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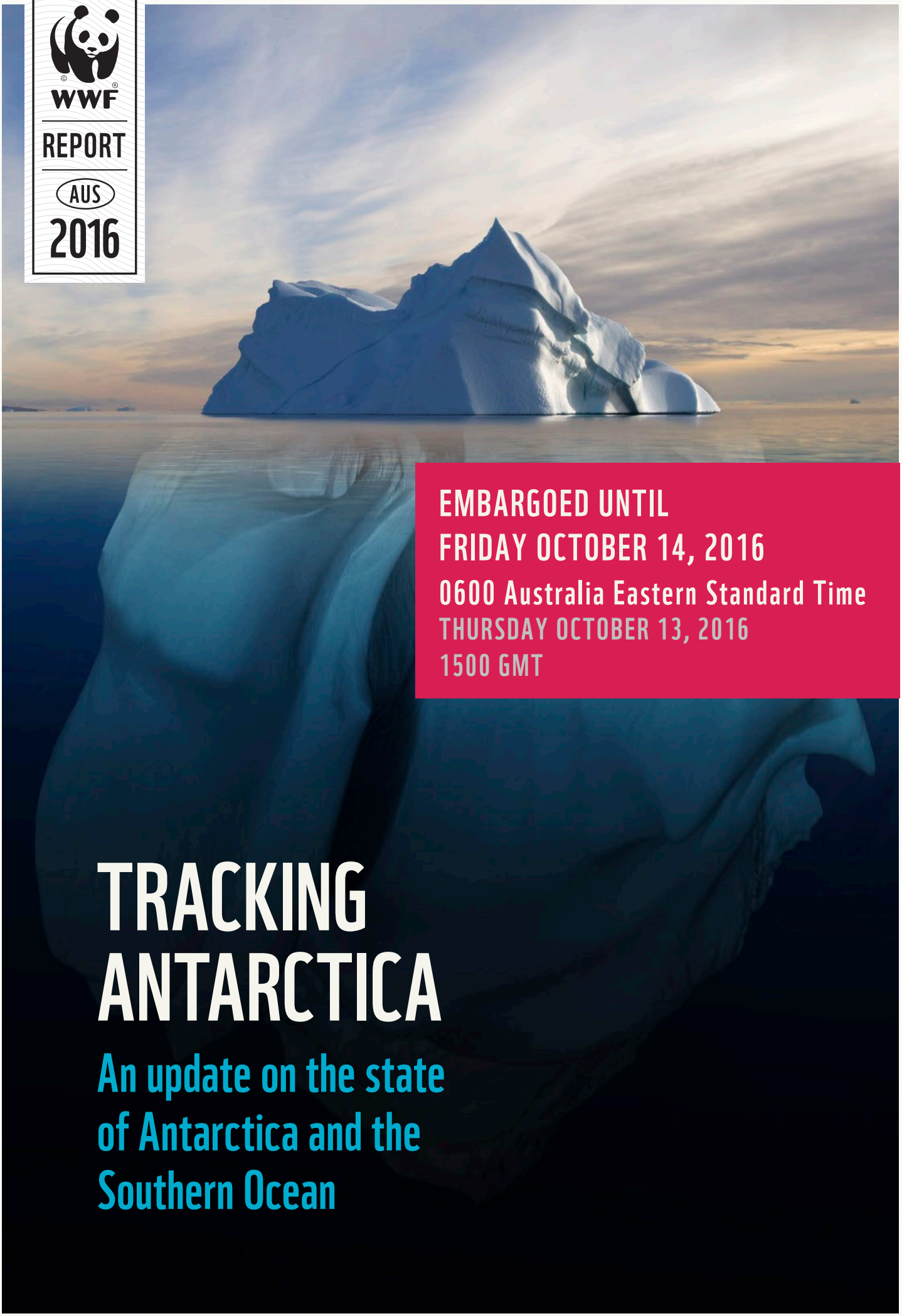

EMBARGOED UNTIL
FRIDAY OCTOBER 14, 2016
0600 Australia Eastern Standard Time
THURSDAY OCTOBER 13, 2016
1500 GMT

TRACKING ANTARCTICA

An update on the state of Antarctica and the Southern Ocean

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CREDITS & ACKNOWLEDGEMENTS

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WWF is one of the world's largest and most experienced independent conservation organizations, with over 5 million supporters and a global Network active in more than 100 countries.

WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by: conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

The WWF Antarctic Conservation Program works with governments, industry and partners as a voice of credible science. We are located in the key member nations of the CCAMLR, which is responsible for conserving Antarctic marine life. The Southern Ocean is a priority place for the WWF global network because of its scientific and natural value. A key focus of our work is to monitor and report on the state of species, ecosystems and human impacts to communicate innovative solutions and achieve conservation impact.

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FRONT COVER: MELTING ICEBERG SHOWING THE PORTION UNDERWATER THAT IS SCULPTED BY THE SEA. POLAR REGIONS. DIGITAL COMPOSITE. © NATUREPL.COM / BRYAN AND CHERRY ALEXANDER / WWF

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THE LARGEST WILDERNESS ON EARTH

Antarctica is the most isolated continent on Earth. The surrounding oceans are home to more than 8,000 marine species, more than half of which are seen nowhere else in the world.[1]

However, parts of Antarctica warmed rapidly through the second half of the 20th century.[2] The northern part of the peninsula has entered a temporary cooling phase, although temperatures remain higher than measured during the middle of the 20th century.[3] Projected warming will put habitats and biodiversity under increasing threat. Large numbers of researchers, support staff and tourists, pollution and non-native species arriving through direct human assistance, and activities such as fishing will continue to increase the vulnerability of Antarctic ecosystems, mammals, fish, and birds.

Changes in polar climate will have global effects. Glacial retreat is taking place, and melting of land-based ice raises sea level as does the thermal expansion of seawater as temperatures rise.

The oceans surrounding Antarctica are warming,[4] affecting worldwide heat and sea levels.[5] These changes have direct impacts on the climate worldwide.

Protecting Antarctica, and the Southern Ocean that surrounds it, is beyond the capacity of any one country or organisation. The Antarctic Treaty System is the network of arrangements through which governments work together to this end, mainly through the Antarctic Treaty and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). Ocean life is conserved through coordinated international management by CCAMLR, which has competency to make binding consensus decisions about controlling the use of marine living resources.

Conserving Antarctic marine life is the objective of CCAMLR, established by international convention in 1982. CCAMLR regulates all fishing throughout the Southern Ocean around Antarctica, seeking to achieve conservation including 'rational use' of living marine resources, while maintaining existing ecological relationships. CCAMLR has adopted numerous conservation measures that set precautionary catch limits that have successfully dealt with illegal, unreported and unregulated (IUU) fishing and that have eliminated bycatch of seabirds to near zero within the convention area.

WWF supports a precautionary and science-based approach to identify the pressures and threats to the planet's largest wilderness. *Tracking Antarctica* provides a scientific update on the state of Antarctica and the Southern Ocean and identifies ways to respond to the challenges to ensure the wonders of the Antarctic are preserved for generations to come.

Establishing broad, well-managed,[6] marine protected areas (MPAs) is a vital part of delivering effective biodiversity conservation. In protected areas of the ocean, activities are managed, limited or entirely prohibited.

Future management of the krill fishery through sound science

For management purposes, the Southern Ocean is divided into statistical areas, sub-areas and divisions with catch limits set by CCAMLR.[7] Currently, the krill fishery is managed through a series of Conservation Measures relating to aspects of operation of the fishery including: precautionary catch limits, gear restrictions, data reporting, notification of intent to fish, minimisation of incidental mortality, observer deployment as well as measures regulating exploratory fisheries.[8]

CCAMLR aims to develop a feedback approach to aid ecosystem-based management of Antarctic krill fisheries.[9] Feedback management (FBM) is system that uses information on the status of the ecosystem to alter the levels of fishing in order to ensure that the desired state of the ecosystem is sustained.[10] This process relies on monitoring the status and dynamics of the ecosystem including krill stocks, their predators, and the fishery.

In 2009, distribution of krill catches was allocated to subareas by Conservation Measure 51-07 (CM 51-07) to allow for inter-annual variation in the distribution of krill aggregations, and alleviate the potential for adverse impacts of the fishery in coastal areas on land-based predators. CM 51-07 is set to expire at the end of 2016 unless renewed by consensus agreement and is the first of four stages of development of a krill feedback management strategy.[11]

Although an ambitious goal with significant technical challenges operating in the remote Southern Ocean, an effective feedback management system is a key to the future sustainable management of krill fisheries and its iconic species.

SCORECARD: How well are we conserving the Antarctic?

MAJOR CONCERN | WATCH LIST | SIGNIFICANT PROGRESS BEING MADE

TOPIC	STATUS	RECOMMENDED SCIENCE BASED ACTION
ADDRESSING CLIMATE CHANGE	• Climate change is the biggest threat to the Antarctica and the Southern Ocean through ice loss, ocean warming and acidification. Melting of land-based ice is adding to sea level rise globally, will affect Antarctic biodiversity and worsen the threat from non-native species. Loss of sea-ice and acidification will affect krill and other important marine organisms. • Climate change has been acknowledged by CCAMLR & Antarctic Treaty Consultative Meeting (ATCM) as a threat and has been prioritised in work plans; more action is needed.	• CCAMLR needs to explicitly integrate climate change monitoring and adaptation measures into its work in cooperation with ATCM.
ESTABLISHING A COMPREHENSIVE SYSTEM OF MPAS	• CCAMLR committed to create a representative system of marine protected areas by adopting Conservation Measure 91-04. However, progress to implement MPAs have slowed.	• Designate current Ross Sea / East Antarctic MPA proposals at CCAMLR with a timeline for establishing a comprehensive system.
KRILL FISHING	• Global demand for fish meal and omega supplements are likely to lead to increased krill fishing, which is currently concentrated along the Antarctic Peninsula and Scotia Arc. The most recent large-scale survey to estimate krill biomass and distribution in this area was in 2000. • Currently, the krill fishery does not have scientific observers on all vessels. CCAMLR Conservation Measure 51-06 requires a minimum requirement for 50% for all vessels operating in the fishery.	• Extend Conservation Measure (CM 51-07), develop feedback management (FBM) with improved real-time monitoring and status reporting of krill stocks, their predators, the fishery and incorporating impacts of climate change. • Increase frequency of krill surveys to better understand biomass with participation of the fishing industry to use vessels as platforms for science. • Increase observer coverage to 100% to assist in data collection and reporting as recommended by the CCAMLR Scientific Committee.[12]
PROTECTING ICONIC ANTARCTIC SPECIES	• Krill fisheries overlap with critical feeding area for baleen whales, seals, penguins, and other seabirds. • The CCAMLR Ecosystem Monitoring Program (CEMP) was established in 1985 in accordance with the ecosystem approach embodied in Article II to monitor the effects of fishing on both harvested species (target species) and dependent species (predators).	• Krill fishing must not deplete local wildlife food sources. CCAMLR must progress subdividing catch limits between smaller scale management units (SSMUs) to ensure the protection of both krill dependent wildlife and krill populations. • Increase the number of CEMP sites and using land-based and at-sea monitoring, monitor movement patterns, behaviour and energetic needs of predators limiting catches in areas overlapping with critical feeding habitat.

TOPIC	STATUS	RECOMMENDED SCIENCE BASED ACTION
PREVENTING INVASIVE SPECIES	• Rising temperatures and increased human activities are increasing the risk of invasive species, and species can move southward as the ocean warms. There is increased introduction of non-native species on the Antarctic Peninsula by the growing numbers of tourists and researchers.	• Parties to the Antarctic Treaty must keep Antarctica safe from invasive species through enhanced biosecurity measures.
CURBING POLLUTION	• Persistent organic pollutants (POPs) have been measured around Antarctica and detected in wildlife. Microplastics from outside Antarctica are emerging as a threat in the region.	• Fishing, tourism companies and government research agencies must protect the Antarctic from pollution delivered by human activities through diligent environmental management practices.
STOP ILLEGAL, UNREPORTED & UNREGULATED (IUU) FISHING	• The Atlantic, Indian and Pacific sectors of the Southern Ocean have experienced IUU fishing, which uses destructive methods affecting other species and the ecosystem. • IUU fishing has decreased substantially (>90%) since the 1990s through the electronic catch documentation scheme, a black list of IUU vessels, and an extensive system of detection and inspection of vessels, including satellite-based monitoring systems and naval patrols.	• All states should ratify and implement the FAO Port State Measures Agreement, further strengthen the catch documentation scheme, adopt measures controlling transhipment and ongoing vigilance needed to ensure IUU fishing does not increase.
REDUCING SEABIRD BYCATCH	• Reducing seabird bycatch is a global conservation issue. Within the CCAMLR convention area, implementing regulations and effective mitigation techniques by legal fishing vessels have achieved a near zero bycatch of seabirds.	• Continued monitoring, regulations and CCAMLR to share experience and advocate for adjoining regional fisheries management organisations (RFMOs).

*All views expressed in the scorecard are those of WWF

SOUTH AMERICA

SOUTH AFRICA

Roughly 7,000 scientists and 33,000 tourists visiting Antarctica each year accidentally carry seeds and spores.[34] More than 70,000 seeds enter the region annually.

SCIENTISTS
7,000

TOURISTS
33,000

SEEDS
70,000

INTRODUCED PLANTS
OVER 200

There are around 300 to 400 species of lichens, several hundred species of fungi,[80] 100 species of mosses, 25 species of liverworts and just two native species of flowering plants.

People have introduced more than 200 plant species to sub-Antarctic islands and parts of the Antarctic continent.

BLUE WHALE
ENDANGERED

FIN WHALE
ENDANGERED

SEI WHALE
ENDANGERED

SPERM WHALE
VULNERABLE

SOUTHERN RIGHT WHALE
RECOVERING

HUMPBACK WHALE
RECOVERING

ANTARCTIC MINKE WHALE
DATA DEFICIENT

Classification of the IUCN Red List of Threatened Species - some populations of humpback whales and southern right whales are showing strong recovery.[54]

WEDDELL SEA

CHINSTRAP PENGUIN
LEAST CONCERN

EMPEROR PENGUIN
NEAR THREATENED

ADÉLIE PENGUIN
NEAR THREATENED

GENTOO PENGUIN
NEAR THREATENED

MACARONI PENGUIN
VULNERABLE

KRILL FISHERIES VALUE PER YEAR (SOUTHERN OCEAN)
US$241,000,000

There are around 380 million tonnes of krill in the ocean,[73] similar to the total weight of human life on the planet.

A third of Adélie penguin colonies in Antarctica could disappear by 2060 due to the impacts of climate change.

Antarctica has the potential to contribute more than a metre of sea level rise by 2100 and more than 15 metres by 2500, if emissions continue unabated.[22]

In East Antarctica, large numbers of 'supraglacial' or meltwater lakes have been forming in summers between the year 2000 and 2013.

SOUTH POLE

Sea ice reduction will affect crabeater, leopard, and Ross seals.

In 2016, southern hemispheric carbon dioxide concentrations, for the first time since monitoring began, exceeded 400 parts per million.

Increasing quantities of plastic are washing up on the Antarctic coastline and sub-Antarctic islands

SOUTHERN INDIAN OCEAN

AMUNDSEN SEA

ROSS SEA

SOUTHERN OCEAN

SEABIRD BYCATCH MORTALITY 2012
CLOSE TO ZERO

Seabird bycatch mortality in CCAMLR managed fisheries has dropped from almost 7,000 a year in 1997 to close to zero in 2012.

From 1996 to 2006, researchers estimate that IUU fishing killed between 151,000 and 543,000 seabirds.[29]

SUSTAINABLE ANNUAL CATCH
3,000 TONNES

At higher latitudes the Ross Sea Antarctic toothfish fishery, managed by CCAMLR, is considered sustainable with a relatively small annual catch of 3000 tonnes.

Illegal, unregulated and unreported (IUU) fishing has been reported in the Atlantic, Indian and Pacific sectors of the Southern Ocean.

AUSTRALIA

THREATS TO ANTARCTICA

The first recorded people to visit Antarctica were explorers and sealers in the 1800s.[13] It is less than 200 years since humans first set foot on the Antarctic continent.

Current monitoring of human impacts on Antarctica is poor. Better recording of the extent of human activities is essential to understand potential impacts on Antarctic species, such as birds, marine mammals and lichens and mosses.

EMPEROR PENGUINS (APTENODYTES FORSTERI) AT FLOE EDGE AT TERRA NOVA, ROSS SEA, ANTARCTICA. © NATIONAL GEOGRAPHIC CREATIVE / PAUL NICKLEN / WWF

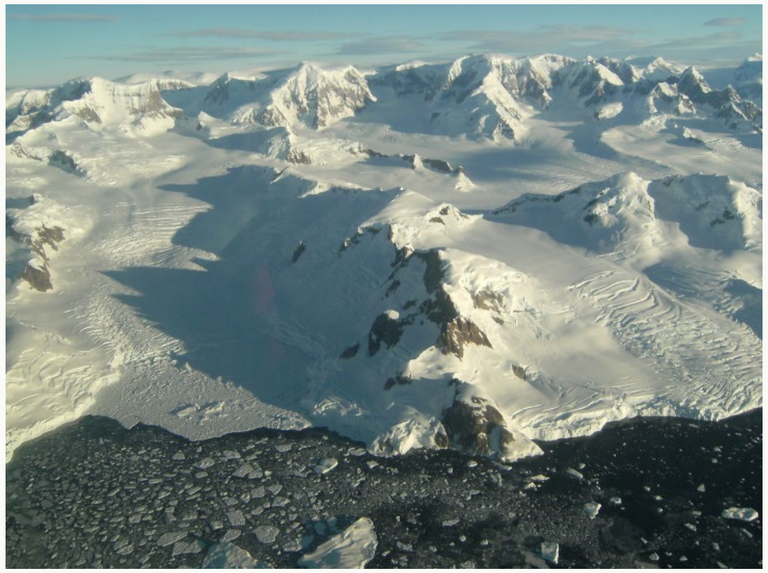
CLIMATE CHANGE

In 2016, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) reported that southern hemispheric carbon dioxide levels had, for the first time since monitoring began, exceeded 400 parts per million. Global annual temperature records have been broken for the past decade and a half.[14]

While long-term global warming is fact, not everywhere on the planet is warming at the same rate. Antarctica is warming. With a temperature increase of about 2.4°C from 1958 – 2010, Central West Antarctica is one of the fastest-warming regions on the planet.[15] In 2016, researchers reported that since the late 1990s, stronger summer winds have lowered temperatures on the Antarctic Peninsula by approximately 0.5°C per decade. These large natural variations can overwhelm the signals of human-induced global warming, so declines are likely to be short-lived, with the scientists projecting the warming to re-emerge later this century.[3] Furthermore, the oceans surrounding the Peninsula are warming. The temperature of the upper ocean west of the Antarctic Peninsula has risen by nearly 1.5°C since the 1950s.[4]

596 of the 674 glaciers along the west coast of the Antarctic Peninsula have retreated since records began in the 1940s. Ocean warming is the primary cause.[16]

Overall, Antarctica is losing ice.[17] Ice loss, caused by ice flowing more rapidly into the sea has been greatest along coastal sectors of the Antarctic Peninsula and West Antarctica. Ice thickening further inland and over much of East Antarctica from increased snowfall may have partially offset this loss.



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Coastal glaciers in Graham Land, western Antarctic Peninsula.

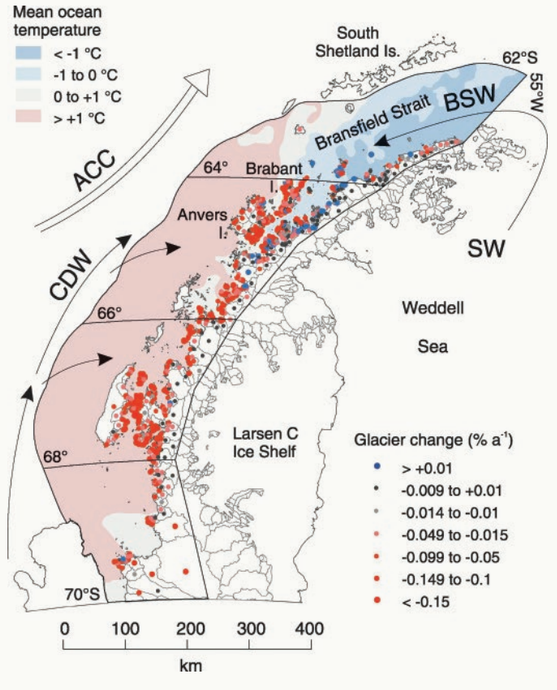

Figure 1: In recent decades, hundreds of glaciers draining the Antarctic Peninsula (63° to 70°S) have undergone systematic and progressive change. Ocean-induced melting are the primary cause of retreat for glaciers in this region 16. This figure shows the mean ocean temperatures and overall glacier area changes on the Antarctic Peninsula 1945-2009. Ocean circulation and water masses are shown systematically: Circumpolar Deep Water (CDW), Bransfield Strait Water (BSW), Antarctic Circumpolar Current (ACC) CDW, and Shelf Water (SW).[16]

The melting Antarctic ice sheet is likely to have increased its contribution to sea level rise over the past two decades. There has been an acceleration in ice outflow since the 1990s, especially in the Amundsen Sea sector of West Antarctica.

Climate change is likely to cause loss of biodiversity in Antarctica[18] and worsen the threat of invasion by non-native species and spread of native species to new areas. Two native flowering plants (*Deschampsia antarctica* and *Colobanthus quitensis*) in the maritime Antarctic have increased in abundance at some sites due to warming.[4]

Climate scientists project that warming of the Southern Ocean and Antarctica will accelerate through this century, with increased heating from the ocean and the atmosphere. This is likely to reduce the area of sea ice.[19]

Researchers expect thinning of the West Antarctic Ice Sheet to be dominated by ongoing melting ice in the Amundsen Sea sector until at least the 22nd century. However, other regions of West Antarctica could thin to a similar extent if the ocean warms sufficiently.[20] Research suggests a more rapid and larger contribution to global sea level rise from Antarctica.[21,22]

Ocean acidification, caused by absorption from the atmosphere of increasing carbon dioxide, is likely to affect the Southern Ocean this century. Corals, molluscs and other important marine organisms will be threatened as they cannot absorb the calcium carbonate they need to maintain their skeletons.[4] Acidification is dissolving the shells of free-swimming sea snails (pteropods) in Southern Ocean water.[23]

Researchers predict that the entire population of Southern Ocean krill could collapse by 2300, with catastrophic impacts on the entire ecosystem, unless carbon dioxide emissions are significantly reduced.[24]

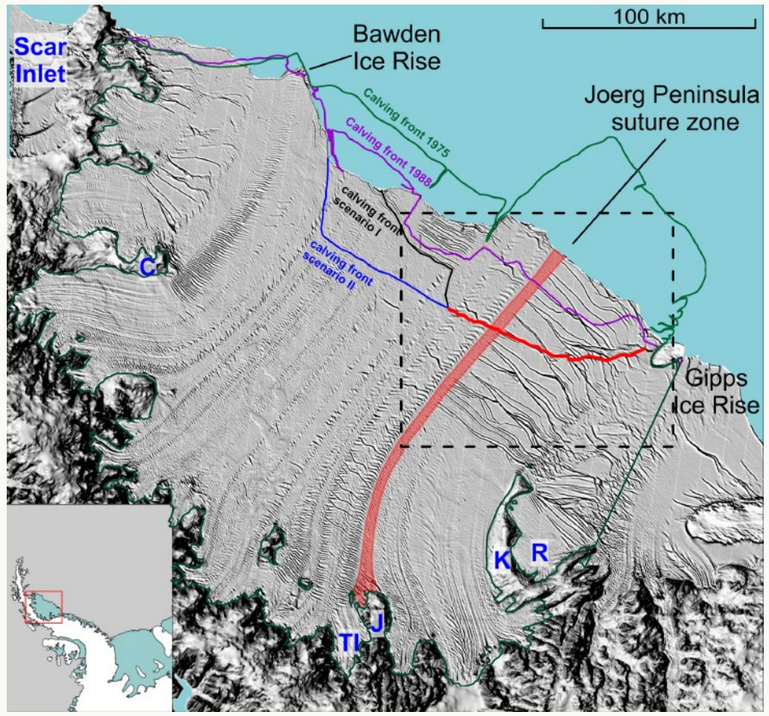

Figure 2: The Larsen C Ice Shelf is approximately 50,000 km². The red line shows the location of the developing rift (as of January 2015) and a selection of previous and predicted future calving fronts.[25] As of August 2016, the full length of the rift is now 130 km. Computer modelling suggests that the remaining ice could become unstable and lose 9-12% of the ice shelf area.[26] Geographic features of interest are marked (TI – Trail Inlet, K – Kenyon Peninsula, R – Revelle Inlet, J – Joerg Peninsula, C – Churchill Peninsula). The highlighted flow line indicates the location of the Joerg Peninsula suture zone.

TOURISM AND RESEARCH

Tourist numbers steadily increased until the global financial crisis of 2007-08. Tourist numbers are again rising, with 38,000 people travelling to Antarctica during 2015-2016 season as reported by the International Association of Antarctic Tour Operators (IAATO).

There are more than 100 Antarctic research stations including around 70 permanent research stations on the continent, run by countries from every continent on Earth. The stations can accommodate more than 4,000 staff. Station numbers – and scientists' visits – have increased significantly since 1902 when Scottish naturalist William Bruce and a crew of researchers, explorers, and sailors established the continent's first staffed station.

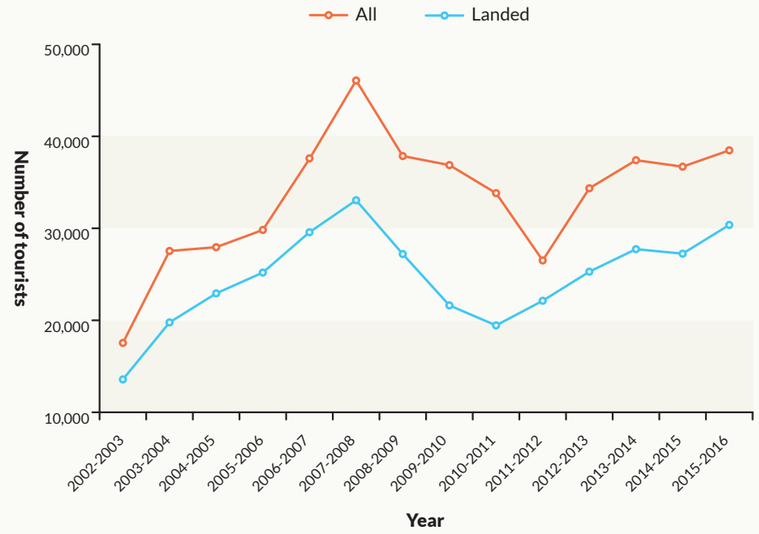

Figure 3: Antarctic tourist numbers 2002-2003 to 2015-2016. "Landed" means those who set foot on the continent or an island in Antarctica whether they arrived by ship or air, such tourists typically spend 6-30 days in Antarctica. "All" is all tourists who went to Antarctica whether or not they set foot ashore. This group typically cruise for just 3-4 days in Antarctic waters as part of a longer cruise trip and also includes those who fly over in a sight-seeing flight that takes a matter of hours.

ILLEGAL, UNREGULATED AND UNREPORTED FISHING

Although less than 0.1% of the world's finfish catch comes from oceans around Antarctica,[27] illegal, unregulated and unreported (IUU) fishing has been reported in the Atlantic, Indian and Pacific sectors of the Southern Ocean. Estimates of how much fish are caught by IUU vessels can be uncertain. For example, CCAMLR estimated (based on information provided through active surveillance of IUU vessels) that 3,615 tonnes of Patagonian and Antarctic Toothfish were taken by IUU fishing in 2006-2007, but the figure is likely to have been 5,671 tonnes based on comparisons between reported catch landed in ports with the total estimated trade.[28]

As well as the threat to fish stocks, IUU fishing uses destructive methods that affect other species and the ecosystem. From 1996 to 2006, researchers estimate that IUU fishing killed between 151,000 and 543,000 seabirds.[29] Vessels engaged in IUU fishing use gillnets, prohibited in the Convention Area, which are likely to have a considerable impact, particularly in relation to bycatch and the physical marine environment.

INVASIVE PLANT AND ANIMAL SPECIES

Antarctica's ice-free area makes up just 0.34% of the continent, providing little land where sparsely distributed plants can grow.[30] Increasing temperatures, and human visitors accidentally carrying plant seeds, are increasing the risk of invasive species.

Pigs, sheep, reindeer and rabbits were introduced to sub-Antarctic islands in the past by sealers and whalers for food, and attempts have been made to eradicate them.[31] Rats and mice accidentally introduced still threaten seabird colonies.[32]

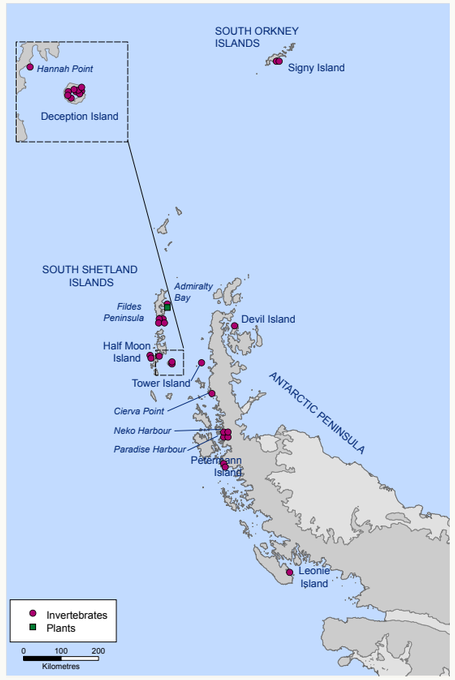

Figure 4: The known distribution of non-native terrestrial species within Antarctica.[38]

People have introduced more than 200 plant species to sub-Antarctic islands and parts of the Antarctic continent, adding to the two Antarctic native flowering plants and about 110 native moss species.[33] Roughly 7,000 scientists and 33,000 tourists visiting Antarctica each year accidentally carry seeds and spores – on average about 10 seeds per person, with field scientists proportionally carrying more. More than 70,000 seeds enter the region annually.[34] Introduced seeds include species that may have come from climatically similar places, increasing the chances of them germinating.[35]

Ships rarely release ballast water in Antarctic waters, but marine invasive species could be introduced from the hulls of tourist and research ships. To date only one non-native marine species has been recorded in the Antarctic marine environment.[36]

It's not just people and ships that could be responsible for introducing species – the Southern Ocean transports aquatic vegetation carrying crustaceans, worms, snails and other seaweeds. Other natural colonisation routes include wind, birds and marine mammals. Introduced species can't currently survive in the frigid Antarctic conditions but with climate change and warming oceans, some of these invaders could eventually colonise the region.[37]

While many land-based species have been introduced and caused substantial impacts on sub-Antarctic islands, so far none have been confirmed as invasive in Antarctica.[38] While sub-Antarctic islands have been infested with rats, cats, mice and even domesticated animals, Antarctica is too extreme for larger animals to survive. Some plants and animals have become established on the northern Antarctic Peninsula and off-shore islands (Figure 4). Policy development to protect Antarctic ecosystems from invasive species is slow, and there is little monitoring of impacts, so non-native species eradication, and preventing their introduction in the first place, are vital.[38]

POLLUTION AND OTHER THREATS

Strict regulations require scientists and tourists to take waste home and fishing vessels not to dump waste in CCAMLR waters.[39] The exception is sewage.[40] Untreated sewage from research bases can introduce bacteria, such as E. coli, to the Antarctic ecosystem. Researchers have found bacterial strains similar to those found in humans in marine ecosystems, and have discovered antibiotic resistant genes in bacteria isolated from shellfish.[41]

Inadequate fuel storage at bases can leak hydrocarbons. Five to 50 times the average concentration of trace metal pollutants, such as lead, have been detected in soil and moss samples from the Fildes Peninsula, one of the most visited sites in Antarctica, and other areas of high human use.[42]

Persistent organic pollutants (POPs), toxic compounds resulting from human activities, have been measured around Antarctica. Although they can come from research stations and shipping, POPs come predominantly from outside Antarctica, with the Southern Ocean a sink rather than a source of some POPs.[43] POPs have been detected in Antarctic wildlife since the 1960s, for example accumulating in the blubber tissue of whales.[44]

Increasing quantities of plastic are washing up on the Antarctic coastline and sub-Antarctic islands. While the relatively common 1980s, occurrences of penguins entangled in plastic six-pack drink fasteners has stopped, debris from ships and fishing vessels can entangle, or be swallowed by, penguins.[45] The effects of microplastics on the Southern Ocean food web are being investigated and are still unknown.[45] However, exposure of microplastics to some fish species can inhibit larvae hatching, decreased growth rates, altered feeding preferences, and lowered responses to predators.[46]

FISHERIES

There are two species of toothfish: Patagonian and Antarctic. Fisheries for toothfish are very valuable and occur in parts of the Southern Ocean, especially in the continental shelf slope. With Antarctic toothfish a top predator, and there being few large fish species in the Ross Sea, any population reduction may increase their prey (including bottom dwelling fish) and affect numbers of toothfish predators (especially Weddell seals, type-C killer whales and sperm whales). The long-line approach to catching toothfish may also affect Antarctic skates and other bycatch species.

Antarctic krill are used for aquaculture and poultry feed, as omega-3 health supplements for humans, in pet food, and in medicine.[47] The current annual catch of krill represents less than 0.5% of the estimate of the standing biomass of krill, which is small compared to other fisheries, and fishing has remained below this catch limit.[32] However, while the overall fishery catch is low relative to the total biomass, fishing is on the increase. Furthermore, fishing takes place in areas that overlap with areas where breeding penguins and seals feed near their colonies, as well as where many other krill predators feed, such as whales, fish and squid.[48,49]

STATE OF ANTARCTIC BIODIVERSITY

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WHALES

In 1904, a Norwegian whaler arrived at the South Atlantic island of South Georgia and reported that he could see the whales in their hundreds and thousands. There were huge populations of blue whales, fin whales and humpbacks, southern right whales and other species.[50]

Within just 50 years, intensive whaling had driven whale species living in the Southern Ocean, such as blue, humpback and sei whales, close to extinction.[51] Two million whales were killed in the southern hemisphere alone, most of those in the Antarctic.[52] Despite commercial whaling bans and declaration of the Southern Ocean as an international whale sanctuary, recovery rates are variable. Some populations still show no sign of recovery.[53] Although non-lethal research has demonstrated that whales do not need to be killed for scientific research, Japan continues its controversial whaling program. In fact, Japan proposes killing up to 333 minke whales each year until 2027.

The International Union for Conservation of Nature (IUCN) lists blue, fin and sei whales as endangered species, and sperm whales are classified as vulnerable to extinction. Antarctic minke whales are listed as 'data deficient'. Antarctic blue whales have not been hunted for many decades and are the largest animals on the planet. Their vocalisations are the most powerful underwater biological sound and can travel thousands of kilometres. However, their numbers are just in the low thousands. Humpback whales are showing strong recovery, as are some, but not all, populations of southern right whales.[54]

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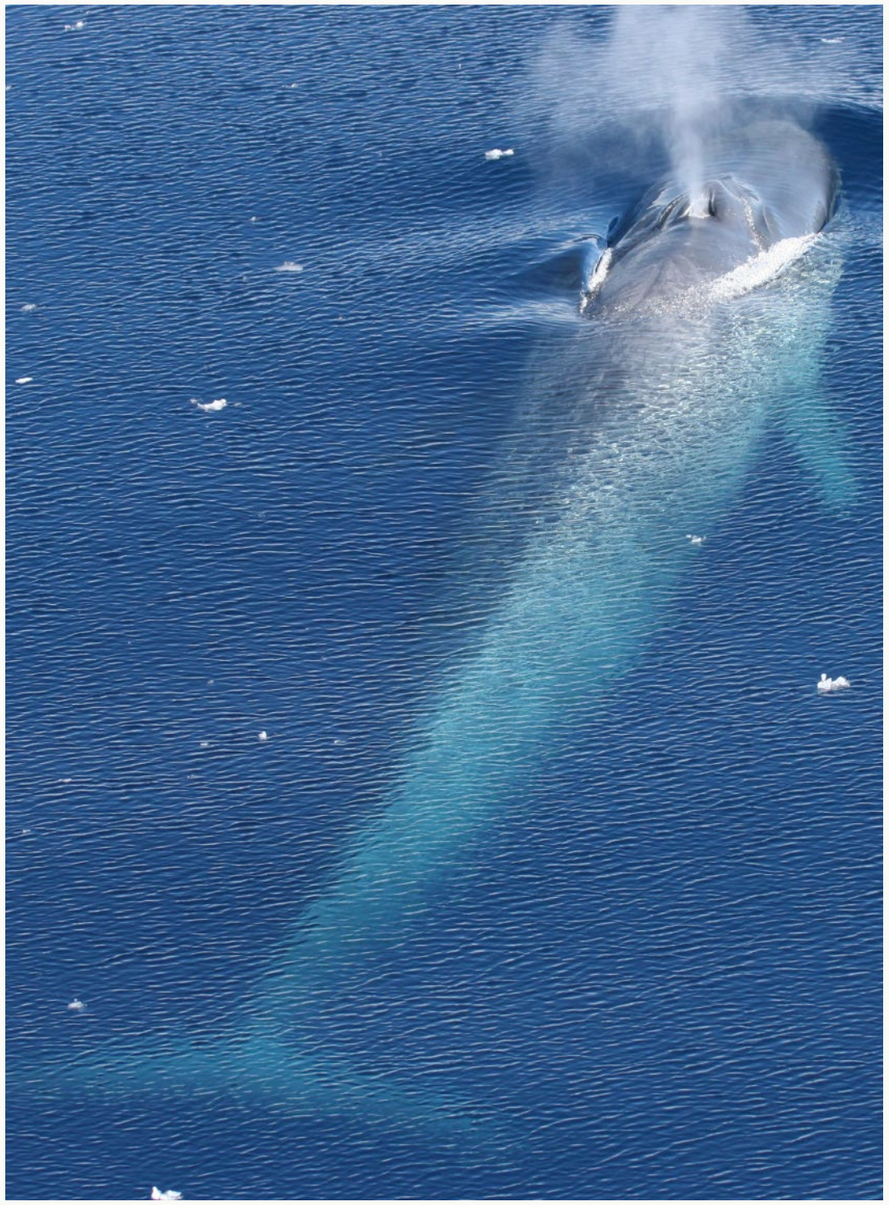
Killer whales (*Orcinus orca*) hunting a leopard seal (*Hydrurga leptonyx*) in pack ice, Neumayer Channel, Antarctica. Research has revealed there are at least five distinct forms of killer whales in the Antarctic – Types A, B1, B2, C and D.[55] Each have a distinct prey specialization on minke whales, seals, penguins and fish.



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An Antarctic blue whale (*Balaenoptera musculus*) estimated to be almost 30 metres in length off of Queen Maud Land.

PENGUINS

There are 18 species of penguins. Emperor and Adélie live on the Antarctic continent while chinstrap and gentoo nest predominantly on islands. King, macaroni, rockhopper and royal penguins live on sub-Antarctic islands. Emperors mostly breed on sea ice along the coast, although small numbers breed on land or ice shelves.[56] In the western Antarctic Peninsula most Adélie and chinstrap populations have declined, whereas gentoo populations have mostly increased.[57]

The greatest immediate threat to Antarctic penguins is changes to sea-ice. Climate change is likely to cause changes to sea-ice, leading to a continent-wide decline and regional near extinction of emperor penguins by the end of this century.[58] Paradoxically, increases in sea-ice cover in the East Antarctic region are forcing penguins to walk longer distances to reach the open sea to obtain food. In 2013-14, all chicks from the 25,000 breeding pairs of Adélie penguins in one colony of East Antarctic died, many starving while waiting for their parents to return with food.[57]

Gentoo penguin *(Pygoscelis papua)* and chicks.

© MICHAEL HARTE

About a third of Adélie penguin colonies in Antarctica could disappear by 2060 due to the impacts of climate change on food supply of krill and fish.[59]

Scientists are calling for more population monitoring, more information on habitats that need to be protected, and data on interactions with fisheries and on possible feeding shifts.

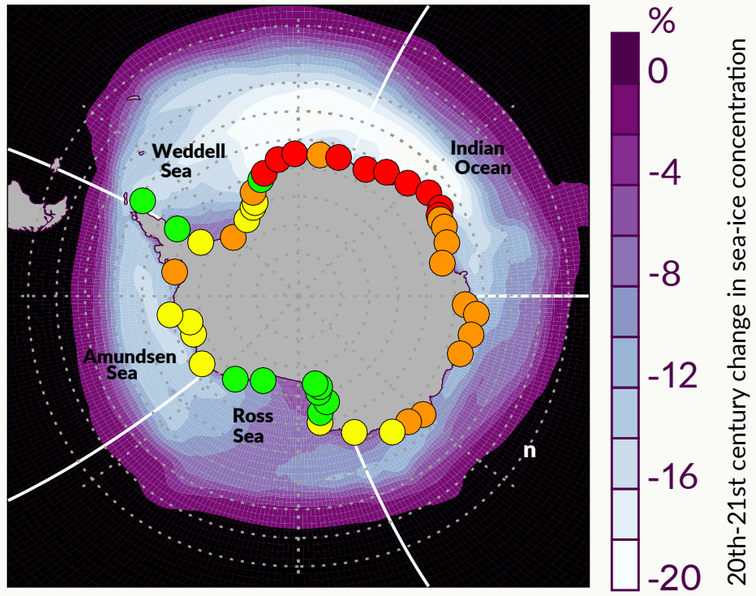
Adélie penguins *(Pygoscelis adelia)* diving off an iceberg.

© NATUREPL.COM / TIM LAMAN / WWF

Figure 5: Locations of emperor penguin (*Aptenodytes forsteri*) colonies (dots) with conservations status predicted for the end of the 21st century:

- red: 'quasi extinct'
- orange: 'endangered'
- yellow: 'vulnerable'
- green: 'not threatened'

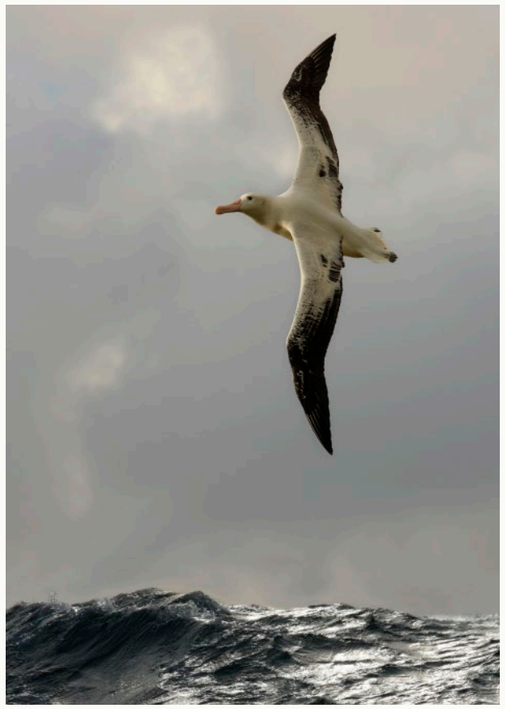
Also shown are the annual mean changes of sea ice.[58]



FLYING SEABIRDS

More than 130 species of flying seabirds – albatrosses, petrels, skuas, gulls, terns and other species – are present in the Southern Ocean south of 40°S, and more than 100 million breed around the Antarctic coastline and islands.[60]

Many seabirds have long lives, and their late maturity, low number of eggs and infrequent breeding mean even small increases in their natural mortality threaten their numbers.[32] For example, a 50-year study of the southern giant petrel on the island of Signy shows its population halved in the past two decades, although it is unclear if the cause of the decline is reduction in food availability due to decreasing sea ice or other factors.[61]



Wandering albatross *(Diomedea exulans)* flying over open ocean.

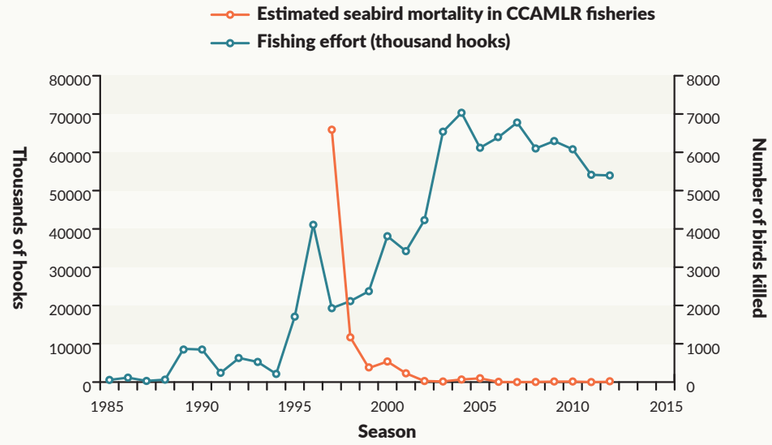
Of the 346 seabird species globally, 97 are threatened, 17 are critically endangered, and a further 35 are near threatened, according to the Red List classification of the IUCN.[62] Furthermore, a review of the 29 species covered by the Agreement on the Conservation of Albatrosses and Petrels (ACAP) showed that global populations of 38% of these species declined, 28% increased and 28% remained stable between 1993 and 2013.[63] However, seabird bycatch by legal fisheries managed by CCAMLR has been reduced thanks to the collaboration between scientists, policy-makers and industry, which led to the introduction of a seasonal closure (when most birds were breeding), and requirements to set long-lines at night and to sink them more rapidly, making the baited hooks inaccessible to scavenging birds.[32]

Consequently, seabird bycatch mortality in CCAMLR managed fisheries dropped from almost 7,000 a year in 1997 to close to zero in 2012, despite an increase in fishing (Figure 6).[64]

Furthermore, governments, the fishing industry, and non-government organisations (NGOs) have worked together to minimise IUU fishing in the Southern Ocean, and reduce its negative impact on seabirds due to bycatch.

It is estimated that IUU fishing has decreased by more than 90% since the peak levels in the 1990s.[67] Populations of albatrosses and other large seabirds have likely benefited from this large reduction in IUU fishing pressure.[68]

Figure 6: From 1985-2012, seabird bycatch has been reduced due to effective regulation and mitigation measures by legal fisheries in CAMLR convention area.[65, 66]



SEALS

Antarctica is home to six seal species – Ross, Weddell, crabeater, leopard, fur and elephant seals. Fur seals are the smallest: an adult female typically weighs 150 kg, while male elephant seals (bulls) can weigh up to 4,000 kg. Antarctic fur seals and elephant seals live north of the pack ice zone and breed in dense colonies on beaches;[60] neither species is considered endangered. However, the rapidly changing climate in the Southern Ocean represents a threat to fur seals, with its major food supply, krill, varying widely.[69] The frequency and intensity of 'good' krill years is declining.[70] Sea ice reduction would affect crabeater, leopard, and Ross seals,[4] which inhabit pack ice surrounding the Antarctic continent.

The Convention for the Conservation of Antarctic Seals (CCAS) was established in 1972 in response to concern that there may be a resumption of sealing. CCAS bans the commercial take of seals within the Antarctic Treaty area.[71]

Two crabeater seals *(Lobodon carcinophagus)* lying on an ice floe in Grandidier Channel, Antarctica.

ANTARCTIC KRILL

Krill are small, semi-transparent crustaceans and a vital component of the Antarctic ecosystem. They are a main source of food for many mammals such as seals and whales, as well as birds and fish.[72] There are around 380 million tonnes of these shrimp-like crustaceans in the ocean,[73] similar to the total weight of human life on the planet.[74] They live for about seven years and are no larger than a little finger.

Antarctic krill (*Euphausia superba*) are shrimp-like crustaceans no larger than a little finger.

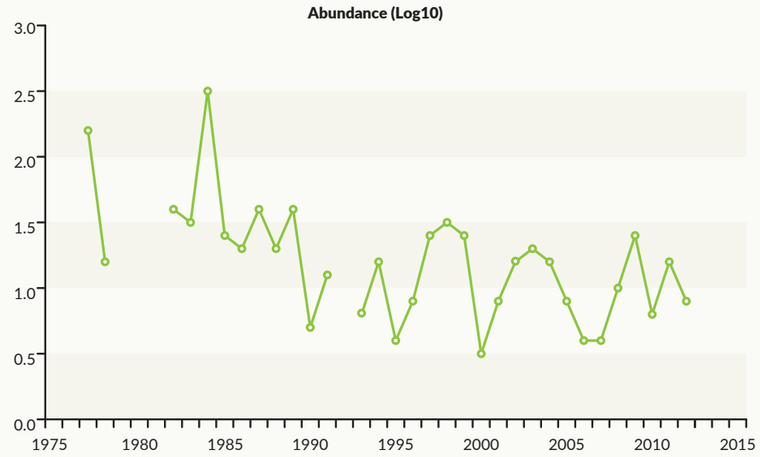
Antarctic krill occupy many different habitats: under sea ice, the surface water layer (0-10 m) of the open ocean/sea-ice, the seafloor and the vertical water column between 200 m and the seabed.[75]

Although krill densities vary significantly from year to year,[49] sparse data from research and fishing expeditions suggest the decline identified in the early 1980s has not continued (Figure 7), while there are no data on trends in other parts of the Southern Ocean.[76]

A decrease in krill since the mid-1970s is plausibly associated with reductions in winter sea-ice coverage in the Antarctic Peninsula and Scotia Sea.[48] As krill larvae feed on microorganisms under the ice, sea-ice reductions affect their survival.[77] Future ocean warming may cause a shift in krill habitat,[78] and ocean acidification may further threaten krill as increased carbon dioxide levels interferes with hatching of and development krill larvae.[24]

The role of Antarctic krill in supporting predators might be more significant than that of any comparable species elsewhere in the world's oceans.[79] Abundance may also be affected by the recovery of finfish, whales and seals that prey on krill, but it is unclear if the food web feedbacks will result in krill increasing or decreasing.

Figure 7: Density of Antarctic krill in the southwest Atlantic (10°E to 90°W).[76]



Krill plays a key role in the Antarctic ecosystem and are a critical food source for many Southern Ocean species such as whales, seals, fish, penguins and other seabirds.

FLORA

There are no trees or shrubs in Antarctica, and just two native species of flowering plants: Antarctic hair grass (*Deschampsia antarctica*) and Antarctic pearlwort (*Colobanthus quitensis*). These occur along the western Antarctic Peninsula and on the South Orkney Islands and the South Shetland Islands.

There are around 300 to 400 species of lichens, several hundred species of fungi,[80] 100 species of mosses, and 25 species of liverworts. These are able to survive in low temperatures. The greatest diversity of species is found along the western Antarctic Peninsula where the climate is generally warmer and wetter than elsewhere on the Antarctic continent.

THE ANTARCTIC PENINSULA

TOURISM

2015-16
38,000

2016-17
43,000+

POLLUTION

5-50 times the average

Concentrations of trace metal pollutants such as lead detected in soil and moss samples

KRILL FISHING

245,000 tonnes

Average annual catches of Antarctic krill, increasingly focused aroundthe Antarctic Peninsula

WHALES

Central America

8,300km

Antarctica

The longest migration of humpback whales recorded between the Antarctic Peninsula and Central America

SEABIRDS

Greenland

Antarctica

80,000 km

Distance traveled by Arctic terns every year - the longest known animal migration

8.5 million km

Distance covered by a wandering albatross over a 50 year lifespan

CLIMATE

596 OF 674

West coast glaciers have retreated since records began

130 km

The Larsen C ice shelf - the fourth largest in Antarctica - is developing a rift now 130 km long

PENGUIN POPULATIONS

ADÉLIE

GENTOO

SOUTHERN OCEAN

SOUTH AMERICA

DRAKE PASSAGE

WEDDELL SEA

KRILL FISHING

Antarctic krill is commercially fished and is the largest fishery in the Southern Ocean, involving vessels from Norway, Korea, Japan, China, Russia, Chile, the Ukraine and Poland. The peak in commercial krill fishing was in the early 1980s, with annual catches of about 500,000 tonnes; this led to the formation of CCAMLR.[81]

Krill fishing occurs in the southwest Atlantic, including at South Georgia, the South Orkney Islands, and the Antarctic Peninsula – CCAMLR Area 48.[82] Catches have increased over the past 20 years (Figure 8) and, although still significantly lower than they were in the 1980s, are increasingly focussed on this area (Figure 9).

Scientists use computer models to simulate the krill population – number of births, the rate of growth and the rate of death – to predict what might happen with different levels of fishing. There is an estimated biomass of 60 million tonnes of Antarctic krill in Area 48 derived from dedicated research surveys.[8]

For Area 48, CCAMLR sets a precautionary catch limit of 5.61 million tonnes – approximately 10% of the estimated biomass in the region. To avoid krill fishing effort from concentrating in small areas, an overall 'trigger level' of 620,000 tonnes is set via Conservation Measure 51-01 (CM 51-01).[85] Catches are allocated to subareas by Conservation Measure 51-07 (CM 51-07) to allow for inter-annual variation in the distribution of krill aggregations, and alleviate the potential for adverse impacts of the fishery in coastal areas on land-based predators (Figure 10).[11]

Figure 8: Tonnage of Antarctic krill (*Euphausia superba*) caught in areas of the Southern Ocean[83]

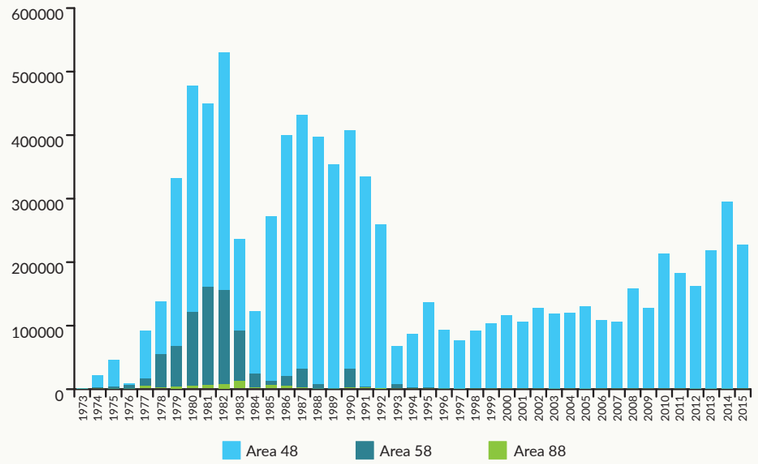
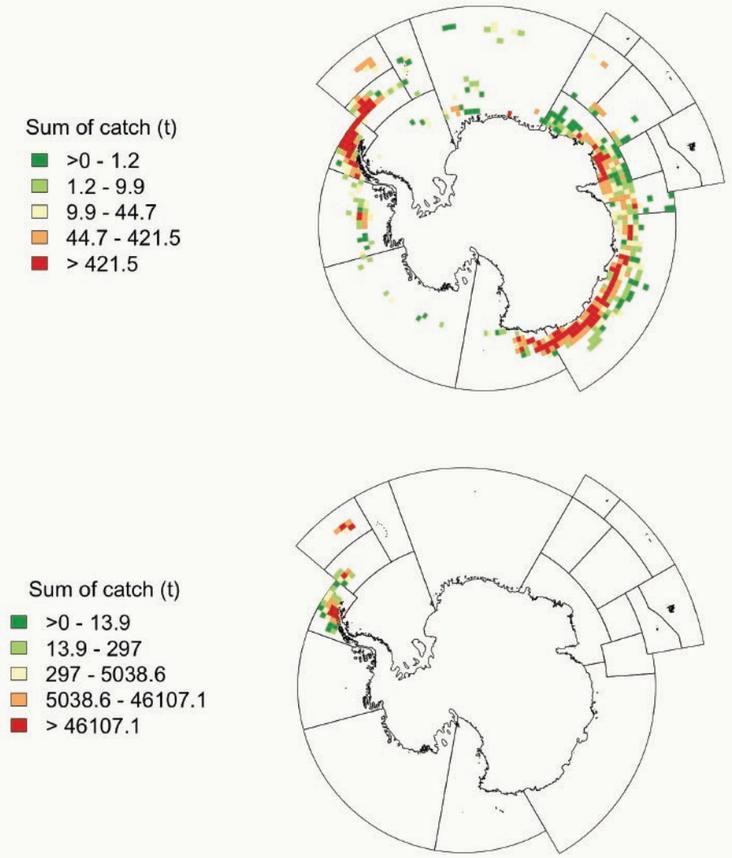


Figure 9: Krill fishing has focussed on the Antarctic Peninsula and Scotia Arc in recent years, as shown by the spatial distribution of krill catch in the 1980s (above) and 2010 to 2015 (below).[84]



CCAMLR has agreed that any expansion in the krill fishery should not happen unless the scientific data indicates that it will continue to be sustainable. CCAMLR's approach to managing the krill fishery is to minimise the impact on the ecosystem rather than trying to maximise the size of the fishery.[86]

In 2015, average annual catches of Antarctic krill have increased to about 54,000 tonnes at South Georgia, 40,000 tonnes in the South Orkneys, and 151,000 tonnes around the Antarctic Peninsula (compared with the eight million tonnes consumed by penguins and seals).[84] This catch is less the 0.5% of the estimated biomass in the entire area.

Critical feeding habitat for whales, seals and penguins where krill catches occur need to be carefully managed and must take into account climate change impacts.[78]

In 2003, CCAMLR agreed to define a suite of small-scale management units (SSMUs) for Area 48 that are based on the distribution of krill, krill predator foraging range and the fishery. However, there has been no agreement on the allocation of catch limits at this scale.[84] This is critical next step in the developing feedback management of the krill fishery and ensures species that rely on krill remain safe.

The Association of Responsible Krill harvesting companies (ARK) facilitates an industry contribution to an ecologically sustainable krill harvest through activities such as sharing information, promoting research, and holding regular meetings. Aker BioMarine and Olympic Seafood are the only two krill fishery companies certified sustainable by the Marine Stewardship Council (MSC).[87]

Antarctic krill is potentially the largest crustacean fishery in the world in terms of tonnes caught. The economic value of the krill fisheries in the Southern Ocean is US$241 million per year. Unlike most of the world's large fisheries it has scope to expand[76] and could become the largest fishery of any type.[82]

© AKERBIOMARINE

The Aker BioMarine vessel Antarctic Sea fishes for Antarctic krill. It is certified as sustainable by the Marine Stewardship Council (MSC).

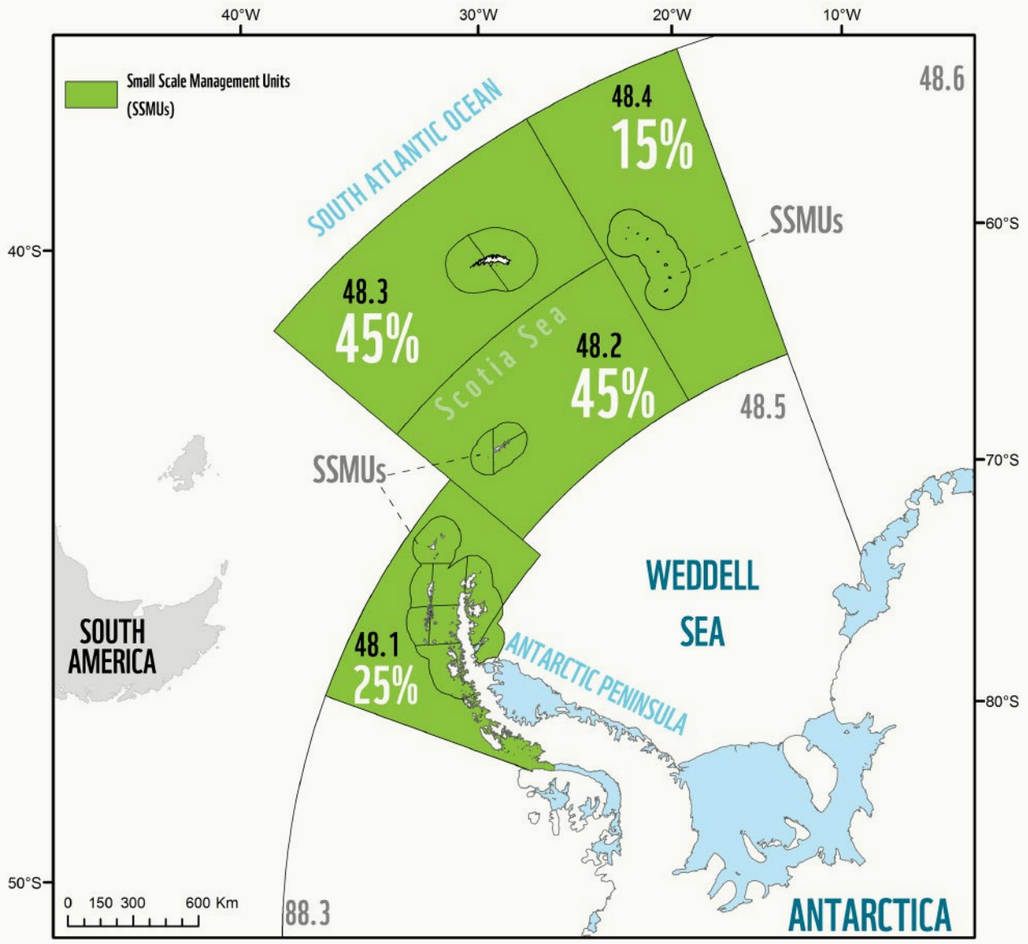


Figure 10: Distribution of allowable krill fishing in areas 48 subareas (CM 51-07): Area 48.1: 25%, 48.2: 45%, 48.3: 45%, 48.4: 15%. The fishery will close in a subarea if the 'trigger level' is reached in a season. Conservation Measure 51-07 is set to expire at the end of the 2015/16 fishing season.

INVASIVE SPECIES

Antarctica's biota has evolved and diversified in relative isolation.[88] Thus, isolation is threatened by impacts associated with climate change and rapidly increasing human movement both into the region and between its distinct ecoregions.

For example, many introduced plant species are from regions such as the Arctic and sub-Antarctic, where conditions are similar to those in the Peninsula, making establishment more likely. Some of these species have already established at several locations; for example an annual bluegrass, *Poa annua*, can out-compete the only two indigenous vascular plant species found along the Antarctic Peninsula, is found on the shores of Admiralty Bay, King George Island, having recently been removed from other areas.[89] Terrestrial species continue to arrive, and climate change is expected to increase the likelihood of establishment and further impact by such non-indigenous species.

TOURISM

The majority of tourist ships visit the Antarctic Peninsula, which is up to two days' sailing across the Drake Passage from South America. Most visits are from November to March. Summer means milder temperatures, less ice and more visible wildlife.

Although visits are usually short, they are concentrated into a small number of landing sites, creating potential for cumulative, long-term impacts if not well-managed.

The total numbers of visitors travelling to Antarctica during 2015-16, with the International Association of Antarctic Tour Operators (IAATO) members, was over 38,000, an increase from the previous season.[90] More than 50 tourist vessels visited during that period.

Overall, levels of visitation have been increasing steadily since 2011-2012, with further growth expected.[91]

Most (99%) seaborne passengers travelled to the Antarctic Peninsula with 21% of these on 'cruise only' vessels that do not make landings. The remainder visited the Peninsula on vessels carrying fewer than 500 passengers, which make landings.

Activities such as tourism place pressure on the environment. For example, ships to the Antarctic may carry on their hulls a diverse range of non-indigenous species as fouling.[92] There are also risks of ships spilling oil and disturbing wildlife.

Hikers climb up a snow covered hill, Neko Harbor, Antarctica.

RESPONDING TO THE CHALLENGE

SCIENTISTS MEASURE THE SEA LEVEL OF THE ROSS SEA. © NATIONAL GEOGRAPHIC CREATIVE / PAUL NICKLEN / WWF

MONITORING ANTARCTIC MARINE LIFE

To establish a baseline of plant and animal life, in 2014, international researchers published the *Biogeographic Atlas of the Southern Ocean,*[56] a census of Antarctic marine life. The five-year project assessed the nature, distribution and abundance of all the living organisms of the Southern Ocean.

The findings will help monitor biodiversity, discover biodiversity hotspots, detect and understand the impacts of environmental changes, and predict future distributions of species. Importantly, the atlas will support conservation and sustainable management strategies.

PROGRESS MADE COMBATTING IUU FISHING

Illegal, unreported, and unregulated (IUU) fishing occurs in the high seas regulated by CCAMLR, but at lower levels than in the 1980s and '90s[32] due to CCAMLR member nations regularly patrolling many of the legal fishing grounds, maintaining IUU vessel lists, a catch documentation scheme, and other measures. There is likely to have been a significant reduction in IUU fishing due to international cooperation, information sharing, inspection and investigation regimes.

The world's first binding international accord specifically targeting IUU fishing, the UN FAO Port State Measures Agreement, became international law in June 2016. Signed by 29 countries and the European Union, it aims to detect IUU fishing when ships come to port, making it much harder for illegal catches to enter national and international markets.

Seabird bycatch mortality in CCAMLR managed fisheries has dropped from almost 7,000 a year in 1997 to close to zero in 2012, despite an increase in fishing[64] thanks to the collaboration between scientists, policy-makers, industry and NGOs.

FISHERIES MANAGEMENT

Fishing for Patagonian toothfish began in the late 1970s around the Scotia Sea[93] while Antarctic toothfish fishing began in the late 1990s. As the Patagonian toothfish's range is largely outside waters managed by CCAMLR, its management is split between different countries' exclusive economic zones (and some high-seas regions), making data on catch size and stock structure problematic. Although IUU fishing for Patagonia toothfish remains problematic in some areas, a number of Patagonian toothfish fisheries are now MSC certified.[94] At higher latitudes the Ross Sea Antarctic toothfish fishery, managed by CCAMLR, is considered sustainable with a relatively small annual catch of 3,000 tonnes.

CCAMLR takes an ecosystem-level, precautionary approach to fisheries management.[82] Measures include regular monitoring of stocks through mark-release programs, setting catch and bycatch limits, analysing impacts on predators and prey, and adjusting management decisions in light of new information.[95]

The Coalition of Legal Toothfish Operators (COLTO) was founded in 2003 by legal industry members to eliminate IUU fishing for toothfish. It now focuses on promoting legal and sustainable toothfish fisheries. While five fisheries are certified sustainable by the Marine Stewardship Council (MSC) for Patagonian toothfish, the Ross Sea toothfish longline fishery is the only one certified sustainable for Antarctic toothfish.[96]

CCAMLR was established in 1982 to sustainably manage fisheries, especially krill, in the Southern Ocean. It has banned gillnets and bottom trawling, required mitigation methods to avoid seabird bycatch (such as weighting fishing lines) and implemented spatial management as part of a suite of measures to minimise bycatch, reduce the risk of ecosystem effects, and lessen threats to seabirds.[95] However, some previously overexploited fish stocks show little sign of recovery.[82]

CCAMLR intends to develop a feedback approach to aid ecosystem-based management (EBM) of Antarctic krill fisheries in the complex and uncertain conditions typical of Antarctic marine ecosystems.[9]

To progress sound feedback management, CCAMLR needs to ensure; krill catches are not too localized; krill catches do not adversely affect breeding land-based predators; there is some indication of the health of krill stocks; there is some indication of the health of the entire ecosystem; there is good information on the state of the fishery and the management system is simple, understandable and effective.[98]

CCAMLR Scientific Committee recommends four stages of development for krill feedback management (FBM). The current stage one is limiting spatial distribution of catch limits among subareas in Area 48 via Conservation Measure 51-07 (CM 51-07). Stages two and three include developing ecosystem based models and sourcing additional data to monitor predator species in areas of critical feeding habitats and conducting additional surveys to estimate krill biomass using research and fishing vessels at SSMU scales. Stage four involves implementing a final feedback strategy.[99]

CCAMLR has stated the next stage of FBM development involves increasing catches from the trigger level (CM 51-01) to a higher interim catch limit and/or changes in the spatial distribution of catches that are adjusted based on results from the existing CCAMLR Ecosystem Monitoring Program (CEMP) and other data.[12]

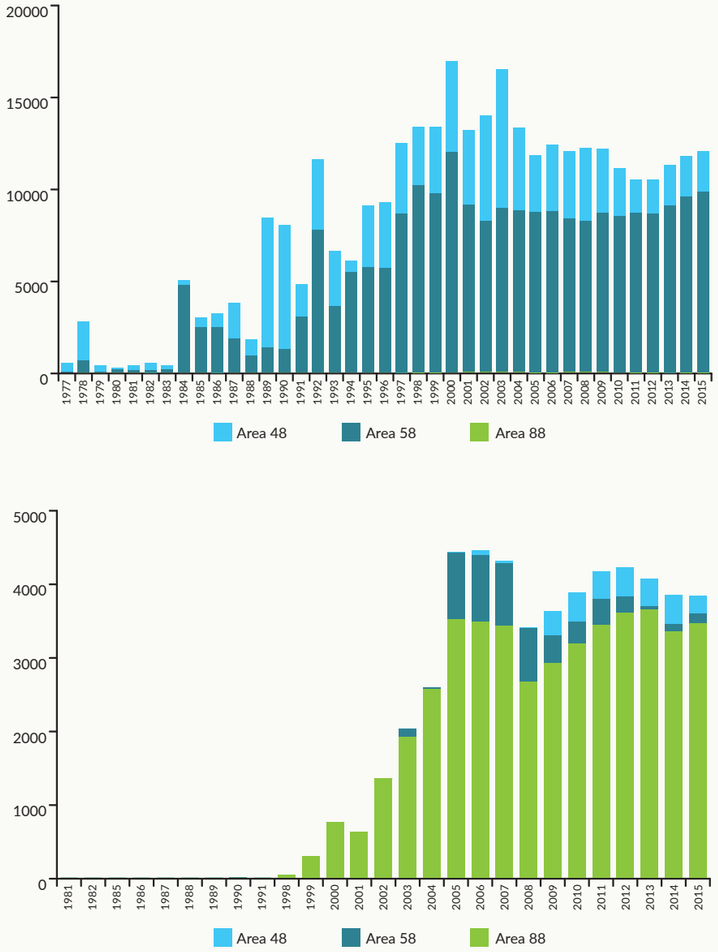


Figure 11: Amount of Patagonian toothfish (*Dissostichus eleginoides*, top) and Antarctic toothfish (*Dissostichus mawsoni*, bottom) caught in areas of the Southern Ocean.[97]

"WWF recommends CCAMLR extend CM 51-07 and progress next stages of developing krill feedback management (FBM) with improved real-time monitoring and status reporting of krill stocks, their predators, the fishery and incorporating impacts of climate change."

PROTECTING THE ANTARCTIC ENVIRONMENT

The Protocol on Environmental Protection to the Antarctic Treaty (known as the Madrid Protocol) entered into force in 1998. It designated Antarctica as a 'natural reserve, devoted to peace and science' and established environmental principles for all activities conducted there. The Protocol covers scientific research, tourism, environmental management and prohibits mining.

© SYLVIA RUBLI / WWF

Iceberg, Pleneau Bay. Visitors from the Icebreaker Kapitan Dranitsyn, on a zodiac. Antarctic Peninsula. Antarctica

MARINE PROTECTED AREAS

The Southern Ocean covers 10% of the world's oceans and includes some of the most productive marine areas in the world. There are almost 9,000 registered Antarctic marine species, with a great many species yet to be described.[1] Specialised benthic and pelagic habitats support a diverse range of species and foraging grounds for seabirds and mammals.[1] Many species are found only here, often limited to distinct areas, are slow growing, and have largely existed without impact from human activity until recently.[100] These species and habitats are particularly vulnerable to environmental changes.[101]

The circumpolar current has been an effective barrier to mixing, leading to Antarctica and the Southern Oceans having been isolated from other influences for millennia. This relative stability has led to strong niche differentiations and specialised adaptations, but also a likely high degree of vulnerability and low tolerance to relatively rapid changes in temperature, such as those we are currently witnessing.

An understanding of the spatial characteristics of large ecosystems such as the Southern Ocean is important for the achievement of a range of scientific, management and conservation objectives including ecological modelling, ecosystem-based management of living resources, and the establishment of a representative system of marine protected areas. Bioregionalisation is a process that aims to partition a broad spatial area into distinct spatial regions, within which representative networks of MPA can be identified and established, using best available scientific information.[102] Bioregionalisation workshops initiated by WWF and the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE-CRC) in 2006,[102] helped inform demarcation of nine MPA planning domains.

CCAMLR has committed to the creation of a representative system of marine protected areas (MPAs) in the Convention area (Figure 12). MPAs are designed to protect areas of ocean, coastal and seabed biodiversity. Specific activities are managed, limited or banned in these areas to protect habitat or to achieve conservation objectives. MPAs protect regions from damage and exploitation, allowing species to multiply, and they provide a resource that will allow scientists to assess the consequences of human-caused disturbances, such as climate change.

Marine protected areas will help conserve important Antarctic biodiversity and can be reference to help monitor and understand the effects of fishing outside these regions, as well as the impacts of climate change on Antarctic and Southern Ocean ecosystems.

There are two proposals with CCAMLR – one for a system of MPAs in the East Antarctic, and one for an MPA in the Ross Sea region. Two more MPA proposals are in development, for the Weddell Sea and for the Antarctic Peninsula.

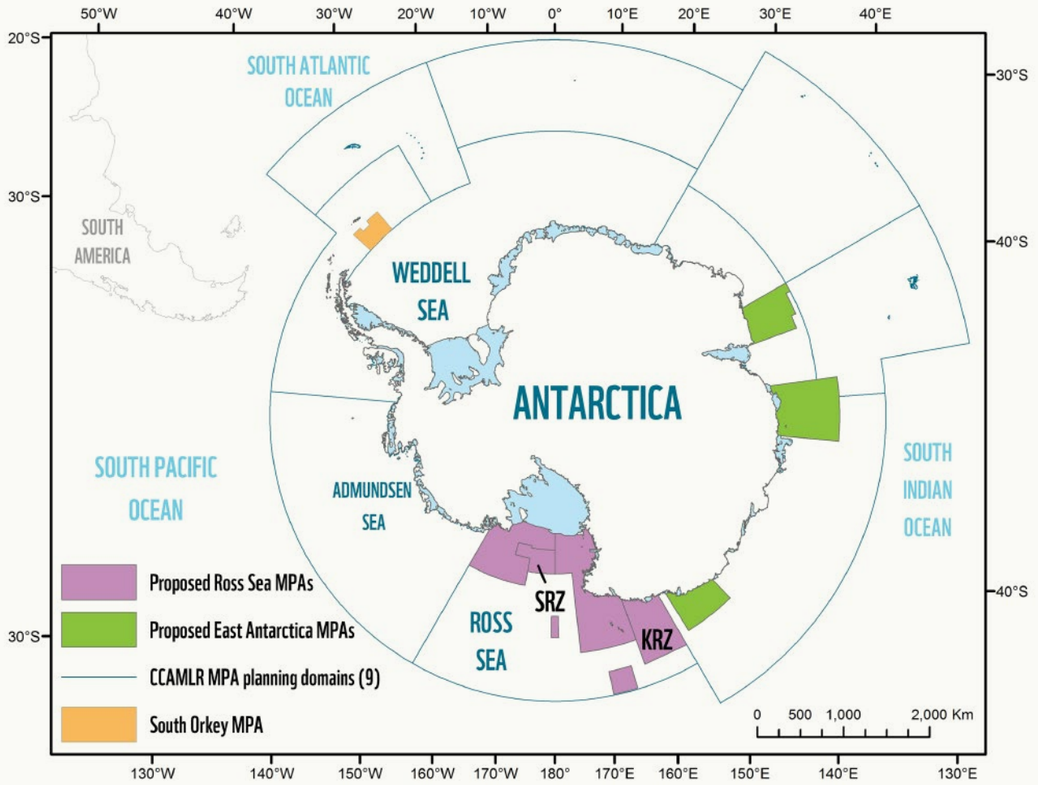


Figure 12: Map proposed MPAs, CCAMLR MPA planning domains and South Orkney MPA. The Ross Sea MPAs are 1,550,000 km2 in total area consisting of 1,117,000 km² no-take marine reserves, a 110,000 km2 special research zone (SRZ) allowing for limited research fishing for krill and toothfish and a 322,000 km² krill research zone (KRZ) allowing for controlled research fishing for krill. The East Antarctica MPAs are 946,998 km² and are multiple use MPAs.

By maintaining all trophic levels of the ecosystem and increasing species and genetic diversity, MPAs can enhance resilience to environmental change, including the impacts of climate change.[110]

Establishing marine protected areas – a key component of biodiversity conservation

A marine protected area (MPA) is an area where human activities are limited, managed or prohibited to conserve and protect the marine environment including biodiversity, ecosystem processes, species and habitats.

At the 2002 World Summit on Sustainable Development (WSSD) many states committed to establishing networks of representative marine protected areas based on science and international law by 2012. CCAMLR undertook to implement this commitment. In 2011, CCAMLR adopted Conservation Measure 91-04 (CM 91-04) to provide a framework for the establishment of MPAs. It requires that MPAs are based on best available science to achieve the following objectives:

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; and
6. Protection of areas to maintain resilience or the ability to adapt to the effects of climate change.

Full implementation by CCAMLR of CM 91-04 would create a system of MPAs, including no-take marine reserves in the oceans around Antarctica. Our vision is to implement a comprehensive system of MPAs, representing all major habitats and ecosystems, building a safety net for the Antarctic. Implementing CCAMLR conservation Measure 91-04 would go a long way towards achieving this vision.

IMPORTANCE OF TECHNOLOGY TO MONITOR AND EVALUATE ACTIVITIES

Antarctica and the Southern Ocean are remote and difficult and expensive to study. Technology enables remote monitoring of biodiversity and human activities. Small recorders attached to animals let researchers study their behaviour and activity with minimum disturbance. There is no need to harm animals, such as whales, to study them. Even the collection of genetic samples for determining population structure can be conducted using non-lethal biopsy techniques.[103]

Researchers have used acoustic recordings to track Antarctic blue whales, fin and humpback whales. By tagging a small number of blue whales, they have learnt that whales travel long distances (80-100 km per day), interspersed with time in feeding grounds, often close to the ice edge.[104] Scientists also use passive acoustic recorders[105] and other tags to study the underwater behaviour, feeding rates, and energetic demands of whales and other species that feed on krill.

Scientists use satellite images to track penguin colonies and numbers. Emperor penguin guano stains the ice, which allows estimates of the population size and density, even in isolated parts of the continent, although ground measurements remain necessary to confirm satellite estimates.

For years, satellites have tracked temperature and ice changes across Antarctica and ozone depletion in the atmosphere above. New tools being used include fibre-optic cables in boreholes that track ice temperature and movement. Sensor tags deployed on species such as elephant seals, help monitor hard to reach locations to study potential future changes in global ocean circulation patterns.[106]

RESPONSIBLE TOURISM

The growing number of tourists travelling to Antarctic regions, which are threatened by climate change, are exacerbating the problem. Cruise ships and aircraft release greenhouse gases at especially high levels for those visiting the Antarctic, up to approximately eight times higher per capita and per day than average international tourism trips.[109]

The International Association of Antarctic Tour Operators (IAATO) is a member organisation that promotes the practice of safe and environmentally responsible private-sector travel to the Antarctic. The Madrid Protocol requires that anyone planning activities in the Antarctic, including tour operators, must submit environmental impact assessments associated with their intended activities. For IAATO operators, this includes prevention of waste disposal and discharge, respecting scientific research and protected areas, and response plans for any environmental emergencies.

ADAPTATION TO CLIMATE CHANGE

Adaptation can be autonomous or direct (Figure 13).[107] Species can adapt autonomously without human intervention, such as by changing migration routes. Direct adaptation is where humans assist, for example through translocation of species, modifying habitats, or increasing the adaptive capacity by, for example, reducing fishing.

Options for Antarctica mostly involve decreasing a species' sensitivity to climate change by managing other stressors. These include preventing the introduction of invasive species by researchers and tourists, setting strict rules for tourist interactions to minimise stress, ensuring fishing pressure on krill does not compromise the performance of predator species, and identifying, protecting and managing marine and terrestrial protected areas that are predicted to confer resilience to the wider ecoregion in a climate-altered future.

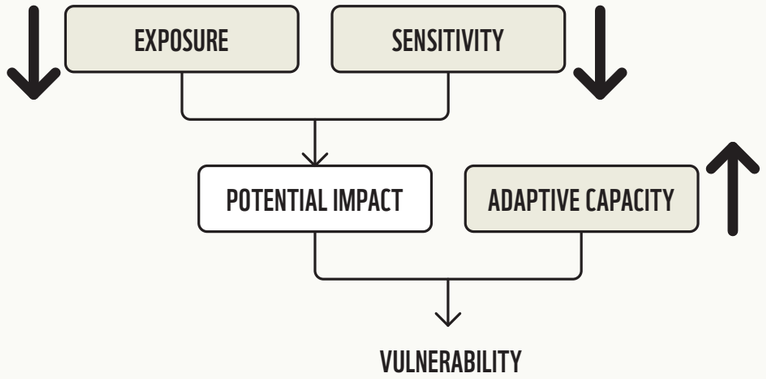


Figure 13: Reducing the exposure and sensitivity to climate change impacts, and increasing adaptive capacity by minimising impacts of other human activities, can reduce vulnerability to climate change impacts.[107]

Antarctic fish are vulnerable to changes in the ocean and their ability to adapt is mixed. Having evolved in isolation, many species in the Southern Ocean are found nowhere else, so any inability to adapt to climate change would reduce their numbers.[108]

Many options for adaptation in Antarctica are in their formative stages, and there is a need to gather information on species' sensitivity to climate change.

Emperor penguin (*Aptenodytes forsteri*) adults and chick, Dawson-Lambton Glacier, Antarctica.

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EMPEROR PENGUIN (*APTENODYTES FORSTERI*) PAIR, SNOW HILL ISLAND, ANTARCTICA. © NATIONAL GEOGRAPHIC CREATIVE / JAN VERMEER / WWF

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ILLEGAL FISHERIES

IUU fishing has decreased by more than 90% since the peak levels in the 1990s though international cooperation, but we remain vigilant.

CLIMATE

Parts of Antarctica are experiencing significant warming; climate change poses a major threat to species and the environment.

KRILL

WWF recommends increasing the frequency of krill surveys to better understand biomass with participation of the fishing industry to use vessels as platforms for science.

INVASIVE SPECIES

Non-native species eradication, and preventing their introduction in the first place, is vital.

100% RECYCLED

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WWF

Why we are here

To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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