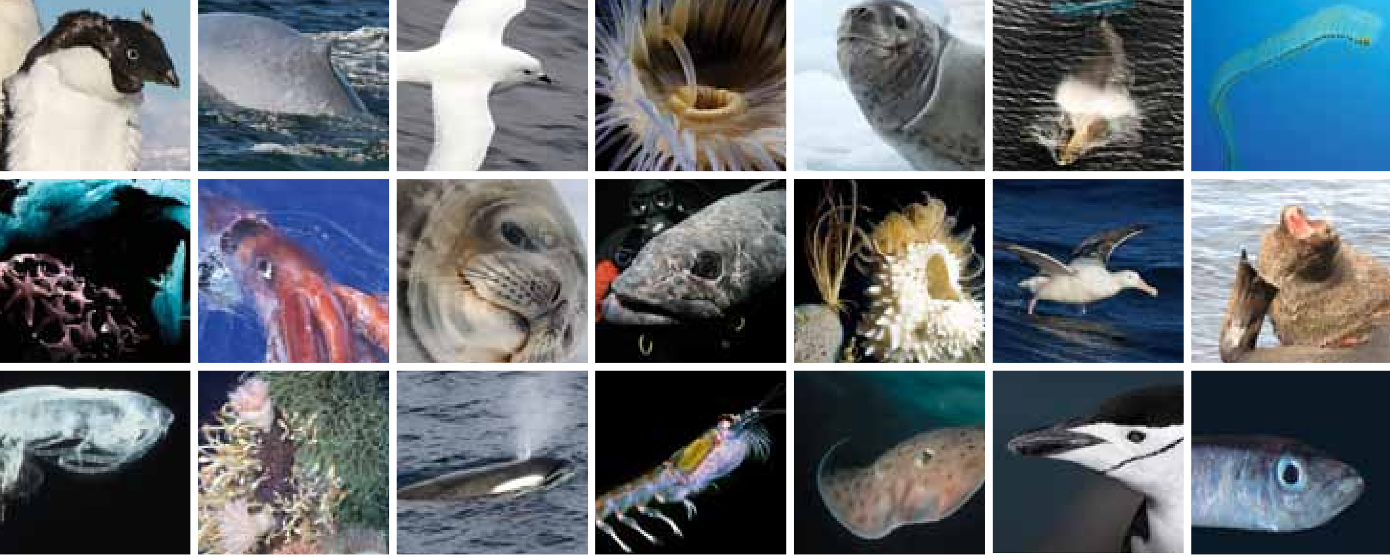

THIRTY THREE ANTARCTIC SPECIES WE LOVE*

(*and whose homes must be protected)

ANTARCTIC OCEAN ALLIANCE

PROTECTING THE WILD SOUTH

www.antarcticocean.org


Image by John B. Weller

Introduction

Simply put, the oceans are our life support system. They are the blue heart of the planet. But despite this, we have witnessed the ocean undergo massive changes in just the last 50 years. Overfishing has reduced thriving populations of big fish to tiny remnants of their formerly prosperous masses. Dead zones incapable of supporting marine life have arisen in some places around the world and climate change is placing ever increasing stresses on marine species and habitats. It is not only marine life that has been affected: even the water itself has begun to acidify because of rising carbon dioxide levels in the atmosphere.

Despite these and other problems, there is still hope that we can restore and protect the health of the ocean. This hope led to the identification of a global network of Hope Spots, special places that can help restore the ocean we depend on for our survival. Two of those Hope Spots, the Ross Sea and East Antarctica, are in the Southern Ocean. This is a special area of the world, where the continent is protected, but the surrounding ocean is not. Nevertheless, the Antarctic remains a place of vibrant marine life, and every year scientists learn more fascinating details about the diverse and unusual species that thrive in this harsh but beautiful environment. Protecting these magnificent creatures and their home is critical for the knowledge base we need.

The 33 species profiled here are a small sample of the many that live in the Southern Ocean. Each one matters, whether beautiful or ugly, large or small, predator or prey. Antarctica is known for its iconic penguins, seals, and whales, but its other species are just as interesting. From coral that can pick itself up and move across the ocean floor in search of food to a squid that has the largest eye of any known animal, Antarctica's ecosystems have a richness and complexity that we are only beginning to appreciate. New species are discovered regularly. Perhaps most important, some areas of the Southern Ocean, like the Ross Sea and the Weddell Sea, have been found to have some of the lowest levels of disturbance of any marine ecosystems. These areas serve as natural laboratories where we can learn how healthy ecosystems function, and how species within them interact, without human interference – something that is sadly no longer possible in most of the world. This is one of the best areas for us to continue to learn the nature of nature.

We therefore have an important opportunity to protect these ecosystems while they are healthy. Antarctica has some of the largest marine mammal and seabird populations left on the planet. Some of those species are at serious risk from climate change, as warming temperatures reduce the availability of food and change their habitat. Others may have trouble surviving as ocean acidification, which will affect the polar regions first, takes hold in large areas. While we know little about many Antarctic animals, we do know that they have often evolved to be slow-growing, with adaptations that suit them for extreme cold conditions. Many may not be able to tolerate warmer temperatures and increased human impacts. If we don't want to lose these creatures before we even have the chance to study them, we must take action now.

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Climate change is likely to be the main threat to Antarctic species over the next century, but as other human activities such as tourism, shipping, bioprospecting, and fishing increase, additional strain will be placed on these ecosystems. Fishing lines, trash and plastic can inadvertently damage delicate seafloor creatures. Invasive species may take advantage of warmer temperatures and crowd out native species unable to adapt quickly. Oil degrades much slower under cold temperatures. Singularly and collectively, these threats are placing increased stress on the marine life of the Southern Ocean. Marine Protected Areas (MPAs) and no-take marine reserves cannot stop climate change, but they can help limit the number of stressors in a given area. In addition to protecting unique areas that may not be found anywhere else in the world and increasing their resilience to a changing climate. MPAs can also serve a very important function as reference areas where we can measure climate change impacts without the influence of other human activities, such as pollution and overfishing.

The organisation that has authority over the Southern Ocean, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has taken a bold step in ocean conservation by declaring its intent to create the world's first high-seas MPA system around Antarctica. Most of the ocean is beyond national borders, and if the nations that make up CCAMLR succeed in designating a full system of MPAs, they will have accomplished something extraordinary and leave a lasting legacy for our grandchildren and beyond.

Years ago when CCAMLR was created, its members declared that it would manage fisheries with a precautionary, ecosystem-based approach. The MPA network is entirely consistent with this approach and the next logical step in protecting Antarctica's diverse and irreplaceable ecosystems for future generations. CCAMLR has been debating proposals for MPAs in the Ross Sea and East Antarctica for several years now.

This report underpins the urgency for these nations to live up to their commitments and demonstrate their global leadership by designating the proposed MPAs at their 2014 meeting. Doing so would show the world that it *is* possible for nations to come together, put aside their individual issues and do the right thing for the ocean and all the people who depend on it for survival.

19 Areas of Proposed Protection

In 2011, the Antarctic Ocean Alliance (AOA) identified 19 areas that should be included in a representative system of marine protected areas and marine reserves. As CCAMLR meets for its 33rd meeting, the 33 species presented in this report broadly represent those that should be protected. Many species have extensive, even circumpolar distributions, while others can only be found within a limited geographic range and nowhere else in the world. The adaptations that allow these species to survive and thrive are as varied and different as their survival strategies, size and appearance. However, what these species all share, from the giant blue whale to miniscule zooplankton, is a dependence on the unique ecological balance found in the beautiful yet harsh Southern Ocean environment. It is CCAMLR's mission to ensure that this balance is maintained. For some of the species in the report, where appropriate, we have provided information about the relevant taxonomic group to which they belong rather than just information on the individual species. While mammals and birds have been fairly well studied, many fish and invertebrates have not. By profiling an entire group of related species, we can provide more fascinating facts and information and further understanding of some of the less well-known groups.

1 Antarctic Peninsula

- Antarctic krill are considered central to the functioning of the Southern Ocean food-web but may be particularly sensitive to a changing climate
- Bone worms have only been known in the Southern Ocean since 2012
- Climate change reference area

2 Weddell Sea

- Leopard seals are one of Southern Ocean's most fearsome predators
- Glass sponges have quickly colonised areas following ice shelf collapse

3 South Orkney Islands

- Marbled rockcod populations have still not recovered from overfishing in the 1970's
- High benthic biodiversity
- The Scotia Sea around the South Orkneys have some of the highest numbers of Echinoderm species

4 South Georgia

- Members of the icefish family are almost entirely lacking in haemoglobin in their blood
- Salps' faeces may play an important role in transporting nutrients to the deep sea

5 South Sandwich Island Arc

- The Yeti crab is a common species around hydrothermal vent communities in volcanically active zones
- More species of sea spiders may exist in the Southern Ocean than warmer oceans

6 Maud Rise

- Antarctic petrel are the most southerly breeding bird in the world
- Copepods could be the most numerous type of zooplankton in the Southern Ocean

7 Bouvetøya

- Chinstrap penguin numbers appear to be declining
- Eel cods resemble eels but have antifreeze proteins in their blood like toothfish

8 Ob & Lena Banks

- Skates are common bycatch species listed as near threatened by the IUCN
- Blue Whales are recovering from hunting much more slowly than other whale species

9 Del Cano Region High Seas

- Wandering albatross has the largest wingspan of any bird
- High levels of land-based predators
- Benthic environment including seamounts and canyons

10 Kerguelen Plateau High Seas Area

- Lanternfish use bioluminescence to communicate and confuse predators
- Orcas are the highest predator on the Southern Ocean foodchain
- Recovering toothfish populations
- Vulnerable marine ecosystems and canyons

11 BANZARE Bank

- Grenediers are common bycatch in toothfish fisheries
- Recovering toothfish populations
- Vulnerable marine ecosystems and canyons

12 Kerguelen Production Zone

- Antarctic fur seal primarily hunt krill and fish
- Rugose seabed habitats
- Area of high productivity

13 Eastern Antarctic Shelf

- Emperors are the most ice dependent penguin species
- Snow petrels are one of the most southerly breeding birds
- Climate change reference areas

14 IO Deep Sea

- Unique benthic habitats including troughs, shelf commencing canyons, ridges and thermohaline current formed sediments
- Anemones can be found in the deepest parts of the Southern Ocean

15 Ross Sea

- Intact top predator assemblage
- Silverfish are highly important prey for top predators
- Antarctic toothfish fill a shark-like top fish predator role in the Southern Ocean
- Bending coral (*Alcyonacean, Gersemia antarctica*) continually bends itself over to locate food in seafloor sediments
- Least disturbed oceanic ecosystem
- Climate change reference area

16 Northern Ross Sea Seamounts

- The colossal squid is the largest know invertebrate
- Toothfish breeding habitat

17 Balleny Islands

- Land-based predator foraging ranges
- Adélie penguin are seen as a bellweather species for environmental change
- Antarctic Minke whales feed mainly on krill
- Rare benthic habitat

18 Amundsen & Bellingshausen Seas (West Antarctic Shelf)

- 195 species of Antarctic mollusks have been found since 2007
- Antarctic mollusks are particularly vulnerable to ocean acidification
- Recognised vulnerable marine ecosystems

19 Peter I Island

- Area of high productivity
- Weddell seals dive to 600 metres to feed on deep dwelling toothfish
- Antarctic fulmars breed later due to climate change

Image by John B. Weller

MAMMALS

The two groups of mammals that have made Antarctica their home are pinnipeds (seals) and cetaceans (whales) and these marine mammals display a wonderful array of adaptations that enable them to survive in what is possibly the most brutal climate on earth.

Special adaptations are found in many Antarctic mammals. From the Weddell seal, whose teeth have evolved into forward-pointing incisors that allow them to bite and carve holes in the ice, to the lithe-bodied, massive-jawed leopard seal, whose hunting prowess in the icy waters is surpassed only by the orca, it is truly survival of the fittest in Antarctica.

Food supply is also an issue for most of the Antarctic mammals. All except killer whales are at least partially if not solely dependent on krill as a food source. Temperature changes in the Southern Ocean may already be affecting the abundance and location of krill, which in turn affects where krill-eating mammals will mate and breed. But most importantly, it will determine whether or not they survive at all.

Read on to learn about the small community of mammals who have been able to adapt to the harsh Antarctic climate, but are facing increasing threats to their existence.


Image by David Neilson

1

Weddell Seal

Leptonychotes weddellii

Weddell seals have a reputation for being easy for humans to approach and study on the ice or on land, but in the water they are skilled predators with an unusual hunting strategy. They are rather large, with a length of about 3 m and a weight of 400 to 450 kg[1]. They are distinguished by their extraordinary ability to dive to depths of 600 m for more than an hour[2]. This allows the Weddell seal to feed on deep-dwelling fish such as the Antarctic toothfish and other fish in the family nototheniidae. They also feed on invertebrates such as krill and they occasionally hunt penguins[3,4].

Photographer John B. Weller relates an extraordinary experience while diving in the vicinity of these amazing pinnipeds:

"The blast was so loud that I didn't recognise it as a noise. It seemed as though a jet engine had started in my head, a shockwave of buzzing bees exploding through my body. I couldn't see! My eyes defocused. My entire body felt numb and unresponsive. I had no idea if I was breathing or not.[5]"

Weddell Seals are distinguished by their extraordinary ability to dive to depths of 600 m for more than an hour[2].

Scientist David Ainley connects Weller's experience with an unexplained Weddell seal behaviour. Some seals have been observed bringing large Antarctic toothfish up to the surface. These fish don't have any injuries and are still alive, and it was unknown how the seals manage to capture such large prey alive without biting it. Weller and Ainley hypothesise that the seals likely use "sonic bursts" to stun and thus easily capture their prey[6].

Image by Liam Quinn

2

Leopard Seal

Hydruga leptonyx

Leopard seals are at the top of the food web in East Antarctica and the Southern Ocean, and are only preyed on by killer whales. They have large heads with massive jaws, big eyes and lithe bodies, making them well adapted for stalking, hunting and grabbing prey. They feed on a variety of species, including fish, krill, penguins and other seals, often feeding on whatever species is most abundant nearby[7]. Leopard seals are an ice-loving species and regularly haul out onto pack ice or seasonal ice[8]. Males are about 3 m long and females are typically a little larger. They can live for 20 to 40 years[9].

As very solitary animals, they do not leave the water to court or mate and only females and pups are seen in pairs. This seal is not easily disturbed by humans but is quite curious and known to stalk, approach, and even grasp people[10].

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National Geographic photographer Paul Nicklen encountered one of these curious leopard seals while diving in Antarctica. The seal, a female, appeared to be trying to nurture Nicklen, bringing him penguins she had caught. When he didn't eat the live penguins, she tried dead ones[11]. This fierce predator could just as easily have decided to turn him into dinner instead of feeding him dinner, but fortunately didn't identify Nicklen as food. Despite their excellent predation skills, their association with ice (and the association of some of their prey species with ice) may put them at risk from changes in ice extent and location due to climate change[12].


Image by Lara Asato

3 Antarctic Fur Seal

Arctocephalus gazella

Antarctic fur seals are one of the most numerous seal species in the Antarctic. Throughout most of the year, they are dispersed at sea but aggregate in colonies in October and November during their breeding season. Males arrive before females to claim a territory, which they defend aggressively with loud noise and physical fighting. Although their territories might be small, they are necessary for males to monopolise the affections of multiple female seals at once. Once females arrive, they pup, mate after about a week, and then leave for hunting trips. Males are much larger than females, and can be more than three times their weight and almost half a metre longer[13].

Depending on availability, Antarctic fur seals primarily hunt fish and krill, but will also eat other crustaceans, squid and penguins[14]. They in turn are hunted by killer whales and leopard seals. Although sealing once came close to wiping them out, Antarctic fur seals have staged a comeback even more impressive than Elvis Presley's[15]. At one point, there were only a few thousand seals left[16,17]. Today, there are an estimated four to seven million[18]. Well over 90% of the population breeds in the South Georgia Islands, which is an incredibly large aggregation of mammals. Though we don't exactly know how fur seals have recovered from exploitation so quickly, their growing numbers represent a conservation success story. In the rest of the world, many large mammals are experiencing declines. It's heartening to know that they are currently thriving in the Antarctic. Nevertheless, emerging research suggests that climate change-related impacts, specifically decreases in krill in some areas, have already started affecting at least one fur seal population on South Georgia[19].

Although sealing once came close to wiping them out, Antarctic fur seals have staged a comeback even more impressive than Elvis Presley's[15].

4

Blue Whale

Balaenoptera musculus

Any description of blue whales includes a number of superlatives and startling comparisons. With lengths of around 30 m and weights of over 100 tonnes, they are the largest animals on earth[20]. Blue whales can live for at least 80 years[21]. Blue whale calves give some idea just how large these creatures are. Calves are about 8 m long at birth (that's more than four men of above average height) and drink enough milk (over 300 litres) to pack on 3.6 kilograms of additional weight every hour[22]. But all that food is necessary to grow to more than triple their birth size and weight.

Perhaps one of the most intriguing facts about blue whales is their choice of diet. Tiny krill are the blue whale's primary prey, and blue whales consume millions to sustain their huge bodies. Conveniently for them, Antarctic krill habitually congregate in large swarms of billions of individuals, making it somewhat easier to consume the quantities they need. These swarms draw blue whales to the Southern Ocean every year. Because of their size, these giants have almost no predators, but may be attacked by orcas on occasion[23].

Blue whale calves are about 8 m long at birth (that's more than four men of above average height).

Blue whale hunting was banned in 1966 by the International Whaling Commission[24] and the species is now on the IUCN Endangered List[25]. It is unclear why the blue whale population, though increasing, has not recovered significantly since the end of the whaling era. Part of the reason may be that they only give birth every two to three years. The global population likely exceeded 350,000 prior to whaling, which depleted them by over 95%[26]. Since then, the population has grown slightly to about 10,000 to 25,000[27]. Though hunting has ceased, they still may be impacted by human activities. For example, krill are considered to be very sensitive to climate change. Changes in the krill population caused by fishing or climate change would likely affect blue whales significantly.

Image by John B. Weller

5

Antarctic Minke Whale

Balaenoptera bonaerensis

The Antarctic minke whale is a baleen whale often found in the Southern Ocean and, together with the blue whale, is the furthest south migrating rorqual (the largest group of baleen whales, from the Norwegian word røyrkval, meaning "furrow whale"[28]). Antarctic minke whales have been observed migrating all the way to the Arctic[29]!

Antarctic minke whales mostly eat Antarctic krill and other krill species and as a result are most common near the edge of pack ice but can also occur within it[30]. These relatively light and lean whales, which are smaller than most other baleen whales, are also clever. New information gleaned from tagging minkes in the Southern Ocean reveals that they are skilled at feeding on krill under sea ice[31], lunging more quickly than any other baleen whale[32]. Sea ice is thought to be a place of refuge for krill, but minkes may have figured that secret out.

Antarctic minke whales have been observed migrating all the way to the Arctic[29]!

Recently, research on minke whales helped solve a mystery that had puzzled scientists since the 1960s. During winter and spring, scientists would record what they termed a "bio-duck" sound at various locations in the Southern Ocean, but did not know what made the sound[33]. Researchers recently tagged two Antarctic minke whales with microphones, and subsequently recorded the quacking noise. It is unknown what the noise means. However, whales are known for their complex underwater communications so we can probably assume they aren't just doing animal impressions. Like other krill consumers, minkes may be at risk if climate change results in diminished sea ice or reduced krill populations.

6 Killer Whale

Orcinus Orca

Killer whales are a very distinctive toothed whale and encountered in almost all oceans and seas, although a large portion of the global population is found in Antarctic waters. Recent research suggests that there are several distinct "ecotypes" of killer whales, some of which may be separate species[34]. The ecotypes B and C are among those likely to be separate species and are common in Antarctica. Type B eat marine mammals and Type C, also known as the Ross Sea killer whale, specialise in fish, particularly Antarctic toothfish[35].

Among all animals, killer whales are second only behind the sperm whale for having the heaviest brain[36]. They use this brain for some terrifyingly effective hunting. Orcas are fond of eating Weddell seals, and to get at the seals more easily, they "wave wash" them off ice floes. Working in groups, several whales send large waves of water over the floes to dislodge the seals, who fall into the sea and are summarily eaten. This hunting technique is an example of their extremely complex social behaviour, cooperating in groups and teaching younger whales in the pod[37]. They are also incredible travellers. Type B killer whales sometimes migrate enormous distances into the subtropics and an individual has been recorded to travel 9400 km in only 42 days[38].

Orcas are fond of eating Weddell seals, and to get at the seals more easily, they "wave wash" them off ice floes.

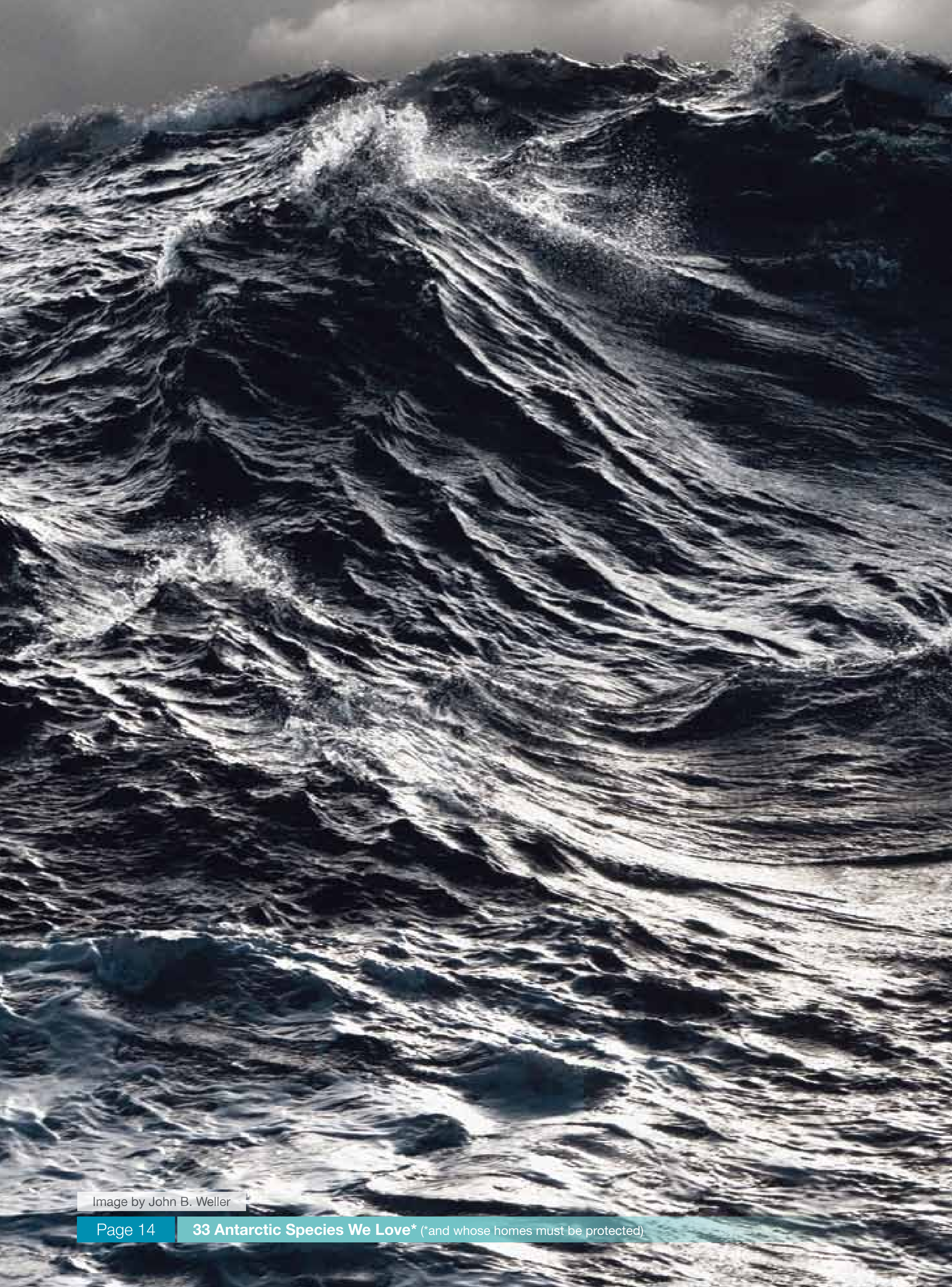


Image by John B. Weller

FISH

Antarctica boasts a huge diversity of fishes that are supremely adapted to their unique and harsh environment. Many Antarctic fish species, particularly in the Notothenioid suborder, (notothenioids are a fish suborder that make up the majority of Antarctic fish species) possess antifreeze molecules called glycopeptides that help enable them to survive Antarctica's cold waters. Members of the icefish family lack hemoglobin, the protein that most vertebrates use to transport oxygen in their blood, but instead are able to absorb oxygen directly from the surrounding water. Some fish species are adapted to live their entire lives near the deep seafloor and lack swim bladders, the gas filled organs used by most fish to adjust their buoyancy. Other species have developed special fat reserves to provide the neutral buoyancy they need to lay their eggs directly under the sea-ice. Each Antarctic fish species plays an important role in the food web, many as prey items for animals like seals, whales, colossal squid and penguins.

The unique life histories and habitat use of most Antarctic fish are not well understood. Some of these species share a common set of characteristics – they are slow growing, late maturing and long lived. Whether exploited directly or taken as bycatch, these characteristics make populations of these fish species highly susceptible to being overfished. Because these species are particularly well adapted to the unique conditions of the Antarctic, they are expected to be very sensitive to small changes in climate as well as sea-ice loss. Read on to learn about a few of our favourite Antarctic fishes that need protection from the combined threats of climate change and fishing.

7

Antarctic Silverfish

Pleuragramma antarcticum

Krill seem to get a lot of the attention in the Antarctic. But they aren't the only ones keeping the Southern Ocean ecosystem functioning. The Antarctic silverfish is highly abundant in areas such as East Antarctica and the Weddell and Ross Seas and an important prey fish for many species such as seals, whales and penguins in those regions.[39,40,41,42]. Unlike similar prey fish, it is slow-growing and lives up to 10 years[43]. Like an experienced scuba diver, it has attained neutral buoyancy, which is due to its minimal skeleton and high fat content[44]. This enables silverfish to lay their eggs just under sea ice, where they are better protected from being eaten, which is a threat for eggs of bottom-dwelling species[45]. Silverfish are also protected in the frigid waters by antifreeze glycopeptides in their tissues[46].

Unlike similar prey fish, the Antarctic silverfish is slow-growing and lives up to 10 years[43].

This small fish is well adapted to the seasonal changes of the Weddell Sea, and feeds on available zooplankton, including copepods and krill of any size depending on the stage of fish's life[47,48]. This opportunistic fish will even eat its own kind[49]. Both its feeding as well as reproductive ecology are connected with the availability of sea ice and polynyas – areas of open water surrounded by sea ice that are crucial food sources for many species[50], making it potentially vulnerable to climate change despite its diverse diet.


Image by Rob Robbins

8 Antarctic Toothfish

Dissostichus mawsoni

The species Antarctic toothfish is a key species in Antarctic marine ecosystems, known as the "shark" of the Southern Ocean because of its role as top predator. Toothfish, also known as Chilean sea bass, produce antifreeze proteins that keep their body fluids from freezing in the frigid waters[51]. Unlike its relative, the tiny silverfish, it is one of the two largest fish in the notothenioid suborder, and grows up to 1.6 m in length with a life span of 30 years[52]. It is usually found in fairly deep waters[53], though it is neutrally buoyant and can ascend to midwater areas. Females and males spawn after about 16 and 13 years respectively. This high reproductive age makes this species particularly vulnerable to overfishing. Additionally, toothfish spend significant amounts of time in areas difficult for researchers to access and key aspects of their life histories are not yet known.

As the Southern Ocean lacks many of the sharks and other large fish species found in other ocean ecosystems, Antarctic toothfish therefore fill a shark-like niche in the Antarctic ecosystem. They feed mainly on smaller fish and cephalopods, but also on other invertebrates and even birds[54]. Nevertheless, they are

Females and males spawn after about 16 and 13 years respectively. This high reproductive age makes this species particularly vulnerable to overfishing.

thought to be an important prey species for Weddell Seals, orcas, and colossal squid. Antarctic toothfish fisheries occur in many regions of the Southern Ocean including East Antarctica, the Ross Sea and the Weddell Seas. Antarctic toothfish fisheries are regulated, but there remain significant uncertainties about their life histories and their role in the food web, making it difficult to understand the impact of fishing on the ecosystem. A growing body of research indicates that top predators play incredibly vital roles in many ecosystems, and without them significant and often surprising changes can occur[55]. More research is urgently needed to unlock the mysteries of these bird-eating, deep-dwelling predators.

Image by Darci Lombard

9

Icefish

family Channichthyidae

Members of the icefish family (*Channichthyidae*) are abundant in parts of the Southern Ocean, but perhaps because they live on the bottom, in depths of up to 800 m, not much is known about them. At about 30 to 60 cm in length, most icefish are larger than an Antarctic silverfish but smaller than an Antarctic toothfish. Their exact role in the ecosystem is unknown, but at least one study found that several species of seal eat them[56]. With Antarctic toothfish and silverfish, they belong to the notothenioid suborder, but anti-freeze proteins make it even more unique than the average notothenioid.

Members of the icefish family are almost entirely lacking in hemoglobin. All other vertebrates use hemoglobin to transport oxygen in their blood, but icefish are able to get their oxygen directly from the surrounding water. They have also developed other adaptations to go along with their hemoglobin-free, clear blood: larger hearts that pump more blood than those of other notothenioids, and wider capillaries[57]. One might think that there must be some advantage to abandoning red blood, but strangely enough, so far one hasn't been found. Researchers think that perhaps icefish got lucky and lived in areas with few other fish species[58]. Thus it didn't matter much that icefish had less efficient circulatory systems, because they had few competitors.

All other vertebrates use hemoglobin to transport oxygen in their blood, but icefish are able to get their oxygen directly from the surrounding water.

Some evidence suggests that icefish may be particularly sensitive to changes in their environment. Researchers found that after iceberg scouring events, the abundance of a species called Myers' icefish declined[59]. The breakup of ice shelves such as Larsen B due to climate change may therefore indicate that threats to this species will increase, since the breakup of major ice shelves can enable glaciers to flow more quickly from land to sea, increasing scouring events. Icefish may also be more sensitive to changes in ocean acidity[60], and the Southern Ocean is expected to experience the impacts of ocean acidification before other parts of the world's oceans[61]. Icefish have managed to hold on for millions of years, but they may not be able to survive for much longer.

Image by Dr Paul Zahl

10 Lanternfishes

family Myctophidae

Species in the Myctophid or lanternfish family are found all over the world, including in the Southern Ocean. Major species include *Electrona antarctica*, *Electrona carlsbergi*, and *Gymnoscopelus nicholsi*. In pelagic regions of the Southern Ocean, there are more *Electrona antarctica* lanternfish by number and by weight than any other fish. This, however might not be what you find most interesting about them. As their name implies, they carry their own light source around with them in the form of photophores, which are organs that bioluminesce by means of a chemical reaction. Interestingly, these photophores aren't primarily used to illuminate the water around them, but instead are hypothesised to play a role in communicating with other members of their species as well as in confusing predators.

Lanternfish are typically not very large. *E. antarctica* only measures about 10 cm or fewer in length, but nevertheless makes a huge journey every day, travelling up to the 0-300 m depth range at night, and descending to 650-920 m during the day[62]. Other lanternfish species in the Southern Ocean undertake similar migrations. It sounds like a lot of work, but it is actually a pretty smart way to stay in the dark and out of sight of predators all day[63]. Of course, that doesn't mean they don't get eaten. Birds and seals are their main predators. These unassuming fish, about which not much is known, are yet another reminder of the complexity of Antarctica's marine ecosystems. While krill are a keystone species in many areas of the Southern Ocean and are the subject of much scientific research, lanternfish and other species which also occupy the lower trophic levels of the food web may play an important role in the wider ecosystem. Acquiring a better understanding is important particularly since it has been suggested that lanternfish could be targeted to make fish meal or fish oil, both of which are growing industries[64].

Lanternfish photophores aren't primarily used to illuminate the water around them, but instead are hypothesised to play a role in communicating with other members of their species.

11

Antarctic Eel Cods

family Muraenolepididae

Antarctic eel cods (Muraenolepididae family) are not true eels, although they do resemble them – hence their name. These fish were originally thought to live only in the Antarctic and sub-Antarctic, but new species have been discovered outside of these areas. Eel cods are not a well understood fish family. For example, only a few years ago, it was determined that the species *Muraenolepis microcephalus* should actually belong to a different genus, *Notomuraenobathys* instead[65]. Like many other Antarctic fishes, eel cods have antifreeze substances in their blood to prevent freezing in cold water. For the eel cod *Muraenolepis marmoratus* this anti-freeze substance is similar to that found in notothenioid family[66], although they are not related. This is unusual because most non-notothenioids have a different type of antifreeze protein[67]. In any event, eel cods can withstand the Southern Ocean much better than the average human. Most species are around 30 cm in length, and unlike many Antarctic species that hide in the depths during the day, juvenile *M. marmoratus* hang out in shallow waters near the surface[68]. This means that they are eaten by king penguins[69] (and possibly others), which is bad for the eel cods but good for hungry penguin chicks. Generally, eel cod adults stay near the bottom of the ocean, in waters anywhere from 100-1000 m or more deep, depending on the species. As with so many Southern Ocean fish, more studies are needed to truly understand the mysterious life histories of eel cods.

Like many other Antarctic fishes, eel cods have antifreeze substances in their blood to prevent freezing in cold water.

Image by Peter McMillan/NIWA

12 Grenadiers

Macrourus genus

Antarctic Grenadiers are also known as rattails, and this unflattering name is an accurate reflection of their less than beautiful appearance. Though little known, Whitson's grenadier (*Macrourus whitsoni*) seems to be of the most abundant non-notothenioid species in some areas of the Southern Ocean[70]. However, research has not been comprehensive, so we don't really know how many there are. We do know that they are the kind of fish (long-lived, slow-growing) that are vulnerable to overfishing, so the amounts caught accidentally in the Antarctic and Patagonian toothfish fisheries (sometimes as much as 480 tonnes) could threaten the health of the overall population[71].

The organisation with management authority over the Antarctic toothfish fisheries in the Southern Ocean, CCAMLR, operates by following the ecosystem and precautionary approaches. This progressive way of managing fisheries and ecosystems ultimately means that managers institute rules to make sure that fishing doesn't take place unless there is a good reason to believe it will not harm the target species or the ecosystem as a whole. Bycatch of grenadiers presents a challenge for CCAMLR. It is difficult and expensive to do research in the Southern Ocean, but there is a risk to this species from fishing. CCAMLR has set limits on the amount of bycatch that a toothfish vessel may take before it is required to move to another location. Still, more research will be required to fully understand whether these rules are enough to protect the grenadier. A new species, *Macrourus caml*, was only confirmed in 2013 (previous examples of the species had been misidentified), underscoring how little we know about this group[72].

A new species, Macrourus caml, was only confirmed in 2013 (previous examples of the species had been misidentified), underscoring how little we know about this group.


Image by Jeff Rotman

13 McCain's Skate

Bathyraja maccaini

The McCain's skate is one of several species of rays and skates living in the Southern Ocean. It inhabits waters from inshore to 500 m depth[73]. This large skate is probably very slow-growing, reaching its total length of 120 cm after 10 years or more. This late maturity and the fact that it is common bycatch in bottom trawl for icefish and longline fisheries for Antarctic and Patagonian toothfish put it at risk. McCain's skate is currently listed as an IUCN Near Threatened species[74], one of the few Antarctic species to be on this list. Worldwide, skates and rays are threatened by human activities. Out of seven Antarctic species in the IUCN Red list database, three, including the McCain's skate, are listed as Near Threatened. The other two species are Murray's Skate (*Rhinoraja murrayi*) and the Kerguelen Sandpaper Skate (*Bathyraja irrasa*). Both of these skates have limited ranges, and have been caught as bycatch in fisheries both legal and illegal, making it difficult to assess the status of their populations[75]. Further efforts to assess and study all Antarctic skates will be critical to ensuring that their populations stay healthy.

McCain's skate is currently listed as an IUCN Near Threatened species[74], one of the few Antarctic species to be on this list.


Image by David Fleetham

14 Marbled Rockcod

Nothothenia rossii

These days, only a few species of fish in the Southern Ocean are being commercially fished. This was not always the case, however. The marbled rockcod (*Notothenia rossii*), along with several other species you've probably never heard of, including the grey rockcod (*Lepidonotothen squamifrons*), humped rockcod (Gobionotothen gibberifrons), and the spiny icefish (*Chaenodraco wilsoni*), used to be fished in Antarctic waters. The story of why the marbled rockcod fishery and others have been closed is a useful cautionary tale. Fishing began in the 1970s, but huge catches quickly caused the population to collapse. Over 500,000 tons were harvested from the fishery around South Georgia Island in just two years, and then catches rapidly declined[76]. Fisheries for other species experienced similar booms and busts. At the time, there was no country or group of countries managing Southern Ocean fisheries, making it difficult to set catch limits or understand what was happening to the fish populations being harvested. Fortunately, the problem was recognised and in 1982, when the Convention on CCAMLR was signed by 14 countries, so establishing rules and a management framework for fisheries around Antarctica.

The marbled rockcod populations have not recovered despite not being fished for more than two decades.

Soon afterwards, CCAMLR began closing fisheries, including those for *N. rossii*. However, it was too late. The marbled rockcod populations have not recovered despite not being fished for more than two decades. Unlike the Antarctic toothfish, which is vulnerable to overfishing because of its slow growth, late maturity and long lifespan, marbled rockcod are a relatively short-lived species, not living much longer than 16 years[77]. Overfishing of the Elephant Island stock seems to have occurred because catches were almost as large as the entire stock[78]. The hope is that such disasters will not happen in the future, thanks to CCAMLR's adoption of a precautionary and ecosystem approaches to management. This approach prevents the kind of "fish first, ask questions later" policy that led to the collapse of *N. rossii* and other populations.

Image by John B. Weller

BIRDS

The birds of Antarctica are like no others. Able to withstand the harshest climate on earth, each species has its own unique survival techniques and characteristics ranging from shared parenting and monogamy to walking on ice or plunging into near freezing waters. From the wandering albatross who can soar for hours and has the largest wingspan of any living bird, to the flightless emperor penguin who may waddle and toboggan up to 120 kilometres to reach open water to forage, these Southern Ocean birds have found a way to make the most of this icy environment. Others, such as chinstrap and Adélie penguins seek ice-free areas and build nests of pebbles, or prefer to nest on rocky cliffs and ledges, like the Antarctic petrel.

Long-lived and slow to reproduce, the common thread among these fearless birds is the important role they play in Antarctica's intricate food web, both as predator and prey. Not only do they provide a glimpse into the great bio-diversity of this region, but they also provide invaluable insight into the effects of climate change and human activity on ocean health. Read on to find out more about how these incredible birds have adapted to survive in this demanding environment and what they can tell us about the future.

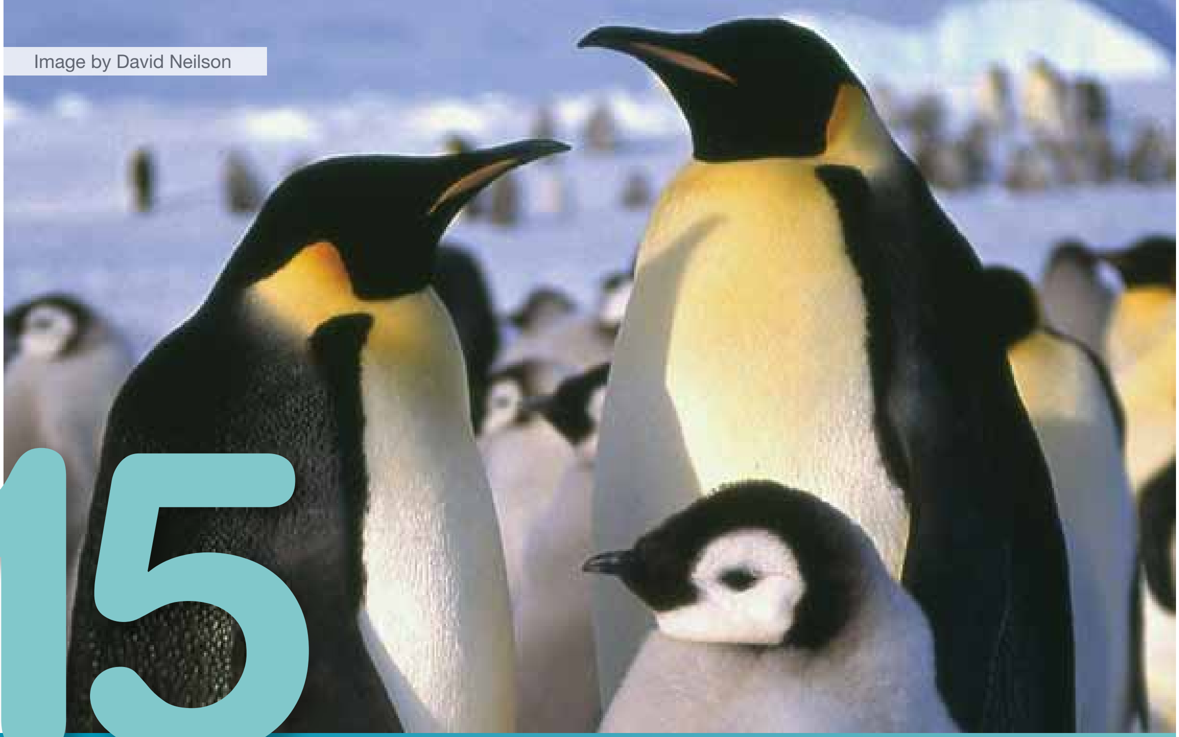


Image by David Neilson

15

Emperor Penguin

Aptenodytes forsteri

This largest of all penguins can grow to nearly 1.15 metres tall and weigh up to 40 kg[79]. The emperor's stature may be one of the reasons why they are the only penguin species to breed on sea ice during Antarctica's dark and frigid winter[80]. Their devotion to their chicks in this harsh environment makes them some of the most impressive parents in the animal kingdom. Emperor penguins pair up each year at the breeding site and stay together throughout the season. Shortly after the female lays the pair's sole egg and carefully transfers it to the male, she begins a trek of up to 120 kilometres to reach open water to forage for food[81]. Meanwhile the male incubates the egg in a brood pouch above his feet for a little more than two months as temperatures drop. By the time the females return, the male has fasted for almost four months and has lost up to 50% of his body weight.

Emperor penguins inhabit colonies around the coast of Antarctica[82] and forage primarily on Antarctic silverfish, krill and squid[83]. They can dive up to 565 m[84] and have developed an extraordinary adaptation. Their heart rate, which is usually around 73 beats per minute, speeds up to as high as 256 beats right before and after a dive and slows down in the water to as low as 6 beats per minute toward the end of the dive[85].

Climate change is predicted to have disastrous effects on emperor penguins, with projected losses in some colonies by as much as 81% by the end of the century[88].

While they can live up to 40 years[86], emperor penguins are one of the most ice dependent of all penguin[87] species and their life cycle is strongly linked to changes in sea ice. A decrease in sea ice concentration can have a negative effect on population size and reproductive success. Climate change is thus predicted to have disastrous effects on emperor penguins, with projected losses in some colonies by as much as 81% by the end of the century[88]. However, these tough birds may be able to adapt and breed in new locations[89].

Image by Bob Zuur

16 Adélie Penguin

Pygoscelis adeliae

Adélies may be the smallest of Southern Ocean penguins[90], but they make up for it by having a range along the entire Antarctic coast and on some of its nearby islands. Similar to emperor penguins, Adélies have a unique dependency on pack ice and live in the outer portion but not on the edge of the pack ice in winter. They use breathing holes in the ice created by minke whales to enter and exit the water[91] where they hunt for fish, krill and squid[92]. Due to its dependency on the ice and its sensitivity to changes in the ecosystem, the Adélie penguin is often seen as an indicator species for environmental changes.

In spring, Adélies migrate toward land to join a breeding colony. The male establishes the territory and both mates are involved in building and maintaining the nest, which involves protecting it from neighbouring pairs as the penguins are known to steal pebbles from each other. The female usually lays two to three eggs before leaving to forage. Upon their return, both mates take turns hunting, incubating the eggs, and feeding the chicks. After 50 days, many of which the chicks spend without their parents, they will have developed their juvenile plumage and head for the sea[93].

Adélie penguins use breathing holes in the ice created by minke whales to enter and exit the water[91] where they hunt for fish, krill and squid[92].

While fairly slow on land, Adélies travel much more efficiently in the water, swimming or "porpoising" (periodically leaping out of the water), and reach speeds of 4.4 metres per second[94]. They usually dive for several minutes and go down as far as 170 metres deep.


Image by David Neilson

17 Chinstrap Penguin

Pygoscelis Antarcticus

Most penguins are considered to be cute, but the chinstrap penguin's horizontal facial stripe, gives it a particular charm. But don't be fooled – they are far from cuddly. Longtime penguin researcher Ron Naveen notes that unlike their close relatives the gentoo and Adélie penguins, chinstraps "will rush up to you immediately, squawking like crazy, and loudly, as if they need to closely inspect your passports…They will stab if you don't back off[95]." Like their close relatives, the Adélies and gentoos, they also have a penchant for stealing rocks from their neighbours to build the nests where they incubate their eggs. Currently there are millions of chinstrap penguins, some of them in colonies ranging from 55,700 pairs on the Antarctic Peninsula[96] to 20,000 pairs in the South Shetland Islands[97]. In the 1990s, the estimated world population of chinstraps was 7.5 million pairs[98], which, now, is believed to be declining[99] — and in the Antarctic Peninsula, chinstraps are declining significantly[100]. For example, at Deception Island, the large chinstrap colony at Baily Head now stands at 50,408 breeding pairs[101], down from previous estimates of as many as 100,000 breeding pairs[102].

Chinstraps 'will rush up to you immediately, squawking like crazy, and loudly, as if they need to closely inspect your passports'.

Chinstrap penguins stick to relatively warmer Antarctic and sub-Antarctic climates, not venturing further south than the Antarctic Peninsula. When at sea, they also inhabit areas with less dense sea ice. Thus, it had previously been hypothesised that the warming of the Peninsula (part of the overall pattern of climate change) would benefit chinstraps, due to their affinity for less icy areas. However, recent research, as noted above, has shown that chinstraps (along with Adélies) are actually significantly declining in the rapidly warming Peninsula region[103,104]. Although scientific knowledge of Antarctic ecosystems has advanced considerably over the past few decades, there's clearly still a long way to go before we can predict how Antarctic ecosystems will change as the planet continues to warm, and what this means for its birds and wildlife.

18

Antarctic Petrel

Thalassoica Antarctica

The Antarctic petrel is found along the entire Antarctic coastline, and also breeds on nearby islands[105]. Its range includes the pack ice, where it can be found throughout the year, an area where it has little competition from other birds [106].

Antarctic petrels breed further south than all other birds[107]. Although they depend on the sea to feed, they nest much further inland[108]. The Antarctic petrel breeds in colonies on cliffs or on the ground of the Antarctic continent[109]. Mating pairs perform elaborate courtship rituals during which they clash bills, toss their heads and wag their tails[110]. Feather care is very important in Antarctic petrels as they protect the bird from the harsh Antarctic environment only if clean, dry and oiled by the bird[111].

These birds feed mostly on fish and krill but also on crustaceans and squid[112]. To find their prey, they use their excellent eyesight to follow other birds to feeding grounds, where they congregate in large numbers[113].

Feather care is very important in Antarctic petrels as they protect the bird from the harsh Antarctic environment only if clean, dry and oiled by the bird[111].

The shelter provided by some Antarctic petrel nests is of particular importance because shelter prevents chick predation from predators like the south polar skua (*Catharacta maccormicki*)[114]. Regional climate change has made Antarctic petrel nests more vulnerable to predation by southern giant petrels (*Macronectes giganteus*), leading to decreases in breeding success and survival[115].

19

Snow Petrel

Pagodroma nivea

The beautiful, entirely white snow petrel is one of the most southern breeding of all birds[116]. Its thick plumage protects it from the wind and icy water and these birds meticulously oil and clean their feathers, sometimes by taking "baths" in the snow[117]. They breed in colonies further inland where the female occupies a nest and is courted by the male with dance-like movements and beak "fencing"[118].

Snow petrels mostly eat Antarctic silverfish along with krill and some other fishes[119]. They typically hunt in icy areas[120]. The global population is thought to be larger than 4,000,000 individuals[121], and they are found on Antarctica and the nearby islands of South Georgia and the South Sandwich Islands.[122]

As with many Antarctic species, snow petrels are abundant and not directly threatened by humans. Still, they are a decidedly cold-climate species and changes due to climate change may impact them directly. Scientists are studying them closely through tracking devices that will provide information on foraging and thus potentially give clues to changes in marine ecosystems[123].

Snow petrels breed in colonies further inland where the female occupies a nest and is courted by the male with dance-like movements and beak "fencing"[118].

20 Wandering Albatross

Diomedea exulans

The huge wandering albatross has the largest wingspan of any living bird. Thanks to their amazing wingspan, which can spread between 2.5 to 3.5 m (8 ft. to 11.5 ft.) they can remain in the air for many hours without flapping their wings[124]. They also are resilient despite the harsh environments they inhabit and are able to live for half a century[125].

The wandering albatross reproduce on a number of islands in the Southern Ocean, including South Georgia, Crozet, Kerguelen, Prince Edward, and Macquarie[126]. During their courtship they display rituals that make use of their immense size and unusual sounds, including a rapid sequence of head movements, snaps, ritualised preening and vocalisations[127]. Their nighttime feedings consist of a range of squid, small fish, and crustaceans[128]. They have a unique gland above their nasal passage, which allows them to get rid of salt from seawater they take in along with their food[129].

Thanks to their amazing wingspan, which can spread between 2.5 to 3.5 m they can remain in the air for many hours without flapping their wings[124].

The International Union for Conservation of Nature now lists the wandering albatross as a species of vulnerable status[130]. This is unfortunately due to bycatch in toothfish fisheries[131]. Measures introduced by CCAMLR have reduced bycatch of albatrosses[132] in Southern Ocean fisheries to near zero[133] although they still end up as bycatch in non-CCAMLR management fisheries north of the Southern Ocean and by Illegal, Unregulated and Unreported (IUU) fishing.

Image by JJ Harrison

21

Antarctic Fulmar

Fulmarus glacialoides

Though not as well-known or well-studied as its penguin neighbours, the Antarctic fulmar (also known as the Southern fulmar) is quite abundant in the Southern Ocean[134], with an estimated population of 2,000,000[135]. Like other albatrosses and petrels, its plumage is grey and white, and it has a hooked beak. However, it is unique from other species in several ways. For example, this bird does not nest on the ground, and instead prefers rocky ledges on high cliffs. That might make them sound like they prefer to be alone, but they are far from solitary. They spend much of their lives in a flock with other Antarctic fulmars, or in large colonies during breeding season. Antarctic fulmars lay a single, white egg during late November or early December.

They spend much of their lives in a flock with other Antarctic fulmars, or in large colonies during breeding season.

They are predominantly surface eaters, although they will occasionally dive for their food[136] and dine mostly on Antarctic silverfish, krill and squid[137]. Though several species of albatrosses and petrels that feed or breed in the Antarctic region have experienced steep population declines due to entanglement in fishing lines, fulmars do not appear to be at a similar risk[138], even though they have been observed around fishing vessels. Like many Antarctic seabirds, they are threatened by climate change[139], and are already breeding later in response[140]. And like other species in the Antarctic ecosystem, they are affected by human pollution, including DDT used in other parts of the world and found to accumulate in their bodies[141].

INVERTEBRATES

Even though these animals do not have backbones, invertebrates are critical to the backbone of the Southern Ocean ecosystem. These incredible animals, including worms, clams, crustaceans, octopuses, snails, and sea stars, appear to have had an evolutionary field day in the isolated frigid waters of Antarctica. From the tiny bone-eating worms to the largest invertebrate species known on earth, these organisms have developed bizarre and unique adaptations as diverse as the species themselves.

Antarctica is known for its spectacular underwater geological formations including seamounts, canyons, and ridges that support unique and diverse invertebrate species assemblages. Combined with the continental shelf, these special places host rich benthic communities dominated by invertebrates like bivalves, polychaetes, and sea stars. These organisms in turn provide habitat for others, such as the glass sponge, which some fish species use as a place to lay hundreds of eggs, or urchins that provide elevated habitat for other species.

Invertebrates are also crucial to the pelagic and sea-ice portions of the Southern Ocean ecosystem. While many invertebrates are important prey, Antarctic krill (*Euphausia superba*) are considered to be the keystone species supporting the entire Antarctic food web. Other zooplanktonic invertebrates are important for energy transfer: copepods transfer plant energy up the food web, and gelatinous salps export nutrients to the deep sea through rapid excretion.

New invertebrate species are being discovered every year in the waters surrounding Antarctica, and little is known about the biology and distribution of the species already known to science. Antarctic invertebrates are extremely vulnerable to climate change and ocean acidification, the consequences of which are expected to cascade through the entire Antarctic food web. Read on to learn about a few of our favourite Antarctic invertebrates that need protection from the combined threats of climate change, ocean acidification and fishing.

Image by Uwe Kils

22 Antarctic Krill

Euphausia superba

The Antarctic krill lives up to its name (*superba* means magnificent or superb in Latin). No other species is considered to be as central to the functioning of Antarctic ecosystems. Everything from small fish to huge whales depends on Antarctic krill for survival, which is why their response to climate change is the focus of many scientific studies. Krill are small shrimp-like crustaceans of about 6 centimetres in length. They are found throughout the Southern Ocean, and they form very large swarms of billions of individuals in some areas. They mostly eat plant plankton, or algae growing on the underside of sea ice, and therefore transfer plant energy to species higher in the food web, an important ecosystem function.

Because they are so critical to the ecosystem, krill have long been a particular focus of scientists and policymakers. Concerns about the impacts of the development of a fishery for krill were an important consideration in the decision to establish CCAMLR, which implements the ecosystem and precautionary approaches to management. Unfortunately, these may not be enough to protect them. Climate change impacts such as warming leading to reduced sea ice and ocean acidification are projected to have a negative effect on Antarctic krill habitat, particularly in the Weddell Sea[142], which could adversely affect their predators[143]. The life cycle of krill is linked to the availability of sea ice, which provides feeding grounds in the winter as well as nursery grounds for larvae[144]. Nevertheless, CCAMLR can take these impacts into account to ensure that the fishery does not stress krill populations even further. This will be a critically important task in the coming years.

Krill mostly eat plant plankton, or algae growing on the underside of sea ice, and therefore transfer plant energy to species higher in the food web

23 Antarctic Anemones

order Actiniaria

Antarctic anemones are an interesting group, and new species discovered in the past few years have revealed more about the diversity of this group. Two species of anemones, *Isosicyonis striata* and *Isosicyonis alba*, have only been fully studied relatively recently[145]. They are usually a few centimetres tall, and are pinkish or brownish in colour. *Isosicyonis striata* has stripes. Despite their small size and unexceptional appearance, the species of this genus have a few remarkable traits. *I. striata* has an unusually high number of nematocysts, cells that fire stinging barbs for protection or to capture prey[146]. Most unique is the relationship both species have with Antarctic sea snails. The sea snails host the anemones on their back, and appears to almost merge with them. Further details of this relationship are not yet known[147], but one hopes that the snail gets something in return for hauling the anemone all over the seafloor.

***I. striata* has an unusually high number of nematocysts, cells that fire stinging barbs for protection or to capture prey[146].**

Another new anemone species, *Edwardsiella andrillae*, has adopted the puzzling strategy of living on the underside of the ice shelf–upside down[148]. Most anemones prefer more hospitable surfaces, such as the seafloor (or snail shells), and no other anemone species is known to latch onto ice. *E. andrillae* burrows most of its body into the ice shelf, with only the tentacles exposed and in the water. Scientists are not yet sure how they can do that, since they don't appear to have any special adaptations that would allow them to get through hard ice[149]. Sea anemones have also been found in the very deepest Antarctic waters. One recently identified species, *Iosactis antarctica*, makes its home in soft seafloors in depths of 2800 to 3200 metres[150]. Antarctic anemones clearly are able to make the most of any habitat they encounter.

Source unknown

24

Colossal Squid

Mesonychoteuthis hamiltoni

Despite its enormous size, the colossal squid remains the most elusive animal of the Southern Ocean, living in depths of more than 2000 metres. With a mantle length of up to 4 metres[151] and a record weight of 500 kg, it is the world's largest invertebrate[152]. It has huge eyes, a large beak and hooks on the clubs at the end of its tentacles. With these characteristics, it sounds like a real-life sea monster. However, as a rather slow-moving species that ambushes its prey[153], its behaviour is unfortunately not very monster-like. The colossal squid is an apex predator, feeding on large fish such as Antarctic toothfish, but, especially as a juvenile, it is also important prey for toothfish[154], sleeper sharks and sperm whales[155].

Most of what we know about these mysterious creatures comes from accidental encounters. Colossal squid occasionally are hauled in by longliners fishing for toothfish. When the squid try to pluck a free dinner off the lines, they sometimes refuse to let go even when the line is hauled back onto the fishing vessel, resulting in the retrieval of all or part of the animal. Other information about them has been gleaned from examining the stomach contents of toothfish and sperm whales.

With a mantle length of up to 4 metres[151] and a record weight of 500 kg, the colossal squid is the world's largest invertebrate[152]

One specimen obtained from a New Zealand fishing vessel in 2007 was pulled in on a fishing line intact, and is now on display at the Te Papa Museum in Wellington. This squid's eye measures 27 cm across, which is the largest known animal eye. However, its beak is smaller than some of those that have been found in sperm whale stomachs, indicating that perhaps this squid had not reached its maximum size. We clearly still have a lot to learn about these deep-sea giants.

25

Antarctic Sea Spiders

class Pycnogonida

When you think of Antarctica, you probably think of gorgeous icescapes and charming animals. You probably don't think about a place swarming with spiders. Yet the Antarctica of stunning scenery is the same place where hundreds of sea spider species (pycnogonids) lurk in the water. In fact, there are well over 200 different species of sea spider in the Antarctic and sub-Antarctic[156], with 20% of all pycnogonid species living in that area[157]. The diversity of Antarctic sea spiders may be greater than that found in warmer areas of the ocean, with some regions such as the South Shetland Islands and the eastern Weddell Sea having particularly high numbers of distinct species[158].

Antarctic sea spiders live in both shallow and deep waters, proving that there are few corners of the world safe for those terrified of arthropods. Because they are not actually arachnids, they do not look like typical land spiders, with bodies that are much smaller and thinner and extremely long legs. Some species are also quite large. The leg span of the species *Colossendeis megalonyx* can reach 50 cm across, while other species have leg spans as small as 3 cm[159].

There are well over 200 different species of sea spider in the Antarctic and sub-Antarctic[156], with 20% of all pycnogonid species living in that area[157].

They eat mostly invertebrates[160]. When they aren't draining the liquids from their prey, the males of some species act as incubators, carrying around eggs and sometimes the larvae of their offspring[161]. These creepy Antarctic inhabitants are quite fascinating, and despite being well-studied, we are still learning more about them and discovering new species.

Image by Hartmut Olstowski

26

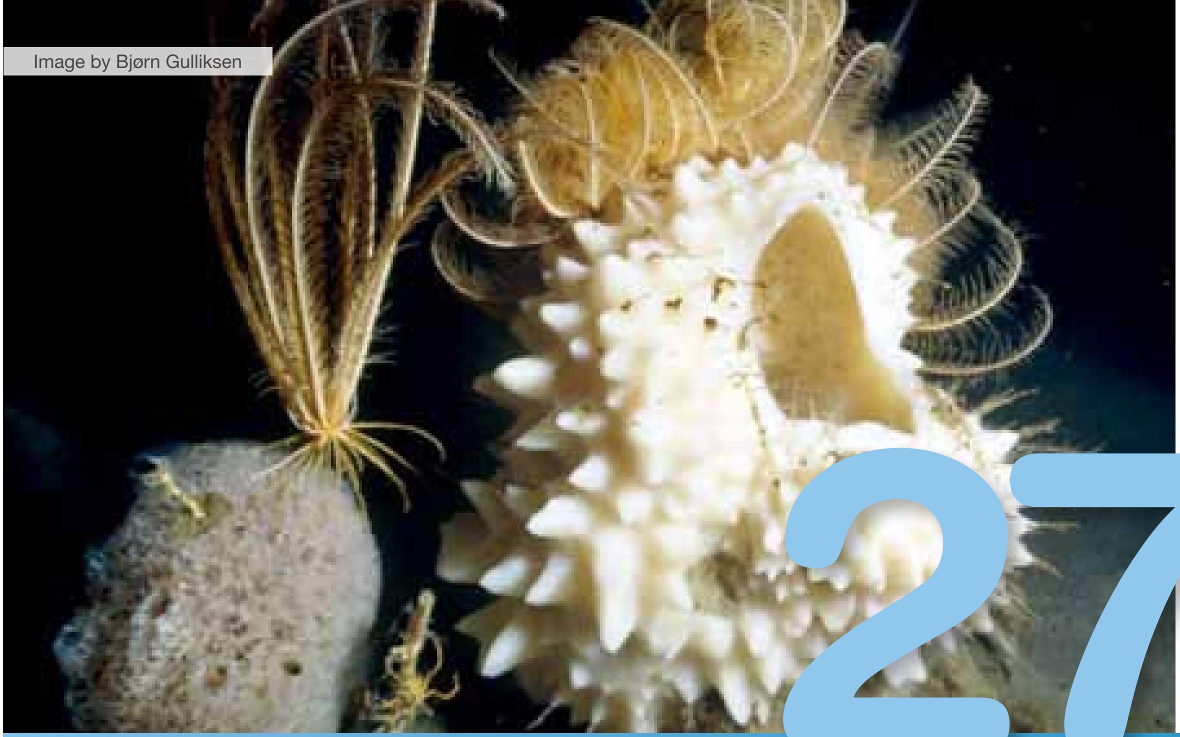
Salps

Salpa thompsoni and *Ihlea racovitzai*

Salps (*Salpa thompsoni and Ihlea racovitzai*) have received some negative publicity in the past few years. These marine invertebrates are tunicates, which are part of the subphylum that includes sea squirts, and thus are filter feeders and low in the food web. In 2004, an important study of the relationships between salps and another prey species, Antarctic krill, determined that warming temperatures benefited salp populations while harming krill, potentially causing problems for animals that eat krill[162]. Salps are clear, gelatinous blobs and may not be as appetising as krill to predators, who would be deprived of a major food source. Although population increases may pose a problem for large swaths of the Antarctic ecosystem, it might not be all bad. Some evidence suggests that salps may be a more popular and nutritious food source than previously thought, with their tendency to move slowly a bonus for predators and their fellow zooplankton[163]. Krill and other tiny crustaceans seem to feed on them as well[164]. Some crustaceans even enter the salp and feed on its insides, then make the leftover shell their new home[165].

Salps excrete faecal pellets containing lots of nitrogen and carbon, and these pellets fall down to deep sea areas where not a lot of these nutrients are available[166].

Another benefit of salps is their waste, which benefits the marine environment. Scientists, who probably are not allowed to talk about their work at the dinner table, have measured the content and rate of salp defecation, with intriguing results. Salps excrete faecal pellets containing lots of nitrogen and carbon, and these pellets fall down to deep sea areas where not a lot of these nutrients are available[166]. Therefore, salps can potentially provide a valuable source of organic material for creatures that live on the seafloor. Nevertheless, changes in the salp population are indicators of potentially widespread impacts on the Antarctic ecosystem from climate change. Despite their contributions to the ecosystem, their expansion may spell trouble for krill predators unless they can develop a taste for tunicate.



27

Glass Sponges

class hexactinellid

This year, it was reported that a human woman has lived to be 120 years old[167]. If the glass sponges that live in Antarctica could read, they would be utterly unimpressed by this news. Glass sponges are a type of long-lived, deep-sea sponge found throughout the world, but are especially numerous in Antarctica[168]. They are thought to live hundreds and perhaps thousands of years, so making it to 120 is quite easy for them. They get their name from their skeletons, which are composed of silicon dioxide, the same material we use to make glass.

Although their lifespan is exceptionally long, in some ways it is not surprising. Glass sponges are suspension feeders feeding on plankton[169], but most live at depths where plankton is in relatively short supply (1000 m or more). Even Antarctic species that live in shallow depths of 30-40 m, such as the glass sponge *Rosella nuda*, have limited food because they live in ocean areas where plankton is not abundant at any depth[170]. Slow growth rates and long lives mean that glass sponges can survive without needing as much food as other organisms might[171]. However, recent research suggests that glass sponges can grow quickly when the opportunity arises, such as when an ice shelf collapses[172]. The collapse of the Larsen A ice shelf created new open-ocean areas in which plankton could grow, and this new food source appears to have allowed glass sponges to move fairly quickly into formerly ice-covered areas[173].

They are thought to live hundreds and perhaps thousands of years.

The ability of these species to move into new areas is very important for seafloor communities. Glass sponges are important components of Antarctic seafloor life, providing food as well as shelter and transforming the ocean floor into a habitat for other species such as small mollusks and polychaetes[174]. Fish have been found to deposit thousands of eggs onto a single glass sponge[175]. They also shelter the juveniles of many species, including brittle stars and sea spiders[176]. Because sponges are so critical to the broader ecosystem, policymakers have designated special areas in Southern Ocean where fishing gear that touches the seafloor is not allowed so that it will not disturb or kill them[177]. Given that their usually slow growth means they will recover slowly from disturbance, such protection efforts are necessary to protect the whole community of bottom-dwelling animals.

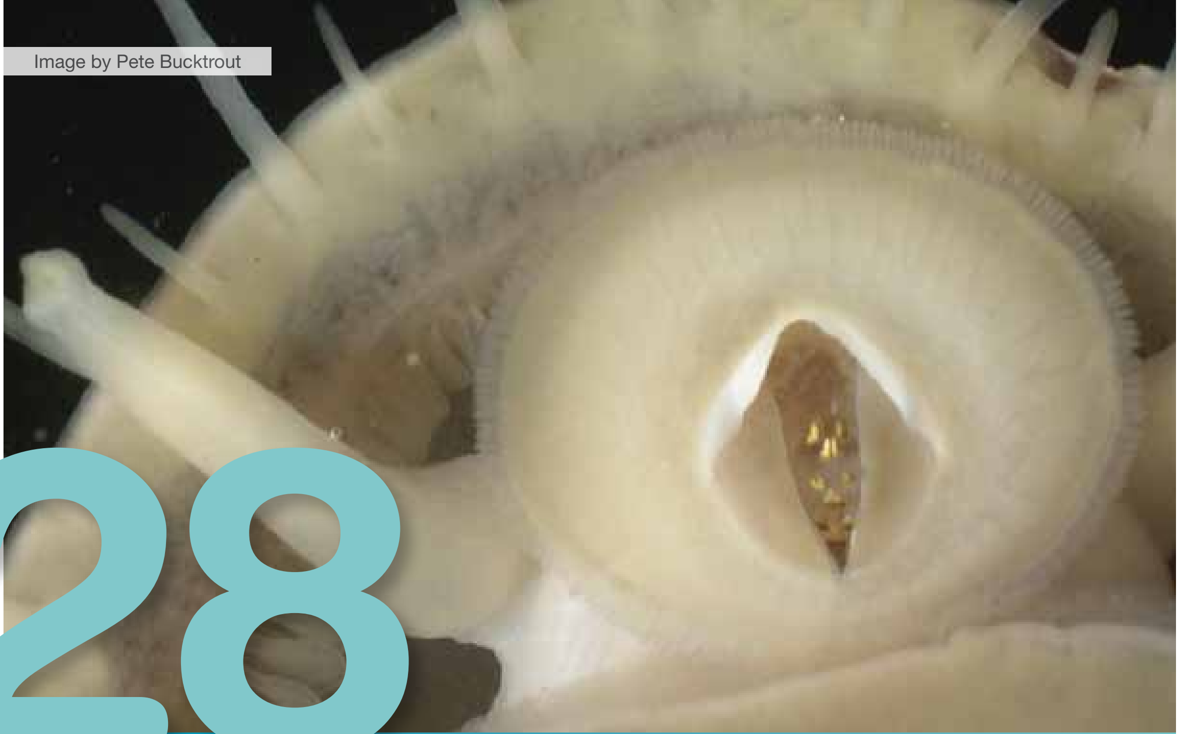


Image by Pete Bucktrout

28

Southern Ocean Mollusks

phylum Mollusca

Currently 163 species[178,179] of bivalve mollusks (e.g., clams, oysters, mussels, scallops) and 568 species[180,181] of gastropod mollusks (e.g., snails, slugs, nudibranchs) have been discovered in the Southern Ocean. There have been 195 new species described since 2003[182], and new species continue to be discovered[183]. While parts of the continental shelf, Western Antarctic peninsula, and Subantarctic islands have been sampled; more species may be discovered in these areas and via exploration of deeper waters[184].

Most Antarctic bivalve and gastropod species are rare, and relatively few have circumpolar distributions[185]. Recent research has discovered thriving ecosystems rich with species new to science including species of mollusks and other invertebrates like sponges and worms. These mollusk “hot spots” are found on unique geological formations throughout the Southern Ocean including parts of East Antarctica (Maud Rise[186], Gunnerus Ridge, Enderby, Prydz, Wilkes, MacRobertson, and d’Urville Sea-Mertz seamounts)[187], Bouvetøya[188], Peter I Island[189], and South Orkney[190] and South Georgia Islands[191] near the Antarctic Peninsula.

Far from being only passive filter feeders, mollusks increase oxygen concentration in upper sediment layers via bioturbation – the natural mixing of sediments through biological processes[192]. Many important predators, including Weddell seals[193] and fishes[194,195] rely on mollusks for food. A natural product called lovenone found in the skin of the nudibranch Adalaria loveni has shown toxicity against certain human cancer cells[196].

Many important predators, including Weddell seals[193] and fishes[194,195] rely on mollusks for food.

Scientists are still discovering new species and understanding their ecosystem services, but even as we begin to learn about them, Antarctic mollusks are at risk[197]. Antarctic calcified organisms are particularly vulnerable to increasing ocean acidification[198] because many are weakly calcified[199]. As the ocean acidifies, it can result in the calcium carbonate-based shells of invertebrates dissolving. In their absence, the communities they compromise are likely to be among the first to experience the cascading impacts of ocean acidification[200].

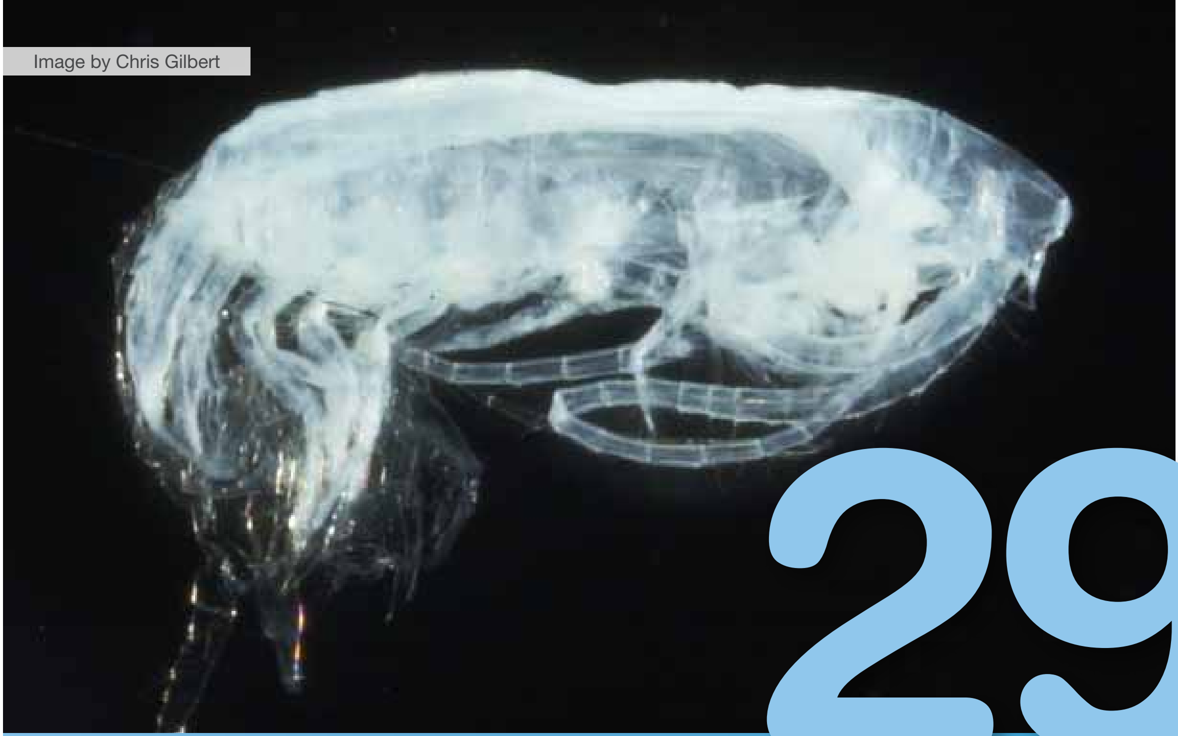


Image by Chris Gilbert

29 Copepods

subclass copepoda

In the Antarctic, the crustaceans that get all the attention are krill, which are certainly a major food source for a huge variety of species. But they are not the only ones propping up the upper levels of the food web. At 1–2 mm in size, copepods are smaller than krill, and in fact are eaten by them, but they comprise a large percentage of the zooplankton floating at the top of the water column. One study of zooplankton in the Weddell Sea found that copepods were the most numerous and had the most number of distinct species[201]. In addition to being eaten by krill, they are also eaten by silverfish and lanternfish, and in some areas may be part of an alternative pattern of energy transfer to organisms higher up in the food web[202]. Typically, krill are often considered the primary link between plant plankton and upper level predators such as fish, penguins and whales. However, scientists have reported an alternate scenario in which copepods, lanternfish and squid are the link instead of krill[203]. Even in the famously krill-centric ecosystem of Antarctica, there can be surprises.

When ice melts and blooms form, plankton eaters and the animals that eat them have to take advantage of the short-lived feast.

Since copepods are dependent on plant plankton for food, they are strongly influenced by seasonal changes in ice[204]. Many Antarctic species similarly have life cycles tied to the formation and melting of sea ice because plankton blooms do not occur under ice. When ice melts and blooms form, plankton eaters and the animals that eat them have to take advantage of the short-lived feast. Different copepod species respond to these seasonal changes in different ways. Some copepods show slower metabolic rates in pack ice compared to ice edge or open ocean regions[205]. They additionally time reproduction to coincide with plankton blooms[206]. Copepods may also be affected by climate change[207], highlighting the potential for warmer temperatures to affect the ecosystem at every level.


Image from AOA archive

30

Antarctic corals

subclass octocoralia

Like many of their Antarctic counterparts, Antarctic corals remain little known, lacking the popularity of their tropical relatives. But there are corals in Antarctica, proving once again that the Southern Ocean has everything you'd want in an ocean, except warm, sunny beaches. While many corals are in the deep sea and are therefore difficult to study, there have been some interesting research findings. While some species of coral possess stinging cells called nematocysts that can ward off predators, some Antarctic corals do not have very good nematocysts. Instead, they give off chemicals that send a strong message to stay away. An order of soft corals called the Alcyonaceans, eight species of which live in Antarctic waters, produces compounds that seem to keep sea stars and amphipods away, and kill bacteria[208,209].

There are corals in Antarctica, proving once again that the Southern Ocean has everything you'd want in an ocean, except warm, sunny beaches.

Although producing chemicals that keep predators away is a pretty ingenious adaptation, one Alcyonacean, *Gersemia antarctica*, has another amazing adaptation. To feed on seafloor sediments, it bends itself over, brushes against the sediments, and stands back up again. Then it picks itself up and moves to find new sediments to eat[210]. If you're thinking that you weren't aware that coral can move, you are not alone. No other soft coral has been known to do this. Thus Antarctic corals are yet another incredible species populating the rich and diverse Antarctic seafloor. They provide yet another reason to study and map these habitats, so that they can be sufficiently protected from potential damage by human activities.

Image by Thomas Dahlgren

31

Bone-eating worms

Osedax antarcticus and *Osedax deceptionensis*

All over the world, bone-eating worms seek out fallen whale and fish bones resting in sediments deep in the ocean. Until recently, it was unknown whether there were any in the Antarctic. A group of scientists suspected that the large number of whales in the Antarctic would provide a good food source for these worms, and hypothesised that there were likely to be previously undiscovered species in the Southern Ocean[211]. The researchers therefore placed whale bones in the Southern Ocean in a few locations around the Antarctic Peninsula, and left them for a year. Upon retrieving the bones, they found large numbers of worms devouring them. Just one rib had 202 specimens within 100 square centimetres. They determined that these worms constituted two new species. The most abundant species, *Osedax antarcticus*, has red frond-like body parts called "palps" that stick out of the bone while the rest of the body burrows into the bone. Only one individual of the other species, *Osedax deceptionensis*, was found[212].

All bone-eating worms, including *O. antarcticus*, lack sharp teeth or other body parts that can cut through bone, and instead produce acids that can break it down[213]. As they also lack a digestive system, they rely on symbiotic bacteria to turn the bone into nutrients[214].

Bone-eating worms lack sharp teeth or other body parts that can cut through bone, and instead produce acids that can break it down[213].

Bone-eating worms also exhibit the phenomenon of male dwarfism, in which the male is a mere fraction of the size of the female. Multiple males attach themselves to a single female, apparently devoting their entire lives to doing little more than mating with her. In general, larvae of this species develop into females if they happen to land on bone and into males if they land on a female[215]. Males keep their grips on females with chaetae, a type of bristle possessed by many worm species. The existence of Antarctic bone worms, which were only discovered in 2012, highlights both how much we still have to learn about marine ecosystems, and how incredibly diverse marine life can be. Even in the depths of the Southern Ocean, there exist at least two different kinds of worms whose sole purpose in life is to digest whale bones.

Image by Julian Gutt

32 Antarctic Crabs

infraorder Brachyura

While Antarctica is rich in many types of marine life, such as echinoderms and sponges, it has relatively few crustaceans. This is likely because few species can tolerate cold water temperatures[216]. Still, there are plenty of crabs in some parts of Antarctica. There were enough king crabs (*Paralomis spp.*) around South Georgia and South Orkney Islands to try to establish a fishery in those areas. However, the fisheries were not found to be economically profitable, so for now the crabs can rest easy.

Yet maybe not too easy, since some of these crabs have a parasite that renders them sterile[217]. Furthermore, some scientists have further suggested that Antarctica's lack of crabs may not last long because increasingly warmer waters will allow, and already are allowing, species to invade new territories and possibly destroy seafloor dwellers that don't have any adaptations to protect them from powerful claws[218]. Sounds horrifying, but some recent evidence suggests that the situation might not quite be so dire and that there is no invasion so far[219]. As one of the scientists involved notes, though there may be good news on crabs, the apparently conflicting information highlights that there are large gaps in our understanding of Antarctic ecosystems. This could hamper our ability to understand the impacts of climate change, including the impacts of invasive species[220].

Yeti crabs are typically hairy, but the new species has hair is on its chest instead of its limbs[222], leading scientists to nickname it the "Hoff" crab after actor David Hasselhoff[223].

Another kind of Antarctic crab has also drawn media attention recently, but for different reasons. In 2012, scientists reported that during the discovery of deep-sea hydrothermal vents in Antarctica, a new species of yeti crab was also found[221]. These crabs have to deal with the opposite kind of temperature problem as others in the Southern Ocean – the liquid coming out of the vents is at the toasty temperature of 352.6°C. As their name implies, yeti crabs are typically hairy, but the new species has hair is on its chest instead of its limbs[222], leading scientists to nickname it the "Hoff" crab after actor David Hasselhoff[223]. Scientists have not yet discovered whether the crab looks good running down the beach in a red swimsuit. The exciting discovery of these new vents, the first known in the Southern Ocean, illustrates once again how little we know about the deep sea, including its hairy inhabitants.

Image by John B. Weller

33 Antarctic Echinoderms

Phylum Echinodermata

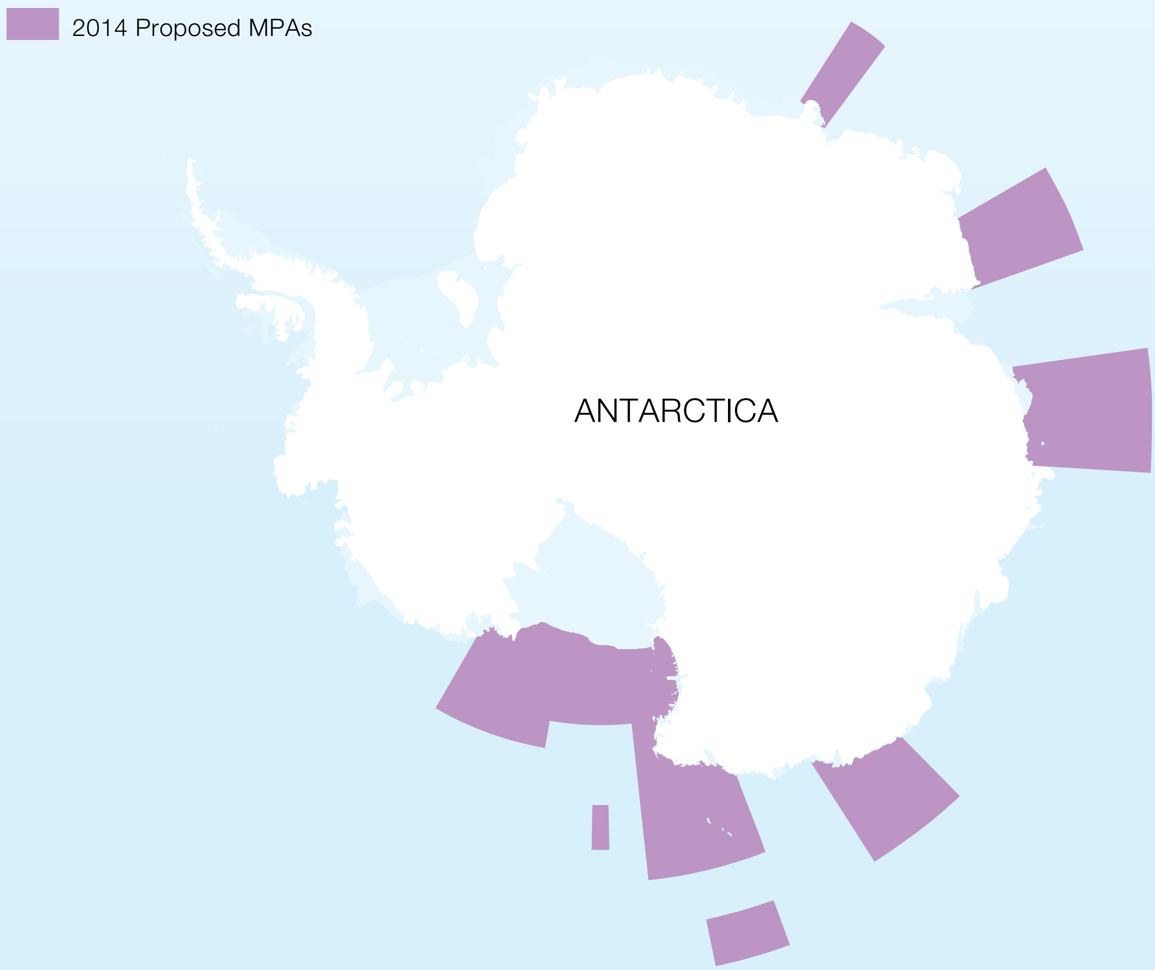
Echinoderms are a phylum of sea animals with a large variation in appearance, encompassing sea cucumbers, sea urchins, and starfish. Though you might think of such species inhabiting tide pools, there are also plenty of representatives dwelling in the Antarctic, including in the deep sea. There are 219 different species of brittle stars (ophiuroids) alone[224]. The Scotia Sea and East Antarctica are the most diverse regions, with over 70 different brittle star species found in each[225]. Antarctica is also home to a species of starfish that can have as many as 50 arms, *Labidiaster annulatus*, and can grow to be over 60 cm[226]. Though it lives on the bottom with glass sponges and other seafloor dwellers, it can eat moving animals such as krill and is one of the few starfish that can do so[227]. The cidaroid sea urchins are another unusual group. Lacking a covering or epithelium on their spines, which repels uninvited guests in other urchin species, they actually seem to attract seafloor animals looking for quality high-rise habitat[228]. Researchers have found that the presence of cidaroids increases local populations of some species and the number of different species represented[229]. Another unusual looking echinoderm is the sea pig, a type of pig-shaped deep-sea sea cucumber with short legs. They live in very deep waters and congregate in herds numbering in the hundreds.

Another unusual looking echinoderm is the sea pig, a type of pig-shaped deep-sea sea cucumber with short legs.

Unfortunately, some recent evidence indicates that echinoderms may be at risk. One of the major impacts of increased carbon dioxide emissions is ocean acidification, the process by which increasing amounts of atmospheric carbon are incorporated into the ocean, decreasing the pH. The poles will experience ocean acidification earlier than other areas, and the more acid environment is expected to have a wide range of impacts on marine species. Analysis of the impacts of acidification on the sea star *Odontaster validus* indicate that at the pH levels predicted to occur in the Antarctic in the near future, fertilisation and larvae will be negatively affected[230]. This would be problematic for them as well as entire seafloor communities, since *O. validus* plays an important role in maintaining the balance of species[231].

MPA Proposals

CCAMLR is currently considering two mature proposals for the Ross Sea and East Antarctic regions. Proposals for the Weddell Sea, Antarctic Peninsula and other areas of the Southern Ocean are underway. It is critically important that CCAMLR designate the current proposals in Ross Sea and East Antarctica in 2014, with no further changes to scale or strength, in order to protect the habitats of the incredible species represented in this report. It is equally important that these and future designations are visionary, and of sufficient scale that they collectively provide comprehensive, adequate and representative protection of the Southern Ocean.



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