THE POLAR WILDLIFE REPORT

Susan Crockford

The Global Warming Policy Foundation
Briefing 63

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Report 63, The Global Warming Policy Foundation

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About the author

Dr Susan Crockford is an evolutionary biologist and has been working for more than 40 years in archaeozoology, paleozoology and forensic zoology.[1] She is a former adjunct professor at the University of Victoria, British Columbia and works full time for a private consulting company she co-owns (Pacific Identifications Inc). She is the author of *Rhythms of Life: Thyroid Hormone and the Origin of Species*, *Eaten: A Novel* (a polar bear attack thriller), *Polar Bear Facts and Myths* (for ages seven and up, also available in French, German, Dutch, Portuguese, and Norwegian), *Polar Bears Have Big Feet* (for preschoolers), and the fully referenced *How the Polar Bear Came to Be (upcoming in 2023)*, *Sir David Attenborough and the Walrus Deception*, *The Polar Bear Catastrophe That Never Happened and Polar Bears: Outstanding Survivors of Climate Change,*[2] as well as a scientific paper on polar bear conservation status and a peer-reviewed paper on the distribution of ancient polar bear remains.[3] She has authored several earlier briefing papers, reports, and videos for GWPF, as well as opinion pieces for major news outlets, on polar bear and walrus ecology and conservation.[4] Susan Crockford blogs at www.polarbearscience.com.

Foreword

This *Polar Wildlife Report* is intended to provide a brief view of the habitat and conservation status of critical wildlife species in the Arctic and Antarctic, with commentary on inconsistencies and sources of bias found in the literature that won't be found elsewhere. It is a peer reviewed summary of the most recent information on polar animals, relative to historical records, based on a review of the 2022 scientific literature and media reports. It is intended for a wide audience, including scientists, teachers, students, decision-makers and the general public.

Executive summary

- There were no reports from either hemisphere in 2022 that would suggest polar wildlife is suffering as a result of reduced sea-ice extent; in both the Arctic and Antarctic, less summer sea ice and increased primary productivity over the last two decades has meant more food for all animals, and explains in part why polar wildlife has been thriving.
- Arctic sea ice in summer has declined since 1979 but the trend flattened after 2007; coverage was again well below average in the Barents and Chukchi Seas in 2022, where continued high primary productivity has provided abundant food resources for wildlife; winter ice coverage in 2022 was slightly lower than 2020, but overall has shown a relatively flat trend since 2011.
- Ice-dependent polar bears worldwide probably now number about 32,000, with a wide range of potential error; a survey of Western Hudson Bay polar bears in 2021 found a population decline of 27% since 2016 that did not correlate with lack of sea ice; a genetically-distinct subpopulation of polar bears was discovered thriving in south-east Greenland; western Barents Sea bears (Norway) are still doing well despite the most profound summer sea ice loss of all Arctic regions.
- Atlantic walrus numbers are still low, but recovering in the Barents Sea and eastern North America; a new population estimate of Pacific walrus in 2019 showed more than 200,000 exist in the Chukchi/Bering Sea area; more killer whales were reported visiting the Eastern Canadian Arctic; in Alaska and the Western Canadian Arctic, bowhead whales are thriving.
- Antarctic sea-ice extent has barely changed since 1979: vital winter ice has slightly increased overall, while summer ice has slightly declined (with its lowest extent in December 2022), all while overall primary productivity has increased; a new sea-ice predictive model acknowledges previous flaws and does not predict a future decline until 2050 at the earliest.
- Krill are crucial prey for many species (especially huge numbers of great whales and penguins) that live or feed in the Southern Ocean; future intensification of commercial fishing of krill (largely to feed farmed fish) is likely the largest conservation threat to local wildlife, given recent geopolitical tensions over effective fisheries management.
- Numbers of fin, blue, humpback, and southern right whales feeding in Antarctic waters in summer have increased in recent years, and while minke whale numbers appear to have declined, an estimated 500,000 individuals still frequent the region.
- Killer whales (orcas) are the top predator in the Southern Ocean and most populations appear to be thriving; all ice-dependent seals in Antarctica are listed as of 'least concern'.
- Several albatross and large petrel species are considered 'vulnerable' due to deadly interactions with long-line trawlers fishing for Antarctic toothfish (aka Patagonian sea bass), while overfishing of this cod-like species and the herring-like Antarctic silverfish are also a concern.
- Emperor penguins, the largest and most ice-dependent penguin species, were classified as 'Threatened' on the US Endangered Species List in 2022 but remain 'Near Threatened' according to the official 'Red List' because of the large size of their breeding population and uncertainty of future sea-ice predictions, which sea-ice experts acknowledge.

1. Introduction

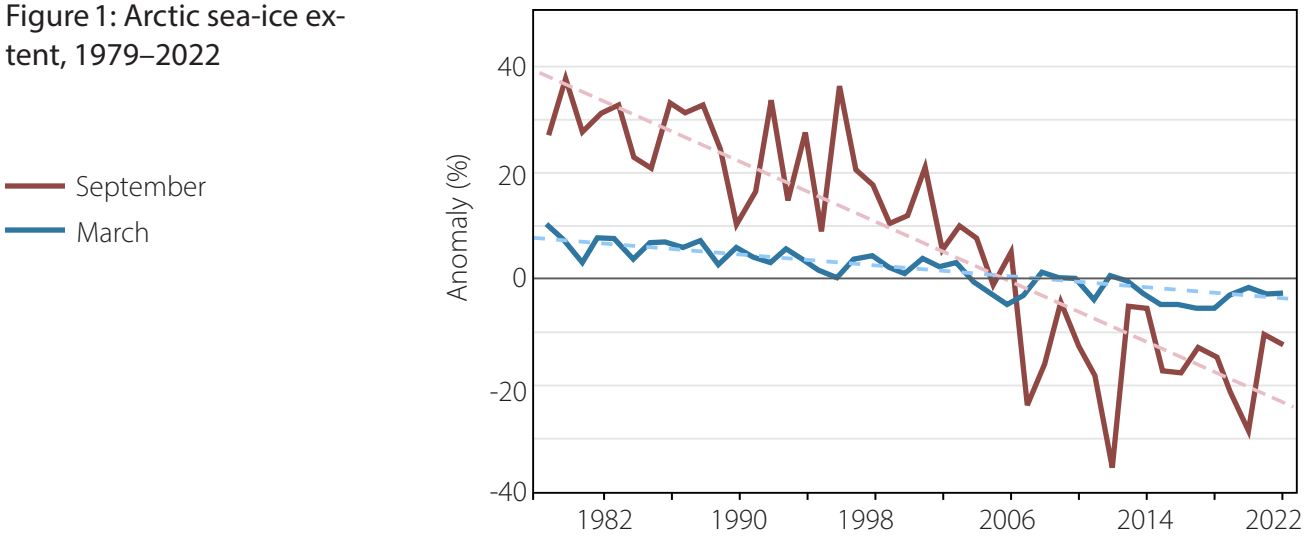
There were no reports from anywhere around the Arctic or Antarctic in 2022 that would suggest that polar wildlife is suffering as a result of reduced sea-ice extent: no starving polar bears or walrus, no beach-cast dead seals, no marked declines in great whale numbers, no drowned penguin chicks. Inuit in Canada reported more polar bear conflicts with humans, more likely to be an effect of more bears and more people rather than less summer sea ice. The only subpopulation of polar bears that appears to have recently declined did not correlate with any reduction in summer sea ice: some other, unknown, cause was to blame. Contrary to expectations, Antarctic sea ice has been increasing since 1979. Inuit in eastern Canada (Davis Strait) report a marked decline in ringed seal numbers since 1950, but otherwise there were no reports of population declines or reduced health in Arctic seals or walrus. A few Antarctic penguin species and the minke whale appear to have suffered a recent decline in abundance that is unrelated to sea-ice cover. Overall, Antarctic wildlife of all kinds appears to be doing well. In both the Arctic and Antarctic, less summer sea ice and increased primary productivity over the last two decades has meant more food for all animals, and explains in part why polar wildlife has been thriving.

2. The Arctic

Sea ice and primary productivity

According to the NOAA Arctic Report Card 2022, summer sea-ice extent (at September) has declined markedly since 1979 (36.5%), although winter ice levels (at March) have declined very little (9.3%) (Figure 1).[5] However, in recent years, the trend in March sea-ice coverage has flatlined (since 2011), driven by strong ice production along the Siberian coast; the trend in summer ice extent has been static since 2007.[6] As a consequence of continued low summer sea-ice extent and reduced ice thickness (which allows beneficial under-ice phytoplankton blooms in summer),

Figure 1: Arctic sea-ice extent, 1979–2022



studies show primary productivity in many regions has continued to climb between 2003 and 2022, especially in the Barents and Chukchi/Bering Seas. Even production of bottom-dwelling phytoplankton has been increasing in some regions.[7] These phytoplankton blooms provide abundant food for all organisms in the Arctic food chain, including zooplankton ('krill'), benthic invertebrates (such as clams), fish, and marine mammals.[8]

Sea-ice conditions vary regionally across the Arctic in all seasons (Figure 2 shows the locations of the areas discussed). In 2022, winter sea ice at the end of March was low in the Sea of Okhotsk and western Barents Sea but more abundant than usual in Baffin Bay and the Bering Sea. In September, some ice persisted in the Chukchi Sea, which also happened in 2021; however, extent was below normal elsewhere except in the Barents and East Greenland Seas, which had about average ice coverage.[9]

Figure 2: Arctic regions.

Western Hudson Bay (WH) sea-ice coverage and its relationship to polar bears are often considered a 'bellwether' indicator for conditions predicted in a warmer world. Since the abundance of WH polar bears as it relates to length of the ice-free period is now used as a proxy for all other subpopulations, these bears and their sea-ice habitat figure disproportionately in predictions of future species survival and health of the planet in general.[10]

In 2022, breakup of sea ice along Western Hudson Bay was about what it had been in the 1980s (11 July ± 4 days), although a large number of bears tagged a few months earlier by researchers stayed on rapidly-declining sea ice until late August.[11] Most bears, even those that came ashore earlier than others, appeared to be in good condition.[12] In the fall, freeze-up was also like it had been in the 1980s (Nov. 16 ± 5 days).[13]

Summer breakup dates after 2015 have yet to be incorporated into the scientific literature.[14] However, a report by Erin Miller and colleagues in 2022 provided new fall freeze-up dates to 2020: these have been similar to dates in the 1980s (Nov. 16 ± 5 days) except in 2016 when ice didn't form until the first week of December.[15] The authors found no statistically significant temporal trend in sea ice or departure dates of polar bears from shore between 1991 and 2020, contradicting statements often found in the media that WH fall sea-ice coverage has been steadily declining over the last 30 years.[16]

Polar bears

Polar bears are the apex predator of the Arctic. They currently have a relatively large population size, and there has been no change in their historical range since 1979. The International Union for the Conservation of Nature (IUCN), in their 2015 Red List assessment, again listed the polar bear as 'Vulnerable' to extinction, and in 2016, the US upheld its 2008 decision to list the species as 'Threatened' under the US Endangered Species Act.[17] Both decisions were based on computer-modelled future declines, not observed declines. In Canada, where roughly two thirds of entire population lives, polar bears were listed as a species of 'Special Concern' in 2018.[18]

The latest IUCN Polar Bear Specialist Group (PBSG) estimate, published in July 2021, is 26,000 (range 22,000–31,000),[19] but took the lowest of several recent estimates available for the Chukchi Sea and ignored figures used in the 2015 IUCN assessment for the Kara and Laptev Seas.[20] Survey results postdating the 2015 assessment plausibly bring the mid-point total to about 32,000, with a fairly wide margin of error (Figure 3).[21] This is much more than the 7,493 (6,660–8,325) bears the public was assured would be all that would remain[22] given the sea-ice conditions since 2007.[23]

For a detailed discussion of the status of all 19 subpopulations, see the *State of the Polar Bear Report 2020*.[24] In 2022, the official government report on the 2017–2018 Davis Strait subpopulation survey was finally made available.[25] It confirmed

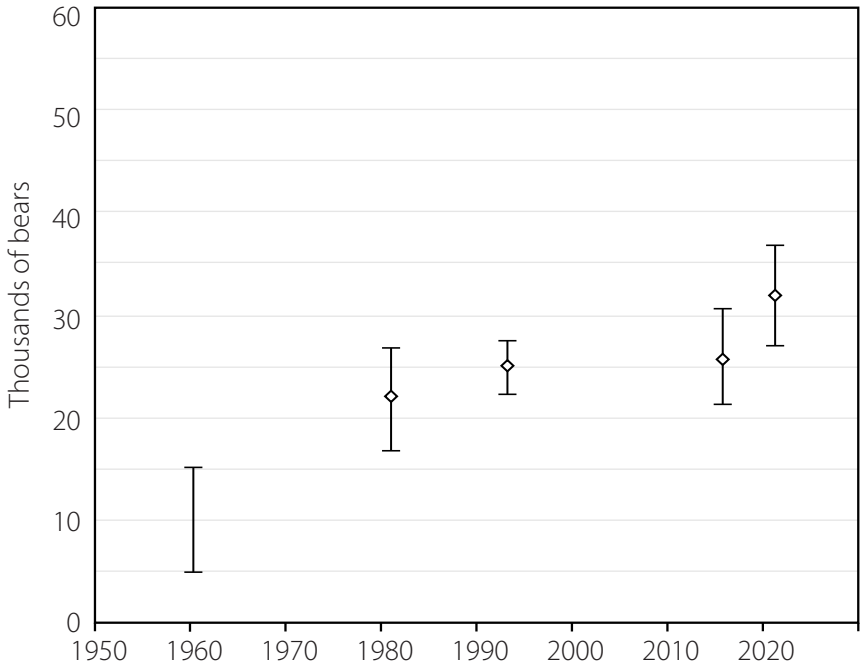


Figure 3: Estimates of the global polar bear population

1960 to date. The 1981, 1993, and 2015 estimates are from the IUCN PBSG, 1960 from Crockford 2019 (pp. 102–105) and Anonymous 1966 (p. 11), and the 2021 estimate is from Crockford 2022.

earlier news reports of an estimate of 2,015 bears (range 1,603–2,588), statistically indistinguishable from the 2007 estimate of 2,158 (range 1,833–2,542). What hadn't been made public by the media earlier was that no correlation had been found between polar bear survival and sea-ice conditions (e.g. neither length of ice-free period or mean summer sea-ice concentration). An increased harvest rate *was* considered to be a concern. Other evidence – especially bears in better condition in recent years compared to 2007 – suggest the Davis Strait population may be stable or even increasing, although the authors suggest a stated Nunavut management objective to reduce the subpopulation had been successful.[26]

Also in 2022, some results of an aerial survey of Western Hudson Bay in late summer 2021 were released to the media, but the government report with full details was withheld. Although a 27% decline in numbers since 2016 was reported (618, compared to 842 in 2016), it was emphasised that this phenomenon did not correlate with a decline in WH sea-ice coverage: instead, an unexplained lack of ringed seal prey was suggested as an explanation.[27]

Overall, bears in virtually all regions have been reported to be in good condition in recent years. Improved body condition has been reported for Davis Strait bears in 2017/2018 (compared to those examined a decade before) and more recently for bears in M'Clintock Channel, Gulf of Boothia, and Kane Basin in the Canadian Arctic, confirmed by on-the-ground experiences of Inuit in Davis Strait and Gulf of Boothia.[28] In the Svalbard region of the Barents Sea, the body condition of male bears in the spring of 2022 was below what it had been in 2021 and well below 2019, but well within the natural range of variation since 1993 (conditions in 2003 were worse).[29]

Despite concerns that continued low summer sea-ice coverage would precipitate more conflicts between polar bears and people, it hasn't quite worked out as expected.[30] While Inuit in Canada, especially, have noted more problems with bears compared with previous decades, they usually attribute this phenomenon to more bears, not less ice, and some residents have pointed out that polar bears tend to be more aggressive when their population densities are high.[31] A perceived increase in problems with bears visiting garbage dumps across the Arctic in recent years has also been blamed on hunger, although with little evidence.[32] An alternative explanation is an increase in human population (and thus more garbage) *and* higher polar bear numbers over the last six decades (Figure 3).[33]

Overall, recent data collected from across the Arctic, but especially in the western Barents Sea and Western Hudson Bay, do not support the assumption, stated repeatedly by scientists in the field, that summer sea-ice loss inevitably leads to reduced polar bear survival: in WH, a population decline of 27% over five years was not associated with any lack of ice, and in Svalbard, polar bears are still doing well despite the greatest summer sea-ice loss of all Arctic regions.[34]

Walrus, seals, and whales

Ringed seals (*Pusa hispida*) and bearded seals (*Erignathus barbatus*), and particularly their pups, are critical prey of polar bears across the Arctic.[35] In some regions, other seal species, walrus (*Odobenus rosmarus*), beluga (*Delphinapterus leucas)*, and narwhal (*Monodon monoceros*) are consumed as well,[36] and bears may also scavenge the carcasses of bowhead whales (*Balaena mysticetus*) that have died naturally or as a consequence of indigenous hunting.[37] These species are also important food resources of indigenous Arctic peoples, and healthy populations are critical to human survival in the Arctic.

Walrus

In 2017, the US Fish and Wildlife Service determined that the Pacific subspecies of walrus (*O. r. divergens*) no longer required the statutory safeguards it had enjoyed since the Marine Mammal Protection Act of 1972.[38] In 2022, the latest population assessment for Pacific walrus in the US portion of the Chukchi Sea was published, with the total put at 189,000 (135,000–251,000) in 2019, based on animals counted at Point Lay, Alaska in late summer.[39] As this 'most accurate to date' estimate did not include animals located in the Russian portion of the Chukchi Sea or the southern Bering Sea at the time of the survey,[40] it seems likely the entire Pacific walrus population count is well over 200,000, despite continued summer sea-ice loss in the region. This is similar to an estimate from 2015 (283,213; range 93,000–478,975).[41]

In contrast, the Atlantic walrus subspecies (*O. r. rosmarus*) has not rebounded from historical overhunting to nearly the same extent, but the numbers are recovering regardless: it was

classified by the IUCN in 2016 as 'near threatened', an important step below 'vulnerable', which took into account healthy population numbers (about 25,000 at that time). Even as summer sea ice declined markedly, the Svalbard population increased by 109% between 2006 and 2018 (and 42% between 2012 and 2018), for a final estimate of 5,503 (Figure 4).[42] However, since walrus are notoriously difficult to count accurately, this is almost certainly an underestimate.[43] In neighbouring Russian territory of Franz Josef Land, walrus numbers in 2017 were estimated to be approaching 'pre-hunting levels' of 9,000–11,000.

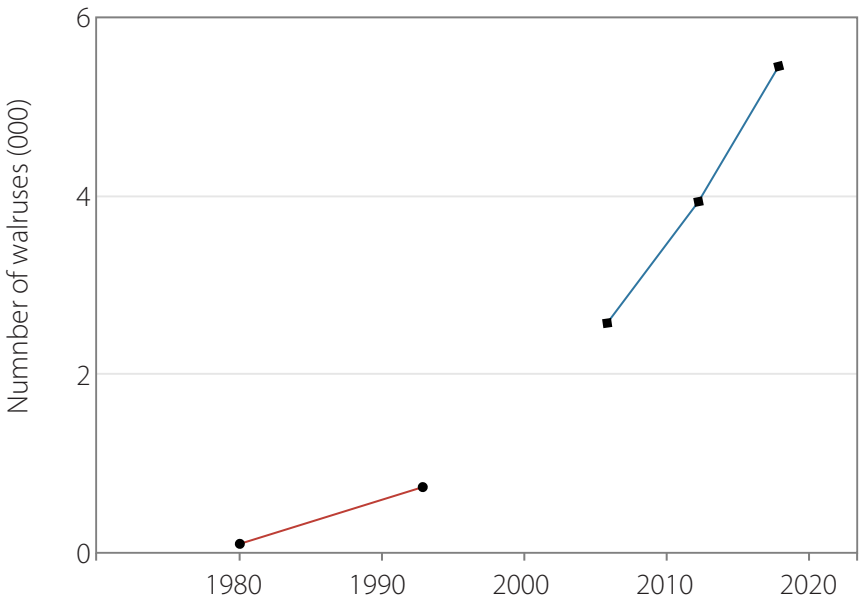


Figure 4: Walrus population in Svalbard since 1980

The numbers on the graph start with two baseline estimated numbers provided in 1980 and 1993 (1980 = 100 and 1993 = 741), and conclude with population counts from aerial surveys done in 2006, 2012, and 2018 (2006 = 2629; 2012 = 3886; 2018 = 5503). From Norwegian Polar Institute 2022d.

On the other side of the Atlantic, Inuit in Eastern Canada have noticed that walrus seem to be moving seasonally in response to sea-ice changes, but consider the walrus to be 'not at risk', given an estimated 21,400 individuals in 2021. In spite of this, the Canadian government Species at Risk Act listed the Atlantic walrus as of 'special concern' in 2017.[44]

Seals

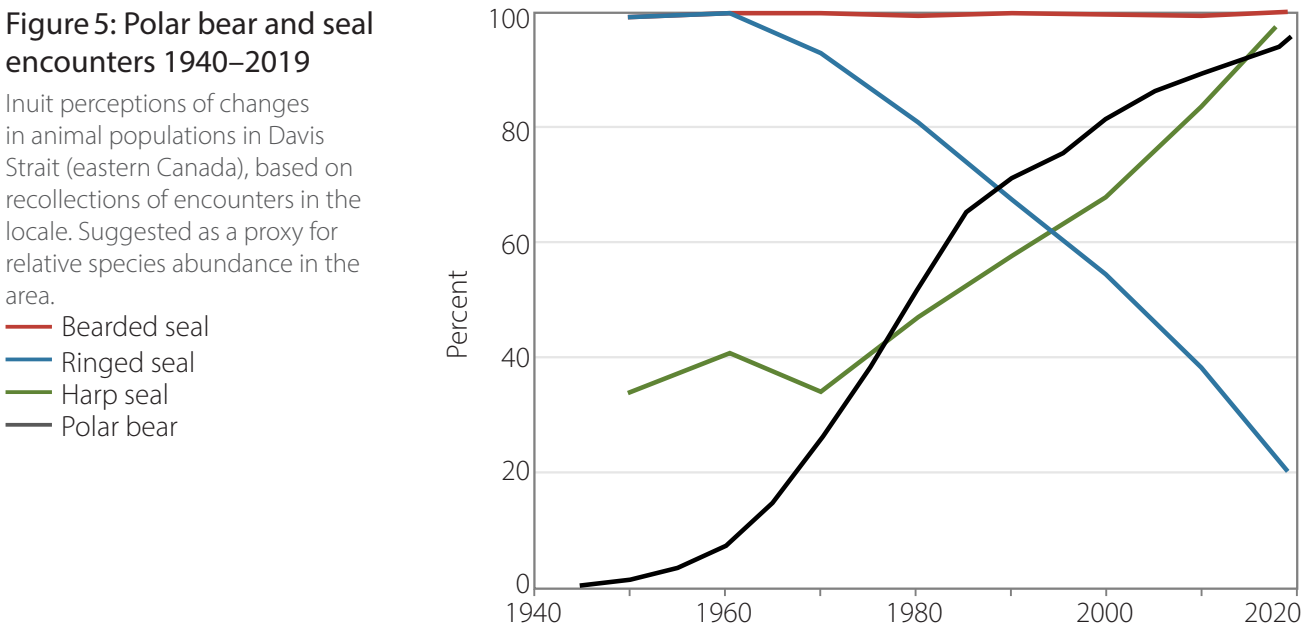
A report by Nunavut Inuit in the Davis Strait region of eastern Canada revealed that (Figure 5):

- Numbers of bearded seals have been unchanged over the last seven decades.
- Harp seal and polar bear numbers have steadily increased from very low abundance.
- Ringed seals, which used to be very abundant, have steadily declined.[45]

While a marked decline in ringed seal numbers in Davis Strait since the 1950s has not been reported by biologists, it appears that no studies have been done. Furthermore, as this region connects via Hudson Strait to critical polar bear habitat in Hudson Bay, a region-wide decline in ringed seal numbers might explain

Figure 5: Polar bear and seal encounters 1940–2019

Inuit perceptions of changes in animal populations in Davis Strait (eastern Canada), based on recollections of encounters in the locale. Suggested as a proxy for relative species abundance in the area.



the recent polar bear population decline in Western Hudson Bay, as discussed above. Possibilities offered by Inuit to explain the decline in ringed seals included: an increase in polar bear predation (especially during the pupping season); an increase in community harvests; ringed seals moving to other areas (either following prey, or due to displacement by other species); lack of sea ice; warmer ocean waters; increase in fox predation; and changing winds.[46]

Whales

Although some scientists are worried about the future of narwhal and beluga in the Arctic, at this time there is no evidence that most subpopulations of these species are struggling due to reduced sea-ice coverage in summer.[47] On the other hand, research on bowhead whales in the western Arctic has revealed a marked increase in numbers over the past 30 years, despite recent sea-ice changes and aboriginal subsistence hunting. The study authors suggest this is likely due to increases in ocean primary productivity.[48]

Historically, killer whales (orcas, *Orcinus orca*) have been rare visitors to the Arctic. However, scientists have noted an increase in sightings, especially in the Cumberland/Lancaster Sound region of the eastern Canadian Arctic and in Hudson Bay, which seems to be correlated with reduced summer sea ice. However, the same phenomenon has been noted in the Gulf of St Lawrence (which is always ice-free in summer), indicating that the influx of the predatory whales might have another cause (Figure 5).[49] Perhaps not coincidently, in the summer, thousands of pregnant beluga whales* (known to be preyed upon by killer whales) use the Cumberland/Lancaster Sound area in the High Arctic and western Hudson Bay, especially to give birth and nurse their newborns, while a few hundred reside year-round in the

* Note that belugas inhabit Arctic and sub-Arctic waters of North America and Eurasia but oddly not Eastern Greenland.

Figure 6: Summary of killer whale population movements

1. Lancaster Sound, Cumberland Sound. 2. Hudson Bay. 3. St Lawrence Estuary. Reference: Halliday et al. 2022.

St. Lawrence River estuary.[50] Contrast this relative rarity of killer whale sightings in the Arctic during the summer to the tens of thousands estimated to frequent the Southern Ocean, including pack ice habitat *in winter* (Section 7). This suggests these predatory whales do not have an inherent aversion to sea ice.

Birds and fish

Birds

According to a new report in 2022, most geese species that migrate into the Arctic to breed and raise their chicks remain abundant, with either increasing or stable trends.[51] Lesser snow geese (*Anser caerulescens caerulescens*) and Aleutian Canada geese (*Branta hutchinsii,* a small, formerly endangered subspecies) in the Western Arctic (Bering/Chukchi Seas) have been doing especially well in recent years.[52] A report that 450 sea birds died in the Bering and southern Chukchi Seas this year was well below previous years.[53] The authors admit they don't really know the cause of these die-offs but suggest it is most likely to be starvation. A US Fish and Wildlife Service report on the die-off phenomenon in 2016 noted that sea birds can starve to death if they haven't eaten in as few as four days, which makes them vulnerable to any disruption of feeding, especially during storms.[54]

Fish

Some species of bottom-dwelling invertebrates and fish have been documented expanding north into the Arctic from their usual locations in temperate waters (notably in the Barents, Bering, and Beaufort Seas), but it is clear that such changes cannot be blamed exclusively on warming caused by human fossil fuel use and may not be permanent.[55] So-called 'regime shift' changes have occurred naturally in the past: sea-ice changes along the coast of East Greenland are well documented, as are changes in eastern Canada, the Bering Sea, and the Svalbard region of the Barents Sea.[56]

3. The Antarctic

Sea ice and primary productivity

In contrast to the Arctic, which is an ocean basin largely surrounded by land, the Antarctic is a frigid continent surrounded by an ocean that freezes extensively in winter. However, usually, very little sea ice persists over the austral summer because it is virtually all thin, first year ice (around 1 m thick at most).[57] Antarctic winter sea-ice area (at September) has been increasing slowly since 1978 at a rate of about 1.7% per decade, especially in the Ross Sea,[58] and summer ice levels (at February) have declined slightly (Figure 7).

On 1 September 2021, winter sea ice reached its annual maximum. This was both a record high (18.75 mkm$^{2)}$ and the second-earliest annual peak on record, likely due to the second-lowest temperatures on record for June-July-August. In 2022, maximum winter ice extent was back down to 18.19 mkm^2 (at 16 September).[59] According to sea-ice experts, these latest readings exemplify the extreme inter-annual variability that has been documented over the last decade, both for overall ice extent and regional extent around the continent. The greatest maximum extent recorded since 1978 was in 2014 (20.11 mkm^2 at 22 September; *average* for that month was 19.76 mkm^2), although 2013 and 2012 were almost as high (Figure 7).[60] A recent paper has found that along the Antarctic Peninsula, '85% of the ice shelf perimeter…has advanced since the early 2000s, in contrast to the extensive retreat of the previous two decades', which they attribute in part to a stabilising effect from increased sea-ice extent.[61]

Stable Antarctic ice extent over the last few decades contradicts the expectations of global sea-ice loss predicted by climate models.[62] Moreover, a new model published in 2022 does not predict significant winter sea-ice loss in the Southern Ocean until about 2050 – more than three additional decades of stable sea-

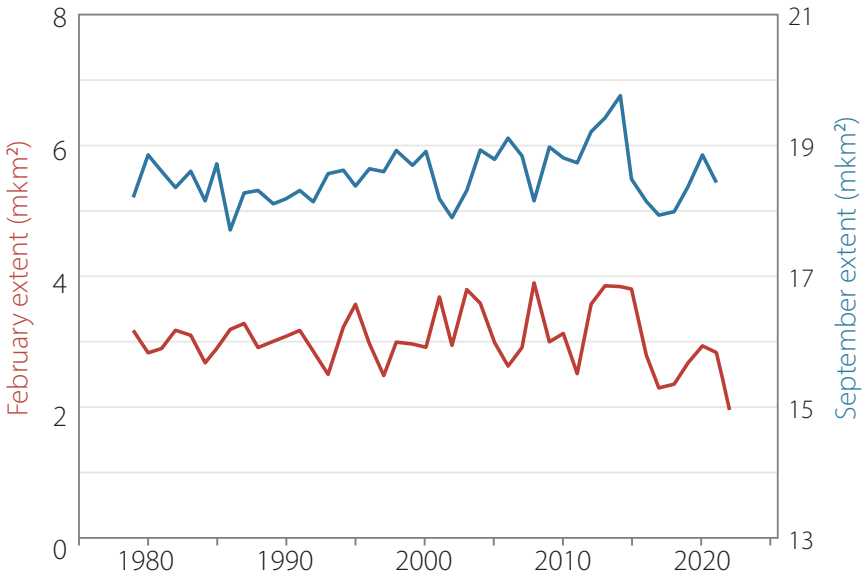


Figure 7: Antarctic sea ice extent, 1979 to date.

Monthly averages for September (max) and February (min). From Colucci 2022 https://www.severe-weather.eu/global-weather/antarctic-sea-ice-extent-record-low-anomaly-observed-rrc/.

Figure 8: Typical summer sea ice extent in the Southern Ocean

Shown here for February 2020

ice cover.[63] Unfortunately, such long-overdue revisions to sea-ice projections have not been incorporated into the biological models used to predict survival and conservation status of Antarctic species dependent on sea ice. Their populations are thus still predicted to decline over time.[64]

Satellite observations indicate continued strong primary productivity in most regions of the Southern Ocean over the last two decades, especially in the Ross Sea and off the coast of the Antarctic Peninsula, but also in coastal polynyas (areas of open water surrounded by ice) around the entire continent.[65] As in the Arctic, phytoplankton blooms provide abundant food for all organisms in the food chain, but especially krill (*Euphausia superba*), the shrimp-like crustacean that is the foundation of the Antarctic ecosystem.[66] There are several hot-spots of krill abundance: a huge one in the Weddell Sea and several others scattered around the continent.

Krill are preyed upon by hundreds of thousands of whales that converge on the Southern Ocean every summer. Several important fish, penguin, and seal species also depend on them, as do squid and flying sea birds. Humans now do as well. Trawlers from China, Norway, South Korea, Ukraine and Chile fish for krill commercially, and while their catch has long been restricted to a maximum of 620,000 tons annually – about 1.6% of the estimated 400 million tons (range 300–500 t) total biomass – they have never yet removed that much (e.g. the largest catch of 450,000 tons was reached in 2020).[67]

Whales and seals

Whales

In the Antarctic, the top of the food chain is occupied by the

killer whale. Killer whales hunt like packs of wolves, consuming small whales, seals, penguins, and fish. Some prowl the Southern Ocean at the edge of the sea ice in summer (where many of their prey species congregate to feed) but others penetrate the pack ice to hunt year round. Four ecologically and genetically distinct 'ecotypes' of these killer whales exist, each with a distinctive overall size and variant of the species' typical facial markings (e.g. eye patch).[68]

- Type A, the largest (males ~8.0–9.5 m), hunts in the ice-free waters of the Southern Ocean just beyond the pack ice during the austral summer, feeding primarily on diminutive Antarctic minke whales (*Balaenoptera bonaerensis*) and calves of larger whale species.
- Type B1, aka the 'pack ice killer whale,' is smaller (males ca. 7.8 m) and eats primarily Weddell seals (*Leptonychotes weddellii*), which groups cooperatively to 'wave-wash' prey off small ice floes.
- Type B2, the Gerlache killer whale, is smaller still (males ~6.4 m) and often hunts in large groups in open water off the Antarctic Peninsula in summer, primarily for small penguins (especially gentoos and chinstraps), but perhaps also fish.
- Type C, the 'dwarf killer whale,' is the smallest (males 6.0 m, females 5.5 m); it hunts deep in the pack ice and prowls cracks in the landfast ice of the Ross Sea, feeding primarily on large Antarctic toothfish (Chilean sea bass, *Dissostichus mawsoni*).

Types B2 and C appear to be year-round residents, as both have been observed in the pack ice in winter and summer.[69] Killer whale type B2 (the small, penguin-eater) seems to be overall about twice as abundant as types A and type B1, although around the Antarctic Peninsula in 2017/2018 it was found to be more than seven times as common (~102 for B1 – apparently a slight decline since 2010 – vs ~740 for B2, statistically similar to estimates in 2010).[70] Over a similar period (ending 2016/2017), type A killer whales increased significantly in abundance (from ~91 to ~149).[71]

The Southern Ocean has the largest concentration of orcas worldwide, and killer whales are the second-most abundant whale found off Antarctica, after minke whales.[72] A series of surveys in 2001 estimated the total killer whale population in Antarctic waters in the summer was ~25,000–27,000, but this estimate was likely an underestimate at the time given that survey vessels did not venture into the pack ice that many orcas frequent.[73] In 2020, the Australian Antarctic Program estimated their abundance at 70,000.[74]

Perhaps it's not a coincidence (given the growing abundance of predatory Type A killer whales) that numbers of Antarctic minke whales have apparently declined in recent years. The species currently numbers about 500,000, down from about 720,000 in earlier assessments (an apparent 31% decline). Although there

are concerns about the accuracy of these figures, in part due to the tendency of this species to enter the pack ice (where survey ships seldom enter), the species was listed as 'near threatened' in 2018 by the IUCN.[75]

Other species of Antarctic whales are recovering from historic industrial hunting of whales, many of which congregate off the extremely productive Antarctic Peninsula to feed in the austral summer. Southern fin whales (*Balaenoptera physalus quoyi*) numbered about 8,000 individuals in 2019 and have recently established large feeding aggregations of 50–150 individuals, which they did before historic whaling decimated their populations; globally, the species is still listed as 'vulnerable' by the IUCN, even though numbers are increasing, because the population is much smaller than it was before modern whaling.[76] The International Whaling Commission (IWC) determined that the population size of humpback whales (*Megaptera novaeangliae*) in the Southern Hemisphere had rebounded to about 70% of pre-hunting levels.[77]

There are estimated to be approximately 3–4,000 southern right whales (*Eubalaena australis*) in the southern hemisphere, a slow recovery from near extinction due to over-hunting prior to 1935. It is classified as of 'least concern' by the IUCN.[78] In contrast, Antarctic blue whales (*Balaenoptera musculus intermedia*), which often enter the pack ice, are also slowly recovering (estimated 6,500 individuals, range 5,000–8,000), but were considered 'critically endangered' by the IUCN in 2018 because their numbers comprised only about 2.5% of their pre-exploitation abundance.[79]

Seals

There are only four species of ice-dependent seals in the Antarctic, versus six in the Arctic (seven if you count the walrus). Southern elephant seals (*Mirounga leonina*) and Antarctic fur seals (*Arctocephalus gazella*) are not ice-dependent, although they do forage in Antarctic offshore productive zones, including the pack ice, even in winter.[80]

Weddell seals are among the largest seals (~2.5–3.5 m long; weight 400–600 kg) and have been observed diving to 600 m. They primarily eat squid and fish, especially Antarctic toothfish and silverfish (*Pleuragramma antarcticum*). Weddell seals make their breeding and pupping colonies on stable landfast ice in the late winter/spring (September–November) but move into the pack ice during the austral summer to feed. Uniquely among seals, females may occasionally produce twins. Weddell seals are the second most abundant species of Antarctic phocid, after the crabeater seal: the total population was estimated at about 300,000 individuals in 2011.[81] The IUCN classified the crabeater as being of 'least concern' in 2015, due to 'widespread occurrence, large population size and lack of major threats'.[82]

Leopard seals (*Hydrurga leptonyx*), Ross seals (*Ommatophoca rossii*) and crabeater seals (*Lobodon carcinophagus*) all breed and

pup within the mobile pack ice and all are listed as of 'least concern' by the IUCN. Crabeaters are the most abundant seal in the Southern Ocean, with estimates of at least 7 million animals.[83] They do not in fact eat crabs, but are voracious consumers of krill, which they strain out of the water with specialized multilobed teeth. Their primary predators are leopard seals, which take a large percentage of young crabeaters each year. Leopard seals are about the same size as Weddell seals, and abundance is estimated at 220,000–440,000 animals. Young leopard seals primarily eat krill but adults switch to eating young seals, fur seals, and penguins.[84] Ross seals, which eat squid and fish, are the least common species and their abundance is uncertain.[85]

Penguins

Several species of penguins breed on sub-Antarctic islands but feed in Antarctic waters during the non-breeding season, including macaroni (*Eudyptes chrysolophus*), southern rockhopper (*Eudyptes chrysocome*) and king (*Aptenodytes patagonicus*). Of these the macaroni penguin is the most abundant (estimated at 13 million adults), but is declining (IUCN, 'vulnerable'), southern rockhoppers (estimated at 2.5 million adults) have recently declined due to habitat loss, human disturbance and competition from commercial fishing (IUCN, 'vulnerable'), while king penguin numbers are stable at about 2.2 million adults (IUCN, 'least concern').[86]

Gentoo (*Pygoscelis papua*), chinstrap (*Pygoscelis antarctica*), and Adélie (*Pygoscelis adeliae*) penguins require ice-free ground for nesting in summer: gentoos and chinstraps choose sub-Antarctic habitats for nesting, but feed in Antarctic waters year-round, while Adélies prefer ice-free ground along the Antarctic coast in summer and pack ice in winter.[87] Gentoo populations are considered stable (IUCN, 'least concern'), with a population of about 774,000 adults.[88] Adélies are currently increasing in abundance (IUCN, 'least concern'), with population estimates of 14–16 million individuals.[89] Chinstrap numbers have declined in some regions but increased in others (overall abundance, about 8 million adults) and while it is listed as 'least concern' by the IUCN, it is considered at risk for possible overall declines.[90] There are concerns that chinstrap penguins in particular are vulnerable to future declines in krill abundance anticipated to occur over the next century due to predicted sea-ice loss due to human-caused climate change (but see Section 6 on sea ice).[91]

Emperor penguins (*Aptenodytes forsteri,* up to 100 cm tall) are the only species that breeds, lays eggs, and feeds its chicks to fledgling stage on landfast ice in Antarctica (Figure 8). Also unique to this species, it conducts these physiologically demanding tasks over the frigid winter and spring months (Figure 9). Consequently, emperor penguins are the only species apt to be directly affected by annual or decadal variations in Antarctic sea-ice extent.

Emperor penguin populations in 2019 were found to have grown by up to 10% since 2009 – to as many as 282,150 breed-

Figure 9: Breeding range of the emperor penguin

A few sites are well offshore. Red circles are the new sites reported in 2020 by Fretwell and Trathan. Major ice shelves are named.

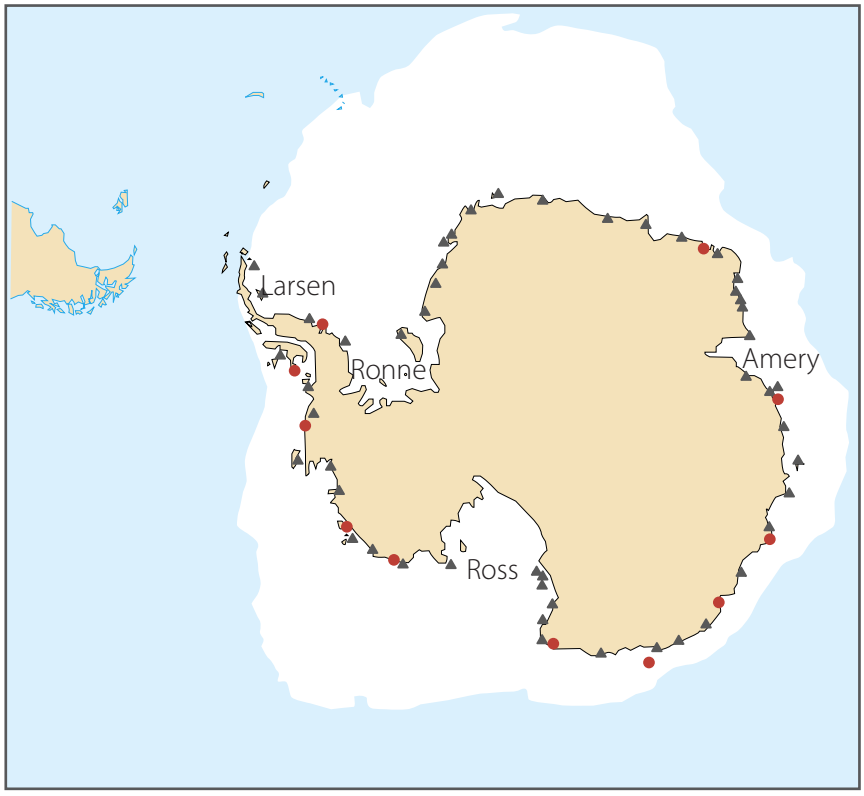
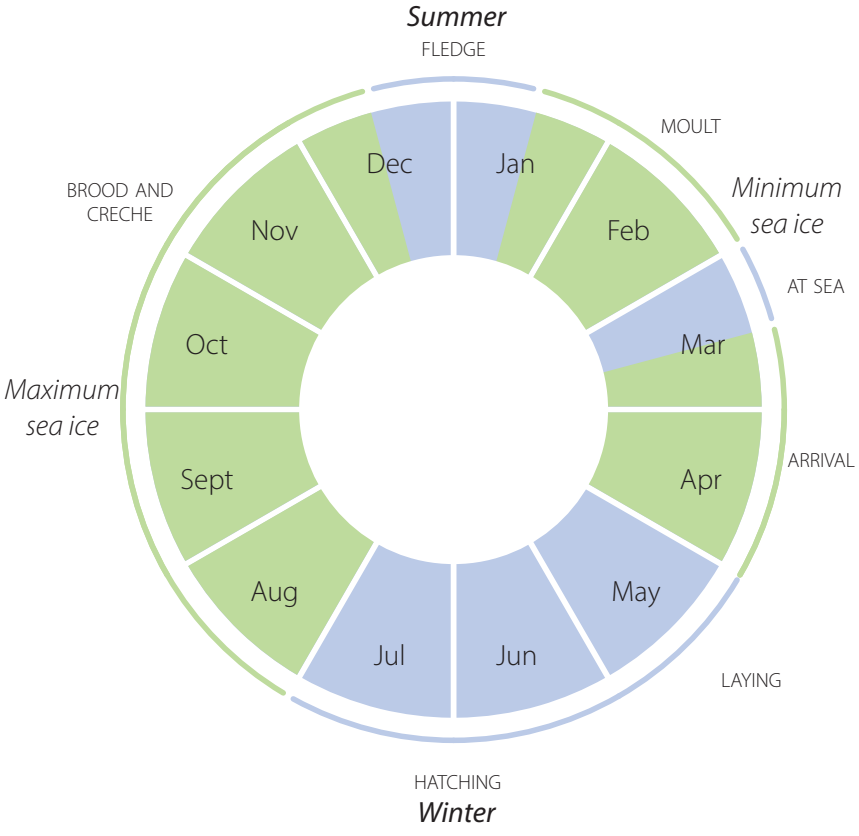


Figure 10: Emperor penguin breeding cycle.

From Amos, BBC 5 Aug 2020.



ing pairs (up from about 256,500) out of a total population of over 600,000 birds – despite a loss of thousands of chicks in 2016 when an ice shelf collapsed in the Weddell Sea.[92] Nevertheless, biologists studying this species petitioned the IUCN to upgrade emperor penguins from 'near threatened' (at 2018) to 'vulnerable'[93], based on models that use the most extreme (and therefore highly unlikely) RCP8.5 'worst case' climate change scenario.[94] Not only do these extreme models implausibly suggest emperor penguins could be close to extinction by 2100, they also fail to account for the fact that recent sea-ice loss has not been nearly as severe as expected, further calling into doubt the accuracy of these predictions.[95]

In 2019 the IUCN declined to change its 2018 assessment, stating: [96]

> This species is listed as near threatened because it is projected to undergo a moderately rapid population decline over the next three generations owing to the projected effects of climate change. However, it should be noted that there is considerable uncertainty over future climatic changes and how these will impact the species.

So far, the localised die-off of chicks in one of the many colonies along the edge of the Weddell Sea in 2016 has not recurred. However, in 2022 the US Fish and Wildlife Service responded to pressure and formally listed the emperor penguin as 'threatened' under the Endangered Species Act.[97]

Other birds and fish

Birds

A variety of albatrosses, petrels, skuas, fulmars, shearwaters, gulls, and terns, nest in summer on sub-Antarctic islands or at ice-free locations around the Antarctic continent (especially the Antarctic Peninsula) and feed in the rich offshore waters of the Southern Ocean. Several albatross and large petrel species are considered 'vulnerable' by the IUCN due to their penchant for stealing baited hooks set by long-line trawlers fishing for Antarctic toothfish.[98]

Fish

The Antarctic toothfish is a cod-like species that can reach lengths of over 2 metres and, because it is fished commercially, has generated concerns of over-harvesting.[99] The toothfish eats krill and Antarctic silverfish, and is preyed upon by some killer whales and Weddell seals. The small schooling Antarctic silverfish (aka 'Antarctic herring') is also an important prey species for some killer whales, humpback whales, minke whales, Weddell seals, and at least two species of penguins (Adélies and emperors).[100]

4. Discussion

Contrary to expectations, while Arctic sea-ice extent has seen an overall decline since 1979, that trend has stalled in recent years: since 2007 for summer ice and about 2011 for winter ice. Also

contrary to expectations, the open-water season in Hudson Bay has not continued to increase since a 'step change' took place in 1998. This explains why a recent decline in polar bear abundance in Western Hudson Bay did not correlate with lack of sea ice. However, summer ice has declined over the Barents Sea to a much greater extent than any other Arctic region since at least 2003, and this has had the opposite effect expected for seal and polar bear populations because of the increased primary productivity that a longer open-water season promotes: Barents Sea polar bears are thriving. A similar phenomenon has been documented in the Chukchi Sea: less summer ice has meant more seals and abundant, healthy bears.

In contrast, Antarctic sea-ice area has been surprisingly stable: overall winter ice cover has increased slightly since 1979. Perversely, climate models used to forecast future conditions (assumed to be driven by ever-increasing human-caused carbon dioxide emissions) predicted marked declines in Antarctic sea ice over the recent decades and even more over the 21st century.

Sea-ice experts have documented their concerns about this discrepancy between observations and model predictions for more than ten years; in 2022 a model proposed that virtually stable Antarctic winter sea-ice cover could be expected to continue to at least 2050, with only modest declines after that. However, this evidence has apparently been ignored by biologists proclaiming future declines in abundance of Antarctic species (especially krill, and several penguin species).

This is especially apparent for the emperor penguin, for which the most pessimistic models predict near-extinction by 2100 due to winter sea-ice loss: not only are the 'worst-case' scenarios that underlie these claims implausible (due to far-fetched assumptions of future carbon dioxide emissions), but the sea-ice factor is now also known to be quite flawed. It is apparent that emperor penguins were listed in the US (in late 2022) as 'threatened' based on predicted winter sea-ice loss using a justification that ignored well-founded evidence – published in the scientific literature by reputable sea-ice researchers – that the sea-ice models used were not fit for purpose.

The same flawed sea-ice models underlie claims of marked future declines in Antarctic krill abundance, and of resulting species collapse across the continent, a function of the central role that krill plays in Antarctic ecology. All such predictions should therefore be considered flawed.

A decline in winter sea ice blamed on climate change cannot be the primary driver of changes in Antarctic faunal abundance, simply because winter ice extent has not declined. Chinstrap penguins and minke whales, for example, appear to have suffered recent declines in abundance but

those changes are unrelated to a loss of winter sea-ice cover.

Overall, Arctic and Antarctic wildlife of all kinds appeared to be doing well, with very few exceptions. Polar bear, Atlantic walrus, and bowhead numbers in the Arctic continue to recover from overhunting, as do fin, humpback, blue, and southern right whale numbers in the Antarctic (although some more slowly than others).

There were no reports from either hemisphere in 2022 that would suggest polar wildlife is suffering as a result of reduced sea-ice extent (in summer for the Arctic, winter for the Antarctic): no news of starving polar bears or walrus, beach-cast dead seals, or drowned penguin chicks. In both the Arctic and Antarctic, less summer sea ice and increased primary productivity over the last two decades has meant more food for all animals, which explains why polar wildlife has been thriving.

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