Best 1988, Wace & Holdgate 1976).

Best et al (2009) extracted figures from the IWC of 1040 whales taken between 1934-1967, but mostly (97%) between 1961-1967, in the 'Tristan Square' (35-39°59'S, 10-14°59'W). These include 648 Sperm, 329 Southern Right, 58 Sei, 4 Fin, one Humpback, and one Pygmy Right Whale (though this actually adds up to 1041, not 1040!). The positions for Right Whale captures are mostly grouped tightly around the top islands, but some extend in a line to the east between 37°S and 38°S. 27% of the sightings were cow and calf pairs, with 68% of these off Tristan between Sandy Point and Stonyhill Point. For the Sperm Whales, females and small males (11m or less in length) were only taken north of 37°30'S and mostly to the west of the islands, while larger males ranged more widely, particularly farther south and east. The 58 Sei Whales were all taken north of 38°S, and mostly to the east of the archipelago. The four Fin Whale records were all distant from Tristan, with the closest at 175km east of Tristan. The Humpback was taken 40km south west of Tristan, and the Pygmy Right 450km north east of Tristan.

Best et al (2009) also report Jonathan Lambert, the first Tristan settler, describing lancing and shooting Killer Whales as they beached themselves when trying to catch elephant seals, though they do not say if this was a successful way to kill them.

Seabirds

Between 1870-1950 the decline of whaling combined with the replacement of sail by steamships and the opening of the Suez Canal in 1869, all conspired to take shipping away from Tristan. Trade declined, and islanders returned to subsistence crofting, supplemented by fishing and hunting native and feral animals (Wace and Holdgate 1976). Seabirds and seals were still abundant on Tristan, and islanders collected albatrosses, petrels, penguins and their eggs for personal consumption. It is thought that Tristan held hundreds of thousands of pairs of Northern Rockhopper Penguins in the 1870s. These were rapidly depleted by killing for food, bait and decorative head plumes. Today, following protection since 1976, there are some 10,000 on the island. The Tristan Albatross (gony) was extinct on Tristan by 1907 from human exploitation, perhaps exacerbated by rat predation, and has not returned. The Atlantic Yellow-nosed Albatross (molly) was historically killed for food on Tristan, Nightingale and Inaccessible, with up to 2,000 eggs and 1,500 chicks killed per year in the 1950s. The scale of the islanders' predation on seabirds towards the end of the period of subsistence crofting is described in papers produced after the Norwegian Expedition in the 1930s (Cristophersen 1940, Munch 1945, Henricksen and Oeding 1940, Hagen 1952).

Figure 121: Traditional canvas-covered sailing boats formerly used for birding expeditions to Nightingale. Nowadays the trip is much quicker and less dangerous in fast rigid-hulled inflatable boats with powerful engines.

By the late 19th century, with the wildlife on Tristan depleted, it became necessary to go on regular trips to Nightingale and Inaccessible for bird fat and eggs, and seal blubber. Feral pigs and goats were also killed. In the 1970s, between 25,000 and 40,000 penguin eggs were taken annually for food from Nightingale and Middle (Alex) Islands. Up to 15,000 Great Shearwater (petrel) eggs, 50,000 chicks and several thousand adults were collected annually at Nightingale in the 1970s.

Eventually, with the establishment of the crayfish fishery and the revenue it generated enabling purchase of merchandise from off-island, pressure on the wildlife reduced. Wace and Holdgate (1976) consider that, overall, the human impact on the outer islands has remained negligible, especially away from the coasts. However this presumably refers to direct human hunting; the impact on bird populations of biota introduced by humans has been severe, particularly of mice on Gough and feral pigs and goats at Inaccessible.

Current exploitation of seabirds is confined to harvesting of Great Shearwater (petrel) chicks and eggs and penguin eggs at Nightingale. There is a total estimated population of great shearwaters at Nightingale of 2-3 million pairs, so current harvesting levels are not considered a threat (Ryan 2007). Consumption of penguin eggs has decreased in recent years, and provided only a-eggs (the first of two laid) are collected, and disturbance is minimized, the current harvest is considered sustainable (Ryan 2007), although penguin populations are probably still decreasing.

Figure 122: Left: Northern Rockhopper Penguins on Nightingale with islanders' huts above; the huts are used for sleeping and cooking on bird harvesting trips. Penguin eggs are still harvested but adult birds are no longer killed for food. Right: petrels (Great Shearwaters) being smoked over an open fire.

6.2. Fishing

6.2.1 History of fishing

Local line fishing

The abundant local fish have always been an important resource for islanders. Andrew (1992) outlines the early history of local line fishing for personal use and as bait for rock lobster fishing. He estimated that approximately 61.5 tons of linefish were caught for bait by the local fleet in 1989, made up of eight commonly caught species, with bluefish (47%) and fivefinger (30%) making up 77% of the catch by mass. The other 23% was made up of stumpnose, soldier (*Sebastes capensis*), snoek, mackerel, steambras and jacopever (*Helicolenus mouchezi*) in that order. In recent years yellowtail *Seriola lalandi*, easily caught on lines, have increased in numbers and become an important food fish; they were comparatively rare around Tristan at the time of Andrew's studies. Currently approximately 15 tons of fish are taken for bait, usually a by-catch of fivefinger and soldiers (*Sebastes capensis* and *Helicolenus mouchezi*) caught in the lobster traps and hoopnets, and 12-18 tons of fish are taken by the vessels annually for direct consumption (James Glass pers. comm.).

Figure 123: A local line catch of yellowtail (*Seriola lalandi*) and fivefinger (*Acantholatris monodactylus*), both popular eating on Tristan.

Andrew (1992) worked on aspects of the biology and reproduction of local fishes, and noted that any commercial exploitation would have a pronounced effect on the structure of fish stocks at all the islands (and that in order to show profits, the stocks at all islands would have to be exploited). This would effectively reduce the reservoirs of unexploited stocks thought to sustain the local Tristan fishery.

Limited shelf areas around the islands, and recruitment of most of the stocks from within the local area, would theoretically allow local fish stocks to become easy targets for over-exploitation.

Andrew (1992) also points out that it is generally accepted that species tending towards r-selection (i.e. that have life histories focused on production, with features such as high fecundity, rapid growth and relatively low longevity) are suitable candidates for exploitation. On Tristan, these would be bluefish, stumpnose, snoek and mackerel. On the other hand, fivefinger, the two soldier species and steambras are not strongly r-selected (longer lived and slower growing). However these fish made up a significant proportion of the total catch at Tristan. Few negative effects were apparent on the stocks at the time, but he warned that it would be easy to overfish in a very short time. He advised that companies applying for lobster fishing concessions on the islands should be required to provide their own bait from elsewhere. Currently, approximately 40 tons of imported hake heads, a by-product from a separate South African MSC-certified fishery, are used to bait commercial lobster traps each season.

Commercial line and trawl fishing

Information on this section has been largely provided by James Glass, Director of Fisheries on Tristan, and Charles Kilgour, fisheries biologist who worked on Tristan as part of a Darwin project in 2015-16. Permits have in the past been issued for demersal long-lining for southern butterfish (bluefish) *Hyperoglyphe antarctica* (MacAllister Elliott & Partners 2011). One vessel only was given a seasonal license. Bycatch was mostly jacopever *Helicolenus mouchezi* and false jacopever *Sebastes capensis.*

Deepwater trawl licenses were granted in 1997, 2000, 2001, 2003, 2014 and 2015. Fishing is permitted within the Tristan Maritime Zone (EEZ) only outside a 50nm buffer zone around each of the islands, leaving the seamounts found across the EEZ between 38.4°S and 40.3°S as the only fishable grounds. Between 1997 and 2003 the fishery targeted primarily alfonsino (*Beryx decadactylus*) and bluefish (*Hyperoglyphe antarctica).* Bycatch included jacopever (*Helicolenus mouchezi*), horse mackerel (*Trachurus* sp.) and steembrass (*Polyprion* sp). In 2014 and 2015 trial fishing was conducted at the seamounts targeting primarily bluefish and jacopever, with a bycatch of Butter snoek (*Lepidopus caudatus*), Snoek (*Thyristes atun*), Pomfret (*Brama australis*), Southern rover (*Emmelichys nihdus*) and stumpnose (*Rhabdosargus* sp.).

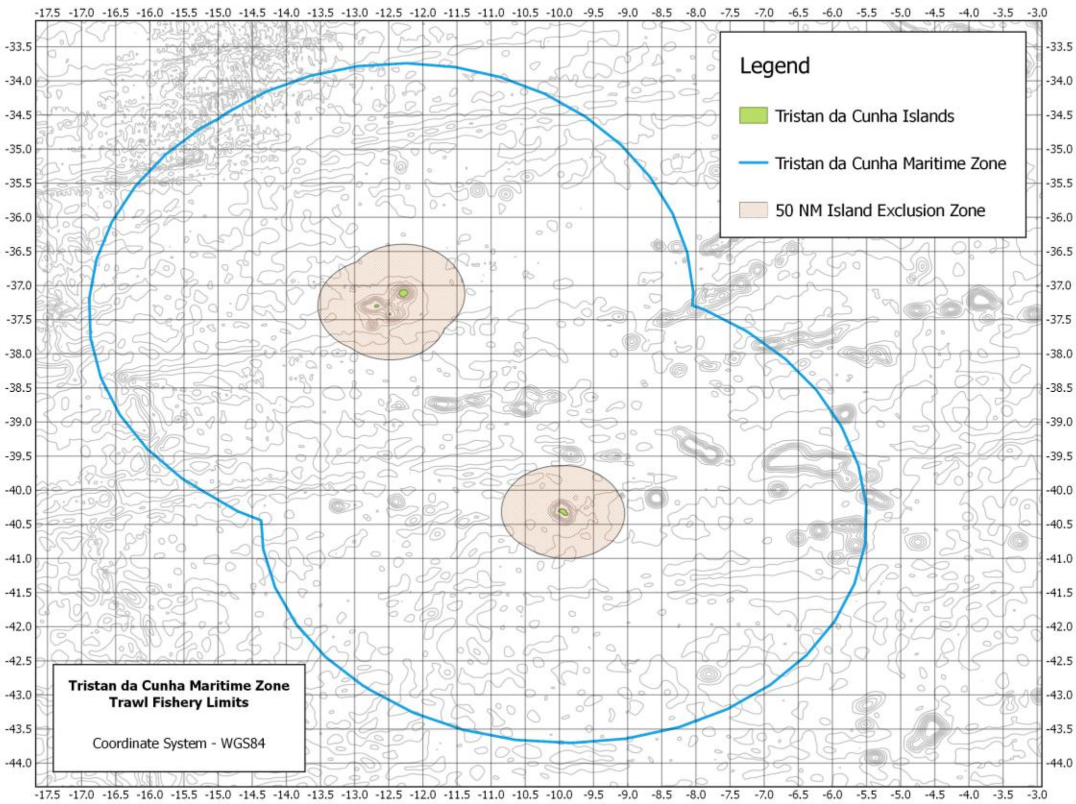

Figure 124: Map showing the limits of the Tristan da Cunha Maritime Zone (EEZ) at 200nm from the islands (blue line) and the 50nm exclusion zone for trawling licenses (buff area). (Charles Kilgour, Tristan Fisheries Department)

Deepwater trawling is a controversial fishing activity that can damage vulnerable benthic habitats and should only be licensed under strict controls. In 2014 the license conditions for the deepwater trawl fishery in the Tristan da Cunha Maritime Zone were updated to include improved catch reporting and sampling, increased mesh sizes, seabird mortality mitigation measures, shark bycatch controls and controls on interactions with vulnerable marine ecosystems. The fishery is operated with 100% observer coverage and currently is limited to a maximum of one license and a short 21-day season. The new license conditions are designed to ensure that the management controls on the fishery follows or exceeds recommendations from the South East Atlantic Fisheries Organisation (SEAFO) and 'best practice' at other UKOTs in the South Atlantic.

Licenses for pelagic longline vessels targeting either tropical tunas or southern bluefin tuna have been issued sporadically depending on interests and legitimacy of the various fishing operations in the Southern Atlantic. Recent increase in interest for licenses to target southern bluefin tuna (*Thunnus maccoyii*) within Tristan's EEZ could be a result of measures by the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) to curb IUU fishing which has previously operated essentially unchecked (Collette 2011). Establishing and monitoring catch quotas for this endangered species is the responsibility of CCSBT. However, in response to renewed interest in licenses the Tristan da Cunha Fisheries Department updated the license conditions for pelagic longline vessels operating in the Tristan da Cunha Maritime Zone. The new conditions include mitigation measures to reduce seabird mortality, controls on catches of elasmobranchs, and updated bycatch reporting requirements in line with or exceeding recommendations from CCSBT and ICCAT.

Lobster fishing

Fishing for Tristan rock lobster *Jasus paulensis (tristani)* began at Tristan in 1949, though it was not until freezer shipments to South Africa in the late 1960s and the introduction of steel traps deployed on longlines in 1974 that commercial exploitation began in earnest. Over the years, the fishery has been characterized by a series of changes in vessels and fishing gear used (Glass 2014). For the outer islands of Nightingale, Inaccessible and Gough, wooden vessels and dinghies with hoop nets were replaced by steel vessels operating longlines with traps and 5-7m powerboats operating with both hoop nets and steel powerboat traps. For the local fishery at Tristan da Cunha, dinghies were replaced by 5m powerboats, and later 7m powerboats, deploying hoop nets and powerboat traps. These changes in fishing techniques have seen catches increase and decrease over the past 60 years of operation (Glass 2014). There is a general feeling that the lobster populations were initially overfished, with some recovery since conservation measures were put in place, the most important being the introduction of TACs in 1991. Later measures included a minimum landing size (CL), seasonal closures, boat and trap restrictions, and a ban on taking egg-bearing females. Together with the appointment of new concession holders in 1997, the fishery turned around from a declining one to steady increases in CPUE between 1996 and 2006 (Glass 2014). However recent falls in CPUE have again caused concern.

Roscoe (1979), Andrew (1992) and Glass (2014) outline the early history of fishing for Tristan rock lobster. In 1949, the Tristan Exploration Company (TEC) was granted sole rights to export rock lobsters, and set up a small canning factory on the island. The company initially fished using a single vessel, the *Pequena,* operating out of Cape Town. She carried 12 dinghies, used only hoop nets, was crewed by islanders and South Africans, operated at the northern islands during the summer and froze her own catch. With additional finance from the UK, the TEC formed the Tristan Development Company (TDC) in 1950, and in 1951 commissioned a second ship, the *Isolda* (renamed *Tristania)*, which carried 26 dinghies and fished mainly at Gough. In 1953 the *Pequena* was replaced by the larger *Voorbok*, (renamed *Frances Repetto*), which carried 18-22 dinghies. Table xx summarises the larger vessels operating in the lobster fishery over the years, together with their gear, and the ships are illustrated in Glass (2014).

The two larger fishing ships *Tristania* and *Frances Repetto* continued to fish while there was no factory at Tristan after the 1961 eruption, and in 1965 the *Frances Repetto* was replaced by the larger *Gillian Gaggins*. She initially carried 25 dinghies, but a few were later replaced by powerboats. Following a successful experiment in 1967 by a chartered fishing vessel, the *Tristania* began using traps on long-lines in 1969, fishing mainly at Gough. Two new vessels, the *Hilary* and *Melodie*, designed for fishing with traps, were commissioned in 1971, and also had seawater tanks let into the deck to hold live catches. The *Gillian Gaggins* then became their factory ship, processing and packing the catch. The *Tristania* was replaced by the larger *Tristania II* in 1973, and in 1974 the fleet was reorganised by taking the *Gillian Gaggins* out of commission, and refitting the *Hilary* and *Melodie* so that their catch could be processed (frozen and tailed) aboard. The *Melodie* was withdrawn in 1976, and the *Hilary* was replaced in 1984 by the *Hekla*, a 68m steel ship converted from a cargo vessel, for longline fishing, processing and packing for export. The *Tristania II* was replaced in 1997 by the *Kelso*, built in Japan in 1971 as a fisheries patrol vessel. She operated in the fishery until she was sold on in 2009.

Figure 125: The fishing ship *M.V. Edinburgh*, the only large vessel currently operating in the rock lobster fishery, here fishing at Gough in 2014.

Currently the only large vessel fishing is the *M.V. Edinburgh*, (the *Hekla* renamed), still operating (2016) after 32 years in the fishery. She is supported by the *Baltic Trader*, a cargo ship which carries product back to Cape Town. Both vessels also carry goods and a maximum of 12 passengers each trip, and are a vital lifeline for islanders.

Operating years	Vessel	GRT (Tons)	Gear
1948-1953	*Pequena*	184	12 dinghies, hoop nets
1951-1972	*Isolda* renamed *Tristania*	628	26 dinghies, changed from hoop nets to longlines in 1969/70
1953-1965	*Voorbok* renamed *Frances Repetto*	316	20 dinghies, hoop nets
1965-1973	*Gillian Gaggins*	793	20 dinghies, later some replaced by 2 powerboats. Changed to plastic top-entry traps on longlines in 1969. Converted to mother-ship in 1971.
1974-1984	*M.F.V. Hilary*	303	Longlines with traps
1974-1976	*M.F.V. Melodie*	303	Longlines with traps
1973-1997	*M.F.V. Tristania II*	603	Longlines with traps 2 powerboats
1984 -present	*M.V. Hekla* renamed *M.V. Edinburgh in 1997*	708; 1085 after refit in 1997	Longlines with traps 2-5 powerboats
1997-2009	*Kelso*	1678	Longlines with traps 2-6 powerboats

Table 11: The larger vessels used to catch rock lobsters at the Tristan and Gough, together with years of activity, GRT (tons) and gear types used (adapted from Glass 2014).

Roscoe (1979) reports that the TDC was not very successful in its first decade, partly because of the difficulties of operating from Cape Town, a huge distance away, and also because the majority of islanders, who fished from dinghies launched from the shore, regarded fishing as supplementing rather than replacing their traditional subsistence economy. The factory had limited freezing and cold storage facilities, but the process of canning was difficult and inefficient, and many cans of tails were subsequently condemned.

Canning was worthwhile only when all dinghies went fishing, so if only a few boats were prepared to fish no fishing took place even though sea conditions might have been suitable. Also from January to May, islanders were occupied with harvesting potatoes or with birding trips to Nightingale for birds and guano. From 1955 to 1958, islanders fished on average 32 days per year, using hoop-nets. Fishing was initially restricted to the northern coasts of Tristan, near the settlement, until a motorboat was purchased in the mid-1950s to tow the dinghies around the island.

Canning was abandoned in 1960 and larger freezing facilities were installed, increasing output from less than 45mt to 52.5mt in 1960/61. Then the factory, together with the relatively sheltered beach used by islanders to launch boats, was destroyed by the volcanic eruption in 1961. After the islanders returned to Tristan in 1963, the factory was rebuilt, being completed in 1966. In the interim, Island fishermen continued to fish with dinghies and hoop nets, delivering their catch direct to the large vessels. The fishing company was now called Tristan Investments Limited (a subsidiary operating company to the South Atlantic Islands Development Corporation (SAIDC)). The fishery suffered a serious setback in February 2008, when the fish factory caught fire and was completely destroyed. However a new factory was built, to modern EU specifications, increasing the potential market and this opened in July 2009. From 1965, the local fleet of dinghies was gradually replaced by larger motorboats that could fish further afield. In 1968, steel traps covered with chicken wire were added to the gear, changing to nylon mesh netting in the 1980s (Glass 2014). A small harbor was completed at the Settlement on Tristan in 1967. 15 powerboats were fishing from the harbor in 1973 (Roscoe 1979), increasing to 20 by 1990. A patrol boat to service the local fleet was added in 1970. The depths fished also increased, from around 110m to up to 200m. At the time of Andrew's study, in 1989-90, local powerboats ranged from 5-7m long, with 5m boats carrying 10 traps and 25 hoop nets, and 7m boats carrying 15 traps and 25 hoop nets.

Table 12 summarizes the boats and gear used by local fishermen over the years. Since 1997, there has been a reduction in boats and gear in the local fleet, in response to an increase in CPUE, and the demand for a superior quality product (Glass 2014). The reduction from 18 powerboats to 9 in 2003/4 was mainly to restrict landings to the factory to a manageable level. All 36 fishermen were retained, but now four fishermen share a boat on a rotational basis, two at a time.

Figure 126: A fine fishing day at Tristan in 2005. Tristan fishermen are hauling hoop nets into a colorful powerboat, with Inaccessible Island in the background.

Year	Boats	# of boats	Gear used
1949-1961	4m dinghies	20 dinghies	Hoop nets
1965-1979	4m dinghies and 5-7m powerboats	20 dinghies and powerboats	Hoop nets & traps
1980-1999	5-7m powerboats	20 powerboats	Hoop nets & traps
1999-2000	5-7m powerboats	19 powerboats	Hoop nets & traps
2001-2003	5-7m powerboats	18 powerboats	Hoop nets & traps
2004-present	7m powerboats	9 powerboats	Hoop nets & traps

Table 12: Summary of the numbers and types of boats and fishing gear used by local lobster fishers around Tristan da Cunha Island (from Glass 2014).

The fishery has used various methods of catching rock lobsters over the years (Table 13 and Figure 127), from simple baited hoop nets buoyed individually, to large steel monster traps set on longlines of up to 65 traps. Monster traps were first used in the fishery in 1974, after a poacher was caught using them at Inaccessible (James Glass pers.comm.).

The monster traps replaced the small Kavel plastic traps, and are thought to be 1.8 times more efficient (Pollock 1981). The two vessels then operating would deploy 4-6 longlines each with 35-65 traps hauled twice every 24hours, weather permitting (Roscoe 1979). However the monster traps are very heavy, and the impact on other benthic marine life of them landing on the seabed, being dragged by currents, and on hauling, is unknown, but likely to be greater than the smaller traps and hoop nets.

Gear type	Dates used	Description
Hoop nets	1949-present	Steel hoop 0.7m diameter with 50mm mesh attached, extending for 1m. Bait attached in center. Buoyed individually
Willow traps	1949-1961	Barrel-shaped traps of French willow, with weight inside
Beehive (ink well) traps	1997-1999	Frame of 16mm steel covered with 70mm mesh netting.
Plastic traps	1970- early 1980s	Plastic top-entry kavel traps, and similar oval collapsible traps, set attached to longlines
Steel/powerboat traps	1970s - present	Semi-cylindrical top-entry traps, 1m long with escape bars 50mm apart. Initially wire-covered, later with mesh netting varying from 60-75mm over the years, eventually set at 70mm in 2011.
Monster traps	1974-present	Heavy cuboidal steel-framed traps 120x80x50cm, with two entries and a bagged end. Baited in center.

Table 13: Types of gear used in the Tristan lobster fishery, with approximate dates (information from Glass 2014). Traps are illustrated in Figure 127

Figure 127: Fishing gear used in the Tristan lobster fishery over the years (see also Table xx). (Reproduced from Glass 2014).

1. Hoop net.
2. Beehive or inkwell.
3. Monster trap
4. Willow trap
5. Plastic or Kavel trap
6. Powerboat trap or pot

Historic fisheries management

There is a general feeling that early fishing operations overfished stocks, at a time when there was little knowledge of lobster biology and habitat to apply to management of the fishery. Early investigations were undertaken at Tristan by Mrs M.K. Rowan, who produced unpublished reports to the TDC (1940, 1950). Later the SAIDC, then the sole concessionaire for the territory's marine resources, were required by the British Government to monitor the state of the fish stocks. Heydorn (1969) undertook a brief survey in 1967 and advised on the collection of fisheries statistics.

Roscoe (1979) reports the results of extensive sampling to establish the composition of the population at each island, and aspects of the rock lobsters natural history. He found that in 1971-73, rock lobsters caught around Tristan were smaller and less abundant than in 1949/50 when exploitation began, while at the offshore islands abundance and average size of tails had fallen only slightly. Total catches had declined from around 300mt in the 1960s to 255mt from 1970 onwards, and the catch per unit effort had decreased considerably since 1965. He suggested that conservation measures (a minimum size limit) should be considered, and that there should be no increase in exploitation. A minimum legal size (MLS) of 70mm carapace length was introduced at the outer islands in 1981 and at Tristan in 1984. The MLS was later adjusted for each island.

Figure 128: Checking the carapace length of the catch with calipers. Currently the MLS is 70mm at Tristan and Nightingale, 66mm at Inaccessible and 75mm at Gough.

Figure 129 shows estimated catches from the 4 islands from 1967 for Tristan and 1970 for the other islands, collated from various sources by MARAM (Macalister Elliott & Partners 2011). The authors say that data before the current concession holder started operation in 1996 is probably not very reliable, but the general picture is of a fishery which initially gave high catches when management was less stringently enforced, leading to a period of declining catches. The data for Gough is less reliable than for the other islands; because of its great remoteness, no permanent population, and no effective policing, the potential for illegal, undetected and unregulated (IUU) fishing of a high-value catch is real.

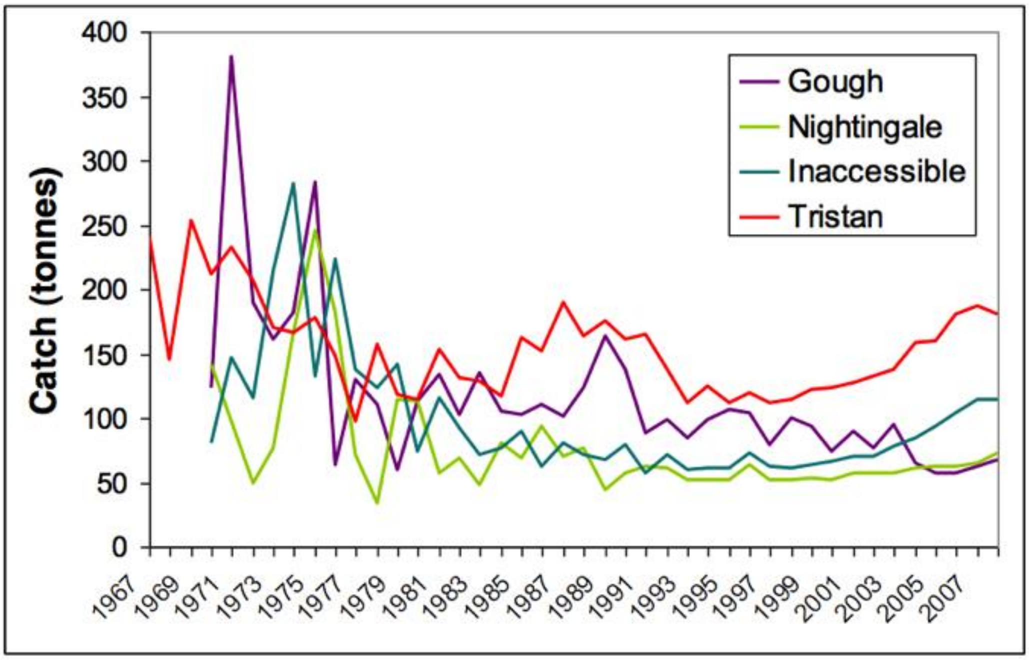

Figure 129: Trends in estimated catches (tons) of rock lobster from the four islands, starting in 1967 for Tristan and 1970 for the other islands. The earlier data (pre 1996) is probably not very reliable. [Reproduced from MacAlister Elliott and Partners Ltd. 2011]

Peak catches at Gough in 1971/72 (380mt) and 1975/76 (283mt), and at Inaccessible in 1974/75 (282mt) and 1976/77 (224mt) coincide with the entry of two new longline vessels into the fishery (*Hilary* and *Melodie*), and the replacement of the *Tristania*, which used only dinghies, with the *Tristania II*, which used traps on longlines and set from powerboats. The introduction of monster traps in 1974 also immediately increased catch rates. Glass (2014) comments that lower CPUE values after 1992 may be a result of depredations following longlining around Tristan in 1992, when the harbour was closed for restoration; this was the first time that a vessel operating with longlines and powerboats had fished around Tristan for an extended period. He says that the sharp increase in CPUE between 1995 and 2005 reflect either a recovery in the lobster population or improved fishing efficiency.

Since 1991, TACs have been set by the Fisheries Department (formerly part of the Natural Resources Department); from 1997, these have been rarely exceeded. The lobster fishing concession was revoked in 1996 because of breach of regulations, and a new concession was granted in 1997, including a new suite of regulations to govern the fishery (Glass 2014). Tighter management and better compliance and reporting since then has led to improvement in stock status, with associated recent increases in TACs for the top islands.

Glass (2014) notes that the interpretation of fishing effort for the fishery remains challenging given the past changes in gear, method and vessels, and also shifts in fishing seasons. This affects the trends in catch rates or CPUE, which can be used as indicators of abundance of a fished population. Prior to 1970, catch and effort data were not separated by island, but only reported as values for all islands combined. Historical data on catches are available from the 1967/68 season, though other biological data such as morphometrics, size composition, sex ratios, reproduction and growth only started being collected from 1971. More detail of the history of fisheries management is given in Glass (2014).

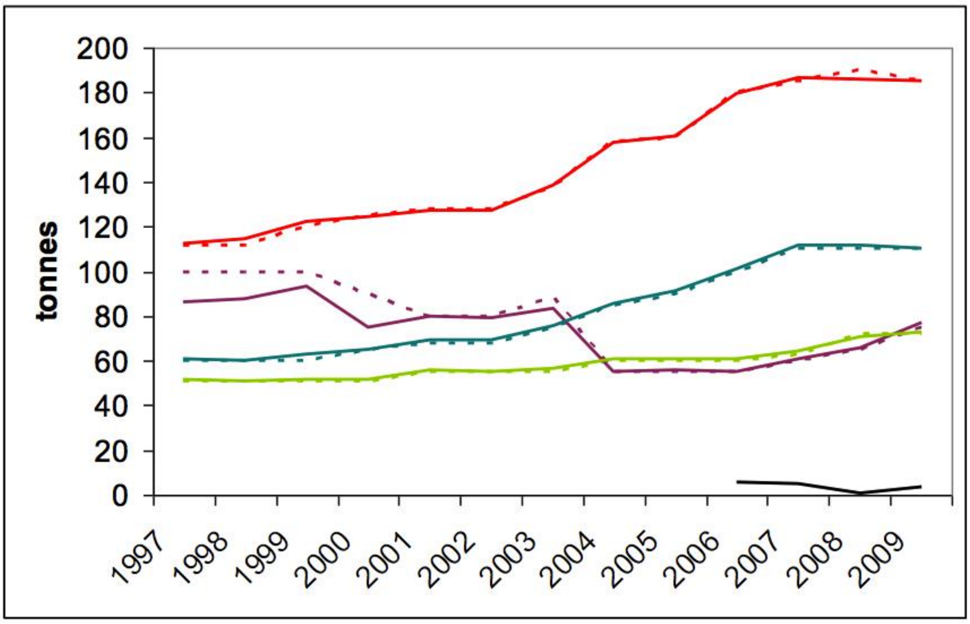

Figure 130: Catches (solid lines) compared to TACs (dotted lines) for each island. Tristan - red; Gough - purple; Inaccessible - blue; Nightingale - green. The black line is catches from surveys in recent years. [Reproduced from MacAlister Elliott and Partners Ltd. 2011]

6.2.2. Current fisheries

Currently only rock lobsters *Jasus tristani (paulensis)* are fished commercially inshore around the Tristan islands. This fishery provides 70-90% of the island's income, enabling the community to be largely self-sufficient, unlike many UKOTs. A by-catch of octopus (*Octopus vulgaris*) with very small quantities of (*O.magnificus)* is also sold commercially. Between 310 and 442 tons of rock lobster have been landed annually since 1996; in the 2014/15 fishing season 18 tons of octopus were also caught.

Due to the steep topography and small size of the islands, only a small total area is suitable habitat for lobsters, and available for the fishery. The planar area around the islands to the 100 fathom (183m) depth contour was estimated by Roscoe (1979) to be 96sq km at Gough, 71 sq km at Tristan, 38 sq km at Nightingale, and 124sq km at Inaccessible, making the total area for the fishery 329 sq km.

The rock lobster fishery is unique in the world in that it is licensed to only one operator, Ovenstone Agencies (Pty) Ltd (a subsidiary of the British company Eurex), based in Cape Town, under a long-term concession. Therefore the ability to exert management control and achieve long term sustainability is superior to that in similar fisheries elsewhere. This has enabled the fishery to apply for and recently achieve Marine Stewardship Council (MSC) certification (MacAlister Elliott and Partners Ltd. 2011). The fishery has passed its annual audits, and also a reassessment in 2015.

Ovenstone currently uses a single fishing vessel, the 68m long *MV Edinburgh*, to fish the offshore islands of Gough, Nightingale and Inaccessible. The vessel sets fleets or longlines of large ('monster') steel traps in depths of 50-150m (up to 200m). Usually 16 lines are set at a time, each with 20 traps. Smaller box traps are set by four powerboats, operating from the mother ship, in shallower water inshore; each boat can deploy up to 80 traps, in two sets of 40. The waters around Tristan island are fished by Tristanians employed by Ovenstone, using small inshore boats supplied by the company. The *Edinburgh* does not normally fish around Tristan, but in recent years has taken a small quota at Tristan if it is not fished by Tristanians by the end of the fishing season (25th August to 30th April). Hake heads, a by-product of an MSC-certified hake fishery in South Africa, are used to bait the lobster traps, replacing former use of local fish as bait.

Figure 131: Fishing from the MV Edinburgh at the offshore islands. Clockwise from top left: preparing to set longlines from the stern deck; a monster trap going overboard; hauling a good catch of lobsters; re-baiting the traps with hake heads; setting smaller traps inshore from a powerboat; packaged product processed on ship.

Figure 132: Fishing at Tristan. Left: a powerboat with traps and hoop nets ready to ready to go fishing. Right; weighing the catch at the harbor at the end of a fishing day.

Rock lobsters caught by the *Edinburgh* are processed onboard, while those caught around Tristan are processed in a modern factory on Tristan, rebuilt in 2008-2009 to high standards after the previous factory burnt down. Processed catch is transported to Cape Town on the *Edinburgh*, or on another cargo vessel, the *Baltic Trader*, for eventual export to Japan, the USA, and increasingly Australia, where the native rock lobster fishery has collapsed in recent years. Tristan rock lobster was also introduced to the European market in November 2014 (tristandc.com). The journey to Cape Town takes six days (more in bad weather - the record is currently 13 days) and runs about eight times a year transporting islanders, goods and visitors.

Figure 133: Rock lobsters caught around Tristan are processed in the factory on Tristan then driven to the harbor for loading onto the ships for transport to Cape Town. Above right: Tristan is a welcome sight after 6 days at sea. The *Edinburgh* and *Baltic Trader* provide vital transport for islanders, visitors and goods between Tristan and Cape Town.

Management and conservation of stocks

The current key objective for the Tristan rock lobster fishery is to ensure that the fishery can continue in the long-term to support the island financially; it is largely because of the fishery that the island is not financially dependent on subsidies from outside (MacAlister Elliott & Partners 2011). There is also an overall policy for the archipelago that in effect states that management and protection of the marine environment and maximum yield from the fishery are twin objectives (Tristan da Cunha Island Council 2009). To this end, various regulations governing the fishery are set out in the concession agreement, as well as in specific permit conditions relating to the areas fished.

Fishing effort on Tristan is limited by the number of boats (currently 12) and the amount of gear used (currently 14 box traps and 32 hoop nets per boat). In practice the local fishery is severely limited by sea conditions, with the harbor only accessible for about 90 days a year. Between 1994-2015 fishing days varied widely from 18-72 days per year. The fishing season for the local boats starts on July 1st, and continues until the TAC is caught. There is no closed season at Tristan as there is no overnight fishing (berried lobsters are only caught at night), although in practice island fishermen tend to cease fishing on April 30th to have two months to service boats and gear.

For the other islands, weather is not critical as the *Edinburgh* can work in heavier seas than the local boats, and can move to whichever side of the island is most sheltered. For the 2009-10 season, there were 69 fishing days at Inaccessible, 29 at Nightingale and 24 at Gough (MacAlister Elliot & Partners 2011). To protect berried lobsters, the licensed fishing season for the outer islands is from 25th August until 31st May, but as an additional conservation measure the island and fishing company have agreed that fishing at the outer islands does not start until September.

The TAC for each island is set annually by the Tristan Government on advice from the Fisheries Department, which in turn is advised by the Marine Resource Assessment and Management Group (MARAM), University of Cape Town. MacAlister Elliot & Partners (2011) note that, although advice from MARAM plays a key role, more anecdotal factors such as the views of fishers, observers, and the skipper of the *MV Edinburgh* are also considered in setting TACs. A precautionary approach is taken on setting TACS, as follows (Glass 2014):

- CPUE increases, year 1, TAC maintained
- CPUE increases, year 2, TAC increased 5 tons
- CPUE decreases, year 1, TAC frozen
- CPUE decreases, year 2, TAC reduced by minimum of 5 tons

The minimum landing size (MLS) varies slightly between the islands, in response to different population structures at each island. Estimates of carapace length at maturity of female lobsters vary between 56-60mm (Pollock 1981; Roscoe 1979). The MLS at Tristan and Nightingale is set at 70mm carapace length, which gives females a chance to spawn before being caught in the fishery.

At Inaccessible, where there are greater numbers of smaller lobsters, and they apparently do not grow as large, the MLS is 66mm; up to 40% of the catch at Inaccessible is undersized and discarded. At Gough, the MLS has been increased recently to 75mm, as very few undersized lobsters were being caught, and the TAC was not reached. A standard mesh size of 70mm is used on all the traps, and lobsters can escape, at least in theory, from the opening through which they entered.

A fisheries observer from Tristan is present on the *Edinburgh* at all times when the ship is fishing.

Landings and stock assessment

Table 14 shows the catch of the fishery at the four islands in recent years. The figures show a general increase in total catch, to a maximum of 442 tons in 2009/10, but the breakdown between the islands shows variations between them. There was a decrease at Gough between 2004/5 and 2008/9, where quotas were lowered because the full TAC was not caught here in the early years of the present concession. The fishery at Nightingale, the island with smallest fishing area, was closed from March 2011 to November 2012 after the wreck of the bulk carrier *Oliva* spilled 1,500 tons fuel oil and 65,000 tons soya beans into the sea. Catches from Inaccessible were high between 2005/6 and 2009/10, but have recently returned to former levels.

Season	Gough	Nightingale	Inaccessible	Tristan	Total
1996/7	104	63	73	119	359
1997/8	86	51	61	112	310
1998/9	88	51	60	114	313
1999/0	93	51	63	122	329
2000/1	75	51	65	124	315
2001/2	80	56	69	127	332
2002/3	80	55	69	133	337
2003/4	83	56	75	138	352
2004/5	55	61	86	158	360
2005/6	56	61	91	161	369
2006/7	55	61	101	180	397
2007/8	61	64	112	187	424
2008/9	66	71	112	186	435
2009/10	77	72.6	109.9	182.5	442
2010/11	86.8	62.7	53.3	180.8	383.6
2011/12	95.8	*0	53.7	174.8	324.3
2012/13	95.6	40.4	70.4	171	377.4
2013/14	95.6	66.2	70.9	166	398.7
2014/15	105.5	75.4	78.2	Still fishing at time of report	

Table 14: Recent catch (tons) for the Tristan islands from Ovenstone summary reports provided to the Tristan Fisheries Department and MARAM. *Nightingale fishery closed for 2011/12 season following the *Oliva* incident (reproduced from MacAlister Elliott & Partners 2011, updated from 2009/10 fishing season by Tristan Fisheries Department).

Stock assessment and fishery modeling

MacAlister Elliott & Partners (2011) detail the modeling used to derive estimates of surplus production (i.e. the annual sustainable yield), used in setting TACs for the fishery. Catch per unit effort (CPUE) data, a standard measurement used in most fisheries as the basis for modeling, has proved problematic at the islands as there are several different catch methods used - powerboats at Tristan deploying both traps and hoop nets, while the Edinburgh uses powerboats and longlines at the offshore islands. Attempts have been made to correct and standardize the effort data in order to produce standardized time series of CPUE which can act as an unbiased proxy for stock biomass at each island. However the results were inconclusive in identifying trends over the period of the Ovenstone concession.

Recent TACs are considered to be conservative and precautionary, especially for Gough. Quotas are regularly reviewed with input from MARAM at the University of Cape Town. Fishery independent biomass surveys have been running since 2006, and are carried out prior to the start of each fishing season. MARAM and the Tristan Fisheries Department have been working together to produce Harvest Control Rules (HCR) and Operation Management Procedures (OMP) as part of MSC certification requirements. These are currently in place in Tristan, Inaccessible and Gough and will be introduced at Nightingale for the 2016/17 season. Fuller details of current fishery management can be found in Glass (2014) and MacAlister Elliott & Partners (2011).

Glass (2015) notes that some findings from his study of lobster fecundity at the islands may be cause for concern. The CPUE at the three northern islands has declined since 1996, especially at Tristan and Inaccessible, and the average size of lobsters has also declined in recent years. Both the number and size of eggs carried by female lobsters also appears to be lower than in previous studies, although this may be due to differences in study methods. Taken together, these changes could imply some reduction in the productivity of the lobster stock, perhaps due to long-term oceanographic changes or fisheries impacts.

Glass (2015) also comments that Tristan da Cunha, like other small island territories of the UK, is being encouraged to establish marine protected areas, and that it is often claimed that such areas can enhance fisheries, by protecting large adults which contribute to recruitment.

IUU fishing

Roscoe (1979) noted that poaching has been a recurring problem at the islands, and said that poaching had occurred in 1970, 1972, 1973 and 1974, and, judging by the recovery of fishing gear by the company, there must have been other occurrences of illegal fishing. From catches landed at Cape Town, it had been estimated that since 1965 (up to Roscoe's work in 1971) at least 75 tons of tails had been taken illegally.

IUU fishing at Gough is proven for some years, notably in 2003/4 and 2004/5 seasons, when 35 and 44 tons respectively were detected by documentation of landings and export of *Jasus tristani* from vessels other than the *MV Edinburgh* at Cape Town. Apart from Vema Seamount, where lobster populations were rapidly depleted following uncontrolled international fishing between 1964-1966 (Heydorn 1969) (and have apparently never fully recovered) there is no other source area for *Jasus tristani* landings in Cape Town, which makes illegal landings here relatively easy to detect, particularly with modern methods of genetic testing (but see notes below on recent genetic work showing that *J. tristani* is probably conspecific with *J. paulensis* from St Paul & Amsterdam in the southern Indian Ocean). The reported illegal catches of the order of 40 tons are a significant amount out of a small lobster population vulnerable to overfishing, and where the legal fishery lands only around 400 tons per year. MacAlister Elliott & Partners (2011) note that Ovenstone had not sighted any suspicious vessels or gear, or had reports of sales of *J. tristani* since the 2006/7 season. However, in January 2014 a fishing vessel departed the waters near Gough without identifying itself after being challenged by the *MV Edinburgh*, which had just arrived (Captain Clarence October, pers. comm.).

The fisheries observer working on licensed fishing vessels (for finfish) on the sea mounts in 2014 and 2015 found evidence of six different types of illegal fishing gear including gillnets, longlines and traps.

Policing such a remote area is very difficult and costly. UK navy vessels, and a fisheries patrol vessel that normally covers the Falklands and South Georgia, occasionally visit Gough, but provide little deterrent to opportunistic illegal fishing when they are not around. With improved equipment for detection of vessels near the top islands in recent years, illegal fishing there is less likely. The island now monitors shipping inside the Tristan da Cunha Marine Zone (EEZ) through satellite detection of AIS signals from a system called Exact Earth. This in theory will allow the island to detect suspicious behavior from large vessels using AIS (most fishing vessels found in the middle of the south Atlantic). However vessels can easily switch off or tamper with AIS systems and the internet connection on the island makes monitoring this system difficult.

Bycatch

The fishery has a bycatch of octopus, generally between 10-16 tons (with highs of 22 tons in 2003/4 season and 18 tons in 2014/15), which is caught in the lobster traps and also sold. The species caught appears to be predominantly *Octopus vulgaris*, which has a global distribution in tropical and temperate waters.

A second, deeper water species, thought to be *O. magnificus* (although there is some doubt as to this identification) is caught more rarely. *O. magnificus* also occurs on the continental shelf of South Africa. The two are not recorded separately in catch records, but *O. vulgaris* is reported to make up around 90% of the octopus catch. (On Tristan, octopus ('catfish') are caught for both personal consumption and for bait).

Figure 134: Octopus are common around the islands, and can grow very large. They are a bycatch of the rock lobster fishery, and are also sold commercially.

Several fish species are caught regularly in lobster traps, and often retained for personal consumption of fishermen and crew, or for use as bait. Fivefinger *Nemadactylus monodactylus* and the two scorpaenid fishes, *Sebastes capensis* and *Helicolenus mouchezii*, are regular bycatch. The MSC final report mentions *S. capensis* as a bycatch species, but not *H. mouchezii*, possibly because they are both called 'soldiers' locally. Although less commonly caught than *S. capensis* (Andrew et al 1995), *H. mouchezii* is caught in traps in deeper water (Latham 2014; see below). There is a minimum size limit for retaining all these species.

To further quantify amounts and type of bycatch, a study as part of a Darwin Plus project (DPLUS 005) looked at bycatch from monster traps set by the *Edinburgh* during a 7-day period around Tristan (Latham 2014). Of 1080 traps sampled, 546 (50.6%) contained at least one item of bycatch. A total of 1099 bycatch items were recorded, averaging one bycatch record for every 5.19kg of lobster caught. Only eight species were recorded; fivefinger *Nemadactylus monodactylus* was the largest occurrence at 35.9%, followed by *Octopus vulgaris* (24.5%), jacopever (soldier) *Helicolenus mouchezi* (18.5%) and false jacopever (soldier) *Sebastes capensis* (17.2%). Tristan whelks *Argobuccinum tristanense* were also relatively common in traps; recorded more rarely were starfish *Henricia* sp, the hairy conger *Bassanago nielseni* and branches of a seafan.

When the results from this study were analyzed further into depth ranges, observers found that occurrences of bycatch decreased with depth, with 446 records from 29-49m, 374 from 50-99m and 279 from 100-151m (from approximately similar numbers of traps in each depth range). This reflects the depth preferences of the main bycatch species, with records of fivefinger, octopus and whelks highest in the shallow traps, false jacopever *Sebastes capensis* in similar numbers at all depths, and jacopever *Helicolenus mouchesi* in greater numbers in traps deeper than 50m. Gorgonian fragments were only present in traps deeper than 50m. Latham (2014) commented that, particularly when there are large numbers of lobsters in the catch, whelks are under-recorded by their observation method, and recommended a total count on the sorting table at the end of each line. Further recording to establish any differences at other islands, particularly at Gough with its different marine communities (which include greater numbers of *Sebastes capensis* in shallow water, and greater numbers of whelks, (Scott & Holt in prep)), and during different seasons, was also recommended.

Figure 135: Whelks (left) are a common bycatch in fish traps, and three-spotted swimming crabs (center) are also regularly caught. The curious round bellowsfish (piper) *Notopogon lillei* is common below 40m at all the islands, and occasionally caught in traps.

Fish species caught occasionally or rarely in lobster traps, and generally discarded, include the banded snipefish (piper) *Centriscops obliquus*, round bellowsfish (piper) *Notopogon lillei*, the serranid *Lepidoperca coatsii*, and the hairy conger *Bassanago nielseni*. Latham (2014) comments that it was not clear from observing the release of discarded fish whether they survive or suffer any significant sub-lethal effects. On several occasions fivefinger were seen to swim when discarded overboard, but jacopever and false jacopever, especially those from deeper traps, often had over-inflated swim bladders and did not appear to swim when released.

Effects on other species

Seabirds

Setting of traps for lobsters is not a threat to seabirds, and they are not at risk from daytime fishing operations. Giant petrels and skuas are attracted to the ship and powerboats by discarding of lobster shells, other products of shipboard processing and unwanted bait. However at night, many seabirds, particularly prions, storm petrels and smaller petrel species, are attracted to ship lights and in the early days of fishing deaths occurred from ship strikes. Following advice from seabird experts, deck lights are now switched off and blinds used on ship windows at night, reducing bird deaths to almost zero.

Seabed life

In depths of less than 50m, the hoop nets and smaller box traps used to catch rock lobsters are likely to do little damage to seabed life. Above 40m, marine life is accustomed to strong water movement and the seabed is heavily urchin-grazed, so organisms here are adapted to rigorous conditions including scour from loose cobbles and pebbles moving around in storms. Delicate animals are confined to crevices, caves and overhangs where urchins cannot reach (Scott 2008, 2010a, 2010b, Scott& Holt in prep), and which are not likely to be impacted by fishing gear. Life on vertical walls and boulder sides may occasionally be damaged on hauling and setting the heavier traps.

Very little is known about seabed life at the main depths fished by the heavier 'monster' traps. These heavy steel traps have the potential to damage delicate animals and those that project above the seabed if they land on them or are dragged across the seabed; the ropes connecting them could also dislodge seabed biota.

A survey by BAS (2013), using seabed trawls and camera, has provided some information on seabed life between 150-300m around all four islands, although this was limited to relatively level seabeds. Small cup corals were abundant on all hard substrata, as well as loose-lying on sediments; it is not known whether the latter were originally attached. Limited information was gathered from rugged bedrock, which is likely to be the main lobster habitat, but in places seafans were abundant together with other octocorals, erect bryozoans and sponges. Black coral *Leiopathes* sp was found off the north of Nightingale.

The octocorals and black coral carried many small animals, including brittlestars, anemones, barnacles and tubeworms. All these organisms stick up from the seabed and are vulnerable to snagging on traps. Cup corals and the seafan *Callogorgia* have been seen (rarely) by divers in depths of 28-40m, and both are abundant by 150m, so obviously become abundant somewhere in between; the depths commonly fished by monster traps are 50-200m. *Callogorgia*, other seafans and cup corals are occasionally brought up on traps (pers.obs.), but much of the biota snagged by traps is likely to wash off during hauling.

Figure 136: Some animals in deeper water that may be vulnerable to damage from heavy fishing gear. Left: sea fans at 40m (Tristan). Right: camera lander image from around 170m depth northwest of Nightingale, with black coral (white, to left of photo; only the skeleton is black), erect hydroids and bryozoans, and small cup corals.

When the *Edinburgh* was setting monster traps off Tristan in 2014, observers inspected a subsample of five traps from each line of 20 traps, for biota that had been caught inside the trap or snagged on rope on the outside of the trap (Latham 2014). 41 traps from eight lines were observed over two days, in an area to the south east of Tristan between Cave Point and Sandy Point. 18 traps had fragments of seabed fauna and/or flora, most prevalent being small sections of seafan (four traps) and bryozoan (three traps). However, the observers concluded that the level of flora and fauna retained on the trap was not sufficient to accurately reflect any interaction of the traps with the seabed, as it is likely that most of the larger biota which was snagged washes off during hauling.

Tristan is the only island that is mainly fished by local boats using smaller capture gear. However, in recent years, the *Edinburgh* is increasingly 'mopping up' Tristan quota if it is not fished by islanders at the end of the season, using longlines of monster traps. This may be of concern; while the impact of longlines of monster traps on the seabed biota and lobster habitat is still unknown, it is likely to be more damaging than the smaller local traps and hoop nets. Maintaining Tristan free of the heavier gear and more intensive fishing may well be beneficial for seabed biota, and lobster stocks in the longer term.

Organizations and others involved in fishery management

The organizations involved in fisheries management and their roles are summarized in Table 15. Outside 'stakeholders' are also invited to submit comments on re-assessments for MSC certification. Experts in the field are consulted from time to time, and a recent Darwin Plus project (DPLUS005) provided a fisheries expert to work with the fisheries department on island for several months to provide advice on data gathering and processing, and on aspects of research needed on lobster biology.

Organization	Role
Tristan Fisheries Department	Responsible for the day-to-day management of the fishery – gathers and analyses data, enforces regulations, makes recommendations to the Island Council and Administrator on TACs and other regulations.
Tristan Island Council and Tristan Island Administrator	Recommendations on the resource are made by the Tristan Fisheries Department for consideration by the Island council headed by the Administrator who then ultimately approves the allowable catch and any other fishing conditions.
Ovenstone Agencies (Pty) Ltd.	The sole concession-holder for the fishery – operates the fishery. Provides data on catches and effort to the Fisheries Department. As the only concession holder, the regular fishing activity by the *MFV Edinburgh* provides Tristan da Cunha with

	the main transport and cargo link with the outside world, as well as the main source of income for the Island.
MARAM, University of Cape Town	Provides scientific support to the Fisheries Department on data analysis and stock assessment. Paid by Ovenstone for this work
Governor of St. Helena, UK Foreign and Commonwealth Office (FCO), UK Department for International Development (DfID)	The Governor of British Overseas Territory of St. Helena (employed by the FCO) is the formal head of Tristan da Cunha, although in practice the Island Council and Island Administrator play a more significant role. DfID provide funds from time to time, such as for reviews of the management and assessment of the fishery.
MRAG	MRAG have been employed by the Tristan administration and funded by DfID to undertake the above review.
MSC, London MacAlister Elliott & Partners, Lymington	MSC assessment of the rock lobster fishery

Table 15: Organizations involved in the Tristan rock lobster fishery, and their roles (from MacAlister Elliott & Partners 2011)

6.2.3. Biology of the Tristan rock lobster *Jasus tristani*

Taxonomic status

For some time authorities have been debating the taxonomic status of *Jasus* rock lobsters in the Southern hemisphere. Holthuis & Sivertsen (1967), focusing on morphological features, recognized two main groups of the genus *Jasus*, a 'typical' 'lalandii' group (six species), with squamiform sculpturing on the abdomen, and a 'verreauxi' group with no sculpturing, and only one species (*J. verreauxi*, now placed in a separate genus, *Sagmariasus*). They further subdivided the 'lalandii' group on the basis of differences in carapace spines, into a 'lalandii' subgroup made up of *J. lalandii*, *J. edwardsii* and *J. novaehollandiae*, and a 'frontalis' group including *J. frontalis* from the Juan Fernandez Islands, *J. tristani* from Tristan, Gough and the Vema Seamount, and *J. paulensis* from the St Paul & Amsterdam Islands in the southern Indian Ocean. *Jasus novaehollandiae* has since been synonymised with *J. edwardsii*, and another species, *J. caveorum*, was described in 1995 from seamounts southeast of Pitcairn Island in the southeast Pacific (Webber & Booth 1995).

Recent genetic work has shed further light on relationships between apparently disjunct populations in the South Atlantic and Indian Ocean. Groeneveld et al (2012) sequenced genes from samples of lobsters from Gough, Inaccessible, Vema Seamount and two Indian Ocean sites, Seamount 150 and St Paul and Amsterdam Islands, and found that they were highly similar across their range, and different to all other *Jasus* species. They suggested that *J. paulensis* and *J. tristani* should be synonymised (as *J. paulensis*, the prior name). This has been accepted by WoRMS (World Register of Marine Species), which now lists *J. tristani* as an unaccepted name. Other populations of rock lobsters have been reported by exploratory fishing at other Indian Ocean seamounts, but have not always been identified to species; the authors say there are probably many more small populations of *Jasus tristani/paulensis* dispersed throughout the southern Indian Ocean.

Figure 137: Tristan rock lobster *Jasus tristani*

Genetic work has also indicated that there is 'shallow but significant' genetic partitioning between the populations at Vema and the Tristan islands, while no differences were detected between samples from Tristan, Nightingale, Inaccessible and Gough (von der Heyden et al 2007). The authors suggested that limited gene flow between Vema and the other locations was possibly mediated by larval dispersal in the South Atlantic gyre system.

Results are interpreted to show that *J. tristani* populations in the southern Atlantic share a most recent common ancestry that dates back at least one million years, estimate population divergence between Vema and the other populations at approximately 270,000 years ago, and suggest that *J. tristani* underwent a population expansion between 12,000 and 99,000 years ago. Pollock (1990) suggests that local extinctions may have occurred at Gough and at St Paul & Amsterdam during glaxial maxima, followed by recolonizations from ancestral northern areas (Tristan and Vema). This is not supported by values of genetic diversity, which are higher in the Indian Ocean populations than at Tristan (Groeneveld et al 2012), but there may be other explanations for this.

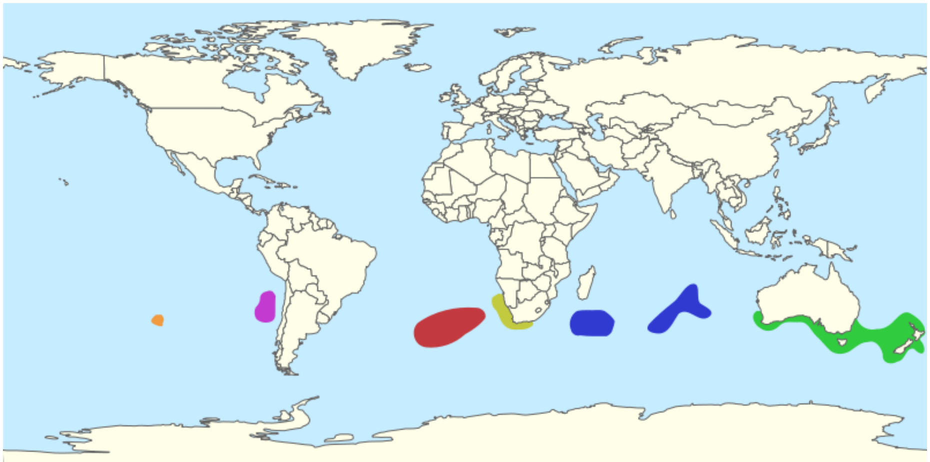

Figure 138: Approximate distributions of the extant species of *Jasus*. Orange: *J. caveorum*; pink: *J. frontalis*; red: *J. tristani*; yellow: *J. lalandii*; blue: *J. paulensis*; green: *J. edwardsii*. (*J. tristani* and *J. paulensis* are now regarded as the same species (Groeneveld et al 2012)). [After Phillips 2006]

The taxonomic status of rock lobster populations and any current connectivity between them has implications for fisheries management. For example, it is important to establish whether long-lived larvae produced in one area sustain populations in other areas, which may also support a fishery. There is a fishery for *Jasus tristani/paulensis* at St Paul and Amsterdam Islands, over 6,000 km distant from Tristan. Although the recent genetic work indicates high connectivity between these populations, the mechanisms remain unknown, and for the purposes of fishery management, they are currently treated as separate populations.

Habitat and biology

Scott and Franklin (2011) summarized information from various sources on the biology of *Jasus tristani*, to inform actions following the wreck of the Oliva on Nightingale; this work is the source of much of the information below.

Tristan lobsters generally occur on rocky seabeds in depths less than 200m, but have been reportedly caught as deep as 300 fathoms (550m) to the northwest of Nightingale (Heydorn 1969). Direct observations of adult lobsters within diving depths (above 30m) indicate that, at least during the day, they prefer rocky ground, inhabiting crevices, vertical walls, overhangs, cave roofs, and holes under boulders, and are also found within the kelp forest (Pollock 1991, Scott 2010, 2015). They are also occasionally seen walking across open sediment areas.

Like other rock lobsters, *J. tristani* are assumed to venture out at night to forage for food. Female lobsters are caught in traps only at night. In rock pools on Tristan, young lobsters were observed to come out of hiding at dusk and climb to an elevated position on kelp plants (S Scott, pers. obs. 09.10.11). Limited work on examination of their gut contents found them to contain mainly seaweed, including kelp and smaller red seaweeds (Heydorn 1969, Pollock 1991, Scott 2008), though these authors generally agree that a significant part of their nutrition probably comes from epiphytic animals and infauna that are often abundant amongst the seaweeds, and ingested with them. Shallow seaweed turfs contain small bivalves, worms and crustaceans, and kelp fronds and other seaweeds often have bryozoans, hydroids and spirorbid worms attached. Heydorn (1969) commented that the eagerness with which bait is taken indicates that eating seaweed is by necessity and not by choice. Pollock (1991) reported that adult lobsters also eat urchins, barnacles, and whelks, and considered them to be opportunistic omnivores, feeding on both plant and animal material they come across while foraging away from their shelters. Heydorn (1969) did not find remains of sea urchins in the stomach contents of lobsters, but commented that the spines are possibly too stout to be masticable.

Lobsters do not feed while molting (James Glass, pers. comm.). Diet changes according to moult stage, season and habitat are well known in other rock lobster species. For example, the Australian western rock lobster *Panulirus cygnus* postmolt lobsters prefer epiphytic coralline algae (e.g. *Corallina* species), while intermoult forms prefer molluscan items (Scientific Certification Systems 2012). Adult *Panulirus cygnus* eat similar but larger food to that of juveniles - coralline algae, mollusks, small crustaceans, polychaete worms and sipunculids.

The main predators of adult rock lobsters are octopus, which are numerous and grow very large on Tristan. Sharks and seals may also take adult rock lobsters. Very small lobsters are very vulnerable to predation by fish as well as octopus. A study of the diet of fivefinger *Acantholatris monodactylus* found that they regularly eat juvenile lobsters (Andrew & Hecht 1992). Pollock (1991) reported that several small lobsters with carapace length 20-30mm, found by divers in the algal turf at the waterline and released 2m deeper, were immediately eaten by soldierfish *Sebastes capensis*. Recently, a juvenile lobster was found in the gut of a porgy (*Diplodus argenteus*), a fish introduced to Tristan with a stranded oil rig in 2006 (Charles Kilgour, pers.comm). These fish are now abundant all around Tristan and more research is needed to establish whether they likely to impact on lobster populations.

Figure 139 - Left: post-puerulus lobster newly settled from the plankton, just starting to acquire pigmentation. (centimeter scale). Right - many cast molts of lobster pueruli are washed up on Tristan beaches after storms.

The limited amount of work done at the top islands on depth and habitat distribution of pueruli larvae newly-settled from the plankton, and very small post-pueruli juveniles, has indicated that they inhabit the lower shore and very shallow subtidal, mainly in the surf zone, and that barnacle shells and small holes, as well as dense seaweeds, are important refuges from predatory fish (Pollock 1991, Scott 2008). During subtidal surveys at Gough, the only place very small lobsters were seen was amongst barnacles, hard leafy coralline seaweeds and other seaweeds in the subtidal fringe (Scott and Holt, in prep). Juvenile lobsters (estimated 0 to 3-4 years old), are also common in rock pools, especially in the extensive rock pool and reef systems at Runaway Beach and around the harbor on Tristan. After storms, numerous casts of pueruli and young juveniles (depending on season) are cast ashore on Tristan beaches near these rock pools. There are no equivalent areas of extensive rock pools on the other islands, although there are a few on Nightingale. These pools have fewer predatory fish than the open coast, but are still patrolled by large octopus that can presumably consume large numbers of small lobsters. In Tristan rock pools at least, these large octopus are regularly caught for consumption or bait.

Areas of smaller boulder habitat in shallow water are probably also an important refuge for juvenile lobsters, and provide a safe route to deeper water. Pollock (1991) suggests that greater numbers of juvenile lobsters surviving into the deeper subtidal at Inaccessible, where shallow boulder habitat is more extensive than at the other islands, accounts for the difference in the size structure of populations here compared to the other islands. The larger numbers surviving at Inaccessible consequently have to compete more for food and do not grow so fast, resulting in a larger numbers of smaller lobsters.

The lack of knowledge of the biology of these small lobster stages was highlighted after the wreck of the bulk carrier Oliva at Nightingale in 2011, when there was concern over the effects of oil on tiny lobsters in the surf zone, the area most likely to be affected by oil slicks (Scott and Franklin 2011). Diving surveys were done too late to observe any immediate mortality, and there were no previous counts for comparison. Research into the habitat, depth preferences, seasonality and other aspects of the biology of these very young stages is a priority for the ongoing Darwin Plus Project (DPLUS005).

Figure 140: Abundant juvenile lobsters in rock pools at Runaway Beach, Tristan.

Tristan rock lobsters have a pronounced seasonal cycle of growth and reproduction (information from James Glass, Director of Fisheries on Tristan). On Tristan, female lobsters moult in shallow water sometime between February and May, and do not feed while molting. They then mate and come into berry (carry eggs and developing larvae) from May onwards (autumn/winter on Tristan).

Large numbers of berried lobsters can be found in rock pools between June and October. The peak berry season is June to August (winter), when 75% of adult females are in berry. By September, 90% of females have released their larvae into the sea, with a few, mostly smaller females, releasing until November. Male lobsters moult September to November.

Larvae of the various *Jasus* species can spend 8-24 months drifting in the ocean currents (Booth 2006), going through many moults as a flattened, transparent, leaf-like and leggy phyllosoma larva, before returning to coasts or shallow seamounts where they finally metamorphose into a post-larval stage (puerulus) and settle on the seabed. The larval development of *J. tristani* is assumed to follow this general pattern, but how long the larvae remain out at sea and how they find their way back to Tristan is still the subject of debate. From Tristan, passive drifting in residual surface currents would take newly-spawned larvae towards the South African coast, then in a huge gyre northwards around the Atlantic, through tropical waters, eventually drifting back to the Tristan islands - improbably small targets in a vast ocean - up to three years later. Local gyres may provide a short-cut to this route. *Jasus* larvae can also delay final metamorphosis ('mark-time' molting) to extend their time in the plankton (Booth 1994), which has implications for settling times, enabling larvae to settle over many months of the year. However, more recent work on larvae of *Jasus* species, which sampled a wide area of ocean spanning the distributions of several species (although not *J tristani*), and used DNA analyses to identify larvae to species level, found the vast majority of larvae within a relatively short distance (50 to several hundred km) of their parent species coastal range, suggesting that they had mechanisms to keep them from drifting too far away (Booth and Ovenden 2000). Mechanisms suggested for keeping the larvae near their home patch include selectively using sub-surface currents, and requiring cues specific to their 'home' coast before they will settle. However, it is not known if *Jasus tristani* larvae use such cues. The recent genetic work connecting *J tristani* and *J paulensis* (Groeneveld et al 2012, see above) also has implications for larval dispersal mechanisms, to explain the genetic connectivity between the widely separated rock lobster populations on the Tristan islands, the Vema seamount, and the seamounts and islands of the southern Indian Ocean.

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7. Conservation and threats

7.1. Current protection measures

7.1.1. Designations and boundaries

The need for conservation was formally recognized by the 1976 Conservation Ordinance which declared Gough Island and adjacent territorial waters out to three nautical miles a wildlife reserve, and broadly provided for the conservation of flora and fauna of all the islands, as well as the territorial waters. The 1976 legislation was amended in 1984, 1986 and finally in 1997, when Inaccessible Island and its territorial waters, within 12 nautical miles of the island, was declared a Nature Reserve. The same amendment changed the designation of Gough Island from a Wildlife Reserve to a Nature Reserve, and extended the area of the Nature Reserve to include the territorial waters out to 12 nautical miles. In February 2006, the Tristan da Cunha Conservation Ordinance 1976 was replaced by the modern and comprehensive Conservation of Native Organisms and Natural Habitats (Tristan da Cunha) Ordinance 2006. This update declared all breeding colonies of the Northern Rockhopper Penguin on Tristan as Nature Reserves, and also allowed Tristan to join the Agreement on Conservation of Albatrosses and Petrels (ACAP).

In 1995 Gough and the surrounding waters to three nautical miles was declared a World Heritage Site (WHS). In 2004 the site was extended to include Inaccessible Island and the surrounding waters of both islands to 12 nautical miles. In 2008, the UK Government designated Gough and Inaccessible islands and their territorial waters Wetlands of International Importance under the Ramsar Convention, followed by formal listing by the Convention in September 2009 as site number 1868 (Gough) and 1869 (Inaccessible).

Early management plans were produced for Gough (Cooper and Ryan 1994) and Inaccessible (Ryan and Glass 2001), and these contain comprehensive accounts of the natural and human history of the islands. A Site Management Plan was produced for the WHS (RSPB and Tristan da Cunha Government 2010), which sets out the shared vision and management objectives of the Tristan Island Council and other stakeholders for the period 2010-2015. This document sees the threat from non-native invasive species as the key conservation challenge, and in the case of Gough and Inaccessible, especially from introduced House Mice *Mus musculus*, plants and invertebrates. Both eradication of existing pests and prevention of further introductions are seen as important goals, whilst minimizing further disturbance.

A Tristan Conservation Officer was appointed in 2005, initially to the Agriculture and Natural Resources Department, but since 2008 the Conservation Officer has headed a separate Conservation Department within the government structure. Tristan has been included in the UK's ratification of 16 multilateral environmental agreements (MEAs), including (as well as World Heritage and Ramsar) the Convention on Biological Diversity, Convention on International Trade in Endangered Species, and the Convention on Migratory Species.

The Tristan da Cunha Fisheries Limits Ordinance 1983 (amended 1991 and 1992) defines the fisheries limits around Gough and the Tristan top islands as 200nm, within which commercial fishing without a license is prohibited. At a meeting of the Tristan Island Council in 2001, the whole island group out to these 200nm limits was declared a whale sanctuary.

An assessment of the environmental protection frameworks in the UKOTs (FIELD and RSPB 2013) concludes that for native species, the legislative framework of Tristan da Cunha provides robust general protection, complemented by the Tristan Biodiversity Action Plan (BAP) and ACAP. The site protection framework also has robust elements, although further management plans are needed. It is not clear in legislation that new site designations would take place on science-based criteria. However, the document considers the development control framework as very limited, and that it has not been seen as a local legislative priority. It highlights the lack of Environmental Impact Assessments (EIAs) for infrastructure and development projects, although action points in the Tristan BAP include that policies will be produced that require EIAs, and the proposed construction of a new harbor will undergo EIA in particular to mitigate introduction of potential invasive species. It also comments that the lack of EIA procedures and the absence of ability to appeal decisions is an area of weakness for the Tristan people. The document gives an overall assessment of framework protection as: Species - moderate; Sites - moderate; Development control - very weak/absent; People - Weak.

7.1.2. Biodiversity action plans

Biodiversity Action Plans for Tristan have been produced, updated and adopted by the Tristan community (Tristan da Cunha Government and RSPB 2012). The plan for Tristan is to some extent an 'umbrella' plan for all the islands, but there is a separate site-specific management plan for the Gough and Inaccessible WHS (updated in 2015), and one for Nightingale is in preparation. These plans and annexes to them contain much useful background information on biodiversity and habitats, the threats to them, and agreed actions towards their conservation and sustainable use.

The overall goal of the Tristan BAP is "to conserve the native biological diversity of Tristan da Cunha so that the people of Tristan da Cunha continue to benefit from it and the entire world is enriched by it. To this end, the plan seeks to halt, and in some cases reverse, the rate of biodiversity decline on Tristan da Cunha. The plan will enable the people of Tristan da Cunha to contribute actively to the conservation of biodiversity on their islands and to benefit from it." Main objectives of the plan are:

1. Conservation is integrated into all Government programs, policies and plans (both those of Tristan Government and those of the UK that affect Tristan).
2. Support for biodiversity conservation is strengthened on Tristan.
3. Tristanians have the capacity to manage biodiversity effectively.
4. The impact of invasive alien species is reduced or eliminated.
5. The sustainable use and management of the marine environment is enhanced.
6. The knowledge of Tristan's key habitats and species is increased.

The BAP lists many and far-reaching aims, with the document to be revised and updated every five years. It includes introducing and enforcing adequate conservation legislation to protect species and habitats; maintaining optimal conservation status of the protected sites in the Tristan da Cunha group; and strengthening technical skills to manage biodiversity effectively.

Section 5 of the BAP concerns enhancement of the sustainable use and management of the marine environment, and this is reproduced in full here:

5.1. The sustainability of the legal fishery will be ensured (Environment Charter Commitments 1, 3, 7)

5.1.1. Advice on fisheries management will be sought from other South Atlantic UK Overseas Territories, South Africa and the UK.
5.1.2. Fish stocks will be monitored in order to provide better data to inform quota levels.
5.1.3. Marine Stewardship Council (MSC) certification requirements for the Tristan Rock Lobster fishery will be complied with.
5.1.4. A monitoring plan to monitor the Catch Per Unit Effort (CPUE) of the Tristan Rock Lobster at Nightingale until the fishery returns to pre-*Oliva* catches will be developed and implemented.
5.1.5. Harvest Control Rules (HCR) and Operation Management Procedures (OMP) will be implemented.
5.1.6. Research into the larval and early settlement stages of the Tristan Rock Lobster will be instigated in order to better understand recruitment to the fishery and prediction of sustainable yields.

5.2. The impact of the legal fishery on the marine environment will be minimised (Environment Charter Commitments 2, 6)

5.2.1. All fishing vessels (long-liners and trawlers) will carry a Fisheries Department observer or International Observer on board to verify compliance with license conditions and to ensure that bycatch mitigation measures are used.
5.2.2. Fishing licenses will include a condition that mitigation measures are employed to minimize by-catch of non-target marine species and seabirds.
5.2.3. Data on bird bycatch will be collected in updated Fisheries logbooks and analysed annually, and made available through the Tristan da Cunha website.
5.2.4. Existing procedures for ship-to-ship, and ship-to-shore transfer of fuel will be followed and contingency measures will be in place and implemented in the event of a fuel spill.
5.2.5. Fishing activities will not facilitate the spread of alien marine introductions between the islands.
5.2.6. Fishing activities will have minimal effects on deep-water seabed life. This requires much greater knowledge of deep-water marine life and habitats around the islands.

5.3. Illegal fishing in the Tristan EEZ will be minimised (Environment Charter Commitments 2, 6, 8)

5.3.1. Regular patrol assistance will be requested from licensed fishing boats, research vessels and naval vessels.
5.3.2. The means of setting up a system for monitoring fishing vessels in the Tristan EEZ will be investigated. This may include use of a long-range patrol vessel and surveillance by remotely operated radar installed on either Nightingale or Inaccessible Islands.
5.3.3. An Automatic Identification System (AIS) to monitor vessels passing within 100 miles of Tristan and Gough Islands will be installed.
5.3.4. The scale of illegal fishing will be determined by monitoring reports of landings of Tristan Rock Lobster at foreign ports.
5.3.5. Tristan Government will engage with regional and international fisheries organisations especially the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the South East Atlantic Fisheries Organisation (SEAFO).

5.4. The marine biodiversity of Tristan will be maintained at its current level (Environment Charter Commitments 2, 7, 10)

5.4.1. The existing collections of preserved marine animals and seaweeds will be identified.
5.4.2. Published information from previous surveys on the marine ecosystems will be collected and collated and further work required to establish a baseline of information on marine life will be identified and implemented.
5.4.3. The contingency plan for alien marine introductions and other marine incidents will be revised and implemented.
5.4.4. Fisheries and Conservation department staff and Darwin team members will have familiarity with the identification of the introduced marine species in the marine environment contingency plan.
5.4.5. The potential impact of introduced species on the native marine life, particularly on economically important species will be identified, and mitigation measures to minimise the likelihood of such introductions occurring will be introduced.
5.4.6. The status of the alien South American Silver Porgy *Diplodus argenteus argenteus* and its impacts on the local fish and marine ecosystem will be monitored.
5.4.7. The settlement of alien marine invertebrates and distribution of vertebrates that arrived with the oil rig will be surveyed.
5.4.8. Alien marine species introduced at Nightingale as a result of the grounding of the MS *Oliva* will be identified and contingency measures for control/eradication will be developed and implemented. In particular, the mussels that arrived will be relocated and eradicated.
5.4.9. Improved sewage handling on Tristan will ensure that impact on the marine environment is minimised.

5.4.10. Awareness on island of the issue of plastic and other pollution at sea will be raised and international partners supported to address this issue.
5.4.11. The potential impact of experimental long-lining and trawling around the Tristan islands on Shepherd's Beaked Whale *Tasmacetus shepherdi* will be investigated.

Section 6 of the BAP is concerned with improving baseline information on species and habitats. For the marine environment, this includes:

6.5. Baseline information on marine animal and plant species and habitats around the Tristan islands will be expanded (Environment Charter Commitments 2, 7)

6.5.1. Fur seal numbers on Tristan will be counted annually (Annex 9).
6.5.2. Southern Elephant Seals *Mirounga leonina* will be monitored on Gough.
6.5.3. The occurrence of cetaceans, in particular, Shepherd's Beaked Whales around Tristan will be investigated.
6.5.4. Specialist collection and identification of lesser-known marine animal and seaweed groups will continue.
6.5.5. Basic knowledge on the dynamics of the shallow water marine environment, including seasonal changes, food chains and reproductive timing and requirements of key marine species will be acquired.
6.5.6. Intertidal and subtidal diving surveys on Gough using methods comparable to those used on Tristan, Nightingale and Inaccessible will be carried out.
6.5.7. Key habitats and species in deeper waters around the islands, using video and limited remote sampling will be surveyed and documented.

Other key points for the marine environment include (with paragraph numbering as in the BAP document):

1.4.2. The proposed construction of a new harbour, or improvements to the existing harbour, will be preceded by an environmental impact assessment, in particular to reduce the risk of introducing invasive species.

1.4.4. Any expansion or diversification of fisheries will be preceded by an environmental impact assessment.

3.1.3. Programmes will be introduced to monitor any harvest of Great Shearwater *Ardenna gravis* eggs and chicks and Northern Rockhopper Penguin *Eudyptes moseleyi* eggs on Nightingale and Middle (Alex) Islands.

3.2.12. With assistance from the Foreign and Commonwealth Office, the establishment of a Particularly Sensitive Sea Area (PSSA) and/or a Marine Protected Area (MPA) around the Tristan islands will be investigated.

Raising awareness, both on and off the island, of biodiversity issues also results in many action points.

7.1.3. International conventions

As a part of a UK Overseas Territory, Tristan is included under the ratification by the UK of various international conventions, including: The Convention on Biological Diversity (the CBD); The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); The Convention on Wetlands of International Importance, especially as Waterfowl Habitat (the Ramsar Convention); The Convention on the Conservation of Migratory Species of Wild Animals (CMS); The Convention Concerning the Protection of the World Cultural and Natural Heritage (the World Heritage Convention) (Gough and Inaccessible WHS, and territorial waters to 12 nautical miles).

Seabirds and seals that breed on the Tristan islands spend significant proportions of their lives outside the Tristan da Cunha EEZ, and their conservation in international waters is facilitated by international agreements, in particular: The Convention on Conservation of Antarctic Marine Living Resources (CCAMLR); The Agreement on the Conservation of Albatrosses and Petrels (ACAP).

The priorities for action under ACAP are the monitoring of populations of the Tristan Albatross *Diomedea dabbenena*, Atlantic Yellow-nosed Albatross *Thalassarche chlororhynchus*, Sooty Albatross *Phoebetria fusca*, Southern Giant Petrel *Macronectes giganteus*, Spectacled Petrel *Procellaria conspicillata* and Grey Petrel *Procellaria cinerea*. Another priority is the eradication of rodents from Tristan da Cunha and Gough and the development of rigorous quarantine procedures on materials entering Tristan and moving between the islands, especially in respect of rodents and avian diseases. The ACAP implementation plan for Tristan was adopted in 2009 with a prioritized work program defined.

7.2. Current threats

7.2.1. Non-native species

In common with many island ecosystems around the world, non-native invasive species are considered the most important immediate threat to the ecology of the WHS (Ryan 2007, RSPB and Tristan da Cunha Government 2010), and the Tristan islands generally. Feral cats, pigs and goats, all of which affected seabird populations in the past, have been extirpated from the islands, but rodents (mice on Gough and rats and mice on Tristan) remain a serious problem, eating eggs and chicks of seabirds, and endemic invertebrates and plants. Nightingale and Inaccessible are so far free of rats and mice, and it is essential for the wildlife there that they remain so. Rodents also affect agriculture on Tristan by damaging crops. Invasive introduced plants threaten natural vegetation and habitats. In the sea, introduced biota often arrive unnoticed and are more difficult to detect until they become abundant. However the porgy fish that arrived with a stranded oil rig has spread and multiplied rapidly and now qualifies as a marine invasive.

Mice and rats

On Gough, introduced House Mice are having a serious negative effect on seabird productivity, through eating the eggs and chicks of burrow-nesting seabirds (Wanless *et al.* 2007, Cuthbert *et al.* 2013a, Dilley *et al.* 2015). Mice are also playing a large part in the decline of the iconic Tristan albatross (Cuthbert and Hilton 2004, Wanless *et al.* 2009a, Davies *et al.* 2015), which despite its large size has not evolved any defense against such predators. The Tristan Albatross is now in the highest risk category of Critically Endangered on the IUCN Red List. The small population of around 1800 pairs, which breed almost entirely on Gough, is decreasing by 3% per year, with low recent breeding success of 23% (Wanless *et al.* 2009a, Cuthbert *et al.* 2014). In 2014, of 1,704 nests counted in January, only 163 had large chicks in September, making the overall breeding success on the island only 9.6%, the lowest ever recorded (Davies *et al.* 2015). A staggering 600,000 seabirds are estimated to be killed each year on Gough by mice (RSPB 2016).

Previous studies of mouse predation on Tristan Albatross chicks (Cuthbert and Hilton 2004, Wanless et al 2007) reasonably assumed that most chicks injured by mice were killed by Southern Giant Petrels and Brown Skuas because these birds are frequently observed feeding on freshly dead albatross chick carcasses. However Davies *et al.* (2015) provide graphic evidence of direct deaths from mouse attacks, by closely monitoring 20 chicks in the Gonydale study colony using photos and film. Only five of the 20 chicks survived to fledge, and of the 15 that died, 14 were killed by mice. All except one of the 14 died directly from their mouse wounds within 2.7-5.1 days. The remaining mouse-wounded chick was killed by a Southern Giant Petrel. Mice attack at night, gnawing at the body wall, making wounds usually at the chick's rump, but also the back of the neck, top of the head, side of the lower mandible or the wings. Parent birds make little or no attempt to protect the chick. Irritated by their wounds and the feeding mice, the chicks were unable to sleep, and the researchers concluded that the chicks eventually died from a combination of physical injury and exhaustion. Mouse predation rates peaked in May-June, at the start of the Austral winter, when other food sources for the mice become scarce. Mouse injuries have also been observed recently on Altlantic Yellownosed Albatross and Sooty Albatross chicks (Cuthbert *et al.* 2013b). Such attacks are very infrequent, but the rapid increase in mouse attacks on large chicks of Thalassarche and Phoebetria albatrosses on Marion Island indicates that these species may also be at risk on Gough (Dilley et al 2016).

Figure 141: Three mice feeding from a wound made by mice in a live Tristan Albatross chick, with a fourth mouse nearby. The mice attack in the hours of darkness, and the parent bird does not have the instinct to protect her chick, which took 3.3 days to die from its wounds (Davies *et al.* 2015). The iconic Tristan Albatross is facing extinction unless mice can be extirpated from Gough. [Photo: Ben Dilley]

Mice are also responsible for considerable mortalities amongst burrow-nesting petrels on Gough (Dilley *et al.* 2015). Gough is home to at least 13 species of burrowing petrels, including virtually the entire global population of the Atlantic Petrel (Endangered), and MacGillivray's Prion [Endangered, Ryan *et al.* subm.], and significant global populations of the Grey Petrel (Near Threatened), Great Shearwater, Little Shearwater, Soft-plumaged Petrel, Kerguelen Petrel, Broad-billed Prion, Common Diving Petrel and at least three species of storm petrel. The breeding success of these burrowing petrels on Gough appears to be very poor, with exceptionally low burrow occupancy and breeding success in four species studied from 2009-2011 (Cuthbert *et al.* 2013b). Atlantic Petrels, Soft-plumaged Petrels, Broad-billed Prions and Grey Petrels had burrow occupancies in the range of 4-42% and breeding success of 0-44%. Winter-breeding species were hardest hit, including the near-endemic Atlantic Petrel, which suffered particularly high chick mortality. The authors concluded that Gough Island's formerly abundant petrel populations are greatly threatened by the impact of predatory house mice, which can only be halted by the eradication of this species from the island.

To further clarify the effects of mice on chicks of burrow-nesting birds, Dilley *et al.* (2015) used an array of cameras to record activity inside nest chambers. They found that mice killed chicks of all species of burrowing petrels studied on Gough Island, including the largest, Grey Petrel and Great Shearwater. Their cameras recorded fatal mouse attacks on Soft-plumaged Petrel, MacGillivray's Prion, Atlantic Petrel and Great Shearwater chicks, and live Broad-billed Prion and Grey Petrel chicks were found with mouse-inflicted wounds. All mouse-injured chicks except one subsequently died from their injuries. The mice killed chicks within hours of hatching whilst still being brooded by their parents, and would also attack large chicks many times their own body size. Mice also ate unguarded petrel eggs. Burrowing petrels were affected year-round, though winter-breeding petrels (Atlantic Petrels, Broad-billed Prions) were worst affected. In Prion Cave, 60 nests of the newly-discovered MacGillivray's Prion were documented over two breeding seasons. In the first year (2013/14), there was 85% hatching success, but chick survival was very low, giving an overall breeding success of 15%. In the second year (2014/15), 60 nests were again monitored, with further video evidence of mice attacking and killing chicks, and all chicks died, giving an average breeding success over both years of only 7%.

Dilley *et al.* concluded that petrels, particularly the smaller and rarer species, are likely to be extirpated from Gough if mice are not eradicated in the near future. Davies *et al.* (2015) note that the Tristan Albatross population cannot sustain current levels of chick mortality, and any further increase in mouse attacks will only accelerate the rate of population decrease.

The endemic Gough Bunting (finch) *Rowettia goughensis* is now listed as Critically Endangered because of ongoing contraction of its range on Gough resulting from mouse predation of eggs and chicks. Below around 400m elevation, nests are now confined to cliffs and offshore stacks. The proportion of juveniles in the population had declined from 50% to 20% over 15 years, suggesting that recruitment is too low to sustain the population (Ryan and Cuthbert 2008).

Mice are also suspected of affecting a number of invertebrates and plants, including many rare and/or endemic species. For example the endemic flightless moths, still common on Nightingale and Inaccessible, have become rare on islands with mice in the archipelago.

Figure 142: Weighing around 35g, the introduced House Mice on Gough are 50-60% heavier than on any other island. [Photo: Ben Dilley]

On Tristan, mice and black rats *Rattus rattus* have undoubtedly exacerbated the demise of birds, and are hindering re-establishment following the cessation of hunting by humans. Nightingale and Inaccessible are currently free of rats and mice, but are vulnerable to accidental introduction from Tristan, and also from marine incidents such as the grounding of the bulk carrier MS *Oliva* on Nightingale in 2011.

Fortunately there appear to have been no introductions of rats or mice from this particular wreck due to conservation efforts, but ship traffic past the islands has increased greatly in recent years, and the islands, particularly the uninhabited ones, remain vulnerable to shipwrecks and the introduction of pests from them.

Davies *et al.* (2015) note that it is possible to eradicate invasive rodents from islands, and although there have been past failures, the successful eradication of mice, rats and rabbits from Macquarie Island (Tasmania Parks and Wildlife Service 2014) is extremely encouraging given that Gough, at around 65km^2, is about half the area of Macquarie. Aerial baiting at Macquarie took place in 2011, followed by hunting with specially trained dogs to remove the small number of rabbits that survived the baiting. Only a year after baiting, populations of some bird species on Macquarie were already increasing, with the island's burrowing petrels being the main beneficiaries. In particular, Blue Petrels, previously restricted to breeding on offshore rock stacks due to rat predation, have begun to breed again on the main island. Likewise, Grey Petrels have shown increased breeding success and have fledged greater numbers of chicks; both positive indicators even in these early days. In the first breeding season since baiting finished, Antarctic Terns bred on the island's cobblestone beaches in far greater numbers than previously, when they were restricted to less accessible rock stacks. The project was declared successful in 2014, after no more rodents were detected.

Following the necessary trials of bait uptake, the favored approach is to distribute poisoned bait (active ingredient brodifacoum) aerially across the entire island at a rate that ensures all mice are exposed to the bait, at a time when mice are not breeding, when there is least food available for mice, and when the most nesting birds are absent from the island, i.e. in winter. This presents huge (but not insurmountable) logistical problems for these remote islands, particularly for Gough. Complete coverage of baiting is required to target all rodents, and flying helicopters in winter when the least favorable weather can be expected is possibly the greatest risk to the plan. There are challenges in setting up the required facilities for handling and storing equipment on an island with minimal infrastructure; Gough has only a small meteorological base. For the island biota, impacting non-target species that are present in winter is a serious concern. On Gough, the endemic moorhens and finches are most at risk, and a captive program is suggested for these, with the birds released after the baiting exercise is completed and any residual toxicity judged safe. The moorhens definitely eat bait pellets so the risk to them is high; the finches are less likely to eat pellets so the risk is lower. Brown Skuas (the subspecies *Catharacta antarctica hamiltoni* is endemic to the Tristan islands) are also at risk from eating bait as well as scavenging poisoned carcasses, although the skuas also occur on the other Tristan islands (as do the Gough Moorhen), so some mortality on Gough is considered acceptable at a population level. Given the overall benefits to the populations of nesting seabirds and endemic land birds, not to mention invertebrates and vegetation, the benefits for the island ecology of ridding the island of mice greatly outweigh the risks.

On Tristan, the eradication of rats and mice by poison baiting is further complicated by the presence of the human population, together with associated domestic and farmed animals and agriculture. Here, very careful planning is required to minimize impacts, including hand-baiting instead of aerial broadcast at the Settlement, and any eradication plan would require the approval and cooperation of the entire island community (Brown 2007a). However, mice and rats are serious pests of agriculture as well as wildlife, so there would be many benefits to islanders resulting from their eradication, both directly through increased agricultural opportunities, and indirectly through wildlife tourism, one of the few sources of income for islanders with the potential to increase in the future. Rats cause significant damage to stored potato crops, and steel cages have to be used to protect seed potatoes. They dig up newly planted potatoes, damage other vegetables including pumpkins, tomatoes and corn cobs, and also take hens eggs. They are also reputed to spread disease.

For many reasons, ridding Gough of mice is a top conservation priority for the UK Overseas Territories (Dawson *et al.* 2015). Feasibility studies to this end have been completed (Parkes 2008), and operational plans and funding bids are at an advanced stage (Broome and Garden 2013; RSPB 2016). Costs for the eradication of mice at Gough are estimated at £6.1 million (ACAP 2016), not a vast amount given the probable benefits, with an estimated 600,000 seabirds a year saved, and several species from probable extinction. The RSPB has launched a funding bid for £7.8 million for the Gough Restoration Program (RSPB 2016), to include eradication of both mice and the invasive procumbent pearlwort *Sagina procumbens* (see below). Following the necessary lead-in actions, bait-spreading is scheduled for 2019, with follow-up monitoring until at least 2021.

Feasibility studies and operational plans have also been drawn up for ridding Tristan of both mice and rats (Brown 2007a, 2007b).

Introduced plants

The introduction of invasive weed species can drastically alter vegetation structure, resulting in habitat changes that can impact on native species of both plants and animals. Terrestrial plants are largely out-with the remit of this marine report. However, invasive plants can affect seabirds at their nesting sites, where they rely on dense vegetation for protection from predators, for nest materials and root support for burrows, so two examples are included here to illustrate the problems.

Many non-native plants have become established on the islands, particularly on Tristan, where some invasives have become pests in agriculture and gardens, while others have become dominant in several natural habitats. Once established, introduced plants can be extremely difficult to eradicate, unless they are large and easily located, or have limited distribution. An example of the former is New Zealand Flax *Phormium tenax*, introduced to Tristan as a thatching material and still used as windbreaks. On St Helena, where it is also introduced, this plant now covers large areas, where it grows densely, excluding most other plants. Fortunately it spreads relatively slowly and can be removed before it becomes too dominant, and eradication programs are ongoing on Nightingale and Inaccessible.

At the other end of the plant scale, Procumbent Pearlwort *Sagina procumbens* is a creeping, invasive perennial weed that produces many tiny seeds that can germinate quickly to form dense swards, and once the creeping plants establish over a large area with a soil bank of persistent seeds they are extremely difficult to eradicate. It is listed as one of the "One Hundred of the World's Worst Invasive Alien Species" due to its spread on cool temperate and sub-Antarctic islands (Visser *et al.* 2010). It has become invasive on at least 14 islands in the Southern Ocean (Cooper *et al.* 2010), including Tristan da Cunha, and was first discovered on Gough in the 1998. In some sub-Antarctic environments it forms large, dense mats (Visser *et al.* 2010), and threatens particularly upland habitats at Gough. At Gough, control measures have been employed around the Base area since 2000, including physical removal, herbicides, and heat and salt treatments to destroy seeds. This has been successful in halting the spread, and plants are now mainly confined to a 400m stretch of rocky coastal cliffs, where there is relatively low vegetation cover. However, this is a complex area with difficult access, and efforts continue to finally eradicate it from Gough. Visser *et al.* (2010) compared eradication methods, concluding that the most successful approach was a combination of monthly herbicide application together with soil stripping, where all native vegetation is removed, then remaining soil is grubbed out and collected or dumped into the sea, followed by blasting of the area with high-pressure hoses to strip the site down to bare bedrock. Before eradication started in 2000, germination trials recorded a staggering 98,000 Sagina seedlings emerging per m^2 from topsoil collected from infested areas around the weather station. Following various treatments, this figure has dropped steadily to only 105 per m^2 post 2008. However, continued vigilance is required to detect and quickly remove any seedlings before they can set seed; in summer, plants mature within 6-8 weeks.

This case history graphically illustrates the huge effort and funding required to eradicate an invasive weed once it has become established, even from a very small area. It also emphasizes the high importance of applying biosecurity measures to minimize the chances of invasive plants getting there in the first place. One possible source of the original infestation is supply containers that had been previously used on Marion Island, being used at Gough; containers dedicated to each island are now used. At Gough, a footbath at the entrance to the base sterilizes footwear worn by staff and visitors as they enter or leave the base, to minimize spread of seeds and soil by boots. Biosecurity measures are also vital to avoid introductions to Inaccessible and Nightingale from Tristan. Eradication efforts are ongoing, and the funding bid for the Gough restoration project (RSPB 2016) includes continued effort to eradicate Procumbent Pearlwort as well as the House Mouse.

Introduced species in the marine environment

Introduced species are also a potentially serious threat to Tristan's unusual marine ecosystem. Marine species have always arrived on Tristan by chance, on floating kelp or other marine debris, an entirely natural process of colonization. They generally arrive in small quantities, and most are unlikely to survive the rigorous conditions on a Tristan seashore, or will be quickly eaten by fish and other local marine life. Others may settle in with no adverse effects on native flora and fauna. However, some species are potentially invasive, with the potential to substantially alter intertidal and shallow-water communities. For example, there are currently no large mussels or grazing seasnails on Tristan seashores, which are consequently covered with dense seaweeds, which in turn harbor huge numbers of tiny animals, food for fish and young lobsters, and shelter for tiny lobsters newly-settled from the plankton. On many continental shores where large mussels occur, they often densely cover large areas of seashore to the exclusion of seaweeds and other organisms, and could drastically alter communities on Tristan shores.

With the increasing amounts of man-made materials in the sea, and in particular long-lived plastics, introductions attached to floating debris can also be expected to increase. A draft contingency plan for action on alien introductions to Tristan discusses their potential effects, and highlights recent shipping incidents (Scott in prep.).

Figure 143: Floating man-made debris, especially long-lived plastics, can carry new species to remote locations like Tristan. This hard hat found in a Tristan shore pool carries the usual stalked barnacles *Lepas* sp, but also small hydroids and red seaweeds

Very little is known about the ecology of Tristan marine life, particularly the life histories, interactions, diets, seasonal changes and other requirements of key species, which makes even informed guesses as to the likely fate and effects of introduced species difficult. Current research funded by the Darwin Initiative is aimed at increasing the knowledge of some of these basic processes, but far more work is required.

Oil rig stranding June 2006 - a potential mass introduction event

In June 2006 a production platform (oil rig) that was being towed from Brazil to Singapore broke loose in a storm and eventually ran aground in 15m depth at Trypot on the south coast of Tristan. This rig, previously positioned in Brazilian waters, carried virtually its own ecosystem on the large area of submerged rig legs, with at least 60 species not native to the islands, some of them potentially invasive (Wanless *et al.* 2009). This was a potential introduction event on a massive scale. Many of the biota that covered the legs of the rig (particularly hard corals) died because seawater temperatures at Tristan were considerably colder than in Brazil, but many survived, including potentially invasive brown mussels *Perna perna* and large barnacles. On the advice of biologists the rig was eventually towed off and sunk in deep water, to minimize the chances of marine life settling from it, but this action was greatly delayed by a combination of winter weather and bureaucracy, and many species could have spawned or left the rig in the eight months the rig was aground. No funding was made available for monitoring for the establishment of aliens in the wake of the rig stranding, with the result that to date monitoring has been sporadic and opportunistic, on the back of other work. Non-native invertebrates that may have managed to establish from the rig may not be detected for many years, but at least there is a good initial record including comprehensive specimen collections from the rig. A fish that arrived with the rig, the South American silver porgy *Diplodus argenteus argenteus*, had a much more visible profile and its establishment is therefore better documented (see below).

Figure 144: Left – Oil rig stranded on Tristan in 2006. Centre - The submerged part of the rig was covered with non-native marine life. Warm-water corals died (right), but many invertebrates, including urchins, starfish, crabs, bivalves, whelks, barnacles, seasquirts, anemones, sponges and hydroids, and even a small fish (blenny), survived (below) amongst the coral skeletons

Mussels

Live Mediterranean mussels *Mytilus galloprovinicalis,* a species that has been invasive elsewhere, were found by divers in the propeller shaft cowling of the wreck of the cargo ship MS *Oliva* 11 months after the vessel foundered in March 2011. The mussels were large, approximately 40mm long, therefore mature. Specimens seen were later removed, and so far mussels of this species have not been found on the shores of Nightingale, but there has been limited monitoring for their presence. Numerous Mediterranean mussels were also found in the sea chests of the *SA Agulhas* (Lee and Chown 2007), while she was in dry dock in Cape Town in 2006. As well as other subantarctic islands, this ship visited Tristan and Gough on research and staff changeover trips in September-October each year until 2011, when she was replaced by the new *SA Agulhas II,* operating from 2012. From the age (size) of the mussels, the authors concluded that some of them had probably survived multiple trips into much colder subantarctic waters. These mussels could easily have spawned in warmer Tristan waters; changes in temperature are known to trigger spawning in many marine invertebrates. The *Agulhas* visits Tristan after the winter lay-off in Cape Town harbor, a prolonged period when sessile marine life could settle, and be subsequently transported elsewhere. Cape Town harbor is a hotspot for introduced invertebrates in South Africa (Griffiths *et al.* 2010). There have been no checks of other vessels that visit the islands regularly (currently the fishing company ships *Baltic Trader* and *Edinburgh*), and that spend extended time in Tristan waters. The *Baltic Trader* in particular sits in the harbor in Cape Town for long periods between visits to Tristan.

Silver porgy *Diplodus argenteus argenteus*

A non-native fish that arrived with the rig, the South American silver porgy *Diplodus argenteus argenteus*, has bred rapidly in Tristan waters and is now well-established around Tristan (Scott *et al.* in prep.). A shoal of 30-50 adult porgy were seen swimming under the rig together with native fivefinger on dive surveys in October 2006. These fish had not seen before in Tristan waters by islanders or recorded on marine biological surveys, and had obviously arrived with the rig. Genetic testing later confirmed this species identification (Tim Andrew, pers. comm.). In its native waters the porgy is a fast growing, fast breeding, broadcast spawner, and so far is appearing that way on Tristan; by 2016, 10 years after the rig stranding, it was abundant all around the island. Current work aims to establish more information on its diet and behavior at Tristan, and its possible effect on native fish species and lobster populations.

Figure 145: Adult porgy off the harbor, Tristan in 2014.

The porgy has so far been seen only around Tristan, and not the other islands, and appears to be confined to shallow water above about 6m. However, as it is a broadcast spawner, it is probably only a matter of time before it reaches the other northern islands. Eggs could be transported in seawater to the other islands, particularly as a result of fishing operations or in ballast water, while adults or juveniles could accompany towed or other slow-moving structures.

Seaweeds

Work is ongoing to identify other recent introductions; several seaweed species are likely contenders. The relatively sheltered harbor on Tristan, though small, may well be the place where some accidental introductions have been able to get a foothold before spreading to adjacent areas. In February 2014, the red seaweed *Bonnemaisonia hamifera*, which has hooked branches which entangle it with other biota and so can exist without a holdfast, was found in large masses in the center of the harbor (Scott *et al.* in prep.) This species had not been recorded from Tristan before, and it is not yet known how it arrived there, but it has been introduced to many places around the world from its native range in Japan or adjacent waters. Several conspicuous seaweeds not recorded by the Norwegian Expedition in the 1930s have been noted by recent surveys, some in or near the harbor area, and have probably arrived at the islands since the late 1930s. Their effects on native species, if any, are unknown.

7.2.2. Marine incidents and pollution

As small rocky islands and islets surrounded by deep water, the Tristan islands have hosted shipwrecks as long as humans have travelled in ships. Early shipwrecks probably introduced rats and mice. A recent shipwreck, of the 2-year old bulk carrier MS *Oliva* which ploughed into Nightingale in the early hours of March 11 2011, shows that even in this era of GPS, radar, and high-tech navigation and detection systems, Tristan is not safe from human error. The *Oliva* broke up, releasing 1500 tons of heavy fuel oil into the sea, which killed at least 3,000 rockhopper penguins, and also threatened the population of juvenile lobsters that live mainly in the top few meters of the subtidal, the zone most affected by oil. Fishing operations off Nightingale had to be abandoned until there was no further risk of contamination of rock lobsters.

Figure 146: Top: The bulk carrier MS *Oliva* off Spinners Point, Nightingale in March 2011, just before breaking up and already spilling oil. Bottom: Rockhopper Penguins covered with oil spilled from the MV *Oliva*. More than 3000 were cleaned and cared for by islanders and rescue specialists, but most of the birds died. [Photo: Trevor Glass]

Less high-profile but arguably as damaging as the oil was her cargo of 65,000 tons of soya beans spilled over the seabed, smothering urchins and other marine life. The effects of this will never be fully known because of delayed investigation at the time, and lack of relevant monitoring after the incident. Rotting soya was seen by islanders drifting in the water as marine 'snow' for many months after the incident, and was still present in anoxic masses on the seabed at 120m depth off southeast Nightingale six months later.

The trade in soya beans between Brazil and the Far East has increased significantly in the past few years, with the Tristan islands directly on the shipping route, so future similar incidents are unfortunately likely unless the islands are given a mandatory wide berth by commercial shipping.

This could be effected through the International Maritime Organisation's designation of Particularly Sensitive Sea Area, which is 'an area that needs special protection through action by IMO because of its significance for recognized ecological or socio-economic or scientific reasons and which may be vulnerable to damage by international maritime activities'. Applications for this designation may be submitted by a member government of the IMO (which the UK is). Associated protective measures can include ships' routing measures, reporting requirements, discharge restrictions, operational criteria, and prohibited activities, and should be specifically tailored to meet the need of the area to prevent, reduce, or eliminate the identified vulnerability of the area from international shipping activities. Flagging up the islands as an area to be avoided on charts and route-planners, and banning of discharges within Tristan waters are obvious measures that could be taken to protect the islands' marine wildlife, and to minimize the risks of another MS *Oliva* incident.

7.2.3. Longline fishing

Many seabirds throughout the South Atlantic and Southern Ocean have in the past been killed by being caught on longlines, set mainly for tuna (pelagic longlines) and Patagonian toothfish (demersal longlines). Seabirds range over huge distances, and are thus vulnerable to impacts well outside the islands' territorial limits. Reid *et al.* (2013) tracked 14 non-breeding Tristan albatrosses from Gough between 2004-2006, and found that birds foraged in the south west Atlantic during the austral summer, and the south east Atlantic and Indian Oceans as far east as Australia during the Austral winter, with foraging effort concentrated in areas of upwelling and increased productivity. The area of the southwest Atlantic used by the birds in summer has relatively low longline fishing at this time, so birds are at less risk of being caught. However in winter, the birds visited areas of high fishing effort, particularly in the Indian Ocean and off southern Africa. Bird catches off South Africa were also fairly low provided appropriate mitigation measures were taken, and only three birds are recorded as killed in the South African pelagic longline fishery between 1998-2005, and none since 2005 (Reid *et al.* 2013), However, mitigation measures are not currently used north of 25°S, so Tristan Albatrosses and other seabirds including Atlantic Yellownosed Albatrosses and Spectacled Petrels remain at risk from the Namibian pelagic longline fishery.

Figure 147: Albatrosses killed by a single South African vessel fishing for tuna in international waters for 3-4 months in the late 1990s. The kill has now been reduced dramatically by the use of streamers while setting baited lines, and by setting at night. [Photo: Peter Ryan].

Tuck *et al.* (2011) determined 22 seabird species to be at serious risk from fishing mortality in the South Atlantic; albatrosses from South Georgia and Tristan da Cunha had the highest risk scores. A study of bycatch in the Taiwanese longlining fleet (Yeh *et al.* 2012) estimated total seabird incidental mortality from pelagic longline fishing in the southern Atlantic Ocean to be 3500-6000 birds per year from 2004 to 2008. Most frequently caught seabirds were Black-browed, Atlantic Yellow-nosed, and Wandering albatrosses, as well as Spectacled and Southern Giant petrels. Combining the results of this study with that of others, a wide area to the east of Tristan and Gough, and between the islands and South Africa was identified as containing 'hotspots' for seabird bycatches; fleets from Taiwan, South Africa, Namibia, and Japan were major fishers in these areas. Spectacled Petrels (endemic to Inaccessible) and Great Shearwaters (virtually endemic to the Tristan group) were killed by long-line fisheries off South America and in the North Atlantic respectively (Ryan *et al.* 2006, Dunn 2007). The WHS Management Plan notes that the Endangered Sooty Albatross is also likely to be caught, though there is no published bycatch data to support this. It is thought that longlining caused adult survival rates of Tristan and Atlantic Yellow-nosed albatrosses on Gough to fall below that needed to sustain their populations (Cuthbert *et al.* 2003, Cuthbert *et al.* 2005, Wanless *at al.*

2009). However, latterly the severe impact of mice has become better appreciated while the impact of longlining has moderated.

Within the Tristan EEZ, occasional licenses are sold for pelagic fishing for tuna, and demersal fishing for bluefish and alfonsino. In the years 1995-1999, 18 pelagic licenses were sold to Japanese (16 permits) and Portuguese (two permits) vessels (Glass *et al.* 2000), while only three pelagic licenses were sold, to South African ships. Fisheries observers on the three demersal cruises reported that considerable numbers of birds were attracted to ships while setting lines during the day, but only one Great Shearwater was killed, a mortality rate of 0.001 birds per 1000 hooks. Observations of the pelagic (tuna) fishery were only made on a truncated fishing trip on only one vessel (two sets of around 3000 hooks each taking six hours to complete). This fishing trip, in mid-winter, had a bycatch rate of more than one bird killed per 1000 hooks. The toll could be even higher in summer when the birds are breeding at the islands, and the limited data suggest that this fishery poses a significant threat to seabirds in Tristan waters. The demersal vessels used bird-scaring lines, the pelagic fishery did not. The authors suggested that permit holders should be encouraged to apply mitigation measures to reduce seabird bycatch, including setting lines only at night; using a bird-scaring line; ensuring the line sinks quickly through appropriate weighting; and limiting the amount of offal discarding, and dumping offal only on the side away from the hauling station. However, they stopped short of recommending making these conditions mandatory, as this might result in increased fishing without a permit.

Glass *et al.* (2000) noted that the demersal fishery lost 93,650 hooks, out of 693,700 set (13.5%), and that this was due to the 'exploratory nature' of the cruises. This may indeed partly reflect setting on rugged terrain for these exploratory trips, but the loss of this staggering number of hooks is very likely to have damaged deepwater benthos by snagging.

The only cetacean apparently attracted to the fishery was a single beaked whale, possibly a Shepherd's Beaked Whale T*asmacetus shepherdi*, which stayed with the demersal fishery for approximately two hours while the line was being hauled; observers could not tell if it was taking fish from the line.

Measures to reduce or eliminate the by-catch of seabirds from longline fisheries are relatively easy and cheap to carry out. The birds are caught on the baited hooks as they are set, and then dragged underwater to drown. Setting lines at night, use of appropriate weighting, and the use of bird-scaring lines streamed out above the baited line, is now widely-employed mitigation measures to limit bird access to baited hooks and have greatly reduced the numbers killed. Seabird deaths around South Georgia in the Southern Ocean have declined by 99% since regulations were enforced (Anderson *et al.* 2011), and South Africa achieved a drop of 85% bycatch in its foreign-licensed fleet in 2008, when a cap was placed on the number of seabird deaths permitted. In April 2011, Brazil passed a law requiring the use of stringent seabird bycatch measures in their domestic tuna longline fleets. Other methods such as pods to contain the baited hooks, which only release the hooks when >10 meters underwater, are currently being trialed. However, the number of long-line fishing vessels around the world is enormous, setting thousands of kilometers of line with an estimated one billion baited hooks every year. For albatrosses and other seabirds on Gough also suffering reduced productivity from predation of chicks by house mice, even a few bird deaths from fishing is a serious problem.

7.2.4. IUU fishing

Unregulated fishing is both a threat to Tristan's economy and the marine ecosystem, through potential overfishing of stocks and damage to seabed life. In such a remote location, IUU fishing is very difficult to police, although vessel detection in the area has much improved in recent years. For the lobster fishery, the fact that *Jasus tristani* is only fished in the South Atlantic at the Tristan islands means that illegal landings can be detected by genetic testing at Cape Town (although the recent genetic work showing that *J. tristani* from Tristan and *J. paulensis* from St Paul and Amsterdam Islands are the same species (Groeneveld *et al.* 2013) has to be considered when testing landings). However for other fisheries, particularly for deeper species with a wider distribution, where there is no easy way to tell where they were caught, IUU catches are much less likely to be detected.

As well as damage to fish stocks from IUU fishing, deep-water seabed life may be particularly vulnerable to damage from bottom fishing, with fragile organisms such as sponges, sea fans and corals easily damaged by heavy or dragged fishing gear and lines. Little is known of the deep-water benthos around the islands, but a few hauls from 200-400m have revealed a rich fauna of sea fans, small hard corals and black coral. Black coral has long been used to make jewellery, but it is slow-growing, very long-lived and hence vulnerable to exploitation. Research on *Leiopathes* black coral from the Azores, the same genus as that found on Tristan in 2013 (BAS 2013), has established that colonies were up to 2,300 years old (Carriero-Silva *et al.* 2013), and vulnerable to fishing, including demersal longline fishing (Sampaio *et al.* 2012). Black corals were also important structural organisms, providing habitat for other marine life. This applies to other erect corals and gorgonians. Samples of gorgonians collected by Agassiz trawl in 2013 (BAS 2013) had many small brittlestars, anemones and other biota attached to them. All black coral species are listed under Appendix II of the Convention on International Trade in Endangered Species (CITES), which means that any country signed up to CITES and intending to export must prove scientifically that the export is not detrimental to the coral populations, and must also issue export permits in order to track and monitor the trade.

7.2.5. Disturbance

Physical disturbance

The islands are generally protected from disturbance by their great remoteness, but harvesting of seabirds and eggs, the presence of fishing and tourist ships, tourists coming ashore, and marine incidents are all potential sources of disturbance to wildlife. Great Shearwater eggs and chicks are harvested at Nightingale but because the birds nest in burrows, birds in neighboring burrows are unlikely to be disturbed. Also the terrain is such that large areas of the colonies are inaccessible to humans. Harvesting of Northern Rockhopper Penguin (Endangered) eggs at the islands is also a disturbance; again large areas are in dense tussock and not easily inaccessible. Some disturbance to penguins, other birds and fur seals occurs when islanders and researchers are resident for longer periods on Nightingale, and to a lesser extent on Inaccessible. Research on seabirds can be intrusive, but is generally of short duration and provides vital information on breeding, diet and other aspects of the birds natural history, which is ultimately used for the birds' own conservation.

Figure 148: Cruise ship passengers exploring Nightingale. Local guides (and dense tussock) prevent straying from the path, and little disturbance is caused to wildlife during their few hours ashore.

Tourism at the islands is currently at a very low level, because of the islands' extreme remoteness, lack of mass transport, and difficulties of landing in poor sea conditions. Visitors are based on Tristan, or on smaller cruise ships that visit for a few hours, or at most, 2-3 days. On the uninhabited top islands, tourists can go ashore on day trips.

All visitors, including cruise ships and research vessels, are required to obtain permission and to take island guides, who generally ensure tourists stay to main paths, if only for their own safety. There is potential for increased wildlife tourism, but it is never likely to be on a scale that becomes a problem for wildlife. The main threat from visitors is from the increased potential for accidental introduction of invasive species, rather than direct disturbance.

Light pollution

Lights can cause disturbance to seabirds at night, when they become confused and disorientated by them, and crash into ship superstructure or buildings, sometimes causing injuries or death. This is a particular problem at Gough, with lights at the Base, and on the fishing ships. Formerly, night-strikes on the fishing ships affected thousands of individuals of eight or more species annually (Ryan 1991), but now regular visitors such as the crayfish fishing ship *Edinburgh* and the research vessel SA *Agulhas II* operate blackouts at night when possible, much reducing this disturbance. Glass and Ryan (2013) reported that over the three years 2010-2013, 723 seabirds from nine species were recorded coming aboard the MV *Edinburgh*, with at least 39 (5.3%) dying as a result. However, this represented an average of less than two birds per night, compared to 130 birds per night in 1989 (with up to 900 birds on some misty nights). Birds killed were Broad-billed Prions (41%), Common Diving-petrels (23%) and storm petrels (*Pelagodroma marina* and *Fregetta grallaria/tropica* 36%). The more enlightened expedition and cruise ships also minimize lighting at night. Other passing ship traffic on long sea routes, some of which passes close to the islands, is unlikely to be aware of this problem.

Seabirds including petrels and shearwaters are unable to take off from ships decks or enclosed areas between buildings, and need to be caught and launched into the air at a time when they will not be affected by lights, or caught by predators. Contamination with oily water on ships can result in feathers losing their waterproofing and insulation properties, so that birds became sodden or cold. If released in this state, birds often drown or fall prey to skuas and giant petrels (Ryan 1991).

7.2.6. Plastics and other seaborne pollution

Breeding seabirds import pollutants from distant foraging areas, resulting in contamination of the terrestrial ecosystem. This is evidenced by the large amount of plastic carried in seabird stomachs (Furness 1985, Ryan 1987a). Plastic ingestion is common in seabirds breeding at Tristan-Gough, recorded from at least 18 species (Furness 1985, Ryan 1987a, P.G. Ryan unpubl. data). Plastic fragments imported by seabirds are frequent in the lowland peats of Gough Island. Great Shearwaters are particularly important in this regard, because they are trans-equatorial migrants, foraging in the relatively heavily-polluted north-west Atlantic Ocean during their non-breeding season. Ryan (1987b) found plastic present in the stomachs of 19 of 20 (95%) female Great Shearwaters examined immediately after egg-laying at Gough in November 1984. He found no correlation, positive or negative, of plastic mass of up to 1500mg with indicators of body condition in the birds, as measured by bird mass and fat index. In a subsequent study, Ryan (2008) found that between the 1980s and 1990-2006, the numbers of plastic particles ingested by five seabird species had not changed significantly, but the proportion of virgin industrial pellets had decreased by 44-79% in all five species (Great Shearwater, White-chinned Petrel, Broad-billed Prion, White-faced Storm Petrel and *Fregetta* storm petrels), four of which were sampled at Tristan da Cunha. He suggested that the consistent decrease indicated a global change in the composition of small plastic debris at sea over the two decades of the study.

Seabirds also import pollutants in the form of heavy metals and persistent organochlorides (OCs) (Muirhead & Furness 1988, Ryan *et al.* 1988, Becker *et al.* 2016). Ryan *et al.* (1988) analyzed the amounts of OCs (polychlorinated biphenyls (PCBs), DDE, DDT and deildrin) in adult fat tissue and eggs of 20 Great Shearwaters at Gough. Plastic was present in the stomachs of 19 of the 20 birds sampled. They found a positive correlation with PCBs and the mass of plastic ingested by seabirds, but not of plastic with the other OCs. PCBs have become ubiquitous pollutants of marine food webs, especially in seabirds, and may be responsible for reduced breeding success, increased risk of disease and altered hormone levels, as well as direct mortality. There was no correlation between the amounts of OCs in adult fat tissue and the amounts in eggs.

Of the heavy metals, mercury is particularly toxic, influencing endocrine-related mechanisms and sex hormones. Sub-lethal effects on birds include adverse impacts on blood and tissue chemistry, metabolism, growth, development, reproduction and behavior (Becker *et al.* 2016). Though it occurs naturally in the environment, human activities have increased the amount of mercury cycling by a factor of three to five. Birds accumulate mercury in their feathers, excreting it when they moult, and analysis of feathers provides a non-destructive way of producing an index of seabird contamination with mercury.

Becker *et al.* (2016) studied mercury contamination in 25 seabird species breeding across a latitudinal gradient across the Southern Ocean, from Gough through Marion Island to Byers Peninsula in the Antarctic. Overall, seabirds at Marion Island had highest mercury levels, Gough was intermediate and Byers Peninsula lowest. They found that consumers of Krill *Euphausia* spp. and other zooplankton had low mercury concentrations (at Gough, Common Diving-petrel and Broad-billed Prion), while seabirds eating squid or carrion had high mercury concentrations (ascending order: Kerguelen Petrel, Southern Giant Petrel, Soft-plumaged Petrel, Sooty Albatross, Atlantic Petrel, Northern Giant Petrel, Great-winged Petrel). Consumers of crustaceans or fish had intermediate concentrations; at Gough this included White-faced Storm Petrels, Northern Rockhopper Penguins, Great Shearwaters, Atlantic Yellow-nosed Albatrosses, and Subantarctic (Tristan) Skuas. Measurements repeated in 2009 at Gough showed much higher mercury levels than in the mid-1980s in feathers of Sooty Albatrosses (by 187%), Soft-plumaged Petrels (53%) and Atlantic Petrels (49%), while Southern Giant Petrels showed no significant difference.

Chronic oil pollution from washing of tanks and spillages at sea can also affect foraging seabirds, which ingest the oil when preening. Experience with African Penguins indicates that these birds are very sensitive to oil, and can die from a patch of oil only around 3x3cm (Peter Ryan pers. comm). No similar data is available for Northern Rockhopper Penguins, but of more than 3000 that were oiled following the MS Oliva wreck off Nightingale, a significant proportion died.

Figure 149: This Northern Rockhopper Penguin at Inaccessible had swum through a patch of oil at sea, resulting in heavy oiling of its feathers. The bird would almost certainly have died from this pollution. [Photo: Peter Ryan]

7.3. Future threats

7.3.1. Fisheries

From time to time the island receives requests for licenses to fish species other than rock lobsters. For example, in 2007 the island sought advice on a request for exploratory fishing in inshore waters for species including yellowtail, whelks and sharks, with a bycatch of whitefish and octopus. Biologists urged extreme caution, as the biology of these species is little known, and fisheries for species such as whelks and sharks in other places have been notoriously short-lived because of these species' slow reproduction rates. On this occasion a license was not granted. However, this is a real issue for islanders, as licenses for further sustainable fisheries would be a welcome addition to Tristan's revenue.

The coastline of the islands drops rapidly into deep water, with small erosion platforms in places (such as west of Inaccessible) but no continental shelf, and the seabed appears rugged in many places. This limits the type of fishery and fishing gear that could operate nearshore in future, and fortunately limits the practicality of using destructive bottom trawling and dredging. The shallow waters are already fished fairly intensively for rock lobsters, and future applications for licenses are likely to involve longlining for deepwater species, or pelagic offshore fishing. Little is known of the marine life of deep water of the slopes off the islands and seamounts, so the impact of fishing on wildlife and habitat conservation is difficult to assess. However, dredge hauls have already indicated that there are at least some 'hotspots' of diversity, including long-lived, slow-growing communities with habitat-forming species such as gorgonians and black coral. For any proposed deepwater fishery to be sustainable the probable impacts would need to be very carefully considered, and much more information on deepwater marine life is needed to enable any meaningful assessment.

Figure 150: Slow-reproducing species such as sharks (Broadnosed seven-gilled shark *Notorynchus cepedianus*) and whelks (endemic whelk *Argobuccinum tristanense*) are not generally suitable candidates for sustainable fisheries.

Several seamounts occur within the waters of Tristan's EEZ. These are also at risk from short-term gain fisheries. Little is known of their marine life, and the caveats above apply. The Vema seamount, between Tristan and South Africa (outside the Tristan EEZ), is an example of an abundant rock lobster population that was virtually fished out in a very short time between November 1964 and December 1966 (Heydorn 1969). The fishing ground on the summit of this seamount has an area of only around 16 square miles, a very small area of habitat, which Heydorn (1969) describes (from dives at 42-62m) as very rugged, with towering rock outcrops, and numerous crevices, steep-sided gullies and caves; ideal lobster habitat. The export of frozen tails from exploitation of this small seamount declined rapidly from 594,280 lb (270 tonnes) in 1965 to 66,830 lb (30 tonnes) in 1966 - a prime example of an opportunistic and unsustainable fishery. The seamounts within Tristan's EEZ are also at risk from IUU fishing, as they are well offshore from the islands, and difficult to police effectively.

7.3.2. Coastal development

Large coastal infrastructure developments on the Tristan islands are generally unlikely, because of the extreme exposure and inaccessibility of much of the coast. However islanders have long called for improved harbor facilities at Tristan, the only landing place for people, goods and fish. The current harbor is very shallow, subject to swell, and consequently unusable on many days. Some rock was removed in 2016 from the harbor floor to improve depth, but the harbor itself remains small. An improved harbor would greatly facilitate fishing and landing operations, as well as improve prospects for increased tourism.

Figure 151: The harbor at Tristan da Cunha.

A new larger harbor would likely impact on the coast to the east of the existing harbor, where the many rock pools in the rock flats are currently a good settlement place and nursery ground for juvenile lobsters. Rock flats form a relatively rare intertidal habitat on Tristan and may be critical shelter for tiny lobsters. The pools are also a good habitat for other marine invertebrates. Biodiversity Action Plans recommend EIAs as an essential part of the planning for any infrastructure developments impacting on the marine environment. EIAs could include mitigation measures such as ensuring that new structures provide good habitat for marine life. In particular, lobster settlement rates might be given a boost by providing refuges for young lobsters, and early experiments to establish the likely success of different refuge designs (e.g. simple holes in concrete) at different depths would be a valuable line of research.

7.3.3. Climate change

Climate change could alter physical factors including seawater temperatures, current speeds and direction, possibly resulting in huge shifts in the marine ecosystems of the Tristan islands. Understanding of the functioning of these ecosystems at the islands is critical for an evaluation of likely changes, but this understanding is at a very early stage, and requires much more research, particularly into the basic requirements of keystone species.

Kelp forests may be particularly vulnerable to climate change. Kelps are major primary producers in cool shallow seas, and kelp forests provide a sheltered habitat on which many other species depend. On Tristan, kelp is a major part of the diet of rock lobsters and urchins, two keystone species in the shallow marine ecosystem. Kelps require cool water; worldwide, the distribution of giant kelp *Macrocystis pyrifera* is limited to temperatures below 20°C. During the 1982-83 and 1997-98 El Nino periods, giant kelp disappeared from its normal distribution range in the Baja California peninsula; in 1998 the maximum temperature reached was 19.3°C (Valdez *et al.* 2003), a value which is already exceeded at times at the Tristan top islands, where kelp fronds can be seen disintegrating in summer (pers. obs.). Variations in harvests of giant kelp in Baja California had a strong inverse correlation with water temperatures, with particularly low kelp yields in 1958, 1983 and 1998, when water temperatures rose during El Nino events. Valdez *et al.* (2003) comment that the effect of raised temperatures may be to limit the availability of nitrates for kelp growth. The kelp beds in Baja California did not re-establish until the temperature decreased. Any increase in seawater temperatures at Tristan could cause the giant kelp forests to disappear from the top islands, with knock-on effects for other key species including urchins, lobsters and fish. The much smaller pale kelp *Laminaria pallida* also forms kelp forest on the islands; this is regarded as a 'warm-temperate' species (Dieck and Oliveira 1992), so its upper temperature limit may be somewhat higher than that of giant kelp.

Warming seawater temperatures are likely to make colonization by warmer-water species more successful. The marked increase in abundance in recent years of the yellowtail or Cape mackerel *Seriola lalandi* at the Tristan top islands may be an example of this already happening, although with fish movements it is notoriously difficult to pin down the cause, as multiple factors are often responsible, and yellowtail has also increased in numbers in cooler waters in other places in its range (e.g. Tasmania).

Changes in speed and direction of ocean currents are likely to affect larval dispersal, especially of those organisms with long-lived larvae, including lobsters and fish. The larvae of Tristan lobsters are thought to spend at least 10-12 months at sea, and the mechanisms by which they find their way back to Tristan are not known. Changes in currents may also affect the type and origin of floating debris reaching the islands, together with its attached organisms.

Changes in ocean currents and temperatures are also likely to alter the distribution and abundance of the planktonic and pelagic organisms that form the major part of the diet of seabirds. Wide-ranging seabirds may have the ability to seek out food sources in different locations, but changes in food abundance could have profound effects on seabird survival and reproductive success.

In short, the effects of climate change are unknown, and the scenarios above are open to alternative interpretations. However, whatever the eventual changes, good background information on keystone species and their biology is essential to underpin more accurate predictions of the resulting changes, and to prepare for adjustments that may be needed following changing circumstances. As part of a Darwin Initiative project, information-gathering on key species, monitoring of biota on the shore and in the subtidal, and deployment of temperature loggers in the subtidal at all four islands has been initiated, and is being continued by islanders.

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