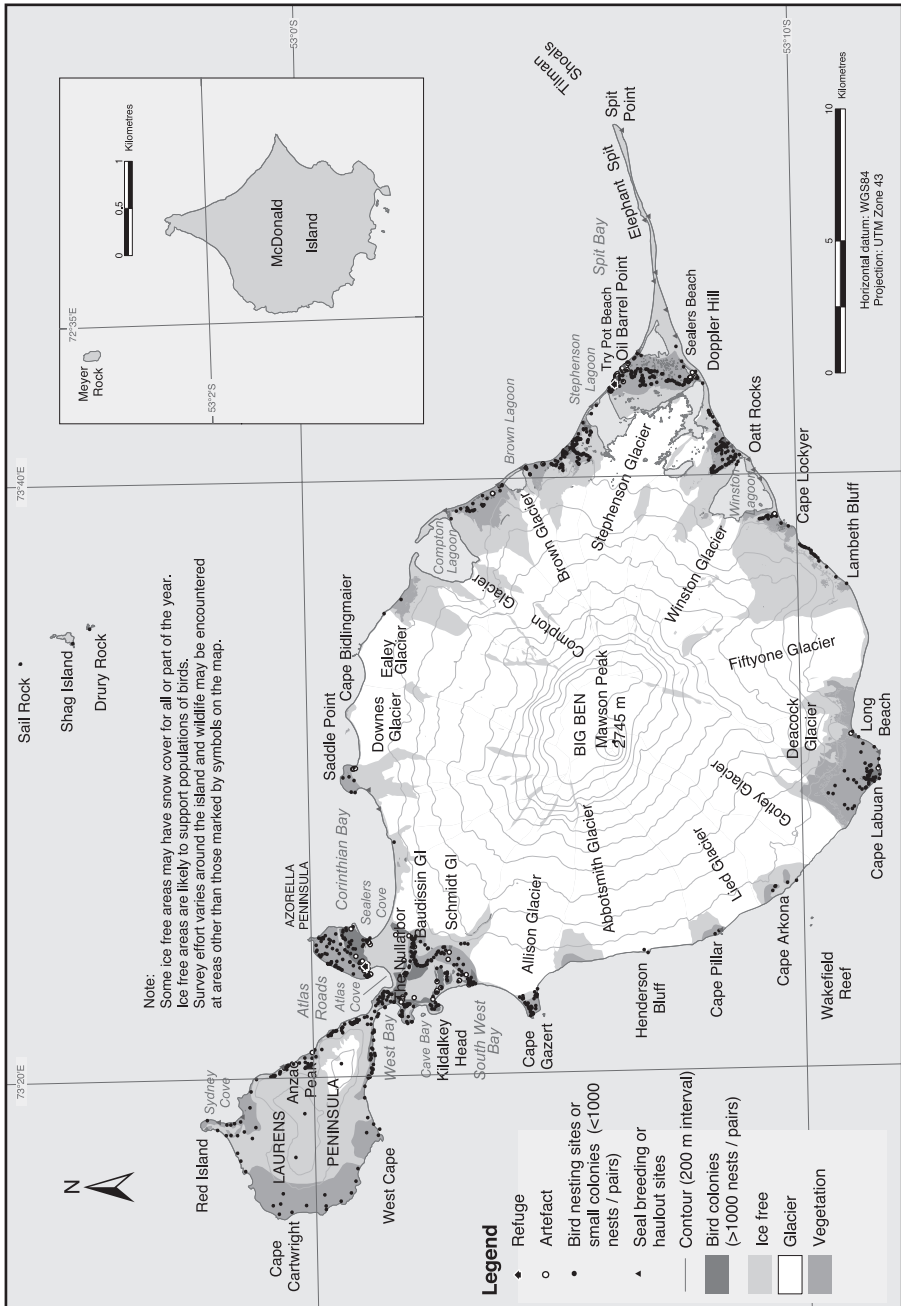




Part 3 A Description of the Heard Island and McDonald Islands Marine Reserve

Figure 7. General map of Heard Island and the McDonald Islands



Heard Island and McDonald Islands Region

Heard Island (53°06'S, 73°32'E) and the nearby McDonald Islands are located in the Indian Ocean sector of the Southern Ocean, approximately 4000 km south-west of Australia and 1000 km north of the Antarctic continent (see Figure 1). The nearest land is the Kerguelen group of islands (Îles Kerguelen) 440 km to the north-west which, with the Heard-McDonald group, form the only exposed parts of the submerged Kerguelen Plateau.

Heard Island is approximately 43 km long, stretching from Laurens Peninsula in the north-west to the end of Elephant Spit in the south-east, with a land area of 368 km². The majority of this area comprises Big Ben, a heavily glaciated and roughly circular volcano of around 18–20 km in diameter. Recent and possibly ongoing volcanic activity has changed the size and shape of the McDonald Island group; a comparison of satellite images taken in 1980 and 2003 indicates that McDonald Island itself has doubled in size and is now connected to the previously separate Flat Island by a low isthmus (see Geology and Geomorphology below). A low-lying spit and reef also extend over a kilometre to the east of McDonald Island. The McDonald Island group, including Meyer Rock one kilometre to the north, now covers an area of approximately 2.45 km². Other islets include Sail Rock, Shag Rock and Drury Rock which lie approximately 10 km north of Heard Island (see Figure 7).

The islands, plus several offshore rocks and shoals and the 12 nm territorial sea, collectively comprise the Territory of Heard Island and McDonald Islands (the Territory), which is the most isolated territory of Australia and one of the most isolated locations on Earth. The seas surrounding Heard Island and McDonald Islands (HIMI) form part of Australia's exclusive economic zone (EEZ), which extends to a distance offshore of 200 nm, with the exception of an area to the north-west where Australia has an agreement with France on the delimitation of the EEZ boundary between HIMI and the Îles Kerguelen (see Figure 2).

The following sections give a brief description of the history and characteristics of the HIMI region, with particular emphasis on the areas contained within the HIMI Marine Reserve. More information about the HIMI region and Reserve is available from the references listed in the bibliography at the end of this Plan, and from the Australian Antarctic Division (AAD) website at www.aad.gov.au

History

Although the nearby Îles Kerguelen were frequently visited by sealing vessels from the 1770s and there was shipping activity in the southern Indian Ocean since before 1800, Heard Island and the McDonald Islands remained unknown until the mid-1800s³⁴. Captain Peter Kemp of the sealing vessel *Magnet* may have sighted land in the vicinity of Heard Island in 1833, and the captain of another sealing vessel, the *Charles Carrol*, reported sighting land south of the Îles Kerguelen in 1849³⁵. However, the discovery of Heard Island is attributed to Captain John Heard on the merchant vessel *Oriental*. Captain Heard made a confirmed sighting of the island on 25 November 1853 when travelling from Boston to Melbourne on a newly recommended, more southerly, ‘great circle’ route³³. The McDonald Islands were discovered on 4 January 1854 by Captain W. McDonald on the *Samarang*³³.

Within a few years of discovery, sealing operations had commenced at numerous locations around the Heard Island coast. The first landing was by a sealing expedition at Try Pot Beach on 15 February 1855 during a visit by the American whaler *Corinthian*, under the command of Captain Erasmus D. Rogers. The first party to overwinter comprised crew from the brig *Zoe*, who remained ashore undertaking sealing operations from March to October 1856³³. In December that year the schooner *Alfred* was driven ashore at Spit Bay, becoming the first of at least 14 vessels to be wrecked on or near the island³³.

More than 40 vessels made over 100 voyages to Heard Island seeking ‘sea–elephant’ (southern elephant seal – *Mirounga leonina*) oil in the three decades following the island’s discovery³⁴. The highest level of human activity ever at the island occurred during the sealing period from 1855–1882, with production of seal oil and visitation peaking in 1857–1859 and declining thereafter. Few details are known of the brief, sporadic visits by sealers and whalers during the early 20th century.

Five scientific visits are known from the late 19th and early 20th centuries, with brief visits by the *Challenger* and the *Arkona* in 1874, the German South Polar Expedition in 1902, and in 1929 by a French mineral–prospecting expedition and the British, Australian and New Zealand Antarctic Research Expedition (BANZARE) led by Douglas Mawson. The latter group travelled on to Antarctica to undertake activities that form part of the foundation for Australia’s claim to a substantial part of the Antarctic continent.

No further visits to Heard Island are known until the establishment of the Australian National Antarctic Research Expedition (ANARE) station at Atlas Cove in December 1947. The station was occupied between December 1947 and March 1955, providing a base for extensive scientific activities on the island throughout that period.

Several summer visits by the Australian Antarctic program and several private expeditions, including an overwintering American expedition (1969) and a French expedition (1971), were conducted between 1955 and the late 1970s. The first recorded landing on the McDonald Islands occurred by helicopter in 1971³⁶, with the second almost a decade later in 1980³⁷.

A resurgence in Australian Antarctic program activities on Heard Island commenced in the mid-1980s, with three successive summer expeditions between 1985 and 1989, a brief midwinter visit in 1990, an overwinter expedition in 1992, and summer expeditions in 2000/01 and 2003/04.

Several brief landings were also made by personnel involved in fisheries surveillance patrols conducted between 1997 and 2004, which used both civilian and Australian Defence Force vessels. Shore parties from some patrols undertook small scale cleanup and reconnaissance tasks in preparation for later Australian Antarctic program expeditions³⁸.

Heard Island and McDonald Islands Marine Reserve

The United Kingdom formally established its claim to Heard Island in 1910, marked by the raising of the Union Jack and the erection of a beacon by Captain Evensen, master of the *Mangoro*. Effective government, administration and control of Heard Island and the McDonald Islands was transferred to the Australian Government on 26 December 1947 at the commencement of the first Australian National Antarctic Research Expedition (ANARE) to Heard Island, with a formal declaration that took place at Atlas Cove. The transfer was confirmed by an exchange of letters between the two governments on 19 December 1950.

The conservation values of the HIMI region have long been appreciated. The need for formal protection of the natural values of the Territory was formally acknowledged with the approval by the Australian Parliament of the *Heard Island and McDonald Islands Act 1953* (HIMI Act) which, among other things, made provisions for the protection of wildlife and the making of ordinances for the administration of the islands.

The islands of the Territory were listed on the Register of the National Estate in 1983 for their significant natural and cultural features (see section 1.2 Conservation Significance of the Reserve and Appendix 5). The value of these features was further recognised and protected through the *Environment Protection and Management Ordinance 1987* (the EPMO), made under the HIMI Act. The EPMO provided a legal regime for the protection of the Territory's indigenous plants and animals, including the obligation to prepare a management plan for the Territory and the requirement for a permit to enter or undertake activities in the Territory.

In 1990 the Australian Government nominated the Territory for inclusion on the World Heritage list, citing the islands' outstanding natural processes, the undisturbed environment and important ecosystems, the range of landform features and their aesthetic qualities. The nomination was deferred by the World Heritage Bureau, which requested further information on the Territory's conservation values, legal status, proposed boundaries and management plan for the site.

The *Heard Island Wilderness Reserve Management Plan*, made under the EPMO, came into effect on 14 February 1996. The plan provided priorities for decisions that would affect the Territory, defined appropriate uses and activities, outlined management areas and contained management strategies for protecting the Territory's values.

Later in 1996 Australia submitted the additional information requested by the World Heritage Bureau in a second nomination. This nomination was accepted, and the Territory was inscribed on the World Heritage list on 3 December 1997 for its outstanding natural universal values. The World Heritage Committee noted that the site 'is the only volcanically active subantarctic island and illustrates the ongoing geomorphic processes and glacial dynamics in the coastal and submarine environment and subantarctic flora and fauna, with no record of alien species'.

In 1998 the HIMI region was identified in Australia's Oceans Policy as one of five areas where the Australian Government would preferentially pursue a marine park, to ensure Australia's temperate and subantarctic waters were incorporated in the comprehensive and representative system of marine protected areas and to help protect Australia's unique marine biodiversity.

A subsequent report, *Conservation of marine habitats in the region of Heard Island and McDonald Islands*⁵, documented the conservation values of the HIMI region and, using the Australian and New Zealand Environment and Conservation Council (ANZECC) criteria for the identification and selection of marine protected areas under the National Representative System of Marine Protected Areas (NRSMPA), proposed boundaries for a marine reserve to provide ongoing protection of these values.

In January 2001 the Government announced the initial proposal to declare a Commonwealth reserve (Marine Reserve) under the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) in the HIMI EEZ. Following extensive consultation with key stakeholders from industry, conservation groups and government, the proposal was revised and released in May 2002, with some of the initially proposed areas declared as a conservation zone under the Act (see Figure 2). It was agreed that the conservation zone areas would undergo further assessment to determine their conservation values and fisheries resource potential before again being considered for incorporation in the Reserve.

Stakeholders were supportive of the revised proposal and on 16 October 2002 the Heard Island and McDonald Islands Marine Reserve (the Reserve) was proclaimed under section 344 of the EPBC Act as a Commonwealth reserve, for the purpose of protecting the conservation value of the Heard and McDonald Islands and the adjacent unique and vulnerable marine ecosystems.

In summary, the Reserve covers an area of approximately 6.5 million hectares (65 000 km²), including:

- Heard Island and the McDonald Islands and the associated territorial sea;
- the central portion of the plateau area to the north of the territorial sea extending out to the Australian EEZ boundary;
- a portion of the western plateau around Coral Bank;
- a small area to the south of the territorial sea; and
- a portion at the north–east of the plateau area, including areas over and around Shell Bank and part of the north–eastern plateau out to the limits of the EEZ.

In addition to the land and waters within these areas, the Reserve also includes the seabed and subsoil to a depth of 1000 m.

At the time of preparing this Plan, the conservation zone assessment program is still underway.

The location of the Reserve is represented in and the boundaries of the Reserve are represented in Figure 2. The boundaries of the Reserve are outlined in the Schedule to the Proclamation document, which is reproduced at Appendix 1.

Climate

The large–scale climate of the HIMI region is strongly influenced by its mid–latitude location in the Southern Ocean, south of the Antarctic Polar Front (the meeting point of subantarctic surface waters and colder Antarctic surface waters) and in a zone of strong and persistent westerly winds (the ‘furious 50s’) associated with deep low–pressure systems. The maritime setting of the islands leads to low seasonal and daily temperature ranges, persistent and generally low cloud cover, frequent precipitation and strong winds. The local climate on Heard Island is significantly influenced by the island’s perennial ice cover and mountainous nature, particularly the orographic effects of Big Ben on precipitation, snow accumulation, winds and cloud cover³⁹. The relatively low–lying McDonald Islands are free of permanent ice and, while windy, do not experience the highly changeable conditions of Heard Island.

Due to intermittent human occupation, meteorological observations at Heard Island are incomplete, although there are good records for the periods 1947–1954 (manual measurements from Atlas Cove) and 1997–2004 (data from automatic weather stations at Atlas Cove and Spit Bay). Monthly average temperatures at Atlas Cove range from 0.0° to 4.2°C, with an average daily range of 3.7 to 5.2°C in summer and –0.8 to 0.3°C in winter.

The highest recorded temperature at Atlas Cove was 15.8°C in February 2001. Air temperatures at Spit Bay, only 25 km to the east can be remarkably different, with monthly mean temperatures being as much as 1.3°C higher. Spit Bay also experienced an extreme monthly maximum temperature of 21.6°C in April 1992, which is 10.8°C higher than for the April record at Atlas Cove³⁹.

Winds at Heard Island are predominantly westerly, although the direction of local winds is greatly influenced by surrounding topography. At Atlas Cove, monthly average wind speeds range from a low in December and January of 7.2 m/s (around 26 km/h) to a high of around 9.3m/s (around 33.5 km/h). A maximum daily wind gust of greater than 50m/s (180 km/h) has been recorded on several occasions. Wind records from other parts of the island are less comprehensive, with observations also being influenced by local topography, although it is known that wind speed generally increases with elevation and that violent, localised wind storms are common³⁹. Strong, dry, gusty and warm Föhn winds, which develop on the lee side of Big Ben, are an important element of the climatic conditions for some parts of Heard Island and lead to higher average monthly temperatures and more frequent high temperature events at Spit Bay compared with Atlas Cove³⁹.

Observations at Atlas Cove and Spit Bay indicate that annual precipitation at sea level on Heard Island is in the order of 1.3–1.9 m (water equivalent)⁴⁰, with precipitation occurring on 75% of days during the 1948–1954 period at Atlas Cove³⁹.

The high relative humidity at Heard Island (mean >80% year-round) together with the mountainous topography and strong winds, result in persistent cloud cover and often-spectacular cloud formulations, such as cap, lenticular and rotor (collectively ‘wave’ clouds) commonly observed over and downwind of Big Ben and to a lesser extent Laurens Peninsula³⁹. Atlas Cove, at the western end of the island, experiences significantly greater cloud cover (average 7.3 octas, where an octa equals one eighth of the celestial dome) than Spit Bay at the eastern end, in the lee of Big Ben.

There is considerable evidence that the climate of Heard Island is changing, with observations at Atlas Cove indicating an increase in average annual air temperature of almost 1°C between the periods 1948–1954 and 1997–2001³⁹. This mirrors similar changes interpreted from observations at nearby Îles Kerguelen and elsewhere in the southern Indian Ocean. These increased temperatures are having a significant effect on the Heard Island environment, with glacial retreat leading to the formation of lagoons and freshwater lakes, and exposing new land for colonisation by plants and animals.

Terrestrial Environment

Geology and Geomorphology

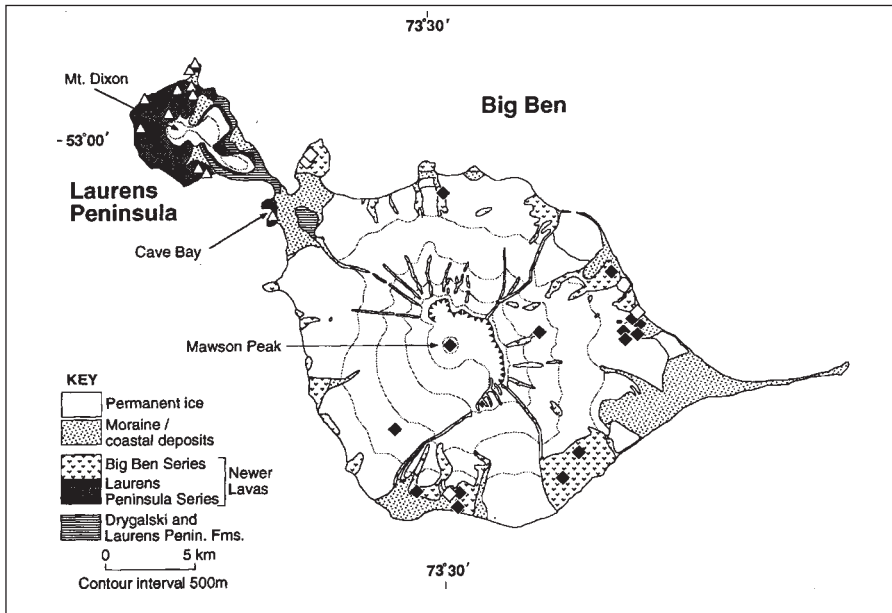
Heard Island and the McDonald Islands are located on the relatively shallow (<1000 m deep) central part of the submarine Kerguelen Plateau. The islands collectively comprise one of two (with Îles Kerguelen) surface exposures of the Plateau which, with an area of approximately two million square kilometres, is one of the largest submarine plateaus on Earth. The Kerguelen Plateau began to form approximately 115 million years ago (mya). Recent geological investigations suggest a formative period extending over 80 million years⁴¹, with the formation of Heard Island commencing approximately 45–50 mya and continuing to this day.

Heard Island essentially consists of two oval-shaped regions connected by an extensive, low gravel isthmus near Atlas Cove (The Nullarbor) (see Figure 7). The main part of the island is dominated by Big Ben, a massive volcanic cone between 18 and 20 km in diameter that rises to a height of 2745 m at Mawson Peak, and sits approximately 400 m above a large ice-covered plateau to its north, east and south-east^{42,43}. The smaller oval of Laurens Peninsula (about 8 km long and 6 km wide) rises to 715 m at Anzac Peak and contains three main snow- or ice-capped peaks, the northernmost of which, Mt Dixon, is a volcanic dome that has probably been active in the last few hundred years⁴³. The eastern end of the island terminates in Elephant Spit, a changeable sand and gravel feature affected by the prevailing easterly ocean currents, which extends offshore for approximately 10 km.

The geology of Heard Island is the result of three distinct phases, as evidenced by three main stratigraphic formations presently recognised on the island: the Laurens Peninsula Limestones (mid-Eocene ~44 mya to mid-Oligocene ~29 mya), the Drygalski Formation (late Miocene to early Pliocene ~5.3 mya) and the Young Lavas (Quaternary ~1.8 mya to today)^{41,43} (see Figure 8). The Laurens Peninsula Limestones contain calcareous nanofossils and foraminiferids and are observed as extensive outcrops on the southern and north-eastern sides of Laurens Peninsula, although it is thought that they occur as a basement under much of the island⁴³.

The Drygalski Formation overlies the Laurens Peninsula Limestone (see Figure 8) and is readily identified on Laurens Peninsula and under Mt Drygalski as sedimentary rocks, some possibly glacial, with interbedded basaltic flows and intrusions. It occurs on much of the island as solid, cliff-forming strata 300–350 m in thickness⁴³. The Drygalski Formation is in turn overlain by the Young Lavas, which give Heard Island its shape and consist of the youngest rocks on the island. Two lava series are recognised: the Laurens Peninsula series, which forms much of the Laurens Peninsula and magmatic rocks from Cave Bay, and the Big Ben series which forms much of the remainder of the island. These two series have differing petrographic characters, indicating contrasting magma plumbing systems⁴³. Elemental and isotopic geochemical properties also differ between the two series.

Figure 8. Geological sketch map of Heard Island



(adapted from Barling, Goldstein & Nicholls 1994⁴⁰)

McDonald Island appears to be an uplifted and eroded portion of a shallow submarine volcano and is composed of phonolitic lava, very different from that which characterises Heard Island. Shag Island, Sail Rock and Drury Rock are emergent outcrops that have not been studied⁴².

The geomorphology of HIMI is the product of close interaction between volcanism, glaciation, and vigorous marine processes⁴⁵. Both Heard Island and the McDonald Islands are volcanically active. Eruptions have been observed regularly on Big Ben⁴² and recent satellite imagery of McDonald Island clearly shows its altered coastline and topography as a result of vulcanism (see Figure 9). There are numerous records of pumice being washed ashore around Heard Island in the last 100 years – it is now believed that some of it originated from the McDonald Islands. Volcanic activity on McDonald Island has been observed during visits to the islands since 1997 and observations of sporadic volcanic activity on Heard Island have been reported over the past twenty years⁴².

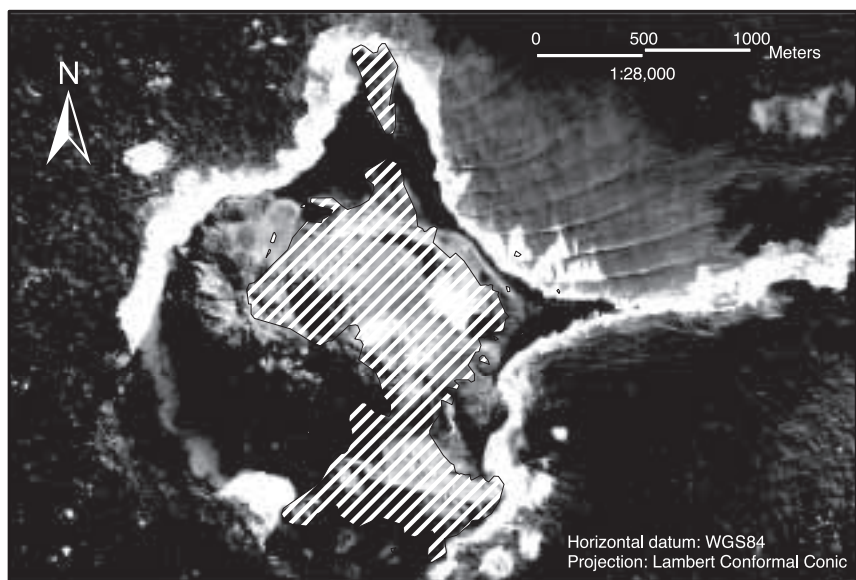
The most obvious volcanic feature is Big Ben, but other volcanic landforms, including scoria and cinder cones, craters, domes, open vertical volcanic conduits, lava flows and lava tubes, are found throughout Heard Island, with concentrations on Laurens and Azorella Peninsula⁴⁵.

Azorella Peninsula, in particular, contains a diverse range of volcanic landforms and near-pristine systems that display unique interactions between local physical, climatic and biological elements. Importantly, the Peninsula also contains the only lava tubes recorded from the Antarctic or subantarctic regions²⁰.

The substantial glaciation of Heard Island and periods of glacial advance and retreat, in keeping with climate change, have resulted in the occurrence of widespread erosional and depositional landforms. Erosional features include glacial valleys, ice-abraded bedrock surfaces, trough heads, rock bars, cirques, arêtes, cols and horns. Glacial processes have also produced depositional features such as lateral, medial, hummocky and end moraines, the most prominent of which occur in the Dovers Moraine complex, deposited by the Stephenson Glacier. Other prominent depositional features are alluvial and beach deposits, such as those which form The Nullarbor between Laurens Peninsula and the main part of the island.

The islands are constantly exposed to vigorous westerly ocean waves generated by the 'furious fifties', resulting in the presence of wide-spread erosional and depositional coastal landforms. Persistent wave-action has produced the steep cliffs found around much of Heard Island, with the coastline in some areas punctuated by steep beaches of sand, shingle, cobbles and boulders, as well as bars and spits resulting from the drift alongshore of substantial quantities of glacial and volcanic sediment⁴⁵.

Figure 9. Satellite image of McDonald Island taken in 2004 overlaid with a shaded area indicating the island's extent in 1980



Glaciology

Heard Island has extensive ice cover, with glaciers covering 70% (257 km²) of the island and permanent snow covering a further 2%⁴⁰. Steep glaciers descend radially and rapidly from the summit of Big Ben towards the coast. It is thought that the age of the oldest ice may be around 100 years⁴². Some of these glaciers currently terminate in the sea, while others terminate inland as a result of glacial retreat, which has led to the formation of widespread glacial lakes and lagoons. There are extensive snowfields on Laurens Peninsula, and several smaller glaciers that descend from the summits of Mt Dixon, Mt Anzac and Mt Olsen.

This extensive glaciation of Heard Island results from the island's high altitude and its position south of the Antarctic Polar Front. There are twelve major glaciers and numerous minor glaciers that radiate outwards from the summit of Big Ben or from the peaks of Laurens Peninsula, flowing towards the coast⁴⁰. The largest of these is the Gotley Glacier, which descends for over 13 km from the island's highest point (2745 m at Mawson Peak) to the coast west of Cape Labuan, covering an area of 27.4 km² with an estimated mean thickness of 59 m⁴⁰. There are no glaciers at the McDonald Islands.

Since the earliest visits to Heard Island in the mid 19th century numerous maps, drawings, photographs and satellite images have recorded the extent of ice-free land. This shows that the glaciers on Heard Island changed little between 1860 and 1929⁴⁶. Many glaciers on the eastern and northern sides of the island receded slightly between 1929 and 1955, more widely between 1955 and 1963, (some) advanced between 1963 and 1971, and receded extensively since then. Major glacial retreats have typically been restricted to the glaciers that begin below 1500 m above sea level (asl)⁴⁶. The glaciers with a larger elevation range and high mass turnover, such as the Gotley Glacier, lose much of their ice through calving into the sea rather than surface melt⁴⁰.

Climate change appears to have been responsible for dramatic changes to the glaciers on Heard Island between 1947 and 1988, when the total ice area decreased from 288 km² (79% of the island) to 257 km² (70% of the island). This recession, and the intermittent advances in the glaciers, correlate strongly with increases and decreases in regional sea surface and air temperatures^{39,40}. The contribution of volcanic activity to these changes in glacial extent is considered negligible^{39,47}.

The extent of glaciers on Heard Island is currently decreasing, with a corresponding development and expansion of pro-glacial water bodies, and increased bare ground available for colonisation by plants and animals. Preliminary results of field work at Brown Glacier in 2003/04 indicate that the glacier has retreated by approximately fifty metres since 2000/01, and has lost as much as eleven metres in thickness on the lower slopes⁴⁸. A correlating reduction in glaciers on Îles Kerguelen, approximately 300 km to the north-west, and north of the Antarctic Polar Front, shows that the warming at Heard Island is characteristic of regional trends³⁹.

Terrestrial and Coastal Flora

Low-growing herbaceous flowering plants and bryophytes are the major components of vegetation on HIMI. The vascular flora at HIMI is comprised of the smallest number of species of any major subantarctic island group, reflecting its isolation, small ice-free area and severe climate⁴⁹. Twelve vascular species are known from Heard Island, of which five have also been recorded on McDonald Island⁵⁰⁻⁵³ (see Appendix 15). Bryophytes (mosses and liverworts) and lichen contribute substantially to overall biodiversity of Heard Island with 62 bryophyte species and 71 lichen species recorded at the time of preparing this Plan⁴⁹. The 1980 survey of McDonald Island⁵² found lower diversity than that on Heard Island. Recent volcanic activity will have altered the distribution and abundance of the vegetation dramatically.

The low plant diversity of HIMI most likely reflects the islands' isolation, small size, severe climate, the short, cool growing season and, for Heard Island, substantial permanent ice cover. The vascular flora covers a range of environments and, although only six species are currently widespread, glacial retreat and the consequent connection of previously separate ice-free areas is providing opportunities for further distribution of vegetation into adjacent areas. None of the vascular species is endemic to HIMI, although *Pringlea antiscorbutica*, *Colobanthus kergulensis*, and *Poa kerguelensis* occur only on subantarctic islands in the southern Indian Ocean.

The recorded terrestrial flora of HIMI is typically subantarctic, but with a higher abundance of the cushion plant *Azorella selago* than other subantarctic islands. Heard Island is also the largest subantarctic island with no known human-introduced plants.

Areas available for plant colonisation on Heard Island are generally the result of retreating glaciers or new ice-free land created by lava flows³⁰. Today, substantial vegetation covers over 20 km² of Heard Island, and is best developed on coastal areas at elevations below 250 m^{49,54} (see Figure 7).

Bryophytes are present in most of the major vegetation communities and often occupy habitats unsuitable for vascular plants, such as cliff faces. A total of 43 moss species and 19 liverwort species have been recorded at the time of preparing this Plan⁴⁹ (see Appendix 16). Lichens are common on exposed rock and dominate the vegetation in some areas⁴⁹. Seventy one species have been recorded on Heard Island, including several soil and moss-inhabiting species. Four mosses, eight lichens and a number of algal and fungal species are also recorded from McDonald Island⁵².

At least 100 species of terrestrial algae are known from Heard Island, commonly in permanently moist and ephemeral habitats⁵⁵. Forests of the giant Antarctic kelp *Durvillaea antarctica* occur at a number of sites around Heard Island² and at least 17 other species of marine macro-algae (seaweeds) are known, with more to be added following the identification of recent collections (see Appendix 17).

The low diversity in marine macro-algae is due to the island's isolation from other land masses, unsuitable beach habitat, constant abrasion by waves, tides and small stones, and the extension of glaciers into the sea in many areas.

Evidence from microfossil records indicates that ferns and woody plants were present on Heard Island during the Tertiary (a period with a cool and moist climate)⁵⁶. Neither group of plants is present today, although potential Tertiary survivors include the vascular plant *Pringlea antiscorbutica* and six moss species^{49,57}.

The main environmental determinants of vegetation on subantarctic islands, including HIMI, are wind exposure, water availability, parent soil composition, salt spray exposure, nutrient availability, disturbance by trampling (from seabirds and seals) and possibly altitude⁴⁹. At Heard Island, exposure to salt spray and the presence of breeding and moulting seabirds and seals are particularly strong influences on vegetation composition and structure in coastal areas.

Heard Island has a range of terrestrial environments in which vegetation occurs. Seven general vegetation communities are currently recognised, although vegetation composition is considered more of a continuum than discrete units^{49,58}:

Open cushionfield vegetation is the most widespread and abundant vegetation type on Heard Island. It is characterised by *Azorella selago* cushions interspersed with bryophytes, small vascular species and bare ground with 20–75% cover, and found mainly at altitudes between 30–70 m asl.

Fellfield describes vegetation with abundant bare ground and less than 50% plant cover. Fellfield may occur as a result of harsh climatic and/or edaphic factors, or recent deglaciation which has exposed bare ground.

Mossy fellfield is a community with high species richness and consists of bryophytes and small *Azorella selago* cushions. It is found at altitudes between 30–150 m asl in areas with intermediate exposure.

Wet mixed herbfield occurs on moist substrate, mostly on moraines and moist lee slopes (often in association with burrowing petrels colonies) at low altitude (<40 m asl) where the water table is at or close to the surface. Species richness is highest here of all the communities, with dominant species being *Poa cookii*, *Azorella selago*, *Pringlea antiscorbutica*, *Acaena magellanica*, and *Deschampsia antarctica*.

Coastal biotic vegetation is dominated by *Poa cookii* and *Azorella selago*, and occurs mainly on coastal sites of moderate exposure and in areas subject to significant influence from seals and seabirds.

Saltspray vegetation is dominated by the salt-tolerant moss *Muelleriella crassifolia* and limited in extent, being found at 5 m asl on lavas in exposed coastal sites.

Closed cushionfield is found on moraines and sand at altitudes mostly below 60 m asl. Dominated almost entirely by *Azorella selago* cushions that often grow together to form continuous carpets and can be subject to some burrowing by seabirds.

Other vascular plant species and vegetation communities and species—found on other subantarctic islands north of the Antarctic Polar Frontal Zone—are missing from the Heard Island flora, although it is possible that some species may colonise the island if climate change produces more favourable conditions⁵⁸.

One of the most rapidly changing physical settings in the subantarctic has been produced on Heard Island by a combination of rapid glacial recession and climate warming. The consequent increase in habitat available for plant colonisation, plus the coalescing of previously discrete ice-free areas, has led to marked changes in the vegetation of Heard Island in the last 20 years or so. Some plant species are spreading and modifying the structure and composition of communities, some of which are also increasing in distribution⁴⁹. It is likely that further changes will occur, and possibly at an accelerated rate. Changes in population numbers of seal and seabird species are also expected to affect the vegetation by changing nutrient availability and disturbance through trampling.

At the time of preparing this Plan there is one plant species on Heard Island considered to be an alien, *Poa annua*, a cosmopolitan grass native to Europe. It is thought to have been naturally introduced, probably by skuas from Îles Kerguelen where it is widespread, because the grass was initially recorded in 1987 in two recently deglaciated areas of Heard Island not previously exposed to human visitation, while at the same time being absent from known sites of past human habitation⁵⁹. Since 1987 *Poa annua* populations have increased markedly in density and abundance within the original areas and have expanded beyond these areas^{49,60}. Expeditioner boot traffic during the Australian Antarctic program expedition in 1987 may be at least partially responsible for the spread of the grass beyond the initial two deglaciated areas but it is probably mainly due to dispersal by wind and the movement of seabirds and seals facilitating further spread around the island⁶⁰. Genetic studies of the different populations on Heard Island are currently in progress and may provide insights into the origin and spread of the species on the island.

The potential for introducing additional plant species (including invasive species not previously found on subantarctic islands) by both natural and human-induced means is high⁶¹. This is due to the combination of low species diversity and climatic amelioration. During the 2003/04 summer a new plant species for Heard Island, currently identified as *Leptinella plumosa*, was recorded. Only one small specimen was found growing on a coastal river terrace that had experienced substantial development and expansion of vegetation over the past decade⁶². The species has a circumantarctic distribution and occurs on many subantarctic islands⁶³. It will be of great interest to monitor its future distribution on Heard Island.

Wetlands

Heard Island has a number of small wetland sites scattered around its coastal perimeter, including areas of wetland vegetation, lagoons or lagoon complexes, rocky shores and sandy shores, including the Elephant Spit. (Further information about the wetland areas is given in Appendix 4, which includes a map at Attachment B). Many of these wetland areas are separated by active glaciers. There are also several short glacier-fed streams and glacial pools. Some wetland areas have been recorded on McDonald Island but, due to substantial volcanic activity since the last landing was made in 1980, their present extent is unknown.

The HIMI wetland is listed on the *Directory of Important Wetlands in Australia*⁷ and, in a recent analysis of Commonwealth-managed wetlands, was ranked highest for nomination under the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention) as an internationally important wetland³. A draft of the Ramsar Information Sheet required for nomination of the wetland is included in Appendix 4.

Six wetland types have been identified from HIMI covering approximately 1860 ha: coastal 'pool complex' (237 ha); inland 'pool complex' (105 ha); vegetated seeps mostly on recent glaciated areas (18 ha); glacial lagoons (1103 ha); non-glacial lagoons (97ha); Elephant Spit (300 ha) plus some coastal areas (Scott 1999). On Heard Island, the majority of these types suites are found below 150 m asl⁸. The wetland vegetation occurs in the 'wet mixed herbfield' and 'coastal biotic vegetation' communities described above.

The wetlands provide important breeding and feeding habitat for a number of Antarctic and subantarctic wetland animals. These include the southern elephant seal and macaroni, gentoo, king and southern rockhopper penguins, considered to be wetland species under the Ramsar Convention. Non-wetland vegetated parts of the islands also support penguin and other seabird colonies.

Terrestrial, Freshwater and Coastal Invertebrates

Heard Island supports a relatively low number of terrestrial invertebrate species compared to other Southern Ocean islands, in parallel with the low species richness in the flora—that is, the island's isolation and limited ice-free area⁶⁴. Endemism is also generally low and the invertebrate fauna is exceptionally pristine with few, if any, (successful) human-induced introductions of alien species²⁴. Two species, including the thrip *Apterothrips apteris* and the mite *Tyrophagus putrescentiae* are thought to be recent, possibly natural, introductions⁶⁴. An exotic species of earthworm *Dendrodilus rubidus* was also collected in 1929 from a dump near Atlas Cove⁶⁵, and has recently been collected from a variety of habitats including wallows, streams and lakes on Heard Island²⁶. A list of the terrestrial invertebrates presently known from Heard Island is given in Appendix 18.

The arthropods of Heard Island are comparatively well known with 54 species of mite and tick, one spider and eight springtails recorded. A study over summer at Atlas Cove in 1987/88 showed overall densities of up to 60 000 individual springtails per square metre in soil under stands of *Pringlea antiscorbutica*. Despite a few recent surveys, the non–arthropod invertebrate fauna of Heard Island remain poorly known⁶⁴.

Beetles and flies dominate Heard Island's known insect fauna, which comprises up to 21 species of ectoparasite (associated with birds and seals) and up to 13 free–living species. Approximately half of the free–living insects are habitat–specific, while the remainder are generalists found in a variety of habitats, being associated with either supralittoral or intertidal zones, *Poa cookii* and *Pringlea antiscorbutica* stands, bryophytes, lichen–covered rocks, exposed rock faces or the underside of rocks⁶⁴. There is a pronounced seasonality to the insect fauna, with densities in winter months dropping to a small percentage (between 0.75%) of the summer maximum⁶⁶. Distinct differences in relative abundances of species between habitats has also been shown, including a negative relationship between altitude and body size for Heard Island weevils⁶⁴.

The fauna of the freshwater pools, lakes, streams and mires found in the coastal areas of Heard Island are broadly similar to those on other subantarctic islands of the southern Indian Ocean. Many species reported from Heard Island are found elsewhere. Some sampling of freshwater fauna has been undertaken during recent expeditions and records to date indicate that the freshwater fauna includes a species of Protista, a gastrotrich, two species of tardigrade, at least four species of nematode, 26 species of rotifer, six species of annelid and 14 species of arthropod⁶⁷.

As with the other shore biota, the marine macro–invertebrate fauna of Heard Island is similar in composition and local distribution to other subantarctic islands⁶⁸, although relatively little is known about the Heard Island communities compared with the well–studied fauna of some other locations in the subantarctic region, such as Macquarie Island and Îles Kerguelen.

Despite Heard Island's isolation, species richness is considered to be moderate, rather than depauperate, although the number of endemic species reported is low⁶⁹. The large macro–alga *Durvillaea antarctica* supports a diverse array of invertebrate taxa⁷⁰ and may play an important role in transporting some of this fauna to Heard Island⁶⁹.

The rocky shores of Heard Island exhibit a clear demarcation between fauna of the lower kelp holdfast zone and the upper shore zone community, probably due to effects of desiccation, predation and freezing in the higher areas. The limpet *Nacella kerguelensis* is abundant in the lower part of the shore, being found on rock surfaces and on kelp holdfasts. Other common but less abundant species in this habitat include the chiton *Hemiarthrum setulosum* and the starfish *Anasterias mawsoni*. The amphipod *Hyale* sp. and the isopod *Cassidinopsis* sp. are closely associated with the kelp. Above the kelp holdfast zone, the littornid *Laevilitorina (Corneolitorina) heardensis* and the bivalve mollusc *Kidderia bicolor* are found in well–sheltered situations, and another bivalve *Gaimardia trapesina trapesina* has been recorded from immediately above the holdfast zone. Oligochaetes are also abundant in areas supporting porous and spongy layers of algal mat^{71,72}.

Birds

Heard Island and the McDonald Islands are free from introduced predators and provide crucial breeding habitat in the middle of the vast Southern Ocean for a range of birds (see Figure 7 and Appendix 19, which gives scientific names for the species mentioned below). The surrounding waters are important feeding areas for birds and some scavenging species also derive sustenance from their co-habitants on the islands.

Nineteen species of birds have been recorded as breeding on Heard Island⁷³ and the McDonald Islands, although recent volcanic activity at the McDonald Islands in the last decade is likely to have reduced vegetated and un-vegetated nesting areas⁷⁴. Current estimates of breeding populations, population trends and approximate breeding schedules are given in Appendix 19.

Penguins are by far the most abundant birds on the islands, with four breeding species present, comprising king, gentoo, macaroni and rockhopper penguins. The penguins mostly colonise the coastal tussock and grasslands of Heard Island, and have previously been recorded as occupying the flats and gullies on McDonald Island.

Other seabirds recorded as breeding at Heard Island include three species of albatross (wandering, black-browed and light-mantled sooty), southern giant petrels, cape petrels, four species of burrowing petrels (Antarctic and fulmar prions, common and South Georgian diving petrels), Wilson's storm petrels, kelp gulls, subantarctic skuas, Antarctic terns and the Heard Island cormorant⁷⁴. Although not a true seabird, the Heard Island sheathbill also breeds on the island. Both the cormorant and the sheathbill are endemic to Heard Island.

A further 28 seabird species are recorded as non-breeding visitors or from at-sea surveys⁷⁴. Appendix 2 lists the non-breeding species, and indicates the conservation status of each breeding and non-breeding species listed under the EPBC Act. Figure 7 indicates the locations of recorded nesting sites and colonies.

All recorded breeding species, other than the Heard Island sheathbill, are listed marine species under the EPBC Act, four are listed threatened species (endangered-southern giant petrel; vulnerable-wandering albatross, Heard Island cormorant and Antarctic tern), and five are listed migratory species (wandering albatross, black-browed albatross, light-mantled sooty albatross, southern giant petrel and Wilson's storm petrel).

Under the EPBC Act a recovery plan has been made for albatrosses and giant petrels, which calls for ongoing population monitoring of the species found at HIMI, and at the time of preparing this Plan a draft recovery plan has also been made for the Heard Island cormorant and Antarctic tern.

The recorded populations of some seabird species found in the Reserve have shown marked change. The king penguin population is the best studied seabird species on Heard Island and has shown a dramatic increase since first recorded in 1947/48, with the population doubling every five years or so for more than 50 years⁷⁴.

A paper reviewing population data for black-browed albatrosses between 1947 and 2000/01 suggested that the breeding population had increased to approximately three times that present in the late 1940s⁷⁵, although a CCAMLR Working Group was cautious about the interpretation of the increasing trend given the disparate nature of the data⁷⁶, as discussed in the paper. The discovery of a large, previously unknown, colony of Heard Island cormorants in 2000/01 at Cape Pillar raised the known breeding population from approximately 200 pairs to in excess of 1000 pairs⁷⁴. On the other hand, the breeding population of southern giant petrels decreased by more than 50% between the early 1950s and the late 1980s.

Research undertaken in 2003/04 into the feeding habits and foraging range of several bird species, using satellite trackers, data loggers and close to real-time sampling of prey species will contribute to the further understanding of the Heard Island food web and to the sustainable management of the commercial fishery adjacent to the Reserve.

Seals

There are three breeding species of seal at HIMI, the Antarctic *Arctocephalus gazella* and subantarctic *A. tropicalis* fur seals and the southern elephant seal *Mirounga leonina*. Four other species of Southern Ocean seal have been recorded from Heard Island: Ross *Ommatophoca rossii*, crabeater *Lobodon carcinophagus*, leopard *Hydrurga leptonyx* and Weddell *Leptonychotes weddellii* seals. Each of these seal species is a listed marine species under the EPBC Act, and the southern elephant seal and subantarctic fur seal, for which a recovery plan has been made, are listed as threatened species (vulnerable) (see Appendix 2).

The breeding population of Antarctic fur seals at Heard Island has increased dramatically⁷⁷. The most recent survey in 2000/01 recorded a fourfold increase since 1987/88⁷⁷. The non-breeding population, which is made up of immigrants from Îles Kerguelen and South Atlantic Ocean populations⁷⁸, far exceeds the breeding population with the total island population exceeding 29 000 individuals⁷⁷. The predominant item in their diet is fish, primarily pelagic myctophids, with mackerel icefish *Champscephalus gunnari* also being taken in high numbers⁷⁹. Studies undertaken in 1992/93 indicated that female fur seals forage to the north-east of Heard Island, whereas males ranged around the shelf and forage in deep water south of Heard Island. The extent of competition, if any, between seals and commercial fishing operations in the region is presently undetermined due to the absence of long-term data. It is expected that recent research will define food web linkages of fur seals, and other important foragers and help ensure that fisheries in the region are ecologically sustainable.

Southern elephant seals are the largest seals in the world; males can weigh 4000 kg while females may reach 900 kg, and their life expectancy may exceed 20 years⁸⁰. They are by far the most abundant seal on Heard Island, coming ashore to breed and moult. Extensive sealing at Heard Island greatly reduced the population during the 19th century. The breeding population at Heard Island has decreased, with a birth rate in 1985 40% below that of 1948⁸¹.

Breeding occurs through the spring, with pups born in September and October. The diet of southern elephant seals at Heard Island is predominantly fish and squid, with adult females mainly foraging along the south–east edge of the Kerguelen Plateau in summer and close to the Antarctic continental shelf in winter^{81–83}, adult males foraging closer to the Antarctic continental shelf in winter⁸⁴ and juveniles spending most time on or at the edge of the Kerguelen Plateau⁸¹. Resightings of individuals marked at Heard Island have been made from as far away as Australia’s Casey station, over 3000 km away.

Subantarctic fur seals are an uncommon species at HIMI^{77,85}, as are Weddell, crabeater and Ross seals⁸⁰.

Leopard seals are the most commonly occurring, non–breeding seal species visiting Heard Island, which serves as a major wintering area for the species⁸⁶. Haul–out locations vary depending on weather conditions, but the preferred sites are Corinthian Bay, Atlas Cove, South West Bay and West Bay⁸⁷. It has been suggested that leopard seals may be seen in greater numbers at Heard Island than anywhere else in the world⁸⁶. It is possible that climatic changes mean that fewer leopard seals now visit in winter, as may the other vagrants⁸⁸.

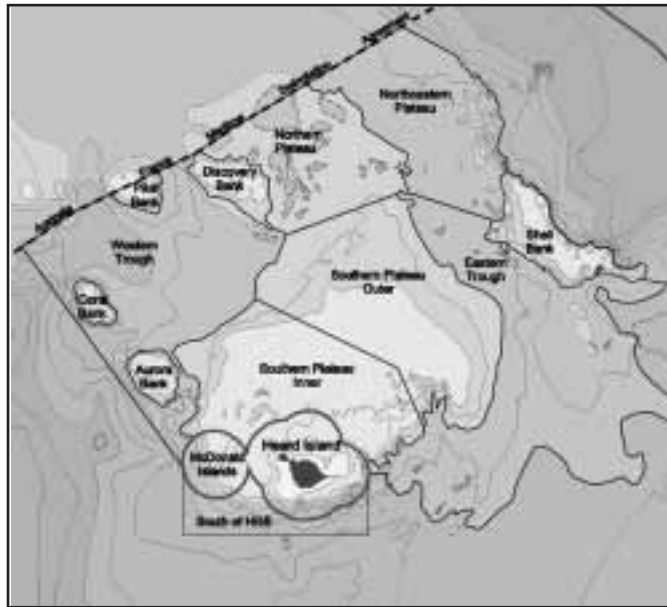
Marine Environment

Heard Island and the McDonald Islands are surface exposures of the surrounding submarine Kerguelen Plateau, the largest oceanic plateau in the world. The confluence of major east–moving oceanographic currents in the region, as well as small–scale upwelling, eddies and gyres caused by varied submarine topography, appear to create a variety of benthic and pelagic habitats¹.

Samples taken in the HIMI region, as part of the global Ocean Drilling Program, indicate that primary surface sediments in the region comprise siliceous diatom mud or ooze, with some areas containing quantities of calcareous sediments and foraminifera⁸⁹. Qualitative analysis of benthic invertebrates taken as by–catch during benthic trawls in the region indicated that a range of species are present, with echinoderm species being the most prevalent¹, including seven species that are possibly endemic to the Heard Island region.

An analysis by Meyer et al. (2000) of the available information about benthic assemblages, substratum and the physical characteristics of the marine environment surrounding HIMI indicates that the areas of the EEZ shallower than 1000 m can be potentially divided into 13 different biophysical local units¹ (see Figure 10). Of these biophysical units, nine are represented in the marine areas within the Reserve (see Appendix 20).

Figure 10. Biophysical local units around HIMI



(adapted from Meyer et al. 2000)

The marine areas can be more broadly classified into five as the western, central, southern and north–eastern areas, plus the territorial sea. Collectively these areas contain:

- unique features of the benthic environment surrounding HIMI;
- representative portions of the different habitat types in the region; and
- the pelagic area where land–based marine predators concentrate their local foraging activities.

The territorial sea supports nearshore marine species and is a foraging area for many flying birds based on the islands. The southern area is likely to be highly productive, with a diverse range of benthic assemblages in depths of 500–1000 m. The western area, including Coral Bank, displays diverse assemblages of benthic invertebrates, particularly gorgonian corals and barnacles. The central area, including Discovery Bank and portions of the northern and southern plateaux, is habitat for long–lived glass and other erect sponges, and a nursery area for commercial fish species. In the north–eastern area, Shell Bank supports a separate stock of mackerel icefish, small aggregations of a variety of other fish species, a diverse echinoderm assemblage and a unique shell–grit habitat different from the surface sediments found elsewhere in the region.

This north–eastern area, including areas of the north–eastern plateau, is also an important foraging area for land–based marine predators in the HIMI region. A summary of the physical and biological characteristics of the individual biophysical units is given in Appendix 20.

Oceanography

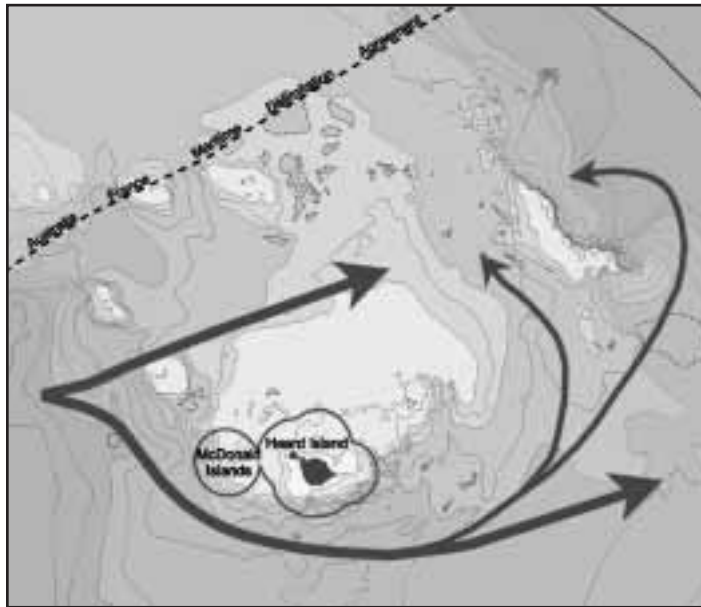
The remote location of the Reserve has made oceanographic study difficult and infrequent, although three comprehensive physical surveys were carried out in conjunction with marine biology in the region during the 1990s¹.

The Kerguelen Plateau is surrounded by deep ocean basins. To the north–west is the Crozet Basin, to the north–east is the Australian–Antarctic Basin, to the east is the Labuan Basin, to the south is the 3500 m deep Princess Elizabeth Trough, and to the south–west is the Enderby Basin⁸⁹. The northern and central parts of the Kerguelen Plateau have shallow water depths (<1000 m) and contain a major sedimentary basin (the Kerguelen–Heard Basin). The southern plateau is characterised by deep water, from 1500 to 2500 m⁸⁹.

The Kerguelen Plateau is a major topographic barrier to the easterly flow of the deep–reaching waters of the Antarctic Circumpolar Current (ACC). The ACC links all the major oceans and is driven by the world’s strongest westerly winds, found between about 45°S and 55°S⁹⁰.

Most of the ACC is thought to be deflected in a north–easterly direction and to travel over the shallow section of the plateau, north of Îles Kerguelen⁹¹. The ACC then travels down the eastern side of the plateau⁹¹, where a relatively warm inflow of bottom water occurs between the Plateau and the mid–ocean ridge⁹². In the Heard Island region, most water is thought to flow in an easterly direction both to the north and south of the island, although there is a stream of water that moves in a north–westerly direction through the trough between the relatively shallow central plateau and west of Shell Bank. Water is also known to eddy around the east of Shell Bank in an anticlockwise direction (see Figure 11).

Figure 11. Surface currents in the HIMI region



(adapted from Meyer et al. 2000)

Several frontal systems exist in the southern Indian Ocean, identified by sharp boundaries of temperature, salinity and density between different water masses, especially in the upper few hundred metres. The most important front in the HIMI region is the Antarctic Polar Front, which is typically defined as the northern limit of a temperature minimum of 2°C at the 100 to 300 m depth range⁹³⁻⁹⁵. The Polar Front is oriented in a north, north-easterly direction as it passes around the south of Îles Kerguelen up to latitude 48°S. From there it curves in a south-easterly direction back down to about 50°S. Directly north of Heard Island it is estimated to be between 48°S and 49°S⁹³.

The most biologically productive area of the HIMI EEZ is the 200–500 m deep undulating plateau that lies mostly to the north and east of Heard Island⁹⁶. This area comprises the most important foraging areas for land-based marine predators in the HIMI region¹.

Fish

There have been no systematic studies of the fish fauna surrounding HIMI and the current state of knowledge is based on sporadic records, incidental catches and beach-washed specimens⁹⁷. However, the nearshore fish community (within 12 nautical miles of the coast) around HIMI is known to be similar to those at other subantarctic islands, with the families Nototheniidae (Antarctic cods) and Channichthyidae (icefishes) dominating in numbers of species and in abundance^{97,98}. The list of species recorded from the nearshore waters is given in Appendix 21.

In general, the fish fauna is distributed widely across the plateau around HIMI, with noticeable variation from shallow to deep water, and between Shell Bank in the east and the remainder of the banks and plateau areas. It is believed that the Kerguelen/Heard region is a single unit with regard to the fish, and four species are endemic to the region (*Lepidonotothen mizops*, *Gobionotothen acuta*, *Notothenia cyanobrancha*, and *Channichthys rhinocerotus*)⁹⁹.

Most of the inshore species also occur on the wider Heard Island Plateau¹⁰⁰ although, as would be expected, the number of inshore species is lower than on the plateau. Two species, *N. cyanobrancha* and *Paranotothenia magellanica*, have been found only in the inshore waters, as with other subantarctic islands.⁹⁷ The inshore species can be divided into five groups according to their use of the area:

- species that are restricted to close inshore waters of depths less than about 30 m for their entire life, e.g. *N. cyanobrancha*, *P. magellanica*, *Harpagifer spinosus*;
- species that spend their juvenile stages close inshore but are widespread on the plateau as adults (*Notothenia rossii*);
- species where a part of the adult population inhabits the close inshore area while the remainder of the population inhabits deeper water, both within and outside the territorial sea (*C. rhinocerotus* and *Notothenia coriiceps*);
- species that are widespread on the Heard Island Plateau in depths of 100–500 m including equivalent parts of the territorial sea (*Bathyraja* spp., *Muraenolepis orangiensis*, *Zanclorhynchus spinifer*, *Dissostichus eleginoides* juveniles, *G. acuta*, and *Champsoscephalus gunnari*); and
- vagrants from the mesopelagic zone in deep water at the margins of the plateau (*Krefflichthys anderssoni*, *Paradiplospinus gracilis*).

In the deeper waters on the marginal slope and beyond of the Kerguelen Plateau (greater than 500m deep), the dominant species or groups are the toothfish, macrourids and skates. Beyond the plateau in the oceanic waters pelagic groups such as the myctophids dominate the fish fauna.

Australian commercial fishers have operated in the HIMI AFZ since 1997 and have targeted Patagonian toothfish (*Dissostichus eleginoides*) and mackerel icefish (*Champscephalus gunnari*). Prior to the commencement of the Australian commercial fishery the only recorded fishing activity in the HIMI region is some exploratory Polish fishing in 1975 and the Soviet catch of mackerel icefish in the early 1970s¹⁰⁰, each occurring prior to the establishment of the AFZ and the entry into force of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). In recent years, Patagonian toothfish has also been poached by illegal fishers in areas of the AFZ, mainly to the east and north of HIMI.

Cetaceans

Cetacean records for the HIMI region are sparse due to lack of survey effort, but the waters around HIMI and the Kerguelen Plateau are recognised in *The Action Plan for Australian Cetaceans* as offshore locations of high productivity and importance for cetaceans¹⁶. The remains of seven species of cetacean have been found washed ashore at Heard Island, including skulls of pilot whales *Globicephala melaena*, strap-toothed beaked whales *Mesoplodon layardi*, spectacled porpoises *Phocaena dioptrica*, Minke whales *Balaenoptera acutorostrata*, hourglass dolphins *Lagenorhynchus cruciger*, and southern bottlenose whales *Hyperoodon planifrons*⁸⁰—an adult female of this species was also found stranded on Heard Island¹⁰¹. Shaughnessy (2000) records sperm whale bones and two dolphin heads found on Heard Island in 1929¹⁰².

Species observed at sea in the HIMI or Kerguelen Plateau region include the blue whale *Balaenoptera musculus* and fin whale *Balaenoptera physalus*^{102,103}, killer whale *Orcinus orca*^{16,80,103}, hourglass dolphin^{16,103,104}, strap-toothed beaked whale¹⁶, spectacled porpoise^{16,103}, humpback whale *Megaptera novaeangliae*^{103,105}, sperm whale *Physeter macrocephalus*, Minke whale^{103,105}, long-finned pilot whale *Globicephala melas*^{16,103}, southern bottlenose whale¹⁰³, Commerson's dolphin *Cephalorhynchus commersoni*, dusky dolphin *Lagenorhynchus obscurus*, Arnoux's beaked whale *Berardius arnouxii* and southern right whale *Balaena australis*¹⁰³. As with all areas of the Australian EEZ, the HIMI EEZ forms part of the Australian Whale Sanctuary established under the EPBC Act. It is an offence to kill, injure, take, trade, keep, move, interfere with or treat a cetacean within the Australian Whale Sanctuary, except under certain circumstances. Each of the above species is a listed cetacean under the EPBC Act and several are listed as threatened and/or migratory species (see Appendix 2). Under the EPBC Act recovery plans are in preparation for several cetacean species recorded in the HIMI region, including blue, fin, humpback and southern right whales.

Cultural attributes

Sealing Sites

Evidence of sealing activities on Heard Island is still present at several coastal sites (see Figure 7). These sealing sites comprise stone platforms, hut footings or ruins, occupied caves, barrels, and graves¹⁰⁶. Stone platforms, comprised of large beach cobbles formed into subcircular mounds raised above the general level of surrounding seal wallows, and used as platforms for working activities, are recorded from Long Beach, Spit Bay North, Try Pot Beach and Lavett Bluff. The ruins of a variety of huts used for domestic and/or industrial purposes, and built from a range of materials, are found on virtually all the sealing beaches. These huts sites—one of which is located in the shelter of an overhang, and two others are located in small lava-cave sites at Red Island and Long Beach—show evidence of occupation. Barrels and barrel pieces are widespread across the beaches, and two barrel caches are known from Oil Barrel Point and Red Island.

The significance of these sealing sites, which are relatively rare and almost untouched by human agency since their use, is recognised in HIMI's listing on the Register of the National Estate.

Shipwrecks

Over 100 visits to Heard Island by over 40 whaling ships and other vessels are known to have occurred in the sealing period¹⁰⁷. Ships rarely planned to anchor at the island for any length of time, generally only making brief visits to deploy and retrieve seal gangs who would work the beaches while the ship returned to Îles Kerguelen or went whaling¹⁰⁶. Of those ships at least 14 are recorded as having been lost and some of these were wrecked or lost at the island during the mid-late 19th century¹⁰⁷, including the *Mary Powell*, thought to have been driven into ice cliffs at Brown Glacier in 1858/59¹⁰⁸, and the *Trinity*, which was wrecked at Spit Bay in October 1880 leaving its crew stranded on the island until January 1882^{109,110}. No specific locations of wrecked ships are known but shipwreck material has been recorded at Walrus Beach, Skua Beach and along the northern beach at Spit Bay¹⁰⁶. These remains and any others from shipwrecks over years 75 old are automatically classified as historic shipwrecks under the *Historic Shipwrecks Act 1976*.

Atlas Cove ANARE Station

Remains of Australian National Antarctic Research Expeditions (ANARE) from 1947–1955, and expeditions by other countries including the UK, USA and France, are present at Atlas Cove. The ANARE station at Atlas Cove was the first permanent ANARE base established in the Southern Ocean, and was continually occupied by between 10 and 15 people each year between 11 December 1947 and 9 March 1955. The station, which consisted of a variety of huts and facilities, supported research in the fields of geology, geophysics, meteorology, upper atmospheric physics and biology.

Along with the Macquarie Island station, Atlas Cove provided opportunities to test structures and operations in high southern latitudes, which lead to the successful establishment of Mawson station, the first permanent Australian station on the Antarctic mainland, in 1954.

In 2000/01 several parts of the Atlas Cove station were removed as they were in an advanced state of decay and were both an environmental and safety hazard. Aside from building foundations, machinery and scattered artefacts, there is only one building that remains standing and largely intact; the 1950 ANARE recreation hut. Adjacent to the station site, within the vegetated area of Azorella Peninsula, there is a cross that commemorates the deaths in 1952 of two ANARE personnel, Richard Hoseason and Alistair Forbes. Some apparatus used for collecting water for the station remains in the moraine adjacent to the Baudissin Glacier, which is now several hundred metres from the glacier itself. Remains of other structures used during the ANARE period, including the Absolute Magnetic Hut and Magnetograph Hut on the western edge of The Nullarbor at 'Windy City', and the Seismic Hut several hundred metres north-east of the Station Area, are also present. These remnants collectively provide a clear 'footprint' of the original station and are recognised for their historical significance and importance in the study of the colonisation of the subantarctic by humans in HIMI's listing on the Register of the National Estate (see Appendix 5).

Scientific Values

The subantarctic zone in general is a region of immense importance to a full understanding of how the Antarctic system exerts its effects on the rest of the planet. It is a region where the nutrient-rich Antarctic waters meet the nutrient-impoverished sub-Tropical waters and where there is significant transport of nutrients carried by the Antarctic Circumpolar Current (ACC). It is one of the regions where, both in the sea and on land, the consequences of atmospheric warming can be clearly seen. The Reserve constitutes a uniquely appropriate location for conducting of scientific research into global warming, environmental change and its consequences, due to a combination of the islands' position south of the Antarctic Polar Frontal Zone (APFZ), the presence of permanent ice caps and retreating glaciers, the simple vascular flora, and vegetation communities free from confounding influences of introduced herbivores. The terrestrial fauna of the islands is a sensitive indicator of marine change and is of significance with respect to Australia's sustainable management of the HIMI fishery.

The key drivers for scientific work in the Reserve can be broadly classified as:

Management: Science assists the achievement of management objectives for the Reserve, including meeting requirements under legislation and national and international agreements.

Location: The Reserve is located in an isolated and unique geographical location of the subantarctic, south of the APFZ and in the flow of the ACC.

Content: The Reserve contains unusual, unique and highly dynamic features, physical and biological systems and natural processes.

Condition: The Reserve shows very little evidence of anthropogenic influence and consequently displays features, physical and biological systems and natural processes in a relatively undisturbed condition.

Of these drivers, the latter three promote the conduct of scientific research in the HIMI region that cannot adequately be undertaken elsewhere. Examples of the key scientific values of the region, arising from these drivers, are given in Table 2.

Table 2. Key scientific values and drivers for research in the HIMI region

Key Scientific Value	Driver(s)
The natural, undisturbed communities of the HIMI region are excellent indicators of environmental change and impacts of environmental change.	Condition (undisturbed terrestrial and marine ecosystems)
Heard Island provides a unique opportunity to measure the rate of glacial retreat, as an indicator of climate change.	Location (south of the APFZ) Content (presence of permanent glaciers)
The islands are still forming, giving a unique opportunity to gain an understanding of island and plateau formation.	Content (presence of exposed geological features and processes)
Heard Island provides opportunities to obtain records of past climate from a temperate latitude.	Location (subantarctic, south of APFZ) Content (glacial ice, peat/sediment records)
The islands are an appropriate site for studying the development of marine plateaux.	Content (surface exposure of Kerguelen plateau)
Big Ben provides unique opportunities for studying deep-earth magmatic processes.	Content (presence of volcano and active volcanism)
As an ecosystem so far largely unaffected by human impact, Heard Island is a unique site for measuring physical processes and addressing fundamental biological problems, testing ecological theory and assessing and modelling the dynamics of environmental change and associated biological responses.	Location (in flow of ACC) Content (unique, unusual and dynamic processes, biologically & trophically simple ecosystems) Condition (little-disturbed ecosystems processes)
The HIMI region is one where effects of climate change on the marine environment can be clearly seen.	Location (in the Sub-Antarctic zone, where much oceanic thermal exchange takes place)
The islands provide a significant site for understanding how, and from where, colonisation of recently exposed land occurs in areas undisturbed by human activities. Low species numbers provide an opportunity to investigate their interactions with relatively reduced complexity.	Content (recently deglaciated land, new land from active volcanism) Condition (undisturbed ecosystems)
Heard Island is a critical site for recording biotas along an Antarctic terrestrial transect. This provides a means to identify and monitor the effects of climate change in the region.	Location (isolated location, subantarctic, south of AFPZ) Content (biologically and trophically simple terrestrial ecosystems, rapid climate warming) Condition (relatively pristine biota)
Possibilities for direct examination and understanding of the early geological history and geological evolution of this region of the Southern Ocean.	Location (subantarctic, Kerguelen Plateau) Content (exposed stratified rocks & geological formations)
The Reserve provides a scientific reference area for the study of ecosystem function within the HIMI region.	Location (HIMI region) Condition (undisturbed marine ecosystems)
Heard Island is one of few stable platforms in the Southern Ocean for the establishment of observatories (geophysics, meteorology).	Location (Southern Ocean) Content (terrestrial areas)

Table 1 in section 6.5 indicates the research and monitoring activities that are proposed to be pursued to meet Reserve management requirements and obligations, and elaborates on their management drivers.

Uses of the Reserve

Due to its isolation and persistently severe weather and sea conditions, human use of the Reserve has been, and remains, limited. Since the first landing on Heard Island in 1855, there have been only approximately 240 shore-based visits to the island, initially for the purposes of wildlife resource exploitation and then for research, management, tourism, recreation and surveillance purposes. There have been only two known landings on McDonald Island. Terrestrial and marine research, as part of the Australian Antarctic science program, is currently the main human use of the Reserve, and Australian commercial fishing in the adjacent HIMI fishery is the most frequent activity in the region.

Scientific Research, Monitoring and Reserve Management

Although hindered by the extreme isolation and unfavourable working conditions, scientific studies have been carried out on Heard Island since 1874, when scientists from *HMS Challenger* made geological and botanical collections during a three hour visit to Corinthian Bay¹³¹. The first substantial information about the island's geology, flora and fauna was collected during a one day visit by the German South Polar Expedition led by Baron E. von Drygalski on board the *Gauss* in 1902. Visits in 1929 by Aubert de la Rue and Mawson, who led the BANZARE group bound for Antarctica, were the only other scientific visits prior to the establishment of the ANARE station in 1947. The period of occupation from 1947–1954 marked the beginning of sporadic but ongoing expeditions by the Australian Antarctic program, which continue to the present day.

Following the Australian occupation of the ANARE Station at Atlas Cove from 1947–1955, scientists from France and the U.S.A. made regular visits to Heard Island between 1968 and 1971. Only occasional visits were then made until the mid 1980s, when interest again increased. The AAD has undertaken approximately 33 visits to the HIMI region to conduct science in the terrestrial and marine areas and to conduct environmental management activities, such as the removal of waste material from the Atlas Cove area. Research has involved a broad range of terrestrial and marine science disciplines, including geology, geomorphology, vulcanology, meteorology, terrestrial and marine ecology, glaciology, oceanography and cultural heritage study.

Recent scientific programs at Heard Island have focussed on understanding the effects of climate change on the biodiversity and function of terrestrial and lake ecosystems; studying the glacial systems of Heard Island as an indicator of climate change and variability; monitoring long-term trends in seabird populations; and examining the interactions between key land-based marine predators and their interactions with prey, the ocean and benthic environment and commercial fisheries.

Recent Australian Antarctic program expeditions to Heard Island have generally been multi-disciplinary research programs, with shore parties of mostly scientists, with logistical support crew, field training officers and a doctor. They usually split into project-specific groups, accommodated in huts or tents at Spit Bay, Atlas Cove and other minor camps distributed across the island. Some programs have needed wide-ranging working and living sites.

Research expeditions generally involve stays on the island of a few weeks or months with consequent deployment and retrieval of a large quantity of equipment—including huts, building materials, stores and scientific equipment—making such visits very different from the very short duration (usually only hours) visits by tourists or fisheries patrols. Power is supplied by small diesel generators, solar cells and wind generators. Wastes are stored for return to Australia, incinerated (where combustible and non-toxic) or, in the case of human wastes and washing water, disposed of into the ocean.

Extensive marine biological and oceanographic research has also been conducted in the HIMI EEZ since 1990. The AAD coordinates scientific research programs in the HIMI region that address sustainable use of resources and ecosystem dynamics and that contribute directly to management measures developed under CCAMLR. Ship-based marine science research is undertaken on an irregular basis and has included fish stock assessment surveys and studies of the foraging activity of land-based predators. Commercial operators in the HIMI fishery are required, as a condition of their authorisation to fish, to contribute vessel time and services to facilitate an annual fisheries research program in the HIMI region.

The Australian Antarctic science program is seeking to increase its subantarctic research in the HIMI region to reflect the increasing interest in and importance of the region from a scientific and marine resources perspective. Current intentions are for the AAD to support Australian Antarctic program summer visits to the region approximately every three years over the next decade. These visits would provide opportunities to undertake research, monitoring, and any required on-site management activities. These visits would also provide opportunities to implement a strategic monitoring approach for the Commonwealth subantarctic marine protected areas (the Reserve and the Macquarie Island Marine Park) which is currently under development.

Private Expeditions

The wildlife, vegetation, cultural heritage, spectacular landscape and remoteness of HIMI are major attractions for private recreational and tourist visits. However, due to the large distance from major ports, the persistently rough seas and associated uncertainties in landing or conducting activities upon arrival, there have been few privately-organised visits to the islands since the cessation of sealing and whaling activities in the early 1900s. Landings and activities during each of these private visits have focused on Heard Island.

A small number of private yachts and commercial tourist vessels have visited Heard Island, although few successful landings have been made due to poor weather. Other private expeditions include brief visits by ham radio enthusiasts, private scientific groups and mountaineering parties. Successful ascents of Big Ben have been made on three occasions: by members of the Southern Indian Ocean Expedition in 1965, by members of the *Anaconda* expedition in 1983 and by members of the Australian Army Alpine Association in 1999/2000.

Although the number of private visits per decade to the HIMI region shows little or no sign of increasing in the foreseeable future, tourism to the Antarctic, particularly the Peninsula area, has been growing steadily since the early 1990s, with many voyages including visits to several subantarctic or Antarctic sites²⁷. Future increases in recreational and tourism activities, if any, could be expected to be concentrated ashore at Heard Island and within the territorial sea.

Surveillance Activities

Surveillance patrols in the HIMI region are by civilian and Australian Defence Force vessels and are principally aimed at enforcing fisheries legislation and detecting and deterring illegal foreign fishing activities within the HIMI AFZ. These patrols also provide opportunities for the surveillance of other illegal activities in the Reserve. Details of the frequency and duration of these patrols and the areas visited are confidential. However, surveillance patrols cover the waters of the Reserve, making landings at Heard Island to check for evidence of illegal activities and to undertake limited, opportunistic management tasks.

A treaty signed by Australia and France in 2003 also provides for cooperative surveillance activities in the adjacent EEZs surrounding HIMI and Îles Kerguelen (see section 2.8 International Agreements). Under that treaty it is possible that French vessels may undertake surveillance patrols in the HIMI EEZ, including within the Reserve.

Shipping

The HIMI region is remote from any major population centres and conventional shipping routes but does receive visits from vessels involved in scientific research, fishing, fisheries surveillance and occasionally from tourist and other private vessels. The ports from which these vessels have departed in recent years include Hobart, Fremantle, Albany, Esperance, Port Louis (Mauritius), Durban (South Africa), several ports in New Zealand and a variety of locations in Antarctica. Consideration needs to be given to the potential impacts of such traffic, particularly if it increases in the future.

Refuge/Shelter

Seas in the HIMI region are normally rough, and occasionally become sufficiently severe that vessels in the area seek a place of refuge in the lee of Heard Island. Such vessels would normally contact the AAD or Australian Search and Rescue (AusSAR). The AAD generally maintains one or two refuges on Heard Island which are equipped with basic provisions but because their presence and ability to be maintained varies with AAD's operational requirements they should not be relied upon for shelter.

Fisheries

Due to its remoteness and lack of permanent population, there is no indigenous or recreational fishing activity in the HIMI region. Australian commercial fishing within the HIMI EEZ occurs outside a 1 nm buffer around the 12 nm territorial sea and began in April 1997. It targets mackerel icesh *Champscephalus gunnari* and Patagonian toothfish *Dissostichus eleginoides*. Fishing is concentrated in a few main locations and fishing vessels may cross the Reserve to reach fishing grounds. Consistent with the Reserve being assigned to the IUCN category strict nature reserve, commercial and recreational fishing in the Reserve is prohibited.

The HIMI fishery falls within the area of application of CCAMLR, statistical division 58.5.2. It is managed under the provisions of the *Fisheries Management Act 1991* and the *Heard Island and McDonald Islands Fishery Management Plan 2002* by the Australian Fisheries Management Authority (AFMA) in a manner that complies with or exceeds the standards required by the CAMLR Commission. Management provisions for fishing in the region include precautionary catch limits for both target and bycatch species, that take account of predator-prey relationships; independent scientific observers on all voyages; collection and analysis of a wide range of catch data and samples; restrictions to minimise non-target species interactions, and ongoing research on the ecological sustainability of targeted and bycatch fish stocks.

The Australian Fisheries Management Authority, in consultation with AAD and fishing industry representatives, maintains a rolling five year Strategic Research Plan for the HIMI fishery, which also contributes information to understanding the environmental impacts of fishing in the HIMI region. Holders of Statutory Fishing Rights in the fishery contribute resources to, and assist in the conduct of, an annual fisheries research program to assess the status of fish stocks and other issues related to the presence of a commercial fishery, as stipulated in the management plan for the fishery. Some of this research is undertaken in areas within the Reserve under strict permit conditions. This research typically includes an annual survey designed to obtain reliable estimates of recruitment for each target species and other work to assist in monitoring of the potential impacts of the fishery on non-target species and the ecosystems of the HIMI region.

Illegal Fishing

Illegal foreign fishing is considered not to target the Reserve and to occur in the same locations as the legal fishing. Such fishing therefore primarily threatens the fish targeted by the licensed fishery. Australia is committed to combating illegal fishing in the EEZ around HIMI, and the region is the focus of growing national and international efforts to combat illegal fishing. A voluntary *International Plan of Action for Illegal, Unreported and Unregulated (IUU) Fishing* has been developed through the Food and Agriculture Organisation of the United Nations, within the framework of the Code of Conduct for Responsible Fisheries, and further measures may be adopted by CCAMLR. Australia's compliance and response actions are primarily the responsibility of AFMA and the Department of Agriculture Fisheries and Forestry (DAFF), in close consultation with the AAD, Attorney General's Department, Department of Foreign Affairs and Trade, Department of Defence and Australian Customs Service.

Mineral/Petroleum Exploration and Extraction

The definition of 'mining operations' in the EPBC Act includes all activities associated with petroleum and mineral exploration and recovery. The Act prohibits mining operations in Commonwealth reserves unless they have been authorised in accordance with the EPBC Act and are carried out in accordance with a management plan made under that Act (s.355).

There is currently no exploration or extraction of minerals or petroleum resources in the HIMI region, which is part of the remote frontier region of the Kerguelen Plateau. While some areas in the Kerguelen Plateau region may have potential petroleum prospectivity, given the speculative nature of mineral or petroleum exploration in deep ocean basins it is unlikely that the HIMI region will provide opportunities for commercial or petroleum activities in the foreseeable future. This management plan does not allow mining operations in the Reserve. Future reviews of the management plan for the Reserve will reconsider this issue taking account of any new developments in exploration and environmental protection technologies.

Pressures on the Conservation Values of the Heard Island and McDonald Islands Marine Reserve

The islands and surrounding waters of the Reserve are an excellent example of a relatively untouched subantarctic environment. This is due to the absence of a local human population, the low frequency of human visitation and the minimal amount of commercial resource activity in the region to date. This situation is not static and there are many actual and potential pressures on the values of the Reserve. Most of these pressures are human-related and can be managed with varying degrees of intervention and effort. Others are natural pressures largely beyond human control. The following sections provide a general outline of the pressures on the values of the Reserve and Table 3 gives a summary of which aspects are relevant to the uses described in the previous section. Appendix 22 also lists some of the main conservation-related risks in the Reserve and cross-references relevant descriptions and prescriptions within this Plan.

Natural Processes

The Reserve environment is naturally highly dynamic. The present condition of the environment may be affected by a range of natural processes, including volcanism, coastal erosion, glacial retreat or advance, severe storms, natural arrival and establishment of new species and increasing, decreasing or relocated wildlife populations.

Natural disturbance to ice-free areas, and the creation of new ice-free areas, through landslips, glacial retreat or wildlife trampling, favours the establishment of new species, including alien species²⁷. The effects of moisture, wind, wind blown sand and debris and direct disturbance by elephant seals and other wildlife may result in the loss or degradation of cultural heritage items. Coastal erosion also threatens cultural heritage sites, particularly those remaining from the sealing era, many of which were located close to the beaches to be near seal colonies.

It has been suggested that the number of fur seals at Heard Island will continue to expand until either food availability or breeding space limit pup production, which could potentially result in a total resident population of approximately 304 000 within 20 years⁷⁷. Such an increase in fur seal numbers may lead to trampling of vegetation, eutrophication of waterbodies, competition with other wildlife for breeding sites, disturbance to seabird nesting sites and impacts on the surrounding marine ecosystem through increased competition for food sources, as has been recorded at other subantarctic islands. Rapidly increasing king penguin numbers may have similar effects.

Active volcanism at the McDonald Islands has recently had a dramatic influence on the environment, resulting in the coalescing of the previously separate McDonald Island and Flat Island, and affecting local wildlife colonies, vegetation and ecosystems to an as yet unknown extent. Volcanic activity at Heard Island could produce similar effects and may also affect the benthic habitats adjacent to the islands through landslides and deposition⁷.

Introduction and Spread of Alien Species and Disease

The human introduction and spread of invasive species is now recognised as one of the most significant threats to biodiversity^{112,113}, particularly at islands, being capable of causing major alterations to the structure and function of both marine and terrestrial ecosystems, including the extinction of local and global populations^{114–119}.

At the time of preparing this Plan there are no known alien species on McDonald Island and only four terrestrial species considered as aliens on Heard Island: the vascular plant *Poa annua*; the thrip *Apterothrips apteris*; the mite *Tyrophagus putrescentiae*²⁴; and the worm *Dendrodrilus rubidus*²⁶, making these islands one of the least biologically-disturbed regions on the planet²⁷.

While the likelihood of species introductions and invasions are difficult to predict, there is a possibility that a wide variety of terrestrial, freshwater and marine taxa could be introduced to the Reserve, potentially resulting in substantial alteration of ecosystem functioning and local extirpation of many different species²⁷. Climate warming, as has been observed in the HIMI region, is likely to increase the probability of alien species becoming established and may also enhance the impacts of alien species that become established^{27,61}.

The impacts of biological invasions on other Southern Ocean islands have been significant, with a range of species including reindeer, cats, rabbits, plants, insects and rodents having devastated seabird breeding populations, modified plant communities and landforms, changed invertebrate communities, reduced biodiversity and contributed to local extinctions²⁴. On Macquarie Island a five year effort was required to eradicate cats and action is still required to rid the islands of rabbits and rats which are having a heavy impact on the vegetation and nesting habitat of burrowing petrels and albatrosses.

The major risk to the biosecurity of the Reserve is the introduction of rodents, which have had huge impact on the biota and ecosystems of many other subantarctic islands and which, if introduced to the islands, would almost certainly have a similarly effect. Invasive vascular plants have considerable consequences for the local diversity of both of plants and invertebrates. The cosmopolitan grass *Poa annua*, already found on Heard Island, could be the first vascular plant to colonise McDonald Island. Flies, beetles and bugs are the most likely invertebrate invaders with potentially significant effects on prey or host plants and local ecosystems.

Humans have a direct role in such invasions, with the likelihood of alien establishment closely related to the number of individuals introduced and the number of introduction events. Human activity in the Reserve is expected to continue to slowly increase in line with interest in the region for science, tourism and fisheries. The management goal must be to prevent the introduction of alien species by minimising the risk of introductions occurring.

Human-induced Wildlife Disturbance

Human activities can disturb seabird and seal breeding colonies, and may decrease juvenile recruitment into the population or increase adult mortality, resulting in the decrease or loss of breeding colonies, populations or even entire species. Breeding failure as a result of natural processes is inevitable from time to time and most species are adapted to recover from such losses. However, disturbance arising from human activities may contribute to decreases in breeding success¹²⁰. The extent of such disturbance to the seal and seabird populations at HIMI is currently unknown but is considered likely to be minimal, due to the low levels of human visitation and the enforcement of precautionary wildlife approach guidelines.

Wildlife colonies in the Reserve are concentrated in the ice-free coastal areas which are also the main areas of human activity on land. A variety of activities in the Reserve may disturb individuals, including through the intentional catching and manipulation of animals for research purposes. Other unintentional, but potentially significant localised disturbance may occur when habitat is altered or destroyed. Excavations and the placement of facilities or equipment can collapse or contaminate burrows, and birds can strike structures and guy wires. Approach by people on foot or in vehicles, vessels or aircraft can also significantly disturb wildlife. Marine mammals and seabirds are at risk of colliding with vessels while foraging or migrating in open waters, particularly if vessel sounds and lights attracts the animals or masks important natural signals and communications.

Species differ in their sensitivity to human presence and associated activities and responses may vary by location and by the time of year or stage of breeding cycle. However, all animals can be disturbed and will react in such ways as changing breeding habitat, refraining from breeding and deserting colonies or nests. Disturbance can increase the mortality of young from predation, exposure, trampling or disorientation, which reinforces the need to apply caution at all times when around animals.

Although not targeted in the Reserve, illegal fishing is known to impact the HIMI region through direct taking of fish; bycatch of fish, seabirds and seals; loss of fishing equipment and damage to benthic species and habitat. Legal fishing operations in the fishery adjacent to the Reserve, while strictly regulated, also contribute to pressure on the region's biodiversity.

Human-induced Physical Disturbance

Most of the Reserve is free from persistent or obvious signs of human disturbance, which is rare among subantarctic islands and is one of HIMI's greatest values. Physical disturbance could degrade this value, detracting from the natural visual and wilderness qualities of the environment and having direct adverse effects on features, species, habitats and ecosystems. People moving by foot or vehicle through terrestrial areas, particularly coastal ice-free areas, can cause localised effects such as compaction of soil, damage to vegetation cover and suppression of its re-establishment; damage to sensitive geological features; disturbance and damage to cultural heritage sites; and destruction of invertebrates and their habitat.

Disturbance can be exacerbated by the inappropriate placement of refuges, camping sites, monitoring equipment, survey markers and other facilities. Souveniring may be an additional pressure, particularly relevant to cultural heritage.

Scientific research sometimes requires the taking or disturbance of animals and plants, or destroying their habitats, to further understand them. Sampling vegetation, soils and other geological features may result in environmental damage which, individually may be negligible but may result in more substantial cumulative impacts over time. In the marine areas of the Reserve, benthic sampling may also result in long-lasting effects on benthic species and habitats, such as sponges, corals and bryozoan assemblages.

Terrestrial and Marine Pollution

Marine pollution is a potential pressure associated with shipping activities in the HIMI region and takes the form of fuel or oil spills, sewage or waste water discharge and the introduction of anthropogenic marine debris. Major fuel or oil spills would affect water quality and may cause extensive mortality to marine animals and land-based marine predators and damage to important habitats on a large scale. In the unlikely event of a major spill there would be limited capacity to respond except by the vessel causing the incident or another vessel if one is in the area. A response through the *National Plan to Combat Pollution of the Sea by Oil and Other Noxious and Hazardous Substances* would be difficult, because of HIMI's remoteness and the absence of any permanent station. It is unlikely that most vessels could mount effective response action because of limited resources and hostile sea and weather conditions.

Floating debris is a major hazard for marine mammals and seabirds that may be attracted to the debris and become entangled, causing restricted mobility, starvation, infection, amputation, drowning or smothering. Five entangled seals were discovered and disentangled at Heard Island during the 2003/04 Australian Antarctic program expedition⁸⁸. The significance of such hazards was recognised with the listing of *Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris* as a key threatening process under the EPBC Act on 13 August 2003. A threat abatement plan to address the issue is under preparation. Under Australian law, all shipping is regulated to minimise impacts from the discharge of wastes, flotsam and oil spills. Nevertheless, the potential threat remains, because debris from other parts of the Southern Ocean may drift into the HIMI region. Consideration needs to be given to the potential impacts of shipping activities, particularly if this traffic increases in the future.

Terrestrial pollution can also greatly affect the values of the Reserve, detracting from natural scenic and wilderness qualities and potentially adversely affecting species, habitats and ecosystems. Disposal of human waste and grey water may temporarily change the local nutrient regime and ecosystem functioning.

Although this is likely to be minimal compared with that from the abundant wildlife⁴⁹, it may represent a disease risk. Contamination by hazardous liquids, including fuels (through spills from storage vessels or when refuelling) and chemicals, can cause localised but long-lasting soil contamination, degradation of vegetation and invertebrates and may damage wildlife it eaten²¹. Wind-blown debris from unsecured wastes or stores degrades scenic landscape values and, particularly in the case of plastics, may injure, infect or even kill wildlife through ingestion or, in the case of food scraps, the introduction of disease agents. Apart from their climate change effects, atmospheric emissions from other parts of the world are likely to have negligible environmental impact on the Reserve when compared to the local volcanic emissions.

Table 3. Summary of potential impacts from human activities in the Reserve

Activity/Use	Terrestrial environment	Marine environment
<p>Scientific research, monitoring & area management</p>	<ul style="list-style-type: none"> - localised damage to vegetation and invertebrate/burrowing bird habitat through trampling, vehicle use, aircraft landings and installations - localised and/or wider disturbance of seals and seabirds by persons on foot, or by the use of vehicles, vessels or aircraft - seabird collision with installations - introduction and spread of terrestrial and freshwater alien species via footwear, clothing, equipment, vehicles, vessels and aircraft - localised disturbance of wildlife through animal handling and manipulation, under permit - localised landscape and soil contamination through leak/spill/discharge of hazardous chemicals/materials and wastes - loss or degradation of cultural heritage items through damage, disturbance or souveniring - damage to coastal habitats, ecosystems and species from marine pollution - loss or degradation of wilderness and aesthetic values from installations, track formation, landscape disturbance - removal of samples 	<ul style="list-style-type: none"> - damage to benthic communities and seabed from trawling and anchoring - taking and/or by-catch of fish species, seabirds and marine mammals through trawling or long-lining - introduction and spread of marine alien species via vessels, small craft and other equipment used in the water - vessel collision with marine mammals and seabirds - ingestion of, or entanglement in, floating debris by marine mammals and seabirds - disturbance of marine mammals from vessel noise - oil/chemical spills
<p>Tourism and recreation</p>	<ul style="list-style-type: none"> - localised damage to vegetation and invertebrate/burrowing bird habitat through trampling and aircraft landings - localised and/or wider disturbance of seals and seabirds by persons on foot or by the use of vessels or aircraft - introduction and spread of terrestrial and freshwater alien species via footwear, clothing, equipment, vessels and aircraft - loss or degradation of cultural heritage items through damage, disturbance or souveniring - damage to coastal and near-shore habitats, ecosystems and species from marine pollution 	<ul style="list-style-type: none"> - introduction and spread of marine alien species via vessels, small craft and other equipment used in the water - vessel collision with marine mammals and seabirds - ingestion or entanglement in floating debris by marine mammals and seabirds - disturbance of marine mammals from vessel noise - oil/chemical spills

Activity/Use	Terrestrial environment	Marine environment
Surveillance activities	<ul style="list-style-type: none"> - localised damage to vegetation and invertebrate/burrowing bird habitat through trampling and aircraft landings - localised and/or wider disturbance of seals and seabirds by persons on foot or by the use of vessels or aircraft - introduction and spread of terrestrial and freshwater alien species via footwear, clothing, equipment, vessels and aircraft - loss or degradation of cultural heritage items through damage, disturbance or souveniring - damage to coastal and near-shore habitats, ecosystems and species from marine pollution 	<ul style="list-style-type: none"> - introduction and spread of marine alien species via vessels, small craft and other equipment used in the water - vessel collision with marine mammals and seabirds - ingestion or entanglement in floating debris by marine mammals and seabirds - disturbance of marine mammals from vessel noise - oil/chemical spills
Shipping	<ul style="list-style-type: none"> - damage to coastal habitats, ecosystems and species from marine pollution 	<ul style="list-style-type: none"> - damage to near-shore habitats, ecosystems and species from marine pollution - introduction and spread of marine alien species via vessels, small craft and other equipment used in the water - vessel collision with marine mammals and seabirds - ingestion or entanglement in floating debris by marine mammals and seabirds - disturbance of marine mammals from vessel noise
Refuge/shelter	<ul style="list-style-type: none"> - introduction and spread of terrestrial and freshwater alien species via footwear, clothing, equipment, vessels or aircraft - localised and/or wider disturbance of seals and seabirds by persons on foot or by the use of vessels or aircraft - damage, disturbance or collection of cultural heritage items - damage to coastal and near-shore habitats, ecosystems and species from marine pollution 	<ul style="list-style-type: none"> - oil/chemical spills - introduction and spread of marine alien species via vessels, small craft and other equipment used in the water - vessel collision with marine mammals and seabirds - ingestion or entanglement in floating debris by marine mammals and seabirds - oil/chemical spills