



ANTARCTIC
OCEAN
ALLIANCE 
PROTECTING THE WILD SOUTH

ANTARCTIC OCEAN LEGACY:
**A VISION FOR
CIRCUMPOLAR
PROTECTION**

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EXECUTIVE SUMMARY

In October 2011, the Antarctic Ocean Alliance (AOA) proposed the creation of a network of marine protected areas (MPAs) and no-take marine reserves in 19 specific areas in the Southern Ocean around Antarctica¹. This report, *Antarctic Ocean Legacy: A Vision for Circumpolar Protection*, now provides the AOA's full vision for this network with particular reference to the ecological values of the chosen areas.

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the body that manages the marine living resources of the Southern Ocean, has set a target date of 2012 for establishing an initial network of Antarctic MPAs. This report identifies areas for consideration as MPAs and no-take marine reserves, and describes the rationale for the 19 areas.

The AOA report starts with an introduction to the region, followed by threats – most notably climate change and resource extraction – describes the geography, oceanography and ecology of the 19 areas identified, and outlines the case for protection. The report provides recommendations presenting the scale and scope of potential marine protection.

The Antarctic Ocean Alliance acknowledges that there remains a need for considerable effort in the international process for determining the final network. For the past seven years, CCAMLR Member countries and scientists have made progress in developing plans for MPAs and no-take marine reserves in the Southern Ocean. The AOA offers this report as a contribution to that ongoing effort with the hope of helping CCAMLR meet their 2012 goal. The AOA's intention is to work with CCAMLR Members and their scientific bodies to develop appropriate protection for these unique and valuable ecosystems. This report does not make definitive proposals in all areas, but it does in a number of areas. For those without specific boundaries, the report urges CCAMLR Members to consider the unique environmental aspects of each in deciding on the level of protection.

In this report, the AOA proposes protection of large-scale Southern Ocean ecosystem processes that are critical for ecosystem and species protection. Areas have been selected that collectively capture a wide and representative range of habitats and ecosystems and include key biodiversity hot spots. These include different environmental types, as well as pelagic and seafloor features such as seamounts, ridges and troughs. The proposal includes areas critical to the life-history stages of endemic species such as the Antarctic toothfish – the region's top fish predator – and other predators. It encompasses the breeding and foraging grounds of other upper trophic level fauna, such as penguins and seals. Several areas proposed for protection, such as the Ross Sea and East Antarctic, will serve as critical climate reference areas and climate refugia for ice-dependent species.

Areas that are particularly vulnerable to climate change, such as the Western Antarctic Peninsula, are included. The proposal should facilitate the continuation and expansion of long-term datasets that underpin crucial research into ecosystem function and environmental change, including the impacts of climate change and ocean acidification. Further, the proposal could help whale, seal and fish populations that are still recovering from historical overexploitation.

The International Union for the Conservation of Nature's World Parks Congress recommends that at least 20-30% of all marine habitats should be included in networks of marine reserves². In line with the scientific values of the Antarctic Treaty, and in accordance with CCAMLR's principles and mandate, the AOA's research has identified over 40% of the Southern Ocean that warrants protection in a network of no-take marine reserves and MPAs. This was determined by combining existing marine protected areas, the areas identified within previous conservation and planning analyses and including additional key environmental habitats described in this report³.

CCAMLR Members have an unprecedented opportunity to establish the world's largest network of MPAs and no-take marine reserves in the oceans around Antarctica as a legacy for future generations. With such a network in place, key Southern Ocean habitats and wildlife would be protected from human interference. The AOA believes that with visionary political leadership, CCAMLR can embrace this opportunity.

The Antarctic Ocean Alliance is an international coalition of leading environmental and conservation organisations and philanthropists from around the world including the Antarctic and Southern Ocean Coalition (ASOC), Blue Marine Foundation (UK), Greenpeace, Mission Blue (US), Oceans 5 (US), WWF, the International Fund for Animal Welfare (IFAW), the International Programme on the State of the Ocean (IPSO), The Last Ocean, Forest and Bird (NZ), ECO (NZ), Deepwave (Germany), Humane Society International, Korean Federation for Environmental Movement (KFEM), Whale and Dolphin Conservation Society (WDCS) and associate partners the Natural Resources Defense Council (NRDC), Greenovation Hub (China), Oceana and other groups worldwide.



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In line with CCAMLR's philosophy of precautionary management, the AOA's research has identified over 40% of Southern Ocean that warrants protection in a network of MPAs and large no-take marine reserves.



Iceberg in the Southern Ocean.
Image © Greenpeace / Jiri Rezac.



INTRODUCTION

The Southern Ocean constitutes roughly 10% of the global ocean, yet less than 1% is strictly protected in MPAs or marine reserves. MPAs align with CCAMLR's central objective of conserving Antarctic marine life while managing its rational use in accordance with three principles embodied in Article II of the CAMLR Convention:

1. Prevent any harvested population to decrease to levels 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 minimise the risk of change to the marine ecosystem based on the best available science⁴.

Although often depicted as a frozen region dominated by breathtakingly beautiful but sterile glaciers, Antarctica is bursting with life – but mostly marine life. Below the icy ocean surface, bright-colored seastars, sponges and other bottom-dwelling creatures of all shapes and sizes blanket the seafloor. Strange fish, with clear white blood and anti-freeze in their bodies, lurk throughout the water column. On the surface, penguins, flying seabirds, seals and whales abound amidst the ice, foraging in krill-rich waters.

Many marine habitats, in deep water or under ice, have yet to be studied, but almost every Antarctic research expedition discovers new species that were previously unknown to science. Many of these Southern Ocean species are found nowhere else on Earth. The Antarctic truly remains one of the world's last wild frontiers.

Despite the harsh wind and cold, the Antarctic supports vast numbers of seabirds and marine mammals, many species of which breed on land and forage in the water. While most of the world's populations of large mammals and birds are shrinking, the

Antarctic still has penguin breeding colonies large enough to deafen human ears with their insistent calls. The Antarctic also has millions of crabeater seals, which are believed to be the second-most populous mammal on earth⁵.

Likely because of the remoteness and harsh weather, some areas of the Southern Ocean remain the most intact marine ecosystems left on the planet. The Ross Sea and Weddell Sea are two areas that have remained free from widespread pollution, invasive species, bottom trawling or other large-scale commercial fishing operations⁶. With few such ecosystems remaining, scientists have a dwindling number of places where they can study how ecosystems function in the absence of large-scale human interference.

In other areas, past whaling, sealing and overfishing has decimated populations. Fortunately, the Southern Ocean is now a whale sanctuary and some whale populations are on their way to recovery. Previously exploited seal species have largely recovered since the cessation of sealing. Since 1982 commercial fishing has largely been brought under international management by the Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR), though illegal, unregulated and unreported (IUU) fishing continues to be a threat.

One major driver of Southern Ocean biodiversity is its geography. Seamounts, known to be hubs for marine biodiversity, are scattered throughout the Southern Ocean, including in the Ob and Lena Banks region, the East Indian Ocean sector of the Southern Ocean, the mid-Atlantic ridges including Bouvetøya, and in areas north of the Ross Sea. The Kerguelen Plateau, Maud Rise and BANZARE Bank are raised seafloor areas that provide the foundation for incredibly productive and biologically rich regions. Additionally, the waters surrounding most of the Southern Ocean islands are hotspots for marine biodiversity and provide critical breeding grounds with important foraging areas for predators.

In planning for a representative network of Southern Ocean MPAs and no-take marine reserves, the AOA identified areas that collectively capture a wide range of habitats and ecosystems, including seafloor and pelagic ecoregions and unusual biological features. For areas of the Antarctic that have not been extensively studied, the report focuses on the presence and diversity of geomorphic features and biogeography to project the potential presence of biologically important habitats.



THREATS

The Southern Ocean faces an uncertain future. Climate change and the resulting alterations in temperature, currents and ice dynamics stand to unravel this intricate polar ecosystem. Past overexploitation has lingering effects, with most whales, as well as many fish species, having yet to fully recover. The current protective measures in place are insufficient to adequately conserve the unique Southern Ocean ecosystems and biodiversity. No-take marine reserves and MPAs will help minimize, or even eliminate, some of the most pressing threats to the Southern Ocean ecosystem.

CLIMATE CHANGE

Rapid, human induced climate change from increased carbon dioxide (CO₂) emissions is affecting all parts of the Earth⁷, and regions of the ice-dominated Antarctic are some of the most rapidly changing on the planet⁸. But the impacts of climate change are not uniform across the region. Parts of western Antarctica have seen an average 2.8°C increase in temperature between 1950 and 2005⁹, the most rapid rise in annual observed temperature anywhere on the planet. Yet other parts of the continent are cooling¹⁰. There is also evidence that Antarctica's persistent seasonal ozone hole (which was diagnosed in the early 1980s) may exacerbate the impacts of climate change¹¹.

Ice Shelves

Ice shelves are thick floating platforms of ice that extend from glaciers and ice sheets on land. These massive features are hundreds of metres thick and yet they are rapidly collapsing in many places throughout the Antarctic. As the ice shelves collapse, the glaciers they extend from can then flow faster from the land to the sea and melt. The enormous Larsen B Ice Shelf disintegrated in 2002 followed by parts of the Wilkins Ice Shelf in 2008¹². Pine Island Glacier, which flows into the Amundsen Sea, has been rapidly melting¹³, with predictions that the main portion of the glacier could be afloat within the next 100 years¹⁴. If this happens, it will potentially trigger the disintegration of the entire West Antarctic Ice Sheet¹⁵. The consequences, which would include sea level rise and changes in ocean salinity, could be devastating to the global environment.



Pagothenia borchgrevinki Notothenioid family.
Image by John B. Weller.

Sea Ice

Every year sea ice forms around Antarctica, effectively doubling the size of the continent. The annual advance and retreat drives ecosystem processes, including primary productivity and provides habitat for a variety of species throughout their life history¹⁶. Around the Antarctic Peninsula and Bellingshausen Sea, sea ice has retreated and the season has decreased by three months¹⁷. The Scotia Sea, north of the Peninsula, has likely suffered the deepest contraction of sea ice in the Southern Ocean¹⁸. These changes in sea ice have been potentially linked to the decline of krill in the Scotia Sea, perhaps by as much as 38 to 81%¹⁹. The presence of ice seems to be essential to their life history, particularly for larval krill, which feed on microorganisms under the ice²⁰. A reduction in krill could have cascading effects throughout the ecosystem since krill are a critical part of the diet of many whales, seals, penguins and fish. Reductions in sea ice also impact many marine animals, especially those, such as crabeater seals, which critically depend on sea ice during various stages in their life cycle²⁰. In contrast,

on the other side of the continent in the Ross Sea, sea ice now retreats later and advances earlier, increasing the sea ice season by more than two months²². This longer ice season, which may partially be due to the persistent ozone hole, means lower primary productivity²³. These changes in sea ice can significantly stress local wildlife. For example, some Adélie penguin populations in the Ross Sea must now winter closer to the ice edge where they feed, which is increasingly further away from their home colonies²⁴.

Continued ice shelf collapse and sea ice retreat will lead to dramatic changes in these marine environments, including the displacement of ice-dependent species and the potential colonization by adjacent or introduced species from warmer latitudes. Meanwhile, scientists are only beginning to unravel the effects of these changes on the local flora and fauna. In areas with dramatic sea ice retreat, like the Western Antarctic Peninsula, the correlative impacts on species must be studied to help inform policy.

Over only the last 200 years, the oceans have become 30% more acidic and if these trends continue, calcifying organisms will suffer deleterious effects. The increased acidity can dissolve their shells and skeletons.

Ocean acidification

As humans continue to pump CO₂ and other greenhouse gases into the atmosphere from the burning of fossil fuels, the oceans absorb the carbon, which lowers the pH, and makes the water more acidic. Over only the last 200 years, the oceans have become 30% more acidic and if these trends continue, calcifying organisms will suffer deleterious effects²⁵. The increased acidity can dissolve their shells and skeletons, while the influx of CO₂ decreases the availability of carbonate ions. This further hinders their ability to build shells and skeletons.

The cold waters of the Southern Ocean are naturally lower in calcium carbonate than warmer waters and thus closer to the tipping point at which organisms will begin to suffer deleterious effects²⁶. Scientists predict that within the next two decades key planktonic species, such as pteropods (small marine snails), will no longer be able to build robust shells²⁷. In time, they may not be able to build shells at all. If pteropods, or other shell-building animals perish, it will have adverse ramifications that will cascade throughout the Southern Ocean ecosystem.

FISHERIES

Due to its remoteness, the Southern Ocean was one of the last areas of the global ocean to experience direct human exploitation. But soon after its discovery in the 1770s, commercial hunters quickly began harvesting the animals living in the frozen waters around Antarctica. Fur seals were the first to be hunted, then elephant seals, followed by the great whales and several finfish species. By the late 19th century, some species of seals were hunted almost to extinction. By the last quarter of the 20th century, some species of whales were also nearly extinct as a result of industrial exploitation. Though some population sizes have shown signs of recovery, the largest whales remain at a tiny fraction of their original population sizes. Some targeted fish populations, such as marbled rockcod, have also not recovered²⁸.



Antarctic toothfish caught in the South Shetlands.
Image by Darci Lombard.

In light of the unregulated and uncontrolled fishing of the past, the initiation of an Antarctic krill fishery in the 1960s and '70s caused serious concerns among Antarctic Treaty nations and scientists. Many feared that a similar pattern of over-exploitation would harm the recovery of the great whale species and be catastrophic to other Southern Ocean species given krill's central role in Southern Ocean food webs²⁹. In response, the Antarctic Treaty Parties initiated negotiation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR Convention). The Convention was completed in 1980 and entered into force in 1982 with the task of ensuring that fishing does not have significant adverse effects on targeted species and the greater Southern Ocean ecosystem. Its 'ecosystem as a whole' principle was a bold step in management of marine living resources³⁰.

Krill

Krill are shrimp-like crustaceans found throughout the Southern Ocean, with the largest population located in the Southwest Atlantic. Countries began harvesting krill in this region, including around the Antarctic Peninsula, South Georgia and South Orkneys, in the 1973/74 season. The fishery rapidly grew, peaking in the 1980s at 550,000 tonnes, before declining to an average annual catch of just over 100,000 tonnes in the early 1990s³¹. Recently catches have grown again, with approximately 210,000 tonnes caught in 2009/10 and 180,000 tonnes caught in 2010/11. This new average of around 170,000 tonnes caught per year during the last four years is an increase of almost 42% over the longer-term trend³².

A variety of factors have led to concern that krill harvests may continue to rise in the future. Most notable is an increasing demand for krill products, including for omega-3 oils in health supplements and aquaculture feed. Perhaps in response to this demand, new countries have taken interest in the fishery. Advances in harvesting technology have also increased the efficiency of fishing. The fishery currently operates from late summer to mid-winter with operation increasingly extending into winter months. Continued changes and reduction in sea ice around the Antarctic Peninsula may soon allow further extension of the fishing season³³.



Antarctic Krill. Image by Lara Asato.

While the recent catches of krill are considered to be only a fraction of the estimated krill biomass, krill may perhaps be the most important player in the Southern Ocean food web. Southern Ocean predators critically depend on krill, including most penguin populations, flying seabirds, many fish and seals, as well as resident and migratory populations of whales. Moreover krill population dynamics are still not fully understood and some regional populations can fluctuate dramatically from year to year. Krill fisheries should be managed with these ecosystem considerations in mind. This includes factoring in the potential impacts of climate change on krill populations.

Finfishing

In the 1960s, fishermen began trawling around some subantarctic islands, for marbled rockcod, mackerel icefish, grey rockcod, Patagonian rockcod, subantarctic lanternfish and Wilson's icefish³⁴. Fish populations were heavily exploited, particularly marbled rockcod – several hundred thousand tonnes of fish were removed in the first few seasons³⁵. By 1990 marbled rockcod populations had plummeted to 5% of their pre-exploitation level and have yet to recover³⁶. Marbled rockcod aren't alone in their slow recovery. Most of the exploited Antarctic fish populations have not rebounded³⁷.

By the mid 1990s, total Southern Ocean toothfish catches exceeded 100,000 tonnes a year, with more than two thirds thought to be caught illegally.

With shallow water species exhausted, in the 1980s fishermen began targeting the deep-water Patagonian toothfish using longlines around subantarctic islands³⁸. This long-lived fatty fish, which can grow larger than two metres in length, was marketed as “Chilean sea bass,” and quickly became a popular menu item in expensive restaurants, mostly in the United States and Europe. The legal fishery for toothfish was regulated by CCAMLR, but IUU fishermen also took notice of this “white gold” – a term fishermen commonly use to describe this lucrative fish. By the mid 1990s, total Southern Ocean toothfish catches exceeded 100,000 tonnes a year, with more than two thirds thought to be caught illegally³⁹. This caused severe declines in local populations of Patagonian toothfish and fishery closures ensued⁴⁰. Many of these populations have not recovered.



Rotting juvenile fish in piece of ghost gillnet.
Image © Greenpeace / Roger Grace.



Crack in the Larsen B Ice Shelf.
Image © Greenpeace / Steve Morgan.

To keep up with market demands, fishing vessels penetrated even more southern reaches of Antarctic waters in pursuit of the Antarctic toothfish, a southern cousin of the Patagonian toothfish. Unfortunately, IUU fishers have followed in their pursuit, switching from longlines to using deepwater gillnets⁴¹. These nets are banned by CCAMLR and pose a significant environmental threat as a result of even higher bycatch levels than long lines and the risk of “ghost fishing,” which refers to nets that have been left or lost in the ocean which continue fishing for years. The amount of toothfish caught in IUU gillnets remains unknown, but is likely substantial⁴². For example, gillnets found by Australian officials in 2009 spanned 130 km and had 29 tonnes of Antarctic toothfish ensnared⁴³.

Since entering into force, CCAMLR has taken steps to implement sustainable fisheries management. The Commission officially closed the majority of directed finfish fisheries due to the depletion of populations, including in the waters surrounding the Antarctic Peninsula and South Orkney Islands, as well as in regions

of the Southern Indian Ocean. CCAMLR has also reduced IUU toothfish fishing through a number of measures, including member nations regularly patrolling many of the legal fishing grounds. In addition to banning gillnets, CCAMLR has banned bottom trawling due to the impacts on the seafloor and has measures in place for protecting vulnerable seafloor habitats⁴⁴.

Despite these efforts, historic overfishing and the persistence of some IUU fishing has left many fishing grounds depleted and the overall ecosystem impacts remain unknown. Most toothfish fishers employ benthic longlines, which can still severely impact seafloor habitats, particularly when they are concentrated in one area over the course of many years. Measures enacted by CCAMLR for identifying and banning fishing in vulnerable seafloor habitats are still insufficient⁴⁵. The designation of a representative system of MPAs and no-take marine reserves in the Southern Ocean will be a valuable tool to conserve ecosystem function and can help to maintain existing populations and contribute to the recovery of depleted populations.

OTHER THREATS

Beyond the threats of climate change and fishing, the Antarctic remains vulnerable to pollution, unregulated tourism and invasive species. Historically, waste from scientific operations was often tossed into the ocean or left behind on land. Today, waste disposal is highly regulated and scientists and tourist operations must pack it out with them. Despite these regulations, some waste still finds its way into the Southern Ocean. Plastic pollution has just begun turning up in the Peninsula region⁴⁶. Mining is banned under the Antarctic Treaty System, but this could be reopened for discussion in 2048⁴⁷. Antarctic tourism draws more than 30,000 visitors per year⁴⁸ and while it is regulated by the Antarctic Treaty Consultative Meeting (ATCM) and responsible practices are encouraged by the tourism industry trade association (IAATO), many are concerned that visitors disturb the environment and associated wildlife. One of the biggest risks posed by tourism is accidental oil spills if boats become grounded or sink. Fishing boats present a similar risk. Invasive species have come to the continent, often from seeds stuck and hidden in the gear and clothing of tourists and scientists and on ships' hulls and in their ballast water. A small number of plant species have readily established themselves on the few ice-free regions, most notably on the Peninsula. A warming climate may facilitate their spread⁴⁹.

Beyond the threats of climate change and fishing, the Antarctic remains vulnerable to pollution, unregulated tourism and invasive species.

OPPORTUNITY AT CCAMLR

Marine protected areas (MPAs) are becoming an increasingly valuable tool among policy makers, scientists and fishers for ensuring the long-term health and sustainable use of our oceans⁵⁰. Recognition of this value was officially noted in 2002 at the World Summit on Sustainable Development (WSSD) in Durban, South Africa, when the nations of the world committed to establishing representative networks of MPAs across the world's oceans by 2012⁵¹.

Note that in this report, MPA is used to describe areas where certain activities are limited or prohibited to meet specific conservation, habitat protection, or fisheries management objectives. A no-take marine reserve refers specifically to a highly protected area that is off limits to all extractive uses, including fishing. No-take marine reserves provide the highest level of protection to all elements of the ocean ecosystem.

Under the CAMLR Convention, Members are required to apply an ecosystem approach to management in ensuring activities in the Southern Ocean do not impact the overall health of Antarctic ecosystems. CCAMLR is supposed to use the best available science in making management decisions that are precautionary and err on the side of preserving ecosystem function⁵². MPAs and marine reserves are essential tools for implementing both precautionary and ecosystem approaches.

Further, Article IX 2 (g) of the CAMLR Convention provides explicitly for “the designation of the opening and closing of areas, regions or sub-regions for purposes of scientific study or conservation.”



CCAMLR headquarters building, Hobart, Australia.
Image by Richard Williams for the AOA.

Recognising the value of MPAs and marine reserves in supporting ecosystem health, CCAMLR has agreed to meet the WSSD goal by 2012⁵³. This commitment has been supported by a series of milestones including:

- The 2005 CCAMLR MPA workshop
- The first bioregionalisation mapping of the Southern Ocean in 2007
- The identification of 11 priority areas and more recently nine planning domains for MPAs
- The designation of the South Orkney Islands southern shelf MPA in 2009
- The CCAMLR 2011 MPA workshop
- The agreement of a Conservation Measure providing a general framework for the establishment of CCAMLR MPAs at the 2011 meeting

The following criteria have been recognized in the general framework MPA Conservation Measure in 2011:

1. Protection of representative examples of marine ecosystems, biodiversity and habitats at an appropriate scale to maintain their viability and integrity in the long term;
2. Protection of key ecosystem processes, habitats and species, including populations and life-history stages;
3. 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;
4. Protection of areas vulnerable to impact by human activities, including unique, rare or highly biodiverse habitats and features;
5. Protection of features critical to the function of local ecosystems;
6. Protection of areas to maintain resilience or the ability to adapt to the effects of climate change⁵⁴.

CCAMLR has both a major opportunity and a responsibility to help meet the WSSD 2012 goal for networks of MPAs. Such an achievement is only possible because of the principles, values and spirit enshrined within the CAMLR Convention, which reflect the central ethos of the Antarctic Treaty. Despite historical occurrences of overfishing, the Southern Ocean still has ecologically robust regions like the Ross Sea and the Weddell Sea, which remain almost completely intact and undamaged. Waiting any longer to put effective management in place risks losing these valuable regions, particularly in the face of climate change.

It is clear that climate change and the resulting sea ice variability and ocean acidification will increasingly put pressure on the marine ecosystems of Antarctica. Humanity will need to adapt to the enormous challenges ahead based on clear guidance from the scientific community. Many scientists argue that Antarctica is an ideal location for gathering this kind of data.

Antarctica has evolved for millennia without a permanent human population and some areas have remained free from human interference and damage. This gives scientists a chance to understand the effects of global climate change, as well as the adaptability of species and potential mitigation strategies, without the results being confounded by the impacts of other human activities⁵⁵. Using MPAs and no-take marine reserves as reference areas ensures scientists can develop a clear picture of the impacts of climate change and ocean acidification. Further, these protected areas can help build the resilience and adaptive capability of Southern Ocean ecosystems. The inclusion of specific “climate reference” areas constitutes a critical part of an effective network of marine reserves. Finally, areas that are warming the slowest can serve as “refugia” – the last suitable habitats for species that depend on ice and cold waters.

By implementing suitable protection now, the legacy of the Antarctic Treaty System and its principles, values and spirit will be carried forward. In the past, these values and provisions have enabled CCAMLR Members to demonstrate commendable leadership in the governance of international spaces. CCAMLR is encouraged to seize this opportunity.

CCAMLR Members have an unprecedented opportunity to establish the world’s largest network of MPAs and no-take marine reserves in the oceans around Antarctica as a legacy for future generations. With such a network in place, key Southern Ocean habitats and wildlife would be better protected from human interference.

The AOA believes that with visionary political leadership, CCAMLR can embrace this opportunity. We urge the Commission for the Conservation of Antarctic Marine Living Resources to fully implement our proposal.



King penguins on South Georgia Island. Image by John B. Weller.



NETWORK OF SOUTHERN OCEAN MPAS AND NO-TAKE MARINE RESERVES

To be effective, MPAs and no-take marine reserves must be large enough to encompass and protect key ecological processes and the life history of the animals that live there⁵⁶. A network of large MPAs and marine reserves that connects these ocean processes across space and time is the most effective and powerful tool to ensure long-term resilience of the Southern Ocean and coastal seas of Antarctica. Since establishing the 2002 target, many countries and institutions have been working to meet the WSSD 2012 goal, including CCAMLR Member nations. AOA recognises all the scientists and Antarctic programs for their contributions towards designating important areas as MPAs and marine reserves in the Southern Ocean.

While a single MPA or no-take marine reserve can protect areas of local importance, a network has the power to ensure better resilience in the Southern Ocean ecosystem. A network can protect all representative habitat types, including seamounts, banks and intertidal regions where animals live, as well as productive open water areas where they breed and feed. As animals grow, feed and breed, they move through space and time. A network of large MPAs and marine reserves covers these different needs. Replication within the network is also important for long-term resilience. Having multiple no-take marine reserves and MPAs protecting similar habitat types provides insurance against human induced or natural disasters, including climate change⁵⁷. These types of networks have already proved successful in social, economic and environmental aspects in other large marine ecosystems, such as the Great Barrier Reef in Australia⁵⁸.

The AOA proposes a network of marine reserves and MPAs in Antarctica that will encompass key biodiversity and productivity hotspots, critical habitats and unique geographical features. The network includes regions still in recovery from historical overexploitation and areas that have never been significantly exploited. Through a network of marine reserves and MPAs, the Southern Ocean's rich and abundant wildlife, which includes many species found nowhere else on the planet, will be protected.

Importantly, a network of MPAs and no-take marine reserves may be our only hope at both understanding and helping to improve resilience against the effects of climate change in marine environments⁵⁹. Some regions of Antarctica have already been drastically altered by climate change. Through eliminating stressors that can be controlled, the Southern Ocean's flora and fauna will have the best chance to adapt in an uncertain future. As an international space, the Southern Ocean's riches belong to everyone. A network of marine reserves and MPAs will help safeguard these riches for generations to come.

The Antarctic Ocean Alliance has chosen 19 areas that collectively form a comprehensive and biologically meaningful network of MPAs and marine reserves. In the following pages, each of these 19 areas is described, including an overview of the geography, oceanography and ecology of the region. A case, or option, for protection is offered for each area.



Pair of Southern Royal Albatross. Image by John B. Weller.

The Antarctic Ocean Alliance recommends the protection of 19 areas in the Southern Ocean through the designation of fully protected marine reserves and MPAs.

1 Antarctic Peninsula

2 Weddell Sea

3 South Orkney Islands

4 South Georgia

5 South Sandwich Islands Arc

6 Maud Rise

7 Bouvetøya

8 Ob & Lena Banks

9 Del Cano Region High Seas

10 Kerguelen Plateau High Seas Area

11 BANZARE Bank

12 Kerguelen Production Zone

13 Eastern Antarctic Shelf

14 Indian Ocean Benthic Environment

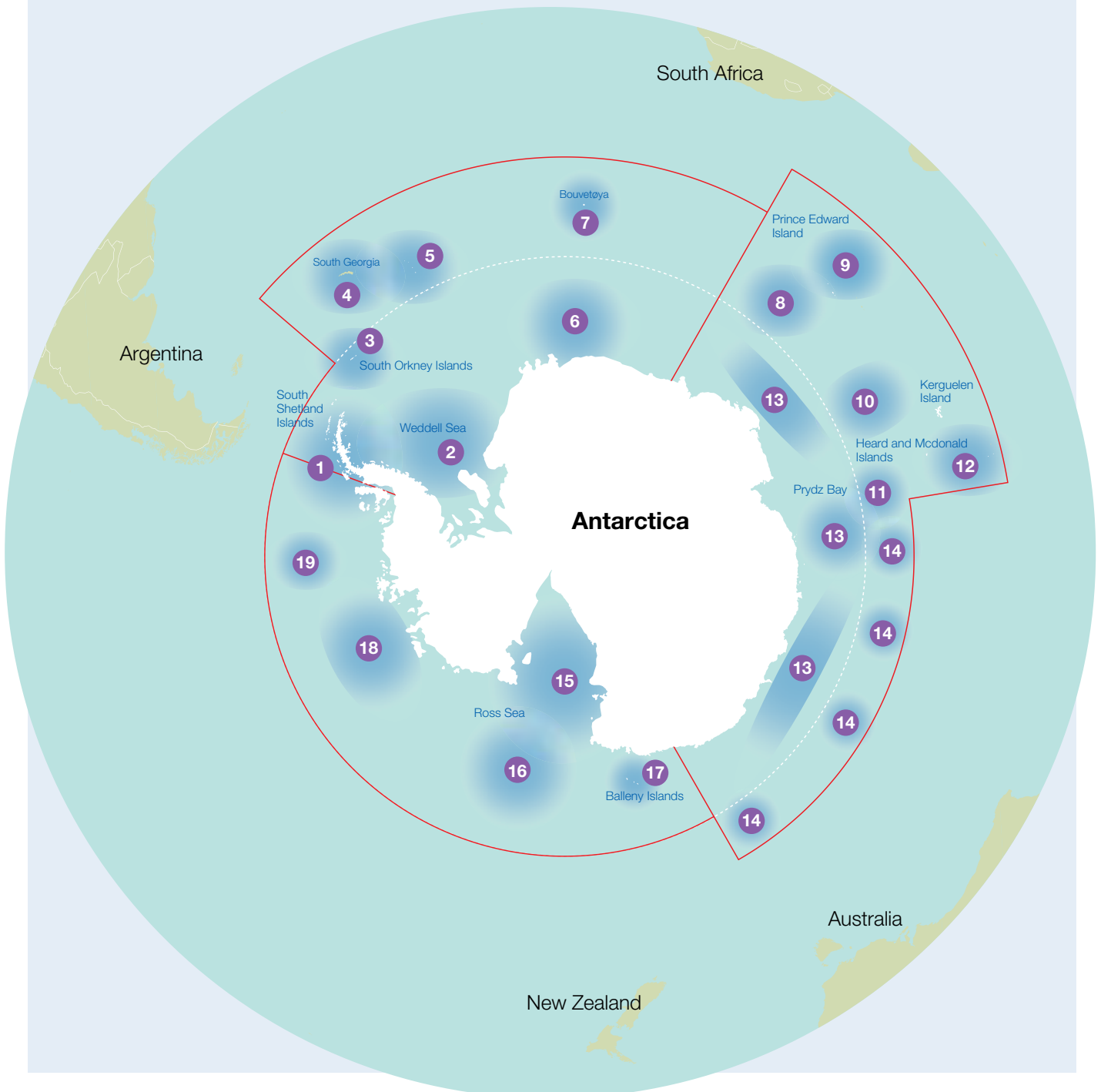
15 Ross Sea

16 Pacific Seamounts

17 Balleny Islands

18 Amundsen & Bellingshausen Seas
(West Antarctic Shelf)

19 Peter I Island





ANTARCTIC PENINSULA

As the northernmost stretch of the continent, the Western Antarctic Peninsula is the fastest warming area in the Southern Ocean and one of the fastest warming areas in the world⁶⁰. The Peninsula and the associated islands support great biodiversity⁶¹ and some of the largest aggregations of Antarctic krill in the Southern Ocean⁶². Because of the

vast abundance of krill, this region also sustains large breeding and foraging populations of penguins, seals and whales⁶³. Yet, some evidence suggests that a reduction in the duration of sea ice caused by climate change is reducing habitat and potentially causing decreases in krill populations and productivity⁶⁴. Regional populations of chinstrap and Adélie penguins are also in rapid decline, possibly due to declines in krill abundance⁶⁵. Furthermore, catches in the Southern Ocean krill fishery, the majority of which operates in the area near the Peninsula, are the highest they've been in almost two decades⁶⁶ and may be expanding further.

A number of small MPAs are scattered throughout the Peninsula region, including around the South Shetland Islands and the Palmer Archipelago. But these tiny areas, managed by the Antarctic Treaty Consultative Meeting, are inadequate to protect the Peninsula's krill populations, millions of breeding birds, marine mammals, and the greater ecosystem.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The Antarctic Peninsula is a prominent peninsula extending north towards the tip of South America roughly 1,000 km away⁶⁷. These narrow waters, referred to as the Drake Passage, are some of the roughest on Earth. The Peninsula extends for approximately 1,500 km with the Weddell Sea to the east and the Bellingshausen Sea to the west⁶⁸. The Peninsula was the last piece of Antarctica connected to any other continent, and with its division began the Antarctic Circumpolar Current (ACC) and the subsequent cooling of the entire continent⁶⁹.

The Peninsula's glacially sculpted coastline has deep embayments and a varied continental shelf that slopes dramatically down to as much as 3,000 m. Deep channels between the embayments help transport heat and nutrients into the shelf domain⁷⁰. This diverse bathymetry and the flows between these embayments help drive the Peninsula region's incredible productivity, which supports the largest krill population in the Southern Ocean⁷¹.



Crabeater seals. Image by Cassandra Brooks.

Large krill aggregations are often found near the continental shelf break⁷². The presence of ice is crucial to their life history, particularly for larval krill, which feed on under-ice microorganisms⁷³. The Western Antarctic Peninsula is an important breeding and nursery ground for krill⁷⁴, perhaps due to these strong seasonal ice dynamics. Despite decades of study, many aspects of krill ecology remain poorly understood. For example, it was only in 2008 that krill were first observed feeding on the deep-seabed at more than 3,500 m depth off the Antarctic Peninsula⁷⁵.

This incredible abundance of krill is at least partially responsible for the species diversity in the West Antarctic Peninsula for both land-based predators and the seafloor community⁷⁶. Krill is the dominant prey of nearly all vertebrates in the area⁷⁷, especially Adélie penguins and crabeater seals, the latter of which consumes an estimated 17% of the krill stock⁷⁸. Both these species are also highly dependent on the presence of sea ice⁷⁹.

One and a half million breeding pairs of gentoos, chinstrap and Adélie penguins make their home around the Peninsula⁸⁰. There are also notable macaroni penguin colonies⁸¹. The penguins are joined by significant populations of crabeater, Weddell, leopard, fur and elephant seals⁸². During the breeding season, penguins and seals stay close to their colonies, foraging and returning repeatedly over the course of many months to feed their dependent offspring⁸³. Crabeater, leopard and Weddell seals spend much of their time out on and amongst the sea ice.

Whales also come to feed on the Peninsula's riches, including killer whales, minke and dwarf minke whales⁸⁴. The region also provides an important summer feeding ground for humpback, sperm, fin and blue whales, all of which are still recovering from the industrial whaling of the past⁸⁵.



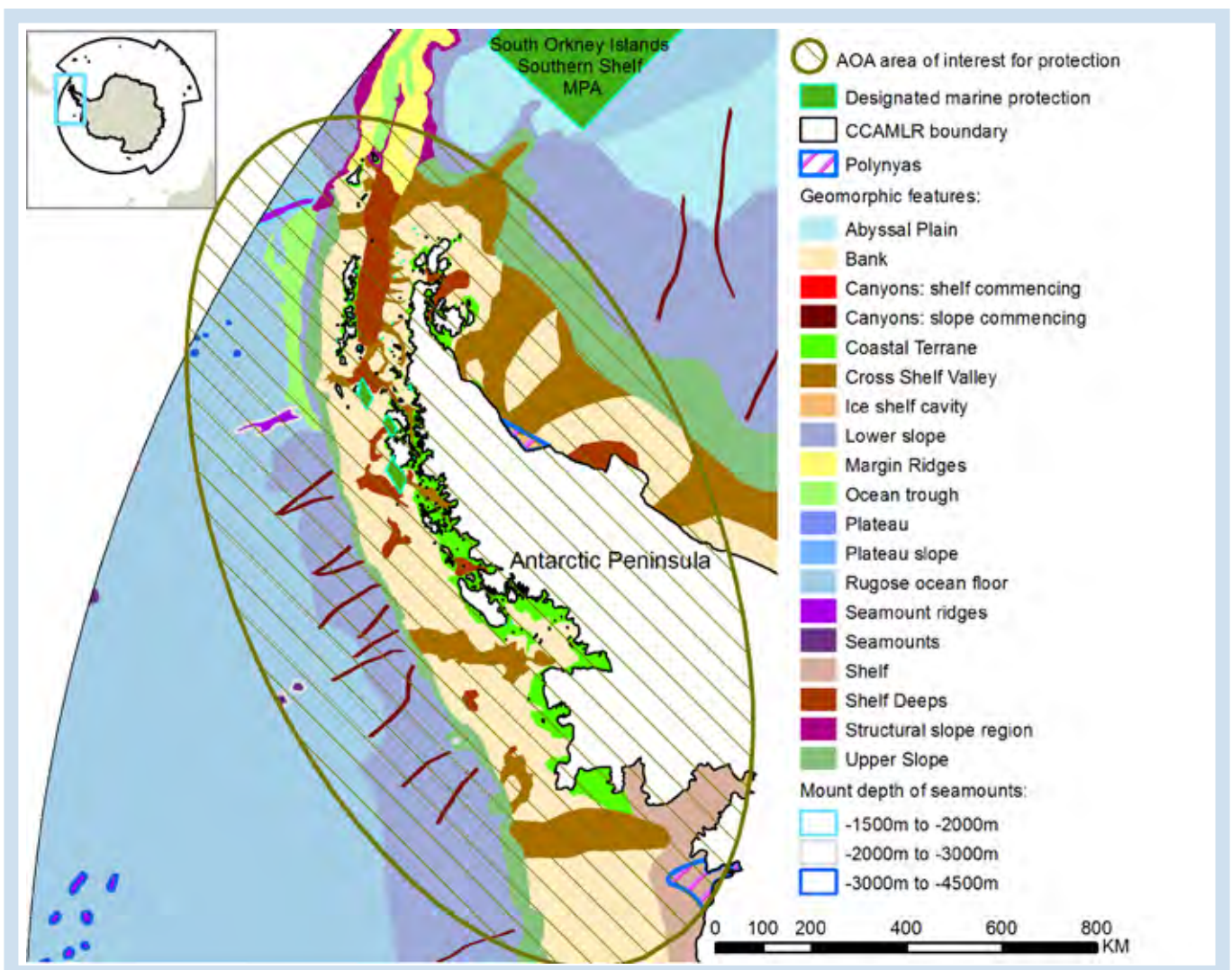
Minke whale. Image by John B. Weller.

A CASE FOR PROTECTION

The Western Antarctic Peninsula is among the most rapidly warming regions on Earth. Since 1950, the mean annual temperature has increased by 2.8°C⁸⁶. Warming, coupled with sea ice reduction, will create positive feedbacks that may work to further increase warming⁸⁷. Rising temperatures have already caused massive reductions in ice. Eighty-seven percent of the Peninsula's glaciers have retreated in recent decades⁸⁸. In Maxwell Bay, King George Island, the duration of sea ice cover decreased from six to three months over 1968 – 2008. The thickness of fast ice, sea ice fastened to land that extends to sea, near Bellingshausen station decreased from 90 to 30 cm over the same period⁸⁹.

If the warming trend continues here, winter sea ice will be gone from much of the region in the near future, with serious ramifications for the Western Antarctic Peninsula ecosystem and its species. Declines in sea ice have possibly contributed to reductions in krill populations⁹⁰. Because the Western Antarctic Peninsula is an important nursery ground for krill, reductions here could have ramifications throughout the Southern Ocean⁹¹.

Antarctic Peninsula area map.



Reductions in krill populations coupled with the effects of climate change are likely to have contributed to declines in both Adélie and chinstrap penguins throughout the region. Chinstrap populations have declined by more than 50% in the last 30 years in the South Shetland Islands⁹². They have also declined off the South Orkney Islands⁹³, the Peninsula⁹⁴ and the South Sandwich Islands⁹⁵. The situation is particularly critical for chinstrap penguins, since their breeding refuges are largely restricted to the subantarctic islands and the Scotia Sea⁹⁶. Key crabeater seal breeding and resting habitat has also disappeared over the last 30 years because of reductions in local sea ice⁹⁷. Meanwhile, climate change allows some penguin species to expand their range as the ice retreats. In response to warming, gentoo penguin numbers are rising as they move south along the Peninsula⁹⁸.



Gentoo penguin. Image by John B. Weller.



Russian krill trawler off South Orkney Islands. Image by © Greenpeace / Roger Grace.

The ecosystem impacts of fishing and reductions in habitat related to climate change have the potential to seriously impact local breeding populations of birds and mammals. MPAs and no-take marine reserves that build on and connect the existing pockets of protected areas in the Western Antarctic Peninsula will buffer these impacts in an uncertain future.

The krill fishery operates largely in the Antarctic Peninsula region and has been increasing in recent years. The ecosystem impacts of fishing and reductions in habitat related to climate change have the potential to seriously impact local breeding populations of birds and mammals. MPAs and no-take marine reserves that build on and connect the existing pockets of protected areas in the Western Antarctic Peninsula will buffer these impacts in an uncertain future. Many countries already have monitoring systems, field stations and long-term research programs in place throughout the Peninsula region. A regional network of no-take marine reserves and MPAs would allow scientists to build on these data sets and to study climate change without the interference of other human stressors. In doing so, they may find potential solutions to aid the survival of the Peninsula's rich wildlife. The AOA plans on completing further analysis of this region to help identify the most valuable areas for protection.



WEDDELL SEA

The Weddell Sea is a large, deep embayment nestled between west and east Antarctica. The region is highly productive, in part due to the Weddell Gyre, a huge clockwise gyre north of the massive Filchner-Ronne Ice Shelf. The sea north of the ice shelf is usually ice-choked, providing

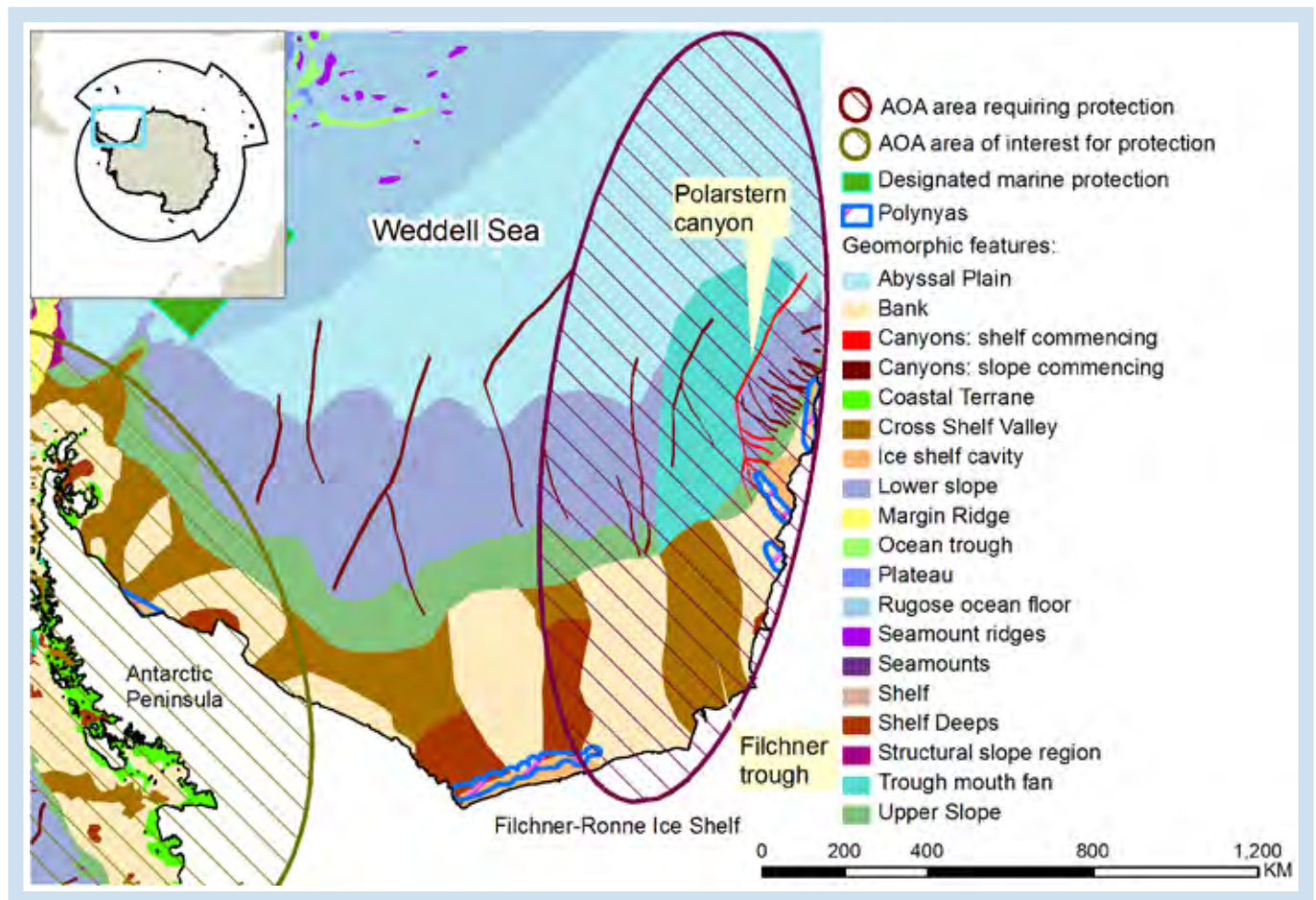
ideal krill habitat and feeding grounds for mammals, fish and seabirds. The Weddell Sea also has incredible biodiversity, from the shallow shelf down to the deep sea, with dozens of new species found on every sampling expedition. Protecting the unique, ecologically intact and diverse deep-water regions of the Weddell Sea in a large-scale marine reserve would ensure that its rich benthic biodiversity, krill populations and large predators will continue to thrive.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The Weddell Sea comprises a wide and deep ice-rich embayment bounded on the west by the Antarctic Peninsula and on the east by Cape Norvegia. At its widest, it is 2,000 km across and encompasses 2.8 million km². The continental shelf stretches out almost 500 km and is very deep – 500 m at the break, with a variety of banks and basins. The Filchner Trough may be its most dramatic feature, carving a deep underwater canyon through the eastern edge of the shelf. At the edge of the continental shelf, the slope drops to more than 4,000 m deep and beyond into the Weddell Basin⁹⁹.

The deep shelf has been carved over millennia by the advance and retreat of the Filchner-Ronne Ice Shelf, which is currently the second largest ice shelf in Antarctica. The ice shelf spans from west to east, swallowing the islands of the Weddell Sea, encompassing roughly 430,000 km². The shelf is an extension of the glaciers on land and calves icebergs off its northern front. In addition to the massive icebergs in the region, the Weddell Sea is famous for its pack ice. This drifting sea ice, which compresses and packs together in large masses, trapped Shackleton and his crew aboard the *Endurance* in their 1914 expedition. In the winter, sea ice extends from the ice shelf beyond the tip of the Antarctic Peninsula¹⁰⁰.

Weddell Sea area map including the Antarctic Peninsula area of interest for protection, pending further AOA analysis.





Photographer Frank Hurley called this image “The Rescue” but in fact it is actually the departure of Shackleton on his famous boat journey. This rare shot was taken on Elephant Island after his journey into the Weddell Sea. (See Alexander, Caroline “The Endurance” p.202, for history of this image), *Elephant Island, South Shetland Islands*. Photograph by Hurley, James Francis (Frank), Australian Antarctic Division, Copyright Commonwealth of Australia.

The Weddell Gyre drives water in a clockwise circulation around the deep Weddell Basin, through the northern Weddell Sea, then east to about 30°E and back¹⁰¹. This gyre, combined with local upwelling and fluctuations in ice cover, makes the Weddell Sea a richly productive region with high abundances of krill.

Many seabirds and mammals are found throughout the Weddell Sea, including Weddell, crabeater and elephant seals¹⁰² as well as minke, humpback, blue and fin whales¹⁰³. These animals likely come to feed on krill, as well as Antarctic silverfish, which are also found throughout the region¹⁰⁴. At the eastern end of the continental slope, outflow from the Filchner Trough mixes with the Weddell Gyre, creating rich foraging grounds for elephant seals and other animals¹⁰⁵. The Weddell Sea is also habitat for the McCain’s skate, an IUCN near threatened species due to its vulnerable life history characteristics, which include slow growth and late maturity¹⁰⁶.

The icy waters of the Weddell Sea have made it difficult for scientists to unveil the full extent of the variety of species that live there. Research thus far suggests that the seafloor harbours extraordinary biodiversity, with many species yet to be discovered.

Research expeditions during the last decade have revealed remarkable benthic biodiversity in the eastern Weddell Sea. In exploring waters between 500-1,000 m deep, scientists pulled up samples of mud and water that at times contained 40,000 animals per litre, many of them new to science¹⁰⁷. Over the course of three trips, scientists found hundreds of new species, including different types of microscopic animals, crustaceans, worms and sponges. Even samples from more than 6,000 m deep showed unusually high species diversity¹⁰⁸.

While the western Weddell Sea still remains largely unexplored, the eastern area is among the highest biologically diverse regions in the Antarctic¹⁰⁹. The exact reason for this rich biodiversity remains unclear, but it may be a result of mixing between the waters of the deep continental shelf and deep sea, which can enhance nutrient levels. The glacial-interglacial pulses of ice shelf advance and retreat may have also driven historical migration in and out of the region as well as pushing species into deeper waters. Deep-water production may have also facilitated migrations of species between the deep sea and the shelf. This deep-water production has been crucial for the benthos – making the Weddell Sea even more diverse than other deep-sea areas¹¹⁰.



Ernest Shackleton on board the *Nimrod* after his farthest trek south, in which he came within 97 miles of the South Pole, Ross Sea. Photograph by Unknown, Australian Antarctic Division, Copyright Commonwealth of Australia.

CASE FOR PROTECTION

The icy waters of the Weddell Sea have made it difficult for scientists to unveil the full extent of the variety of species that live there. Research thus far suggests that the seafloor harbours extraordinary biodiversity, with many species yet to be discovered. The Weddell Sea’s waters are also a haven for krill and all the predators that feed on them. Yet climate change is warming the region, threatening to disrupt this ice-driven environment. Changes in ice could be particularly devastating for krill and for crabeater seals, whose life history depends on the presence of pack ice. The Weddell Sea has notable habitat diversity, including the Filchner Trough, which is the deepest region of the Weddell Sea continental shelf.

Protection of the Weddell Sea as part of a Southern Ocean network of MPAs and no-take marine reserves would safeguard all the threatened animals that live there, including many whale species and the McCain’s skate. It would also conserve the rich benthos, including all the species yet to be discovered in the western Weddell Sea, a region that has been largely unexplored¹¹¹. This protection may be particularly important as the waters off the Western Antarctic Peninsula continue to warm, potentially stressing the myriad of animals living on the continental shelf and in the depths of the Weddell Sea.

SOUTH SCOTIA SEA REGION

(includes South Orkneys, South Georgia and South Sandwich Islands)



SOUTH ORKNEY ISLANDS

The South Orkney Islands, located along the southern edge of the Scotia Sea Arc, provide important breeding and feeding grounds for an incredible array of birds, mammals, fish and invertebrates. The high

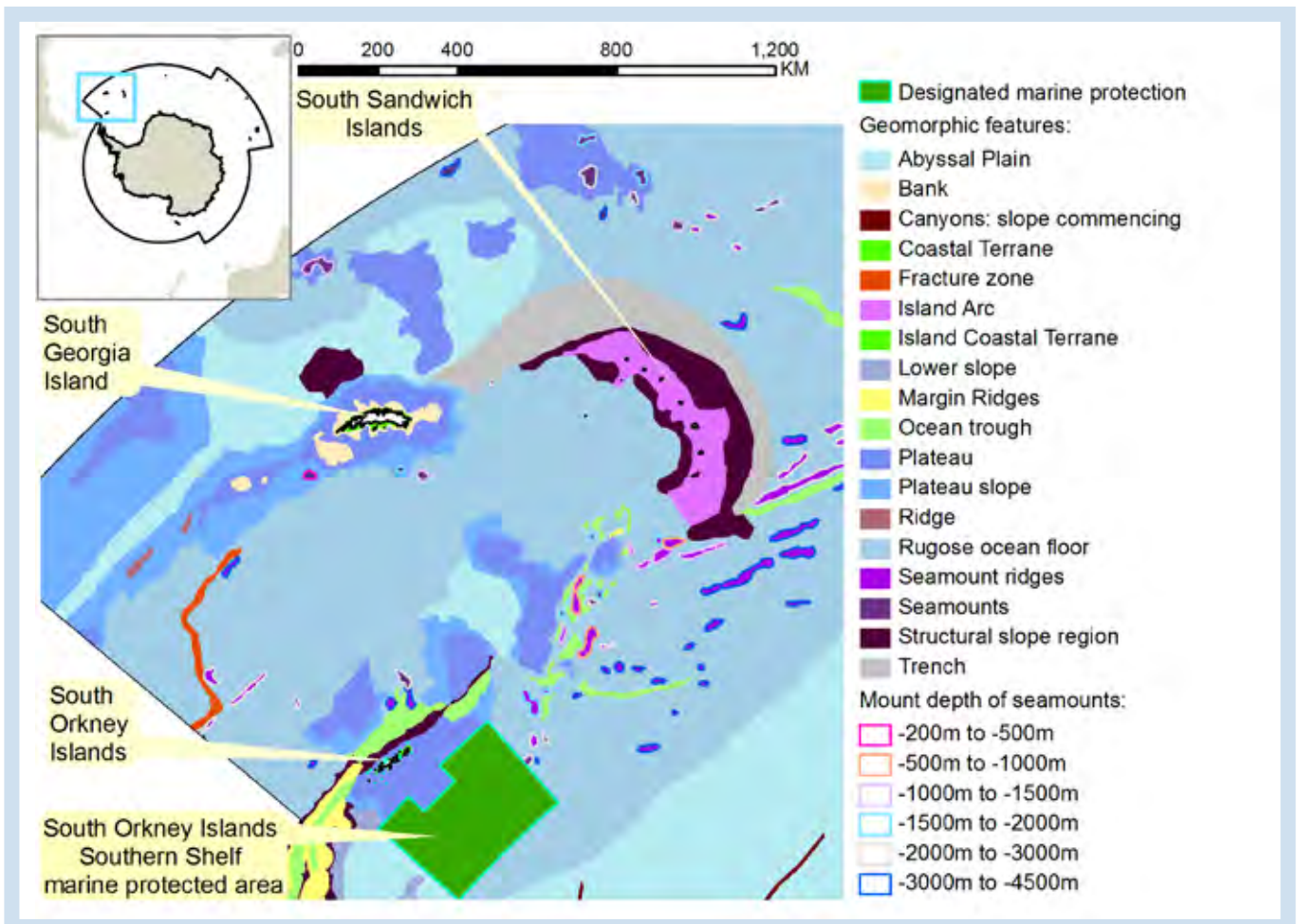
productivity of the area also supports rich benthic biodiversity, many fish species and seasonal foraging ground for whales. In recognition of the region's riches, the United Kingdom proposed a MPA south of the South Orkney Islands. Upon approval in 2009, it became the first no-take marine reserve in CCAMLR's network of Southern Ocean MPAs.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The South Orkney Islands, north of the Weddell Sea, are one of many island groups in the Scotia Sea Arc. The Arc is comprised of a submarine ridge that advances northeast from the Antarctica Peninsula, then makes a hairpin turn west, arcing back to meet the tip of South America. Within the 4,350 km curve of the Arc lies the Scotia Sea.

Like other island archipelagos in the Scotia Sea Arc, the South Orkney Islands are in relatively close proximity to the Southern Antarctic Circumpolar Current Front. These fronts enhance the region's production of plant and animal plankton, creating excellent foraging opportunities for seabirds and marine mammals¹¹². This productivity drives incredible biodiversity on both the seafloor and in the waters above it. This diversity in part comes from the South Orkney Islands' proximity to the Weddell and Scotia Sea and the confluence of these two major bodies of water¹¹³. In addition, the South Orkney Islands are isolated and geologically old. These two characteristics can also spur higher levels of diversity¹¹⁴.

South Scotia Sea region map.





Anemone. Image by John B. Weller.

The stars of the South Orkneys ecosystem are its abundant bird and mammal populations. Forty different species of birds breed or feed in the area¹¹⁵, including the imperial shag, Wilson’s storm petrel, southern giant petrel, brown skua and the southern fulmar¹¹⁶. Hundreds of thousands of chinstrap and Adélie penguins also make their home here, as well as some gentoo and macaroni penguins¹¹⁷.

The South Orkneys also support great numbers of a variety of seals. Elephant seals are the most abundant, but there are also leopard and crabeater seals in the area. Weddell seals breed there in small numbers¹¹⁸ and more than 12,000 fur seals have been observed on Signy Island alone – marking a significant recovery since the height of industrial sealing¹¹⁹.

Besides drawing large numbers of apex predators, the South Orkneys also have a thriving seafloor community. A recent scientific assessment revealed more than 1,000 species in the area, several of which were new to science¹²⁰. Crustaceans, molluscs, bryozoans (“moss animals”) and echinoderms (starfish and sea urchins) are the most species-rich groups¹²¹. Antarctic krill are also abundant in the region, but are subject to large annual fluctuations¹²². The productivity-enhancing fronts of the South Orkneys have also been associated with large populations of squid, which are a major prey item of seabirds and some marine mammals¹²³. Similar to other Antarctic areas, the fish in the area are mostly icefish.

CASE FOR PROTECTION

Historical whaling and fishing has had lingering effects on the whale and fish populations around the South Orkneys. Mackerel icefish, humped rockcod and marbled rockcod were heavily overfished in the 1970s and 1980s and have not recovered¹²⁴. Tens of thousands of blue, fin, humpback and other whales were slaughtered in commercial whaling operations in the 1800s and 1900s and have also not fully recovered¹²⁵. Krill fishing still occurs in waters near the South Orkneys.

The South Orkney Islands southern shelf MPA designation was a positive first step as the world’s first wholly high-seas MPA and will preserve the habitat of the many seabirds and mammals that depend on the waters to the south of the South Orkneys while potentially aiding the recovery of fish and whales. This area also has incredible scientific value. Scientists in the region have been conducting important research on predator ecology, biodiversity and climate change over many decades. The need to expand upon the area currently protected by the existing MPA is now a critical concern. The MPA’s designation as a no-take area will allow this research to continue uninterrupted by other human activities and sets a precedent for other areas in the Southern Ocean.



Wave rolling in ice sea cave. Image by John B. Weller.

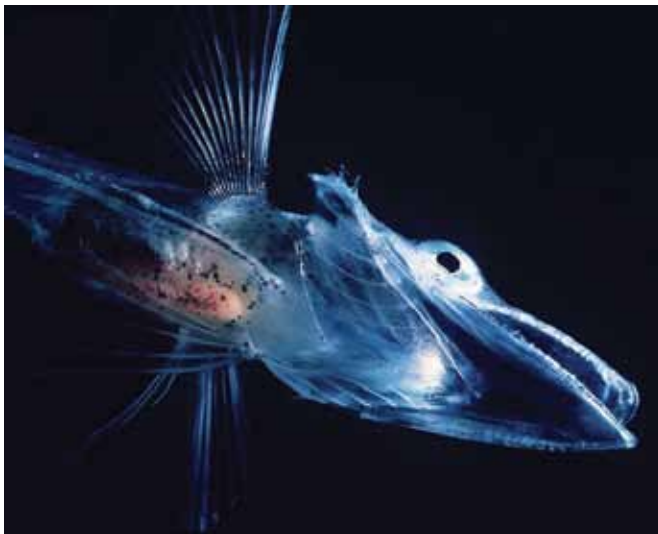


SOUTH GEORGIA

South Georgia Island, a subantarctic island in the Scotia Sea, is only about 170 km long, yet it teems with wildlife. More than four million fur seals make their home here, along with many other species, including perhaps one hundred million seabirds overall. The incredibly productive

waters around South Georgia, full of plankton and krill, nourish the islands' birds and mammals. Studies of the animals living on the seabed around South Georgia have also revealed highly diverse communities with a high level of endemism.

Fishers, whalers and sealers took notice of South Georgia more than two centuries ago, devastating local seal, whale, fish and bird populations, the latter through the massive numbers killed as fisheries bycatch. Seal and whale populations continue to recover, while krill, Patagonian toothfish and mackerel icefish fisheries continue. South Georgia, because of its remarkable abundance and diversity of wildlife, will be a key component of the Southern Ocean network of MPAs and no-take marine reserves.



Larval icefish. Image by uwe kils/wikimedia commons.

The stars of the South Orkneys ecosystem are its abundant bird and mammal populations. Forty different species of birds breed or feed in the area... Hundreds of thousands of chinstrap and Adélie penguins also make their home here, as well as some gentoo and macaroni penguins.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

South Georgia is a mountainous, glacier-covered island located in the north of the region. The island has a wide continental shelf, a feature often associated with high biodiversity. The ocean currents and processes around South Georgia generate vast productivity at levels several times greater than most of the rest of the Southern Ocean. Yet the exact mechanism driving these extraordinary conditions remains uncertain¹²⁶. One major factor is the island's proximity to the Southern Antarctic Circumpolar Current Front, which brings large schools of krill aggregations to South Georgia from the Antarctic Peninsula¹²⁷. The front also increases primary production¹²⁸. These and other factors converge to support an ecosystem that contains astonishingly large populations of species at all levels, from tiny crustacean prey to enormous elephant seal predators¹²⁹. However, the ecosystem may be at risk from climate change – the waters around South Georgia are among the fastest warming in the Southern Ocean¹³⁰.

South Georgia also supports an amazing seafloor community with more numbers of species, greater biodiversity and higher levels of endemism than many other areas of the Southern Ocean¹³¹. In addition to the oceanographic factors mentioned above, South Georgia is an isolated and geologically old island that split from a continent a long time ago. These two characteristics are typically associated with increased biodiversity throughout the world¹³². The result is a rich array of seafloor-dwelling species including substantial numbers of crustaceans, bryozoans, worms, molluscs and starfish¹³³. Many of these species grow slowly and take a long time to mature. These characteristics make it difficult for them to adapt to warming temperatures¹³⁴. Losing these creatures would disrupt the ecosystem, depriving many predators of food.

The waters around South Georgia also have many species of icefish, a family of fish that dominates most fish fauna in the Antarctica. These waters also harbor significant populations of Patagonian toothfish, 20 species of lanternfish, abundances of squid and deep-sea grenadiers, as well as a few sharks, skates and octopuses¹³⁵. Nine endemic species of fish have been found around South Georgia and Shag Rocks¹³⁶. Colossal squid also occupy the island's deep waters.

Krill are a key prey species in Southern Ocean ecosystems and play a critical role in the South Georgia region. Even so, the size of krill populations can vary significantly from year to year. One analysis found that just two years after a period of low abundance, krill density rebounded and was more than 20 times higher than it had previously been¹³⁷. Because so many species depend on krill, periods of low abundance are associated with a decrease in reproductive success for krill-eating birds and mammals¹³⁸.

The large numbers of birds and mammals that breed on South Georgia or forage in its waters are perhaps its most high-profile inhabitants. Twenty-four species of seabirds breed on South Georgia, including four species of penguin, four species of albatross and ten species of petrel, with many more visiting to feed. Some of these species are present in enormous numbers. For example, there are one million breeding pairs of macaroni penguins and 22 million pairs of the Antarctic prion (a flying seabird)¹³⁹.

Whales and seals abound here. Fur seals have apparently recovered from past exploitation with more than four million – greater than 90% of the global population – breeding on South Georgia¹⁴⁰. Fur seals feed mostly on krill, which puts them in competition with the krill fishery during the winter¹⁴¹. Half of the world's elephant seal population also breeds on South Georgia and appear to be at a stable population size¹⁴². Many species of baleen whales, including southern right, humpback and fin whales, are drawn to South Georgia's waters to feed on krill and other zooplankton. Yet due to past whaling, their populations are still recovering¹⁴³. Other South Georgia cetaceans include sperm whales, killer whales (eco-type D)¹⁴⁴, pilot whales and hourglass dolphins. Weddell and leopard seals also feed in the region¹⁴⁵.



Starfish. Image by John B. Weller.

THE CASE FOR PROTECTION

South Georgia has a long history of marine resource exploitation. The hunting of fur seals began in the late 1700s and whaling for blue and humpback whales began in the early 1900s. As whaling ceased, fishers began exploiting mackerel icefish and marbled rockcod, which were quickly depleted¹⁴⁶. Currently the waters around South Georgia support significant commercial fisheries for krill and Patagonian toothfish and a smaller fishery for mackerel icefish. Although the legal Patagonian toothfish fishery has reduced its bird bycatch to nearly zero, many albatrosses and petrels were killed by legal and illegal toothfish longliners in the early days of the fishery. Krill fisheries possibly compete with predators in years of low abundance. Fluctuations in krill populations and climate change may additionally reduce the supply of krill available to foragers and fishers.

There are few places left on earth with top predator populations as abundant as those of South Georgia. Ensuring the survival of these remaining thriving ecosystems requires bold action. The recent announcement of an MPA around South Georgia and the South Sandwich Islands by the United Kingdom (not yet recognised by CCMLAR and disputed by some parties), which includes no-take areas around each island, is a good initial step, but additional no-take areas are needed to ensure the full protection of the ecosystem.



Humpback Whale in Southern Ocean. Image © Greenpeace / Jeri Rezac.

There are few places left on earth with top predator populations as abundant as those of South Georgia. Ensuring the survival of these remaining thriving ecosystems requires bold action.



SOUTH SANDWICH ISLANDS ARC

The South Sandwich Islands, at the easternmost edges of the Scotia Sea, are the most remote and rugged of the region's islands. Formed by ancient

volcanoes and carved by incessant wind and waves, the 11 islands stretch out across 390 km. Despite their unforgiving nature, the South Sandwich Islands provide breeding grounds for almost a third of the world's chinstrap penguins¹⁴⁷. A vast array of other penguins, seabirds and seals breed there as well and even more pass through the surrounding waters to feed on large krill aggregations¹⁴⁸. As large predators forage at the surface, multiple fish species forage in the benthos. In deep ocean areas, researchers recently discovered spectacular hydrothermal vent communities to the west of the islands. Given the incredible biological value of the waters surrounding the South Sandwich Islands, the area is a key component of a Southern Ocean network of MPAs and no-take marine reserves.

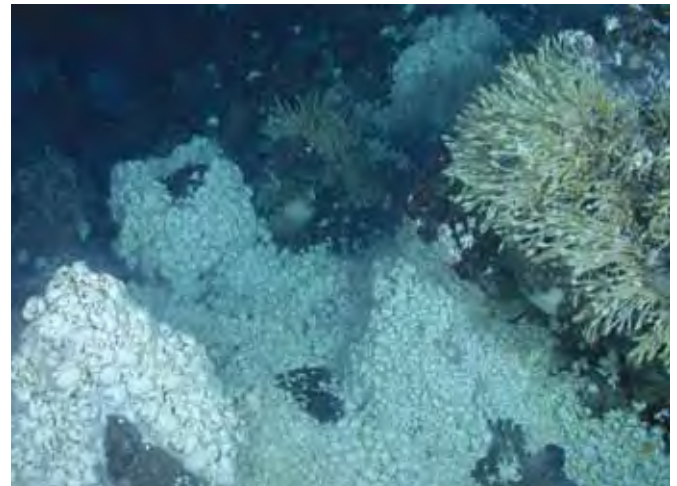
GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The South Sandwich Islands are surrounded by incredibly productive, krill rich waters¹⁴⁹, which in turn support stunning arrays of penguins, flying seabirds and seals. The South Sandwich Islands, are home to roughly three million chinstrap penguins, about 30% of the global population¹⁵⁰. Scientists have suggested that chinstrap penguins originated in the South Sandwich Islands making this location critically important to this species¹⁵¹. Many other penguins also breed here, including thousands of gentoos and tens of thousands of macaroni and Adélie penguins¹⁵². King penguins have also been spotted on several islands.

Thousands to hundreds of thousands of southern giant petrels, Antarctic fulmars, cape petrels, snow petrels, Antarctic prions, Wilson's storm petrels, black-bellied storm petrels, blue-eyed shags, Antarctic skuas, kelp gulls and Antarctic terns breed throughout the Island Arc. Many other seabird species pass through the area, including wandering, black-browed and light-mantled sooty albatrosses¹⁵³.

A variety of seals breed and feed throughout the South Sandwich Islands and surrounding waters, including significant populations of Antarctic fur seals. Elephant seals are frequent visitors on land and at sea. Crabeater, leopard and Weddell seals regularly forage and possibly breed around the islands each year¹⁵⁴.

The varied benthic habitats of the South Sandwich Islands also support many fish and invertebrates. At least 17 species of bottom dwelling fish live here, including many species of icefish, as well as Patagonian and Antarctic toothfishes¹⁵⁵. Scientists are only



Kiwa nov. sp. clustered around diffuse venting. E9 vent field, East Scotia Ridge, 2,400 m depth.

Image courtesy of the NERC CHESSE Consortium.

beginning to unravel the species assemblages of the deep benthos around the South Sandwich slope. During one expedition scientists discovered one new species for every two specimens collected. They also discovered a thick layer of phytoplankton fluff (decayed matter that settled from the surface) on the bottom, suggesting an adequate supply of food for this rich assemblage of species to feed on¹⁵⁶. More sampling would surely reveal even greater biodiversity.

The most dynamic and recent exploration of seafloor biodiversity in the waters surrounding the South Sandwich Islands revealed thriving hydrothermal vent communities to the west of the islands. These chemosynthetic ecosystems, which revolved around 383°C black smokers, are vastly different from hydrothermal vent ecosystems in other parts of the world. Instead of the typically found tubeworms and vent crabs, this Antarctic hydrothermal vent was found to support huge colonies of a new species of Yeti crab, fields of stalked barnacles and a new species of predatory seastar¹⁵⁷. Seamounts and submarine craters are also present around the islands.



Anemones and barnacles (*Vulcanolepas* nov. sp.). E9 vent field, East Scotia Ridge, 2,400 m depth.

Image courtesy of the NERC CHESSE Consortium.

CASE FOR PROTECTION

As with other locations in the highly productive Scotia Sea region, the South Sandwich Islands host commercially valuable populations of krill and smaller numbers of finfish. Fishers do not currently target krill around the South Sandwich Islands, however these waters are considered part of the southwest Atlantic krill fishery.

Fishing for both Patagonian and Antarctic toothfishes began around the South Sandwich Islands in 1992 with low catches recorded. In 2004 the UK revisited the fishery by conducting research to assess toothfish populations. The fishery lands up to 41 tonnes of Patagonian toothfish in the northern portion of the South Sandwich Islands and up to 75 tonnes of both toothfish species in the Southern end of the archipelago¹⁵⁸.



Seal with toothfish. Image by Jessica Meir.

The United Kingdom recently announced an MPA in the South Georgia and South Sandwich Islands (not yet recognised by CCAMLR and disputed by some parties), which includes no-take areas around each island. The highly productive water column supports large aggregations of land-based predators and marine mammals, further complemented by diverse seafloor habitats, including a unique hydrothermal vent community. The limited surveys to date have undoubtedly just scratched the surface in regard to documenting the level of biodiversity to be found in these environments with numerous species waiting to be discovered.

The islands also support globally significant populations of penguins, particularly chinstrap penguins. The South Sandwich Islands are even considered the ancestral home of this species. Protecting breeding and foraging grounds is of utmost importance, particularly for chinstrap penguin colonies, which appear to be declining across the Antarctic Peninsula and Scotia Sea region perhaps due to the effects of climate change¹⁵⁹. Protection should encompass major chinstrap feeding grounds to facilitate their resilience to the impacts of climate change.

6

MAUD RISE

The Maud Rise is a dramatic mid-ocean plateau that rises from depths of 3,000 m to 1,000 m at the southern reaches of the Atlantic sector of the Southern Ocean. This plateau is distinct from other adjacent areas of the Southern Ocean due to lower concentrations of sea ice and the formation of a polynya (an area of open water)

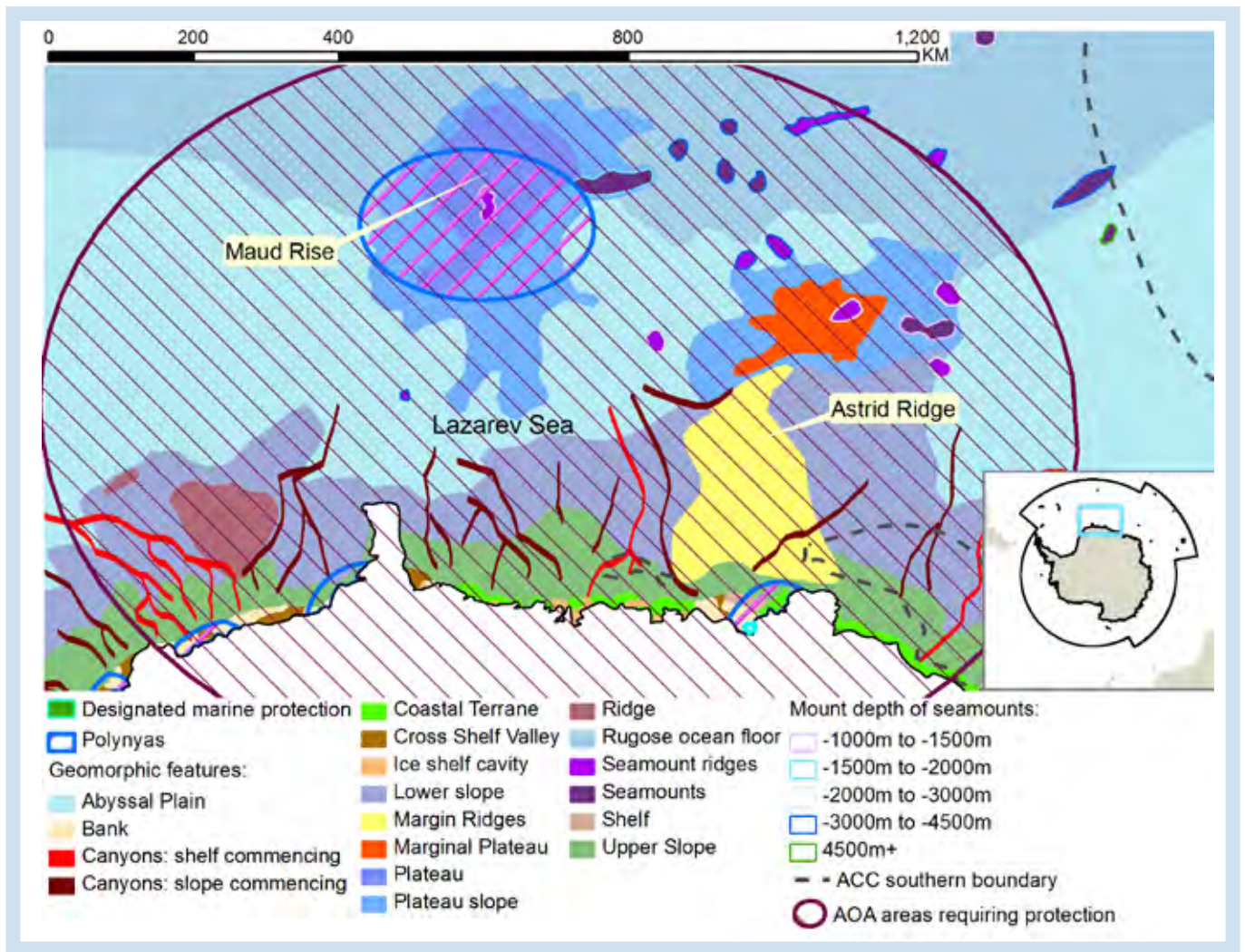
over the Rise. While most Southern Ocean polynyas occur adjacent to the Antarctica continent, the waters overlying the Maud Rise represent one of only two recurring open ocean polynyas in the Southern Ocean¹⁶⁰. Maud Rise is a biologically productive region with large krill aggregations, unique benthos and abundant fish, seabirds and mammals. Research to date has determined that interactions between oceanography, underwater topography and sea ice separate the region, and its ecosystem, from surrounding areas of the Southern Ocean.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The area above and surrounding the Maud Rise has a unique oceanography influenced by the interactions of currents (especially the Weddell Gyre and associated eddies) with the topography of the rise¹⁶¹. To the south of Maud Rise, marginal ridges and plateaus protrude from the continental shelf while numerous canyons carve into the depths. These uprisings modify local currents, enhancing productivity, while the canyons likely help bring nutrient rich waters to and through the area¹⁶². Astrid Ridge in particular is the only margin ridge in the area and one of only a handful in the entire Southern Ocean. Because this ridge extends hundreds of meters up from the continental margin, it is shallow enough to significantly interfere with water flow and drive local upwelling, enhancing productivity. This area also contains one of only two



Antarctic salps. Image by Cassandra Brooks.



marginal plateaus in the Southern Ocean, which further works to drive local productivity¹⁶³. This complex system causes localized currents, jets and eddies which drive local upwelling. Upwelled nutrients then drive pelagic primary productivity, which in turn can support concentrations of higher predators¹⁶⁴. This complex local oceanography likely causes low annual sea ice densities and the periodic formation of a persistent open ocean polynya over the Maud Rise.

The productivity and diverse assemblage of biodiversity extends from the seafloor up through the water column to the surface over the Maud Rise¹⁶⁵. This dynamic sea ice environment supports a high density of zooplankton¹⁶⁶, including substantial krill aggregations directly over the Rise as well as in the coastal area to the south¹⁶⁷. The local abundance of krill drives high concentrations of crabeater seals, minke whales, Adélie penguins, Antarctic petrels and snow petrels¹⁶⁸. The seafloor below is rich with sponges, molluscs, crustaceans and worms, including tube dwelling suspension feeders. Many of these species are unique to the Maud Rise¹⁶⁹.

Some scientists believe that the Maud Rise krill populations may be connected to a larger krill metapopulation that spans the area from the Western Antarctic Peninsula and Scotia Sea to the Lazarev Sea¹⁷⁰. The westward flow of the Weddell Gyre potentially seeds

krill from the Lazarev and Weddell Sea into the Scotia Sea where the main krill fishery operates. If this hypothesis is true, then krill from the Lazarev Sea (including over the Maud Rise) play a key role in supporting fish, birds and mammals across the Atlantic basin of the Southern Ocean including the Scotia Sea. Moreover, impacts to krill populations from climate change or other stressors could reverberate across the entire Atlantic sector of the Southern Ocean.

CASE FOR PROTECTION

As researchers devote more time and resources to studying the Maud Rise, its importance to the Southern Ocean ecosystem and biodiversity is becoming clearer. The low sea ice concentrations and formation of a recurrent open ocean polynya are rare in the Southern Ocean and drive a unique and productive ecosystem. Studies have demonstrated a distinct seafloor fauna. Meanwhile, the pelagic region is strongly connected to the greater Atlantic Basin via the influence of the Weddell Gyre. Protection of the Maud Rise and adjacent waters as part of a Southern Ocean network of MPAs and no-take marine reserves will safeguard the region's unique oceanographic features and biodiversity. Protection of this region would also provide ongoing research opportunities for scientists as they further unravel the marvels of Maud Rise.



BOUVETØYA

Bouvetøya Island is the most isolated island in the world¹⁷¹. As the southernmost volcanic seamount on the Mid-Atlantic Ridge¹⁷², this small, mostly glacier-covered island is more than 1,600 km from the Antarctic continent and 2,600 km from the tip of South Africa. Despite its isolation, most of the major animal groups that inhabit the Southern

Ocean also occupy Bouvetøya and its surrounding waters. These include elephant and fur seals, macaroni and chinstrap penguins and giant petrels¹⁷³. Beneath the surface, Patagonian toothfish, krill and a diverse array of benthic fauna thrive¹⁷⁴.

In recognition of Bouvetøya Island's biological value and uniqueness, in 1971 Norway (which claims the island as a dependency) declared the island and waters out to 12 nm as a nature reserve. Yet beyond the reserve, commercial fishers target Patagonian and Antarctic toothfishes and there may be potential for a krill fishery. Protection of the waters around Bouvetøya would be a vital component of the Southern Ocean network of no-take marine reserves and MPAs.



Giant petrel in Southern Ocean. Image © Greenpeace / Jiri Rezac.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

Located within the westerly flow of the ACC, Bouvetøya is a geologically young volcanic island stemming from the Mid-Atlantic Ridge. As such, the geomorphology of the seabed surrounding Bouvetøya is complex with ridges, rift valleys, fracture zones and unique seamounts¹⁷⁵. The limited sampling of the Bouvetøya benthos has revealed a rich and unique assemblage of animals, many unique to the area, including amphipods, molluscs and bryozoans¹⁷⁶.

This isolated and rugged habitat, which lies at the centre of the ACC and the edge of the Weddell Gyre, may be a critical connection point for species exchange. Bouvetøya shares animal species with the tip of South America as well as the Antarctic Peninsula, Weddell Sea and Scotia Arc, all likely carried via the ACC and Weddell Gyre. The island may provide a landing ground for species, connecting populations over vast geographies, but further study is needed to illuminate these connections¹⁷⁷. The adjoining Mid-Atlantic Ridge has high levels of iron and manganese, which suggests the presence of hydrothermal vents¹⁷⁸. The area may prove an important contact region between vent provinces in the Atlantic, Indian and Southern Ocean.

Almost 20 fish species are found on the shelf and slope surrounding Bouvetøya. These include the commercially valuable Patagonian toothfish, as well as painted notie, bigeye grenadier and a genetically distinct species of grey rockcod¹⁷⁹. The toothfish found here appear genetically distinct from those caught around South Georgia and the South Sandwich Islands, yet similar to those found on the Ob Bank¹⁸⁰.

Antarctic krill also thrive here and support substantial populations of seabirds and mammals. Antarctic fur seals and elephant seals breed here, along with southern giant petrels, southern fulmars and black-bellied storm petrels¹⁸¹. Meanwhile leopard, crabeater and Weddell seals feed in the surrounding waters. Bouvetøya also has significant macaroni and chinstrap penguin breeding colonies, however for unknown reasons, their populations have declined by almost half in the last few decades¹⁸².

Because of its isolation, scientists have only begun to discover Bouvetøya's benthic biodiversity, yet longline fishing may have already altered the unique seafloor assemblages.

CASE FOR PROTECTION

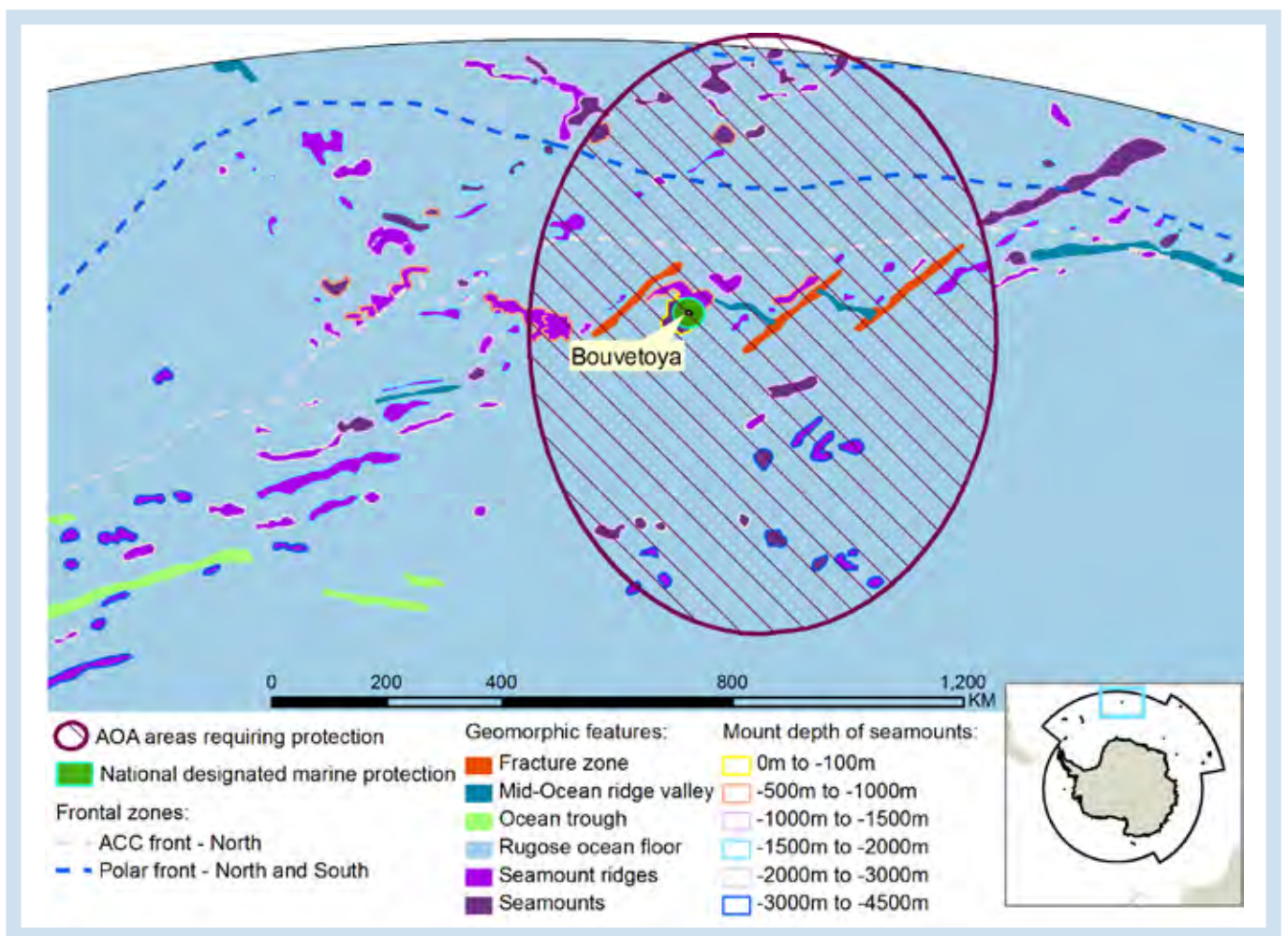
The current 12 nm nature reserve is a good first step towards protecting the unique features of Bouvetøya Island, but it is not enough to encompass important large-scale features. Bouvetøya is geographically isolated, but oceanographically connected. As such, the myriad of ridges and seamounts may provide key connection grounds between distant regions.

The decline of resident penguin populations warrants immediate protection of their foraging grounds to ensure they can access prey without any hindrances, although the reasons why penguin populations have declined remains unclear. Furthermore, because of its isolation, scientists have only begun to discover Bouvetøya's benthic biodiversity, yet longline fishing may have already altered the unique seafloor assemblages¹⁸³. A small legal exploratory fishery exists for Patagonian and Antarctic toothfishes as well as unknown levels of IUU fishing¹⁸⁴. Protecting the waters around Bouvetøya would help conserve penguin populations while also safeguarding all of the local mammals, birds, fish and unique benthic fauna. Given the region's unique geography, Bouvetøya is a critical component of a Southern Ocean network of no-take marine reserves and MPAs.



Leopard seal. Image by Cassandra Brooks.

Bouvetøya area map.



DEL CANO – CROZET REGION



OB AND LENA BANKS

The Ob and Lena Banks are two submarine plateaus located in the Southern Indian Ocean sector of the Southern Ocean. These banks were a popular fishing ground from the earliest days of Southern Ocean

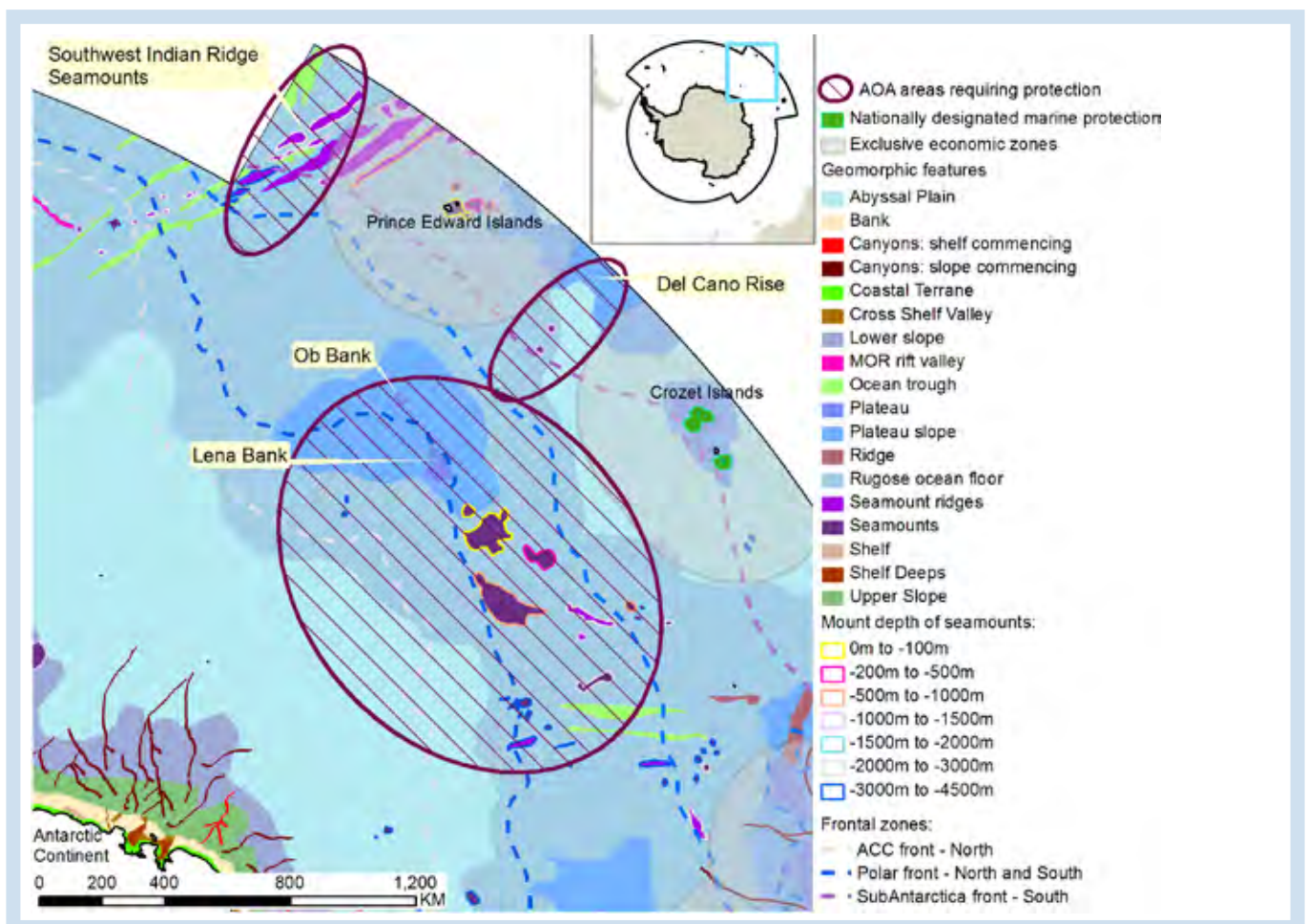
fisheries. Originally exploited for grey rockcod, these plateaus have recently been the site of a Patagonian toothfish fishery. Most of what we know about the Ob and Lena Banks has been as a result of fisheries or related research. Fish populations in the area have been highly impacted by historical IUU fishing. Aside from being an important region for Patagonian toothfish, the Ob and Lena Banks also provide foraging grounds for mammals and other wildlife.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The Ob and Lena Banks are situated southeast of South Africa's Prince Edward and Marion Islands and southwest of France's Crozet Islands. In addition to the Ob and Lena plateaus, the region contains 12 seamounts, including the Marion Dufresne Seamount and two seamount ridges. While yet unsampled, these plateaus, seamounts and ridges may have unique seafloor biota. The region also provides habitat for a variety of pelagic species, including fin, sei, blue and sperm whales, as well as orcas, porbeagle sharks and the benthic Kerguelen sandpaper skate¹⁸⁵.

The Patagonian toothfish population of Ob and Lena Banks has drawn much interest in recent decades. Yet little is known about the relationship of local populations to surrounding islands. Analyses have unveiled genetic similarity between Patagonian toothfish found at Ob Bank and those found around Bouvetøya Island¹⁸⁶. These genetic similarities indicate there may be a large metapopulation of Patagonian toothfish that occupies the broader Southern Indian Ocean sector of the Southern Ocean¹⁸⁷. If this hypothesis proves to be true, overfishing in one area will impact fish populations hundreds of kilometres away.

Del Cano – Crozet region map.





Killer Whale in Southern Ocean.
Image © Greenpeace / Daniel Beltrá.

CASE FOR PROTECTION

Because of overexploitation, the Ob and Lena Banks are currently closed to all finfishing. A grey rockcod fishery developed in the 1970s, but annual catches of up to 30,000 tonnes per year quickly depleted the population. When CCAMLR took over management of the fishery in the 1980s, catch limits were quickly restricted to 2,000 tonnes. Further reductions followed until the fishery was closed in the mid-1990s. Despite a decade and a half without fishing, there is no evidence that grey rockcod have recovered.

Legal fishing for Patagonian toothfish began in 1997, but illegal fishers also quickly took notice. Overharvesting led to stock closures in 2002, though IUU fishers likely continue to exploit this region. Despite the closure of Ob and Lena Banks, it is unlikely that this region of the Southern Ocean can support further fishing activity for decades to come, particularly if IUU fishing continues¹⁸⁸.

Building on CCAMLR's work in closing this area to fishing, the Ob and Lena Banks should be protected as part of a Southern Ocean network of MPAs and no-take marine reserves. The Ob and Lena Banks encompass important habitats, pelagic wildlife populations and oceanographic features. While complete species assemblages of the region remain unknown, diverse bathymetry associated with the banks and seamounts is known to enhance biodiversity. Protecting the Ob and Lena Banks, along with the surrounding seamounts, will provide a refuge for pelagic and benthic fish that live there, including the whales, sharks and skates of the region.



DEL CANO REGION HIGH SEAS

The Del Cano Rise is a deepwater plateau in the Southwest Indian Ocean located between South Africa's Prince Edward Islands to the west and France's Crozet Islands to the east. Lying directly in

the path of the ACC, the Rise serves as an axis between the two island groups providing important feeding grounds for the vast populations of seabirds and seals that breed on the islands¹⁸⁹. South Africa has proposed a marine reserve within the Exclusive Economic Zone (EEZ) surrounding the Prince Edward Islands and France is expected to expand existing MPAs within their EEZ around the Crozet Islands. Yet much of the rich feeding grounds over the Del Cano Rise are unprotected and vulnerable as part of the high seas. Protection of the Del Cano region would safeguard critical habitat for millions of mammals and birds¹⁹⁰, including many threatened or near-threatened albatross species¹⁹¹.



Wandering Albatross. Image by Cassandra Brooks.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The Del Cano Rise is part of a diverse and complex regional bathymetry that is key to the productivity of the Southwest Indian Ocean. The 2,000 m Rise sits between the plateaus that ascend to the Prince Edward and the Crozet Island groups and is just southeast of the Southwest Indian Ridge – a series of jagged undersea mountain ranges and canyons. The Ridge includes a series of transform faults and associated fracture zones that may host hydrothermal vent communities¹⁹².

The region lies directly between two fronts of the ACC, with the Subantarctic Front to the north and the Antarctic Polar Front to the south¹⁹³. The currents interact with the rugged underwater features, forming eddies which entrain nutrient rich water, especially over the Del Cano Rise¹⁹⁴. These eddies drive annual phytoplankton blooms¹⁹⁵, drawing fish and squid, which in turn feed local populations of seabirds and mammals – including the threatened grey-headed and wandering albatrosses¹⁹⁶. Indeed, these production zones over the Del Cano Rise region may enable globally significant population of seabirds and seals to breed at the neighboring islands¹⁹⁷, including king, macaroni and southern rockhopper penguins, northern and southern giant petrels, white chinned petrels, wandering, sooty and light mantled albatross. Fur seals and elephant seals, historically hunted almost to extinction and only recently having recovered, also heavily use these feeding grounds¹⁹⁸.

The greater region of the Southwest Indian Ocean has also historically supported significant populations of Patagonian toothfish. A legal demersal longline fishery for Patagonian toothfish began in 1996, but the fishery soon became overexploited, largely due to excessive IUU fishing that also began that same year. The spawning biomass of the Southwest Indian Ocean toothfish population is now only a small percentage of historical size¹⁹⁹. The legal fishery for toothfish in the high seas of this region has been closed since 2002²⁰⁰.

Protection of the Del Cano region would safeguard critical habitat for millions of mammals and birds, including many threatened or near-threatened albatross species.

A CASE FOR PROTECTION

Currently the Prince Edward and Crozet Islands are protected as a nature reserve to safeguard the millions of birds and mammals that breed there every year. The Prince Edward Islands alone support almost half of the global population of wandering albatross²⁰¹. However, the waters around the islands, including the highly productive Del Cano Rise region and the waters overlying the Southwest Indian Ridge, provide essential feeding grounds for these animals. Protecting these waters will be an important contribution to the protection of the wildlife of the nearby island groups.

Collaborations between South African and French governments, NGOs and scientists to protect the waters around the Prince Edward and Crozet Islands are currently underway. Recognizing the value of the Del Cano Rise, these groups are highly interested in working with CCAMLR to further protect this high seas region²⁰². Protection of the Del Cano region as part of a Southern Ocean network of no-take marine reserves and MPAs would contribute to the protection of countless breeding pairs of seals, penguins and seabirds, including a dozen albatross species that are regarded as threatened or near threatened²⁰³.



King penguin creche. Image by John B. Weller.

KERGUELEN HIGH SEAS REGION

10

KERGUELEN PLATEAU HIGH SEAS AREA

The Kerguelen Plateau's unique geological characteristics give rise to high productivity, rich biodiversity and large top predator populations. Though the region has been heavily targeted by fishers, sealers and whalers, marine life is still abundant, with new species discovered regularly. French and Australian authorities have already protected large portions of the plateau that are within their respective EEZs, but to ensure comprehensive protection and hasten recovery for depleted populations, marine protection should be implemented to cover high-seas plateau areas as well contributing to the Southern Ocean network of MPAs and marine reserves.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The Kerguelen Plateau is a unique geological formation in the Indian Ocean sector of the Southern Ocean known as a volcanic large igneous province (LIP)²⁰⁴, and has also been described as a "microcontinent"²⁰⁵. LIPs are created by the deposition of large amounts of magma over a fairly short geological time. Although once almost completely above sea level, today the plateau has some highly elevated but submerged banks, including the Elan and BANZARE Banks, and two island



Close up, Lanternshark eye. While this image was taken in the Atlantic, similar Lanternsharks thrive in the Antarctic marine environment. Image by David Shale/naturepl.com.

archipelagos, the Heard and McDonald Islands and the Kerguelen Islands, some of the most isolated islands in the world²⁰⁶. The massive plateau alters the flow of the ACC²⁰⁷, generating productivity, which then feeds a large and diverse assemblage of species²⁰⁸.

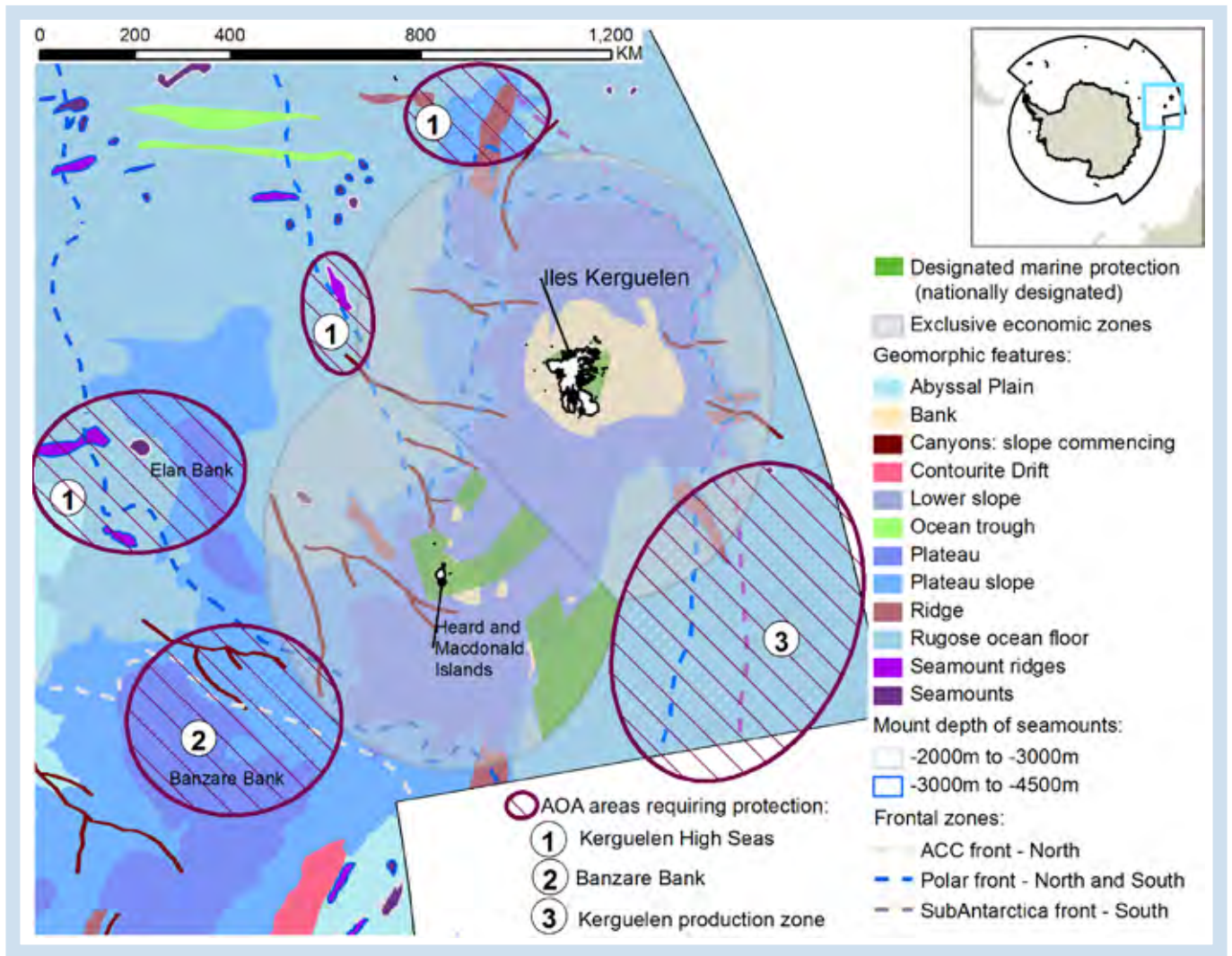
The excellent phytoplankton availability gives rise to large populations of zooplankton and fish, which in turn support substantial populations of penguins, seals and flying seabirds²⁰⁹. These top predators are also attracted to the plateau's archipelagos since these are the only land areas above sea level in the region²¹⁰. Collectively, the plateau possesses an ideal combination of high food availability and suitable breeding locations.

Ecosystem diversity on the plateau begins with the benthic seafloor communities. Successive studies have consistently yielded new species, with most recent estimates of 960 benthic species²¹¹. Further research will likely reveal even greater diversity. Cephalopods (squid and octopus) are also diverse. Thirty-eight species have been found so far, ranging from small to the largest squids on Earth – both colossal and giant squids have been found on the plateau²¹². Two of the squid species on the Kerguelen Plateau are endemic, meaning they are found nowhere else in the world. Squid appear to be an

important source of food for many species on the plateau, including whales, sharks, Patagonian toothfish, seabirds and seals²¹³.

Mammals and birds round out the top levels of the Kerguelen Plateau ecosystem. The Kerguelen Islands are home to Antarctic fur seals and more than 120,000 elephant seals, the second biggest sub-population of the species²¹⁴. Fourteen species of flying seabirds, including black-browed albatross, breed on the plateau's islands. The islands also provide important breeding grounds for four species of penguin – king, gentoo, macaroni and rockhopper²¹⁵. Populations of king and macaroni penguins are the largest, with more than 100,000 pairs of each species²¹⁶. A genetically distinct subspecies of the Commerson's dolphin is endemic to the Kerguelen Islands²¹⁷.

The region also supports many fish species, including the Patagonian toothfish, rockcod and icefish. Lanternfish also flourish in these waters and are an important prey for seabirds and marine mammals, sometimes rivaling krill²¹⁸. The plateau region is also one of the only places where all five species of subantarctic sharks are found. These species include the white-spotted spurdog, a dogfish, the porbeagle, a newly described lantern shark and one undescribed sleeper shark²¹⁹.



CASE FOR PROTECTION

The high plankton productivity of the Kerguelen Plateau ecosystem has resulted in a biodiverse, heavily populated region, which historically experienced heavy exploitation of both fish and mammal resources. Fur seals were completely wiped out by successive waves of sealing. At least 426,000 elephant seals were killed between the early 1800s and mid-1900s²²⁰. Both species of seal are still recovering²²¹. More than a thousand humpback and southern right whales were slaughtered and have yet to recover²²². Beginning in 1970, Soviet Union fishing vessels targeted marbled rockcod, grey rockcod and mackerel icefish around the Kerguelen Islands and to a lesser extent around Heard and McDonald islands²²³. Despite the closure of the Kerguelen fisheries in 1978, most of these species have not rebounded.

The Patagonian toothfish is currently the most commercially important fish on the plateau and is fished by both France and Australia. Although each country manages its fishery separately, evidence suggests that there is a single metapopulation covering the entire West Indian Ocean sector, including the fishing grounds of the Kerguelen Islands, Crozet Islands, Elan Bank, BANZARE Bank, Ob and Lena Banks, Prince Edward and Marion Islands and Heard and McDonald Islands²²⁴.

Illegal fishers have heavily targeted this population in the past several decades and the combined effects of legal and illegal fishing have devastated albatross and petrel populations. The birds are attracted by the bait and offal discharges associated with longline fishing, and many do not survive after becoming entangled in lines and hooks. Over just eight fishing seasons (1999/00 to 2004/05), legal fishing in the French EEZ of the Kerguelen Islands killed more than 40,000 seabirds²²⁵. These totals underestimate the true extent of the problem because it does not take into account seabird bycatch from illegal fishing. Enforcement in recent years has helped reduce illegal fishing significantly and legal fishers now employ fishing strategies that have reduced bycatch to around 200 birds per season. Yet eight of the 14 seabirds that breed on islands in the region are still considered “vulnerable” on the IUCN Red List²²⁶.

The plateau region is one of the only places where all five species of subantarctic sharks are found.

Because of the territorial claims of France for the Kerguelen Islands and Australia for the Heard and McDonald Islands, much of the Kerguelen Plateau is not under the jurisdiction of CCAMLR. Instead it falls within the countries' respective EEZs and both countries have taken strides to designate marine reserves within their territories. Encompassing 65,000 km², the reserve around the Heard and McDonald Islands is one of the world's largest. It covers all the territorial waters (12 nm from shore) and includes numerous different types of seafloor communities²²⁷. The French reserve includes all of the territorial waters around the nearby Crozet Islands (which are not part of the plateau) and large portions of the territorial waters around the Kerguelen Islands²²⁸. This is a promising start for marine conservation of the region.



Gentoo penguin on iceberg. Image by John B. Weller.

Despite these great efforts for marine protection, the regions outside of the EEZs are also a critical part of the plateau's ecosystem, and include foraging ranges for many of the species that breed on the islands. To bolster the protection given by the existing marine reserves, these areas should also be protected as part of a Southern Ocean network of MPAs and no-take marine reserves. Protection will conserve areas yet to be studied while simultaneously protecting the habitat and foraging areas necessary for depleted populations of fish, seabirds and marine mammals to recover.



BANZARE BANK

BANZARE Bank, an elevated bank on the southern Kerguelen Plateau, supports a similar array of wildlife to the greater Plateau region and is also key habitat for Patagonian

and Antarctic toothfishes. Growing evidence suggests that BANZARE Bank may be a spawning ground for a unique population of Antarctic toothfish. Because the Bank has a relative abundance of large fish, it also became a frequented fishing ground for legal and IUU fishers. The catch includes bycatch of skates and grenadiers. Despite only a few years of commercial fishing, toothfish populations have rapidly declined. The longline fishery for toothfish has been closed except to scientific research. Yet IUU fishing likely continues. Owing to its importance for toothfish populations, BANZARE Bank should be protected within a representative network of Southern Ocean MPAs and no-take marine reserves.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

BANZARE Bank, which is a southern extension of the Kerguelen Plateau south of the Polar Front, contains unique and varied bathymetry, including canyon systems commencing at its slope. These canyons likely contain vulnerable species assemblages and may be conduits for bringing nutrient rich water to other regions of the Plateau. Similar to the greater Kerguelen Plateau region, BANZARE Bank likely provides feeding grounds for seabirds and mammals, including sperm, humpback, minke and fin whales²²⁹.

BANZARE Bank is one of the only regions with overlapping Patagonian and Antarctic toothfish populations. In general, the two species are divided latitudinally by the Antarctic Polar Front. The Antarctic toothfish, which evolved unique anti-freeze proteins to keep its blood from freezing, tends to occupy the colder waters further south. Yet on BANZARE Bank, the species overlap considerably from north to south. The division appears to be depth related – Patagonian toothfish are generally caught in less than 1,000 m depth and Antarctic toothfish caught in greater than 1,500 m. This division may be temperature driven, with Patagonian toothfish limited to the shallower warmer waters²³⁰. Populations of both fish appear to be clustered in specific areas rather than spread throughout the potential fishing grounds, making them more vulnerable to overharvesting²³¹.

Fisheries data suggest complex stock structure of both toothfish species over BANZARE Bank with potential links to other regions in the Southern Indian Ocean and perhaps around the greater Antarctic continent²³². The Antarctic toothfish stock is dominated by large fish, with many showing signs that they are ready to spawn. This suggests that BANZARE Bank may be a spawning ground for Antarctic toothfish. Meanwhile few fish less than 100 cm are found on the Bank, suggesting that fish immigrate to the Bank from surrounding areas. The location of eggs or juvenile fish remains unknown.



Antarctic toothfish with diver. Image by Rob Robbins.

Growing evidence suggests that BANZARE Bank may be a spawning ground for a unique population of Antarctic toothfish... Despite only a few years of commercial fishing, toothfish populations have rapidly declined.

In the Ross Sea, mature Antarctic toothfish fish (upon reaching neutral buoyancy at 100 cm) likely make a remarkable spawning migration to seamounts and ridges in the north. The life history structure at BANZARE Bank suggests this population may be following a similar pattern to the Ross Sea population, with neutrally buoyant mature fish migrating in from outside regions²³³. In contrast, Patagonian toothfish found on BANZARE Bank are not showing signs that they are preparing to spawn²³⁴.



Iceberg, Southern Ocean. Image by John B Weller.

CASE FOR PROTECTION

Exploratory fisheries for Antarctic and Patagonian toothfishes on BANZARE Bank commenced in the 2003/04 season. While the catches were relatively low, with a limit of 300 tonnes per year, illegal catches likely ensnared more than five times that amount each season. Within only two to three seasons, the population has diminished. By 2006, CCAMLR expressed concern for the fishery, urgently requesting a stock assessment. IUU fishers, now using indiscriminant gillnets, stand to further impact both toothfish populations, along with any other species present in the depths over the BANZARE Bank. Bycatch in BANZARE Bank fishery varies, but at times accounts for up to 20% of the catch, and includes mostly skates and grenadiers²³⁵.

The complex life history of both toothfish species further complicates management. Catch data suggests a small local biomass with the majority of fish congregating over heavily fished areas. If fish recruit from outside the Bank, as growing evidence suggests, recovery will be severely stunted²³⁶. The potential importance of the Bank as a spawning ground warrants immediate protection. Fishing on spawning aggregations generally results in a very high fishing pressure on populations (e.g. orange roughy). Fishing out the spawning individuals will harm local and regional populations of Antarctic toothfish. Protecting the BANZARE Bank as part of the Southern Ocean network of no-take marine reserves and MPAs is an immediate priority.

12

KERGUELEN PRODUCTION ZONE

The Kerguelen Production Zone is an open water, highly productive region that lies east/northeast of the Kerguelen Plateau and south of the Southeast Indian Ridge system. With a rugged deepwater habitat, directly in the path of the Antarctic Convergence and ACC²³⁷, this region supports large populations of squid and fish²³⁸. In turn, these fish and squid nourish whales and seabirds migrating through the area as well as vast populations of land-based predators which breed on the nearby Kerguelen, Heard and McDonald Islands²³⁹. King penguins, Antarctic fur seals and elephant seals are particularly dependent on the Kerguelen Production Zone²⁴⁰.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The Kerguelen Production Zone is situated at the intersection of a diverse array of large underwater features to the east of the Kerguelen Plateau and its associated islands. To the north and northeast lies the Southeast Indian Ridge system with its assortment of fracture zones that form vast seamounts, canyons and ridges. To the southeast, is the Australian-Antarctic Basin and to the south is BANZARE Bank²⁴¹. In total, the Production Zone encompasses depths between 2,000 and 4,500 m²⁴².

A complex array of currents sweeps through the Kerguelen Production Zone. As the ACC circles Antarctica from west to east, it collides with the Kerguelen Plateau. Water is forced north between



Elephant seals. Image by John B. Weller.

the Plateau and the Southeast Indian Ridge, channeling through the Kerguelen St. Paul Passage and then hitting a sill formed by the Geelwinck Fracture Zone. Water from the ACC also escapes over the Plateau and through Dawn Trough south of the Plateau above BANZARE Bank. As the ACC spills above, across and below the Plateau, it meets a weak westward flow of water coming from the Ross Sea. The confluence of these currents creates a deep cyclonic gyre in the Australian-Antarctic Basin²⁴³, all of which sweeps through the Production Zone.

The Kerguelen Production Zone is also located at the Antarctic Convergence. Here, warm subantarctic waters from the north meet the cold Antarctic waters from the south. These waters, in addition to the ACC, further mix with the iron rich

coastal water coming from the Kerguelen Archipelago. The high iron and favorable light-mixing regime during certain times of year drives a massive phytoplankton bloom over the Kerguelen Plateau that extends east/northeast over the Kerguelen Production Zone²⁴⁴.

This highly productive deepwater habitat provides nourishment for a vast array of local animals. These include the many seabirds that nest on the neighboring islands, as well as fur and elephant seals and a variety of whales. Similar to the Kerguelen Plateau high seas area, the Production Zone has significant populations of squid and myctophids (or lanternfish)²⁴⁵, sharks and deep-sea grenadiers²⁴⁶.



Antarctic petrels over sea ice. Image by John B. Weller.



Diver with seal. Image by John B. Weller.

A CASE FOR PROTECTION

The Heard and McDonald Islands marine reserve designated in 2002 is adjacent to the Kerguelen Production Zone along its eastern edge. The Production Zone's unique placement in the Southern Ocean coupled with diverse seafloor features makes it a highly productive region that birds, mammals and fish depend on. Protection of the Kerguelen Plateau high seas region should include the Kerguelen Production Zone, along with the BANZARE Bank to the south and the high-seas region to the west of the Kerguelen, Heard and McDonald Islands. These regions would collectively be key components of a Southern Ocean network of MPAs and no-take marine reserves.

13

EASTERN ANTARCTIC SHELF

The coastal areas of Eastern Antarctica are home to millions of seals and seabirds. Though considered a “data-poor” region, it is important as a feeding and breeding area for large numbers of penguins, petrels and crabeater seals. Analysis of existing data has demonstrated that there are a number of distinct and diverse benthic ecoregions in the Eastern Antarctic²⁴⁷. Protection of these areas will ensure that a variety of habitats and foraging areas are maintained in their current state. They can also serve as reference areas for climate change researchers to measure the impacts of climate change in an area free from human-induced ecosystem disturbances²⁴⁸.

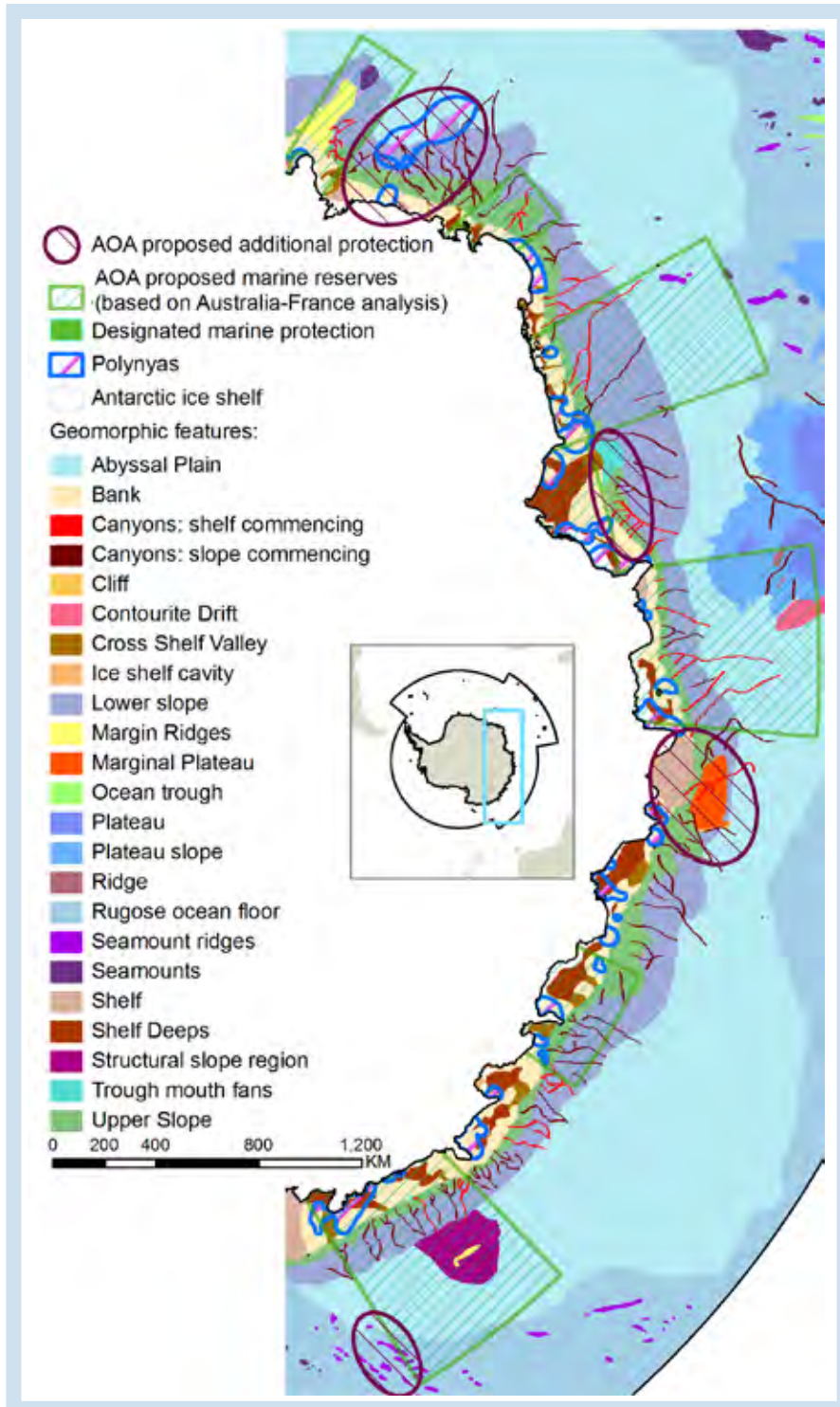


Emperor penguin with chick. Image by John B. Weller.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The vast Eastern Antarctic region extends from 30°E to 150°E, from Enderby Land to Terre Adélie and encompasses many different habitats and oceanographic conditions. The influences of the Weddell and Ross Sea Gyres divide the Eastern Antarctic into three areas, usually referred to as West, Central and East Indian provinces²⁴⁹. The smaller Prydz Bay Gyre circulates within the central province. There are a number of polynyas up and down the Eastern Antarctic coast, including a very large one near Prydz Bay²⁵⁰. Polynyas are typically regions of increased plankton production and are thus incredibly important for polar ecosystems²⁵¹.

Eastern Antarctic region map



Adélie penguins on ice.
Image © Greenpeace / Roger Grace.

Australian analyses presented to CCAMLR of the Eastern Antarctic Shelf have identified a number of areas with different physical and biological characteristics. These areas have been identified as Gunnerus, Enderby, Prydz, Drygalski, Wilkes, MacRobertson and d'urville Sea-Mertz²⁵². Collectively these areas contain an array of unique benthic and pelagic features, including continental shelf pelagic ecosystems, a continental ridge, a biodiversity “hotspot” for molluscs, seamounts, canyons and a probable nursery ground for young krill²⁵³.

Antarctic krill is distributed throughout most of the region and draws large numbers of snow petrels, crabeater seals and penguins. At least 5,000 pairs of emperor penguins breed here, with tens of thousands or more inhabiting the area²⁵⁴. Adélie penguins are even more numerous, with approximately one million pairs²⁵⁵.

Snow petrels, like emperors and Adélies, are one of the few species to breed on the Antarctic continent and they have colonies throughout the Eastern Antarctic. Accurate estimates of their total numbers do not exist, but they appear to be very numerous. In Prydz Bay alone, research surveys estimated more than one million pairs²⁵⁶. Five other species of petrel and one skua also breed in Prydz Bay²⁵⁷.



Crabeater seal. Image by Cassandra Brooks.

Crabeater seals, the most numerous marine mammal in Antarctica and perhaps the world, live throughout the Eastern Antarctic with a total population estimated at about one million²⁵⁸. Information on whales is scant, but humpbacks and minke are the most abundant species²⁵⁹. The fish fauna of the Eastern Antarctic Shelf is typical of the Antarctic with many species of icefish, yet the dominant genera are different than those found in other continental shelf areas²⁶⁰.

CASE FOR PROTECTION

The Eastern Antarctic region has not been as well-studied as many other Southern Ocean areas, but Australia, in collaboration with France, has proposed scenarios for a series of no-take marine reserves and MPAs. The Australian/French proposal suggests protection for many of the different seafloor bioregions that have been identified thus far²⁶¹ and includes potential nursery grounds for toothfish, krill and other species of icefish. The AOA proposes taking this protection further and has identified a number of additional areas and features in the Eastern Antarctic that should be considered for inclusion in a comprehensive and representative network. The features include the Cosmonaut polynya and other significant polynyas, an extension to the Prydz Bay area towards the north to include a unique trough mouth fan and canyons, the seamounts near the far eastern border of the Eastern Antarctic

region and the marginal plateau. Including these areas will increase protection for some of the Eastern Antarctic's most unique ecosystem features. In particular, the Cosmonaut polynya and other polynyas are areas of high productivity and protecting them would preserve these rich feeding grounds. Additionally, since seamounts are often host to a diverse group of species, the eastern d'Urville Sea-Mertz seamounts also deserve enhanced protection so that scientists will have the opportunity to explore them.

In addition, the AOA recommends protecting a larger foraging range for Adélie and emperor penguins as well as crabeater, leopard and elephant seals. More benthic and pelagic zones should also be included. Some of the proposed regions in the Eastern Antarctic have potential scientific value as climate reference areas and as potential climate refuge areas for species displaced by climate change²⁶². Historical fishing in the area has been minimal; however in recent years IUU fishing of toothfish is known to have taken place. Because Eastern Antarctic toothfish populations appear to be small, legal and IUU fishing could quickly devastate them – all the more reason for these waters to be protected as part of a representative network of Southern Ocean MPAs and no-take marine reserves²⁶³. The Eastern Antarctic region, including these areas proposed for protection, will be the subject of a forthcoming report from the AOA.



Underwater seastars and anchor ice. Image by John B. Weller.

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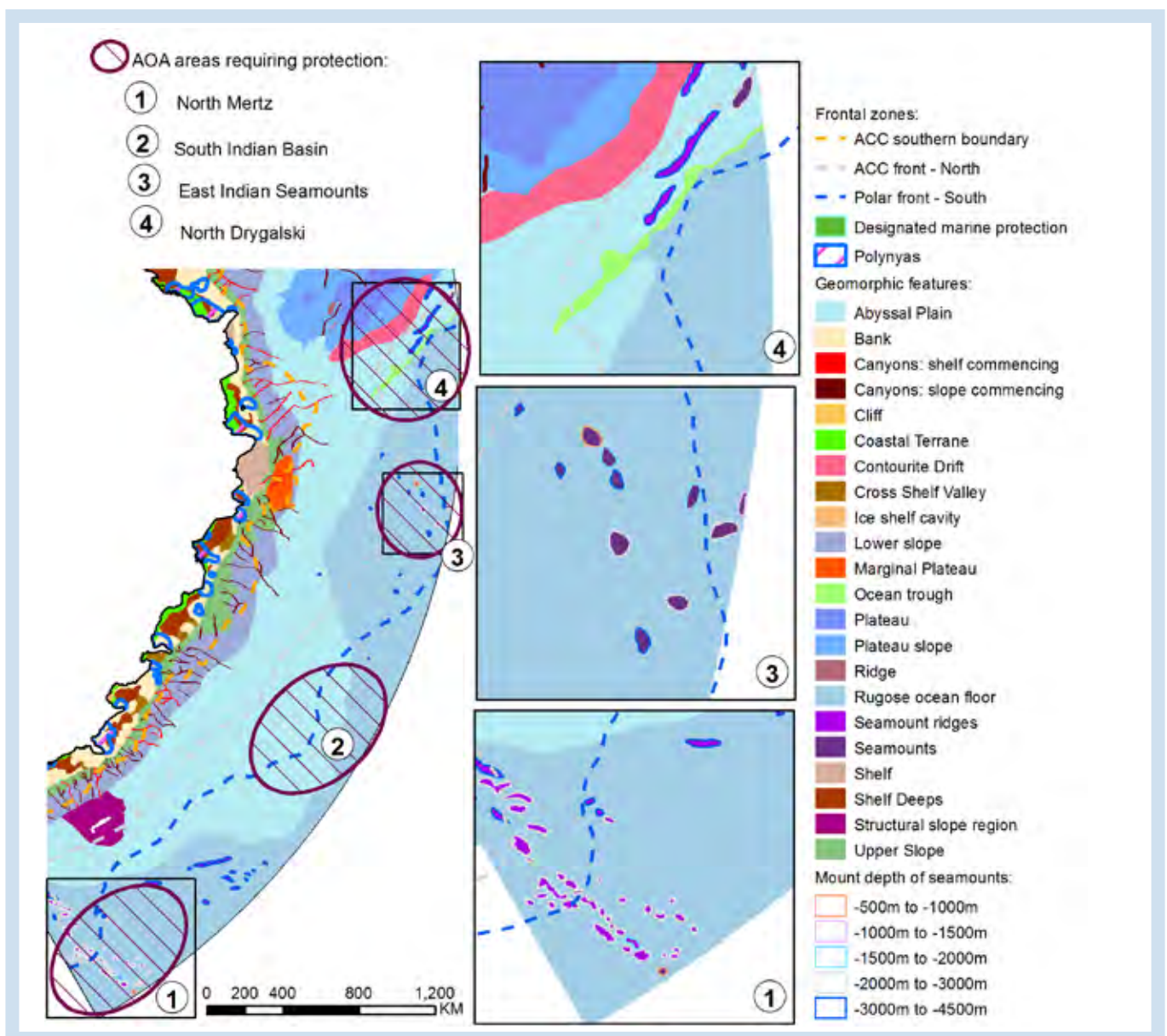
INDIAN OCEAN BENTHIC ENVIRONMENT

The Indian Ocean Benthic Environment encompasses an extensive region spanning from roughly 150°E to 70°E and from 60°S to 55°S. This region includes the western edge of the Pacific-Antarctic Ridge system and much of the Australian-Antarctic Basin. Within this greater location, four specific areas in particular have unique and varied benthic habitats that may be important for Southern Ocean biodiversity²⁶⁴. Because of their potential value, these areas, referred to as North Mertz, South Indian Basin, East Indian Seamounts and North Drygalski, should be protected as part of a Southern Ocean network of no-take marine reserves and MPAs:

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The Indian Ocean Benthic Environment extends along where the southeast Indian Ocean meets the Southern Ocean and includes seamounts, ridges and abyssal plains that collectively span depths from less than 500 m to more than 4,500 m. It is likely an important habitat for sperm whales as well as endangered blue and fin whales²⁶⁵. A large number and variety of seabirds, many of which are endangered, also forage in this area²⁶⁶. This biodiversity may in part be driven by the proximity of the ACC, which flows eastward around the Antarctic continent. Two fronts of the ACC interact with the Indian Ocean Benthic Environment, with the Southern ACC to the south and the Polar Front to the north²⁶⁷.

Indian Ocean Benthic Environment map.



Within the larger Indian Ocean Benthic Environment, four areas are particularly unique. North Mertz, the easternmost corner of the region, encompasses the western edge of the Pacific-Antarctic Ridge system, which includes a distinctive array of seamount ridges as shallow as 1,500 m and as deep as 4,500 m. It includes the boundary between the Pacific-Antarctic Ridge system and the colder, uniformly deeper East Indian Abyssal region to the west.

The South Indian Basin area lies west of North Mertz and encompasses a relatively flat section of the Australia-Antarctic Basin south of the Southeast Indian Ridge. This area, which spans from 3,000 m down to more than 4,500 m, includes some of the warmer seabed habitats of the Australia-Antarctic Basin²⁶⁸.

The East Indian Seamounts, even further west from the South Indian Basin but east of the Kerguelen Plateau, are an isolated aggregation of seamounts in an otherwise deep, relatively flat, basin. The jagged array of seamounts rises from the dark cold depths of the Australia-Antarctic Basin up to only a few hundred metres from the surface²⁶⁹.



Weddell Seal. Image by John B. Weller.

The North Drygalski region comprises the western section of the Australia-Antarctic Basin, east of the Kerguelen Plateau and BANZARE Bank and south of Southeast Indian Ridge. Being situated at the intersection of these distinct geomorphic features, North Drygalski features diverse bathymetry and geomorphology, including the only ocean trough (a long, gently sloping depression in the seafloor) in the Indian Ocean Benthic Environment. This area also has the Southern Ocean's only contourite drift – an expansive mound of mud that is highly influenced by currents that come off the slope out into the abyssal plain region. These distinctive features likely also host unique seafloor communities²⁷⁰.



Orcas. Image by John B. Weller.

CASE FOR PROTECTION

The Indian Ocean Benthic Environment represents an array of unique habitats, which should be protected as part of a Southern Ocean network of no-take marine reserves and MPAs. Four regions within this environment are particularly important. North Mertz contains diverse ridges and seamounts, while the South Indian Basin has warmer water deep ocean basins and North Drygalski has the only ocean trough in the region. The East Indian Seamounts are the only seamounts in an otherwise relatively uniform deepwater basin and are likely to have populations of species found nowhere else on the planet. Untold numbers of seafloor species, as well as habitat for birds, seals and whales, can be protected by designating and implementing marine protection in these areas.

Snow petrels, like emperors and Adélies, are one of the few species to breed on the Antarctic continent and they have colonies throughout the Eastern Antarctic.

ROSS SEA REGION

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ROSS SEA

The Ross Sea, roughly 4,000 km south of New Zealand, is the southernmost stretch of ocean on the planet. This remoteness has protected it from widespread pollution, invasive species and overfishing, making the Ross Sea the most pristine marine ecosystem left on the planet²⁷¹. While just comprising 3.2% of the Southern Ocean, the Ross Sea is its most productive stretch of water and has disproportionately large population of penguins, fish, mammals and invertebrates, with many species found nowhere else on Earth²⁷². As such, the Ross Sea is a living laboratory providing scientists with the last chance to understand how a healthy marine ecosystem functions.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The Ross Sea is an embayment between East and West Antarctica – bounded to the east by Marie Byrd Land and to the west by the Transantarctic Mountains and Victoria Land. To the south is the Ross Ice Shelf, a 400 m thick continuation of the West Antarctic Ice Sheet, which flows down the continent²⁷³. Like the icebergs that calve off its front, 90% of the Ross Ice Shelf is underwater. Shelf depths average 500 m due to ice loading²⁷⁴, with a unique deepening towards the continent and becoming shallower in the offshore direction²⁷⁵. The shelf itself is incredibly varied with banks and basins caused by multiple advances and retreats in the ice shelf over millions of years²⁷⁶.

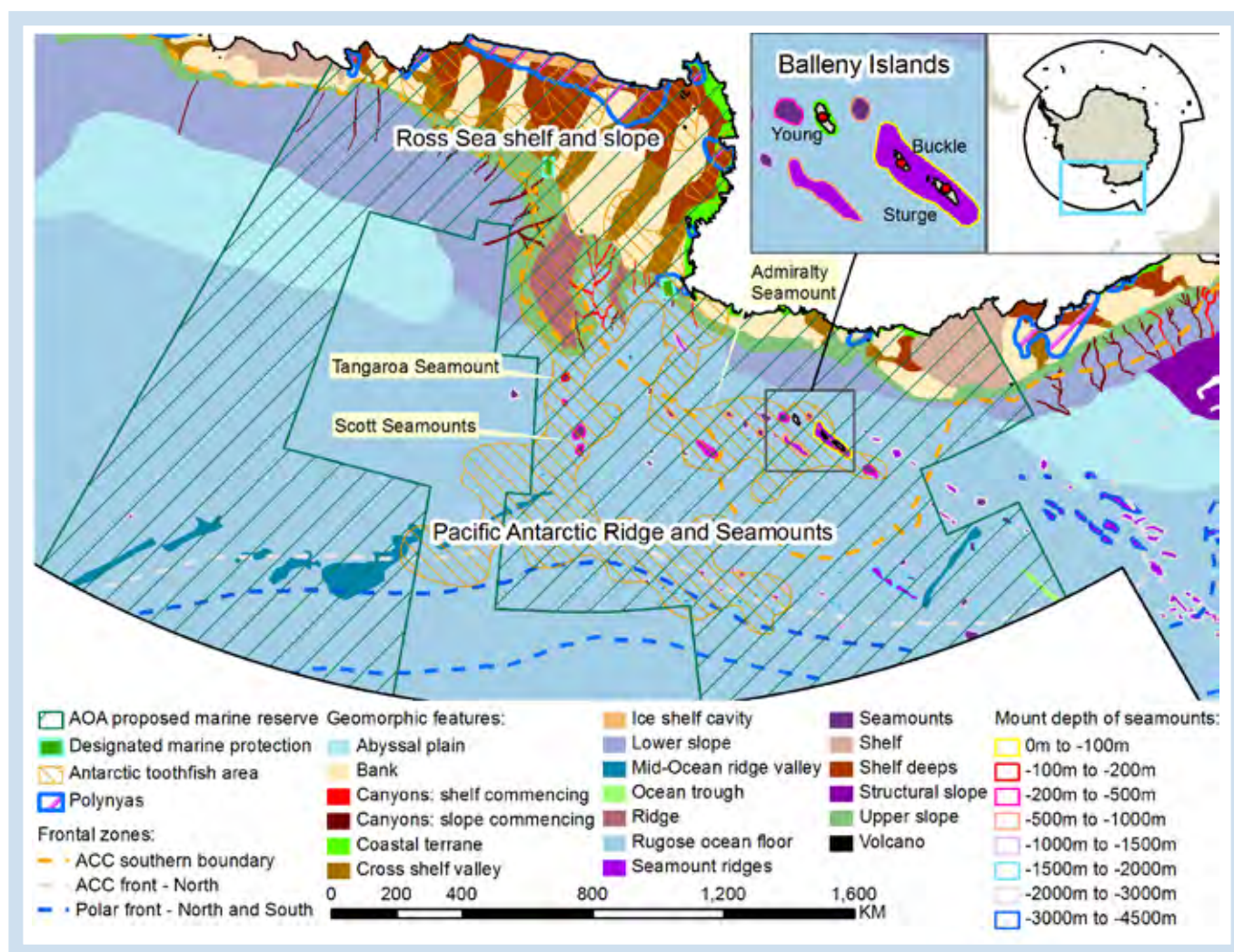
More than a quarter of the Southern Ocean's phytoplankton production occurs in the Ross Sea, making it the most productive stretch of ocean south of the Polar Front²⁷⁷. Several large polynyas form every year in the Ross Sea. The phytoplankton bloom in one of these polynyas is the largest on earth and can be seen from outer space. Each summer this bloom kicks the Ross Sea food web into life²⁷⁸.

While many other marine ecosystems have been altered significantly by human activity, the highly productive Ross sea food web remains much the same as it has for centuries, with rich benthic biodiversity and sizable populations of top predators including toothfish, flying seabirds, penguins, seals and whales²⁷⁹. The seafloor supports amazing biodiversity, including hundreds of sponge species, many bryozoans, more than 150 echinoderms (e.g. sea stars and urchins) and crustaceans²⁸⁰. There are also 40 endemic species found nowhere else on the planet²⁸¹ with new species frequently discovered²⁸². Silverfish and two krill species occupy the water column, providing nourishment for seals, penguins, seabirds, fish and whales. The Ross Sea also supports 95 fish species²⁸³. More than a third of all Adélie penguins make their home in the Ross Sea, along with 30% of all Antarctic petrels and one quarter of all emperor penguins²⁸⁴. Also found here are Antarctic minke whales, Weddell and leopard seals, as well as orcas²⁸⁵, including a genetically distinct population referred to as "ecotype-C" that may be specially adapted to feed on Antarctic toothfish, the top fish predator of the Ross Sea²⁸⁶.



Ross Sea algal bloom from space. Image by NASA.

Antarctic toothfish are by far the dominant fish predator in the Ross Sea, filling a similar role to sharks in other ecosystems. Whereas most Antarctic fish species rarely get larger than 60 cm, Ross Sea toothfish can grow in excess of two metres in length and more than 150 kg in mass²⁸⁷. Being top predators, they feed on a variety of fish and squid²⁸⁸, but they are also important prey for Weddell seals, sperm whales, colossal squid and the ecotype-C killer whale²⁸⁹. While these fish have long been studied for their ability to produce anti-freeze proteins that keep their blood from crystallizing, very little is known about their life cycle and distribution. Scientists do know they live to almost 50 years of age and grow relatively slowly²⁹⁰. They likely mature between 13 and 17 years of age (120-133 cm in length)²⁹¹. Recent research suggests that toothfish have a complex life cycle that includes a remarkable spawning migration²⁹². In the Ross Sea region, adults feed over the continental shelf and slope, down to 2,000 m in depth and then migrate from the Ross Sea continental shelf to northern seamounts, banks and ridges around the Pacific-Antarctic Ridge system²⁹³. But much remains unknown about this important fish – to date no one has ever found a larval fish or an egg.



Southern albatross. Image by John B. Weller.

A CASE FOR PROTECTION

As perhaps the most intact marine ecosystem²⁹⁴ that is home to vast proportions of Southern Ocean wildlife, the Ross Sea has been proposed as a key region to be protected. It would be the crown jewel of a Southern Ocean network of no-take marine reserves and MPAs. The Ross Sea provides a last chance to study how an essentially undisturbed ecosystem functions. In recognition of this, more than 500 scientists have signed a statement supporting the establishment of a marine reserve covering at least the entire Ross Sea shelf and slope²⁹⁵.

The Ross Sea has some of the longest time series and data sets in the Southern Ocean. This is incredibly valuable for researchers, particularly in the face of climate change. The Ross Sea offers scientists a unique natural laboratory to study the impacts of climate change free from the influence of human disturbance. Being the southernmost body of water on the planet, the Ross Sea will be the last part of the Southern Ocean with year round sea ice according to the IPCC²⁹⁶. As such the Ross Sea region will become a refugium for ice-dependent species²⁹⁷.

The most immediate threat to the Ross Sea is the recently developed Antarctic toothfish fishery. Industrial fishing vessels penetrated the Ross Sea in search of toothfish in the winter of 1996. Ross Sea scientists believe they are already seeing impacts on the Ross Sea ecosystem, including changes in the population of Ross Sea ecotype-C killer whales²⁹⁸. Fishery scientists who have been studying Ross Sea toothfish since the early 1970s have no longer been able to catch enough fish to continue their research in some areas of the Ross Sea²⁹⁹.

Industrial scale exploitation of large, deepsea predatory fish have repeatedly proved unsustainable³⁰⁰. The only way to ensure trophic cascades do not occur in the still pristine Ross Sea is to protect areas critical to the life-history stages of the Antarctic toothfish, including the Ross Sea shelf and slope.

The Ross Sea is a living laboratory providing scientists with the last chance to understand how a healthy marine ecosystem functions.

The Ross Sea has been identified by CCAMLR as a key region to be included in a representative network of MPAs. The United States and New Zealand have proposed scenarios for a Ross Sea MPA, but neither have included the central shelf and slope region. This region has diverse bathymetry, including banks and basins. Many of the Ross Sea's top predators forage in this region of the shelf and slope, including Antarctic toothfish, orcas, minke whales, crabeater and Weddell seals, emperors and Adélie penguins and Antarctic and snow petrels³⁰¹. It is essential for CCAMLR to go further than the present United States and New Zealand scenarios and establish a fully protected no-take marine reserve in the Ross Sea region. The Ross Sea marine reserve should be the first step in establishing a comprehensive network of MPAs and no-take marine reserves around Antarctica.



PACIFIC SEAMOUNTS

Directly north of the Ross Sea, the deep seafloor is peppered with isolated seamounts boasting species assemblages found nowhere else on the planet³⁰². These seamounts, which are some of the shallowest ones in the Southern Ocean³⁰³, support unique benthic communities and habitat for whales and Antarctic toothfish, the top

fish predator in the Southern Ocean³⁰⁴. During their spawning cycle, toothfish use these seamounts and the Pacific-Antarctic Ridge system – a complex network of fracture zones and ridges far north of the Ross Sea³⁰⁵. Many of these seamounts and portions of the ridge system have been left out of the Ross Sea MPA planning scenarios that have been put forth to CCAMLR. A comprehensive and representative network of Southern Ocean marine reserves and MPAs must include these unique seamounts. Further, protecting critical toothfish spawning habitat is essential for safeguarding the long-term health of Ross Sea toothfish populations.



Iceberg. Image by Cassandra Brooks.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The Admiralty and Scott Island Seamounts are major seamounts north of the Ross Sea, both grounded at about 67°S. Admiralty Seamount lies roughly 100 km east of the Balleny Islands with the Scott Seamount chain 400 km further east. The Scott Seamount chain consists of Scott Island and multiple seamount summits with very rugged, steep flanks, which is an unusual bathymetry to find near a continental margin³⁰⁶. The nearby Tangaroa Seamount is the only seamount within the 100-200 m bathome in the Pacific-Antarctic Ridge ecoregion, and one of only three seamounts of this kind the Southern Ocean³⁰⁷.

Recent biological surveys have revealed striking and distinctly different assemblages on each of the seamount systems. Admiralty Seamount and its associated knolls were dominated by a new 50 cm tall species of crinoid, or sea lily, and in abundances never before observed³⁰⁸. Dense aggregations of these types of crinoids had only been witnessed in Paleocene fossil records. In addition to crinoids, scientists observed dense populations of brittle stars that are also rarely seen outside the fossil record³⁰⁹.



Ice forms in Weddell Sea. Image © Greenpeace / Steve Morgan.

The faunal assemblages on the Scott Island Seamounts were distinctly different from Admiralty. These seamounts had very few crinoids, but instead had a diversity and abundance of predatory invertebrates, like sea urchins and crabs, as well as other sessile animals like deep-sea corals, sea pens and sponges³¹⁰. Many of these animals likely live to well over one hundred years old, making them incredibly vulnerable to damage by fishing gear³¹¹.

The differences between these seamounts provide a living laboratory to understand what generates seamount biodiversity. Ocean currents may be the driver, with the Scott Seamount largely influenced by the waters of the ACC and the Admiralty Seamount mostly influenced by the colder water of the Ross Sea shelf and slope. Perhaps because of the coldwater influence, the Admiralty Seamount also has a longer and more extensive ice season³¹². Scott Seamount sits at the edge of the Ross Gyre in an area of relatively high productivity³¹³, which is likely why humpbacks and blue whales have been seen in the surrounding waters³¹⁴.

These seamounts and the Pacific-Antarctic Ridge system to the north are also likely critical habitat for Antarctic toothfish. Current research indicates they make a remarkable spawning migration from the Ross Sea shelf and slope out to the Pacific-Antarctic Ridge system where they mate and spawn. Using the currents associated with the Ross Gyre to travel, they then make their way back to the southern Ross Sea. As part of this cycle, juvenile toothfish likely visit the Pacific Seamounts before they move into

deeper waters of the continental slope, achieve maturity and migrate to the northern spawning grounds completing the cycle³¹⁵. As the major fish predator in the Southern Ocean and key prey for Weddell seals³¹⁶, orcas³¹⁷ and sperm whales³¹⁸, the toothfish plays an important role in the food web. Disruptions to its life cycle and population could have unforeseen and ecosystem-wide consequences³¹⁹.

CASE FOR PROTECTION

The United States and New Zealand have each put forward a preliminary scenario for a Ross Sea MPA. Each scenario includes portions of the Pacific-Antarctic Ridge System, with the United States scenario providing more protection to the seamounts located to the northwest of the Ross Sea while the New Zealand scenario provides a degree of protection in the northeast. Since Antarctic toothfish are the top fish predator in the Southern Ocean, their spawning grounds must be protected to ensure ecological resilience continues in the Ross Sea region. Scientists are already beginning to see changes in the Ross Sea ecosystem likely caused by fishing pressure³²⁰. Protecting critical spawning habitat for toothfish could help alleviate these effects and prevent future damage to this pristine ecosystem.

Antarctic toothfish are by far the dominant fish predator in the Ross Sea, filling a similar role to sharks in other ecosystems... while these fish have long been studied for their ability to produce anti-freeze proteins that keep their blood from crystallizing, very little is known about their life cycle and distribution.

The Admiralty Seamount is included in Ross Sea MPA scenarios from New Zealand and the United States. This seamount supports species assemblages found nowhere else on Earth; its protection is of the utmost importance. But the Scott Island Seamounts must also be protected. Admiralty Seamount resembles a living fossil while the Scott Seamounts are evolution in action. Having both of the seamount assemblages protected will allow scientists to better understand seamount ecology, especially for isolated seamounts. Moreover, the Tangaroa Seamount is the shallowest seamount in the Ross Sea region and among the shallowest in the Southern Ocean. This diversity of seamounts, ridges and troughs should comprise a no-take marine reserve as part of a larger Ross Sea marine reserve. Their inclusion is a vital component of a Southern Ocean network of no-take marine reserves and MPAs.



BALLENY ISLANDS

The Balleny Islands are an isolated archipelago in the northwestern Ross Sea region. Part of an ancient volcanic chain, the islands provide important breeding and stopover resting grounds for penguins and flying seabirds. As a rich krill habitat, perhaps due to a seasonal polynya around the islands, the waters of the Balleny Islands also provide feeding grounds for many seabirds, whales and seals³²¹. They also appear to be a crossroads in the Southern Ocean – their location at the centre of the ACC make the islands ideal for intercepting pelagic larvae. As a result, they harbor benthic species found far in wide – from the Ross Sea, the Weddell Sea and the waters of New Zealand³²². The shallow shelf around the islands may also be important for juvenile Antarctic toothfish³²³.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The Balleny Islands, characterized by steep rock and ice cliffs, are the exposed section of a volcanic seamount chain roughly 270 km northeast of Cape Adare. The Archipelago is comprised of three large islands and a number of smaller islands and exposed rocks. Underwater, the trend continues in a series of seamounts³²⁴.

Complex oceanographic currents drive local productivity. The archipelago lies directly in the path of the ACC and is amidst the clockwise flowing Ross Gyre. A seasonal polynya encompasses the islands, providing open water in the middle of ice-laden seas. This polynya is a key feeding ground for penguins, seals and whales.

Being the only island group in the region, the Balleny Islands provide important breeding and stopover grounds for a variety of seabirds and seals. Penguins traveling from the southern Ross Sea likely visit the islands on their way to the edge of the northern pack ice³²⁵. Breeding seabirds on the Islands include Adélie and chinstrap penguins, Antarctic fulmars, cape pigeons, Antarctic petrels and snow petrels. Other birds that pass through the Balleny Islands include Antarctic prions, Antarctic terns, light-mantled sooty and wandering albatrosses, white chinned and Wilson's storm petrels, macaroni penguins, sooty shearwaters, southern giant petrels and south polar skuas. Seals of the region include crabeater, elephant, leopard and Weddell seals³²⁶. Evidence from the Ross Sea toothfish fishery also suggests that the shelves and slopes of the Balleny Islands may be important juvenile habitat for Antarctic toothfish³²⁷.



Crabeater seal. Image by Cassandra Brooks.

The Balleny Islands are the only place outside the Antarctic Peninsula and Scotia Sea region with breeding chinstrap penguins. While only a small number of nests have been confirmed, scientists marvel that they even exist in the Balleny Islands, thousands of miles from the next nearest colony. Here, chinstraps breed alongside Adélie penguins, another anomaly seldom observed³²⁸.

The Islands' isolation and oceanographic position make them ripe for unique and varied benthic species assemblages. Brodie's king crab, a species common off the waters of New Zealand, is found off the Balleny Islands³²⁹. The region harbors endemic mollusc species and shares many species with the nearby Ross Sea. Surprisingly, some invertebrates have only otherwise been found in the Weddell Sea. This suggests that the rugged bathymetry associated with the islands, and further facilitated by the proximity to the ACC, may act as a settling ground for diverse benthic flora and fauna³³⁰. More research is needed to truly reveal the critical role the Balleny Islands play in the broader Southern Ocean ecosystem.

A CASE FOR PROTECTION

In recognition of the Balleny Islands' uniqueness and vast importance for wildlife, Sabrina Island – the northernmost island in the group – was designated as a Specially Protected Area under the Antarctic Treaty. But protecting the land is not enough, the waters surrounding the Balleny Islands should be protected as a no-take marine reserve encompassing all the key habitats and biological processes of the Balleny Islands.

The Ross Sea region, including the Balleny Islands, has supported a significant Antarctic toothfish fishery since 1997. In recent years, however, the Balleny Islands region has been closed to fishing for research purposes³³¹. Full inclusion of the diverse underwater benthic habitats within a no-take marine reserve would likely protect juvenile toothfish, helping to ensure the health of the Ross Sea toothfish population. A no-take marine reserve in the Balleny Islands will be a key component of a representative Southern Ocean network of MPAs and no-take marine reserves.

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AMUNDSEN AND BELLINGSHAUSEN SEAS

Inaccessible and mysterious, the Amundsen and Bellingshausen Seas³³² (ABS) are nonetheless characterized by change. At present, they are some of the most under-explored areas in the Southern Ocean because of challenging sea ice conditions and distances to ports for research vessels. Meanwhile, warming temperatures have begun to alter conditions significantly. Adjacent to the unstable West

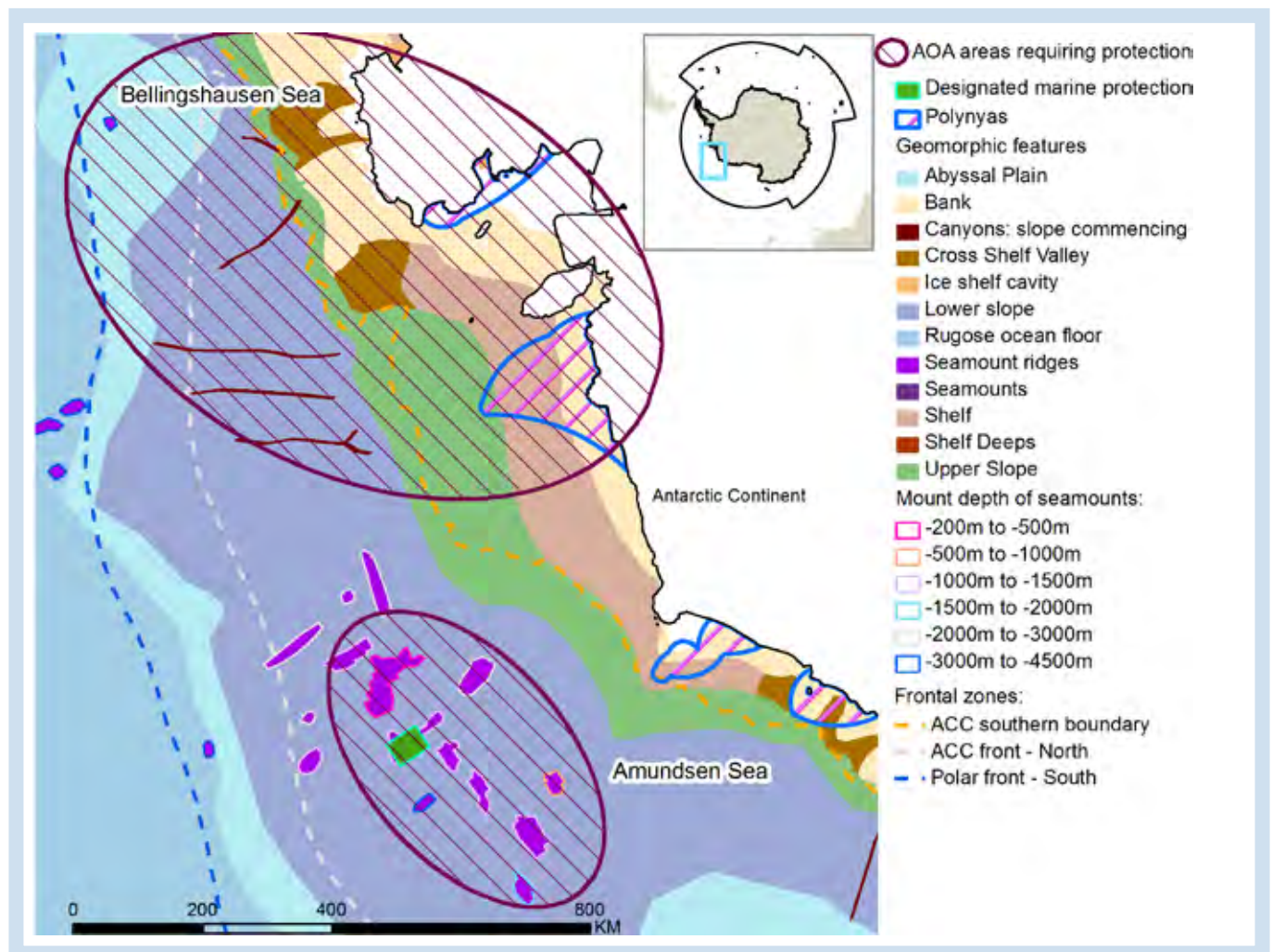
Antarctic Ice Sheet (WAIS), both seas have been experiencing increasing glacial melt, particularly from the Pine Island Glacier in the Amundsen Sea. Protecting these regions on a precautionary basis will ensure that scientists are able to understand the interrelated changes that are occurring and will continue to occur as temperatures in the West Antarctic rise.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

The Amundsen Sea is located east of the Ross Sea on the western coast of Antarctica, between Thurston and Siple Islands. The Bellingshausen Sea is also on the western coast and is located between Thurston and Alexander Islands (just below the West Antarctic Peninsula). The Amundsen and Bellingshausen Seas are characterized by significant sea ice cover, created in part by low temperatures year-round³³³. These conditions have rendered large areas inaccessible to researchers, hindering their acquisition of knowledge about the ABS ecosystems.

Available research suggests that the Amundsen Sea boasts highly productive polynyas, one of which generates some of the greatest primary productivity in Antarctica³³⁴. Yet, very little is known about the region's biodiversity. One recent meta-analysis of Southern Ocean biodiversity did not even include the Amundsen Sea because there was insufficient data³³⁵. Since then, a recent survey

Amundsen and Bellingshausen Seas area map.



of seafloor communities found that 96% of isopod crustaceans in the Amundsen Sea were entirely new species³³⁶. Knowledge of bird and mammal species is similarly limited, but there appear to be good foraging opportunities for seabirds in some areas, such as near ocean fronts and at continental shelf breaks³³⁷. The main seabirds observed in the Amundsen Sea have been emperor penguins, Adélie penguins and snow petrels, with some Antarctic petrels, blue petrels and Antarctic prions³³⁸. Whale surveys indicate that orcas and particularly minke whales are the most common cetaceans³³⁹.



Weathered Iceberg in the Southern Ocean.
Image © Greenpeace / Jiri Rezac.

Knowledge of the ecology of the Bellingshausen Sea is similarly limited. There are highly productive spring polynyas in the Bellingshausen Sea³⁴⁰, and they likely drive local ecosystem dynamics. Benthic communities seem to be sparsely populated with diversity increasing in areas closest to the Antarctic Peninsula³⁴¹. Seabird assemblages resemble those of the Amundsen Sea, with emperor penguins, Adélie penguins, snow petrels and Antarctic petrels³⁴². In the southern Bellingshausen Sea pack ice, minke whales are abundant³⁴³. The fish fauna has been little studied, but initial surveys suggest that the eelpout and cod icefish families make up the majority of species and overall the fauna seems to resemble that of the Eastern Antarctic³⁴⁴.

Most research conducted in the ABS has focused on the impacts of climate change with respect to sea ice coverage and the stability of the continental ice sheet. A long-term decline in ABS sea-ice extent has been recorded starting in the early 1970s³⁴⁵. Furthermore, the WAIS has melted significantly, with the sea level in the Amundsen Sea sector increasing by more than 0.2 mm per year³⁴⁶. The Pine Island Glacier, one of the largest ice streams in Antarctica and located within the Amundsen Sea sector, is rapidly thinning³⁴⁶. The glacier is the focus of significant scientific attention since its melting may have dramatic consequences for the Amundsen Sea as well as the greater WAIS, the collapse of which could lead to significant global sea rise.

A CASE FOR PROTECTION

Ice conditions have largely prevented commercial exploitation in the ABS. The majority of the Amundsen Sea lies within an area currently closed to fishing, but a small portion of the Bellingshausen Sea falls within a krill fishing area. As ice conditions change, these regions could become more susceptible to exploitation, particularly in areas where krill are abundant (e.g. over the Bellingshausen Sea shelf areas²⁴⁸).

The ecology of the Amundsen and Bellingshausen Seas is extremely vulnerable to climate change. As temperatures rise, these regions may become more accessible, leading to increased human activities. Recently, the United Kingdom proposed that any ocean areas under the ice shelves in the area that includes the Amundsen and Bellingshausen Seas should be designated as no-take marine reserves on a precautionary basis in case of ice shelf collapse³⁴⁹. The United Kingdom noted that a variety of changes would result from an ice shelf collapse, including the possible colonization of the area by nearby or even invasive species from geographically distant areas³⁵⁰. Scientists will understand these changes better if there are no other human activities in the area³⁵¹. A marine reserve encompassing an existing CCAMLR designated Vulnerable Marine Ecosystem (VME) in the Amundsen Sea would provide increased protection.



Whales in the Southern Ocean. *Image by John B. Weller.*

Because very little is known about the ABS, protecting open-ocean areas not covered by ice shelves would be advisable as well. As sea ice cover diminishes, scientists should have the opportunity to study these areas before they are irrevocably altered by warming temperatures. The highly productive polynyas that draw penguins and minke whales likely also support other species, including some still unknown to science. Protection of the ABS as part of a Southern Ocean network of MPAs and no-take marine reserves will ensure that the ecology of these areas is fully studied before human activities occur on a large scale.

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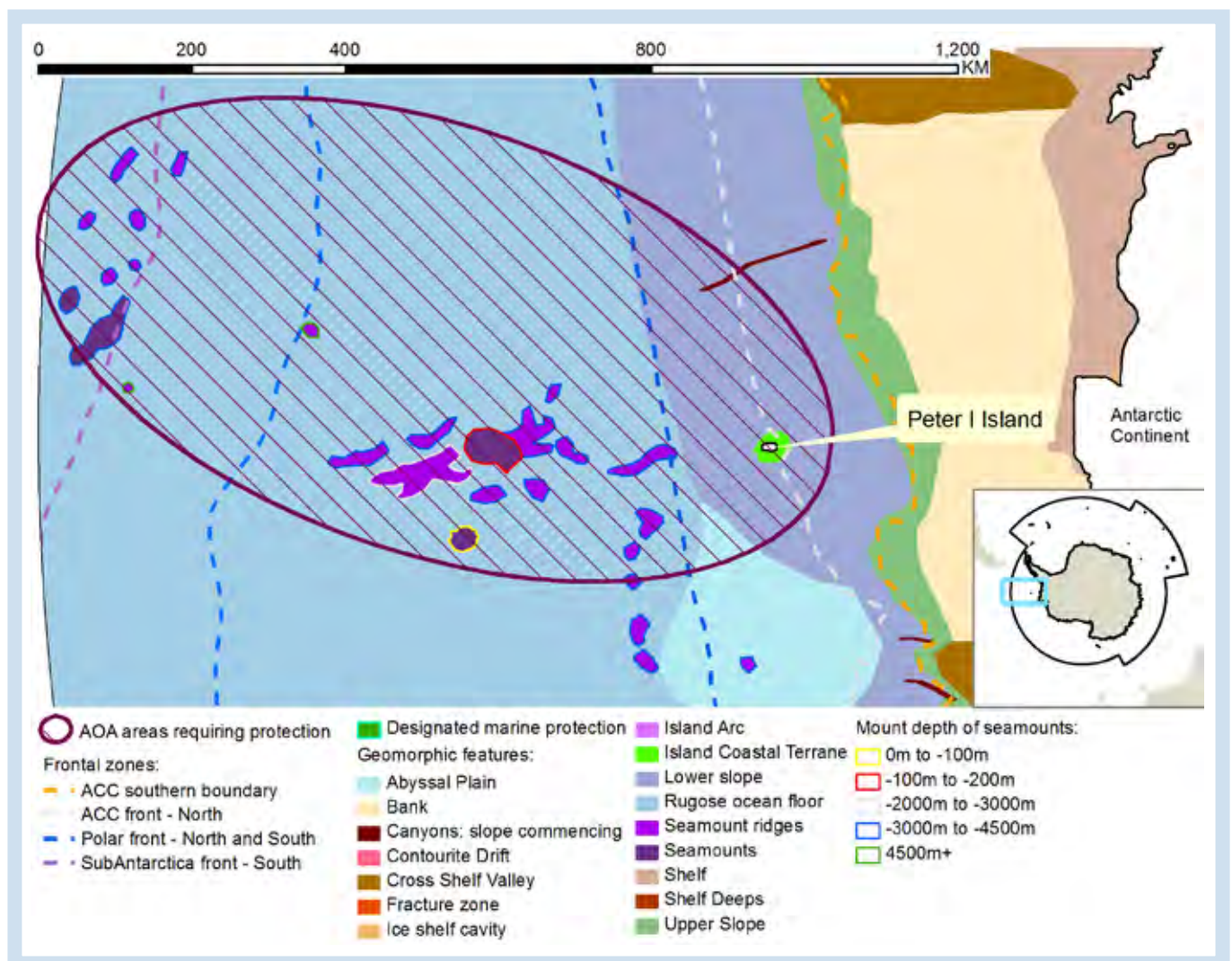
PETER I ISLAND

Peter I Island is a volcanic island located in the Bellingshausen Sea, 450 km from the coast of continental Antarctica. The island, largely surrounded by pack ice, supports small populations of seabirds and seals. Due to the lack of scientific research in the area, we know little about the waters around the island, but they appear to contain unique ecological features, including seamounts, island habitats and unique pelagic environments. The few research expeditions that sampled the waters around Peter I Island revealed notable invertebrate diversity and fish assemblages. The Island, claimed by Norway, is protected, but the waters around it are not.

GEOGRAPHY, OCEANOGRAPHY AND ECOLOGY

Ancient volcanic action worked to shape Peter I Island and the surrounding seafloor, creating rugged and diverse bathymetry. The surrounding area contains unique guyots, or flat-topped seamounts usually formed by extinct volcanoes. Belgica and Lecoite Guyots are among the shallowest seamounts in the Southern Ocean with depths less than 100 m and 200 m respectively. Belgica is approximately 40 km across while Lecoite is 20 km. On the other extreme, north of Peter I Island, lies one of the deepest seamounts in the Southern Ocean with a summit beyond 4,500 m.

Peter I Island area map.





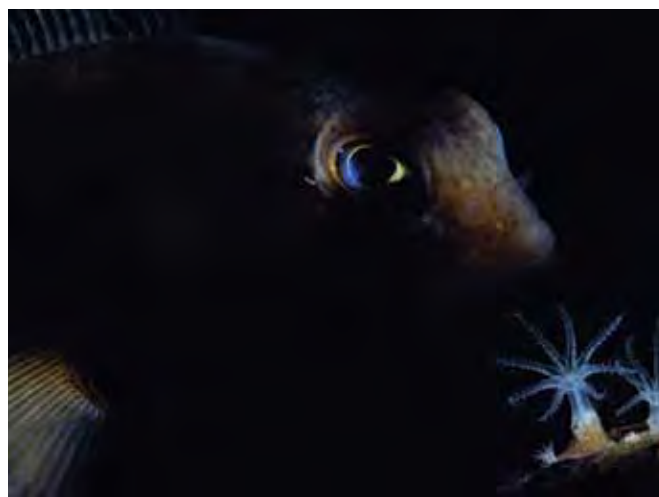
Peter I Island. Image by John B. Weller.

These guyots, seamounts and the shelf and slope around Peter I remain mostly unexplored underwater environments. The few studies of the seafloor around Peter I Island reveal a rich abundance and diversity of invertebrates. The area supports the highest mollusc abundance and diversity within the Bellingshausen Sea³⁵². Stone crabs have also been found off Peter I³⁵³.

Located south of the Polar Front, the waters around Peter I Island are highly productive. The island has small nesting habitats for a number of seabirds including southern fulmars, Wilson's storm-petrels, cape petrels and Arctic terns³⁵⁴. It also hosts colonies of crabeater, leopard and southern elephant seals. Many whale species also likely frequent the area, including sperm, blue, fin and minke whales, as well as orcas.

Due to the lack of scientific research in the area, we know little about the waters around the island, but they appear to contain unique ecological features, including seamounts, island habitats and unique pelagic environments.

The fish assemblages in the waters around Peter I Island remain largely unknown, but the most recent survey suggests they are dominated the notothenioid fish family, particularly the painted notie. The commercially important Antarctic toothfish are also found here. Species normally only found in the subantarctic were also found around Peter I Island, including the emerald rockcod and Charcot's dragonfish. These limited samples only scratch the surface of the potential array of fish species found here³⁵⁵.



Emerald rockcod. Image by John B. Weller.

CASE FOR PROTECTION

Protection of the waters around Peter I Island would encompass many benthic and pelagic species as well as the unique regional features and contribute to a Southern Ocean network of no-take marine reserves and MPAs. The Belgica and Leconte Guyots are extremely rare features that likely support unique species assemblages. The geographic distribution of shallow seamounts is extremely limited, suggesting that full protection is necessary. Extending protection from the Antarctic side of Peter I out to the edge of the CCAMLR boundaries at 60°S would encompass these features. It would also include warmer seabed habitats within the offshore regions of the Amundsen and Pacific Basin ecoregions³⁵⁶.

THE PROPOSAL FOR A REPRESENTATIVE NETWORK OF SOUTHERN OCEAN MPAS AND MARINE RESERVES

Based on the best available science, the Antarctic Ocean Alliance has identified more than 40% of Southern Ocean that warrants protection in a network of MPAs and large no-take marine reserves. This was determined by combining existing marine protected areas, the areas identified within previous conservation planning analyses and including additional key environmental habitats described in this report. The 19 areas proposed should provide protection within a representative network at the species, habitat and ecosystem level. These areas include the most intact marine ecosystems left on the planet in the Weddell and Ross Seas. The proposed network would protect the breeding and foraging grounds of the incredible predator populations that thrive in the Southern Ocean. With increasing threats to pelagic species, a Southern Ocean network of MPAs and marine reserves provides a place of refuge. While knowledge about many of the proposed regions is poor, the AOA suggests protection as a precautionary measure with the intention of conserving unique ecosystems and undiscovered biodiversity. In some regions, protection of previously exploited mammals and fish will allow their further recovery. In others, the protection of the spawning grounds of toothfish and other fish species should maintain the viability and integrity of these species in the long term.

In acknowledging that considerable effort is needed in the international process to determine a final network of MPAs, this report does not make definitive proposals in all areas but does in some as well as outlining key habitats that are important for consideration. The AOA will work further with CCAMLR Members and their scientific bodies to develop appropriate protection for all these unique and valuable ecosystems, with a goal of over 40% of the Southern Ocean protected in a network of MPAs and marine reserves.

This report seeks to protect critical large-scale Southern Ocean ecosystem processes.

This includes protection of:

1. A wide and representative range of habitats and ecosystems;
2. The biodiversity and ecological processes of the Southern Ocean;
3. Critical geomorphic features including the seamounts, ridges and troughs;
4. Regions that facilitate the continuation and collection of long-term datasets that underpin crucial research into ecosystem function and environmental change, including the impacts of climate change and ocean acidification;
5. Areas critical to the life-history stages of endemic species such as the toothfish – the region's top fish predator – and other predators;
6. The breeding and foraging grounds of higher trophic level fauna such as emperor, Adélie and gentoo penguins as well as crabeater, Weddell and Antarctic fur seals;
7. Key biodiversity hot spots;
8. Several areas, such as the Ross Sea and East Antarctic, that serve as critical climate reference areas and climate refugia for ice-dependent species;
9. Whale, seal and fish populations that are still recovering from historical overexploitation;
10. Areas that are particularly vulnerable to climate change, such as the Western Antarctic Peninsula;
11. The most intact marine ecosystems left on the planet, including the Ross Sea and Weddell Sea.

Area	Proposed MPAs and/or MRs to CCAMLR	Suggested AOA approach
Antarctic Peninsula	No MPA proposed so far. There are a number of ATS managed areas with marine components.	A regional network of no-take marine reserves and MPAs that includes key values, features and ecosystems.
Weddell Sea	No MPA proposed	Marine protection that includes key values, features and ecosystems.
South Scotia Sea region, including South Georgia, South Sandwich and South Orkney Islands	CCAMLR MPA south of South Orkneys. UK designated a South Georgia and South Sandwich MPA, which includes 12 nm no-take region around South Georgia and South Sandwich Islands (not recognised by all parties).	Work ongoing – the AOA will consider this area further in the future.
Maud Rise	No MPA proposed.	Marine protection that includes key values, features and ecosystems.
Bouvetøya	Small marine reserve around island to 12 nm.	Larger scale marine protection that includes key values, features and ecosystems.
Del Cano – Crozet Region, including Ob and Lena Banks	Plans for MPAs in South African and French EEZs around Crozet and Prince Edward Islands. Plans for an MPA in South African EEZ around Prince Edward Islands. MPA designated in French EEZs around Crozet Islands. Governments and NGOs are working with CCAMLR on including the Del Cano Rise region.	Building on fisheries closures and the proposed MPAs, larger scale marine protection, including no-take zones that protect key values, features and ecosystems.
Kerguelen High Seas region, including BANZARE Bank	Some protection through MPAs in EEZs of France and Australia. BANZARE Bank is closed to toothfish fishing per CCAMLR.	Extension of EEZ MPAs, including larger no-take areas and protection of BANZARE Bank, to protect key values, features and ecosystems.
Eastern Antarctic Shelf	Australia/France has mapped and proposed an MPA.	Extension of Australia/France proposal to include additional important features, values and ecosystems. To be the subject of forthcoming report.
Indian Ocean Benthic Environment	No MPA proposed.	Marine protection that includes key values, features and ecosystems.
Ross Sea region, including the Balleny Islands and Pacific Seamounts	NZ/US have mapped and developed scenarios for MPAs. The AOA has mapped and proposed marine reserves.	Proposed combination of US and NZ scenarios with an additional three areas all to be protected in a no-take marine reserve (as featured in the AOA Ross Sea report).
Amundsen and Bellingshausen Seas	No MPA proposed.	Marine protection that includes key values, features and ecosystems.
Peter I Island	No MPA proposed.	Marine protection that includes key values, features and ecosystems.

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