ANTARCTIC OCEAN ALLIANCE

PROTECTING THE WILD SOUTH

ANTARCTIC OCEAN LEGACY: A MARINE RESERVE FOR THE ROSS SEA

EXECUTIVE SUMMARY

In October 2011, the Antarctic Ocean Alliance proposed the creation of a network of marine protected areas and no-take marine reserves in 19 specific areas in the Southern Ocean around Antarctica. The Antarctic Ocean Alliance is a coalition of environmental organisations that is calling for large-scale protection of critical marine habitats.

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the body that regulates this marine environment, has set a target date of 2012 for establishing the initial areas in a network of Antarctic marine protected areas.

One of the key places that the Antarctic Ocean Alliance seeks protection for is the Ross Sea region, including the Balleny Islands, the Pacific seamounts and the Ross Sea embayment. This report describes our proposal and the rationale for its designation. This is the first in a series of "Antarctic Ocean Legacy" proposals from the Alliance.

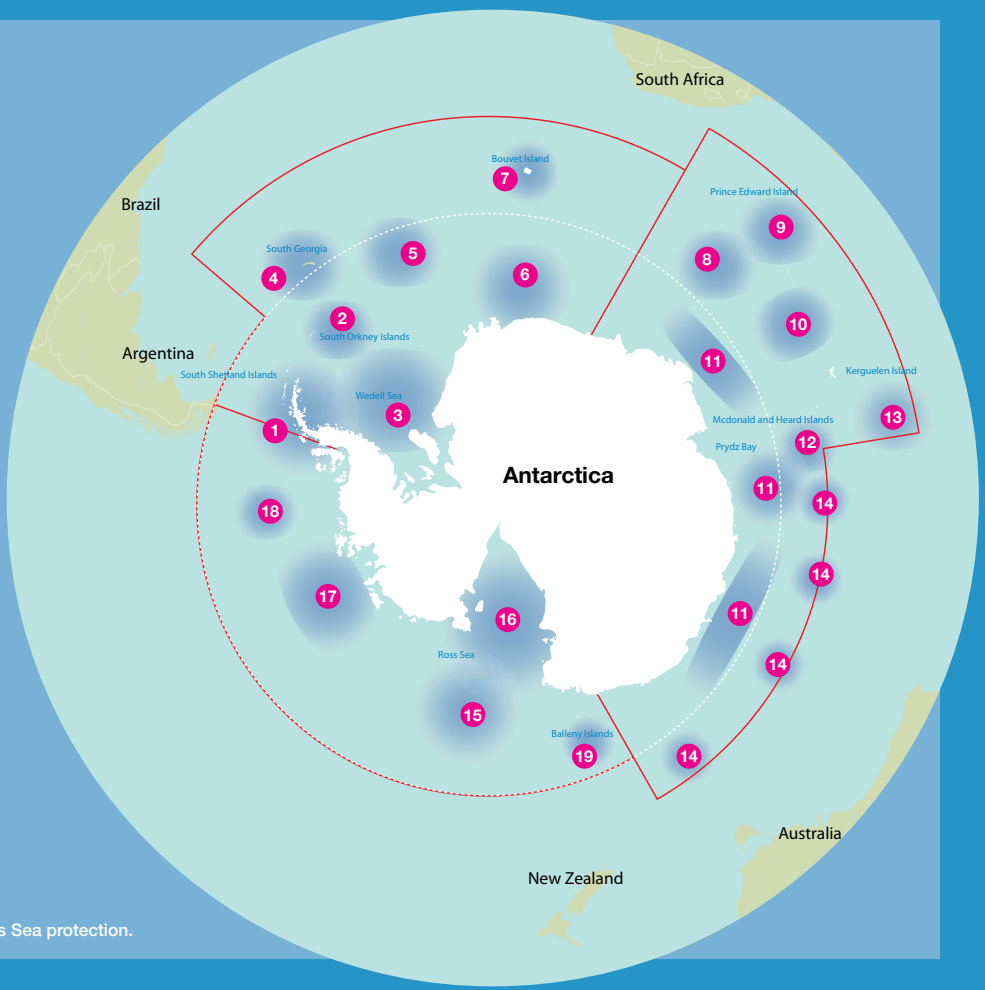
For the Ross Sea region, our proposal is to establish a fully protected marine reserve of approximately 3.6 million square kilometers. This proposal is justified based on the work of scientists, governments and non-government organisations (NGOs) over the past five years highlighting the environmental importance of the region. Over 500 scientists worldwide have supported the call to protect vital Ross Sea habitats including the whole continental slope and shelf because of their environmental and scientific significance.

This report starts with a description of the fascinating ecosystems in the Ross Sea region. It examines the marine research that has been done to date in light of two useful scenarios developed by the United States and New Zealand governments. We conduct an analysis of those scenarios and conclude that the best elements of all this work can be brought together in a combined and enhanced proposal that truly protects the critical, unique and precious Ross Sea ecosystem.

AOA indicative map of a representative network of marine protected areas and no-take marine reserves in the Southern Ocean

1. Antarctic Peninsula
2. South Orkney Islands
3. Weddell Sea
4. South Georgia
5. South Sandwich Islands Arc
6. Maud Rise
7. Bouvetoya
8. Ob & Lena Banks
9. Del Cano Region High Seas
10. Kerguelen Plateau High Seas Area
11. Eastern Antarctic Shelf
12. Banzare Bank
13. Kerguelen Production Zone
14. Indian Ocean Benthic Environment
15. Pacific Seamounts*
16. Ross Sea*
17. Amundsen & Belllingshausen Seas (West Antarctic Shelf)
18. Peter I Island
19. Balleny Islands*

*Areas included in the AOA proposal for Ross Sea protection.



The proposal for a marine reserve put forth by the Antarctic Ocean Alliance in this document seeks to protect large-scale ecosystem processes in their entirety. This includes the:

1. Protection of the biodiversity and ecological processes associated with the Ross Sea gyre.
2. Protection of areas critical to the life-history stages of the Antarctic toothfish – the region's top fish predator. These include the feeding and spawning grounds of the toothfish.
3. Protection of critical geomorphic features including the seamounts, ridges and troughs of the Pacific Antarctic Ridge, and associated life forms.
4. Broad protection that facilitates the continuation and expansion of long-term datasets that underpin crucial research into ecosystem function and environmental change, including the impacts of climate change, particularly ocean acidification.
5. Protection of biodiversity hot spots such as the Ross Sea shelf and slope, Balleny Islands, Pacific Antarctic Ridge and the Scott Seamounts.
6. Protection of the Ross Sea region as a critical climate reference area, and climate refugium for ice-dependent species.

For these reasons we recommend the protection of the Ross Sea region as described in the Proposal section of this report.

The Ross Sea is a keystone in any future Southern Ocean conservation network; its designation as a large-scale marine reserve would be an important and inspirational step for marine protection both in the Southern Ocean and globally. There is an unprecedented opportunity to establish the world's largest network of marine protected areas and no-take marine reserves in the oceans around Antarctica as a legacy for future generations – the most comprehensive regime of its kind on the planet. With such a network in place, key Southern Ocean habitats and wildlife would be protected from destructive human activities. We believe that with visionary political leadership, CCAMLR can grasp this opportunity.

Icebergs Southern Ocean © *Sylvia Rubli WWF – Canon*

Underwater color in the icy Ross Sea *Image by John B. Weller*

CONTENTS

Image by John B. Weller

ABOUT THE ANTARCTIC OCEAN ALLIANCE

The Antarctic Ocean Alliance is a coalition of leading environmental and conservation organisations and philanthropists, including the Antarctic and Southern Ocean Coalition (ASOC), Greenpeace, WWF, the Blue Marine Foundation (UK), Mission Blue (US), Oceans 5 (US), The Last Ocean, Forest and Bird (NZ), ECO (NZ), Deepwave (Germany), Humane Society International (HSI), and associate partners the Natural Resources Defense Council (NRDC), the Korea Federation for Environmental Movement (S. Korea), Greenovation Hub (China), Oceana, the International Fund for Animal Welfare (IFAW), Ocean Planet (Australia), the Whale and Dolphin Conservation Society, and other groups worldwide.

ANTARCTIC OCEAN ALLIANCE
PROTECTING THE WILD SOUTH

INTRODUCTION

Image by John B. Weller

The Ross Sea is a region of astounding beauty, natural wonder, and high biodiversity centred on the Ross Sea itself. Discovered by James Clark Ross in 1841, the Ross Sea is a large horseshoe-shaped embayment in the Antarctic landmass below New Zealand. It was the scene of many of the exploits of the heroic era of Antarctic exploration – Scott's first expedition in 1901-1904, Shackleton's first expedition in 1907-1909, and was the starting point for the race to the pole between Scott and Amundsen in 1911-12. The first Japanese expedition, coinciding with the race to the pole, started just to the east of the Ross Sea. Beginning from these earliest efforts in Antarctic exploration, it has received significant scientific attention and has been the focus of intensive research[1].

Midnight sun over ice *Image by John B. Weller*

The ecosystems of the Southern Ocean including the Ross Sea region are primarily governed by the Convention on the Conservation of Antarctic Marine Living Resources (CAMLR Convention), a key component of the Antarctic Treaty System. This Convention gives CCAMLR the authority to designate marine protected areas (MPAs) and marine reserves within the Southern Ocean[2]. In 2005, CCAMLR began to seriously consider the designation of MPAs; a progressive and unprecedented step given that at that time there were no high seas MPAs or marine reserves in existence. In 2008, CCAMLR identified 11 areas of interest for designating MPAs, including the Ross Sea region.

CCAMLR agreed to a process in 2009 that would enable the creation of a representative network of marine protected areas across all 11 areas by 2012. Then in 2011, CCAMLR refined the 11 priority areas into nine "planning domains", with one domain centred on the Ross Sea region. The Antarctic Ocean Alliance has recognised 19 specific areas within these planning domains where the implementation of marine protection is crucial to ensure Southern Ocean biodiversity is adequately protected.

To ensure meaningful protection of the Southern Ocean, it is absolutely critical that CCAMLR designate a large-scale, no-take marine reserve in the Ross Sea planning domain as a key component of the Southern Ocean MPA network. As the least human-impacted marine region on the earth[3], the Ross Sea can serve as a natural laboratory for researchers studying not only the effects of climate change and the evolution of marine species, but also the function of large-scale ecosystem processes in a relatively undisturbed state[4]. This can greatly enhance our understanding of how ecosystems function and how to minimise human impacts.

Decades of research have revealed that the Ross Sea is a biodiversity hotspot possessing many unique ecological characteristics. The unusually high species richness begins in the depths with some of the best studied benthic (bottom-dwelling) ecological communities[5] in the Southern Ocean. While many other marine ecosystems have been altered significantly by human activity, the highly productive Ross Sea foodweb remains much the same as it has for centuries, with sizable populations of top predators including large fish, sea birds, penguins, seals and whales[6].

The Ross Sea supports large proportions of the world's populations of some of the most well-known and charismatic Antarctic species, including at least[7]:

- 38% of the world population of Adélie penguins
- 26% of the world population of emperor penguins
- 30% or more of the world population of Antarctic petrels
- 6% of the world population of Antarctic minke whales
- 45% of the Southern Pacific population of Weddell seals
- 50% of the world's Ross Sea killer whales (Type C)

THE ROSS SEA REGION

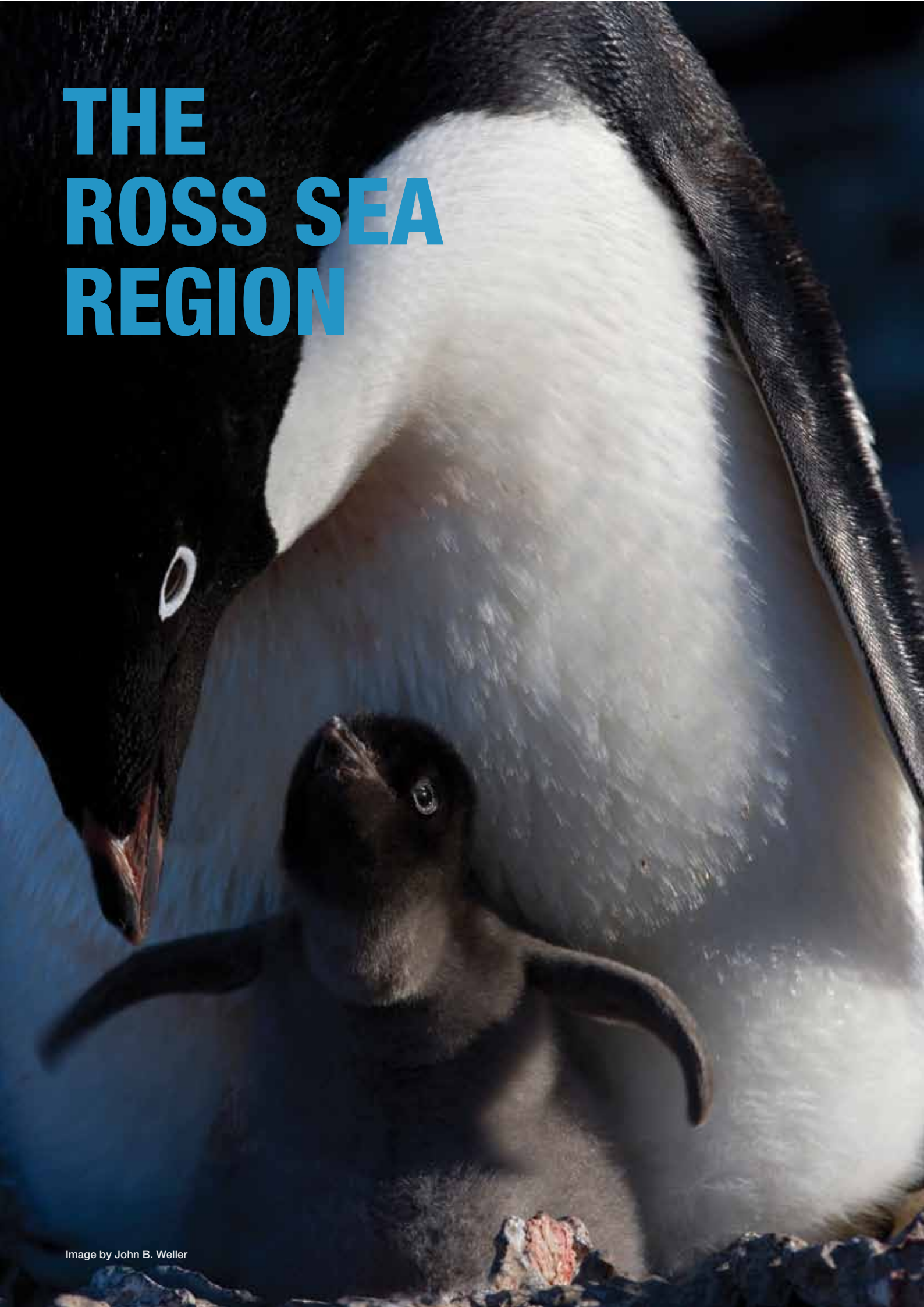


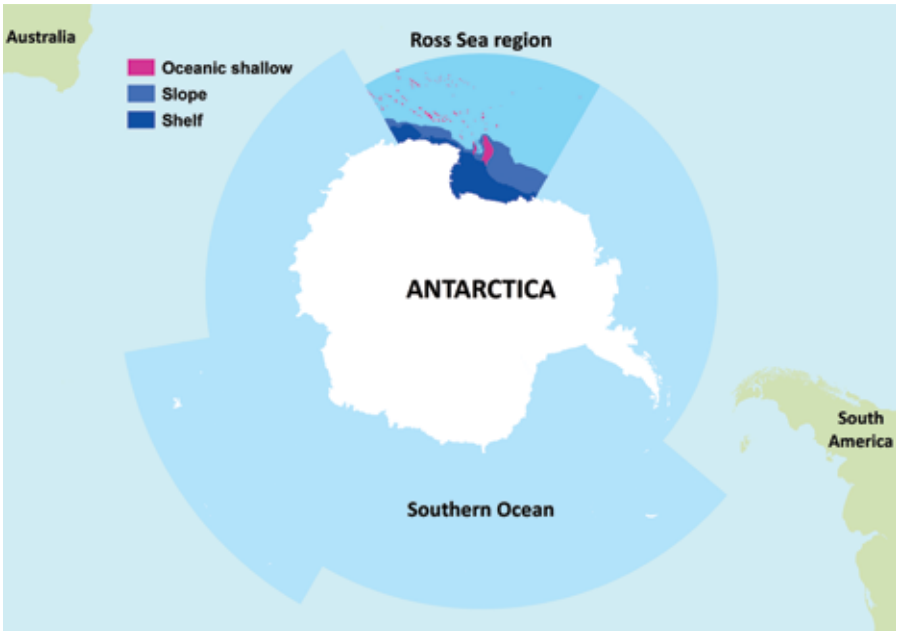
Image by John B. Weller

1 DEFINITION OF THE 'ROSS SEA'

Image by John B. Weller

The Ross Sea is the body of water south of a line drawn from Cape Adare, Victoria Land in the west to Cape Colbeck, Marie Byrd Land, in the east. For the purposes of this report, the Ross Sea region is defined as the waters overlying the continental shelf and slope extending north to encompass the Balleny Islands and Pacific – Antarctic Ridge Seamounts. This larger area includes the waters lying between 150° east and 150° west bounded by the Antarctic continent to the south and the 60° south parallel. This area also corresponds to the Ross Sea planning domain defined by CCAMLR in 2011 to aid the development of marine protection in the region. The Balleny Islands consist of three large and three small islands that are the exposed summits of a volcanic deep-rising seamount chain located approximately 200km northwest of Cape Adare.

Map of the Ross Sea region, relative to the rest of Antarctica



The Ross Sea is one of two areas of the Southern Ocean with a wide and deep continental shelf – the other being the Weddell Sea. Its average depth is 500m, with a shelf break at 800m and a 3000m deep slope[8]. In most other parts of the Antarctic the shelf is narrow or absent. The Ross Sea shelf is also notable because it is shallower at its northern extent with a ridge that runs north-west from Cape Colbeck to the Pennel Bank close to the shelf break. The shelf then gets deeper again as one moves southward towards the Ross Ice Shelf. It is believed that this ridge located at the shelf edge is a glacial feature (terminal moraine) that indicates the maximum advance of the previous glacial period[9]. This deeper area of the shelf contains two troughs, deeper than 900m, located north of Ross Island, and three shallower troughs in the eastern portion of the Ross Sea.

The southern portion of the Ross Sea is overlain by the Ross Ice Shelf, the world's largest floating ice sheet, an extension of the continental ice sheet covering West Antarctica. The ice sheet, which makes up about one-third of the Antarctic ice shelf, has a mean thickness of 250 metres and is half a million square kilometres in area[10]. The Ross Sea polynya (open water surrounded by sea ice) and several other smaller polynyas occur near the Victoria Land coast[11]. Antarctic coastal polynyas are biologically very productive because these areas do not have a thick ice cover and therefore sunlight can penetrate the ocean early in the spring. These polynyas are also the source of a large portion of Antarctic Bottom Water that eventually finds its way into the northern hemisphere as part of the global ocean conveyor belt, a key component of the global climate system.

2 THREATS TO AN INTACT LARGE MARINE ECOSYSTEM

Image by John B. Weller

The near-pristine Ross Sea is one of the last open-ocean, continental shelf ecosystems in which the foodweb has not been subjected to serious or permanent change as a result of human activities. It is recognised as the least impacted open ocean marine area on earth[12].

The Ross Sea region does have a limited history of exploitation activities. However, these past activities (sealing and whaling) were far less intensive and damaging in the Ross Sea than in many other parts of the region, and consequently have had very little impact on the intactness of the ecosystem[13]. Therefore the continental shelf foodweb is currently in a state very similar to that of the past millennia[14]. Climate change and the recently developed industrial fishery in the Ross Sea region are, at present, the biggest threats to this largely pristine environment.

A) PAST THREATS

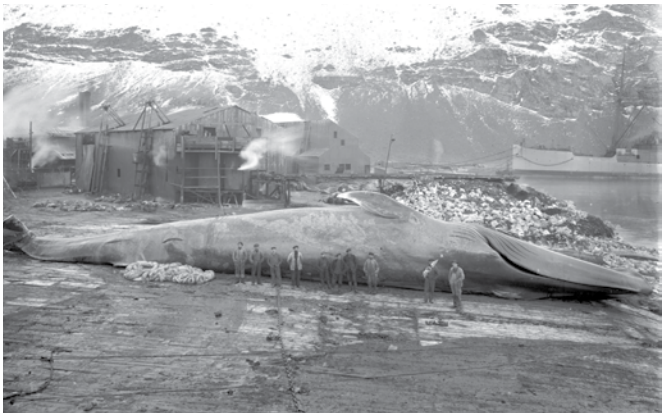
i) Sealing

The Ross Sea was not affected by industrial sealing. Fur seals do not appear to have ever bred in significant numbers within the region[15]. Elephant seals have historically only been present in the region when sub-adult males based on Macquarie Island moulted at a number of locations including Ross Island and the Victoria Land coast. However elephant seals do not have a history of breeding in the Ross Sea. Some Weddell seals were killed for dog food and scientific study in and around Southern McMurdo Sound, but this population has recovered somewhat and stabilized at around two-thirds of its estimated original size. Weddell seals outside McMurdo Sound, which constitute the majority of the region's population, were not targeted. Thus, the Ross Sea seal populations are largely the same as they have been for centuries, unlike those in other areas of the Southern Ocean[16].

ii) Whaling

It is thought that little whaling has been carried out on the Ross Sea shelf itself, where the minke, killer whales and Arnoux's beaked whales exist. During the 1920s, many blue and a few fin whales were caught further north, over the continental slope of the Ross Sea[17]. Industrial whaling for minke whales during the 1970s and 1980s was limited in areas to the north and west of the Ross Sea (Balleny Islands and vicinity). After the introduction of the current moratorium on commercial whaling in the 1980s, the minke whale population has recovered. The current composition of whales (minke, killer and Arnoux's beaked whales), on the Ross Sea continental slope reflects the composition encountered by whalers in the past[18].

Sealers stripping blubber from Sea Elephant at Macquarie Island's South East Harbour 1912. *Image by CA Sandell*



A blue whale and whalers at Grytviken whaling station, South Georgia. Shackleton expedition 1914-1917. *Image by Frank Hurley*

B) CURRENT THREATS

i) Industrial Fishing

The Ross Sea shelf and slope, unlike many other regions, has not had an extensive history of commercial fishing[19]. In 1996, New Zealand began an experimental Antarctic toothfish (*Dissostichus mawsoni*) fishery in the Ross Sea (one metric tonne expanding to 754 metric tonnes by 1999[20]). In 2000, this fishery was no longer considered to be experimental and other nations' fishers along with illegal vessels began to exploit the Antarctic toothfish in the Ross Sea.

As of 2011 an estimated 20% reduction in the size of the adult population (those that are old enough to reproduce) has already occurred, although there are not reliable science-based data on the original population size[21]. The toothfish fishery is concentrated along the Ross Sea slope, in deep water. Scientists are now unable to catch adult and large sub-adult fish in southern McMurdo Sound where 200-500 per year were routinely caught in a scientific tag-release program that began in 1972[22].

Toothfish longliner vessel longlining (fishing) for Antarctic toothfish (Dissostichus mawsoni) near Cape Adare. Fish being hauled in side gate, Ross Sea, Antarctica Region, Antarctica.
Image by Rod Suisted / naturespic.com

Different areas of Antarctica are experiencing changes in salinity from increased freshwater from melting glaciers, and the acceleration of glaciers flowing to the sea.

Melting ice © *Wim van Passel WWF-Canon*

ii) Climate change in Antarctica

Different areas of Antarctica are experiencing different physical effects from climate change. Parts of western Antarctica including the Antarctic Peninsula have seen some of the greatest warming effects on the planet in recent decades[23]. By way of contrast, sea ice extent is increasing in eastern areas including regions such as the Ross Sea[24]. In other places change has not been observed and the climate and ice cover appear more or less stable.

Different areas of Antarctica are experiencing changes in salinity from increased freshwater from melting glaciers, and the acceleration of glaciers flowing to the sea. It is also clear that the Southern Ocean is experiencing a warming effect in the ocean itself, linked to the temperature changes in the atmosphere[25].

Ocean acidification is a direct outcome of the ocean absorbing the increased levels of CO_2 in the atmosphere resulting from human activities such as the burning of fossil fuels[26]. It is a problem of enormous proportions and will impact on the biome of Antarctica in new and unique ways.

The global oceans are already around 30% more acidic than at preindustrial levels[27]. Under the most likely CO_2 emissions scenario[28], by the year 2100, acidification will cause the entire Southern Ocean to become undersaturated in aragonite, a form of calcium carbonate used by key species to develop their shells. The problem is likely to be particularly severe in this region because Southern Ocean levels of aragonite are already relatively low[29].

With such enormous variability, the Antarctic marine environment is under increasing pressure, and yet it offers scientists an unrivalled opportunity for research. Clearly the biological and physical complexity of these areas requires significant protection if these changes are to be documented and understood.

3 ROSS SEA REGION BIODIVERSITY

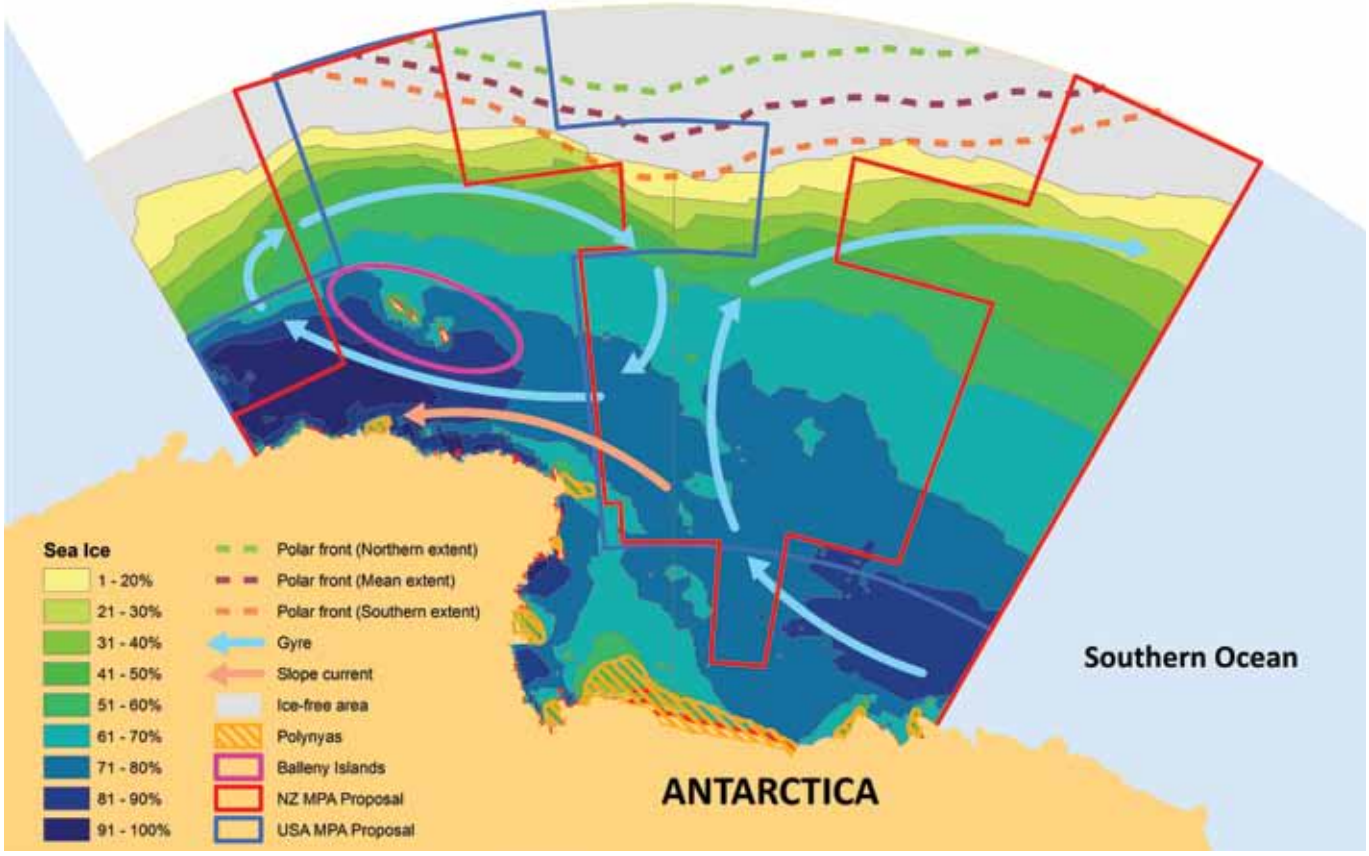
Image by John B. Weller

The Ross Sea is the largest continental shelf ecosystem south of the Antarctic Polar Front[30]. It contains a level of biodiversity that is far greater than that of many other polar areas[31]. This relatively intact ecosystem, with its numerous unique characteristics, is a biodiversity hot-spot[32]. The Ross Sea is therefore a highly ecologically significant region of the Southern Ocean.

The Ross Sea's biodiversity is due in part to its physical characteristics. Though the Antarctic shelf overall is isolated from other Southern Hemisphere shelf areas[33], the Ross Sea shelf is further isolated from the rest of the Southern Ocean because most of its surface water is retained over the shelf and mixes little with water outside the shelf[34]. This isolation means that fish and invertebrate larvae will be less likely to be dispersed, preventing the exchange of species between regions. Thus not only is the Antarctic as a whole a place with a unique marine fauna, the Ross Sea shelf fauna also has its own distinct characteristics[35], including species that are found only there and nowhere else. Over 40 such species, including fish, molluscs, and polychaete worms, have been documented[36]. Additionally, a portion of the Ross Sea shelf was not scoured by ice sheets during periods when these ice sheets were at their greatest extent, thus preserving some ancient seafloor communities from obliteration and enhancing diversity[37].

The physical separation and the large number of species found only in the Ross Sea are unusual in the world's oceans. This makes the Ross Sea an ideal place to study how marine species evolve, adapt and diverge to fill all available ecological niches. For example, a unique genotype of the Adélie penguin, a recently recognised species of killer whale, the type C Ross Sea killer whale, and one subspecies of the Weddell seal are found only in the Ross Sea[38]. Within the Ross Sea region, new species are frequently discovered, and one research expedition alone more than doubled the number of small crustacean species from the order Isopoda[39].

Ecological processes related to water circulation, and ice melt and formation, influence habitat structure and are important to ecosystem function[40 41 42]. The displayed sea ice shows the duration of the year for which an area has more than 85% ice cover[43].



A) PLANKTON AVAILABILITY AND PRODUCTIVITY

The biodiversity of the Ross Sea begins with its unusually high production of phytoplankton (microscopic plant plankton), estimated to be 28% of the total phytoplankton production of the Southern Ocean south of 50° south. The Ross Sea is thus the most productive stretch of ocean south of the polar front[44]. This higher abundance of microscopic plants and animals cascades up the foodweb, resulting in the vast array of seafloor creatures and high numbers of top predators that are able to exist in this hostile environment[45].

Sea Spider *Image by John B. Weller*

Several factors contribute to the high productivity of the Ross Sea. One is the large Ross Sea polynya, the largest polynya on earth, an area that becomes ice free early in spring, providing enough light to drive photosynthesis, allowing plankton blooms to begin very early. Nitrogen and phosphorus are in abundant supply, with iron provided by melting ice, atmospheric deposition, and from the ocean depths sustaining the productivity for much of the summer. Additionally, regional climate patterns have a particularly strong impact on primary productivity driving the upwelling of nutrient-rich water in the Ross Sea[46].

B) ZOOPLANKTON AND COMMON PREY SPECIES

Key species of zooplankton (microscopic animal plankton) and common prey species (smaller schooling fish that form the diet of larger fish and other predators) that support the higher predators of the Ross Sea include three species of krill and Antarctic silverfish.

Krill, a shrimp-like crustacean, is is a key prey species for many of the top predators in the Ross Sea region and is a vital component of the foodweb. One species, crystal krill, is found in the shallower parts of the Ross Sea over the shelf, feeding on phytoplankton. *Euphausia triacantha*, another species of krill, is found in the colder deeper waters of the northern part of the Ross Sea shelf. Finally, Antarctic krill has been recorded in large quantities along the Ross Sea shelf break and in the outer portions of the troughs, as well as around the Balleny Islands.

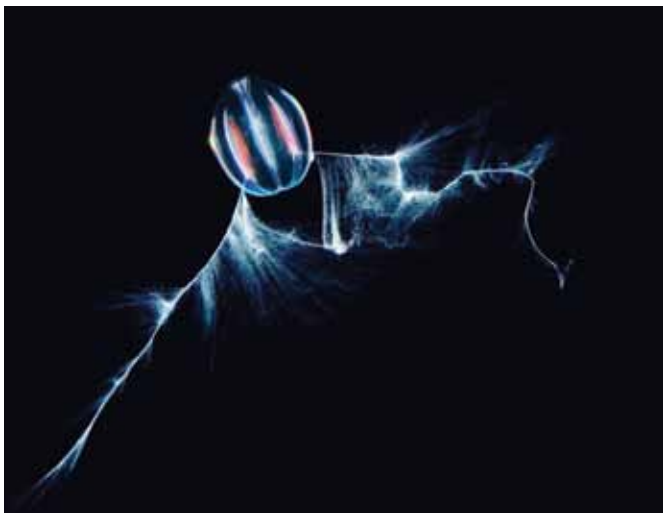
Antarctic silverfish constitute another important source of food for top predators in the Ross Sea, and are the most numerous species in the mid-water zones over the shelf. Although current data is not conclusive, it appears that the western part of the shelf has the highest concentration of adult silverfish[47]. By contrast, silverfish have virtually disappeared from the northern Antarctic Peninsula, possibly due to the loss of sea ice. Silverfish are part of the family that also includes Antarctic toothfish, a top predator. Species preying on silverfish include Weddell seals, Adélie and emperor penguins and Antarctic toothfish.

C) BOTTOM DWELLING SPECIES

Where they have been sampled directly, the bottom habitats (benthos) of the Ross Sea have been demonstrated to be exceptionally diverse[48] although the Ross Sea benthos has not been extensively explored. Nevertheless, the Ross Sea is better studied than other Antarctic continental shelves, and due to the promising results seen so far, is a highly exciting and promising area for further research.

The diverse structure and distribution of these benthic communities in the Ross Sea are influenced by a complex range of factors including the occurrence and presence of sea-ice cover, iceberg scouring, currents and water mass characteristics and bottom geomorphology. Amongst these factors, current flow, depth and geomorphology most strongly influence benthic community density and distribution[49].

The rocky substrate of the shallower (<500 metres) aspects of the Ross Sea favours animals and plants that attach themselves to the seabed, perhaps most notably sponges. Antarctica has been described as a “sponge kingdom”[50] due to the dominance and diversity of sponges in the Southern Ocean, which exceeds that found in many temperate seas[51]. The Ross Sea boasts over 230 species of sponges and is home to some especially interesting and diverse sponge communities. For example, glass sponges are relatively rare throughout the world’s oceans but are abundant in McMurdo Sound. The McMurdo Sound Glass Sponge Assemblage is particularly notable. Many of these sponges are very long-lived and slow-growing, and thus are likely to be vulnerable to disturbance. These and other Ross Sea sponges play a critical role in increasing habitat complexity and species diversity, as they form microhabitats that are used by both mobile and sessile (animals that are permanently attached) invertebrates. Many benthic invertebrates are heavily reliant on sponges for survival, whether for food or for habitat[52].



Mertensiid Ctenophore in the Ross Sea *Image by John B. Weller*

Other major components of the Ross Sea benthos include bryozoans, echinoderms, polychaete worms, molluscs, and crustaceans. Bryozoans, commonly known as "moss animals" due to their formation of large colonies composed of tiny (less than 1 mm) individual animals that together resemble moss, are another major component of Ross Sea benthic communities, where they form a substantial fraction of the biomass. In the northeastern part of the Ross Sea structurally significant bryozoan colonies have been located, including several that are significantly taller than most bryozoan colonies.

Antarcturus on Glass Sponge in the Ross Sea *Image by John B. Weller*

Echinoderms (a phylum that includes sea urchins, starfish, and brittle stars) are typically important in benthic habitats, and the Ross Sea is no exception. There are 157 species of echinoderms in the Ross Sea, and in some areas echinoderms are second only to bryozoans in population density[53]. Although perhaps not as diverse as the groups mentioned above, crustaceans, polychaete worms, and molluscs are also key components of Ross Sea benthic communities. There are 120 species of amphipods (a type of crustacean), and they seem to be one of the most numerous animals under the Ross Ice Shelf[54]. Polychaete worms, which provide an important food source for many Ross Sea fishes, are another diverse group. There are 235 polychaete species known to occur in the Ross Sea and 15 of these species are endemic. Molluscan fauna that have been found in the Ross Sea region include 273 species (187 gastropods, 56 bivalves, and 22 nudibranchs). Within some of these groups many new species have evolved over time. The Antarctic scallop is a significant element of the Ross Sea mollusc fauna – it is abundant, makes up a significant proportion of the biomass and appears to play a major (and atypical) role in cycling carbon from the water column to seafloor sediments[55].

Although rich in some benthic fauna, the Ross Sea nevertheless does not have some typical species such as crabs, many benthic fish, sharks and barnacles[56]. In other oceanic environments these organisms are the predators of the benthic species and due to their absence the large and diverse groups of sponges, bryozoans, and others can exist[57].

Overall, the benthic communities in the Ross Sea have a unique, highly diverse structure and distribution. The changes in community structure and composition have been monitored in the southern Ross Sea for 40 years, one of the longest biotic time series in the Southern Ocean. But perhaps more important, the Ross Sea offers scientists an opportunity to study unique benthic communities within an intact, large-scale ecosystem. Globally, benthic communities are often used as indicators of ecosystem health. Studies of the Ross Sea could therefore provide enormous insight into measuring and understanding the seafloor communities around the world and their relationship to overall ecosystem functioning.

D) ROSS SEA FISH SPECIES

Though comparatively few in number, Ross Sea fish species have several unusual attributes that have generated significant interest from researchers. The Ross Sea fishes include species that live in many different ocean habitats – on the seafloor, near the seafloor, and in open water. So far 95 fish species, including 61 notothenoids (a family of fish that is native to the Antarctic waters that have proteins in their blood to prevent them from freezing) and 34 non-notothenioids have been identified, with seven species that are endemic to the Ross Sea. The notothenioids dominate the ecosystem and boast an unusually high number of species. In fact, the notothenioids are unrivalled by any other fish family globally in their dominance of an ecosystem[58]. This family evolved from one that was primarily benthic to one with members that occupy many different ecological niches. Due to these characteristics, the notothenioids in the Ross Sea represent a unique evolutionary case study for scientists studying how new species emerge and develop different adaptations.

Occupying a role similar to that of the shark in other ecosystems, the top fish predator in the Ross Sea is the Antarctic toothfish. Although the physiology of this species has been intensively studied, many details about its life history have not been confirmed. For example, no eggs, larvae or small juveniles have ever been found. Available knowledge indicates that spawning likely occurs during winter and spring near the Pacific-Antarctic ridge.

Eggs are likely transported by Ross Sea gyres in several directions: west towards the Balleny Islands, south towards the Ross Sea shelf, or east towards the eastern continental shelf and slope[59]. After gaining some size, subadults move to the shelf where they mature, and eventually as adults head towards deeper water to begin the cycle again[60]. Antarctic toothfish are long-lived, living up to 50 years, reaching maturity at around 17 years. They are quite large, reaching up to 175 cm and 80 kilograms. However, they are not thought to spawn annually, and this in conjunction with their late maturity makes them highly vulnerable to overfishing.

The Ross Sea offers scientists an opportunity to study unique benthic communities within an intact, large-scale ecosystem

Antarctic Toothfish, also known as "Chilean sea bass"
Image by Rob Robbins

E) TOP PREDATORS

The Ross Sea has a complete and virtually intact group of top predators, including large fish, birds, seals, and whales[61].

Seabirds

The population numbers of birds within the Ross Sea region are large even though there are relatively few species[62], and the Ross Sea has one of the highest concentrations of seabirds in the world. There are 11 species of birds that breed in the Ross Sea region, including iconic penguin species. The main species of penguins present are emperor penguins and Adélie penguins, with 26 and 38 percent of the world's population breeding in the Ross Sea, respectively. Two of the largest colonies of emperor penguins in Antarctica are located in the Ross Sea region. There are about one million pairs of Adélie penguins.

The Ross Sea is also a major habitat for petrels. There are six species of petrels breeding on the Balleny Islands, but most of the six million petrels of the region breed on mountain tops well inland in Marie Byrd and Victoria lands including Antarctic petrel, snow petrel and Wilson's storm petrel. On the Balleny Islands Antarctic fulmar, Antarctic prion and cape petrel also breed. These birds forage over the shelf and especially over waters at the shelf breakfront, and therefore rely on the high productivity of the Ross Sea waters.

Seal with toothfish *Image by Jessica Meir*

Seals

There are five species of seal that have been recorded in the Ross Sea – crabeater, Weddell, leopard, Ross, and southern elephant. Crabeaters are the most numerous, with an estimated population of more than 200,000, and spend most of their time foraging for krill on the heavy pack ice over the Antarctic Slope Front and in the northern Ross Sea.

The population estimates of Weddell seals in the Ross Sea region are between 32,000 and 50,000 individuals. During the summer these seals are located on the fast ice adjacent to the shore where they breed. In April the adults move north with the pack ice. During the winter these seals are spread throughout the Ross Sea. The Antarctic toothfish is a main prey species of the Weddell seals, and thus toothfish abundance and availability have a significant impact on them.

The existence and abundance of this wide range of predators is one of the defining characteristics of the Ross Sea ecosystem. There are few remaining marine ecosystems that retain their full complement of top predators.

Leopard seals are major Ross Sea predators as well. Approximately 8,000 leopard seals are found in the Ross Sea region on pack ice in frontal areas. The Adélie penguins are a major food source for the leopard seals and therefore large numbers of leopard seals are located in the western Ross Sea where there are the greatest numbers of Adélie penguins.

There is a smaller population of Ross seals, about 5,000. This is a small proportion of the total estimated 101,000 living in the Pacific sector. Very little is known about this species except that they occur throughout the loose pack ice and they appear to eat squid and fish. Southern elephant seals are only present in very low numbers (fewer than 50) and currently do not breed in the Ross Sea.

Orcas *Image by John B. Weller*

Whales

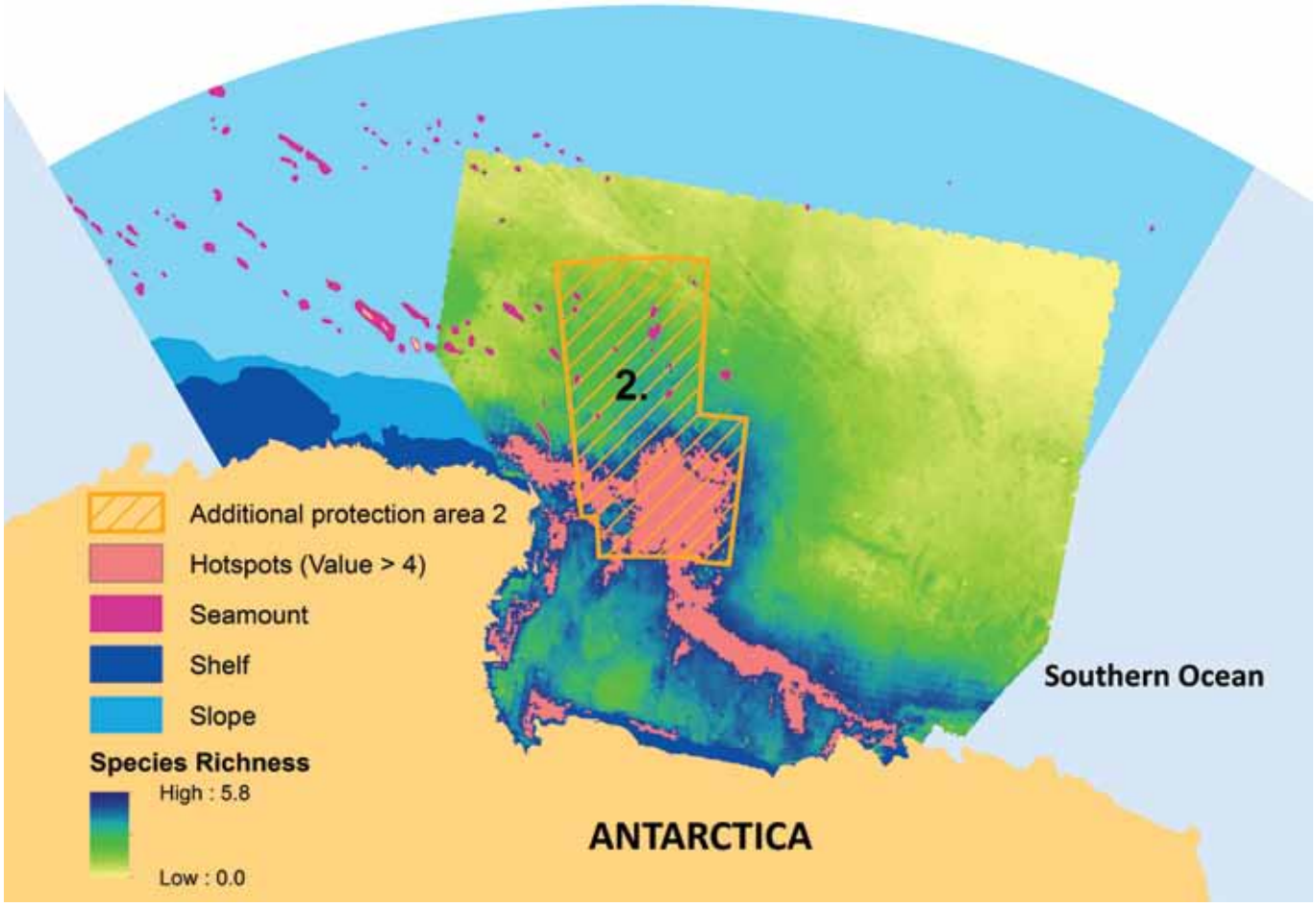
Six species of baleen whales (minke, blue, fin, humpback, sei and dwarf minke) have been recorded in the Ross Sea region. It is estimated that there are 14,300 minke whales over the shelf and slope, making them the most abundant whale. These baleen whales feed on krill and silverfish over the continental slope of the Ross Sea region. There are also six species of toothed whales (sperm, killer, Arnoux's beaked, southern bottlenose, long-finned pilot whales and hourglass dolphin). The killer whale is the most abundant of the toothed whales. It is estimated that there are 3,400 individuals in the Ross Sea region, representing three orca ecotypes, including the "type C" ecotype ("Ross Sea killer whale"). Type C orcas feed heavily on Antarctic toothfish, where as the other two ecotypes feed largely on mammals. Sperm whales, found off the shelf, prey on toothfish and large squid.

Squid

Another predator of great scientific interest is the colossal squid. Though few have been seen by humans, this squid is likely the largest (in terms of weight) of all squid species, and a major prey item for sperm whales. At an estimated 10 -14 meters long, with eyes the size of dinner plates and tentacles with sharp hooks, it is as close in appearance to a real sea monster as anything in the ocean. However, it is probably slow-moving and not aggressive. The full range of prey of the colossal squid is still unknown, but it is confirmed that they eat toothfish, as they have been observed taking toothfish from fishing vessels. In fact, what is thought to be the first intact, mature specimen of colossal squid was retrieved from a toothfish vessel fishing in the Ross Sea in 2007. Another intact but immature specimen was found in the Ross Sea in 2003. These two specimens are the only complete and intact (not from sperm whale or shark stomachs) adult and subadult specimens recovered for further study. The Ross Sea region therefore is likely an important habitat for this mysterious and fascinating creature.

The existence and abundance of this wide range of predators is one of the defining characteristics of the Ross Sea ecosystem. There are few remaining marine ecosystems that retain their full complement of top predators. Moreover, as will be explained in the next section, the Ross Sea will provide a refuge for many iconic Antarctic species as other parts of the continent experience warming temperatures.

Hotspots of species richness. Species richness was derived by summing the probabilities of occurrence for high trophic level marine predators across all species where data was available[63]. For discussion of Additional Protection Area 2 see page 18.



4 CLIMATE CHANGE REFUGE AND REFERENCE

Adélie penguins in the Southern Ocean ©Greenpeace/Jiri Rezac

Climate change is affecting all parts of the earth[64] and some of the impacts in Antarctica are among the most pronounced on the planet. Humanity will need to adapt to the enormous challenges ahead, based on clear guidance from the scientific community. A fully protected large-scale marine reserve in the Ross Sea, in particular, offers science a unique natural laboratory to study the impacts of climate change free from the influence of other types of human activity. However, political decisions need to be bold and visionary in order to take advantage of research opportunities, and to respond to scientific findings.

A) THE ROSS SEA REFUGIUM

The Ross Sea will be the last part of the Southern Ocean with year-round sea ice according to Intergovernmental Panel on Climate Change (IPCC) predictions[65]. The sea ice is predicted to continue to expand over the next few decades, stabilise but then decline thereafter. Therefore in the medium term, sea ice is expected to remain much longer in the Ross Sea than other areas in the Southern Ocean, and perhaps anywhere on the planet. Consequently, the Ross Sea region will become a "refugium" for ice dependent species[66] as well as for the study of changes in the ice and how different species and communities adapt or fail to adapt to changes in sea ice and ocean temperature.

Weathered iceberg in the Southern Ocean ©Greenpeace/Jiri Rezac

B) CLIMATE CHANGE REFERENCE

It is clear that climate change and ocean acidification, in tandem with resource extraction such as fishing will increasingly put pressure on the marine ecosystems of the Southern Ocean. Additionally, there is the strong potential for environmental change and human impacts to be mutually reinforcing.

Empirical data will be needed to compare observed impacts and effects, with climate and physical modelling, and to contrast areas experiencing little impact from humans with areas experiencing more variable impacts. It is for this reason that many scientists argue for large areas of the Southern Ocean to be protected, so that research can be undertaken uninterrupted by other direct human impacts[67].

It is this aspect of the Southern Ocean and the Ross Sea in particular that offers science an outstanding opportunity to study largely undisturbed ecosystems, but also the ways that those ecosystems change and adapt (or become weaker) with the onset and acceleration of climate change. Because the IPCC predicts the Ross Sea will retain year-round sea ice for longer than any other area, it is imperative that it is protected.

Scientific data collections from the Ross Sea region are now among those with the longest time series and largest of any in the Southern Ocean, including strong data series on Adélie penguin populations, species composition, the demography of Weddell seals, Antarctic toothfish populations, hydrographic properties, and benthic fauna[68]. As time goes on, and climate impacts increase, this data will increase in value, providing that climate and ecosystems research can be conducted, without the distortions caused by fishing.

For these reasons, the full protection of the Ross Sea slope and shelf is critical. Beyond the climate issues, undisturbed ecosystems give scientists opportunities to undertake research into environmental change, unrivalled in most parts of the planet, where human beings have been dominant and have impacted nature for millennia[69]. In recognition of this, over 500 scientists have signed a statement supporting the establishment of a no-take marine reserve covering at least the entire Ross Sea shelf and slope[70].

THE OPPORTUNITY AT CCAMLR

The Antarctic Ocean Alliance has identified 19 areas that should be included within a Southern Ocean network of MPAs and marine reserves. It is time for CCAMLR to demonstrate its leadership once again by protecting the Ross Sea region as the crown jewel in a Southern Ocean network of MPAs.

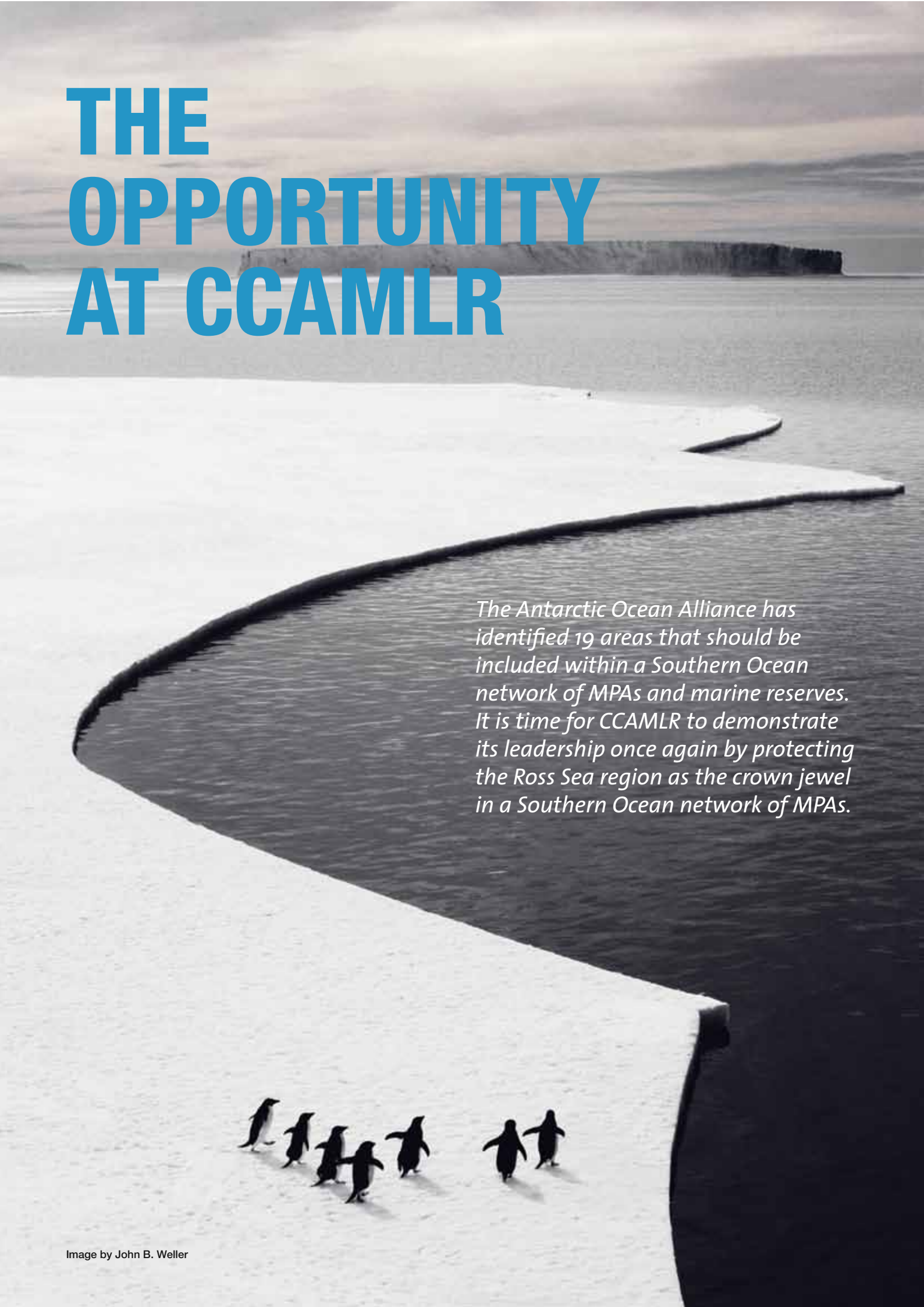


Image by John B. Weller

CCAMLR was established as part of the Antarctic Treaty System to protect the species and ecosystems of the Southern Ocean. Entering into force in 1982, CCAMLR's central objective is to conserve Antarctic marine life while managing the rational use of marine resources in accordance with three principles of conservation:

1. Prevent any harvested population from decreasing so low that it is unable to maintain itself;
2. Maintain and where necessary restore the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources;
3. Prevent or minimize the risk of change to the marine ecosystem based on the best available science.

The CAMLR Convention is explicit in authorizing Members via the Commission to implement spatial and temporal protection, MPAs and marine reserves[71].

As a result of its founding document's commitment to conservation and the principles that underpin its central objective, CCAMLR stands out from other organisations with oversight of areas beyond national jurisdiction in its approach to conserve and manage biodiversity. CCAMLR governments are bound to apply the ecosystem approach to management to ensure that activities in the Southern Ocean do not decrease the overall health of Antarctic ecosystems. CCAMLR must strive to apply a precautionary approach to ensure that best available scientific information as well as uncertainty are taken into account in management decisions to err on the side of preserving ecosystem function.

Diver with seal, Ross Sea *Image by John B. Weller*

CCAMLR signalled its commitment to conservation by agreeing to meet the World Summit on Sustainable Development (WSSD) MPA goal by establishing a comprehensive and representative network of MPAs in the Southern Ocean. From the earliest work on MPAs, the Ross Sea region stood out as a priority for inclusion within an MPA network. In 2008 it was included in an initial suite of 11 priority areas to focus work on developing and implementing MPAs in the Southern Ocean. Those priority areas were then refined in 2011 to nine planning domains, which included the Ross Sea planning domain. Furthermore, CCAMLR established several criteria for MPAs. It is clear that the Ross Sea region meets the criteria agreed by CCAMLR for MPAs and no-take marine reserves, which are:

i. Protection of representative examples of marine ecosystems, biodiversity and habitats at an appropriate scale to maintain their viability and integrity in the long term;

ii. Protection of key ecosystem processes, habitats and species, including populations and life-history stages;

iii. Establishment of scientific reference areas for monitoring natural variability and long-term change or for monitoring the effects of harvesting and other human activities on Antarctic marine living resources and on the ecosystems of which they form part;

iv. Protection of areas vulnerable to impact by human activities, including unique, rare or highly biodiverse habitats and features;

v. protection of features critical to the function of local ecosystems;

CCAMLR governments are bound to apply the ecosystem approach to management to ensure that activities in the Southern Ocean do not decrease the overall health of Antarctic ecosystems.

vi. Protection of areas to maintain resilience or the ability to adapt to the effects of climate change[72].

The Southern Ocean is the one region of the high seas where attainment of the WSSD goal of establishing a network of MPAs by 2012 remains a possibility. Such an achievement is only attainable because of the principles, values and spirit enshrined within the CAMLR Convention. These values and provisions set the Southern Ocean apart and, in the past, have enabled CCAMLR Members to demonstrate considerable leadership in the governance of areas beyond national jurisdiction.

CURRENT PROPOSALS

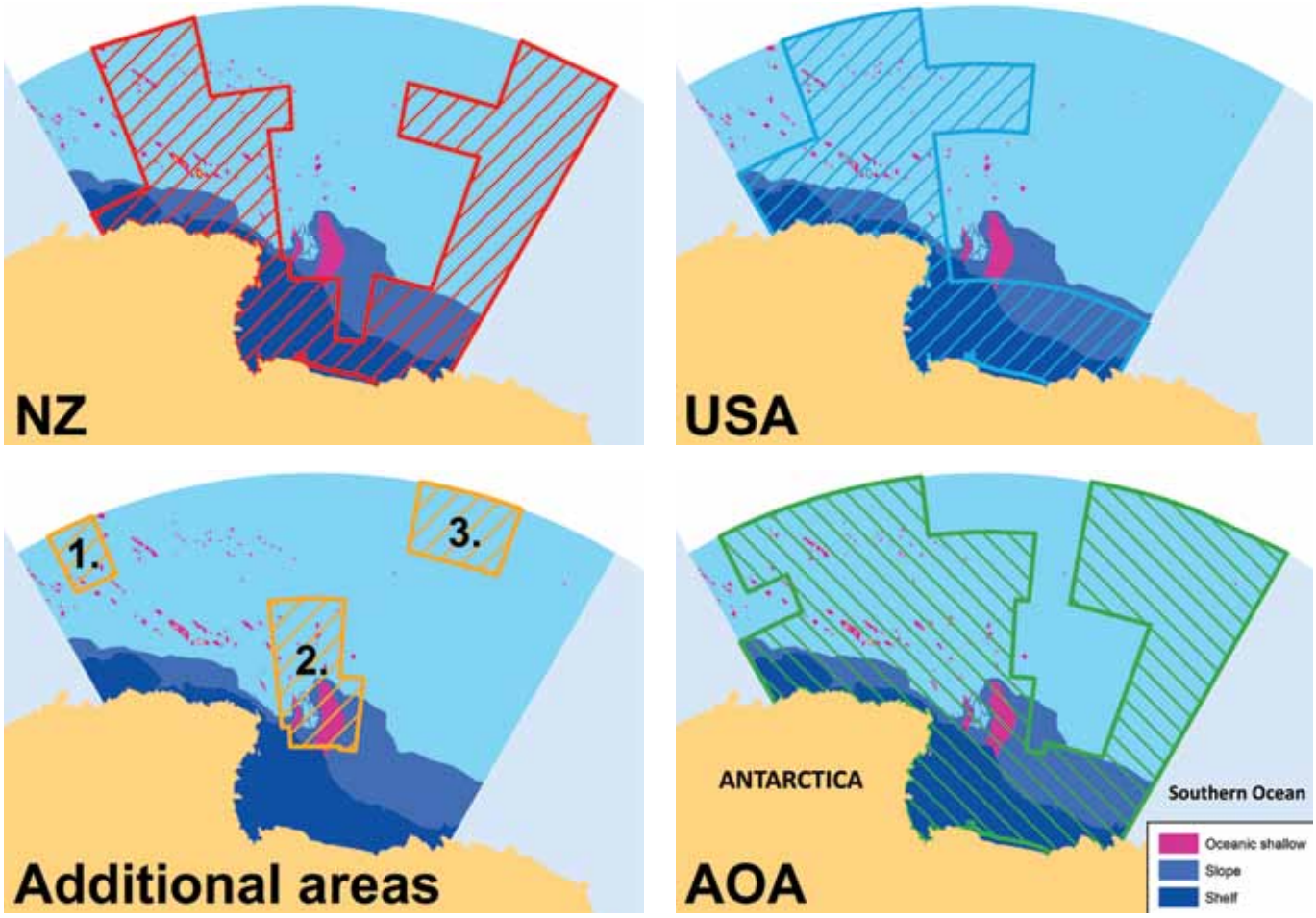
Image by John B. Weller

Within CCAMLR, the importance of protecting the Ross Sea has been recognised. Both the United States and New Zealand governments have proposed scenarios for Ross Sea MPAs. These scenarios were based on extensive analyses of available scientific information, and have provided a significant first step towards protecting the Ross Sea. However, our analysis of the US and New Zealand scenarios identified three additional areas critical to the protection of the Ross Sea region. By expanding the proposed Ross Sea protection area to include these areas, with the combined extent of the US and New Zealand scenarios (while strengthening their levels of protection), the resulting Ross Sea reserve will provide truly comprehensive protection.

ADDITIONAL PROTECTION AREA 1:

The first additional area proposed for protection is located in the north-west sector of the Ross Sea region. The only ocean trough that is located within the Ross Sea region is located here[73]. Additional Area 1 also contains a Mid-Ocean Ridge rift valley that intersects the frontal region of the Antarctic Circumpolar Current[74 75]. Frontal regions are very productive[76 77], especially where the fronts of the Antarctic Circumpolar Current interact with geographic features[78]. Highly productive areas can influence biodiversity at the surface, in the water column and on the seafloor[79].

The NZ and US MPA scenarios, additional areas identified for protection, and an enhanced and strengthened AOA marine reserve proposal. The AOA seeks to ensure the protection of the large-scale Ross Sea ecosystem processes



ADDITIONAL PROTECTION AREA 2:

Additional Protection Area 2 is centrally located within the Ross Sea region. This area approximately consists of half Ross Sea and half Pacific-Antarctic Ridge ecoregions as identified by Douglass et al.[80], traversing the boundary between them. Located within this area is a number of bathomes that indicate the depth stratification of species.

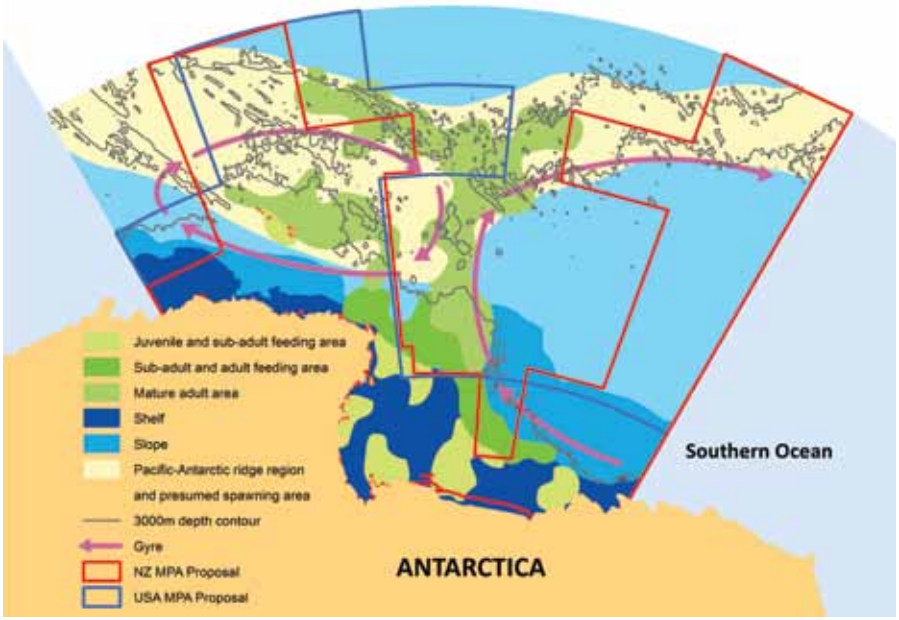
In the southern portion of this area are two ridges, which are the only two that are mapped within the Ross Sea planning region[81]. Connecting these ridges is a network of canyons that commence on the shelf and are also the only canyons of this type that are within the Ross Sea region. Shelf-commencing canyons are key components of the ecological systems in the Ross Sea region transferring nutrients between the shelf and abyssal environments and also provide migration routes for fish and other creatures. Biodiversity and key habitats are often concentrated along such features to take advantage of the passing nutrients. Underwater canyons can also facilitate upwellings and other hydrodynamic events[82], which in turn can enhance primary productivity and thus create local biodiversity hotspots[83]. It is thought that toothfish use these canyons to migrate to the feeding grounds of the Ross Sea slope as they mature into adults[84].

Additional Protection Area 2 is also identified as key feeding ground of mature toothfish on the Ross Sea slope[85]. Since 2005, CCAMLR has agreed that MPAs are valuable tools to protect and maintain key ecosystem processes including life-history stages of Antarctic marine life. This was reinforced in the recently agreed MPA General Measure for MPAs where the protection of populations and their life-history stages was explicitly recognised[86]. Therefore, AOA believes a high priority should be given to establishing protection of the Ross Sea Antarctic toothfish's feeding ground for adult pre-spawning fish.

A significant proportion of the distribution of Antarctic krill within the Ross Sea region occurs within Additional Protection Area 2[87]. It is also an area that intersects with the productive Ross Sea shelf front[88 89]. This krill population plays a role in supporting top predators found to have a high likelihood of occurrence in this region. Identified top predators for this region include emperor and Adélie penguins, Weddell seals and killer whales[92]. The coincidence of these factors plus the identification of the area as a feeding ground for mature toothfish indicate that protection is strongly warranted here at a species and ecosystem level.

Further to the north, the Scott and Tangaroa Seamounts are located within Additional Area 1. The Scott seamount chain consists of Scott Island (179.9°E; 67.4°S) and multiple seamount summits with very rugged, steep flanks which is an unusual topography to find near a continental margin[93]. The abundance and types of seafloor biodiversity at the Scott seamounts differ significantly from the nearby Admiralty Seamounts, 400 km further to the west possibly related to the influence of diverging water mass flows from a gyre in the region[94]. Protecting only the Admiralty seamounts will not adequately capture this diversity. The Tangaroa Seamount is unique as it is the only seamount within the 100-200m bathome in the Pacific-Antarctic Ridge ecoregion, and one of only three seamounts of this kind in the Southern Ocean. Accordingly these areas are considered ecological hotspots.

Important areas for the life cycle of the Antarctic Toothfish. Toothfish areas were generalised from catch data of fish length and are presumed to spawn in the shallower sections of the Pacific-Antarctic Ridge region[90 91]



ADDITIONAL PROTECTION AREA 3:

Additional Protection Area 3 is situated in the north-eastern sector of the Ross Sea region. The dominant geomorphic features within this area are the mid-oceanic ridge rift valleys between the Pacific and Antarctic plates[95]. Mid-oceanic ridges are predictors for hydrothermal vent communities, locations with a high degree of endemism[96] and areas of overlap for species at the northern and southern extent of their ranges where the composition of both benthic and demersal species assemblages change. It is likely that some species are unique to this region including the giant cod, eelpout and blobfish[97].

AOA believes a high priority should be given to establishing protection of the Antarctic toothfish's Ross Sea feeding ground for adult pre-spawning fish.

Further, as with Additional Protection Area 1, Area 3 is a region of high frontal activity. The Polar Front intersects Area 3, indicating a region of higher pelagic productivity, which can influence benthic diversity. This area has also been identified as a presumed spawning area for Ross Sea Antarctic toothfish, a critically important component of the Antarctic toothfish lifecycle[98].

THE AOA PROPOSAL FOR MARINE PROTECTION IN THE ROSS SEA REGION

Image by John B. Weller

The Antarctic Ocean Alliance recommends that CCAMLR establish a fully protected marine reserve of approximately 3.6 million square kilometers in the Ross Sea region as a first step to establishing a a comprehensive network of MPAs and marine reserves around Antarctica. This recommendation is justified based on the best available science, much of which is summarised in this report.

This Ross Sea marine reserve proposal seeks to protect large-scale ecosystem processes in their entirety.

This includes the:

1. Protection of the biodiversity and ecological processes associated with the Ross Sea gyre.
2. Protection of areas critical to the life-history stages of the Antarctic toothfish – the region's top fish predator. These include the feeding and spawning grounds of the toothfish.
3. Protection of critical geomorphic features including the seamounts, ridges and troughs of the Pacific Antarctic Ridge, and associated life forms.
4. Broad protection that facilitates the continuation and expansion of long-term datasets that underpin crucial research into ecosystem function and environmental change, including the impacts of climate change, particularly ocean acidification.
5. Protection of biodiversity hot-spots such as the Ross Sea shelf and slope, Balleny Islands, Pacific Antarctic Ridge and the Scott Seamounts.
6. Protection of the Ross Sea region as a critical climate reference area, and climate refugium for ice-dependent species.

Snow petrel *Image by John B. Weller*

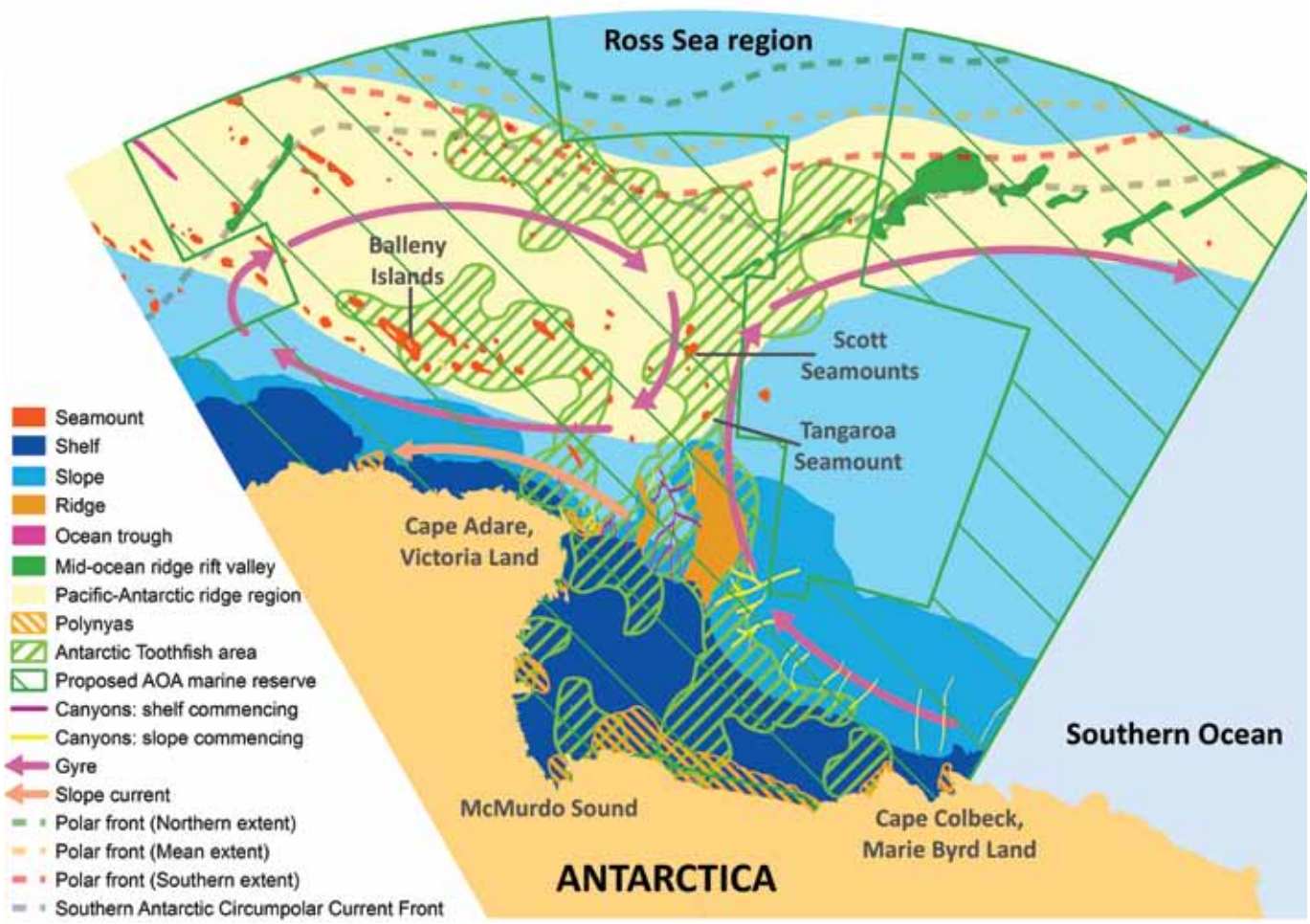
The proposal also recognises that upper trophic level fauna such as penguins, toothfish, and Weddell seals require the entire Ross Sea shelf and slope to complete their annual cycle.

Our analysis of the current scenarios shows that the best elements of the NZ and US MPA proposals can be brought together in a combined, extended and enhanced proposal that truly protects the critical, unique and precious Ross Sea ecosystem.

We urge the Commission for the Conservation of Antarctic Marine Living Resources to fully implement our proposal.

The Antarctic Ocean Alliance recommends that CCAMLR establish a fully protected marine reserve of approximately 3.6 million square kilometers in the Ross Sea region as a first step towards establishing a comprehensive network of marine reserves and MPAs around Antarctica.

The Antarctic Ocean Alliance recommends the full protection of 3.6 million km^2 in the Ross Sea region[99 100 101].



Iceberg in the Southern Ocean *©Greenpeace/Jiri Rezac*

Emperor penguins *Image by John B. Weller*

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This report was printed on recycled paper.

Weddell Seal *Image by John B. Weller*

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