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ANTARCTIC

READER





TABLE OF CONTENTS

SECTION 1

- 2 Conserving the Antarctic
- 2 Guidance for Visitors
- 4 Antarctica's Historic Heritage

SECTION 2

- 5 Places You Might Visit
- 5 Falkland Islands (Islas Malvinas)
- 6 South Georgia
- 8 South Sandwich Islands
- 9 South Orkney Islands
- 9 Weddell Sea
- 10 South Shetland Islands
- 11 Antarctic Peninsula
- 13 The Historic Ross Sea Sector
- 16 New Zealand's Subantarctic Islands
- 17 Macquarie Island

SECTION 3

- 19 Explorers and Scientists
- 19 Terra Australis Exploration
- 20 The Age of Sealers
- 22 The Heroic Age and Continental Penetration
- 24 Mechanical Age and Whaling Period
- 26 Permanent Stations
- 27 Pax Antarctica: The Treaty Period

SECTION 4

- 28 The Antarctic Treaty
- 28 Origin and Members
- 29 Scientific Stations

SECTION 5

- 30 The Physical Environment
- 30 The Antarctic
- 31 The Southern Ocean
- 32 The islands of the Southern Ocean

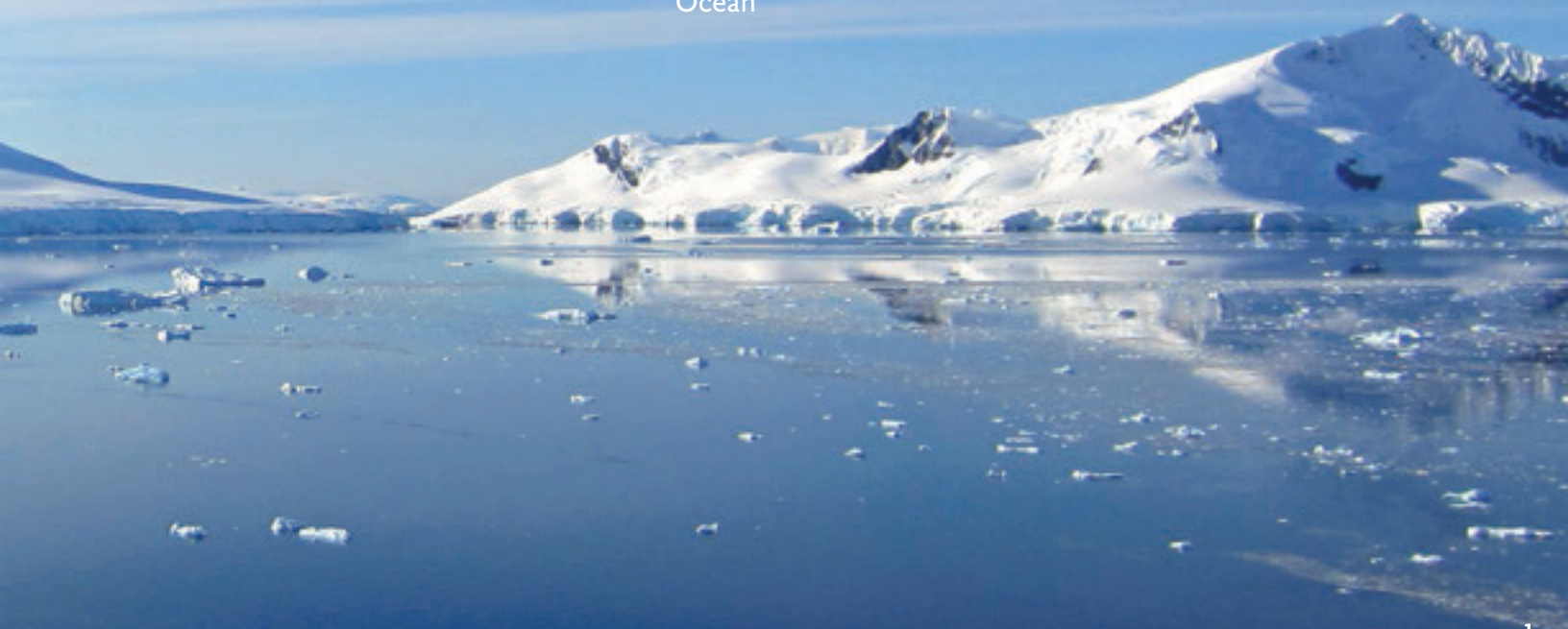
- 32 Geology
- 34 Climate
- 35 The Antarctic Circle
- 35 Icebergs, Glaciers and Sea Ice
- 37 The Ozone Hole
- 37 Climatic Change

SECTION 6

- 40 The Biological Environment
- 40 Life in Antarctica
- 41 Adapting to the Cold
- 43 The Dominance of Krill
- 44 The Krill Predators (or Other Wildlife)
- 44 Antarctic Squids, Fishes, Birds, Seals and Whales

SECTION 7

- 60 Wildlife Checklist



Antarctica is the largest wilderness area on Earth.

SECTION 1

CONSERVING THE ANTARCTIC

Many governments, most non-governmental organizations and all the leading companies arranging expeditions to Antarctic regions are working together to ensure that Antarctica's spectacular scenery, unique wildlife and extraordinary wilderness will be protected for future generations to enjoy.

Our expeditions to these vulnerable and unique habitats are operated in an environmentally responsible manner. Quark Expeditions, with other members of the International Association of Antarctica Tour Operators (IAATO), operate under a voluntary code of conduct for visitors to Antarctica. The code, developed by IAATO members, met widespread approval, and was the inspiration for the guidelines under which the Antarctic Treaty parties operate.

These internationally agreed guidelines apply to all visitors to Antarctic regions, including scientists and support staff working for governmental research programs, as well as participants on organized expeditions, and individual visitors. The essential provisions are included in national laws, so violations may be subject to legal sanctions including fines, or even imprisonment.

The members of the Expedition Team are familiar with these guidelines and will brief you about them, and help you to adhere to them. But you, too, have a part to play. By encouraging your fellow visitors to demonstrate environmentally-conscious behavior, you will assist us to ensure that future generations will be able to continue to experience Antarctica in its pristine beauty.

We appreciate your cooperation.

GUIDANCE FOR VISITORS TO THE ANTARCTIC

Activities in the Antarctic are governed by the Antarctic Treaty of 1959 and its associated agreements, referred to collectively as the Antarctic Treaty System. The Treaty established Antarctica as a zone of peace and science.

In 1991, the Antarctic Treaty Consultative Parties adopted the Protocol on Environmental Protection, sometimes known as the Madrid Protocol, which designates the Antarctic as a natural reserve. The Protocol sets out environmental principles, procedures, and obligations for the comprehensive protection of the Antarctic environment, with its dependent and associated ecosystems. The protocol came into force in 1998.

The Environmental Protocol applies to tourism and non-governmental activities, as well as governmental activities in the Antarctic Treaty area. It is intended to ensure that these activities do not have adverse effects on the Antarctic environment, or on its scientific and aesthetic values.

This Guidance for Visitors to the Antarctic is intended to ensure that all visitors are aware of, and therefore able to comply with, the Treaty and the Protocol. Visitors are, of course, bound by their own national laws and regulations applicable to activities in the Antarctic.

1 | Protect Antarctic Wildlife

Taking, or harmful interference to, Antarctic wildlife is prohibited, except in accordance with a permit issued by a national authority.

- Do not use aircraft, vessels, small boats, or other means of transport in ways that disturb wildlife, either at sea or on land.
- Do not feed, touch, or handle birds or seals, or approach or photograph them, in ways that cause them to alter their behavior.
- Special care is needed when animals are breeding or molting.
- Do not damage plants, for example by walking, driving, or landing on extensive moss beds or lichen-covered scree slopes.
- Do not use guns or explosives. Keep noise, even conversation, to the minimum to avoid frightening wildlife.
- Do not bring non-native plants or animals into the Antarctic, such as live poultry, pet dogs and cats, house plants or any seeds.

2 | Respect Protected Areas

A variety of areas in the Antarctic have been afforded special protection because of their particular ecological, scientific, historic, or other values. Entry into certain areas may be prohibited except in accordance with a permit issued by an appropriate national authority. Activities in and near designated Historic Sites and Monuments and certain other areas may be subject to special restrictions.

- Know the location of areas that have been afforded special protection, any restrictions regarding entry and activities that maybe carried out in and near them.
- Observe applicable restrictions.
- Do not damage, remove, or destroy Historic Sites or Monuments or any artifacts associated with them and in their surroundings.

3 | Respect Scientific Research

Do not interfere with scientific research, facilities, or equipment.

- Obtain permission before visiting Antarctic science and support facilities, reconfirm arrangements 24-72 hours before arrival, and comply with the rules regarding such visits.
- Do not interfere with, or remove, scientific equipment or marker posts, and do not disturb experimental study sites, field camps, or supplies.

4 | Be Safe

Be prepared for severe and changeable weather; ensure that your equipment and clothing meet Antarctic standards. Remember that the Antarctic environment is inhospitable, unpredictable, and potentially dangerous.

- Know your capabilities, and the dangers posed by the Antarctic environment, and act accordingly. Plan activities with safety in mind at all times.
- Keep a safe distance from all wildlife, both on land and at sea.
- Take note of, and act on, the advice and instructions from your leaders; do not stray from your group.
- Do not walk onto glaciers or large snow fields without the proper equipment and experience; there is a real danger of falling into hidden crevasses.
- Do not expect a rescue service. Self-sufficiency is increased and risks reduced by sound planning, high quality equipment, and trained personnel.
- Do not enter emergency refuges (except in emergencies). If you have to use equipment or food from a refuge, inform the nearest research station or national authority once the emergency is over.
- Respect any smoking restrictions, particularly around buildings, and take great care to safeguard against the danger of fire. This is a serious hazard in the dry environment of Antarctica.



Zodiac cruising



Petermann Island

ANTARCTICA'S HISTORIC HERITAGE

The oldest buildings in Antarctica are the two huts of the Borchgrevink expedition which wintered in 1899 (the oldest human habitations on the entire continent). The other huts of the Heroic Age date from the period 1901-1914. They are designated Historic Monuments, and strict rules apply to visiting them. The huts at Cape Adare, Hut Point, Cape Evans, and Cape Royds may only be visited with a designated guide, normally provided by the Antarctic Heritage Trust or the New Zealand Department of Conservation. Conservation and restoration work at the sites is undertaken by the Antarctic Heritage Trust, a private charitable organization. To find out about, and contribute to the cost of maintaining, these important sites you are welcome to communicate with:

The Administrator

New Zealand Antarctic Heritage Trust

P.O. Box 14-091

Christchurch Airport, New Zealand

Tel: +64-(0)3-358-0200; Fax: +64-3-(0)358-0211

aht@antarcticanz.govt.nz

Visitors to the Cape Denison Historic Site (Mawson's Huts) must follow official Visitor Guidelines. None of the huts may be entered without local guidance. For further information, contact:

The Australian Antarctic Division

Channel Highway

Kingston, Tasmania 7054, Australia

Tel: +61 (0)02-323-280; Fax: +61-(0)02-323-288

info@mawsons-huts.org.au

Abandoned huts, refuges, and supply depots in other parts of Antarctica are more recent in origin. Nevertheless, they may also be of great historical interest. They are normally the responsibility of the relevant national governments. However, a charitable trust has been established in Britain - the United Kingdom Antarctic Heritage Trust. Its main objectives include helping the New Zealand Antarctic Heritage Trust to preserve the Scott and Shackleton huts, and preserving at least several early British scientific stations in the Antarctic Peninsula region. For information, or to make contributions, contact:

The United Kingdom Antarctic Heritage Trust

Kingcoed Farm, USK

Gwent, NP15 1DS, UK

Tel: +44 (0) 1291 690305

ukaht@dircon.co.uk

KEEP ANTARCTICA PRISTINE

Antarctica remains relatively pristine, the largest wilderness area on Earth. It has not yet been subjected to large scale human perturbations. Please keep it that way.

- Do not dispose of litter or garbage on land. Open burning is prohibited.
- Do not disturb or pollute lakes or streams. Any materials discarded at sea must be disposed of properly.
- Do not paint or engrave names or graffiti on rocks or buildings.
- Do not collect or take away biological or geological specimens or man-made artifacts as souvenirs, including rocks, bones, eggs, fossils, and parts or contents of buildings or anything in their vicinity.
- Do not deface or vandalize buildings, whether occupied, abandoned, or unoccupied; or emergency refuges. Do not enter them unless requested or authorised by their proprietors, or in an emergency.



SECTION 2

PLACES YOU MAY VISIT

THE FALKLAND ISLANDS (ISLAS MALVINAS)

This British outpost in the South Atlantic was discovered in August 1592 by John Davis, captain of the English sloop *Desire*, who had been blown off course by the westerly winds. But the first known landing was not made until 1690, when John Strong arrived aboard another English sloop, *Welfare*. Strong was actually engaged on a privateering cruise against the French, with whom England was at war at the time.

The islands received an early version of their present name in 1708, when the privateer Woodes Rogers dubbed them Falklands Land in honor of England's First Lord of the Admiralty. Not until 1764 was the archipelago settled. In that year the French explorer Louis de Bougainville established a small colony at Port Louis in East Falkland. Soon afterwards, in 1765, a British expedition came to claim the islands and establish their own settlement at Port Egmont on Saunders Island in the north-west. Neither the British nor the French were, at first aware, of each other's presence.

The French named the islands the Iles Malouines, after the port of St. Malo, from where most of the sailors came. This name is the derivation of in the present-day name used by Argentina, Las Islas Malvinas.

The islands changed hands several times in the following 70 years, with Spanish, British, and then some Spanish from South America living there for short periods. For about 20 years the Falklands were a base for sealers and whalers, many from the United States. In 1832, the US warship *Lexington* sacked a small Argentine settlement in response to the seizure of three United States sealing vessels. The Falkland Islands (Islas Malvinas) permanent re-settlement by the British dates from 1833, when a governor was installed. The new capital was named Stanley in 1845, after Britain's Secretary of State for the Colonies. The next major event of historical significance happened on 2 April, 1982, when Argentine armed forces invaded and occupied the islands. A task force was soon on its way from the UK and eleven weeks later some 12,000 Argentine soldiers (many of

“If Antarctica were music it would be Mozart. Art, and it would be Michelangelo. Literature, and it would be Shakespeare. And yet it is something even greater; the only place on earth that is still as it should be. May we never tame it.”

– Andrew Denton

them poorly trained and ill-equipped conscripts) surrendered and the sovereignty overwhelmingly desired by the inhabitants was restored.

Over the years, ship repairing, as well as the sealing, whaling, and penguin oil industries have provided the islanders with a livelihood. Then sheep farming, mainly for wool, came to dominate the Falklands economy. Today, however, with the prevailing low wool prices on the world market, the Falklands main source of income comes from licenses to exploit the substantial stocks of squid and fish in the surrounding waters. Most of the fishing boats come from Europe and Asia, some with Argentine registry. There is also the future possibility of very large revenues from off shore oil.

Stanley

The population of the Falklands is about 3,400, and today some 2,100 of the people live in or near the capital, Stanley. This pleasant, quiet town has a distinctly old-world Victorian charm. It boasts the southernmost Anglican cathedral in the world (which recently celebrated its centenary), several stores selling items of tourist interest, including locally made woolen goods, a small but excellent museum, and a well-stocked philatelic bureau that sells colorful first-day covers and distinctive stamps. Stanley is the seat of government, which is conducted by an

The Falklands boast no less than six breeding species of penguins: king, gentoo, rockhopper, macaroni, royal, and magellanic.



elected Legislative Council. The Falklands are a British Overseas Territory, and so the Governor is the effective head of state, but in practice his role in domestic affairs is more advisory than executive.

Camp

In Falkland's parlance, anywhere outside Stanley is referred to as camp, a word derived from the Spanish campo, or field. There are some 420 islands in the archipelago. The two large islands East and West Falkland occupy most of the land area. Of the rest, only about 20 are of any size. At one time, most of the land was owned by the London-based Falkland Islands Company (FIC), similar to the old Hudson's Bay Company or the East India Company. Today virtually all of the land is owned locally, either by the Falklands government or by private individuals. FIC's holdings are now mainly confined to some commercial enterprises in Stanley.

The islands are located some 400 km northeast of Tierra del Fuego, the nearest point in South America. The land area is 12,173 square kilometers about (4,700 square miles), occupying about 255 by 135 kilometers (160 by 85 miles), about the size of American state of Connecticut. The climate is cool but pleasant, with summer temperatures averaging about 10°C (50°F), though sometimes reaching 20°C (70°F). In mid-winter, around June and July, the average may be about 7°C (45°F). The rainfall is not excessive, and there is little snow. It can be quite windy at any time of the year.

The typical Falkland countryside is rolling moorland, with sparse low-growing shrubs. There are no native trees, but some trees and bushes, such as gorse, have been introduced for shelter. There is a surprising variety of flowering plants, though many of the flowers themselves are small. One of the most interesting and important plant species is the native tussock grass. This is a tall (2.5 meters or 8 feet), sturdy plant that grows in clumps, generally near the coast. It provides an important habitat for many birds, and shelter for some seals, but has been much reduced by grazing sheep.

Birds and Marine Mammals

The Falklands are of great interest for birdwatchers. There are 63 breeding species and 23 annual migrants, plus a long list of others that occasionally arrive. Thanks to the rich surrounding seas, the Falklands boast no less than six breeding species of penguins: king, gentoo, rockhopper, macaroni, royal, and Magellanic (although the last three are rare). Another five species have been recorded as migrants. The Black-browed albatross breeds here in often very large colonies, and another

six species have been seen offshore. The land birds cover most groups, and include birds of prey, ducks, geese, herons, owls, finches, and thrushes, and a fair number of sea and shore birds.

There are no native land mammals (the indigenous warrarah, or Falkland Islands fox, became extinct in 1876), but plenty of marine mammals, many of them the same as those that frequent Antarctic waters. Among the dolphins found in the Falklands look for Peale's dolphin, a relatively large, coastal species that is regularly seen in small groups. There are two species of eared seals in the Falklands: the Falklands fur seal (a different species from the one in Antarctica), and the southern sea lion.

Visitors should avoid disturbing the wildlife; keep a sensible distance from breeding birds and from seals and sea lions. Since all the land is owned by somebody, visitors should also respect the countryside as they would at home, such as by leaving no litter and leaving all gates as they found them. In particular, it is important to guard against the risk of fire in areas of tussock grass and peat, which are often very dry in the summer. Some landowners request that visitors do not smoke when out of doors.

SOUTH GEORGIA

A slightly crescent-shaped, mountainous island some 1,300 kilometers (800 miles) east-south-east of the Falkland Islands (Islas Malvinas), South Georgia was sighted in 1675. Captain James Cook, who went ashore to claim sovereignty in 1775, was the first person to land at South Georgia. He named the place where he landed Possession Bay. South Georgia was once more ice-bound than it is today, and Cook described it and the South Sandwich Islands as "Lands doomed by Nature to perpetual frigidness: never to feel the warmth of the sun's rays; whose horrible and savage aspects I have not words to describe."

Britain formalized her claim to South Georgia and the South Sandwich Islands, with some other specified territories, in 1908. Today, the islands together form a single UK Dependent Territory; the British government's representative is the Commissioner, who is normally the Governor of the Falkland Islands, ex officio.

South Georgia measures about 160 kilometers (100 miles) long and 30 kilometers (19 miles) wide, and covers an area of 3,755 square kilometers (1,450 square miles). Over half its surface is ice-capped, with 12 mountains rising above 1,800 meters (6,000 feet). The highest point is Mount Paget, at 2,934 meters (9,626 feet), first climbed on 30 December 1964. There are about 160 glaciers, many of which come down to the sea.

The south-west coast faces the prevailing westerly winds and tends to be cold, stormy, and generally inhospitable. There are no safe harbors. The northern coast, by contrast, is in the lee of the central mountains and thus relatively more benign. Several of the fjords offer safe anchorages, and this is where the whaling stations were established beginning in 1904.

First came the sealers, as a direct result of Cook's reports of abundant fur seals in that part of the Southern Ocean. The sealing industry was under way by 1786, and continued until 1912. Long before then, fur seal numbers were so reduced that latterly the only species taken was the southern elephant seal, for its valuable oil. A modern elephant-sealing industry, under government control to ensure the survival of the species, worked from 1910 to 1965.

Norwegian Whalers

The whalers came to South Georgia in 1904 and eventually established six shore-based stations for processing the animals, mainly for their oil but later for other products as well. The law came soon afterwards, in 1909, in the form of a British magistrate based at Grytviken. His staff included customs officers, sealing inspectors, radio operators, mechanics, cooks, etc. His main duty was to control the whaling industry, by ensuring that the terms of the whalers' leases and licenses were observed (conservation, however, did not seem to be a major part of his brief, although laws to preserve the industry restricted the exploitation).

Religion arrived not long after the law, with the consecration of the Whalers' church at Grytviken on Christmas Eve 1913. This has been maintained and is the only building in Grytviken retaining its original function. Several pastors served for various periods and were Norwegian Lutherans, since the whalers were virtually all from that country. The first one remarked, a trifle sadly, that "religious life among the whalers left much to be desired."

In the heyday of whaling in the 1920s there were six stations and one shore depot in operation on the island. It is estimated that between 1904 and 1965, a total of 175,000 whales were caught around South Georgia. In the Antarctic region as a whole, the total for the same period was 1,500,000. Whaling from South Georgia ended in 1965 for the simple reason that the whales had been hunted out.

With the end of whaling, the 14-strong Grytviken administration had nothing to administer but itself, so it was replaced by British Antarctic Survey personnel. Meanwhile, Argentina, which had made its own claim to South Georgia and the South Sandwich Islands from 1925, occupied South Georgia for three weeks in April 1982, before they were evicted by the British.

Following the British-Argentine conflict (the main action being in the Falkland Islands [Islas Malvinas]), the British presence at Grytviken was maintained for 19 years by a small military garrison. The commander acted as magistrate, while the medical officer performed some postmaster duties. There is also a Marine Officer/Harbor Master who dealt with fishing vessels and visiting passenger ships. A small number of scientists from the British Antarctic Survey were based at Bird Island, at the north-western tip of South Georgia and this station has been permanently open from late 1982. This changed in 2001 when new buildings were opened at King\Edward Point accommodating government officers and British Antarctic Survey scientists. A major decontamination programme made the abandoned whaling station at Grytviken safe for visitors and, at the same time, a hydroelectric station was re-established which now provides most of the power, thus vastly reducing the need for importing hydrocarbons.



Gentoo penguins



Elephant seal pup



South Sandwich Islands



Leucistic fur seal pup and mother



King penguins

A 200-mile maritime zone was established around South Georgia and the South Sandwich Islands in 1993, and the fisheries regime takes account of tight limits agreed by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). In 2012, following further research, a series of marine reserves were designated with the object of preserving the fishing industry by conserving stocks.

Visitor Sites

Visitors to South Georgia normally spend time exploring the remains of the former whaling station at Grytviken. There is much to see, including the maintained church and the former manager's house, which now houses an excellent museum on all aspects of the island. There are usually many elephant seals and a few fur seals, and some king penguins in the area. A highlight is the small cemetery where Sir Ernest Shackleton is buried. His name will always be associated with South Georgia following his exploits in 1914 and 1916. After World War I, Shackleton set out on another expedition to Antarctica. His vessel, *Quest*, reached South Georgia on 4 January 1922. He died of a heart attack the next day and was buried in the Grytviken cemetery, according to his widow's wishes. In 2012 the ashes of Frank Wild, a companion of Shackleton from their first Antarctic expedition in 1901 and his second in command of *Quest*, were interred adjacent to Shackleton's grave. Elsewhere, most ships visit the Bay of Isles, where there is a massive king penguin colony on the shore and hillside of Salisbury Plain. Nearby is Prion Island and several small islets where wandering albatrosses and giant petrels nest and may be approached on a board-walk leading to the interior of the island.

Many South Georgia beaches are now densely populated by fur seals, to the extent that it is unsafe to land during their breeding season. However, Zodiac cruises along such beaches can be very rewarding. The Norwegians introduced reindeer, for sport

and meat, in 1909. They have multiplied considerably extended their range along the northern coasts. It is proposed, however, as part of an environmental remedial programme, that they are to be eradicated. This programme is primarily to eliminate the rats and small group of mice, which have inhabited the island for perhaps two centuries and devastate much of the bird life. The loss of the reindeer will be unfortunate, but eradication of the introduced rodents will be an enormous advantage for the island's biology. For biological reasons, especially as all reindeer zones are in rat infested areas, their elimination will, on balance be advantageous (interestingly some have been taken to the Falkland Islands where they are thriving).

SOUTH SANDWICH ISLANDS

The South Sandwich Islands were discovered by Captain Cook in 1775, on the same voyage that he landed on South Georgia. He named them for Lord Sandwich, First Lord of the Admiralty (but better remembered as the inventor of a familiar snack). Together with South Georgia, they are a UK Dependent Territory (see above), although they are uninhabited. Cook sighted a number of the southern islands, several of the more northern ones were surveyed by the Russian Captain Bellingshausen in 1819, and bear Russian names.

Located about 800 km (460 miles) south-east of South Georgia, the islands form a chain some 390 kilometers (240 miles) long, comprising 11 major and several smaller islands with a total area of about 310 square kilometers (230 square miles). Most are ice-capped, and the tallest peak, on Montagu Island, reaches 1,375 meters (4,511 feet). The climate is cold, with frequent snow and strong winds.

The islands are volcanic in origin and some remain active. The island of Zavodovski, for instance, appears in constant eruption and reeks of rotten eggs (the volcano itself is named Mt.

Asphyxia), while the islands of Visokoi, Candlemas, Saunders, and Bellingshausen all show definite signs of activity. Montagu was in violent eruption in the early 2000s. Bristol, Cook, and Thule islands are heavily glaciated and show few signs of warmth or activity. All the islands are steep-sided above the water, and fall away rapidly into deep water (more than 1,500 meters or 5,000 feet). The greatest depth of the Southern Ocean, Meteor Deep, at 8225 m lies just to the east in the South Sandwich Trench.

The area of shallow sea around each island is small and there are almost no anchorages. In fact, only Thule Island has an anchorage and is therefore the only practical site for any kind of habitation. It was on this island that Argentina established a military/ scientific station in 1976. This was closed in 1982 and their station was destroyed by British forces, owing to its use in the invasion of South Georgia. Little is known about these islands, although the British Antarctic Survey has undertaken some biological and geological work there, mainly in the 1960s and 1990s. Vegetation is very sparse. But there's at least one extraordinary wildlife spectacle: Zavodoski Island supports a huge number of chinstrap penguins on its volcanic slopes. Those who have seen this massive penguin colony speak of it with awe (and recall the distinct pungent penguin odour).

SOUTH ORKNEY ISLANDS

A group of rather barren, islands 1,360 kilometers (850 miles) north-east of the Antarctic Peninsula, the South Orkneys were first described in 1821 by the British sealer, George Powell accompanied by Nathaniel Palmer from the United States. The islands are heavily glaciated, and because of their position north of the Weddell Sea, are surrounded by ice during the annual winter freeze-up of the Southern Ocean.

The climate is rather harsh, with strong winds, frequent rain and snow. Snow falls about 280 days each year. Like the Antarctic Peninsula and other maritime islands, this is also a very cloudy region; the average amount of sunshine is just 520 hours per year. There is also much fog.

Despite these unwelcoming weather conditions, the islands have two scientific stations. There is an Argentine weather station, Orcadas, on Laurie Island at the site of a former Scottish base established in 1903. It is the oldest continuously operating station in Antarctica with a long record of meteorological and geophysical data. The British Antarctic Survey operates a research station on Signy Island. Established in 1947, it was until 1995 operated as a year-round station with accommodations for 24 people. Now it is open for summer only. Here, BAS scientists conducted long-term studies of terrestrial and freshwater biology. Research is also carried out on the seabird populations and it was a center for studies of Antarctic marine life. Much of its biology program was recently transferred to Rothera Station. The bird life of the South Orkneys is plentiful, and Coronation Island is an important breeding site for the beautiful, but rather elusive pure white Snow Petrel. There are some large penguin rookeries, and a host of other seabirds also breed here. For scientists, one of the main attractions of the

South Orkneys are the extensive areas of moss and grass which are exposed in summer. Signy Island is famous for its peat moss banks. The deepest of these is over two meters (6.6 feet), and the peat at the bottom is about 4,500 years old.

WEDDELL SEA

A deep indentation in the Antarctic continent between the Antarctic Peninsula and Coats Land, the Weddell Sea was first visited by the British sealer and explorer James Weddell in 1822. Meeting unusually favorable pack ice conditions, he succeeded in sailing as far south as 74°15'S. Navigation in the Weddell Sea is normally quite difficult because of the great amount of sea ice and large icebergs originating from by the Larsen, Ronne, and Filchner Ice Shelves. It is a kind of iceberg factory. Even icebreakers often have difficulty getting around in the southern and western parts of the Weddell.

But a visit can be very rewarding, not least for its historical associations. It played a part in the saga of the Swedish Nordenskjöld expedition. The main expedition hut, built on Snow Hill Island, still stands. On the shores one can find a large number of fossils, reminders of a more temperate era; gastropods, large clams, and spiral-shaped ammonites, all turned to stone. The hut has been refurbished by the Instituto Antártico Argentino.

The area is also central to the Shackleton story, for it was here in 1915 that the men had to abandon their ship, *Endurance*, after it became trapped in the ice. Wrote Shackleton: "It was a sickening sensation to feel the decks breaking up under one's feet, the great beams bending and then snapping with a noise like gunfire."

Today, one of the main reasons to visit the Weddell Sea, apart from ice-watching, is in the hope of seeing the most famous of Antarctic birds, the emperor penguin. Previously known mostly from the area around the far southern coasts of the continent, these largest of the penguins start to breed during the winter months on fast ice. In 1986 several colonies were discovered on the eastern side of the Weddell Sea. One is at the Riiser-Larsen Ice Shelf at 72°09'S, 15°07'W, while another is not far away at Atka Bay, near the German station Neumayer.

These Emperor colonies are not easy to reach because of ice conditions, and are usually visited using ship-based helicopters. Occasional Emperors can be seen on the ice floes of the Weddell Sea, which also supports many seals - including the one named after James Weddell. There are always plenty of other seabirds to look out for as well as spectacular ice formations.

From the Expedition Leader's Diary — Locating the Snow Hill Island Rookery: Historically, Shackleton and Nordenskjöld had reported emperors in the area of the western Weddell Sea. As expedition ship operators into the Weddell Sea, we were always on the lookout for new colonies. In the year 2000 I read the reports of scientists on a flight over Snow Hill Island who had discovered an emperor penguin rookery to the south. They had circled the colony and did an aerial survey and published the

coordinates. I longed for the day we would have the icebreaker with helicopters in the right area at the right time of year to see if we could be the first people to visit this colony on the ice.

In the boreal summer of 2004 I was Expedition Leader on an icebreaker in the Arctic. I gave the coordinates of the Snow Hill Rookery to the Captain, who would be with me in the Antarctic. I explained that no one had visited the rookery on foot so no accurate penguin count had been done. This Captain had been sailing in the Antarctic for years and knew how important the discovery was! In November when I boarded the ship again as Expedition Leader, he was ready for my request, "Captain, our number one priority is to find that Snow Hill colony."

While we crossed the Drake Passage - we informed the guests of our destination. A voyage to the Peninsula does not usually include a visit to an Emperor colony, so this - we hoped - would be a voyage to go down in the history books. The passengers were thrilled!

As we entered the Weddell Sea, Captain and I were delighted to see open water for the first 30 miles. We were equally delighted to see fast ice as we approached Snow Hill. The location of the edge of the fast ice was approximately 25 miles from the coordinates of the colony. The helicopters were prepped and ready to fly as soon as the announcement was made! As Captain looked for the place to berth the ship, a scout helicopter was sent off. We flew out over the fast ice, over Snow Hill Island and down to the sea ice on the far side.

Emperor colonies are not easy to find. You would think the black-backed penguins would stand out against the white ice. But they do not. You must approach at the right angle to the sun to see their backs or shadows. We flew back and forth over the location making an ever expanding circle to see if they were in the area. And there they were - 2 miles off their previous position!

We called back to the ship and said - it was a go - great weather, a long helicopter flight - but we could make it! By the time the reconnaissance party returned to the ship, Captain had lowered the gangway, and the passengers were walking out on the sea ice. A few curious emperor penguins were passing by, while Weddell seals lounged near tide cracks around icebergs. We called everyone back on to the ship for a briefing, then began the 8-hour operation which gave everyone a chance to walk with the Monarchs of the Antarctic.

SOUTH SHETLAND ISLANDS

The 11 major islands, and many smaller ones, of the South Shetland group extend about 540 kilometers (330 miles) in a north-east south-west direction, lying north of and roughly parallel to the Antarctic Peninsula. They are separated from the peninsula by the deep waters of the 180-kilometer wide (100 miles) Bransfield Strait. The South Shetlands were first sighted in February 1819 by William Smith, who was blown off course while rounding Cape Horn on a mercantile voyage. He returned in October of the same year to claim them for Britain as New South Shetland. Edward Bransfield was sent there to carry out mapping and survey work in 1820. The South

Shetlands are of partly of volcanic origin, and include some active and recently active volcanoes, such as Deception Island and Bridgeman Island. Ancient volcanic cones, such as on Penguin Island, are also apparent.

At the north-east end of the South Shetland Islands, and somewhat separated from the rest, are Elephant Island and its neighbor, Clarence Island. Elephant was named because of its abundance of elephant seals and is notable for providing a refuge on Point Wild for Shackleton's men after the loss of their ship, *Endurance*. Twenty-two of the ship's company remained here, under the command of Frank Wild, while Shackleton set off for South Georgia to seek help. No sign of their presence remains although a Chilean memorial has been placed at the site. Visitors can see a number of elephant and fur seals on the beaches around Cape Lookout where landings are generally more practicable, and penguins of several species.

One of the features of the South Shetlands today is the large number of scientific stations that have mushroomed in the area, starting with the International Geophysical Year in 1957-58. The South Shetlands, and especially large King George Island, were popular because of their proximity to the South American mainland and their relatively mild climatic conditions. In addition, those nations which had or may have been considering claims to Antarctica preferred to establish themselves within the sector of their claim. This accounts particularly for the number of stations of South American nations.

Among the eight winter and several summer stations on King George Island is the large Frei Marsh station (Chile) and the adjacent Bellingshausen station (Russia). The former is substantial, and boasts a bank, post office, and souvenir shop, along with a school and a hospital, indeed its several parts have different names. It also has a landing strip used by aircraft from Punta Arenas.

Nearby is a Chilean Air Force base and a small hotel. The Russian station has been reduced, due to economic difficulties. Also in the vicinity are Chinese, South Korean, Argentine, and Uruguayan stations. This is not the wildest or most attractive part of Antarctica. In Admiralty Bay are the Ferraz (Brazil) and Arctowski (Poland) stations, which offer more rewarding possibilities for visits. The United States operates the Pieter J. Lenie summer station at a site called Copacabana near Arctowski but the vicinity is a Specially Protected site under the provisions of the Antarctic Treaty.

Several other sites in the South Shetlands have been declared specially protected areas, and are thus effectively off limits for tourist visits. However, there is still much to see. The chinstrap penguin colony at Half Moon Island (which also has a small Argentine summer station) and the extensive gentoo penguin colony at Yankee Harbour on Greenwich Island are popular. Hannah Point on Livingston Island has a wealth of wildlife, including many elephant seals, penguins of several species, and nesting giant petrels. The exposed rocks provide fascinating examples of the local geology.



Glacier — Danco Island

Both the volcanic islands already mentioned are well worth visiting. Penguin Island offers Adélie and chinstrap penguin rookeries and abundant giant petrels, as well as a hike up the volcanic cone for a spectacular view. At Deception Island, there is a very large chinstrap penguin colony at Baily Head, on the outside of the island. This is a wonderful place, though sometimes difficult to land unless the sea conditions are favourable. Entering the vast flooded caldera through Neptunes Bellows, one sees the remains of a large Norwegian whaling station in Whalers Bay, and the remains of Chilean and British stations which were destroyed during eruptions in 1969. At Pendulum Cove, it is sometimes possible, when the tide is right, to swim in volcanically heated waters near the black sand lava beach. Many visitors enjoy this unusual experience.

Summer stations operated by Argentina and Spain are located on the western side of the volcanic caldera of Port Foster.

ANTARCTIC PENINSULA

At the northeast tip of the Peninsula is the enchantingly beautiful Hope Bay, which is approached through the Antarctic Sound, where many impressively large tabular bergs may be seen. Hope Bay was the site of a British station (Base D), first occupied in 1945 and closed in 1964. The adjacent Argentine station Esperanza was established in 1952. It is a large station manned by Argentine military personnel, several of whom have their families. Here, on 7 January 1978, Emilio Marcos Palma was the first child to be born in Antarctica. Adjacent to the station, and perhaps of more interest to visitors, is a vast Adélie penguin colony. In the background is Mt. Flora where many fossil plants have been found; this is now a protected area. A historic ruin of a stone hut,

where three men from Otto Nordenskjöld's Swedish expedition survived the 1903 winter in very difficult circumstances is near the usual landing and has been partly restored by the Argentines. There is a small open-air museum in its vicinity and the station has a display in one of the older buildings.

Not far away, and just outside the Antarctic Sound in the northern Weddell Sea is Paulet Island, a small volcanic island with a central cone rising to 400 meters (1,300 feet). Enormous numbers of Adélie penguins breed on its rocky slopes, and there is a big colony of Antarctic Blue-eyed Shags as well as the nest sites of Wilson's storm-petrels. It is of historical interest, too, as a wintering site for 20 of the crew of *Antarctic*, the ship of Nordenskjöld expedition which was crushed and sank in February 1903. The substantial remains of their stone hut are still standing and the grave of one of them is in the vicinity.

Traveling south down the western side of the Peninsula, humpback whales can often be seen in the southern Gerlache Strait, and indeed south of here there is always a good chance of seeing these and other whales, such as minke and orcas. There are a number of potentially rewarding visitor sites in this area. Cuverville Island, named after a French admiral by Adrian de Gerlache, leader of the *Belgica* expedition, is a small island dominated by a large, lichen-covered rocky outcrop. It supports a compact colony of gentoo penguins as well as breeding south polar and brown skuas, and nesting Wilson's storm-petrels.

Farther south, in aptly named Paradise Harbour, there is the Argentine Almirante Brown station, which was partly burnt down in 1984 by the station doctor (who could not bear the idea of spending the winter there). Not far away on the Danco

Coast at Waterboat Point is the site of another station, Gabriel González Videla, belonging to Chile. This is set in the midst of a bustling colony of gentoo penguins, with an unusually large number of scavenging sheathbills in attendance. The site is known as Waterboat Point, after two British scientists who chose to winter here in 1921, using a whaler's water-boat for part of their shelter hut (its remains can still be seen). This site, too, enjoys a spectacular location.

Not far distant lies Wiencke Island, at the foot of which is the sheltered anchorage of Port Lockroy (usually approached via the magnificent Neumayer Channel). Port Lockroy was established as Base A by the British Government in 1944, as part of a secret wartime initiative to monitor enemy shipping movements. This expedition was code named Operation Tabarin, after the Bal Tabarin, a well-known Paris night club, because team members would be staying there during the darkness of the Antarctic winter. After World War II, the station continued in a civilian capacity until 1964, when it ceased operations. Surrounded by high mountains, the site has a large and busy gentoo penguin rookery with a small contingent of blue-eyed shags that nest near the shore. Weddell seals are often seen here, and there are a fair number of whale bones on the shore, testifying to its use in the past by whalers. The hut has been restored and is refurbished as a museum by the United Kingdom Antarctic Heritage Trust. Usually three people spend summer there where, as well as maintaining the site, they run a small shop and operate an Antarctic Post Office.

The only United States station in this part of the Antarctic is at Arthur Harbor on the shore of Anvers Island. Palmer Station was established in 1965 and named after Nathaniel B. Palmer, a Connecticut sealer who worked at the South Shetland Islands in 1820. Palmer supports up to 40 people in summer, with about 10 staying for the winter. It is well situated for studies of birds, seals, and the marine ecosystem, as well as other research projects. Guided tours of the station are often provided for groups of about eight persons.

Two islands near Palmer are inhabited by Adélie penguins. Litchfield Island is protected, and may not be visited, but visitors are welcome to explore Torgersen Island, where crabeater and leopard seals are also seen. Site of a long term ecological study, it appears that the number of penguins at Litchfield have declined compared with those at frequently visited Torgersen, which is probably because Litchfield is more prone to being covered in snow.

In 1989, the Argentine supply vessel *Bahía Paraíso* ran aground close to Palmer Station, when the crew and passengers had to be evacuated. Although about 1000 cubic meters of fuel oil and gasoline escaped, most of it was light grade and fortunately did not result in serious long-term environmental damage.

Sailing south, one reaches the Lemaire Channel, a deep, narrow cleft between Booth Island and the mainland of the Antarctic Peninsula. The Lemaire is the place most often cited as the most beautiful in the area, and if it is not blocked by ice, it is a

memorable experience to sail between the channel's sheer cliffs. Seals are often seen on ice floes here, and minke whales may be encountered.

South of the Lemaire there are several islands with penguin colonies, such as Pleneau, Hovgaard, and Petermann. Elephant seals, especially young males, often haul out onto the flat rocks to enjoy communal wallows in the summer sunshine. Charcot first wintered in Antarctica at Booth Island in 1904 and next at Port Circumcision on Petermann Island, site of the southernmost colony of gentoo penguins. There is a small Argentine hut, built in 1955, and a British memorial to three men lost of the sea-ice in 1982, in the vicinity.

Just to the south are the Argentine Islands, a small archipelago of igneous rocks, most with permanent snow cover. The British have had a presence here since 1934, when a geological party and survey under John Rymill wintered, and Faraday station was established on Galindez Island in 1947. This former British Antarctic Survey station is the oldest operational station in the Antarctic Peninsula area. The British transferred the station to the Ukraine in 1995-96 and it is now named after a prominent Polish scientist, "Akademik Vernadsky."

Just south of the Antarctic Circle, Adelaide Island is the site of the British Rothera Station. Scientific studies here concentrate on geophysical and atmospheric physics with the aid of a satellite receiving system called ARIES Antarctic Reception of Imagery of Environmental Sciences. A 915-meter (3,000-foot) airstrip of crushed rock that can take aircraft as big as a Lockheed C130 transport. It is something of a communications hub for this sector of Antarctica and equipped to deploy field parties long distances farther south

Stonington Island in Marguerite Bay has an interesting history. It was the site of East Base, established during Admiral Richard E. Byrd's third expedition, the United States Antarctic Service Expedition of 1939-41 (West Base, or Little America III, was on the Ross Ice Shelf). Wintering complements were 26 and 33 respectively.

The base was reoccupied after World War II by the Ronne Antarctic Research Expedition of 1947-48. Finn Ronne (who had also been a member of the earlier expedition) gathered a crew of volunteers and experienced pilots, borrowed a ship and three planes from the United States Army, and raised over \$50,000 to finance the last of the privately funded, major explorations in Antarctica. One of its achievements was to cross the Antarctic Peninsula to reach the Weddell Sea. The team included the first two women to winter in Antarctica: Ronne's wife Edith, and Jennie Darlington, the wife of Harry Darlington III, the expedition's chief pilot. It operated during the 1947 winter only. A few hundred meters away is the abandoned British Base E, which operated from 1945-75. It was a major site for dog sledging with the remains of dog pens and kennels still to be seen.

In 1989, the Antarctic Treaty declared East Base a Historic Monument, and representatives of the United States National Parks Service and National Science Foundation, plus two British

Antarctic Survey team members, went there in 1992 to effect a clean-up and remove hazardous wastes. Visitors can still see many fascinating artifacts around the camp, including a World War I vintage army tank and tractor, a spare aircraft engine still in its packing crate, canned goods, piles of coal, and bales of hay. Unfortunately, despite its interest, Stonington is quite far south, and the approach is often blocked by ice, a difficult place to reach by ship. Base E, now also a historic site, may be visited at the same time but the extensive main building, although in good condition, is largely empty.

Horse-shoe Island is another historic hut in the region which has remained almost intact but, because of ice conditions, it is rarely visited. Similarly the Argentine station, San Martín, established in 1951 and open continuously from 1976, has had very few visitors.

THE HISTORIC ROSS SEA SECTOR

This part of Antarctica is of extraordinary historic interest, the staging area for some of the most famous expeditions of the heroic age of Antarctic exploration. The chapter on the Exploration of Antarctica tells this story. It is also a region of extreme beauty.

The Ross Sea was discovered by Captain (later Sir) James Clark Ross during his remarkable voyage of 1839-43 with two ships, HMS *Erebus* and HMS *Terror*. They succeeded in penetrating the pack ice far south of New Zealand into the open waters now called the Ross Sea. They found along the coast a range of snow-covered peaks, two huge volcanoes one of them spectacularly active, hundreds and thousands of whales and penguins, and something completely new: a level barrier of ice up to 60 meters (200 feet) high stretching for almost 400 miles (650 km) across their path south. This is now known as the Ross Ice Shelf. Wrote Ross: "We gazed with feelings of indescribable delight upon a scene of grandeur and magnificence far beyond anything we had before seen or could have conceived."

Ross Ice Shelf

Virtually filling what would otherwise be a gigantic bay or inlet in the coast of the continent, and straddling longitude 180°, the Ross Ice Shelf is approximately the size of France. The ice increases in thickness from about 400 meters (1,300 feet) in the north to more than 1000 meters (3,300 feet) in the south. It moves outward at about one kilometer (over half a mile) each year. Huge icebergs regularly calve off the front; the infamous B15, the largest ever measured, separated in 2001 and became a serious hazard to navigation.

Ross Island, on the west side of the Ross Sea and separated from the mainland by McMurdo Sound, is dominated by the active volcano Mount Erebus (3,795 meters or 12,450 feet) and the slightly lower extinct Mount Terror. In November 1979, a New Zealand airliner, during white out conditions, tragically crashed into the side of Mount Erebus, killing all 257 people aboard. For many years following this accident, sightseeing flights were not operated to the continent. They were resumed in 1994. Ross Island was the starting point for three major expeditions,

and played a significant role in a fourth. It is now the site of the massive United States McMurdo Station and New Zealand's Scott Base. Mount Erebus was first climbed on 10 March 1908 by a party from Ernest Shackleton's *Nimrod* expedition.

Hut Point

Located on a promontory called Hut Point near the southern tip of Ross Island, the Discovery Hut was transported from Australia for Captain Scott's first, 1901-04, expedition. Expedition members actually lived on board the ship *Discovery*, and the hut was mainly used as a store room and laboratory. Expedition members sometimes performed plays here, and on such occasions the hut became the Royal Terror Theatre.

Four years later it was used as an advance base for sledging operations during Shackleton's 1907-09 expedition (which was based at Cape Royds). Later still, it was used in 1911-13 by sledging parties during Scott's second expedition (which was based at Cape Evans). The large memorial cross to Scott and his four companions was made in this hut; the cross now stands at the top of Observation Hill. Finally, the hut was used a fourth time in 1915 and 1916 by sledging parties of the Ross Sea party supporting Shackleton's Imperial Transantarctic expedition of 1914-17.

Cape Royds

One of the most picturesque places in Antarctica, Cape Royds on the west side of Ross Island was the base for Shackleton's 1907-09 *Nimrod* expedition. From the Cape Royds hut, Shackleton and three others got to within 97 nautical miles [180 km] of the South Pole before turning back. The first motor transport in Antarctica an Arrol-Johnson car was put ashore here, and during 1908 the book *Aurora Australis* was written,

"We gazed with feelings of indescribable delight upon a scene of grandeur and magnificence far beyond anything we had before seen or could have conceived."

printed, and published in this hut. The hut was also visited by members of Scott's 1910-13 expedition, and again by members of Shackleton's Ross Sea support party, between 1914 and 1916. In front of the hut is the most southerly known Adélie penguin rookery, a specially protected area and not to be visited without a permit although good views may be had from the periphery.

Cape Evans

Also on the west side of Ross Island, between Cape Royds and Hut Point, is Cape Evans site of the most famous, and largest, of all the historic huts. This is the hut used by Captain Scott and his team during the 1910-13 expedition which ultimately resulted in the death of Scott, Wilson, Bowers, Oates, and Evans on

their return from the pole in 1912. When the surviving members departed in 1913 they left behind a large quantity of provisions, equipment, and some clothing. This was later to be of vital importance to ten members of Shackleton's Ross Sea support party (1914-17). They were stranded here when their ship, *Aurora*, was blown out to sea by a blizzard in May 1915. Three of them died, but the remaining seven were eventually rescued in 1917 by Shackleton himself, after he had rescued the Elephant Island party and then traveled to New Zealand to board *Aurora*.

Two anchors from *Aurora* are still embedded in the beach and the remains of Weddell seals killed for food and fuel can be seen in the hut's porch. Within the hut are improvised boots, and other garments and artifacts. A visit to this hut, with all its poignant memories, is an unforgettable experience.

Cape Adare

Cape Adare is a volcanic headland at the western entrance to the Ross Sea. The beach below was home for the 1898-1900 *Southern Cross* expedition led by a Norwegian, Carsten Borchgrevink, and sponsored by a British newspaper owner, George Newnes. The expedition, of 10 men, was the first to winter on the Antarctic continent. One member of the group, a Norwegian biologist, Nikolai Hanson, died here on 14 October 1899. He is buried on top of the Cape, the first known grave in Antarctica.

Cape Adare was later visited by the Northern Party of Scott's 1910-13 expedition, who built a separate hut. The two Borchgrevink huts still stand, but that of the Northern Party has been flattened by the strong, gusty winds. Completely surrounding the huts is the largest known Adélie penguin rookery in Antarctica, with an estimated 280,000 breeding pairs.

McMurdo Station

The largest scientific station in Antarctica, McMurdo is the logistics hub of the United States Antarctic Program (USAP). It is located on the east coast of McMurdo Sound, which was named after Lieutenant Archibald McMurdo of James Clark Ross' 1841 expedition. McMurdo was established in 1955 near the southern extremity of Ross Island and is adjacent to Scott's Discovery Hut. It houses up to 1,200 people in summer, with the winter population reduced to about 180. Something of a cross between a frontier town and a high-tech, modern city, the complex of 100 structures includes a state-of-the-art laboratory facility, repair shops, dormitories, offices, a firehouse, power plant, water desalination plant, stores, clubs, and a coffee shop.

Many of the buildings are constructed on stilts, to avoid disturbing the permafrost, and are linked by above-ground water, sewer, telephone, and power lines. Giant jets of Military Airlift Command, using air strips on the sea ice of McMurdo Sound, transport people and urgent cargo between Christchurch, New Zealand, and McMurdo from October to December. Ski-equipped C-130 aircraft operate on a ski way on the nearby Ross Ice Shelf to February. A few ships visit McMurdo in January to deliver a year's supply of fuel, food, building materials, and other supplies and equipment. McMurdo also provides logistic support for the New Zealand Antarctic

Programme. Italian, Russian, and some other programs also use its facilities. Research in the area includes marine and terrestrial biology, biomedical work, glaciology, meteorology, and upper atmospheric observations. A long-term programme studies the volcanology of Mount Erebus.

Amundsen-Scott South Pole Station

The Amundsen-Scott Station is supplied by air and snow-trains from McMurdo, some 1350 kilometres (840 miles) away by air. It was established at the geographical South Pole in 1956, and a third station, opened in February 2008; each of its predecessors became buried and crushed by the unmelting snow. There are more than 100 people at Amundsen-Scott in summer, dropping to about 40 in winter. The station is served by almost daily flights in summer, but is isolated from mid-February to early November. A metal post sunk in the ice shows the precise point of the South Pole. Its location is re-surveyed every January, with the aid of navigational satellites, since the Antarctic ice sheet is not static (it moves about 10 meters or 30 feet each year at the South Pole during which about 10 cm of ice accumulates). Research at Amundsen-Scott includes glaciology, geophysics, meteorology, upper atmosphere physics, astronomy and biomedical studies.

Scott Base

Scott Base on Ross Island, 4 kilometers from McMurdo Station along a graded road, is the focus of New Zealand Antarctic Programme (NZAP) activity. It was built in 1957, and comprises accommodation, workshops, and a laboratory. It is run by 35 people, who also assist field parties in summer; this number drops to ten during the winter months. NZAP cooperates closely with the USAP, and Royal New Zealand Air Force planes as well as USAF aircraft are used for the long flights to and from Christchurch and McMurdo. A series of wind-powered generators on the ridge between Scott Base and McMurdo station provide a large proportion of its electrical power.

Each year, NZAP supports about 30 projects, involving nearly 250 people. Recent projects include research into the geological history of Gondwana, the nature of sea ice, and biological studies of fishes, penguins, skuas, and Antarctic lakes. Current research focuses on the effects of human activities; biodiversity and ecosystems; climate processes; and terrestrial evolution. From 2009 a conservation laboratory has been open there dealing with artefacts from the historic huts. In the station is one remaining hut from the Commonwealth Trans-Antarctic Expedition of 1956-57 and kept as a museum and quiet room.

Between Scott Base and McMurdo Station is Observation Hill (230 m high, 701 ft), which can be climbed with some effort on a 'goat track' which becomes quite steep and icy near the summit. At the top is a large memorial cross, made of jarrah wood, which was erected in 1913 by comrades of Scott and his companions. It is inscribed with the names of the polar party who perished on the return journey and these words from Tennyson's *Ulysses*: "To strive, to seek, to find - and not to yield."



Assortment of whale bones collected and placed to resemble a skeleton on Goudier Island.

The Dry Valleys

A prime example of one of the most extreme ecosystems in the world can be found at the 29,000 square kilometers (1,100-square-mile) Dry Valley systems of south Victoria Land, within helicopter range of McMurdo and Scott Base. Discovered by Scott and two companions on a sledging expedition in 1903, these valleys are virtually free from ice and snow year-round. They are also almost, but not completely, lifeless. Here, in Scott's words, are "all the indications of colossal ice action and considerable water action, and yet neither of these agents is now at work." Erosion is at work, however, creating strange and beautiful wind-sculpted boulders.

There are some lakes in the Dry Valleys, but of peculiar kinds. Don Juan Pond, for example, is a nearly saturated solution of calcium chloride that never freezes, even at temperatures as low as -51°C (-60°F). Japanese scientists discovered in it a mineral new to science: crystals, called antarcticite, that turn to liquid unless refrigerated. Another water body, Lake Vanda, has no out flow, and has a permanent lice-floe on its surface although open water is found around the edges in the height of summer. Beneath the ice is a layer of cold, fresh water, but beneath that is highly salty water with a temperature of 25°C (77°F). Here live algae, bacteria, and protozoa - but being sealed off from the outside world, apart from incoming solar energy, they survive by recycling nutrients between them.

Other remarkable life forms found in the Dry Valleys are cryptoendolithic communities of lichens, fungi, and algae that actually live inside solid rock. In fact, they live in minute cracks in the rock or even between the crystals of more porous and partly transparent sandstones and granites. Higher animals and plants cannot survive in the arid conditions of the Dry Valleys, where evaporation exceeds precipitation. Curiously, some seals and penguins have wandered here, some 80 kilometers (50 miles) from the sea, where their dehydrated remains are preserved, some for thousands of years. Scott found the skeleton of a Weddell seal, but how it came there is beyond guessing. It is certainly a valley of the dead.

The hanging glaciers, dramatic mountains and unique nature of the Dry Valleys make this one of the most intriguing areas to visit. The whole area has an unearthly beauty.

Commonwealth Bay

The Cape Denison Historic Site is located in Commonwealth Bay in the Australian sector of Antarctica, at about $142^{\circ}40'\text{E}$ longitude. It commemorates the 18 member, Australasian Antarctic Expedition of 1911-14, led by Douglas Mawson, who was knighted in 1914. The expedition received financial support from the Australian and British governments, and also private organizations and individuals. It is named after one of the latter, Hugh Denison of Sydney. Britons will be amused by the names given to opposite ends of the site, Land's End and John O'Groats (the tip of Cornwall and the northernmost point of Scotland respectively). The site is near the longitude of the South Magnetic Pole, and Mawson's scientific program was made important observations of the Earth's magnetic field. Mawson spent a tragic second winter there during 1913 with six others, he was the only survivor of a 3-man party exploring eastwards.

Cape Denison has the reputation of being the windiest place on Earth that people have lived for any length of time. Gravity-driven katabatic winds are common, flowing down the ice slope towards the coast. The average summer wind speed is 24 knots (35 miles per hour); gusts of 130 knots (150 miles per hour) have been recorded. For this reason, landings by Zodiac or helicopter are sometimes impossible. Blue ice on the plateau indicates strong winds, and snow plumes are often seen blowing off the glacier snouts nearby, even when the hut area is calm. Among notable sights are the offshore McKeller Islets, which are covered with snow mushrooms up to 18 meters (60 feet) high on the landward side caused by sea spray whipped up by the winds.

At Commonwealth Bay stands a substantial main hut and workshop, and several smaller huts connected with the scientific studies. Visitors should not enter these huts, and should not take or disturb any artifacts in the area, including animal remains (there are several piles of penguin and seal remains dating from the Mawson expedition). A number of Adélie penguin rookeries



are scattered around the cape, and Wilson's storm-petrels, skuas, and Weddell seals are commonly seen. The whole site, and especially the huts and artifacts, are the responsibility of the Australian government's Antarctic Division, and the Australian Heritage Commission. There have been conservators working there during occasional summers from 1998. The effects of the severe winds are demonstrated by the amazing erosion of the exposed timbers of all the buildings.

NEW ZEALAND'S SUBANTARCTIC ISLANDS

All of the five island groups comprising New Zealand's subantarctic islands are National Nature Reserves, and strictly protected. Each tourist group is accompanied by a Department of Conservation representative. The fauna and flora are rather different from that found at Macquarie because of the islands somewhat more northern location. Each of them has distinct biology, including many endemic species. All of them were visited by sealers who decimated the fur seals and unfortunately introduced alien animals. Long-running programs to control and eradicate the introduced animals, combined with an overall conservation strategy, is allowing the native wildlife and vegetation to recover well. Campbell Island is now free from all introduced species after an exemplary rat eradication programme in 2001.

Tourist visits are permitted only on a select number of these islands and we shall consider three of them:

- Campbell Island, some 700 kilometers (440 miles) south of Bluff, New Zealand, at 52°S
- Enderby Island, one of the Auckland Islands, 465 kilometers (290 miles) south of Bluff at 50°S
- The Snares, just 209 kilometers (130 miles) from Bluff at 48°S

Their climate is described as cool temperate. Another way of putting it is to say that they are generally cool, wet, and very windy! But they have some very remarkable natural attractions to offer.

Campbell Island

This island was discovered in 1810, by Frederick Hasselborough, the Australian sealing captain who also discovered Macquarie in the same year. It is of volcanic origin, and shows evidence of glacial features such as cirques and steep valleys and fjords. With mostly peaty soil (like all of these islands), it has a mixture of tussock grass, bogs, and dense shrub land or dwarf forest. After sheep were removed in the 1980s, the vegetation, especially the megaherbs, is springing up again. Campbell boasts several endemic plants: a forget-me-not, a daisy, a gentian, two buttercups, and a grass.

The star attraction among the animal life is the world's largest breeding colony of Royal Albatrosses and four other albatrosses can also be seen here. There are breeding southern elephant seals, though their numbers seem to be decreasing, as at several other locations in their range. No one seems to know why. There are also a number of rare New Zealand (hooker's) sea lions. The albatrosses nest high on a windy ridge. This is reached along some four kilometres of boardwalk which goes through amazing rata forest up to open grassland and across mires. Towards its end the megaherb gardens are passed and, eventually the high wind-swept cliffs of the precipitous western coast.

Enderby, Auckland Islands

The Auckland Islands group is also volcanic, and the main island supports the richest floral assembly in the Southern Ocean, with 233 kinds of vascular plants. The islands were discovered whaler Abraham Bristow, in 1806. The most important year in the island's history was 1840, because three celebrated Antarctic explorers anchored in Port Ross, opposite Enderby Island. First came Charles Wilkes, from the United States aboard *Porpoise*. He liked what he found, and reported that his crew enjoyed themselves on chowders and fries. Two days later, the Frenchman Dumont d'Urville arrived with his ships *Astrolabe* and *Zélée*. His artist, Le Breton, painted some fine landscapes while at Port Ross.

Most important of the visitors was the British expedition led by James Clark Ross, with *Erebus* and *Terror*. Aboard with him



were two botanists, Joseph Hooker and David Lyall. They collected 80 species of flowering plants, including many that had not been described before. On Enderby, the vegetation has been substantially modified by human visitors and settlers, from sealers and European and Maori farmers to shipwrecked castaways. These people and a host of introduced animals have not helped the local flora. At the landing beach is a small summer research station, which is backed by a tangled rata forest. In 1993 the last of the introduced animals were eradicated and rapid recovery of the vegetation is apparent.

Enderby, about 5 kilometers (3 miles) long and under 2 kilometers (1 mile) across, is a wildlife paradise. It has one of only three major New Zealand (Hooker's) sea lion colonies in the world. The yellow-eyed penguin, a solitary nester that is considered the world's most endangered penguin, breeds on Enderby in greater numbers than anywhere else. Other birdlife includes nesting royal albatrosses, Auckland Island Shags, Auckland Island dotterels, and the flightless Auckland Island teal. A board walk extends from near the landing, through 'Tolkeinesque' rata forest, through open heath where albatrosses nest, and to the northern sea cliffs. From there it is possible to make a guided walk around the eastern end of the island (but it is difficult in places, somewhat weather dependent, and takes several hours). The well-maintained remains of a castaway refuge, built in 1880 are in the forest near the landing where a modern summer station accommodates biologists.

The Snares

This small group of islands, which were discovered in 1791 by Captain George Vancouver, have a land area of just 328 hectares (790 acres) yet it is estimated that the population of breeding seabirds numbers over 6 million, or roughly equivalent to the total number of seabirds around Great Britain and Ireland. The majority of these are Sooty Shearwaters, which gather well before dark and swoop down to their burrows in dark, swirling clouds. It is one of the great wonders of the natural world.

Visitors may not land at the Snares. For one thing, the islands are so honeycombed with seabird burrows that walking might

prove hazardous. But the best way to view the local birds is by cruising slowly along the coast in a Zodiac. You are pretty well guaranteed a good view of the snares crested penguin, endemic to just these islands, entering or leaving the sea at one of its favorite landing spots, such as the aptly named Penguin Slope.

In addition, there are good chances of seeing two other endemic birds Buller's albatross and a subspecies of the shy albatross. Keen birdwatchers with good binoculars will also want to scan the skies or the shore for the mottled petrel, which breeds only here and at a few other places off New Zealand. That might be a hard one to spot, as the birds tend to arrive and depart while it's dark. But there are still other rarities to look for, such as the snares snipe, the snares fern bird, and the snares tomtit - all of them endemic island forms.

New Zealand's subantarctic islands are a natural wonderland with so much to see that most people hardly notice the not always wonderful weather!

MACQUARIE ISLAND (AUSTRALIA)

Macquarie Island is a subantarctic island situated just north of the Antarctic Convergence, halfway between Tasmania and Antarctica. This tiny speck of Australian territory is totally protected, being designated Macquarie Island Nature Reserve. It measures 34 kilometers (21 miles) long and up to 5 kilometers (3 miles) wide.

The island, which is 1,400 kilometers (915 miles) from Tasmania and 1,294 kilometers (845 miles) from Antarctica, is a rare example of uplifted oceanic crust and of great interest to scientists studying sea-floor spreading and continental drift. It consists of a long, undulating plateau bounded by steep slopes and cliffs. Its vegetation is mainly sedges and grassland, including tall tussock grass, but there are no trees. Its climate is generally cold, wet, and windy; the sunniest months are November - February, when about 3.5 hours of sunshine per day can be expected.

Macquarie was discovered in 1810 by Frederick Hasselborough, a New South Wales sealing captain who named it after the



Emperor penguin and chick, Snow Hill Island

governor. Soon after its discovery the fur seals were being over exploited for their skins. Elephant seals and later penguins were killed for their oil. The seals and penguins were slaughtered unremittingly over the years until commercial exploitation finally ended in 1919. During this period, one species of fur seal became extinct, along with an endemic rail and a parakeet. Various birds and mammals were introduced, either deliberately or accidentally, though these are gradually being eradicated and controlled. An eradication programme against the wild cats was successfully completed by 1998 but then rodent numbers increased drastically with rabbits destroying large areas of vegetation. Rodent eradication began in 2008 to eliminate rats, mice, and rabbits. Early reports have the good news of its success, but a few more years will be necessary before this can be confirmed.

Douglas Mawson visited the island on his way to Antarctica in 1911 when he established a relay station for radio signals from his Antarctic base. Mawson loved the island so much that on his return he started a campaign to have it declared a wildlife sanctuary. Eventually this happened in 1933. It is administered by the Tasmanian Department of Parks, Wildlife and Heritage, with logistic and other support provided by the country's national Antarctic Division.

Besides Mawson, who visited the island in 1911 and 1930, other scientific visitors included several of the big names of Antarctic exploration. Bellingshausen came to Macquarie in 1820, Charles Wilkes visited in 1840, Scott came in 1901 (the sealers persuaded him to hand over a bottle of liquor before allowing him to land), and Shackleton was with him aboard *Discovery*.

Abundant Wildlife

Today, much of the wildlife has recovered from the sealers depredations. There are probably 100,000 seals and some 3- 4 million penguins, making it one of the richest wildlife sanctuaries in the world. Among mammals, there are breeding populations of southern elephant seals and three species of fur seals - New Zealand, Antarctic and subantarctic; the leopard seal and New Zealand (Hooker's) sea lion are regular visitors, while Weddell and crabeater seals show up occasionally. Several species of whales are seen offshore, and orcas are commonly sighted near the penguin colonies.

The list of at least 25 breeding birds includes four penguins (king, gentoo, rockhopper, and royal); four albatrosses (wandering, black-browed, grayheaded, and light-mantled sooty); eight or maybe twelve petrels and prions; plus the blue-eyed shag, black duck, Antarctic skua, kelp gull, and small numbers of Antarctic terns. Macquarie is the world headquarters of the royal penguin, of which there are estimated to be some 850,000 breeding pairs.

An Australian research station, established in 1947, on the north end of the island is home to some 40 scientists and support staff in summer and about half that number in winter. Access is by sea (there is no airstrip) and all visitors need a permit. A network of tracks, walkways, and viewing platforms at the station and at Sandy Bay leads visitors to the main attractions, which are easily accessible. These include an enormous rookery of king and royal penguins at Sandy Bay, seals, historic sites and artifacts from the sealing days, and interesting geological features.



SECTION 3

EXPLORERS AND SCIENTISTS

The earliest concepts of Antarctic regions came from the ancient Greek philosophers who determined that the Earth was a sphere and reasoned that there must be a large land mass at its southern extent to balance the known lands in the north.

The earliest concepts of Antarctic regions came from the ancient Greek philosophers who determined that the Earth was a sphere and measured its dimensions. They reasoned that there must be a large land mass at its southern extent to balance the known lands in the north. The boreal constellation Arktos - the Great Bear, was well known to these philosophers thus they called the hypothetical southern lands the opposite; Antarktos. It was a purely theoretical concept and, in practice, entirely unknown. Nevertheless it persisted on ancient maps for over two millennia. Later Latin editions of maps applied the term Terra Australis Incognita (Unknown Southern Land) to the Antarctic regions.

Terra Australis Exploration

The first historical period of Antarctic discovery lasted until about 1780. Its main activity was a variety of explorations and voyages penetrating to far southern regions. Some had exploration and discovery of Terra Australis as a major object while others were merchant vessels blown off course, often by tempests while rounding the southern capes. A consequence of these voyages was the progressive reduction of the hypothetical Terra Australis, and its separation from Australasia. Charts of Antarctic regions progressively showed less land as ancient speculations were steadily disproved. The voyages of Vasco da Gama round the Cape of Good Hope in 1498, of Ferdinand Magellan through the strait which bears his name in 1520, and evidence of the Drake Passage from Francis Drake's voyage

of 1578 demonstrated there were extensive oceans in the far south. Abel Tasman's voyages of 1642 and 1644 proved that Australia was a separate continent with ocean at its southern limits. Tasman also discovered the west coast of New Zealand. What was actually discovered of the huge theoretical Terra Australis was only a few of the remote peri-Antarctic islands as the enormous theoretical southern continent was progressively eliminated from maps. This early period may be regarded as concluding after the three voyages of James Cook (1768- 80) and two of Yves-Joseph de Kerguelen-Tremarec (1771-74).

During this period the first land sighted in the Southern Ocean was South Georgia, seen in 1675 by a merchant vessel sailing from Lima to London which was blown off course while rounding Cape Horn. Bouvetøya, the remotest island on Earth, was discovered in 1739 by a French expedition and, for a while, thought to be an Antarctic cape (sea ice prevented its circumnavigation). Several other peri-Antarctic islands, the more northerly ones, had appeared on charts by this time. Although positions were often dubious these discoveries were: Gough Island as early as 1505, Ile Amsterdam in 1522, Ile Saint-Paul in 1618, Prince Edward Islands from 1663. A variety of non-existent islands had also come to clutter even the best charts. By the latter part of the 1700s chronometers were sufficiently improved to allow accurate determination of longitude. It was with these that Captain Cook, in command of HMS *Resolution* and HMS *Adventure* made the



Captain Robert Falcon Scott

first crossing of the Antarctic Circle on 17 January 1773, reached a farthest south at 71.17°S at 106.90°W (north of Thurston Island) on 30 January 1774, and the earliest definite landing in Antarctic regions on 17 January 1775, on South Georgia. Cook was unlucky in one respect, the two places where he sailed far south were where the coast of Antarctica is also far south, at many other positions he might have discovered the continent.

Practical results of Cook's voyage were not only the discovery of South Georgia and the South Sandwich Islands but also the vast populations of fur seals on them. His third and last voyage also reported a very favorable market for their pelts in China which thus initiated the next phase in Antarctic history. Captain Cook was not impressed by his Antarctic discoveries and wrote that they were "land doomed to perpetual frigidness, never to feel the warmth of the sun's rays, whose horrid and savage aspect I have not words to describe."

Farther east the French explorer, Yves-Joseph Kerguelen, discovered the island which bears his name in 1772 but wrote an excessively favorable description of it. The King sent him back to colonize the island for France in 1773 when the truth was discovered; the colony was not established and, for his exaggerated claims, Kerguelen was sentenced to 20 years imprisonment (although later reduced to six).

THE AGE OF SEALERS

Within a few years, United States, British, and a few other sealers had become the new voyagers of the far south. By 1802 only 27 years after Cook's second voyage the sealers had seriously depleted the fur seals of South Georgia, and several other peri-Antarctic islands. Searching ever farther south from their bases in New Zealand, sealers discovered and started exploiting the fur seals of the Antipodes Islands in 1800, the Auckland Islands in 1806, and Campbell and Macquarie Islands in 1810. Using South Georgia as a base, other sealers discovered and quickly exploited the animals of the South Sandwich and South Shetland Islands. As each new island was discovered, the fur seal colonies were almost wiped out within a few short years.

For instance, the South Shetland Islands were discovered by William Smith (who was blown off course by a storm) in 1819. News of his discovery brought more than 40 ships to exploit fur seal skins and oil from those islands during the next season of 1820-21. In the following season, 1821-22, more than 90 ships were working the islands. By the end of the third year after the islands discovery, more than 320,000 fur seal skins and 940 tons of oil had been taken in the South Shetland Islands, and for all practical purposes the resource had been destroyed. As seals quickly became rarer conflict developed and Robbery Beaches on Livingston Island is a site where, for a week or so, sealers spent more time trying to club each other than the few seals remaining.

The Antarctic Continent was first sighted on 27 January 1820 by Fabien Bellingshausen on a Russian voyage of exploration. Over the course of two summers he became the second man to circumnavigate Antarctica, and did so considerably farther south than did Captain Cook. The coasts he had sighted were the icy ramparts of Kronprinsesse Märtha Kyst and Prinsesse Ragnhild Kyst.

Edward Bransfield, of Britain's Royal Navy, was sent to examine the South Shetland Islands in 1819; he sighted and charted land most probably the Danco coast of the Antarctic Peninsula on 30 January 1820. Later in the year, Nathaniel Palmer, a young sealing captain from Stonington, Connecticut, sailed from the South Shetlands aboard the 47-foot sloop *Hero*, and on 16 November, 1820 sighted what was probably the coast of the Antarctic Peninsula, from a distance of about three miles.



Cape Royds, Ernest Shackleton's signature



Cape Royds, Shackleton's supplies



Ernest Shackleton, back from a farthest south

At this time there may have been numerous small sealing vessels searching the region of the South Shetlands and the Antarctic Peninsula, but it was common for captains to keep their finds secret to protect their commercial interests. Discoveries must have been made during these years that were never publicized because sealers had no interest in them unless seals were found.

On 7 February 1821, the United States sealer John Davis became one of the earliest recorded persons to set foot upon the Antarctic continent when he landed at Hughes Bay on the Antarctic Peninsula. It is interesting to note that at the time of his achievement he said he believed the southern shore he landed on was a continent. But it was not until the following decade that geographers and scientists concluded that the long-sought Southern Continent had indeed been found. There is evidence of other sealers making continental landings but few definite details.

In 1823, the British sealer James Weddell reached 74°15'S in the Weddell Sea during a particularly favourable ice year, the farthest south that any man had ever been. There was very little ice there at that time, unlike today. Weddell found no new sealing grounds, but he did discover a new species of seal which was later named after him.

The last major search for new sealing grounds was made in 1838 by John Balleny. Although he discovered the islands that bear his name, and the Sabrina Coast of Antarctica, he returned from the expedition with only 178 seal skins. The sealing bonanza was over. But by then the collection of oil had become very profitable, and the ship's crews rendered elephant seals, several species of whales, and even penguins into valuable oil. This new industry continued until well into the 1900s.

Sealers and Scientists

During the period from the publication of the reports of the voyages of Cook and Kerguelen until early in the 1900s the majority of visitors to Antarctic regions were sealers, who discovered many and visited nearly all the peri-Antarctic islands, and wintered on several. They were also active in many adjoining regions, notably: Tristan da Cunha, Falkland Islands (Islas Malvinas), Tierra del Fuego, Stewart Island, and Tasmania. The peak of the industry was during the early to mid-1800s and they were nearly all from Britain, Cape Colony, France, New South Wales, New Zealand, Tasmania, or the United States (New England states). Sealers made the earliest landings on the Antarctic continent (1820) and were the earliest to winter in Antarctic regions (especially those who did so involuntarily on the South Shetland Islands, 1821 and 1877). Extended series of consecutive winters were spent on some peri-Antarctic islands where remains of huts, habitations in caves, try-pots, graves, and other relics may still be found.

The Enderby Brothers, a London company, was particularly notable in combining commercial enterprises with exploration. They dispatched exploratory voyages led by James Colnett (1792-94), Abraham Bristow (1805-06), John Biscoe (1830-33),

and John Balleny (1838-39) who all made important discoveries, as well as several other voyages which were not so successful. Samuel Enderby also tried to colonize the Auckland Islands in 1849 but this venture was abandoned barely 18 months later (the shortest-lived British colony).

Sealers often considered that seals had moved elsewhere rather than been so reduced. Consequently they were always on the lookout for new sealing areas but, unfortunately for history, tried to keep such discoveries secret to avoid any competition. There are sporadic inscriptions on rocks, graves, a few wrecks, and sparse other items on the islands, which, with a variety of logbooks, provide clues as to where the sealers operated.

The sealing industry suffered interruptions on several occasions when the United States fleet was reduced by wars, when the crew left when gold rushes occurred in California, Australia, New Zealand, and Patagonia, and when major guano deposits were exploited. Unfortunately their industry vastly over-exploited the seals; first fur seals were reduced to near extinction and subsequently elephant seals were greatly depleted. Fortunately populations of both have now recovered to somewhere near their original sizes (or probably exceeded this in the case of fur seals on several specific islands).

The greatest profits made by the Antarctic sealers came from fur seals and, after these became too scarce to sustain that industry, Elephant seals became the next quarry. This was a vastly different industry for it was the blubber which was taken and used to extract oil. Large cauldrons (over 200 litre), known as 'try-pots', placed over fires were used for this; some were aboard ships like the old style (Moby Dick) whalers (rather hazardous circumstances) and others ashore. The elephant seal industry was not so profitable but endured, slowly in decline, until 1922 when the last old Antarctic sealer, *William A. Graber*, returned from Iles Kerguelen to her home port New Bedford. During elephant seal operations any fur seal unfortunate enough to arrive on a sealing beach where elephants were being taken, was killed which greatly delayed their population recovery. Trypots are the most obvious relics of the old sealing industry and may be seen on many beaches on the peri-Antarctic islands.

Fur seals were reduced to near extinction and subsequently elephant seals were greatly depleted.

The sealing period was dominant for over a century during which about 1200 sealing voyages went to the islands of the Southern Ocean. In this period there were barely two dozen exploratory voyages, but several of these made major scientific contributions. There were inevitable discoveries by sealers and a small number of exploratory expeditions during this period. At least five landings on the Antarctic continent were made by sealers during this period but, as none of them found seals there, the records of these significant historical events are fragmentary. James Weddell, a sealer, reached 74°25'S in what was later known as the Weddell Sea and wrote a good account of his voyage which was published several years after the peak of South Shetland Islands sealing. In contrast very few sealers wrote of their experiences as secrecy about the location of good sealing beaches formed a major part of their success.

Three national exploring and scientific expeditions were active at about the same time: from France (1837-40), United States (1838-42), and Britain (1839-43), which were associated with determination of the positions of the South Magnetic Pole.

Dumont d'Urville's expedition circumnavigated the Earth during which two summers were spent in Antarctic regions. The South Orkney and South Shetland Islands were mapped and sketched, including a particularly fine view of Elephant Island. In the second summer Terre Adélie was discovered and claimed for France. It, and the Adélie penguin, were named after Adele, Dumont d'Urville's wife.

The United States Exploring Expedition, led by Charles Wilkes, examined much of the globe and the Antarctic voyages formed only a small part of its work. First a brief visit to the South Shetland Islands was made followed by an attempt to find land towards Thurston Island but this was too distant and difficult with severe ice. During the second summer much of the outliers of what is now Wilkes Land was seen and some of the island visited. There was a very strange coincidence with the French and British expeditions in the Antarctic, they sighted each other on 30 January 1840 off the Antarctic coast – but both eschewed contact, for reasons never made entirely clear.

The third of these expeditions led by James Ross aboard HMS *Terror* and HMS *Erebus* encountered exceptionally favorable ice conditions and entered the Ross Sea. The coast of Victoria Land was surveyed, the active volcano Mount Erebus discovered and southern progress eventually halted by 'The Great Ice Barrier'. The published maps also included Cape Adare, Ross Island, and McMurdo Sound which subsequently became major sites for many expeditions, some exploring the interior of Antarctica.

These three expeditions were somewhat in competition. In contrast a degree of international co-operation came with the 1874 Transit of Venus which was observed by French, British, German, and United States expeditions from Ile Saint-Paul, Iles Kerguelen, Campbell Island, and Auckland Islands. The first International Polar Year (1882-83) was mainly an Arctic event but a German station operated at Royal Bay on South Georgia for a year. This initial international co-operative research programme was to have many important consequences for the Antarctic.

Charts of the Antarctic progressively improved during this period and showed more land as discoveries accumulated including such important sealing islands as Auckland Islands (1807), Campbell Island and Macquarie Island (1810), South Shetland Islands (1819), South Orkney Islands (1821), and Heard Island (1853). Islands such as Peter I øy (1821) and Balleny Islands (1839) were also discovered but, as they had no seals, were of little interest to their discoverers. Ships sailing on far southern courses, to and from Australia and New Zealand reported quite exceptional numbers of icebergs around the 1830s, 1850s, and 1860s.

THE HEROIC AGE AND CONTINENTAL PENETRATION

Whales had become over-exploited in the Arctic and several whaling reconnaissance voyages were made south in 1882, the first *Jason* voyage and four vessels of the Dundee whaling fleet made reconnaissances in the Southern Ocean and other vessels followed. From this beginning until the end of the First World War was the Heroic Age when coastal mapping and penetration inland eventually to the South Pole was the major Antarctic activity. It was also the beginning of the modern whaling industry, a second period of over-exploitation of the resources of the Southern Ocean.

These whaling reconnaissances aroused much public interest and were a practical beginning of this brief but intense age. There was also a strong theoretical beginning in 1895 with an Antarctic resolution adopted by the sixth International Geographical Congress in London: 'That this congress record its opinion that the exploration of the Antarctic Regions is the greatest piece of geographical exploration still to be undertaken. That in view of the additions to knowledge in almost every branch of science which would result from such a scientific exploration the Congress recommends that the scientific societies throughout the world should urge in whatever way seems to them most effective, that this work should be undertaken before the close of the century'.

The earliest winterings were made south of the Antarctic Circle (1898, aboard *Belgica*) and on Antarctica (1899, at Cape Adare). The last of the peri-Antarctic islands was discovered (Scott Island in 1902) and the general limits of Antarctica became known during this period. The South Pole was reached twice in the 1911-12 summer (33 days separated these events). The earliest Antarctic sound recordings were made in 1902 (aboard *Gauss*) and ciné films in 1903 (aboard *Scotia*). Twice in 1902 aircraft (hydrogen balloons) were used for aerial reconnaissance (from *Discovery* and *Gauss*). Radio communications were established between Antarctica and Australia by Douglas Mawson at Commonwealth Bay in 1913, through a relay station on Macquarie Island. In March 1903 the first permanent meteorological station was opened (on the South Orkney Islands) and in November 1904 the first shore whaling station was established (Grytviken, on South Georgia). Although some governmental assistance was given to several of the expeditions of this stage of history, especially when they were relief ones, the majority were private enterprises, either personal or of an

organization. Icebergs were exceptionally frequent during these years with major occurrences in 1892-94, 1903-04, and 1906-09 when almost every ship sailing between Europe and Australasia reported encounters with vast fields of ice. One can conjecture that calving of some major ice shelves must have occurred.

During this brief, but intense period, exploratory expeditions sailed from Argentina, Australia, Belgium, Britain, Chile, France, Germany, Japan, New Zealand, Norway, and Sweden. Some of the last of the sealers, from Australia, Canada, Chile, France, Newfoundland, New Zealand, Norway, South Africa, and the United States were still working on a few islands. The next industry began with companies from Argentina, Britain, Chile, Newfoundland, and Norway, which commenced Antarctic whaling operations that soon would expand. About a century later there are eleven existing historic huts, although nature and man have destroyed others. Coincidentally at least 17 determined, but unsuccessful, attempts to reach the North Pole were made during the same years, thus the 'Heroic Age' had Arctic and Antarctic components.

In 1901 Robert Falcon Scott, an officer in the Royal Navy, led the *Discovery* expedition to Victoria Land. They built a hut at the southern tip of Ross Island in McMurdo Sound, where *Discovery* wintered. Scott, with two companions, Edward Wilson and Ernest Shackleton, made a southern trek using dogs to pull their sledges. They reached 82°S before having to turn back.

In the same year, Otto Nordenskjöld led a Swedish expedition to the Weddell Sea, but his ship, *Antarctic*, was crushed in the ice and sank. After a series of adventures and extraordinary hardship, involving small groups of men stranded at three different places, the whole party was rescued over two winters later in November 1903. The scientific results of this expedition proved to be very important, despite the major problems which had beset them.

1901 was also when a German Antarctic expedition, led by Erich von Drygalski, aboard *Gauss* sailed. After establishing a small station on Iles Kerguelen they went south to explore and make coordinated observations with Scott's and Nordenskjöld's expeditions. Pack-ice, however prevented them getting closer than about 80 kilometres from the coast where they drifted beset in ice for the 1902 winter. One quick foray was made to the coast where they reached Gaussberg, a prominent isolated volcanic peak.

Jean-Baptiste Charcot organized a French expedition in 1903 which charted large parts of the Antarctic Peninsula region. This work was to be of great importance to navigators in the years to come. Charcot returned in 1908 in the most modern polar ship to date, *Pourquoi Pas?*. Besides exploring and charting further coasts and islands, he tested a lot of improved equipment such as anti-snow blindness goggles, a petrol motor boat, and different types of clothing. Charcot was a very humane man, known as "the polar gentleman," and was one of the first to point out the dangers of over-exploiting the whales. He conducted considerable research in hydrography, geology, botany, and zoology.

The two great quests of Antarctica, to reach the South Pole and the South Magnetic Pole, had still not been attained. Ernest Shackleton returned in 1907, this time in command of his own expedition aboard *Nimrod*. He hoped to take both prizes. He decided to use Siberian ponies, as well as dogs, to haul sledges across the Ross Ice Shelf and up to the polar plateau. But the ponies did not last long and Shackleton's polar party was reduced to man-hauling the sledges. Despite appalling conditions, they reached a point within 180 kilometers (97 nautical miles) of the South Pole before Shackleton decided to turn back. Meanwhile, the other aim of the expedition had been achieved by Shackleton's second-in-command, the Australian Edgeworth David, who led a successful trek to the South Magnetic Pole. The expedition also made the first ascent of the active volcano Mount Erebus (3795 metres) on 10 March 1908, the first ascent of a major Antarctic peak. Among Shackleton's discoveries were coal and fossils in the rocks surrounding the Beardmore Glacier.

Roald Amundsen had long planned to be the first man to the North Pole. But some months before he was due to set out in 1910 news came that both Robert Peary and Frederick Cook claimed to have already reached it. So Amundsen covertly changed his plans and decided to go to the South Pole instead. This put him in direct competition with Captain Robert Scott, who had already announced that he was making another attempt to reach the South Pole.

Amundsen established his Antarctic base on the Ross Ice Shelf at the Bay of Whales, which put his starting point a vital one degree (111 kilometers or 681 miles) nearer the pole than Scott's base at McMurdo Sound. He decided to use dogs, which had proved themselves time and again on his journeys in the Arctic. The traverse to the pole was carefully and methodically planned to the last detail. He reached the pole on 14 December 1911, and to his relief, there was no sign of Scott. The entire journey to the South Pole and back went like clockwork, and took 99 days.

Captain Robert Scott returned to Antarctica early in 1911, and constructed a base at Cape Evans on Ross Island. He then spent the next nine months conducting scientific research and preparing for his forthcoming trek to the pole as soon as spring returned and with it daylight.

The main details of Scott's heroic, but doomed, expedition are well known, but he and four companions reached the South Pole on 17 January 1912, 33 days after Amundsen had departed. It was a bitter disappointment that their Norwegian rival had got there first. On their return journey, the five men were plagued by ferociously bad weather, and a shortage of food and fuel. Evans and Oates died first, and finally Scott, Wilson, and Bowers died in their tent in a blizzard on, or shortly after, 29 March 1912, only 20 kilometers (11 nautical miles) from a supply depot. Their bodies were found eight months later and were buried where they lay on the Ross Ice Shelf.

Ironically, it was Scott's tragic journey that captured the world's attention, while Amundsen's achievement of being the first man to reach the South Pole brought him relatively little glory outside

his native Norway. Another, but perhaps understandable irony is that the tragic end of Scott's polar journey overshadowed the many valuable scientific discoveries of his expedition. Amundsen's journey, by contrast, was a great achievement but of no significant scientific value.

Douglas Mawson, an intrepid Australian who had accompanied Edgeworth David to the South Magnetic Pole and was one of those who had climbed Mount Erebus on Shackleton's 1907-09 expedition, landed his own party at Cape Denison in Commonwealth Bay at about the same time that Scott reached the South Pole in January 1912. His expedition also had a station on the Shackleton Ice Shelf and another on Macquarie Island. His expedition turned into another tale of hardship and courage. Unfortunately, Cape Denison lies in the most violent wind corridor on Earth. The nearly constant gale-force winds caused considerable problems with almost every project Mawson's team attempted, but in November (10 months after they had arrived) the weather relented enough to allow some geographical and scientific work. Mawson led a trek which was to become one of the great survival stories of Antarctica. The two winter parties conducted extensive surveys mapping much of the coast south of Australia. The South Magnetic Pole was reached for a second time when it was noted that its position was changing.

Mawson alone returned from his eastern traverse during which two men died in tragic circumstances. He, with 6, others remained for the 1913 winter in Antarctica at Commonwealth Bay. The Macquarie Island station also remained and relayed the first two-way radio transmission made from Antarctica on 20 February 1913.

Ernest Shackleton had failed in his own attempt to be the first man to reach the South Pole, but he conceived another goal in trying to be the first man to lead an expedition across Antarctica. The plan was to take two parties in two ships and land them on opposite sides of the continent. Shackleton would land in the Weddell Sea and lead six men on a traverse of 3,600 kilometers (2,200 miles) across the continent, via the South Pole. The other group would land south of the Ross Sea and link with Shackleton's group at the base of the Beardmore Glacier to re-supply them and escort them the final distance to the Ross Sea base.

Things did not go well, almost from the start. Shackleton, aboard *Endurance*, entered the Weddell Sea in early December 1914 and found ice conditions especially bad. By 19 January 1915 they were hopelessly trapped in pack ice. They abandoned the ship on 27 October and set up a camp on nearby ice floes. The ship sank a month later. The pack ice was so thick and broken that they were unable to drag the three lifeboats and supplies either to water or land. By early April 1916, after steadily drifting north with the ice, they were able to launch the three boats and reached Elephant Island, about 240 kilometers (150 miles) north-east of the Antarctic Peninsula, six days later.

Although there were no good campsites, they found adequate seals and penguins which provided them with plenty of food, until these soon became scarce during winter. Shackleton decided to set off in the largest boat with five companions to

seek help from a Norwegian whaling station on South Georgia. Departing on 24 April, the six men crossed 1,500 kilometers (800 nautical miles) of rough seas in 16 days in *James Caird* to reach South Georgia.

Unfortunately, they landed on the south side of the island and were forced to climb over an unmapped mountain range with very little equipment to reach a whaling station. Finally, on 30 August 1916, after four months and three unsuccessful rescue attempts, Shackleton returned aboard the Chilean vessel *Yelcho* to rescue the 22 men left behind at Elephant Island. All of them had survived their winter ordeal.

The Ross Sea party also experienced a very difficult time. Ten men were ashore when *Aurora* was blown out in a blizzard. Only seven survived to be rescued in 1917 and the damaged ship was beset drifting for the 1915 winter.

MECHANICAL AGE AND WHALING PERIOD

Thereafter, between the First and the Second World Wars, the majority of vessels operating in the Southern Ocean belonged to the Norwegian whaling fleets and to scientific investigations associated with the industry (which began in 1904 and continued to 1987). Other scientific expeditions of several nationalities were also active, often assisted by the whaling fleets. Indeed the whalers often served as a 'safety net' for expeditions. Whalers were responsible for discovering many coastal regions of Antarctica, especially during the 1930-31 summer when an unprecedented number of ships were on the Southern Ocean (a total of 9 floating factories working from harbors, 32 pelagic factory ships, and 6 shore stations operated with 232 whale-catchers which were supplied by numerous transport ships bringing in fuel and taking processed whale oil out). The inventions making the modern whaling industry practicable were all Norwegian and originally developed by Svend Foyn. Thus the industry was, for much of this period, a Norwegian specialization and one of the many consequences was the proclamation of Norwegian sovereignty over Dronning Maud Land, Peter I øy and Bouvetøya. Exploration of the Antarctic was discontinuous during these years but made much progress generally. The United States resumed activity with several expeditions led by Richard Byrd and Lincoln Ellsworth. These successfully used mechanical methods for aerial and surface traverses (although sledge dogs remained important). The former based operations near the Bay of Whales in a series of stations, all called 'Little America', where winter parties remained during 1929, 1934, and 1940. The earliest use of powered flight (by aircraft heavier than air) in the Antarctic was made from Deception Island on 16 November 1928, by George Hubert Wilkins. This development greatly facilitated inland exploration and mapping thus during the next summer six expeditions used aircraft and even whalers began to use them for whale-spotting. Because of these developments, from the expeditionary aspect, this period included the beginning of what has been termed the 'mechanical age' of Antarctic exploration.

Maps and charts continued a steady improvement. Much of the coast of what would later become Australian Antarctic Territory was mapped, during two summers by Sir Douglas Mawson's British Australian and New Zealand Antarctic Research Expedition (1929-30 and 1930-31). A second International Polar Year was organized for 1932-33 but, owing to economic stringency following the great depression, no Antarctic stations were established for it. Observatories on South Georgia and South Orkney Islands, as well as many vessels of the whaling fleets, contributed data however. The British Graham Land Expedition of 1934-37 conclusively demonstrated that the Antarctic Peninsula is connected to the rest of the continent and not an isolated elongate archipelago as previously thought. The first trans-continental flight was made by Lincoln Ellsworth, from Dundee Island to near 'Little America II' in late 1935 during which several stops were made and high ranges observed farther south.

Biological and physical oceanography of the Southern Ocean, largely because of the whaling industry advanced greatly during this period with British and Norwegian vessels conducting similar research. During the period 1925 to 1927 a German expedition aboard *Meteor* and a British one aboard *Discovery* independently detected the Antarctic Convergence and thus delimited the northern boundary of the Southern Ocean. Early ideas of whaling regulation were advanced during this time, but from the aspect of preserving the industry rather than conserving the whales (although the different approaches would have many results in common).

The discoveries of territory during this inter-bellum period also made it one of increasing territorial claims. British, New Zealand, French, Norwegian, and Australian claims were defined. Admiral Byrd and Lincoln Ellsworth claimed territory for the United States although this has not been followed by formal definitions (a matter of importance after the Antarctic treaty came into force). German claims, at the beginning of 1939 were some of the last events of this period before territorial conflicts occurring with the Second World War greatly changed the circumstances.

As a result of vast improvements in maps of the Antarctic the Australian government published a consolidated map, using all sources available, in 1939, which was accompanied by a detailed handbook. This formed the beginning of modern co-operative mapping and charting work.

The American Richard Evelyn Byrd was already an accomplished polar pilot, having made early flights in the Arctic. He was determined to do the same at the South Pole, and discussed the project with Roald Amundsen, who had plenty of advice to give. Byrd arrived in Antarctica at the Bay of Whales on Christmas Day in 1928 with three aircraft (a Ford Trimotor, a Fokker Universal, and a Fairchild monoplane with folding wings), 95 dogs, and more than 50 men. His base was built on the Ross Ice Shelf 14 kilometers (9 miles) from the edge of the ice, and was named Little America.

Several test flights were made in the ensuing months resulting in numerous discoveries. Other groups undertook geological studies and charting missions. In November 1929 a geological party made the startling discovery that the interior mountains consisted of sandstone with coal deposits, and were therefore part of the Earth's buckled crust rather than volcanic extrusions.

Byrd returned in 1934 with sledges, tracked vehicles, and aircraft to continue his work in Antarctica, making sledge trips and aerial surveys from Little America. This expedition added a great deal to scientific knowledge of the Antarctic, proving for the first time that the two sections of Antarctica were connected. Scientists measured the depth of the continental ice sheet, discovered and mapped vast new land areas, made comprehensive weather studies, found and catalogued new life forms, and much more.

Byrd himself spent the winter alone, 230 kilometers (125 nautical miles) away from Little America in a small hut sunk in the ice, making meteorological observations. He stayed there for four months, but nearly died when the chimney froze and blocked the hut's ventilation. Carbon monoxide fumes from the radio generator and faulty stove affected his judgment and could have proved fatal, but his peculiar radio messages alerted the men at the main base who rescued him.

Byrd returned again in 1939 with the United States Antarctic Service Expedition, the largest Antarctic expedition to date, which accomplished further extensive exploration and important mapping work. He brought with him this time an experimental vehicle called the Snow Cruiser. It was 17 meters (55 feet) long, and the wheels were 3 meters (10 feet) in diameter. It was diesel powered, with living quarters, a laboratory, machine shop, and a darkroom, and had a small aircraft perched on top. Unfortunately, the tires provided too little traction and the motors were too weak to move the vehicle in snow. The farthest it traveled was 5 kilometers (3 miles) from the landing site to Little America.

Another noteworthy event in the history of Antarctic exploration was the first flight across the continent made in 1935 by Lincoln Ellsworth, an American millionaire. He had already flown over the North Pole in 1926 in an airship with Roald Amundsen. This new project, like so many other Antarctic expeditions before it, faced bad weather and numerous setbacks. Ellsworth, a rather shy man who habitually carried for good luck an ammunition belt that belonged to his hero, Wyatt Earp, arrived at the Bay of Whales in January 1934 and set up camp on the ice. He planned to fly from the Ross Sea to the Weddell Sea, and back, a distance of nearly 5,500 kilometers (3,400 miles). Just before he took off, severe ice movements destroyed the camp and nearly destroyed the aircraft, which fell between two ice floes. He was forced to postpone his epic flight.

Returning later the same year, Ellsworth planned to fly the route in the opposite direction. But bad weather conditions and a contrary pilot prevented the flight on this occasion as well. His ship became trapped by ice and he had to remain at Snow Hill Island in the Weddell Sea for several months before getting free.

On 29 November four men, with Byrd navigating, took off from Little America in the Ford Trimotor and flew non-stop to a position near the South Pole, and then returned via a fuel dump. The total time for the round trip was 18 hours 41 minutes, of which the flight time was 15 hours 51 minutes. The same trip had taken Amundsen three months to complete 18 years earlier.



Ellsworth returned to Antarctica for a third time in November 1935 and set up camp at Dundee Island off the tip of the Antarctic Peninsula. On 23 November, he and his new pilot, Herbert Hollick-Kenyon, finally took off on what was to be an eventful flight in a single-engined Northrop monoplane to Little America in the Ross Sea. The total flying time was 14 hours, but they had to make four stops along the way, and on one occasion were trapped in their tent for eight days by a blizzard. They ran out of fuel just short of their goal and were forced to walk the final 26 kilometers (16 miles) to Little America. Nevertheless, their 3,600-kilometer (2,000-mile) journey was a great achievement and showed supreme courage.

PERMANENT STATIONS

The whaling period came rapidly to a halt after German raiders captured or sank most of the Antarctic whaling fleet in 1941 leaving only two land stations operating, both on South Georgia. Thus the potential for military conflict became apparent even in Antarctic regions. Chile in 1940 and Argentina in 1943 made territorial claims which conflicted with earlier ones and with each other. Thus a military and political situation also became dominant in the region. Britain and Australia sent patrol ships and New Zealand established coast-watching parties on peri-Antarctic islands. In 1944 Britain established stations in the South Shetland Islands and on the continent (at Port Lockroy and Hope Bay); from this year Antarctica has been permanently inhabited. Immediately after the war and before 1950 Argentine, Australia, Britain, Chile, France, New Zealand, South Africa, and United States established winter stations on the continent or islands, and most of these became permanent (or at least long-term) stations.

Very soon after the war Operation Highjump, a United States Navy expedition, was active during the 1946-47 summer only but still remains the largest exploratory venture to the continent. An aircraft carrier and a submarine were used and some 65 000 aerial photographs and 3260 meters of ciné film taken, mainly of coastal regions. In total of 13 ships, 23 aircraft and about 4700 men were involved. During the next summer 'Operation Windmill,' largely using helicopters, secured ground control for the new maps covering almost the entire coast.

It was not until 1958 that the first overland transcontinental expedition was made. The Commonwealth Trans-Antarctic Expedition, led by Vivian Fuchs and Sir Edmund Hillary (the

New Zealander of Mount Everest fame), was designed along the same lines as Shackleton's unsuccessful expedition of 1914. Hillary left from Scott Base on Ross Island with four tracked vehicles and four sledges to drive to the Pole, setting up supply and fuel depots along the way.

Meanwhile, Fuchs's group, which was the one to actually make the complete crossing, left the Ronne Ice Shelf in the Weddell Sea with eight vehicles and two dog sledges. They had many problems with crevasses and bad weather, and had to abandon three of the vehicles. The two parties met at the South Pole on 19 January 1958, and proceeded to Scott Base via Hillary's route.

The first International Polar Year was in 1882-83, when 12 nations established 14 bases in Polar Regions to observe and study the Earth's climate and magnetism. It was such a success that it was decided to repeat the exercise every 50 years. The second International Polar Year was held in 1932-33, but scientific techniques were advancing so rapidly that many felt 50-year intervals were too long.

Dr. Lloyd Berkner, a United States scientist, suggested in 1950 that the next collaboration should be an International Geophysical Year (IGY). This idea was enthusiastically received, and some 50 countries offered to take part. Previous polar years had concentrated on the Arctic, but this time the emphasis would be on the Antarctic. Twelve countries (Argentina, Australia, Belgium, Britain, Chile, France, Japan, New Zealand, Norway, South Africa, Soviet Union and United States) agreed to operate stations in the Antarctic.

The period June 1957 - December 1958 was chosen for IGY because solar activity would be at a maximum. Before it began there were 28 stations on the continent and islands and while it was in progress 54 were open and many others were on the islands. The United States established the Amundsen-Scott Base at the Geographic South Pole (as part of Operation Deep Freeze), and the Soviet Union established Vostok base at the South Geomagnetic Pole. Not surprisingly, much of the research that was undertaken became long-term in nature and continues today.

This period was also one when political tension assertions of national sovereignty over Antarctic territories were reinforced. International law was strongly involved and some national politics became passionate; one instance of failure of diplomacy and resort to military force occurred. At the end of this period was the International Geophysical Year (1957- 58), a major event in



Captain Scott in his den, Cape Evans

the development of science throughout the world. It included a cooperative and coordinated concentrated research program which was undertaken by 12 countries some with existing stations in Antarctic regions and others that established observatories for the purpose. In total 54 stations were open for the 1957 winter, which remains the largest number in the Antarctic (19 of them remained continuously open for the next 50 years).

PAX ANTARCTICA: THE TREATY PERIOD AND INTERNATIONAL COOPERATION

This division of Antarctic history began with the Antarctic Treaty. One of the consequences of the International Geophysical Year was a general appreciation of the efficiency of international scientific cooperation in Antarctica in general, and the establishment of the Special (later Scientific) Committee on Antarctic Research in 1958. This, with several other factors, promoted discussions which, in 1959, culminated in negotiation of the Antarctic Treaty by the twelve states then active in the Antarctic (Argentina, Australia, Belgium, Britain, Chile, France, Japan, New Zealand, Norway, South Africa, Soviet Union, and United States). It came into force in 1961 and has subsequently been a major influence on Antarctic affairs.

For most of this period involvement in the Antarctic remained essentially specialized and was the concern only of countries which had experience in the region. From 1983 the United Nations Organization began to consider the Antarctic and many other countries, with less involvement in the region, associated themselves with the debates and a degree of contention developed. The 'Treaty Period' is one when the quotation of Antarctica being the continent for science was essentially true, and when a Pax Antarctica began, which continues to prevail over the Treaty region (somewhat ironically Antarctica has been by far the most militarized continent, as a proportion of population, especially since 1944). The few covert military strategic deployments in Antarctic regions during this period were mainly associated with the 'cold war'.

This period of Antarctic history became more complex as the membership of the Antarctic treaty increased almost four-fold

(to 50 countries in 2012). The pattern of informal cooperation gave way to a vast increase in regulation. Internationally this has manifested itself as instruments associated with the Antarctic Treaty, diverse 'codes of practice', and various other texts, both mandatory and hortatory. Various national laws have been enacted in response to these. The exploitation of Antarctic resources, both mineral and biological, with the consequent protection of the extreme environment was a major subject of concern. This was especially so during the late 1980s; exemplified by the 52 winter stations open in 1989 with redundancy in research and observations (particularly on the South Shetland Islands).

Public interest was close behind as many books, films, and television programs indicated the wonders of the far south to larger audiences. The modern style of tourism had begun in 1966, although several sporadic visits had been made previously. Desire and interest increased however, and received a particular stimulus when, at the time when interest was particularly high, many former Soviet Union vessels, including icebreakers, became available for conversion to Antarctic works (the changes from the dissolution of the Soviet Union similarly caused access to the Arctic to become much less difficult).

Many countries have made territorial claims to Antarctica over the years, based upon discovery, occupation, and geographical contiguity. Today, seven countries still maintain official claims upon parts of Antarctica: Argentina (1943, extended in 1947), Australia (1933), Chile (1940), France (1924), New Zealand (1923), Norway (1931 and 1939), and the United Kingdom (1908). The claims are in accordance with the sector principle established in the Arctic, which delineates wedge-shaped pieces extending to the Pole (though Norway's claim does not reach the South Pole).

The British, Argentine, and Chilean claims overlap, and have been the cause of some disputes over the years. The United States, Russia and several other countries do not make any claims of their own in Antarctica (though they reserve the right to do so in the future), and do not recognize the claims of any other nation.



SECTION 4

THE ANTARCTIC TREATY

Antarctica shall be used for peaceful purposes only... (Article 1)

ORIGIN AND MEMBERS

In 1948 the United States proposed to the seven claimant nations that Antarctica be made an international trust territory, though nothing came of that early initiative. But during the International Geophysical Year of 1957-58 the Soviet Union established a presence in Australian Antarctica, and the United States built stations in New Zealand's territory and Marie Byrd Land. The fact that both these countries intended to stay in Antarctica after the finish of the IGY helped convince the nations involved to continue their cooperation. The IGY was therefore followed by the Year of International Geophysical Cooperation, from January to December 1959.

However, in April 1958 President Eisenhower convened a conference to discuss the future of Antarctica. It was proposed that the continent should be open to all nations for the pursuit of scientific and other peaceful activities. On 1 December 1959 the Antarctic Treaty was signed by the 12 nations which had operated scientific stations in the area during IGY. The treaty was ratified by all twelve countries by on 23 June 1961 when it came into force. It has grown to have 50 adherents by 2012 which represent almost 85% of the world's population.

One of the most important aspects of the Treaty is that the claimant nations have, in effect, frozen or shelved their sovereignty claims indefinitely. They do, however, maintain the underlying existence of these territorial claims by issuing national legislation for such entities as the British Antarctic Territory, the Ross Dependency (New Zealand), and the Provincia de Tierra del Fuego, Antártida e Islas del Atlántico Sur (Argentina). The latter is defined to include the Falklands (Malvinas), South Georgia, and the South Sandwich Islands.

In fact, there are two categories of membership of the Antarctic Treaty. While any country may sign the treaty and thus adhere to its principles (Acceding State), only those that conduct significant scientific research in the region may participate in consultative meetings, and thus take part in the decision-making process (Consultative Party). The Antarctic Treaty System includes the Scientific Committee on Antarctic Research (SCAR) established in 1958; the 1972 Convention for the Conservation of Antarctic Seals (CCAS); the 1980 Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR); and the 1991 Protocol on Environmental Protection to the Antarctic Treaty, commonly known as the Madrid Protocol. The Protocol followed two years of intense negotiations which resulted in the inclusion of a 50-year ban on all mineral exploitation. This is demonstrated by the briefest of all the Articles in the Protocol, comprising just 13 words: 'Any activity relating to mineral resources, other than scientific research, shall be prohibited'. But the Protocol contains a number of other important measures. All human activities must now be planned on the basis of prior environmental impact assessments, and many regulations on waste disposal and marine pollution have been introduced.

The Antarctic Treaty functioned effectively without a secretariat until 2004 when agreement that one should be established was reached and that it will be based in Buenos Aires. Other components of the Antarctic Treaty system are based in Cambridge (Scientific Committee for Antarctic Research) and Hobart (Commission on the Convention for the Conservation of Antarctic Marine Living Resources).

The Antarctic Treaty consists of 14 Articles. The articles may be summarized as:

- 1 | Antarctica shall be used for peaceful purposes only (no military bases, fortifications, manoeuvres, or weapons testing are permitted), but military equipment and personnel may be used to assist in scientific and other peaceful projects.
- 2 | There is to be a freedom of scientific investigation, and any international cooperation which may be needed toward that end.
- 3 | Information regarding Antarctic scientific programs, as well as scientific personnel and the results of scientific work, will be exchanged to permit maximum cooperation, efficiency, and economy of operations.
- 4 | This treaty is not to be interpreted as a renunciation by any signatory nation of previously asserted rights or territorial claims, and no new such claims may be made while the treaty is in force.
- 5 | Nuclear explosions and the disposal of radioactive wastes are prohibited in Antarctica.
- 6 | The provisions of this treaty apply to the area south of 60°S Latitude (except where precluded by the international law of the sea).
- 7 | Any signatory may designate observers to inspect the activities, stations, equipment, vessels, etc., of any other signatory state at any time or place.
- 8 | Designated observers and scientific personnel in exchange programs come under the jurisdiction of their respective governments.
- 9 | Representatives of all signatories shall meet at suitable intervals and places to exchange information, consult upon matters of common interest regarding Antarctica, and make recommendations concerning those matters to their respective governments.
- 10 | Appropriate efforts will be made to ensure no one engages in activities contrary to the principles or purposes of this treaty.
- 11 | It is the responsibility of any signatories involved in a dispute regarding this treaty to consult among themselves peacefully in an attempt to resolve said dispute, and if this is not possible the matter is to be referred to the International Court of Justice for arbitration.
- 12 | This treaty may be modified or amended at any time by unanimous agreement of the signatories.
- 13 | This treaty is subject to ratification by all signatories, and is open for accession by any state which is a member of the United Nations, or any other state only by consent of all signatories.
- 14 | This treaty is written in English, French, Russian, and Spanish, and these equally authentic versions are to be deposited in the Archives of the Government of the United States of America (each signatory is to be given a duly certified copy of the treaty).

THE ANTARCTIC TREATY ADHERENTS

As of end of 2013, the 50 signatories of the Antarctic Treaty are:

- | | | | |
|--------------------|-------------------|----------------------|--------------------|
| 1. Argentina | 14. Denmark | 27. Korea (South) | 40. Slovakia |
| 2. Australia | 15. Ecuador | 28. Malaysia | 41. South Africa |
| 3. Austria | 16. Estonia | 29. Monaco | 42. Spain |
| 4. Belarus | 17. Finland | 30. Netherlands | 43. Sweden |
| 5. Belgium | 18. France | 31. New Zealand | 44. Switzerland |
| 6. Brazil | 19. Germany | 32. Norway | 45. Turkey |
| 7. Bulgaria | 20. Greece | 33. Pakistan | 46. Ukraine |
| 8. Canada | 21. Guatemala | 34. Papua New Guinea | 47. United Kingdom |
| 9. Chile | 22. Hungary | 35. Peru | 48. United States |
| 10. China | 23. India | 36. Poland | 49. Uruguay |
| 11. Colombia | 24. Italy | 37. Portugal | 50. Venezuela |
| 12. Cuba | 25. Japan | 38. Romania | |
| 13. Czech Republic | 26. Korea (North) | 39. Russia | |

SCIENTIFIC STATIONS

In the Antarctic Treaty region there are some 35 winter stations operated by: Argentina, Australia, Brazil, Britain, Chile, China, South Korea, France, Germany, India, Japan, New Zealand, Poland, Russia, South Africa, Ukraine, United States, and Uruguay. Some of these, and several countries, also have stations open only for summer as well as many temporary field camps. Several stations are large and may welcome visitors. Most, however, have a staff of only a couple of dozen persons thus they may find it difficult to welcome groups of visitors. All stations record weather data, most also have geophysical laboratories as well as conducting a wide variety of other research. Most use oil fuel, but increasing amounts of power is being derived from winds and, during summer, solar panels. Many of the islands outside the Antarctic Treaty limit also have research stations. The programmes of all are coordinated through the Scientific Committee for Antarctic Research established in 1958 during the International Geophysical Year. Research is expensive in such remote and hostile regions, thus cooperation and coordination are major economy for all countries involved.

SECTION 5

THE PHYSICAL ENVIRONMENT

The main factors influencing the climate of Antarctica are the waters of the Southern Ocean, the seasonal variations of sea ice, the ice sheet that covers the continent itself, and its high altitude and high (southern) latitude.

ANTARCTICA

There is no single definition of the Antarctic, though the phrase 'The Antarctic' generally means the continent of Antarctica, together with its surrounding ice shelves, islands, and seas. Antarctica refers only to the actual continent. In geopolitical terms, the Antarctic encompasses the whole area south of the 60th parallel, which is the area to which the Antarctic Treaty applies.

From a scientific point of view, the oceanographic and biological boundary formed by the Antarctic Convergence might be the most appropriate outer limit. The Antarctic Circle (at latitude 66°33'S) is not very useful in this respect, since some parts of the continent itself are north of this line.

Antarctica is the fifth largest continent with an area of roughly 14 million square kilometers (5.4 million square miles). Most of this area, however, is made up by a vast permanent ice sheet averaging 2,450 meters (8,000 feet) in thickness. Only about one quarter of a percent of the total landmass is not glacial, visible as mountains and coastal features.

The continent is divided into two parts. The largest, semi-circular part is called Greater Antarctica and much of its edge lies conveniently along the Antarctic Circle in the Atlantic, Indian, and western Pacific Ocean sectors. The curved tail, which is made up of an expanded land mass at its base known as Lesser Antarctica and a long narrow part named the Antarctic Peninsula, extends some 1,200 kilometers (744 miles) towards the southern tip of South America and is located in the eastern

Pacific Ocean sector. Lesser and Greater Antarctica are also termed East and West Antarctica, but this becomes confusing in Ross Sea regions where they occur on the contrary sides.

The Antarctic is the continent of Antarctica and the islands of the Southern Ocean.

Greater Antarctica is mostly covered by ice, but in some coastal areas jagged mountains project through this covering. The Antarctic Peninsula, on the other hand, is a long chain of alpine mountains, topped by an ice plateau and sculpted by many active glaciers. Most of the coast actually consists of ice cliffs, but there are some areas, particularly on the Pacific Ocean side, where one encounters exposed rocky shores.

The Highest Continent

Taking the ice sheet into account, Antarctica is the highest of the world's continents. The highest point is the peak of the Vinson Massif (4,892 meters or 16,050 feet) in the Ellsworth

Mountains along the coast of the Weddell Sea in Lesser Antarctica. There are many mountains over 3,000 meters (10,000 feet), but most are smothered by ice. The ice sheet covering most of Greater Antarctica reaches a height of 4,095 meters (13,780 feet) at Done Argus, while the ice plateau of Lesser Antarctica has an average elevation of less than half that. A Chinese summer station was established there in 2010.

The Transantarctic Mountains the most extensive mountain system in Antarctica stretches for some 4,000 kilometers (2,500 miles) from Coats Land on the Weddell Sea to Victoria Land on the Ross Sea, on the opposite side of the continent. The central section is exposed for nearly 2,000 kilometers (1,240 miles) where it holds back the huge ice sheet. However, many glaciers manage to carve their way through valleys or even over-ride the ranges and eventually merge into the Ross Ice Shelf.

Another enormous mountain range in Greater Antarctica is completely overwhelmed by the ice sheet, the Gamburtsev Subglacial Mountains. There are other huge ranges along the coastal areas which appear as isolated peaks and rock cliffs in the ice only. These are called nunataks, a word of Inuit origin.

Between these vast mountain ranges are extensive low-lying plains and basins, which are covered by some of the thickest ice on the continent. The South Pole itself is located 2,835 meters (9,240 feet) above sea level on top of a layer of ice of almost the same thickness. The underlying bedrock is just above sea level. In some areas of Greater Antarctica the bedrock has been depressed well below sea level by the weight of the overriding ice, which can be more than 4,000 meters (13,100 feet) thick. The maximum measured depth of the ice is 4776 m (15,670 ft).

It appears that much of the Antarctic bedrock has been depressed by many hundred meters due to the sheer weight of ice lying above it. According to some studies, if the ice covering were to be removed completely, Greater Antarctica would rise by approximately 1,000 meters and Lesser Antarctica by 500 meters. At the same time, the water produced by melting ice would raise the level of the Earth's oceans by about 60 meters (200 feet), flooding huge areas of the world.

THE SOUTHERN OCEAN

The Southern Ocean consists of a broad band of generally turbulent water surrounding the continent of Antarctica. The northern limit of this ocean is generally south of 40°S latitude. Westerly winds and the associated West Wind Drift, or Antarctic Circumpolar Current, are outstanding features of the Southern Ocean. They cause massive amounts of water to move constantly from west to east all around Antarctica. This involves water from the surface down to about 3,000 meters (9,900 feet) stretching over a distance of some 24,000 kilometers (14,200 miles).

It has been estimated that on average some 130 million cubic meters of water per second are continuously on the move with this current, four times that of the Gulf Stream, and 400 times that of the Mississippi.

Farther south, however, easterly winds cause a westward-flowing current close to the continent: the East Wind Drift. Along much of the coast, particularly East Antarctica, this is a relatively narrow band, but where it is deflected by deep embayments, such as the Weddell, Bellingshausen, and Ross Seas, it circulates in the form of clockwise gyres.

A ship sailing south to Antarctica will encounter a sharp drop in temperature between 49 and 55°S latitude. At that point one can usually detect subtle changes in both the ocean and the atmosphere. If the weather is calm there may be a sudden fog bank, a line of turbulence, concentrations of feeding seabirds or combinations of those. This delineates the Antarctic Convergence, a zone that surrounds the continent. During the southern summer, the sea temperature may change by 7°C to 3°C (45°F to 37°F) as the convergence is crossed. During winter months the difference in sea temperatures may be as great as 10°C (18°F).

The Antarctic Convergence zone is an important and distinctive biological phenomenon.

Antarctic Convergence

The Antarctic Convergence is a natural boundary between the relatively warm subantarctic surface water and the cold antarctic surface water. Here cold, dense water dives beneath the warmer waters to the north. It is determined by a drop in the sea surface temperature.

The location of the convergence is not a precise line, but varies slightly throughout the year or from year to year, or even century to century. The zone of convergence is an important and distinctive biological phenomenon influencing the distribution of plankton, and the organisms which feed on it (fish, birds, whales and seals). The species found are quite different as one travels across it.

The water south of the convergence is often referred to as the Southern Ocean although not all authorities agree on its limits. This covers an area of about 20 million square kilometers (52 million square miles) or 10 percent of the world's oceans. It contains the coldest and densest ocean on Earth and is notable for its high biological productivity. It plays a major role in influencing oceanic circulation in the southern hemisphere, and indeed in governing the climate of the planet. Antarctic waters run deep. Much of the water around Antarctica is more than 3,000 meters (9,900 feet) deep. The deepest trough in the Atlantic sector, located east of the Scotia Arc, is 8,328 m (27,322 feet) at the Meteor Deep.

Three Water Layers

The Southern Ocean itself is especially interesting because it is composed of three distinct layers of water masses which differ in their temperatures, salinities, and directions of flow. The three distinct layers are driven by westerly winds in constant, eastward-flowing spirals around Antarctica. The upper and lower layers also move gradually northward, carrying cold waters from the Antarctic to the tropics, while the middle layer flows southward (replacing the water lost to the other two currents) and brings nutrients and warmer water from temperate and tropical regions.

Antarctic Surface Water

The top layer, or Antarctic Surface Water, is the water which most directly affects Antarctic plants and animals. It originates at the Antarctic Divergence, which is a narrow zone in the most southerly waters near the continent where subsurface water rises between divergent bands of surface waters.

This layer is constantly chilled by ice and cold air from the continent. In winter it remains below -1°C (30°F), but for a short time in the summer it may warm up to about 3°C (37°F) near its northern boundary at the convergence. The Antarctic Surface Water is characterized by low temperature and low salinity caused by summer melting of sea ice and icebergs.

As the Antarctic Surface Water reaches the Antarctic Convergence it comes into contact with the warmer and saltier Subantarctic Surface Water. There is very little mixing between these two bodies of water. At the point of contact the more dense Antarctic water sinks below the Subantarctic water and continues flowing northward where it becomes known as the Antarctic Intermediate Current. This current cools the coasts of New Zealand, southern Australia, and many oceanic islands. It can still be detected north of the equator in the Atlantic Ocean.

Warm Deep Water

The middle water layer, or Warm Deep Current, is a southward flowing water mass originating from the surface waters of the Atlantic, Pacific, and possibly Indian Oceans. This current wells up at the Antarctic Divergence and is characterized by a high salinity and relatively high temperature. When this water layer reaches the surface it becomes cooler. Some of it becomes less saline and begins to flow northwards as the Antarctic Surface Water.

The Antarctic Bottom Water

The remainder of the Warm Deep Current water drifts toward the continent where it becomes much colder. It then sinks down along the continental slope and flows away from Antarctica along the ocean floor in a northward direction as the lower layer, or Antarctic Bottom Water. This water has a low temperature (-0.5°C or 31°F) and high salinity, and spreads very far into the Atlantic and Pacific Oceans carrying south polar water into the northern hemisphere.

The Drake Passage

The infamous Drake Passage (or *Mar de Hoces* in Spanish) stretches 1,000km (600miles) between Cape Horn and the South Shetland islands. The strait was named for Sir Francis Drake,

who was blown south from the Strait of Magellan in 1578. Over 50 years earlier, Spaniard Francisco de Hoces, was also blown south, claimed he saw land's end, inferring the passage in 1525.

Before the opening of the Panama Canal in 1914, the Drake Passage played an important part in international trade. The stormy seas and icy conditions made the rounding of Cape Horn through the Drake Passage a rigorous test for ships and crews alike, especially for the sailing vessels of the day. At the time, a sailor who had "rounded the Horn" wore a gold loop earring in their left ear, and was entitled to eat with one foot up on the table!

The Antarctic Circumpolar Current flows from west to east through the passage, with an estimated rate of flow between 3,400 and 5,300 million cubic feet (95 and 150 million cubic metres) per second - about the same as 5,000 Amazon rivers. To reach the Antarctic Peninsula it is necessary to traverse this stretch of water at right angles to the current flow. This, coupled with the propensity for high winds in the region, can lead to rough seas, and conditions often referred to as the "Drake Shake." While the seas can be quite lively, our vessels are designed for this type of weather. Conversely, the "Drake Lake" is encountered when the passage is calm.

Many people consider the Drake Passage a rite of passage on their voyage to Antarctica. On our vessels the crossing takes approximately 48 hours with favourable conditions. Due to the great unpredictability of the weather patterns of the Drake Passage, it is really just up to chance which Drake you will experience.

THE ISLANDS OF THE SOUTHERN OCEAN

Distinct from the continent are the 19 islands around Antarctica, several of which are mentioned in the introduction. They are claimed by Australia, Britain, France, New Zealand, Norway, and South Africa although Argentina and Chile make counter-claims over a few of them. Five of these islands are in the region covered by the Antarctic Treaty. They are all comparatively small islands and some, such as Peter I Øy, may be surrounded in pack ice and are rare places to visit. About half of them have ice caps and form somewhat of a transition between Antarctica and the other southern continents. In summer these small specks in the Southern Ocean and adjacent southerly extremes of the other oceans may be teeming with wildlife as their beaches and ice-free areas provide breeding sites for seals and birds. Many of the islands have scientific stations and meteorological observatories. A few have a history of attempts at colonization - but all were unsuccessful.

GEOLOGY

Antarctica's geology has not been studied in nearly such great detail as other parts of the world, for the very good reason that so little of its surface is free from permanent ice. Only in the last few decades have seismic and radio-echo sounding techniques, as well as occasional bore holes, enabled scientists to obtain an idea of what lies beneath the ice.

Greater Antarctica

Greater Antarctica is basically a giant shield of metamorphic rocks dating from Precambrian and early Paleozoic times, as much as 3,800 million years ago. This basement rock contains more recent intrusions, and is overlain by sedimentary rocks in many areas. Basement rocks are exposed in Queen Maud Land and the coastal mountains in the Indian Ocean sector. The younger sedimentary rocks, or Beacon Series, were formed from marine muds, estuarine and fresh water deposits, shales, coal measures, and desert sandstones dating from 400 to 200 million years ago.

The Beacon Series is about 2,500 meters (8,250 feet) thick, and is best seen in the Transantarctic Mountains which were uplifted within the last 35 million years. One can see within this sandstone numerous layers of dark dolerite which were injected long after the sandstone was formed. The fossils of freshwater fish, reptiles, and certain kinds of vegetation confirm that this area was once located in a temperate region.

Lesser Antarctica

Lesser Antarctica and the Antarctic Peninsula are much younger, dating from only about 200 million years ago. Together they consist primarily of two separate mountain ranges made up of metamorphosed sedimentary rocks which were formed in deep sea and contain beds of volcanic ash and lava intrusions. The alpine mountain range forms the Antarctic Peninsula and extends from the peninsular tip to Lesser Antarctica, but disappears under the ice of Ellsworth Land and Marie Byrd Land where it becomes much more widespread. Many of the mountains in this range extend above the ice and form the isolated peaks and outcrops which are seen today in Lesser Antarctica.

Many of these mountains are small, detached crustal plates that were probably once parts of the larger super-continent called Gondwana. A second line of mountains runs along the north-western coast of the peninsula which forms Adelaide Island, the Biscoe Islands, the Palmer Archipelago, and the South Shetland Islands.

A chain of islands and the connected sea floor ridges link the South Shetland Islands with the South Orkney Islands, the South Sandwich Islands, South Georgia, and the South American continental shelf. This area is referred to as the Scotia Arc, which has a long history of volcanic activity and earth movements. Here the Earth's crust is broken into a complex series of tectonic plates.

The mountains of Lesser Antarctica display a tremendous amount of deposition, folding, uplifts, and erosion starting in Precambrian times. During the late Cretaceous or early Tertiary (70 to 60 million years ago) violent upheavals and volcanic activity lifted both the archipelago and the islands of the Scotia Arc. This pronounced volcanic activity continued until about 35 to 40 million years ago.

Several islands in the South Shetlands (e.g. Deception Island) and the South Sandwich group (Zavodovski) are volcanically active even today, and much of Lesser Antarctica still commonly experiences earthquakes. Greater Antarctica is more stable, but it has three very confined areas of volcanic activity (Mount

Erebus on Ross Island, Mount Siple near Thurston Island and Mount Melbourne in Victoria Land).

Fossils found in the Antarctic Peninsula, southern South America, Tasmania and other areas provide evidence of continental drift, and reveal how all these regions may have been joined together in the past to form the super-continent known as Gondwana. Amongst fossil finds are an extinct marsupial called Polydops (also known from Patagonia), extinct penguin species, tree ferns, and cycads like palm trees. Fossilized pollen grains have been found from trees similar to the southern beech (which is found today in Tierra del Fuego and Tasmania), and the monkey-puzzle tree (a native of Chile).

Four Different Poles may be defined in each polar region, although when the South Pole is mentioned without qualification it is the geographic pole that is referred to.

SOUTH GEOGRAPHIC POLE 90°S

A fixed location on the surface of the Antarctic ice sheet (elevation 2835 m, and 1270 km from the nearest coast) which is the southern extremity of the axis of rotation of the Earth. First attained on 14 December 1911 by Roald Amundsen's expedition from Norway. Occupied by 'Amundsen-Scott', a United States scientific station, from 1956.

SOUTH MAGNETIC POLE 64.43°S, 137.32°E (IN JANUARY 2010)

A wandering location on the Earth's surface where conventional lines of magnetic force enter. The direction of the magnetic field is vertical its strength is very variable. The south-seeking end of a compass needle, or any other magnet, is attracted towards this pole. First attained during Ernest Shackleton's British Antarctic Expedition on 16 January 1909 when it was at 72°25'S, 155°16'E, well inland beyond the Transantarctic Mountains. Subsequently it has migrated northward, currently it is in the Southern Ocean, off Terre Adélie, and is moving about 4 km a-1 on a course of 310°. During events such as magnetic storms its diurnal motion may exceed 30 km.

SOUTH GEOMAGNETIC POLE 80.08°S, 107.78°E (2010)

The south end of the axis of the geomagnetic field, which surrounds the Earth and extends into space as the magnetosphere. The Aurora Australis concentrates in the stratosphere approximately 23° around this pole. First attained by a Soviet Antarctic expedition, led by Vyacheslav Averyanov, on 16 January 1957 when 'Vostok', a scientific station, was established on the icesheet (3488 m elevation).

SOUTHERN POLE OF INACCESSIBILITY 85.8°S, 65.8°E

The location on the surface of the Antarctic ice-sheet (3800 m elevation) which is most distant from the ocean; the most difficult location to attain, about 1300 km from any coast. First attained on 13 December 1958 by a Soviet Antarctic Expedition, led by Yevgeniy Tolstikov, which established a temporary scientific station in the vicinity which was occupied during the 1958-59 austral summer.



A vast tabular iceberg showing annual layers of accumulated snow

CLIMATE

Knowledge of Antarctica's climate is relatively recent, and detailed, long-term studies did not really start until the establishment of the first long-term scientific research stations, and especially the activities surrounding the International Geophysical Year of 1957-58. Nowadays, meteorological and related research is an important part of the work sometimes the main work of almost every station in the region and data are accumulating rapidly.

The main factors influencing the climate of Antarctica are the waters of the Southern Ocean, the seasonal variations of sea ice, the ice sheet that covers the continent itself, and its high altitude and high (southern) latitude. There are considerable climatological differences between the sea, the coast, and the interior. For instance, the Southern Ocean has most clouds, followed by Lesser Antarctica, while Greater Antarctica, with its high, arid plateau, has the least cloud cover. The key points to bear in mind are that Antarctica is extremely cold, dry, and windy, with little precipitation.

The Coldest Continent

First, Antarctica is the coldest continent. Mean temperatures in the interior during the coldest month (August) range from -40 to -70°C (-40 to -94°F) and in the warmest month (February) range from -15 to -45°C (5 to -49°F). The lowest outdoor temperature ever recorded on Earth is -89.2°C (-129.3°F), which occurred 1983 at the Russian Vostok station on the ice sheet. At sea level, Antarctic temperatures are some 10 to 17°C (50 to 63°F) colder than the Arctic.

Nevertheless, there are considerable variations. At the sub-Antarctic islands, for example, temperatures may range from about -40°C in midwinter (August) to 14°C in January or February (-40 to 57°F).

The Windiest Continent

Antarctica is also the windiest of the continents. Apart from global wind currents, Antarctica actually develops its own wind systems. Cold dense air essentially slides from the high interior ice sheet towards the lower areas along the coasts. At the edges of the ice plateau the winds accelerate, thereby lifting and

blowing clouds of snow high into the air. The strongest winds are habitually found on the long coastal slopes of Greater Antarctica.

Some coastal areas endure almost constant strong winds, whereas other areas may be quite calm much of the time and then suddenly experience hurricane force winds as air rushes down through glacial valleys. These winds are called katabatic, or down slope, winds.

The famous Australian explorer Douglas Mawson established a base at Cape Denison, Commonwealth Bay, in 1912 and recorded wind speeds for two years. This is reputed to be the windiest place on Earth, because the average wind speed during that period was 72 kph (45 mph), and gusts of more than 240 kph (150 mph) were common. Nevertheless, wind speeds have been observed to drop very significantly just a few miles away from the coast.

Visitors to Antarctica should be aware that katabatic winds can occur quite suddenly, and with little warning, but then may die down again just as quickly. They cause dramatically low effective temperatures, due to the wind-chill factor.

In the Southern Ocean, strong gale-force winds are quite common, especially in the region between 40 - 60S . These cyclonic storms are caused by extremely cold air coming from Antarctica meeting the relatively warm and moist air over more northerly seas. This accounts for the fearsome reputation of the Drake Passage. The storms tend to circle Antarctica from west to east.

The Driest Continent

Surprisingly, Antarctica is the driest continent. By definition, most of the continent is a desert. There is very little precipitation each year in the interior, and the vast amount of ice and snow which make up the polar ice sheet has accumulated over millions of years. The mean annual accumulation for the entire continent amounts to 15 centimeters (6 inches) of water equivalent, which is just slightly more than that of the Sahara Desert. None of this is liquid. Any water in this state results from melting of snow and ice in contact with dark rocks morainic material on glaciers heated by the long periods of sunshine during the Antarctic summer.

Some coastal areas, particularly the west side of the Antarctic Peninsula, receive much more precipitation. The tip of the peninsula receives about 90 centimeters (35 inches) of water equivalent each year. Here and in the South Shetland Islands it may rain, sometimes quite heavily – a typical maritime climate. The frigid air ensures that thunder storms are very rare, virtually all are confined to islands such as South Georgia

Despite what has been said in this section, visitors to the Antarctic Peninsula region need not expect to experience very bad weather as a matter of course. Crossings of the Southern Ocean may be quite easy, and severe storms are infrequent in the summer months. The narrow waterways of the Antarctic Peninsula are quite protected. Likewise, sunny days are rather common in Greater Antarctica and the sun even shines among the subantarctic islands and Antarctic Peninsula. Although visitors should be prepared for cold weather at any time, it is surprising how often it can seem almost too warm to wear a parka especially during windless periods. The average summer temperature is near freezing.

Atmospheric Phenomena

There are some interesting atmospheric phenomena which should be mentioned. Halos are caused by refraction and reflection of light from the sun or the moon on water droplets or ice crystals suspended in the air. They result in the appearance of three 'suns' or three 'moons' in a parallel line above the horizon. These spectacular occurrences are best seen when the sun or the moon is between 15-20° above the horizon. Mirages, caused by the refraction of light on layers of hot and cold air are also common. Perhaps the most remarkable atmospheric sight is the incredibly beautiful aurora australis, or southern lights. This electromagnetic phenomenon is the southern hemisphere equivalent of the aurora borealis or northern lights. It is, however, not often easy to see and a dark night is essential to appreciate it. It is most intense at the time of Sun-spot maxima.

THE ANTARCTIC CIRCLE

It is interesting to understand the significance of the Antarctic Circle and its relation to the hours of daylight. As you travel farther south in the austral summer months, the days get progressively longer. The Antarctic Circle is located at about 66°33'S (its position varies very slightly from year to year, as the Earth wobbles about its axis). The circle marks the northernmost point at which the sun is visible for 24 hours a day at the summer solstice, on or near December 21, when it is at its highest position above the horizon. Before that date, the Sun is still climbing toward its zenith, and afterwards it is descending, so if you reach this region before or after December 21, you would need to sail farther south of the Antarctic Circle to experience a 24-hour day. (An exactly the same, but opposite, process occurs in the northern hemisphere, of course, so that the relevant date to the Arctic Circle is on or near June 21).

ICEBERGS, GLACIERS AND SEA ICE

Sea water freezes at about -1.8°C (28.8°F), depending upon its salinity; the greater the salt concentration, the lower the

temperature at which it freezes. It is interesting to note, however, that ice which forms slowly on the sea surface under calm conditions is generally not salty. Salt molecules in solution tend to concentrate in the remaining liquid as the ice crystals form.

The sea surface around Antarctica freezes each winter, forming a layer of ice 1-3 meters (3-10 feet) thick and extending 100-200 kilometers (60 -120 miles) offshore. Ice crystals start to appear as the surface water cools and approaches the freezing temperature. In calm conditions, the crystals join together, thicken, and form a fibrous structure called young ice or frazil.

Very often a slight swell occurs which causes the young ice to break apart into small sections which then continue to bump and grind against one another. This action forms roughly circular bits of thin ice with raised edges called pancake ice.

As time progresses and air temperatures remain low, more crystals form and the pancakes eventually freeze together to form a solid layer several centimeters thick. Continued cold temperature causes this layer to become attached to the shore if it is close to land, and it is termed fast ice. Fast ice and pack ice generally last throughout the winter. Ocean currents, storms, and tidal movements tend to buckle and crack the fast ice; this process produces open water areas and gives access and breathing places for penguins, seals, whales, etc.

Pack Ice

Fast ice breaks apart and forms ice floes during normal summers, and these floes are moved around by currents until they accumulate and cover large areas as pack ice. Polynias, or open water areas, form offshore when winds and/or currents disperse the pack ice. Near the continent, the pack ice drifts in a westerly direction, but further away the drift is in an easterly direction.

Pack ice areas are difficult to predict, but concentrations generally occur in the Weddell Sea, Ross Sea, and off the Pacific Ocean sector of Lesser Antarctica. The northern limit for the pack ice varies, but in winter and early spring it may extend about 800 kilometers (500 miles) from the coast in some areas. At this time of year it encloses an area of approximately 19 million square kilometers (7.3 million square miles); however, by March, at the end of the summer, the action of waves, currents, and melting has shrunk it again to a mere 4 million square kilometers (2.5 million square miles).

This enormous seasonal process effectively doubles the area of the Antarctic ice blanket during the southern winter from 18 to 34 million square kilometers (7 to 13 million square miles). It has a major effect on world climate by increasing the amount of reflection of incoming radiant energy from the Sun, and reducing its penetration into the sea.

The rate of accumulation of sea ice in autumn and winter (February - September) is much slower than the rate of decay (October - January). It seems possible, noted British biologist Richard Laws, that the layers of pigmented algae found in sea ice may, by absorbing solar radiation in summer, accelerate its disappearance. If so, it is a remarkable example of the influence of a microscopic life form on the world's climate.

In some areas a cold spring season may allow fast ice to remain in place for more than one year. It is then called bay ice. Bay ice which persists for several years may become fused to an ice shelf. Ice shelves are floating ice sheets nourished by the accumulation of snow and often by the seaward extension of land glaciers. Small ice shelves are from 50 m - 300 m thick, whereas the vast Ross Ice Shelf is up to 1,000 m thick near its southern boundary. The seaward face of an ice shelf is termed the ice front.

Tabular Icebergs

Icebergs calve from ice fronts and are generally flat-topped (tabular) and can be very large indeed. They may drift far from their birthplace and last for up to ten years before melting or breaking up. The largest iceberg ever accurately measured calved from the Ross Ice Shelf in March 2000. It was initially 286 km (178 miles) long and up to 40 km (25 miles) wide, with an area of 10,800 square kilometers (4,170 square miles). Although it broke into smaller but still very large pieces within a few months, these drifted westwards and some were still in the Ross Sea six years later becoming substantial hazards to navigation.

Most of these gigantic icebergs come from massive ice shelves like the Ross Ice Shelf, which is larger than Spain, or the Filchner-Ronne Ice Shelf, which releases ice into the Weddell Sea. Some of the Weddell Sea 'bergs carried by the East Wind Drift, and later by the West Wind Drift eventually move away in the general direction of South Georgia. Others, on the western side of the Weddell Sea, are pushed north-westward through the Antarctic Sound (above the northern end of the Antarctic Peninsula). Antarctic Sound has been nicknamed "Iceberg Alley" for this reason.

Smaller Icebergs

Not all Antarctic icebergs ("berg" means mountain in Scandinavian and Germanic languages) are of such huge proportions. Some are much smaller, for icebergs are simply pieces of ice, large or small, which have broken (calved) off the ice sheet, ice shelves, or glaciers, and float in the sea. By definition, however, an iceberg is supposed to measure more than 100 square meters (1,100 square feet) in area, and stand more than five meters (16 feet) above the surface. Lesser bergs are known as "bergy bits."

Most icebergs have between one-seventh and one quarter of their volume above water, depending on the depth of snow on them.

Indications of an iceberg's history can be gleaned by observing its color (which depends on age, density, and air content of the ice). Sometimes horizontal or oblique frozen water-lines at different levels show where the iceberg has melted, and then tilted as it adjusts its center of gravity.

Animals and Ice

Most animals of Antarctica are adapted to living with sea ice. Crabeater seals and Ross seals live on or about the pack ice, and although leopard seals and Weddell seals often spend time ashore, they are also dependent upon ice during much of the

year. Emperor penguins breed on fast ice in the winter, and form colonies as soon as the ice is strong enough (in April). The other penguins all breed on land, during the summer, but they live on the edge of the pack ice for the rest of the year. It greatly extends their feeding ranges.

Many other seabirds use the ice for roosting, as well as a base for hunting. On the other hand, the presence of ice discourages plants and animals from settling in shallow coastal waters and intertidal zones. Algae, seaweeds, marine worms, sponges, sea stars, brittle stars, sea urchins, etc., flourish lower down on the continental shelf where ice does not scour the sea bed.

Sea ice prevents the ocean waters from warming the coasts significantly. It is important to note that islands within the limits of winter pack ice (such as the South Shetlands and South Orkneys) compare closely with the continent in seasonal temperatures, soil types, flora, and fauna. Islands located outside the range of the pack ice (such as South Georgia and Macquarie) have permanent open waters, milder winters, longer growing periods, and much more diversified and advanced flora, and to a great extent, a different fauna.

The Antarctic Ice Sheet

Throughout most of the Earth's history, not only have the differences between polar, temperate, and tropical climatic zones been much less distinct than they are today, but also the Polar Regions were free from permanent ice. But the poles have always received their quota of the sun's radiant energy at a low angle, and therefore have always been cooler than the equatorial region. Why, then, are things so different today?

The polar ice sheets developed after a long period when the Earth was gradually getting cooler. This cooling began some 150 million years ago and continued until about three million years ago. Scientists have determined that the mean surface temperature of the planet dropped from about 20°C to about 10°C (68°F to 50°F) during this period. The drop was probably caused by changes in the distribution of land masses and open water in the Polar Regions themselves.

The composition of the Polar Regions has changed considerably in the last 200 million years because the continents have shifted their relative positions through plate tectonics. Scientists calculate that the Polar Regions did not become frigid enough for permanent ice formation until continental land masses or land-locked seas disrupted the movements of polar ocean currents. While the poles were located in open water, major ocean currents moved relatively warm waters from low latitudes into higher latitudes, which would have dispersed seasonal sea ice before it had a chance to become permanent.

Today, the North Pole is located in the Arctic Ocean which is surrounded by the North American and Eurasian continents, and ice is present year round because there is very little mixing with warm water currents and it cannot drift away. The South Pole, however, is situated on the Antarctic continent, which not only prevents warm waters from reaching it, but the high elevation of the continent is even more conducive to the formation of

permanent ice. The process is self-perpetuating because the shiny white surfaces of snow fields and sea ice reflect solar radiation and prevent normal seasonal warming trends. In fact, except for a brief period during the height of summer, the center of the Antarctic continent radiates more heat than it receives from the sun.

Antarctic Glaciers

We know from geological evidence that cold temperate climates persisted in the South Polar Region as recently as five to six million years ago, but by four million years ago the first Antarctic glaciers reached the coast and started to produce icebergs. These spread around the continent, and marked the beginning of the current Antarctic ice age.

The effects of the formation of the Antarctic ice sheet were felt throughout the world, but it is interesting to note that the ice age in the northern hemisphere began somewhat later - between two and three million years ago - when permanent ice appeared in central Europe and Asia, and also covered the mountains of North America, Greenland, and Iceland. The ice caps have fluctuated considerably in the northern hemisphere during the last million years, but the Antarctic ice sheet has remained relatively stable.

Minor changes in the Antarctic ice sheet have occurred however, as shown by glacial moraines and ice-caused scratches on mountain peaks which are now high above the surface of the ice. Much of the continent is surrounded by a ridge of moraine some 100 -300 kilometers (60 -185 miles) offshore and in waters as much as 500 meters (1,650 feet) deep, which indicates a former edge of the ice mantle.

Still in an Ice Age

The massive bulk of the ice sheet probably would have protected it from changes caused by minor climatic fluctuations, but changes in world sea levels generated by glaciations in the northern hemisphere would have caused the coast of Antarctica to expand and contract considerably, allowing its ice mantle to change size as a result. The northern ice sheets began retreating about 20,000 years ago, and have since uncovered vast areas of land which now consist of tundra and taiga. Antarctica, on the other hand, is still deep in its ice age.

The Antarctic ice sheet contains about 90 percent of the world's ice, representing about 70 percent of all the fresh water on Earth. Its volume is about 30 million cubic kilometers (7,200 cubic miles) and each year it receives some 2,000 cubic kilometers (480 cubic miles) of new snow and ice. However, it loses about the same amount through the calving of icebergs, melting or sublimation, and snow that is blown out to sea. The only other ice sheet is in Greenland and has 9% of the ice on Earth. This leaves only 1% which accounts for all the sea ice Arctic and Antarctic which, despite its vast area, is comparatively very thin.

THE OZONE HOLE

Atmospheric studies have shown there are regional shifts in wind patterns above both poles that tend to isolate the air there from the rest of the Earth's atmosphere during the winter months.

The isolation is most complete when the air temperatures are at their coldest. At the North Pole the phenomenon lasts about two months, but above the South Pole (which is more isolated and considerably colder during its winter) it lasts five months.

In 1985 the British Antarctic Survey published the results of a continuing study of Antarctic atmospheric conditions begun in 1957. Each year since records have been kept there has been a dramatic depletion of ozone (a form of the oxygen molecule which is rare in the lower atmosphere) above Antarctica in the period September to November. The Cambridge-based organization reported that the thinning of the ozone layer above Antarctica had increased greatly since about 1976. At its maximum, the annual ozone hole above Antarctica now covers an area greater in size than the United States of America.

Ozone is found in small amounts in the stratosphere. It is, however, very important to life because ozone shields the Earth from adverse amounts of ultraviolet (UV) radiation. This radiation can be divided into UV-A radiation and UV-B radiation, based upon their respective wavelengths (with UV-B composed of shorter wavelengths). UV-B is the more harmful with regard to life. In mammals it causes sunburn and skin cancer, and has been linked to cataract formation. It is also harmful to plants, ranging from bacteria to food crops.

Recent studies carried out at the United States Palmer Station on Anvers Island, in Antarctica, suggest that increased UV-B radiation reduces the photosynthetic productivity of phytoplankton. Smaller species (diatoms) within the phytoplankton may be greatly reduced. Any such change affecting the base of the simple Antarctic food chain could have far-reaching effects upon the entire ecosystem. Similar studies have shown increased UV-B radiation kills at least some species of copepods (tiny planktonic crustaceans), but it is not yet known what long-term effect it may have upon krill.

Although a variety of gases are involved, chlorine is the major cause of the breakdown of ozone. Most of this chlorine reaches the upper atmosphere from the release of man-made halocarbons (also called chlorofluorocarbon or CFC) chemicals used as coolants in refrigerators and air conditioners, as solvents, as plastic foam dispersants, and as propellants in some aerosol sprays.

While studies in the Antarctic provided the first definite warning of what was happening, it has since been found that the ozone layer suffers periodic thinning over the Arctic, and to a lesser extent elsewhere. Much international effort has gone into reducing the global production and use of halocarbons and related chemicals.

CLIMATE CHANGE

Most of the radiant energy from the sun which reaches the Earth is reflected or radiated back into space. Certain gases in the lower atmosphere, such as water vapor, carbon dioxide, and methane, trap some of the heat before it escapes completely. The effect of these gases is similar to that of glass windows in a greenhouse, and is in fact often referred to as the Greenhouse



A spectacular eroded iceberg

Effect. This trapped heat is necessary to keep the Earth's climate warm enough for life to exist. But there must be a balance to ensure the Earth neither cools nor warms too much.

The greenhouse gases have been steadily increasing for the past 200 years, since the beginning of the Industrial Revolution. Carbon dioxide, the most abundant trace gas in the Earth's atmosphere, has increased more than 25 percent in this period. It is produced through the burning of wood and fossil fuels, such as coal and petroleum products. It is also released naturally by volcanoes, oceans, and decaying plants. There is no doubt that the massive clearing and burning of tropical rainforests occurring today, with burning of fossil carbon, is releasing an increasingly significant amount of carbon dioxide into the atmosphere.

Methane, the second most abundant greenhouse gas, is produced as a by-product of the decomposition of organic material. The most common known sources are swamps, rice paddies, livestock (especially cud-chewing animals), termites, and the emission of natural gas. The concentration of methane is growing at about one percent per year.

The atmospheric concentration of other greenhouse gasses very small by comparison, but some of these compounds are thousands of times more potent in absorbing heat. It has been estimated that the present concentration of greenhouse gases may double sometime in the 21st century, and could raise the average temperature of the earth by several degrees.

The interaction of climatic forces is not completely understood, so it is not yet possible to determine the overall effect of the increasing release of greenhouse gases. The average temperature of the Earth has increased by 0.5°C (1°F) during the past 100 years, and some of the warmest years ever recorded were in the 2010s. These figures do not tell the whole story, however, because there have been many warming trends followed by cooling trends in the past.

Polar scientists are at the forefront of this research. It has been suggested that the vast increases in populations of chinstrap penguins and fur seals in the past couple of decades may be due in part to the possibility that there is now less sea ice (or rather, more open water). Both of these species may act as indicator species regarding global warming because they spend the winters primarily in the water, not on the ice.

In addition, British Antarctic Survey scientists have noted a significant growth in plants. The number of flowering Antarctic hairgrass plants around the Ukraine station Vernadsky in the peninsula region has increased by 25 times in the last 30 years, while the Antarctic pearlwort has increased six-fold in abundance at Signy station in the South Orkneys.

A GLOSSARY OF ICE TERMS

Anchor ice: Submerged ice that is attached to the sea bed.

Bay ice: Fast ice that remains in place for more than one year.

Bergy-bit: A piece of floating ice, generally less than 5 meters above sea level, and not more than about 10 meters across. It is generally of glacier ice, but may be a massive piece of sea ice.

Bergschrund: A crevasse at the edge of a glacier that separates the ice from the rock behind it.

Brash ice: Accumulations of floating ice made up of fragments not more than 2 meters across.

Calve: When a block of ice breaks away from a glacier, an ice front, or an iceberg.

Cirque: The hollowed or rounded recess occupied, or more usually once occupied, by a glacier on a mountain side.

Crack: A fracture in floating sea ice, narrow enough to jump across.

Crevasse: Fissure formed in a glacier, sometimes deceptively covered by a snow bridge.

Fast Ice: Sea ice attached to land.

Floe: A piece of floating sea ice other than fast ice or glacier ice.

Frazil: Fine spicules or plates of ice in suspension in water.

Glacier: A mass of snow and ice continuously moving from higher to lower ground or, if afloat, continuously spreading. The principal forms are: ice sheets, ice shelves, ice streams, ice caps, ice piedmonts, and valley glaciers.

Growler: A piece of ice awash, smaller than a bergy-bit. Growlers can be dangerous, because they are difficult to detect on ships' radar.

Hanging valley: Side valley isolated by a large glacier moving along a newly formed valley at its base.

Ice blink: Silvery-white glare caused by the reflection of distant pack ice on the clouds.

Ice Shelf: A floating ice sheet of considerable thickness attached to a coast. Ice shelves are usually of great horizontal extent and have a level or gently undulating surface. They are nourished by the accumulation of snow and often by the seaward extension of land glaciers.

Lead: Navigable passage between ice floes.

Moraine: Ridge or deposit of rocky debris carried along by a glacier; a terminal moraine marks the farthest advance of a glacier, which is then left behind when the glacier melts and retreats.

Nunatak: A rocky spur or mountain peak projecting from and surrounded by a glacier or ice sheet.

Pack ice: Any area of sea ice other than fast ice.

Polynia: Russian word meaning a patch of open water in sea ice.

Pressure ridge: Ridge formed on sea ice by pressure of one ice floe on another by tidal or current movements.

Sea ice: Any form of ice found at sea which has originated from the freezing of sea water.

Shelf ice: Fast ice which has remained attached to land for a period of years, or the seaward extension of a glacier. Shelf ice may be floating or may be grounded on the bottom.

Tabular berg: An iceberg that is flat-topped and more or less parallel with the waterline, and with no evidence of having rolled over. Formed by calving off an ice shelf.

Young ice: First stage in the formation of sea ice, when ice crystals start to appear in calm water and join together.

SECTION 6

THE BIOLOGICAL ENVIRONMENT

Antarctica, on the other hand, is still deep in the ice age.

Antarctica is very cold, very dry, and very windy. These three qualities are adverse for life to a great extent. The harsh climate tends to freeze living organisms, dry them, and blow them away. These conditions also help to prevent the formation of mature soils. Normally, as rocks are broken down into gravel, sand, clay, and silt, bacteria and algae generate a basic flora in the mineral soil. In other parts of the world vascular plants then move in to colonize the new soil and through chemical processes cause the release of various minerals which can then be utilized by the growing plants.

The minerals thus released also buffer the excess acidity or alkalinity in the soil, and allow the accumulation of humus. This produces an organic, or humic soil which provides a hospitable and nutritive habitat for complex vascular plants. In Antarctica, however, this process is inhibited in several ways. In many areas the constant freezing and thawing cycles break rocks apart, and the constant winds cause rapid erosion. This produces rock debris at a faster rate than primitive plants can colonize them.

Primitive Soils

Low temperatures, frost, winds, and surface streams of melt water make it difficult for immature soils to become stabilized. This causes much of the soil to remain ahumic and poor, and therefore unsuitable for colonization by either plants or animals. Many inland peaks contain mineral soils which are virtually sterile, and some of the dry coastal areas contain small amounts of only the simplest microscopic organisms in the sand and gravel.

The Dry Valleys of south Victoria Land contain ahumic soils and appear to be superficially barren so much so that NASA has studied them for their resemblance to the soils of Mars. The Viking Mars probe was actually tested in the Dry Valleys.

The Antarctic Peninsula region, and some of the coastal areas that receive greater snowfall, hold much richer soils. Here there is enough precipitation to wash harmful concentrations of minerals down through the soil, and form sub surface reservoirs which help to keep plants from drying out during the summer months. Algae, lichens, and mosses grow in these areas, but even here no truly mature organic soils have formed. However, in some regions one may encounter richly organic "ornithogenic" soils, which are largely formed from the guano from colonies of penguins and other birds. In a few distinct, very favourable, locations peat beds may develop beneath mosses and reach depths of perhaps 25 cm (10 inches).

LIFE IN ANTARCTICA

Land Plants and Animals

Considering the harsh climatic conditions and the poor soils, it makes sense that Antarctica has so few species of plants and animals: 360 species of algae, 400 species of lichens, 75 species of mosses and no ferns. Two species of flowering plants occur in the warmer maritime region of the Antarctic Peninsula: the Antarctic hair-grass (*Deschampsia antarctica*) and the Antarctic pearlwort (*Colobanthis quitensis*). All Antarctic plants grow slowly, and only a few species grow taller than 3 centimeters (1.25 inches).

The sparsity, small biomass, and slow growth of the plants preclude the existence of the usual assortment of herbaceous animals. The only terrestrial herbivores to be found are tiny insects and mites that feed mainly on algae, fungi, and rotting plant material. Likewise, the only terrestrial carnivores are tiny mites which feed on the herbivorous mites and insects. Besides mites, the invertebrate fauna includes two midges, springtails, rotifers, tardigrades, and nematodes. Parasitic species, ticks, and mites and internal parasites occur on birds and seals.

Abundant Marine Life

However, animal life abounds in the seas surrounding Antarctica, and migratory seabirds and marine mammals are found in tremendous numbers around the coastal areas during the summer, and on the sea ice during the rest of the year. The reasons for the abundance of life in Antarctic waters are threefold: first, the sea water is cold (cold water holds dissolved gases, such as carbon dioxide and oxygen, much better than warm water); second, the storm-tossed seas with their up-wellings and strong currents keep essential nutrients, such as phosphates, nitrates, minerals in suspension where they can be easily utilized by the immense growths of phytoplankton; and third, the long hours of daylight during the summer months promote almost continuous photosynthesis. The latter process encourages algal blooms that form the underlying basis of the Antarctic food chain.

The phytoplankton of Antarctica consists mainly of tiny diatoms (unicellular plants with cell walls made of silica) and dinoflagellates. The Antarctic Convergence is actually a biogeographic boundary - the largest on Earth - since one finds different populations of planktonic plants and animals, fishes, and even birds, on either side of it.

Animal life
abounds in the
seas surrounding
Antarctica.

North of the convergence the sea floor is primarily calcareous silt formed from the empty shells of countless protozoans. South of the convergence the sea floor consists almost entirely of the siliceous remains of diatoms. When the Antarctic Surface Waters and the Subantarctic Surface Waters meet at the convergence the sudden change in different water temperature incapacitates or kills many planktonic organisms. For this reason seabirds often flock along the convergence.

Biological Productivity

The biological productivity in Antarctic waters is the highest in the world. This productivity can be measured in two ways. The

first is the standing crop of phytoplankton, which is a measure of the amount of chlorophyll in a given sample of surface water. The second is the yield, or water productivity, which is figured by assessing the amount of Carbon 14 assimilated by a given sample of plants.

Both the standing crop and the yield are highest near the islands and along coastal areas because of up-wellings and turbulence - and lowest in the mid-oceanic regions. The inshore waters of the Antarctic Peninsula contain a standing crop that is as much as 10 times greater than neighboring waters, while the yield is as much as five times greater.

The standing crop and yield of Antarctic phytoplankton are at their lowest activity between April and July, when the sun is low or below the horizon, sea ice spreads, and the planktonic populations descend to sub-surface layers. In October, after the ice starts to break up and drift, algal blooms begin and spread south as the ice front recedes.

The ocean south of the Antarctic Convergence comprises about one-twentieth of the world's sea water, but contains a remarkable one-fifth of the world's marine biological production of carbon.

ADAPTING TO THE COLD

All the organisms that live in the Antarctic area have to deal with very harsh conditions. Under normal conditions, the temperature limits for animal activity range from slightly below 0°C (32°F), when body fluids freeze, to 45-50°C (113 -122°F), when proteins coagulate and dissolved albuminoids break down.

The optimum temperature for life is often close to the maximum temperature an animal can tolerate. Climatic fluctuations demand constant adaptation, and both in water and on land animal diversity decreases where conditions approach the limit, such as in polar areas, deserts, and high mountains.

Animals can be divided into two broad types those whose internal body temperature, and therefore metabolism, varies according to the ambient temperature; and those whose internal body temperature remains relatively constant.

Variable Body Temperature

The invertebrates and fishes of Antarctica are of the first kind, and so are directly affected by the ambient temperature. This means that the lower their body temperature, the lower is their metabolic rate. It also means that they run the risk of freezing.

Terrestrial Animals

In Antarctica, terrestrial animals must endure tremendous variations in temperature, whereas the aquatic animals live in a more uniform environment.

To survive freezing an organism must prevent ice from forming inside its cells, and at the same time induce ice formation slowly within the rest of its body, including the contents of the gut, the blood, and the spaces between the cells. Some of them appear to become dehydrated when exposed to low temperatures, and this causes the salts, sugars, and other constituents to concentrate in tissues, thereby reducing the freezing point.

If the cells are not ruptured during freezing the animal stands a good chance of surviving. Freeze-tolerant insects and mites produce cryo-protectant chemicals, such as glycerol, which allow body tissues to survive freezing by reducing the proportion of body water in the ice.

The marine Antarctic environment is very stable, but its temperature is close to or below the freezing temperature of fresh water. Many marine invertebrates deal with this situation by accumulating salts and organic compounds, such as glucose and amino acids, which lower the freezing point of the body fluids.

Antarctic Fishes

The fishes, like marine fishes everywhere, maintain a body salinity slightly lower than that of the sea water in which they live.

Theoretically, one would therefore expect them to freeze at a slightly higher temperature than does sea water (which freezes at -1.8°C , or 28.8°F). Some Antarctic fishes can actually lower their freezing point by accumulating ions, or urea, in their body tissues.

The enzyme systems of Antarctic fishes are so efficient that they are able to remain active even in these extremely cold waters. One family is able to synthesize glycoproteins, which act like an antifreeze by inhibiting the normal growth of ice crystals within their tissues. The content of dissolved oxygen is so high in the cold Antarctic waters that many fishes are able to survive with few or no red blood cells. This gives them a white or nearly colorless appearance. It is interesting to note that if these fishes come in to prolonged contact with sea ice, their tissues will freeze and death results.

Constant Body Temperature

The birds and mammals of Antarctica, on the other hand, are of the second type. They are able to maintain an optimal internal temperature regardless of the cold. Living at the optimum temperature means that their life processes, such as nerve transmission, muscle contraction, digestion, etc., operate at efficient rates but at a high metabolic cost.

To maintain stable high internal body temperatures, these animals must somehow insulate themselves from the cold. The two groups of birds and mammals accomplish this in several ways. Air is a very poor heat conductor and is readily available as an effective insulator. The birds take full advantage of this by using feathers to retain a layer of air around their bodies. Coverts and contour feathers cover fluffy down which holds the air close to the body. Those birds with flexible wings can hold their wings close to the body and receive even more protection from wind and low temperatures.

Feathers

Birds must prevent their feathers becoming waterlogged. Water conducts heat about 25 times better than air, so it very quickly conducts heat from the body. Most Antarctic birds have a very well developed oil gland near the base of the tail. When they preen, the birds rub this oily secretion all over their plumage to make it water resistant.

In addition, birds lack exposed structures, such as ears and tails, which have many blood vessels near the surface. Their legs also carry few blood vessels. This helps to avoid cooling the blood.

The cetaceans (whales and dolphins) protect themselves from heat loss with a thick layer of oil-rich, subcutaneous fat, or blubber.

Penguins are the most aquatic of the seabirds, and have evolved a modified plumage that has highly effective insulating properties. Most birds grow feathers in narrow tracts, and then fluff them out to cover all the exposed skin. Penguins, however, have many more feathers, and almost the entire body surface is covered with a dense, tightly packed growth of feathers. The scale-like outer parts overlap, and are almost impermeable to wind or water. And on the lower shafts grow tufts that form an insulating layer of fluffy down. Besides feathers, penguins also have a thick layer of fat or blubber just below the skin.

In fact, penguins are so well insulated that they are poorly equipped to deal with warm temperatures. The skin of their feet has more blood vessels than other birds, which they use to radiate heat when necessary. They dilate these blood vessels to lose heat on land and constrict them to conserve heat when they are in the sea. This accounts for the rosy pink feet of the nesting or roosting penguins that one sees on land, compared with the white feet of penguins that have just come out of the water.

Insulating Blubber

All the mammals found in Antarctica (except humans, of course) are aquatic. The cetaceans (whales and dolphins) protect themselves from heat loss with a thick layer of oil-rich, subcutaneous fat, or blubber. Unlike most mammals, the cetaceans have virtually no hair and so cannot use air for insulation. They are unable to come out of the water occasionally in order to preen, clean, and aerate their fur. Fat serves a dual purpose since it is not only an excellent insulator, but also is an energy store to allow the animals to survive when food is scarce and affects hydrostatic balance. In general, animals that maintain a constant body temperature need to consume more food, to maintain heat production, when ambient temperatures are low. During this period sunlight is minimal, seas are ice-covered and thus phytoplankton is minimal and food thus sparse. Therefore, the cetaceans with most seals and seabirds migrate to less southern latitudes with a warmer climate during the Antarctic winter. (However, some penguins and seals do remain in Antarctic waters year round. They simply move from the coastal areas, where they spend the summer, to the edge of the sea ice in winter. Weddell seals can remain near the coast in winter, taking advantage of tidal cracks in sea ice to maintain breathing holes and access for feeding.)

Both orders of seals (pinnipeds) have different forms of insulation; blubber or fur, and some have both. As much as 50 percent of the body weight of some species of seals is skin and fat. In fact, seals have such efficient protection against heat loss that they cause little or no visible melting on the ice even after lying in one spot for several hours, and will retain a high internal body temperature many hours after death.

Sidebar: In fact, it was the ever widening search for new fur seal populations, as the known populations were progressively reduced, which led to the discovery of many Antarctic islands in the early 19th century.

Warm Fur Coats

The pelage of most seals consists of two different types of hair: long, coarse guard hairs and short, woolly underfur. Most seals have from two to five underfur hairs for each guard hair, which provides a fur coat of relatively low insulation value, so they rely mostly on their fat to prevent heat loss.

Fur seals, however, are exceptional; they have as many as 70 underfur hairs for each guard hair and this gives them a coat with superb insulation. Unfortunately, the dense, luxurious coat of fur seals was highly valued as a commercial commodity. In fact, it was the ever widening search for new fur seal populations, as the known populations were progressively reduced, which led to the discovery of many Antarctic islands in the early 19th century.

THE DOMINANCE OF KRILL

The zooplankton (animal plankton) of Antarctica is relatively diverse in species, and contains many of the creatures found in other oceans, such as copepods, larval crustaceans, jelly fish, larval sea urchins and sea stars, arrow worms, larval fish, etc. However, the dominant species within the zooplankton are the krill.

The word krill is of Norwegian origin and means very small fish, or whale food, but krill are actually crustaceans. There are some 85 species of krill worldwide, and 11 of these are found only in Antarctic waters. The best known and most important of these is the largest, the 5 centimeter long (2 inches) *Euphausia superba*. It is locally extremely abundant, and is the basis for the larger animal life in Antarctica.

The Antarctic food chain is much simpler than those found in other oceans in that there are fewer levels to go through from the primary producers (diatoms) to the top carnivores (sea birds, seals, whales, etc.). Interestingly, krill, which feed directly upon the phytoplankton, seem to form a major link in that food chain, since it is the primary food for the millions of fishes, squids, penguins, albatrosses, petrels, some seals, and the large baleen whales that inhabit the Southern Ocean. In fact, virtually all the animals visitors encounter in Antarctica are completely dependent upon the vast populations of krill for their food, either directly or indirectly.

Krill Outweigh Humans

The population of Antarctic krill has been estimated at 600,000 billion, and their average density is around 19 million per square

kilometer (50 million per square mile). However, they tend to concentrate in swarms in certain areas. The total weight of krill in the world's oceans is thought to weigh more than the whole human race.

Krill inhabit water only with a temperature below 4°C (39°F), and can live for two or three years, or even more, which is unusual among planktonic animals. Recent research has found that when phytoplankton is scarce in the winter, the adult krill regress to a smaller, juvenile stage. At the beginning of summer they regrow their sexual organs and begin the reproduction cycle again. Females produce up to 6,000 eggs in a season, which are deposited in open water. The eggs sink to about 750 meters (2,500 feet) then hatch into larvae with some resemblance to tiny tadpoles.

The animals must molt 12 times before they become adults. Krill often form dense swarms just below the surface, which actually makes the water appear pink. The reason for this swarming behavior is not fully understood, but seems to depend on factors such as light intensity and availability of food, the phytoplankton. These gatherings, usually of animals within a single age class, enable their predators to capture them with a minimum of effort.

Krill are unusual in several ways. Unlike other planktonic animals they are heavier than water, so must keep moving the whole time to avoid sinking. They hang in the water at an angle of about 55 degrees, constantly paddling with their 10 legs. This also brings water carrying phytoplankton, to their feeding baskets from where it is transferred to the mouth. Forty percent of their energy is used just on remaining in position in the water. If they don't find enough food, or if they are simply weak individuals, they sink towards the bottom where they will eventually suffocate due to lack of oxygen.

Whale Food

The great baleen whales migrate to Antarctic waters every summer to spend several months just feeding on krill increasing their body mass and accumulating fat, which gets them through the rest of the year when food is more difficult to obtain. The baleen whales increase their body weight by as much as 50 percent during this period of intensive feeding. An adult blue whale can consume up to 4,500 kilograms (5 tons) of krill in a day. It has been estimated that the baleen whales consumed 160 billion kilograms (180 million tons) of krill annually, before whaling so drastically reduced their numbers. Today, it is estimated that whales take 27 billion kilograms (30 million tons) every year.

Many researchers believe populations of seabirds and seals have greatly increased with the destruction of the great whales and increased food supply. The crabeater seal (which actually feeds on krill, not crabs) is the most numerous seal in Antarctica, and probably consumes more than 90 billion kilograms (100 million tons) of krill annually. Sea birds take approximately 36 billion kilograms (40 million tons), while fishes and squids probably consume 135 -180 billion kilograms (150 -200 million tons) of krill each year.

Therefore, roughly 320 billion kilograms (350 million tons) of krill are consumed by these animals each year, which represents about 10 percent of the total estimated krill stock of three trillion kilograms (3.5 billion tons). The former Soviet Union and Japan initiated commercial krill fisheries as long ago as the 1960s. Other European and Asian nations have subsequently started similar operations. Krill catching has not proved very successful, but fisheries are a major industry in the Southern Ocean.

Potential Value

Estimates for the annual maximum sustainable yield of krill fisheries range as high as 110 billion kilograms (120 million tons). This would essentially double the entire world's present annual marine harvest. Krill has a protein content of about 55 percent, but must be processed immediately after death because a highly active enzyme causes the protein to decompose very quickly. Processing is also necessary to ensure the krill are not toxic. Krill take in fluorine from seawater, incorporating it in their chitinous exoskeletons. The fluorine contaminates the soft parts shortly after death. Iodine is also concentrated in their eyes.

In the Soviet Union, krill were used primarily for animal feed and for mixing with other meats to produce sausages and fish balls, while in Japan it is sold as cheese, soup mixes, a flavoring, a paste, and a drink.

It is vitally important to determine how much krill can safely be harvested by humans without causing adverse effects on the simple and fragile ecosystem and that the harvest is not unduly concentrated in particular areas.

THE KRILL PREDATORS OR OTHER WILDLIFE

Antarctic Squids

Squids are abundant in the Southern Ocean, an important, but little studied part of the Antarctic ecosystem. Major predators on krill, they in turn are an important component in the diets of toothed whales, seals, the larger sea birds, emperor penguins, and fishes.

Squids, and their relatives the octopuses (which are much less important in Antarctic waters), are invertebrates. Together they are known as cephalopods, and are related to snails, slugs, clams, oysters, etc. However, their highly evolved nervous and sensory systems make them comparable to many of the large predatory vertebrates. With their two fleshy fins, squids can maneuver and swim slowly, but underneath the head is a funnel tube through which the animals can squirt water under pressure, forming a water jet. This allows them to move very fast either forward or backward, and it helps them greatly when catching prey or avoiding predators.

The squids normally grab their prey with the two longest tentacles (there are ten altogether). Suckers on each tentacle help them to hold the struggling prey. The victim is then shifted to the mouth and sliced up into small pieces by a powerful, horny beak before being swallowed.

It is difficult to study the biology and ecology of squids because they are fast, strong swimmers with excellent eyesight and can easily avoid nets. Also, many occur in deep water. Most studies

must focus upon the nearly indestructible squid beaks which are retrieved from their predator's stomachs. A single sperm whale was found to have no less than 18,000 squid beaks. Even less is known about squids in Antarctic waters than elsewhere; several Antarctic species are known only from their beaks. Reports of discovery of giant squids are rare but sucker scars and beak remains demonstrate that some may become huge.

At present, there is virtually no information available on life cycles, growth rates, or reproductive biology of these Antarctic cephalopods. However, it has been estimated that sea birds, whales, and seals may consume some 31 billion kilograms (34 million tons) of squid per year. On this basis, the total Antarctic squid stock is likely to be at least 90 billion kilograms (100 million tons).

Commercial Squid Fisheries

Large-scale squid and octopus fisheries have existed for generations in the Mediterranean, Southeast Asian, and Japanese waters. Japan has operated a fleet of commercial squid fishing boats in the waters around New Zealand since the late 1960s. Fishing vessels from several European and Asian nations are now catching large quantities of squid in the waters around the Falkland Islands (Islas Malvinas) and off the coast of Argentina.

Because of the ever-increasing search for new and unexploited fisheries and fishing areas, many scientists are concerned about the likely development of squid fisheries in Antarctic waters. Much more research is needed to accurately determine stocks and work out reasonable management plans. This is a major goal of CCAMLR (The Commission for the Conservation of Antarctic Marine Living Resources)

Antarctic Fishes

Almost all the fishes in Antarctica are bottom dwellers and rarely encountered. For convenience, the species may be divided into two distinct groups: deep-sea fishes and coastal fishes. The coastal group contains the better known species, including the ice fishes, eel pouts, Antarctic cods, plunder fishes, and dragon fishes, which accounts for about 60 percent of the species and 90 percent of the individuals. Most of the coastal species are unique to the region, but most deep-sea fishes occur elsewhere as well.

As expected, the species diversity is low (only about 200 species have been identified so far), but the number of individuals in these nutrient-rich waters is vast. The marine environment they inhabit is very uniform with regard to temperature, although this is constantly low.

Marine fishes must maintain a blood salinity lower than that of the surrounding sea water. Dissolved salts lower the freezing point temperature of sea water from 0°C (32°F) to -1.8°C (28.8°F). For fishes to survive in near freezing sea water they must concentrate something other than salts in their blood and tissues that will lower their own freezing point to at least that of sea water. Certain ions, such as sodium ions, potassium ions, and chloride ions seem to work very well. Some species even produce glycoproteins which, like an antifreeze, inhibit the formation of ice crystals within their tissues.



Chinstrap penguins and chick



Adélie penguin

No Scales and White Blood

The ice fishes have practically no scales, and lack the oxygen-carrying protein hemoglobin, which is common to all other vertebrate animals. They have a pale, nearly colorless appearance. Although their blood is not red, but a translucent yellowish color, their ancestors were probably red-blooded because they still have non-functional red blood cells. The cold waters hold a high concentration of dissolved oxygen, and these fishes absorb it in through their gills as do other fishes, but it is carried in solution in the blood plasma.

Many species appear rather sluggish. Even so, they are able to maintain considerable activity in these low temperatures because of the presence of very efficient metabolic enzymes. Slow growth rates and long life spans seem to be characteristic of the Antarctic fish fauna. Most species are small in size.

Commercial Fisheries

Several nations catch the fishes of Antarctica. Most attention has been focused on about a dozen species that are the largest and most common fishes encountered around the continental coast and the Scotia Arc.

The first fish species to be over-exploited was the South Georgia cod, which measures up to 90 centimeters (nearly three feet): catches peaked at 400,000 tons in 1970/71. Before fisheries are developed on too large a scale it is important to evaluate the gross potential of the resources, study their population dynamics, develop systems to monitor fish stocks that are exploited, and evaluate the effects of such fisheries on other elements of the ecosystem. CCAMLR, established in 1977 as a result of the increasing commercial exploitation of Antarctic marine resources, monitors populations of fish, krill and squid.

Antarctic Birds

The most obvious and commonly seen animals of Antarctica are the birds. The species diversity is very low, for reasons already explained. Although many more occur, only 43 species of birds breed south of the Antarctic Convergence, nearly all of them seabirds. Many ornithologists believe that Wilson's storm-petrel,

which breeds by the millions in Antarctica, may be the most numerous bird in the world.

Penguins

These birds epitomize the Antarctic. Although the 17 species of penguins are all found in the southern hemisphere, most of them live north of the Antarctic Convergence; the Galapagos penguin actually lives at the equator. Of all the penguins, only the Emperor and Adélie are restricted to Antarctic habitats. All penguins are flightless and adapted for life in cold water, so even those found in the low latitudes are dependent upon cold water currents for their livelihood.

Penguins are the most aquatic of the seabirds, and they spend most of their lives at sea, except when molting or rearing young. Their ancestors were flying birds, as shown by the similarities in their pectoral girdle to that of modern flying species. The main reasons why birds fly are to search for food, evade predators, and migrate; penguins may be said to fly underwater.

The wings of penguins are reduced in size, stiff and flat. They are adapted to propel the birds through the dense medium of water. Unlike most birds, penguins swim by using their wings as flippers underwater rather than paddling with their feet.

Penguins are quite similar in appearance and behavior to the flightless great auk of the northern hemisphere (which became extinct in 1844). That bird had long been known by the name penguin in English, so when the first British sailors arrived in the southern oceans they transferred the name to the newly discovered flightless birds, simply because they looked like the familiar great auk.

Birds that can fly have lightweight or even hollow bones, and air sacs within the body to help reduce body weight and decrease the wing loading. Penguins, however, have dense, solid bones and no air sacs, in order to counteract buoyancy, and dive to great depths.

Their bodies are very streamlined, but even so, when they stop moving their wings they slow down very quickly. To avoid coming to a halt each time they break the surface to breathe,

penguins have developed a method of swimming termed porpoising. This allows them to swim rapidly just below the surface and when necessary propel themselves out of the water in a low arc, take a quick breath, and continue on their way. This may also be useful in escaping from an underwater predator, such as a leopard seal.

Most penguins can submerge for 5-7 minutes, but the largest species (the emperor penguin) can submerge for up to 18 minutes. The emperor penguin dives to 630 meters (2,070 feet). Most other species do not normally go deeper than about 100 meters (330 feet). Penguins' maximum swimming speed is probably about 24 km/h (15 mph), but because of their small size they often seem to be traveling faster.

Penguins generally prey on organisms near the surface, either close to shore or near the edge of pack ice. In Antarctica, the larger species feed primarily on squid, while the smaller species feed mostly on krill, with some fish and squid. During the summer months, however, krill is the main food item for all as is evident from their typically pink-colored excrement.

Virtually all penguins are social and nest in colonies. In Antarctica, most species use open nests lined mainly with pebbles, but also other debris such as bones and feathers. The pebbles are collected from the beach or stolen from other nests. Both sexes share in incubating the eggs and feeding the young. The two largest species, the emperor and king penguins, make no nest at all but incubate eggs and keep their hatchlings on their feet. Since emperor penguins require more time to raise their young, they lay their eggs in winter so that chicks can be fledged before the end of summer while food is still abundant.

Nearly all emperor penguin colonies are on the sea ice, unlike those of other penguins, which nest on land. The male emperor incubates a single egg by balancing it on top of his feet and covering it with a special brood pouch (the same method is used by the king penguin). He must stand upright and shuffle around with the egg for about two months, while his mate is at sea feeding. If the egg hatches before the female returns to relieve him, the male can feed the newborn chick with small quantities of crop secretions containing fat and protein. In some penguin species the young form groups, or crèches, which may then be guarded by just a few adults; this allows most of the adult penguins to spend longer at sea feeding and bringing food for increasingly hungry chicks.

There is always a lot of activity at penguin colonies, and the sights, sounds, and smells are unforgettable. Incubation usually lasts 5 to 6 weeks. The fledging period varies quite widely, with Adélies and chinstraps leaving the colony at about seven weeks, while for gentoos the time is 14 weeks. The young are fed by regurgitation, and take the food from inside the gullets of the adults.

Penguins typically have very strong feet with large, well-developed claws with which to climb slippery rocks or ice. Feathers account for about 80 percent of the penguins' insulative properties, while fat provides the other 20 percent. Penguins have a very high internal body temperature (about

38°C or 101°F) as well as a high metabolic rate. They have no problem surviving indeed, thriving in the cold, harsh climate of Antarctica. There are no terrestrial predators for the adults, but leopard seals and killer whales take them at sea.

Tube Noses

Albatrosses, along with petrels, prions, shearwaters, storm-petrels, fulmars, and diving petrels, are members of a group of seabirds called Procellariiformes. But they have another name which is easier to remember: tubenoses. This refers to their external tubular nostrils that are mounted on the upper plates of their grooved, hooked bills. They expel excess salt from their systems through these nostrils, and a saline solution can often be seen dripping from them (or forcibly ejected). They have a well-developed sense of smell and, indeed, some can use the distinctive odour to help navigate.

Albatrosses

At sea, albatrosses are easily identified by their large size, long narrow wings, short tails, and distinctive flight patterns. They spend most of their lives in the air, and have perfected a gliding flight which allows them to stay airborne with a minimum of effort. They actually seem to enjoy windy, stormy conditions, and it is great fun to watch as they swoop downwards with the wind just above the waves, then turn into the wind to gain height, before turning around to pick up speed and glide with the wind again. They seem to go on for hours like this without ever having to flap their wings.

Albatrosses are usually encountered in the open sea where they often follow ships, taking advantage of the air currents produced as the vessels move. They feed mostly on squid, small fish, and krill, which they catch by landing on the surface and dipping their heads underwater.

These birds have short, strong legs and webbed feet, and will alight on the water to rest or swim around after food. They usually must run along the surface into the wind in order to become airborne again. For identification purposes, albatrosses can be categorized as large or small. The large species are the Royal and Wandering Albatrosses: the latter has the longest wings of any living bird, with a total wingspan of up to 3.45 meters (11.5 feet). The small albatrosses are often called 'mollymawks,' a Dutch word meaning foolish gull and have wingspans of about 2-2.25 meters (7-7.5 feet).

These big, graceful birds are noted for their long distance flights. The champion in this respect is the biggest of all, the Wandering Albatross. Using satellite telemetry, scientists have discovered that parent birds fly as much as 1000 km (560 nautical miles) per day at air speeds of 90 km/h (50 nautical miles per hour) covering anywhere from 1,800 miles to an amazing 9,300 miles in a single foraging flight! Young adult Wandering Albatrosses spend several years at sea before returning to land to breed at about seven years of age.

Most albatrosses perform complex nuptial dances, and they begin to breed in late spring or early summer. They nest on islands that provide good sites for taking off into the prevailing



Gentoo penguins and chicks

wind. Their nests usually consist of mounds built of mud, grasses, moss, and excrement; they lay just one egg.

Incubation normally ranges from 60 to 70 days in small species, and lasts about 80 days in the large ones. Both sexes incubate the egg, and feed the chick at the nest with regurgitated food until it fledges. The small albatrosses breed every year, but the two large species breed only every other year.

Petrels

Most petrels are small to medium-sized seabirds (with the exception of the albatross-sized giant petrel), which have long pointed wings and hooked beaks with both nostrils encased together in a single sheath. Many ornithologists consider the extended tube enables the birds to eject the concentrated brine (produced by the salt gland) away from the face. Thick salt deposits on the facial feathers could be a serious problem for birds that inhabit Antarctica, because they seldom get the chance to clean and preen themselves.

Petrels spend their entire lives at sea, except during the breeding season, and have adapted themselves to the severest storms the Southern Ocean can produce. They are often seen flying just over the surface of the sea, using the wind and air pressure along wave fronts as they glide, bank, and shear the water with their wing tips. It is thought that they can survive very long periods on the wing without true sleep.

These tube-nosed birds feed chiefly on plankton, crustaceans, squid, and small fish, which they pick up from the surface. The predatory giant petrels, however, take eggs and chicks of other birds, and will even attack weaker adult birds and molting penguins. They also eat carrion, and the whalers and sealers called them stinkers, based on observation of their feeding habits, and capacity to project malodorous oily vomit.

Petrels have webbed feet and float very high in the water as they paddle around looking for food. They can, if necessary, dive a short distance below the surface. However, they are so buoyant that it is difficult for them to stay submerged for more than a few seconds.

Most species are gregarious, and some of them form huge colonies during the breeding season. Most nest in holes, rocky crevices, or on rock ledges, while a few (including the giant petrel) actually construct a nest out of pebbles, feathers, and other available materials.

All species normally lay a single egg, both sexes share in the incubation and feeding of young (usually one mate is away feeding while the other tends the egg or chick). Incubation ranges from 6 to 8 weeks, depending on the species. The chick is fed by regurgitation, and often the food consists of a very aromatic and oily secretion. Some species, notably the fulmar, can defend themselves by spitting this oil at intruders. Fledging takes 7 to 8 weeks in most species, but 14 to 19 weeks in the largest species.

Storm-Petrels

These are the smallest of the oceanic seabirds. Storm-petrels are about the size of swallows, and in fact are often called sea swallows. Another common name given to them by seafarers of old was Mother Carey's chickens. This name, applied especially to Wilson's Storm-petrel, has an interesting origin. Fishermen used to fear them, as their appearance was thought to herald an approaching storm.

Portuguese fishermen would cry out *Mata Cara!* (Dear Mother! In reference to the Virgin Mary) when they saw them. English-speaking whalers changed the words *Mata Cara* to *Mother Carey*.

Storm-petrels have a fluttering flight that is much more erratic and weaker than the true petrels (they have been called 'sea-butterflies'). Most species are dark bodied with a white patch on the rump, but some lack the white rump, and others have white bellies and under-wings.

The name petrel itself is derived from St. Peter, and refers to the biblical story of Peter trying to walk on the water. The storm-petrels have a habit of facing into the wind with outstretched wings, and do appear to walk or dance on the water as they pick up tiny food particles between the waves.

Like the albatrosses and true petrels, they are often encountered far out to sea in windy and stormy conditions. It is surprising to see such tiny birds in the open ocean, often hundreds of kilometers from the nearest land. In fact, they are superb long-distance flyers. Wilson's Storm-petrel, in fact, almost rivals the Arctic tern in this respect (though in reverse), migrating north from its Antarctic breeding sites to spend the northern summer as far away as Newfoundland or Ireland.

Most species breed in colonies and nest in protected places such as crevices, under rocks, and within cavities or burrows which they may excavate themselves. Both sexes incubate the single egg, but the eggs and young are often neglected for varying periods during development. Incubation usually lasts 5 to 6 weeks, but may take longer if the egg has been left unattended for extended periods. Both parents feed the chicks, which grow large and fat before their juvenile feathers appear. Fledging normally takes 8 to 10 weeks.

Diving-petrels

The diving-petrels are only found in the southern hemisphere. They are small stubby birds, and the four species are almost identical in shape, plumage, and flying traits. The basic diving-petrel appearance is a black upper body, with white under the body; short wings, legs, and tail; and small bills with separate nostril tubes which open upward instead of forward.

Diving-petrels do not fly very well, or very far. They usually erupt from the water and fly for a short distance with a rapid whirring flight, before diving back into the water. In outward appearance they are very similar to the little auks, or dovebies, of the northern hemisphere and indeed seem to be the southern equivalents. Although they may range far from their breeding grounds they are rarely seen away from inshore waters.

They feed almost entirely on small fishes, which they chase and catch underwater with their short, hooked bills. Like penguins, they swim underwater by propelling themselves with their wings, not their feet. Ornithologists consider penguins must surely have evolved from ancestral birds with habits much like the living diving-petrels.

Diving-petrels have nearly lost the power of flight, and when they molt they are completely flightless and spend several weeks behaving like penguins. They breed on islands, nesting in long burrows which they dig. Like all other tube-noses, they only lay one egg which is incubated alternately by both sexes for about eight weeks. The chicks are fed daily by the parents, and fledging lasts 7 to 9 weeks.

Cormorants (Shags)

Cormorants are medium-sized birds with long necks, long hooked beaks, long rounded wings, and long wedge shaped tails. They are strong fliers, usually traveling in straight level paths, and often in V-shaped groups, much like geese. Some species are called shags, from an Icelandic word meaning beard, and refers to their crest of feathers in the breeding season. Most cormorants are black, but in the southern hemisphere many species are black and white in color.

There has been considerable confusion about the three very similar birds found in Antarctica and adjoining South American waters. Various common names are used, such as imperial, king, and blue-eyed; also the words cormorant and shag are used interchangeably. Most biologists agree that the Antarctic cormorant is a distinct species and that all cormorants in Antarctica are conspecific, i.e. they are all one and the same species. So we shall adopt just one name, and call it the Blue-eyed Shag. The blue eye-ring is conspicuous.

They are essentially coastal seabirds, although they can and often do make long trips over open water. This explains how they reach Kerguelen, Crozet, Macquarie, South Georgia, and other isolated islands as well as Antarctica itself during the breeding season.

Cormorants are expert divers, and can reach considerable depths. They float very low in the water, and when they go under to pursue their prey (usually fish but also squid) they dive with a characteristic forward leap or jackknife manoeuvre.

They propel themselves underwater with their large webbed feet, and often partly open their wings to aid in steering and making sharp turns when chasing fish. Unlike most seabirds, which have webbing between the three forward projecting toes, cormorants have webbing which connects all four toes. This is a much more efficient swimming foot.

Cormorants snatch fish with their strongly hooked beaks and then surface to position the fish so as to swallow it head first. An important difference between cormorants (and their relatives the pelicans, boobies, frigatebirds, tropic birds, and aningas), and other seabirds is that they have no external nostril openings. They must breathe through their open mouths, and often seem to be panting when the gular pouch vibrates during their breathing.

Cormorants are colonial breeders, and in Antarctica often nest near or among penguin colonies. They build large, bulky nests containing mud, kelp, rocks, feathers, and any other convenient material. The clutch is normally 2-5 eggs, and both parents share the 4-week incubation. The young fledge after about 5-6 weeks. The parents feed by regurgitation, and it is fascinating to watch the young birds thrusting their heads deep inside the adults' throats to obtain food. Like penguins, the immature birds often form crèches.

Waterfowl

There are many species of ducks throughout the world, and many of them breed in the high Arctic during summer months. Only two are found in the Antarctic region, however, and

they are very similar in appearance. The South Georgia Pintail is closely related to the South American Yellow-billed or Brown Pintail, and probably represents a fairly recent natural colonization. A resident of South Georgia, this pintail may also be seen very occasionally in the South Shetland Islands. It is very typically duck-like in appearance, is a strong flier, and takes off from the water nearly vertically. The males have sharp tail plumes, and both sexes have a metallic speculum on their secondary flight feathers.

The other duck which may be seen in small numbers in South Georgia is the Speckled Teal (or Yellow-billed Teal), which is common in southern South America and the Falkland Islands (Islas Malvinas). It is extremely similar in appearance to the South Georgia Pintail, but has a shorter neck and tail, and is less spotted on the belly. It is found mainly in the Cumberland Bay area, around Grytviken.

Sheathbills

Sheathbills are plump and pigeon-sized, and indeed even look somewhat like white pigeons. There are only rudimentary webs between the three front toes, and they have a well developed hind toe. They are snow white (except when they have been scavenging in offal and mud), with pink, fleshy wattles, and are most often encountered as they walk deliberately among nesting penguins or along the shoreline. Their behaviour might be called very cheeky. They often approach anything interesting closely and will not hesitate to try it with their beaks and they fly off reluctantly.

Sheathbills fly rather laboriously with short rounded wings. They can swim, and are occasionally seen at sea on ice floes. Their nests may be set within a rock crevice, or in a cavity, or perhaps under a ledge, and are constructed with pebbles, feathers, bones, etc.

They are the most noticeable scavengers of the Antarctic. Sheathbills will eat almost anything of organic origin, including seal feces, spilled (regurgitated) penguin food, seal placentas, dead seal pups, dead chicks, etc. and often suck eggs or even kill live penguin chicks.

There are only two species of sheathbill and both of them breed in the Antarctic and on subantarctic islands. The pale-faced (or snowy) sheathbill is the one most likely to be seen. It breeds on South Georgia and other islands of the Scotia Arc, and on the Antarctic Peninsula. Part of the latter population flies north in winter to southern South America and the Falkland Islands (Islas Malvinas).

The black-faced (or lesser) sheathbill is very similar, but has a black bill. It breeds on Heard Island and some subantarctic islands in the Indian Ocean.

Skuas

Large, predatory seabirds related to gulls and terns, skuas are much more pelagic, and aside from the breeding season spend most of their time at sea. The skuas can be distinguished from gulls by their white wing patches at the base of the primary flight feathers.

Two species occur in Antarctica. These are both stocky, brownish birds which are rather hawk-like in their habits, and have strong hooked beaks and relatively strong talons on their webbed feet. The brown skua is the larger, and has a heavier bill; it is mottled gray-brown overall.

The smaller South Polar skua has a more slender bill, and is easily identified in its pale form, which features a gray body and head that contrasts with a dark back. The dark form of the South Polar skua is quite similar to the brown skua, apart from its less massive appearance, and relatively pale under parts. Hybrids between the two species sometimes occur, indicating that they are closely related.

The skuas of Antarctica are among the largest in their group, which makes them potentially dangerous to almost all the other birds and small animals. They are inveterate egg-stealers and chick-killers. Until penguin chicks are large enough to fend off skuas, they are at constant risk of attack. For the first several weeks, the parent penguins spend much time protecting their offspring from marauding skuas flying overhead waiting to dive on any unprotected egg or chick.

Skuas will chase and harass birds that have food in their beaks until they drop it out of desperation, and will also kill adult petrels and prions. They are active hunters and can kill quite large prey, such as wounded adult penguins, but they will also scavenge when necessary. Brown Skuas have been observed taking milk from nursing elephant seals.

Skuas do not nest in colonies, but are often social breeders. This means several pairs may nest within the same vicinity, but their nests are well spaced for the birds sometimes may cannibalize other members of their species. The Antarctic skuas usually nest near the coasts, either on rocks or on open ground. They may construct nests, if suitable materials are available, and both parents take turns incubating usually two eggs for about four weeks.

Both parents feed the chicks, and defend their eggs and offspring with aggressive ferocity. Visitors should be wary of walking near skua nests, where intruders risk being dive-bombed with frightening speed and power.

Skuas range widely outside the breeding season. Brown skuas may winter near the shores of South Africa, Australia, New Zealand, and South America, while the South Polar skua ventures even farther, to the northern Pacific and Atlantic oceans. One banded sub-adult brown skua is known to have migrated from the Antarctic Peninsula to Greenland.

Gulls

Though primarily coastal seabirds, the gulls that breed in high latitudes, such as the kelp gull of Antarctica, often migrate long distances over open water during winter months.

Gulls have long broad wings and are good fliers, but cannot fly as well as the albatrosses and petrels. They have webbed feet and are good surface swimmers. They are predatory birds, but are not as successful or as fierce as the skuas.



Pintado petrels

Gulls are survivors that will take advantage of any situation they can. They will scavenge when necessary and will eat an impressive variety of foods. They often follow ships in the hope of receiving edible refuse, and many species have actually increased their numbers and ranges as a result of living off mankind's ever growing refuse problem.

Gulls get their food either from the ground, or from the surface. They rarely dive beneath the surface since they are very buoyant and float high in the water.

The kelp gull (sometimes called the Southern black-backed or Dominican gull) is quite large and typically gull-like in appearance. The head, body, and short rounded tail are white, while the upper surface of the wings is black. The bill and legs are yellow. They are easily recognized, for they are the only gulls in Antarctica. Young birds, however, do not attain their adult plumage until their third winter and until then are a mottled brown.

The kelp gull has a very wide range, including South America, South Africa, and New Zealand as well as the Southern Ocean. It nests in rocks and on ledges, and often builds a nest with organic debris, surrounded by a scattering of limpet shells. The limpet *Nacella consinna* is an important food item and its shells are often seen around gull nests. Both parents incubate the 3-4 eggs, and both feed the chicks.

Terns

Terns are closely related to gulls, and some experts consider the two groups as one family. But whereas gulls often soar in up-draft and wind currents, terns have a straighter, more level flight. Most terns are coastal birds, but the two Antarctic species migrate varying distances over open water each year.

The Arctic tern is notable for having the longest annual migration route of any animal on Earth, with some individuals flying 35,500 kilometers (22,000 miles) during a return flight from the Arctic (where they breed) to the Antarctic, and then back to the Arctic. The Antarctic tern, by contrast, travels far less, staying all year in ice-free waters in the Antarctic.

The Arctic and Antarctic Terns are very similar, both in appearance and habits. They feed almost entirely on fish, which they catch by dropping on them from above the water. Terns can hover as they search for prey and can dive a short distance into the water if necessary. They breed at opposite ends of the Earth at opposite seasons, so the Arctic species will be in winter plumage when it visits in the Antarctic summer.

The Arctic tern is notable for having the longest annual migration route of any animal on Earth.

Most terns nest in colonies, but the Antarctic tern often nests on its own, or at best in loose and widely segregated breeding areas. It may lay from 1- 3 eggs, and incubation lasts about 3 weeks. Both parents share incubating and feeding.

The nest usually consists of a simple scrape among loose pebbles. Fledging takes 4-5 weeks, but the parents continue to feed their offspring for some time after that. The eggs and young are well camouflaged against the gray pebbles, and a visitor can easily wander too close without realizing it.

However, Antarctic Terns will soon warn any potential trespasser, by diving and scolding. If this happens, the visitor should retreat, whereupon the terns will resume sitting on their eggs or brooding their chicks.

Pipit

The South Georgia Pipit is the only songbird native to the Antarctic region. It is a sparrow-sized LBJ (little brown job) with



Crabeater seals

a slender pointed bill and a long tail. The plumage is reddish brown, with buff under-parts and characteristic streaking. It feeds on the ground and walks or runs (it does not hop like most small song birds), and continually flicks its tail like a wagtail.

The bird is most likely descended from the Falkland Islands (Islas Malvinas) or South American pipits, but is now considered a distinct species. Their ancestors were probably carried to South Georgia by the prevailing westerly winds.

These birds are remarkably difficult to spot among the tussock grass and other vegetation, but can easily be seen as they prowl along the beaches and streams or among kelp, looking for insects, copepods, and other small creatures. Their distinct call is often the best indication of one in the vicinity. They breed on small rat-free islands off the coast of South Georgia, but do visit the main island to feed. The nests are made of woven grasses and are usually hidden among tussock grass roots. They remain on South Georgia throughout the year, and their distinctive call is the best clue to their presence. When rat eradication is complete on South Georgia they will become much more frequent on the main island, currently they are most common on the small rat-free islets.

Antarctic Seals

Seals belong to the group of marine mammals called pinnipeds (fin-footed). This includes the *Phocidae* (true or blubber seals), *Otariidae* (fur seals and sea lions, or eared seals), and *Odobenidae* (walrus). In Antarctica, there is one eared seal - the Antarctic fur seal and five true seals: southern elephant, Weddell, leopard, crabeater and Ross.

All seals are carnivorous, and except for the fact that their feet are flipper-like to accommodate an aquatic life style, they are very similar to the Carnivore order, which includes the cats, dogs, otters, bears, etc.

The pinnipeds are well adapted to life in the sea. They have an enormous amount of blood in relation to their body size (about twice the amount found in a comparably sized human). A larger content of blood obviously holds more dissolved oxygen and

carbon dioxide, and the animal can therefore survive for longer periods without breathing. This enables them to spend a great deal of time under water searching for food.

During a dive the heartbeat rate slows from perhaps 100 beats per minute to 4 or 5 beats per minute. They normally exhale before diving below the surface but their lungs are dorsally located so as to give them extra stability when they are buoyant at the surface.

Many species of seals, including some of those found in Antarctica, migrate long distances during different seasons of the year. They gather on and around the pack ice and accessible coasts during summer months to breed and molt. The females give birth to one young only. Because the seals disperse after the short breeding season, mating must take place soon after the females give birth.

Although the gestation period is about nine months, implantation is delayed so that the next year's pup is born almost exactly one year later.

The mother's milk contains about 45 percent fat and 10 percent protein (compared to about 4% and 2% respectively in cow's milk), and the seal pups grow very quickly. Most species are weaned in about two months. The males have little or nothing to do with the raising of their offspring.

External ears

While the fur seal and the true seals are fairly closely related, there are some important differences. Fur seals have external ears, their hind feet can be positioned beneath the body to walk or hop on land, the fore limbs are long and broad and provide the motive force when swimming, the soles of their flippers are naked, and they have claws only on the middle three digits of each flipper.

By contrast, the true seals have no external ears, their hind limbs extend straight back in line with the body (obliging the animals to crawl rather clumsily, like an inch worm or caterpillar, when on land) the fore limbs are short and the hind

limbs provide the means for locomotion in water, and there are claws on all digits.

Of all the differences, however, the most important is the composition of the pelage. The fur seals are aptly named for their dense, luxurious coats. Their fur consists of two different types of hairs, guard hairs and underfur, which are arranged in bundles. Each long guard hair is surrounded by up to 70 short under-fur hairs, which gives the animal a highly efficient protective layer of insulation against low temperatures. It also gives it a pelt which once had a high commercial value.

The true seals, on the other hand, rely primarily on a thick layer of subcutaneous oil-rich fat, or blubber, to insulate their bodies from the intense cold. Their fur is not nearly so thick or luxurious. True seals also have guard hairs and under-fur, but there are only a few under-fur hairs associated with each guard hair.

Antarctic Fur Seal

Male fur seals grow to much larger sizes than the females, which is also typical of other eared seals, such as the sea lions. Mature males weigh up to 180 kilograms (400 pounds), and are olive gray to silver on the back with a brownish belly and a dark yoke over the middle (wet ones are much darker than those which have been ashore and are dry). The guard hairs on the neck and shoulders form a thick mane, and the older bulls grow a crest on the top of the head. Females grow to 50 kilograms (110 pounds), but lack a mane or crest, and have a creamier colored chest and throat.

Fur seals favor rocky coastlines with sheltered beaches. The males start to arrive in September or October, and quickly set about establishing territories on the beaches. These bulls are very pugnacious and there is almost constant fighting between them as they maintain and defend their territories from other males. The females begin to arrive at the beaches in late November, and usually give birth two to four days after arrival. Mating takes place about a week after the female gives birth.

The females, or cows, are maintained in harems by the bulls. By the middle of January the harems start to break up, and the exhausted bulls go to sea for short periods to feed. From the end of January to the beginning of March the animals molt. The cows and pups leave the beaches in April but some of the young males may stay around until the end of June.

The Antarctic fur seals dive to about 50 meters (150 feet) and feed mainly on krill; but they also consume fish, squid, and even penguins. During the winter they migrate northwards to warmer waters and individuals have ranged as far north as the South Island of New Zealand.

In the early 1820s, within a few short years of the discovery of their breeding colonies on the South Shetland Islands, were over 60 sealing vessels from the United States and Britain taking hundreds of thousands of pelts a year. The animals were soon almost wiped out and the sealers had to search farther and farther for a field for other populations. It was this search that led to the early discoveries of the Antarctic continent.

It was thought that the South Georgia fur seals might have become extinct, but in 1933 a small colony was discovered to have survived on Bird Island off the northwest tip of the island. From this small beginning, and thanks to protective legislation, the population has increased massively and led to repopulation of other sites in the South Orkney, South Sandwich, and South Shetland Islands. There now may be more than 3,000,000 fur seals on South Georgia and there is consideration of whether to control this explosive population growth.

Southern Elephant Seal

The southern elephant seal has a large circumpolar range which includes most of the subantarctic islands as well as a few coasts of the continent. This is the largest species of seal in the world, surpassing even the walrus in size. The males grow to 6 meters (20 feet) in length and can weigh as much as 3,600 kilograms (4 tons). Females, though large, are much smaller than the males, and grow to about 3.6 meters (12 feet) in length and 900 kilograms (1 ton) in weight.

The male elephant seal is distinguished by his immense size, large inflatable proboscis, and dark gray color. The females are brownish, and lack the enlarged nose of the male.

Elephant seal males maintain and defend breeding territories and harems (like the fur seals). They start coming ashore in August to establish their territories in anticipation of the arrival of the females a few weeks later. Each bull may guard a harem of up to 50 females, though he is often challenged by other males.

The precocious pups, which may be 1.5 meters (4 feet) in length and weigh 36 kilograms (80 pounds), are born about a week after the females arrive. The mothers suckle their young for only about 3 to 4 weeks, and the pups put on weight very quickly up to nine kilograms (20 pounds) per day. The pups have a high mortality rate during the breeding season as some of them are crushed by the huge bulls while they move around defending their territories.

After the pups are weaned they are left by their parents who go to sea to feed. Then the gregarious adults return to the beaches to gather in large, muddy wallows for a month or more while they molt. A tightly-packed elephant seal wallow is an extraordinary sight and smell.

Elephant seals do not truly migrate, because when they leave the breeding grounds and go to sea, they mainly move ahead of the advancing ice pack. They feed mostly on squid, supplemented by fish, which they catch in deep dives to about 1,000 meters (3,300 feet) lasting more than 30 minutes.

After the fur seals had been nearly exterminated by the 1820s, the sealers turned their attention to the elephant seals which were killed for their oily blubber. A large male yielded nearly 400 liters (100 gallons) of high quality oil. The pattern of over exploitation was repeated, and by the mid-19th century so few elephant seals remained that the industry had dwindled but it was 1922 before it finally came to an end. Elephant seals were not reduced so much as fur seals as their products were less profitable - their populations had largely recovered during the 1900s.



Weddell seal



Leopard seal

But numbers recovered and in 1910 elephant seals were again being killed on South Georgia. In due course, conservation regulations were enacted and the industry was sustainable until it finished in 1965. Happily, populations have recovered very well, and the elephant seal is once again common in many parts of its original range.

Weddell Seal

This is the most southerly of the seals and indeed the most southerly of all mammals breeding as far south as 78°S. It is almost always found within sight of land in both summer and winter. Although individuals sometimes wander long distances (they have been found off South Australia and New Zealand, as well as South Georgia, Macquarie, Kerguelen, Heard, the South Orkneys, and even the Falkland Islands [Islas Malvinas]), the species was not discovered until 1823 when Captain James Weddell captured six specimens during his voyage to the southern extent of the sea later named after him.

Male Weddell seals are about the same size as the females, and in fact the females often grow slightly larger than the males. The males establish underwater territories, where they will mate with females that enter, but they do not form harems. Mating takes place in the water.

The Weddell is a rather tubby animal which weighs up to 400 kilograms (900 pounds), with a length of some 3 meters (10 feet). Weddell seals are dark gray above and light gray below, and the entire body is covered with distinctive light blotches and streaks. The face is small, but the eyes are extremely large to facilitate hunting in deep, dark waters under the ice. Fishes make up the bulk of their diet, although they also eat a fair amount of squid and krill. Their favored food is the large Antarctic cod, which can weigh 70 kilograms (154 pounds).

The breeding season starts when the cows haul out on the fast ice in early September and give birth within one or two days. The males often fight with one another if they come too close

together at this time, and the females are fiercely protective of their offspring.

The pups are weaned in about 6 weeks, after they have more than quadrupled their weight to more than 120 kilograms (260 pounds). The cows will have lost about 136 kilograms (300 pounds) during the same period. The pups enter the water very soon after birth, though some are crushed to death by the ice breaking up. It has been estimated that the mortality rate of Weddell seal pups is as much as 50 percent during their first two months.

Weddell seals usually remain near the land year round. During the winter they remain under the fast ice by maintaining breathing holes which allow them to reach the air to breathe. The seal embeds its lower incisor and canine teeth in the ice from below and then revolves its upper incisor and canine teeth in an arc until it cuts a hole. The teeth of older individuals are usually badly worn, and this condition may be an important cause of death in mature animals.

Weddell seals are excellent divers, and have been known to dive to nearly 600 meters (1,900 feet) and remain submerged for more than an hour. Perhaps because they meet few predators on or under the fast ice, they are not much concerned when they occasionally meet humans on land. Their vocalisations are exceptional - the term 'canary of the sea' has been applied to them.

Crabeater Seal

This is the most abundant seal in the world, totaling somewhere between 30 and 70 million. Its population has increased in recent decades, because of the reduced number of whales in Antarctic waters, which has made available greater reserves of food. For despite its name, the crabeater seal lives almost entirely upon krill, not crabs.

The adults of both sexes are about the same size, growing to 2.7 meters (9 feet) in length with a weight of 227 kilograms (500 pounds). This medium-sized seal is long and slim, with light

As the name suggests, leopard seals are predators.

coloured coarse fur. It has a pointed, rather dog-like snout and is often encountered resting on pack ice or ice floes. It is quite common to see adults with prominent scars on their flanks or bellies caused by encounters with leopard seals, or perhaps orcas.

Their teeth are well adapted to an exclusive diet of krill. The specialized molars have five projecting cusps arranged in line with the jaws so as to act as strainers when the jaws are closed. This allows the animal to take in a mouthful of water and retain the krill while forcing the water out of the mouth with the tongue. It is an adaptation that works in a similar way to the baleen plates of the filter-feeding whales.

The females give birth on the drifting pack ice, with each family group separated from other crabeater seals by as much as one kilometer, or half a mile. The pups are born from the middle of September to early November, and are weaned after about a month. They then have to take to the water where they may be attacked almost immediately by predatory leopard seals. Crabeater seals stay mainly near the edge of the pack ice as it extends or retreats, but they need stretches of open water. They are commonly seen lying on the ice floes singly or in small groups. They live all around the continent, but in especially large numbers in the Ross Sea and around the Antarctic Peninsula.

Leopard Seal

As its name suggests, this seal is a predator. It is the only Antarctic seal that regularly eats warm blooded prey. A portion of its diet consists of penguins, but it also eats fish, krill, and even the young of other seals. The leopard seal has three long pointed cusps on its molar teeth, somewhat like the crabeater seal, which enables it to filter krill from sea water in much the same way that the crabeater does.

The sexes are nearly identical, although the females attain slightly larger sizes than the males. The males grow to a length of 3 meters (10 feet), and the females reach about 3.6 meters (12 feet). The typical appearance is a dark gray back shading into a lighter belly marked with leopard-like spots. Leopard seals are long and sinuous and have a very large and powerful head and neck, somewhat snake-like.

The leopard seal has none of the cute appeal of the other seals, but despite its ferocious reputation there have been very few cases of unprovoked attacks upon humans. These are solitary animals, and it is rare to see more than one individual in a particular area. They can be found throughout the pack ice and along coasts during the summer, patrolling the places where penguins gather to dive into the sea. They chase and catch penguins with great speed, often vigorously shaking their prey to break it into smaller pieces before swallowing it.

Like the other seals, apart from the fur seal, they breed and raise their young on the pack ice. Pups are born between November and December, and weaning takes about two months.

Some animals spend their winters near subantarctic islands such as South Georgia and Macquarie, and a few individuals have even been found off southern Australia and New Zealand, South Africa, and South America.

Ross Seal

The Ross seal is the least known of all the pinnipeds. It is a solitary animal and is quite rarely seen as it inhabits the thick pack ice and adjacent waters along the fringes of the Antarctic continent. The species was first described by Captain James Clark Ross during the British Antarctic Expedition of 1839-43. Few sightings were reported during the following hundred years, until the big icebreakers started to penetrate the seals' remote habitat.

Both seals are similar in size and appearance. They grow to about 2.8 meters (9.5 feet), and are dark greenish gray on the back, fading to a light gray on the belly. The head is small and the snout short, and there are light stripes around the throat and flanks. The eyes are large and bulging, which helps it to find food and avoid obstacles in the dark waters beneath the ice.

The Ross seal has very large and well-developed flippers compared with other seals. The incisor and canine teeth are delicate, sharp, and recurved for catching squid, its main source of food (though it also eats fish and krill). Very little is known of its breeding habits.

Antarctic Whales

Cetaceans, the group that includes all whales, dolphins, and porpoises, are air-breathing mammals, but have perfected the ability to live entirely in water. Unlike those other marine mammals, the seals, they never come ashore or onto ice at all.

Their hind legs have completely degenerated and a fluked tail for propulsion has developed. The front limbs have been transformed into pectoral fins, the nostrils have moved to the top of the head, and they have lost their fur. To keep warm, they have a thick layer of oil-rich blubber with which to insulate themselves from the cold waters. The thick layer of blubber also aids buoyancy because fat is lighter than water. In addition, it is used as stored food during times of migration and fasting. Essentially weightless in water, whales have been free to grow to a great size.

Whales inhale before diving (seals do the opposite), but the tremendous pressure exerted by water causes the lungs to collapse thereby compressing the retained air into cartilaginous supply tubes in the bronchial system. Whales have large lungs by comparison with most other mammals. And they are able to exchange up to 85 percent of the air in the lungs at each breath, compared with the 15-20 percent exchange which occurs during normal breathing in humans. Most of the larger species produce a visible vapor blow when they exhale at the surface. This is caused mainly by condensation when the air in the lungs is suddenly depressurized on exhalation into a cold atmosphere.



Humpback whale breaching

Teeth versus Baleen

There are two basic types of whales, those with teeth and those without teeth. The toothed whales include the dolphins, orca (which is actually a large dolphin), and sperm whale. The whales without teeth are known as the whalebone or baleen whales, and feed by filtering plankton through a series of baleen plates suspended from the position normally occupied by upper teeth.

Toothed whales actively pursue relatively large prey such as squid, fish, birds, seals, and other whales. The toothed whales have developed very useful sonar or echolocation systems with which they can locate and capture prey in even the dark water found at great depths. The ultrasonic pulses they transmit are inaudible to human ears, though for communication between each other they use trills, tweets, whistles, and grunts which are easily heard by humans.

The toothless whales feed in quite a different way from those with teeth. Their plates of horny baleen hang down vertically from the roof of the mouth. The inside edge of each plate has the frayed appearance of dense bristles, and the plates overlap one another so the frayed edges form a very efficient sieve. As the whale moves through the water it opens its huge jaws (most species also have expandable throats which increase the efficiency of this method of feeding) and takes in a large quantity of water. The water is squeezed out between the plates, thereby trapping any small prey animals, such as krill, tiny fish, etc., inside the mouth.

This process enables the baleen whales to take advantage of the huge quantities of available krill as well as other small organisms. Different species of baleen whales have different sizes of filter plates which allow them to coexist while feeding on different prey.

Baleen whales typically feed in relatively shallow water because the zooplankton which makes up most of their diet is dependent upon phytoplankton which in turn is dependent upon sunlight. Therefore they are not normally deep divers like some of the

toothed whales, and seldom dive to more than 90 meters (300 feet) below the surface.

The Antarctic baleen whales have a distinct annual cycle of breeding in the warm waters at low latitudes in the winter, and feeding in the cold Antarctic waters in the summer. Baby baleen whales, especially those of the larger species, must undergo an accelerated rate of growth to be weaned by the time they reach the feeding grounds in summer.

Massive Growth Rate

Cetacean milk has a large fat content and a thick consistency, which prevents it from mixing readily with sea water. This helps the baby whale to avoid swallowing too much water when it suckles. The rich, highly nutritious milk allows rapid growth. The extreme example of this is seen in the blue whale, whose offspring may gain weight at the rate of 4.5 kilograms (10 pounds) per hour!

Since baleen whales do not need great speed or agility while feeding, they can afford to grow to a great size. The blue whale, for instance, is believed to be the largest animal ever to have lived on Earth.

Southern Right Whale

This large whale is a slow moving animal, and its body is so rich in oil that it floats, even after death. It was therefore the right species to hunt in the old days of whaling. Both males and females average about 15 meters (50 feet) in length, with a maximum of 18 meters (60 feet), and average about 55,000 kilograms (60 tons) in weight, with a maximum of 96,000 kilograms (106 tons).

The coloring is pure black with some mottling of brown, as well as white callosities above the eyes, near the tip of the snout, and on the chin, and sometimes a white marking on the belly. Its body is extremely broad and smooth. There is no dorsal fin, so it should not be mistaken for any other large whale in Antarctic waters. The right whale has two widely separated blowholes



Humpback whale diving

which produce a high and distinctive V-shaped double spout. The tail of this species, which is broad with very pointed tips and a deep notch, is usually raised above the surface when the animal dives.

The head is very large, about 35 percent of the total body length, and there are no throat grooves. Therefore the animal cannot expand its throat significantly when feeding, like most baleen whales. Instead, it has a narrow and highly arched upper jaw which carries baleen plates more than 2 meters (7 feet) long. The right whale simply swims along with its mouth open and filters food items through its very long baleen plates as it moves through the water.

The southern right whale was greatly over-exploited by the whalers, due to its popularity as a prey species, and had almost disappeared by the end of the 19th century. Now totally protected, it is making a gradual recovery. The whales are most likely to be seen around South Georgia, and at one of their strongholds, the Valdez Peninsula in southern Argentina.

Rorquals

The group of baleen whales known as rorquals share the characteristic of having many throat grooves, which allows the throat to be expanded when feeding. Unlike the right whales, they engulf a single huge mouthful of water and then close their jaws and squeeze the water out through the short baleen plates. The advantage of this method is that with the throat constricted, they assume a surprisingly long and streamlined shape which allows them to swim at speeds as high as 30 kilometers per hour (16 knots). There are five species of rorqual whales in Antarctic waters. Four of them, belonging to the genus *Balaenoptera*, are closely related and differ mainly in size and coloration. They are difficult to identify.

Blue Whale

The blue whale is the largest of the rorquals, and is in fact the largest of all the cetaceans, the largest animal ever to have

appeared on our planet. It can exceed 30 meters (100 feet) in length, and weigh between 80,000 and 130,000 kilograms (90 -144 tons). The maximum recorded weight was 178,000 kilograms (196 tons). The color is hard to evaluate unless one is fairly close, but is a bluish gray, mottled with small white or light gray spots. It has a tiny triangular dorsal fin which becomes exposed long after the blow, and often the flukes are exposed as the animal dives.

The blue whale's blow is typical of all the species in this genus, a high powerful thin column, but it is comparatively bigger than the others.

In Antarctic waters blue whales feed almost entirely upon krill, and a large whale may consume 8,000 kilograms (over 8 tons) of these tiny animals in a day. At the end of the Antarctic summer, the whales move northward where they live off their blubber and gather in small groups for courtship and mating. The females breed about once every three years.

There are separate populations of blue whales in the North Pacific, North Atlantic, and Southern Oceans. The species was seriously over-exploited by the whalers, to the point where it has not yet managed to make much of a recovery. They are usually seen either on their own or in small groups of three or four.

Fin Whale

The fin whale is the next largest cetacean, with a length of up to 27 meters (89 feet). The weight ranges from 35,000 to 45,000 kilograms (40 -50 tons) with a maximum of 80,000 kilograms (90 tons). It is relatively easy to identify since it is a very large species and has a prominent, V-shaped dorsal fin hence its name. The back also has ridges from the dorsal fin to the tail, which gave rise to one of its other names, 'razorback.'

The fin whale is unique among the rorquals in that it is counter shaded, with a black or dark brown back and a white or light colored underside. A close look will show that the fin whale's coloration is asymmetrical, with the right side of the head and lower right lip being pale, while the left side of the head and the



Humpbacks often leap completely out of the water to fall on their backs with a tremendous splash.

lower left lip is a darker color. Asymmetry is unusual in animals, and in this case may be connected with its method of catching krill. It rolls sideways to the right and swims in a tight circle, so that its paler right side is underneath and camouflaged.

The fin whale is probably the fastest swimmer of the great whales, with a top speed of about 18 knots. It not only eats krill, but also feeds on fishes such as sardines, anchovies, Pollack, and squid.

The fin whales blow is a high, vertical spout, and it may sometimes leap clear of the water. Its relatively fast speed saved it, initially, from the whalers but with the introduction of the fast catcher boats, its turn came for over-exploitation. Like other species it is now protected, but there is little information about its population status.

Sei Whale

Sei whales generally avoid the coldest waters closest to the ice, so they are rarely seen near the continent. This species is quite large, averaging about 15 meters (50 feet) in length, and 12,000 to 15,000 kg (14-17 tons) in weight. The coloration is mostly dark steely gray but with a lighter throat and belly. There is usually some light mottling on the flanks and belly. It has a high vertical dorsal fin, rather like that of the fin whale, but it does not arch its back high out of the water, as the fin whale does, when at the surface.

The sei whale is a generalist feeder, favoring krill, but will also eat small schooling fish when the opportunity arises. It is interesting to note that this species often rolls onto its side when feeding, like the fin whale, but will continuously roll first to one side and then to the other.

Antarctic Minke Whale

The smallest rorqual is the minke, or piked whale. It averages about 8 meters (26 feet) in length with a maximum of 10 meters (33 feet). Its average weight is 5,800-7,250 kilograms (6-8 tons), with a maximum of 9,000 kilograms (10 tons). The rostrum, or snout, is very distinctive in that it is narrow and very pointed. The coloration is dark bluish gray above and light gray underneath, with two comparatively pale bracket marks above the flipper extending across the back. Its relatively large, pointed dorsal fin is located far back on the body.

The minke whale does not usually produce a very noticeable spout, because it often begins to exhale before it breaks surface. It often leaps clear of the water, usually two or three times in succession, and has the peculiar habit, for a baleen whale anyway, of approaching ships, which it may dive under, from side to side. It is commonly seen close inshore, and in among the pack ice.

This species is a fast swimmer, and in places where krill are not readily available it often eats small schooling fish and squid. It tends to be a vigorous feeder, with a lot of leaping and splashing accompanying what may almost be described as a feeding frenzy.

Minke whales seem to have flourished following the decimation of the larger baleen whales, because they have taken advantage of the increased food resource. As with most whale species and populations, there are conflicting opinions on numbers but there may be half a million of them altogether, with nearly half that total being found in the Antarctic. The Japanese still catch this species, using pelagic factory ships to take about 400 annually during population surveys of all species. There is opposition to this catch by several countries and whale protection organizations.

Humpback Whale

The humpback belongs to a different genus from the other rorquals. It shares the same general lifestyle as the others, but does not have the same long, sleek body shape. Comparatively broader and more massive, it averages about 15 meters (50 feet) in length with a maximum of 19 meters (62 feet), and weighs about 30,000 - 40,000 kilograms (34- 35 tons) with a maximum of 48,000 kilograms (53 tons).

The body characteristics and its behavior make this the easiest great whale to identify. Its coloration is basically black or dark grey with a white throat area. The ventral surface of the tail is also white, as well as most of the flippers (which are nearly one third the total length of the body). The humpback whale's broad bushy blow is distinctive, as is its dorsal fin which is small but mounted on a fleshy hump. Its head and jaws are covered with fleshy tuberosities, and barnacles are often attached to the body.

Humpbacks often leap completely out of the water to land on their backs with a tremendous splash. Besides breaching, the humpback whale waves and slaps its enormous flippers on the surface of the water to make a loud sound rather like a gun shot, and almost always exposes its great tail flukes when it dives. This species is amazingly acrobatic and energetic and never fails to create excitement among visitors lucky enough to encounter one.

In Antarctic waters the normal feeding method is to lunge forward near the surface, or come up on their prey from below. Humpback whales are famous for communicating with each other by means of long, plaintive, and varied songs. These songs have been intensively studied in recent years. Like other baleen whales, their numbers are now greatly depleted, but they are regularly seen in small groups in Antarctic waters, especially around the Antarctic Peninsula.



Kayakers witness a breaching Minke whale

Arnoux's Beaked Whale

This toothed whale averages about 9 meters (30 feet) in length and weighs 6,400 kilograms (7 tons). It is blue gray in color and has a bulbous forehead, or melon, and a pronounced beak. The lower jaw extends beyond the upper, revealing the foremost pair of teeth. This species has only two pairs of teeth, and they are all in the lower jaw. The flippers are broad and rounded, the dorsal fin is small and triangular and set far back, and the flukes are large and pointed with little or no notch between them.

Both males and females usually bear pale scars on their backs and flanks, presumably caused by the teeth of others of their kind during mating conflicts. This whale is very uncommon, and little is known of its life history. Squid beaks have been recovered from the stomachs of stranded specimens. It has been recorded around South Georgia and the Antarctic Peninsula.

Southern Bottlenose Whale

This smallish species is about 6 -8 meters (20 -26 feet) long and weighs 3,600 kilograms (3 tons). The body is rather cylindrical in the fore section but tapers off towards an elongated tail. It has an enormous melon, which is evidence of its deep diving ability. The tail is very broad with pointed tips. It is usually a deep metallic gray in color, shading to bluish on the flanks, but may also be slightly brownish. The dorsal fin is sickle-shaped and located far back on the body.

The southern bottlenose whale has only one pair of small teeth located at the tip of the lower jaw. Stomach analysis of dead animals suggests that this species feeds mostly on squid and pelagic fish. It is rarely seen, and most studies have been restricted to dead specimens which have been washed up on beaches.

Sperm Whale

This is by far the largest of the toothed whales. Males average 15 meters (50 feet) in length and 36,000 kilograms (40 tons) in weight, and the much smaller females average 11 meters (36 feet) in length and 20,000 kilograms (22 tons) in weight. In profile, this whale is unmistakable, with an enormous square head that makes up one third of the total body length. The lower jaw is long and narrow, and seems rather puny compared to the overall size of the head.

There is no true dorsal fin, but most animals have a series of knobs or lumps on their back with the front one being the largest. Much of the body surface is covered with crenulations, making it look as if the body has shrunk within its skin. The normal coloration is dark gray or brownish (pure white specimens like the mythical Moby Dick have actually been seen, but rarely).

Unlike all other cetaceans, the blow hole of the sperm whale is at the foremost upper point of the snout, and is left of center. The blow is very characteristic because it shoots out in a forward direction and to the left. One can easily identify the sperm whale from its blow, and also tell in which direction the animal is swimming. The flippers are short and stubby, and the tail is very strong and somewhat square in shape (this species usually makes steep dives and exposes its tail as it goes under).

Sperm whales feed primarily on squid, including giant deep-sea species, but also prey on skates, sharks, and a variety of fish. They often bear the distinctive sucker marks from the tentacles of giant squid. They are champion divers, and are known to have dived to at least 3,000 meters (10,000 feet). While most dives are only about 10 minutes long, they can stay underwater for an hour or more.

Solitary males migrate long distances, ranging from equatorial waters in the winter right to the edge of the Antarctic ice in the summer, in the case of non-breeding males. The females and



Orcas

young generally stay closer to tropical waters throughout the year, and are rarely seen in Antarctica.

In the heyday of whaling, sperm whales were caught largely by United States vessels based at New England ports and later at San Francisco. At one time, sperm whales comprised 40 percent, by weight, of the total catch of all species of whales. They were valued mainly for their oil and also for spermaceti, a liquid wax obtained from the whales forehead; this was used for cosmetics, ointment, and candles. A few sperm whales are still hunted from shore stations in the northern hemisphere.

Orca (Killer Whale)

The orca is the largest of the dolphins, and probably the most easily recognized of all cetaceans. It is of medium size, reaching 9.5 meters (31 feet) in length for males and 7 meters (23 feet) for females. They are heavy bodied with a blunt head. Their coloration is very striking with most of the body a glossy black, except for a highly contrasted bright white belly extending onto the flanks, and a patch just behind the eye. There is also a gray saddle mark behind the dorsal fin.

The most obvious feature is the enormous dorsal fin, which is the tallest and most pointed of any cetacean. In adult males it may stand 2 meters (6 feet) in height, while in females and immature males it is more curved and shark-like.

Orcas normally travel in pods of 5 - 20 individuals, usually an extended family. These groups are very cohesive and exhibit a high degree of cooperation in hunting prey and caring for one another. The animals are top predators and feed on a large variety of prey including squid, sharks, rays, fish, seabirds, seals, and even other cetaceans. There are accounts of large whales being attacked by a pod of killer whales acting together rather like a moose being attacked by wolves.

They are seen quite often from ships in the Antarctic, and sometimes change course to get a closer look. They can also be seen spy-hopping, when they rise vertically in the water to look around for prey.

Dolphins

There are two small dolphins which are sometimes encountered within the Antarctic Convergence. The hourglass dolphin can be found all the way to the edge of the ice pack, whereas the Commerson's dolphin may be found at Kerguelen, South Georgia, and at the Falkland Islands (Islas Malvinas). Both species have highly contrasting and distinctive black and white markings.

The hourglass dolphin often leaps out of the water and likes to bow-ride in front of ships, which makes identification quite easy. It is a very fast swimmer and can easily overtake ships moving at 22 km per hour (12 knots) when it wants to. Little is known about the life history of this species, but it seems to be fairly common in cold southern waters, feeding mainly on fish and squid.

Commerson's dolphin is a thick bodied little animal that is more porpoise-shaped than dolphin-shaped. It has a broad flat head, small rounded flippers, and a low rounded dorsal fin. It is usually found in shallow areas near land, including isolated islands. It sometimes jumps clear of the water, but most often just rolls at the surface. It feeds on krill, squid, and small fish.



SECTION 7

WILDLIFE CHECKLIST

Gentoo penguins

It is pretty to see the snow petrel and Antarctic petrel diving on to the upturned and flooded floes.
– Robert F. Scott

ANTARCTIC BIRDS (SOUTH OF THE ANTARCTIC CONVERGENCE)

Penguins

- King penguin (*Aptenodytes patagonicus*)
- Emperor penguin (*Aptenodytes forsteri*)
- Adélie penguin (*Pygoscelis adeliae*)
- Chinstrap penguin (*Pygoscelis antarctica*)
- Gentoo penguin (*Pygoscelis papua*)
- Macaroni penguin (*Eudyptes chrysolophus*)
- Rockhopper penguin (*Eudyptes chrysocome*)

Albatross

- Wandering albatross (*Diomedea exulans*)
- Royal albatross (*Diomedea epomophora*)
- Black-browed albatross (*Diomedea melanophrys*)
- Grey-headed albatross (*Diomedea chrysostoma*)
- Light-mantled sooty albatross (*Phoebastria palpebrata*)

Petrels

- Southern giant petrel (*Macronectes giganteus*)
- Northern giant petrel (*Macronectes halli*)
- Southern fulmar (*Fulmarus glacialis*)
- Cape petrel, or pintado or cape pigeon (*Daption capense*)
- Antarctic petrel (*Thalassoica antarctica*)
- Snow petrel (*Pagodroma nivea*)
- Kerguelen petrel (*Pterodroma brevirostris*)
- White-headed petrel (*Pterodroma lessonii*)
- Soft-plumaged petrel (*Pterodroma mollis*)
- Grey petrel (*Procellaria cinerea*)
- White-chinned petrel (*Procellaria aequinoctialis*)
- Blue petrel (*Halobaena caerulea*)
- Broad-billed prion, Antarctic prion (*Pachyptila vittata*)
- Slender-billed prion (*Pachyptila belcheri*)
- Fairy prion (*Pachyptila turtur*)
- Sooty shearwater (*Puffinus griseus*)

Storm-Petrels

- Wilson's storm-petrel (*Oceanites oceanicus*)
- Black-bellied storm-petrel (*Fregetta tropica*)
- Grey-backed storm-petrel (*Garrodia nereis*)

Diving Petrels

- Georgian diving-petrel (*Pelecanoides georgicus*)
- Common diving-petrel (*Pelecanoides urinatrix*)

Cormorants

- Blue-eyed shag (*Phalacrocorax atriceps*)

Ducks

- South Georgia pintail (*Anas georgica*)
- Speckled teal (*Anas flavirostris*)

Sheathbills

- Pale-faced sheathbill (*Chionis albus*)
- Black-faced sheathbill (*Chionis minor*)

Gulls and Terns

- Brown skua (*Catharacta antarctica*)
- South Polar skua (*Catharacta maccormicki*)
- Kelp gull (*Larus dominicanus*)
- Antarctic tern (*Sterna vittata*)
- Arctic tern (*Sterna paradisaea*)

Perching Birds

- South Georgia pipit (*Anthus antarcticus*)

Vagrants

- Cattle egret (*Bubulcus ibis*)
- Black-necked Swan (*Cygnus melanocoryphus*)

MARINE MAMMALS OF ANTARCTICA & SURROUNDING WATERS

Seals

- Antarctic fur seal (*Arctocephalus gazella*)
- Kerguelan fur seal (*Arctocephalus tropicalis*)
- New Zealand fur seal (*Arctocephalus forsteri*)

- South American sea lion (*Otaria lavesdens*)
- New Zealand (hookers) sea lion (*Phocarctos hookeri*)
- South American fur seal (*Arctocephalus australis*)
- Southern elephant Seal (*Mirounga leonina*)
- Weddell seal (*Leptonychotes weddellii*)
- Crabeater seal (*Lobodon carcinophaga*)
- Leopard seal (*Hydrurga leptonyx*)
- Ross seal (*Ommatophoca rossii*)

WHALES

Baleen Whales

- Southern right whale (*Eubalaena australis*)
- Blue whale (*Balaenoptera musculus*)
- Fin whale (*Balaenoptera physalus*)
- Sei whale (*Balaenoptera borealis*)
- Antarctic minke whale (*Balaenoptera bonarerenensis*)
- Humpback whale (*Megaptera novaeangliae*)

Toothed Whales

- Arnoux's beaked whale (*Berardius arnuxii*)
- Southern bottlenose whale (*Hyperoodon planifrons*)
- Sperm whale (*Physeter macrocephalus*)
- Orca (*Orcinus orca*)
- Hourglass dolphin (*Lagenorhynchus cruciger*)
- Peales dolphin (*Lagenorhynchus australis*)
- Southern right whale dolphin (*Lissodelphis peronii*)
- Commerson's dolphin (*Cephalorhynchus commersonii*)

BIRDS OF PATAGONIA AND TIERRA DEL FUEGO

This list of common birds likely to be seen near Ushuaia and Punta Arenas, is adapted from Canelo, Claudio Venegas. Aves de Patagonia y Tierra del Fuego Chileno-Argentina. Punta Arenas, Chile: Ediciones de la Universidad de Magallanes, 1986, 79 pages.

Rheas

- Lesser rhea (*Pterocnemia pennata*)

Tinamous

- Patagonian tinamou (*Tinamotis ingouti*)

Grebes

- White-tufted grebe (*Podiceps rolland*)
- Silvery grebe (*Podiceps occipitalis*)
- Great grebe (*Podiceps major*)

Albatross

- Black-browed albatross (*Diomedea melanophrys*)

Petrels

- Southern giant petrel (*Macronectes giganteus*)
- Cape petrel (*Daption capense*)
- Great shearwater (*Puffinus gravis*)
- Sooty shearwater (*Puffinus griseus*)

Storm-Petrels

- Wilson's storm-petrel (*Oceanites oceanicus*)

Diving Petrels

- Magellanic diving petrel (*Pelecanoides magellani*)
- Common diving petrel (*Pelecanoides urinatrix*)

Penguins

- King penguin (*Aptenodytes patagonicus*)
- Magellanic penguin (*Spheniscus magellanicus*)

Cormorants

- Neotropic cormorant (*Phalacrocorax olivaceus*)
- Rock cormorant (*Phalacrocorax magellanicus*)
- Blue-eyed shag (*Phalacrocorax atriceps*)

Hérons

- White-necked heron (*Ardea coccol*)
- Snowy egret (*Egretta thula*)
- Cattle egret (*Bubulcus ibis*)
- Black-crowned night heron (*Nycticorax nycticorax*)

Ibis

- Buff-necked ibis (*Theristicus caudatus*)

Flamingos

- Chilean flamingo (*Phoenicopterus chilensis*)

Waterfowl

- Coscoroba swan (*Coscoroba coscoroba*)
- Black-necked swan (*Cygnus melancoryphus*)
- Ashy-headed goose (*Chloephaga poliocephala*)
- Ruddy-headed goose (*Chloephaga rubidiceps*)
- Upland goose (*Chloephaga picta*)
- Kelp goose (*Chloephaga hybrida*)
- Flying steamer duck (*Tachyeres patagonicus*)

Birds of Prey

- Andean condor (*Vultur gryphus*)
- Turkey vulture (*Cathartes aura*)
- Cinereus harrier (*Circus cinereus*)
- Long winged harrier (*Circus buffoni*)
- Bicolored hawk (*Accipiter bicolor*)
- Black-chested buzzard eagle (*Geranoaetus melanoleucus*)
- Red-backed hawk (*Buteo polysoma*)
- Rufous-tailed hawk (*Buteo ventralis*)
- Crested caracara (*Polyborus plancus*)
- Striated caracara (*Phalcoboenus australis*)
- Chimango caracara (*Milvago chimango*)
- American kestrel (*Falco sparverius*)
- Aplomado falcon (*Falco femoralis*)
- Peregrine falcon (*Falco peregrinus*)

Coots

- Red-gartered coot (*Fulica armillata*)
- White-winged coot (*Fulica leucoptera*)
- Red-fronted coot (*Fulica ruftfrons*)

Shore birds

- Magellanic oystercatcher (*Haematopus leucopodus*)
- Black oystercatcher (*Haematopus ater*)
- Southern lapwing (*Vanellus chilensis*)
- Black-bellied plover (*Pluvialis squatarola*)
- Golden plover (*Pluvialis dominica*)
- Two-banded plover (*Charadrius falklandicus*)
- Semipalmated plover (*Charadrius semipalmatus*)
- Rufous-chested dotterel (*Zonibyx modestus*)

- Magellanic plover (*Pluvianellus socialis*)
- Greater yellowlegs (*Tringa melanoleuca*)
- Lesser yellowlegs (*Tringa flavipes*)
- Whimbrel (*Numenius phaeopus*)
- Ruddy turnstone (*Arenaria interpres*)
- Sanderling (*Calidris alba*)
- White-rumped sandpiper (*Calidris fuscicollis*)

Gulls and Terns

- Chilean skua (*Catharacta chilensis*)
- Dolphin gull (*Larus scoresbii*)
- Kelp gull (*Larus dominicanus*)
- Franklin's gull (*Larus pipixcan*)
- Brown-hooded gull (*Larus maculipennis*)
- South American tern (*Sterna hirundinacea*)

Doves

- Rock dove (*Columba livia*)
- Eared dove (*Zenaida auriculata*)
- Black-winged ground dove (*Metriopelia melanoptera*)

Hummingbirds

- Green-backed firecrown (*Sephanoides galeritus*)

Kingfishers

- Ringed kingfisher (*Ceryle torquata*)

Woodpeckers

- Striped woodpecker (*Picoides lignarius*)
- Chilean flicker (*Colaptes pitius*)
- Magellanic woodpecker (*Campephilus magellanicus*)

Ovenbirds and allies

- Common miner (*Geositta cunicularia*)
- Short-billed miner (*Geositta Antarctica*)
- Scale-throated earthcreeper (*Upucerthia dumetaria*)
- Bar-winged cinclodes (*Cinclodes fuscus*)
- Grey-flanked cinclodes (*Cinclodes oustaleti*)
- Dark-bellied cinclodes (*Cinclodes patagonicus*)
- Blackish cinclodes (*Cinclodes antarcticus*)
- Thorn-tailed rayadito (*Aphrastura spinicauda*)
- Plain-mantled tit spinetail (*Leptasthenura aegithaloides*)
- Lesser canastero (*Thripophaga pyrrholeuca*)
- Austral canastero (*Thripophaga anthoides*)
- Wren-like rushbird (*Phleocryptes melanops*)
- White-throated treerunner (*Pygarrhynchus albogularis*)
- Andean tapaculo (*Scytalopus magellanicus*)

Flycatchers

- Great shrike tyrant (*Agriornis livida*)
- Black-billed shrike tyrant (*Agriornis Montana*)
- Fire-eyed diucon (*Pyrope pyrope*)
- Rufous-backed negrito (*Lessonia rufa*)
- Tufted tit tyrant (*Aniorettes parulus*)
- Patagonian tyrant (*Colorhamphus parvirostris*)

Phytotomidae

- Rufous-tailed plantcutter (*Phytotoma rara*)

Swallows

- Chilean swallow (*Tachycineta leucopyga*)
- Blue and white swallow (*Pygochelidon cyanoleuca*)
- Cliff swallow (*Hirundo pyrrohonota*)
- Barn swallow (*Hirundo rustica*)

Wrens

- House wren (*Troglodytes aedon*)
- Grass wren (*Cistothorus platensis*)

Thrushes

- Austral thrush (*Turdus falcklandii*)

Mockingbirds

- Patagonian mockingbird (*Mimus patagonicus*)

Pipits

- Corredera pipit (*Athus correndera*)

Finches and allies

- Patagonian yellow finch (*Sicalis lebruni*)
- Rufous-collared sparrow (*Zonotrichia capensis*)
- Yellow-winged blackbird (*Agelalus thilius*)
- Longtailed meadowlark (*Sturnella loyca*)
- Shiny cowbird (*Molothrus bonariensis*)
- Austral blackbird (*Curaeus curaesus*)
- Patagonian sierra finch (*Phrygilus patagonicus*)
- Common diuca finch (*Diuca diuca*)
- Black-throated finch (*Melanodera melanodera*)
- Yellow-bridled finch (*Melanodera xanthogramma*)
- Black-chinned siskin (*Carduelis barbatus*)
- House sparrow (*Passer domesticus*)

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