STATE OF THE POLAR BEAR REPORT 2020

Susan J. Crockford

The Global Warming Policy Foundation
Report 48

State of the Polar Bear Report 2020
Susan J. Crockford

Report 48, The Global Warming Policy Foundation

Contents

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, and Norwegian), *Polar Bears Have Big Feet* (for preschoolers), and the fully referenced *Polar Bears: Outstanding Survivors of Climate Change* and *The Polar Bear Catastrophe That Never Happened*,[2] as well as a scientific paper on polar bear conservation status.[3] She has authored several earlier briefing papers, reports, and videos for GWPF on polar bear and walrus ecology and conservation.[4] Susan Crockford blogs at www.polarbearscience.com.

Preface

From 1972 until 2010,[5] The Polar Bear Specialist Group (PBSG) of the International Union for the Conservation of Nature (IUCN) published comprehensive status reports every four years or so, as proceedings of their official meetings, making them available in electronic format. Until 2018 – a full eight years after its last report – the PBSG had disseminated information only on its website, updated (without announcement) at its discretion. In April 2018, the PBSG finally produced a standalone proceedings document from its 2016 meeting,[6] although most people would have been unaware that this document existed unless they visited the PBSG website.

This *State of the Polar Bear Report* is intended to provide a yearly update of the kind of content available in those occasional PBSG meeting reports, albeit with more critical commentary regarding some of the inconsistencies and sources of bias present in the corpus of reports and papers. It is a summary of the state of polar bears based on a review of recent and historical scientific literature. It is intended for a wide audience, including scientists, teachers, students, decision-makers and the general public interested in polar bears and Arctic ecology.

Executive summary

- Results of three new polar bear surveys were published in 2020. All three populations were found to be either stable or increasing.
- Southern Beaufort polar bear numbers were found to have been stable since 2010, not reduced as previously assumed, and the official estimate remains about 907.
- M'Clintock Channel numbers more than doubled, from 284 in 2000 to 716 in 2016, due to reduced hunting and improved habitat quality (less multiyear ice).
- Gulf of Boothia numbers were found to be stable, with an estimate of 1525 bears in 2017; body condition improved between study periods and thus showed 'good potential for growth'.
- At present, the official IUCN Red List global population estimate, completed in 2015, is 22,000–31,000 (average about 26,000) but surveys conducted since then, including those made public in 2020, would raise that average to almost 30,000. There has been no sustained statistically significant decline in any subpopulation.
- Reports on surveys in Viscount Melville (completed 2016) and Davis Strait (completed 2018) have not yet been published; completion of an East Greenland survey is expected in 2022.
- In 2020, Russian authorities announced the first-ever aerial surveys of all four polar bear subpopulations in their territory (Chukchi, Laptev, Kara, and Barents Seas), to be undertaken between 2021 and 2023.
- Contrary to expectations, a new study has shown that females in the Svalbard area of the Barents Sea were in better condition (i.e. fatter) in 2015 than they had been in the 1990s and early 2000s, despite contending with the greatest decline in sea ice habitat of all Arctic regions.
- Primary productivity in the Arctic has increased since 2002 because of longer ice-free periods (especially in the Laptev, East Siberian, Kara, and Chukchi Seas, but also in the Barents Sea and Hudson Bay), but hit records highs in 2020; more fodder for the entire Arctic food chain explains why polar bears, ringed and bearded seals, and walrus are thriving despite profound sea ice loss.
- In 2020, contrary to expectations, freeze-up of sea ice on Western Hudson Bay came as early in the autumn as it did in the 1980s (for the fourth year in a row) and sea-ice breakup in spring was also like the 1980s; polar bears onshore were in excellent condition. These conditions came despite summer sea-ice extent across the entire Arctic being the second-lowest since 1979. Data collected since 2004 on weights of females in Western Hudson Bay have still not been published: instead, polar bear specialists have transformed standard

body condition data collected in 1985–2018 into a new metric for population health they call 'energetics', which cannot be compared with previous studies. Meanwhile, they continue to cite decades-old raw data from previous studies to support statements that lack of sea ice is causing declines in body condition of adult females, cub survival, and population size.

- Contrary to expectations, in Western Hudson Bay many polar bears remained on the deteriorating sea ice much longer than usual in summer, and stayed ashore longer in fall after official freeze-up thresholds had been reached, calling into question the assumed relationship between sea-ice coverage and polar bear behaviour and health. Some bears that left the ice in late August and then returned before late November would have spent only three months onshore – about one month less than normal in the 1980s, and two months less than in the 1990s and 2000s.
- There were few problem polar bear reports in 2020, except for one fatal attack in August, in a campground near Longyearbyen, Svalbard. Ryrkaypiy, Chukotka, which in 2019 was besieged by more than 50 bears that had congregated to feed on walrus carcasses nearby, avoided a similar problem in 2020 by posting guards around the town. The town of Churchill, Manitoba saw the lowest number of problems bears in years.
- In 2020, virtually all polar bear research was halted across the Arctic for the entire year due to restrictions on travel and efforts to isolate vulnerable northern communities from Covid-19.

1. Introduction

The US Geological Survey estimated the global population of polar bears at 24,500 in 2005.[7] In 2015, the IUCN Polar Bear Specialist Group estimated the population at 26,000 (range 22,000–31,000),[8] but additional surveys published since then have brought the total to near 30,000 and may arguably be as high as 39,000.[9] This is only a slight-to-moderate increase, but it is far from the precipitous decline polar bear experts expected given a drop of almost 50% in sea-ice levels since 1979.[10] This indicates summer sea-ice levels are not as critical to polar bear survival as USGS biologists assumed.[11] Despite 2020 having had the second lowest September ice extent since 1979 (after 2012), there were no reports from anywhere around the Arctic that would suggest polar bears were suffering as a result: no starving bears, no drowning bears, and no marked increases in bear conflicts with humans. Indeed, contrary to expectations, several studies have shown that polar bears in many regions have been doing better with less summer ice, either because multiyear ice has been replaced with more productive seasonal ice, or because the increased primary productivity that has come with longer open-water seasons has been a net benefit.

2. Conservation status

Polar bears currently have a relatively large population size and their historical range has not diminished due to habitat loss 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, just as it did in 2006.[12] Similarly, in 2016, the US Fish and Wildlife Service upheld its 2008 conclusion that polar bears were 'threatened' with extinction under the US Endangered Species Act (ESA).[13] In both of these instances, polar bear conservation status is based on computer-modelled future declines, not observed declines.

In contrast, in 2018 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) decided to continue to list the polar bear as a species of 'Special Concern', as it has done since 1991, rather than upgrade the status to 'Threatened.'[14] Since roughly two thirds of the world's polar bears live in Canada, the decision means that most of the species is still managed with an overall attitude of cautious optimism. This brings a refreshing spark of rationality in the world of polar bear conservation.

None of these official assessments changed in 2020.

3. Population size

Global

Since 1968, the PBSG has produced a number of estimates of the global polar bear population. The latest, appearing in September 2019, mentions the IUCN's 22,000–31,000 global estimate in passing, but it rejects without explanation the figures used in the IUCN assessment for the Laptev Sea, East Greenland, and Kara Sea subpopulations, and insists on a global average figure of 25,000.[15]

Survey results postdating preparation of the 2015 Red List assessment, including those made public in 2020, have brought the mid-point total at 2017 to almost 30,000. Survey results from Davis Strait and Viscount Melville, all completed in 2018 or before but not yet made public, may put that global mid-point estimate above 30,000.[16] While there is a wide margin of error attached to this figure it is a far cry from the 7,493 (6,660–8,325) bears we were assured would be all that would remain[17] given the sea-ice levels that have prevailed since 2007.[18]

In early 2020, Russian authorities announced their plan to perform aerial population surveys of the entire Russian Arctic. These would begin in the Chukchi and East SIberian seas in 2021, proceed with the Laptev and Kara seas in 2022, and end with the eastern Barents Sea (including Franz Josef Land) in 2023.[19] It remains to be seen if this project will go ahead as planned, given travel restrictions due to Covid-19.[20]

Subpopulations by ecoregion

In 2007, the US Geological Survey defined four Arctic sea-ice 'ecoregions' (Figure 1).

- The 'Seasonal' ecoregion represents all the subpopulation regions where sea ice melts completely during the summer, stranding polar bears onshore.
- The 'Divergent' ecoregion includes all subpopulation regions where sea ice recedes from the coast into the Arctic Basin during the summer, leaving bears the option of staying onshore or remaining with the sea ice.
- The 'Convergent' ecoregion is the subpopulation regions where ice formed elsewhere drifts towards shore all year long.
- The 'Archipelago' ecoregion represents subpopulations in the Canadian Arctic archipelago.

The ecoregion concept now appears to have been accepted as a useful assessment methodology for polar bear health[21] although this was abandoned in favour of an individual subpopulation approach for a model published in 2020 that predicted future survival potentials[22], almost certainly because it is now apparent that all subpopulations within a single sea ice 'ecoregion' have not responded similarly to local declines in summer sea ice.[23] The 'ecoregion' approach is used here to present the current subpopulation status of each management region in the Arctic, updated to 2020.

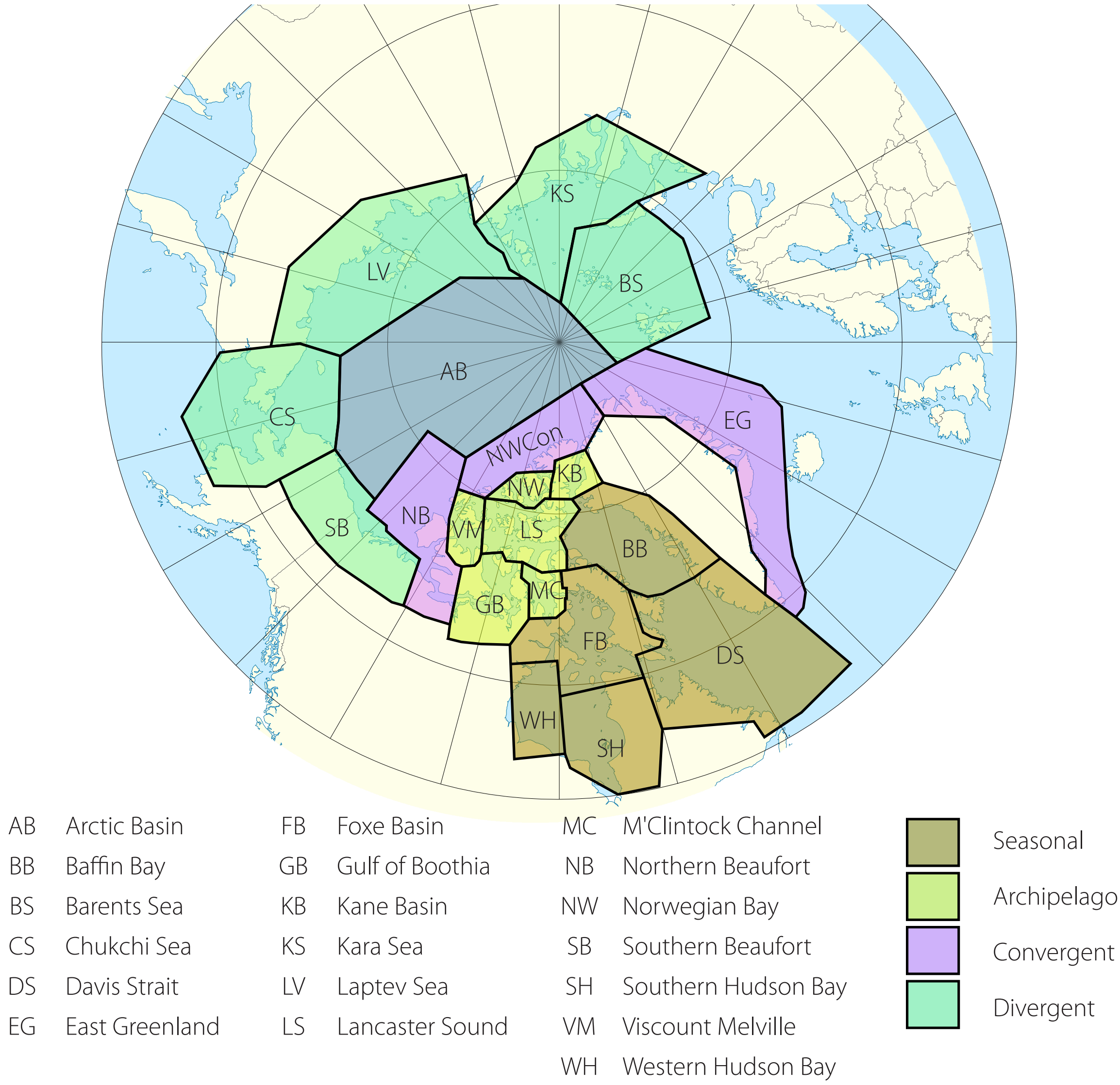


Figure 1: The four Arctic sea ice ecoregions.

The Arctic Basin (AB) is not considered to be a sea ice ecoregion. The Convergent region 'NWCon' (also known as 'Queen Elizabeth – Convergent') is not a recognized polar bear subpopulation.

Baffin Bay – Seasonal

The polar bear subpopulation estimate at 2013 for Baffin Bay (BB) was 2,826±767, a 36% increase over 1997. In 2019, the PBSG considered the BB trend 'data deficient', effectively dismissing the 2013 survey results, although aboriginal traditional knowledge assessed the population in 2018 as 'stable'.[24] However, in March 2020, one of the authors of a paper on changes in body condition and litter size that resulted from the 2013 survey, PBSG member Stephen Atkinson, stated that the group's findings were consistent with the Inuit view.[25]

Davis Strait – Seasonal

Estimates of the Davis Strait (DS) subpopulation have been repeatedly revised upwards, from 726 in the 1970s[26] to 2,158 (range 1,833–2,542) after a comprehensive survey in 2007.[27] Subsequent growth in the harp seal population[28] provided the potential for a further increase in polar bear numbers and this is probably

reflected in the 2018 Environment Canada status assessment as 'likely increasing'.[29] As a consequence, it is highly likely that the actual population size at 2018 (eleven years after the last survey) was well above 2,500, especially since harp seal numbers have grown further still, according to a new population survey published in 2020.[30] However, the results of a 2017–2018 survey of polar bears in DS has yet to be made public (although a preliminary report on the first year of the survey indicated that bears of all ages were generally 'well-fed' and that the density of bears was 'as expected').[31] In 2019, the PBSG listed DS bears as 'likely stable' rather than increasing.[32]

Foxe Basin – Seasonal

Estimates of the Foxe Basin (FB) population have grown from 2,197 (1,677–2,717) in 1994, to around 2,580 in 2009–10.[33] The population was considered 'stable' by Environment Canada in 2014, as well as by the PBSG in 2014 and 2019, while traditional knowledge considered numbers to be increasing.[34]

Western Hudson Bay – Seasonal

Regehr and colleagues performed repeated mark–recapture surveys of a core region of Western Hudson Bay (WH), estimating the population in 2004 at 935 (range 794–1,076), a statistically significant decline from the previous survey in 1987.[35] This result was used as persuasive evidence that polar bears were threatened with extinction.[36] Subsequent surveys have covered different parts of the region and used different methodologies, making comparisons difficult, and it is not clear that there has really been a decline in population.

In a late 2018 interview with UK journalist David Rose, polar bear researcher Andrew Derocher conceded that there had been 'a recent period of stability' in the region.[37] But WH polar bears may be doing even better than just holding their own: in late 2018, the Nunavut Government insisted that several indicators suggested that the WH population had increased in size, with sea-ice coverage since 2016 similar or better than in the 1980s (i.e. 'normal').[38] Despite this, in 2019 the PBSG listed the WH subpopulation as 'likely decreased'.[39]

Southern Hudson Bay – Seasonal

By 2005 the Southern Hudson Bay (SH) subpopulation had been stable since the mid-1980s at about 1000 animals.[40] Results of a more recent aerial survey, completed in 2016, showed a 17% decline in population size, from 943 to 780 (range 590–1029), but this was not statistically significant.[41] However, something called a 'Monte Carlo simulation' (a technique never used before in polar bear population size estimates, as far as can be determined) was applied 'to better inform managers about the status of the subpopulation'. Since this test determined that the decline could be real, the authors reported an actual drop in abundance for the first time in SH. However, information on sea ice conditions and the body condition of the bears have not been

published,[42] although one of the authors has conceded that any population decline seems uncorrelated with ice levels.

Since 2016, as for WH, SH sea ice has been more like it was in the 1980s (i.e. 'normal').[43] Traditional knowledge indicates an increase in SH bear numbers while the PBSG in 2019 considered it 'likely decreased'.[44]

Barents Sea – Divergent

The Barents Sea (BS) population was found to be around 2,650 (range 1900–3600) in 2004,[45] with nearly three times as many bears in the Russian sector as in the Norwegian.[46] A 2015 survey of the Norwegian sector reported a 42% increase in abundance, although the large uncertainty meant that the increase was not statistically significant.[47] If the results had been extrapolated to the entire region, the BS population would be about 3,749.[48] This approach, which is not unusual in the field,[49] would have been reasonable in this case because sea-ice conditions in the Russian sector have been less seasonally volatile that in the Norwegian sector.[50] However, the researchers involved did not adopt it, and the proceedings document from the 2016 PBSG meeting argued that because there was no statistically significant increase between 2004 and 2015, it could not conclude that the population had grown.[51] As a consequence, the official BS population size remains at 2,650 (range 1900–3600) and in 2019 the PBSG considered it 'likely stable'.[52]

Kara Sea – Divergent

A first-ever Kara Sea (KS) population estimate, completed in late 2014, potentially added another 3,200 or so bears to the global total.[53] This estimate (range 2,700–3,500), derived by Russian biologists from ship counts, was included in the official global count published in 2015 by the IUCN Red List.[54] An earlier estimate of about 2,000 bears at 2005 was used by American biologists to support the 2008 ESA status assessment, but this was an unofficial figure that does not appear in any document.[55] However, if it was accurate at the time, it may indicate a population increase has taken place. Despite this, the PBSG in 2016 and 2019 still listed the Kara Sea status as 'unknown'/'data deficient' and did not mention the 2014 Russian estimate.[56]

Laptev Sea – Divergent

In its 2005 assessment, the PBSG gave an estimate for the Laptev Sea (LS) population of about 1,000, based on den counts from the 1960s to the 1980s,[57,58] but changed this assessment to 'data deficient' in 2013 and 'unknown' in later years.[59,60] In contrast, the 2015 IUCN Red List assessment used the out-of-date estimate of 1,000.[61] However, hunting of polar bears has been banned in the region since 1957, and sea ice declines in all seasons have been less than in the neighbouring Kara and Barents Seas.[62] This suggests the population is almost certainly three or more times bigger.[63] Despite this, the PBSG in 2019 listed this subpopulation as 'data deficient' and the population size as 'unknown'.[64]

Chukchi Sea – Divergent

Considered 'declining' by the PBSG in 2009, based on existing and projected sea ice losses,[65] the assessment for the Chukchi Sea (CS) changed to 'data deficient' in 2013 and 'unknown' in 2014–17.[66] However, because a number was required for predictive models, the long out-of-date estimate of 2,000 was used for the 2015 Red List assessment.[67]

However, a 2016 capture-recapture survey[68] generated a population size of about 3,000 (range 1522–5944), making it the largest subpopulation in the Arctic. Larger-than-average family groups were also found,[69] suggesting that CS bears were in good condition and reproducing well.[70]

It was also reported that bears spending the summer on Wrangel Island, the region's main terrestrial denning area, had reversed a previously observed decline, with the population rising from about 200–300 individuals in 2012 and 2013 to 589 in 2017.[71] A 2019 fall survey of the northern part of the island found bears to be in good condition, with at least one litter of four cubs photographed.[72] All indicators suggest this subpopulation is productive and healthy despite recent changes in summer sea ice that means bears that come ashore for the summer arrive about 20 days earlier than they did in the 1980s.[73] Poaching is no longer considered an issue and in 2019 the PBSG listed the subpopulation as 'likely stable'.[74]

Southern Beaufort Sea – Divergent

As noted above, although officially categorised as a subpopulation in the Divergent ecoregion, there are good reasons to believe that the sea ice conditions in the Southern Beaufort Sea (SB) are unique. The first survey of the region in 1986 generated an estimate of about 1,800 individuals, and this fell to about 1,526 at the start of the new century, after a series of thick spring sea ice episodes. By 2010, the population was thought to have fallen to 907 (range 548–1270),[75] although the survey may not have sampled the entire geographic range adequately. The PBSG did not, however, make an adjustment to the population estimate as they had previously done for other subpopulations when such problems with estimates later became evident (e.g. Davis Strait).[76]

A report published in 2020 regarding a population survey completed in 2015 of the Alaska portion of the SB found 573 bears in 2015 compared to 562 in 2010 for the same region, indicating the population had not declined as expected.[77] The study authors concluded that since Alaska now made up 78% of the entire subpopulation (after the boundary change in the east), 'abundance and survival rate estimates derived from bears sampled in Alaska should serve as a robust index for survival rates and abundance of the entire [SB] subpopulation.'[78] As a consequence, the current population size is estimated at 907.

The report on polar bears by the Committee on the Status of Endangered Wildlife in Canada published in June 2019 acknowledges concerns that the 2010 estimate was lower due to 'annual

variability in ice conditions' (see Section 5) that resulted in bears shifting to the Northern Beaufort (NB).[79] It therefore proposed an 'equally valid' estimate for SB of 1,215 bears at 2006 (arrived at by taking 311 bears away from the 2006 SB estimate of 1,526 and adding it to NB subpopulation estimate).[80] This figure is currently the one used by the joint Inuvialuit/government body charged with managing SB and NB subpopulations in Canada.[81] For management purposes in Canada, the SB subpopulation is considered to be in 'likely decline' and the PBSG considers it to be 'likely decreased'.[82] However, many Inuit in the Canadian portion of the region feel that polar bear numbers have been stable or increasing within living memory.[83]

Northern Beaufort Sea – Convergent

The last population count for the Northern Beaufort Sea (NB) was made in 2006, so is now more than ten years out of date. It generated an estimate of 980 (range 825–1,135), although the lead author of the study suggested a more accurate estimate would be 1,200–1,300 due to northern areas that were not sampled.[84] At that time, the population appeared to have been relatively stable over the previous three decades. The boundary with SB has been moved east, to near Tuktoyaktuk, for Canadian management purposes, a change provisionally accepted by the IUCN PBSG in 2017.[85] Updated maps from Environment Canada now incorporate this boundary change.[86] The current population estimate suggested to account for the boundary change with SB is 1,291 (980 plus 311, see discussion in SB above) but the estimate used for management purposes is 1,710 (an adjustment for unsampled areas of the region during the 2006 count); the population is considered stable or 'likely stable' by Inuit and Canadian government authorities; it is listed as 'likely decreased' by the PBSG.[87]

East Greenland – Convergent

Although there has been no comprehensive survey of the East Greenland (EG) subpopulation, in 2001 the PBSG estimated there were 2,000 bears (in part based on harvest records that indicated a fairly substantial population must exist).[88] However, this figure was subsequently reduced, for no apparent reason, to 650 bears,[89] and by 2014, EG numbers were simply said to be 'very low.' It is simply not true that the PBSG has never provided an estimate for EG, as they now claim on their website.[90]

Surveys of hunters in northeast Greenland in 2014 and 2015 suggested an increase in numbers of bears coming into communities compared to the 1990s,[91] and in the southeast it was said that an abundance of seals was increasing the bear population.[92] In 2019, the PBSG listed EG as 'data deficient' with an 'unknown' population size.[93] The first comprehensive population survey should be completed by 2022.[94]

Arctic Basin – a subpopulation but not an ecoregion

In the original classification of the sea-ice ecoregions, a narrow portion of the Arctic Basin (AB) north of Greenland and Ellesmere

Island was at first called 'Queen Elizabeth – Convergent' and later 'Northwest – Convergent' (NWCon; Figure 1), but that nomenclature now seems to have been abandoned, probably because it is not a distinct subpopulation region for polar bears.[95] The PBSG treats the Arctic Basin as a 'catch-all' region because it contains bears moving between regions and those from peripheral seas (such as the Southern Beaufort and Barents) who use it as a summer refuge during the ice-free season. Both single bears and family groups have been seen feeding on ringed seals during the summer, and both ringed seals and their fish prey have been documented as being present.[96] AB is given a population size estimate of zero but there is some evidence that the productivity in some areas of this region is higher than previously assumed and it is thus possible that a small number of polar bears may live there year-round.[97]

Kane Basin – Archipelago

A 2013 survey of Kane Basin (KB) polar bears confirmed what local Inuit and some biologists have been saying for years: that contrary to the assertions of PBSG scientists, KB polar bear numbers have not been declining.[98] Previously, the PBSG had confidently said they were declining due to suspected over-hunting. The 2013 survey generated an estimate of 357 (range 221–493) and the population was sugested to be 'stable to increasing'.[99] However, the survey authors expressed concerns with sampling methodology and differences in the areas surveyed, and suggested 'some caution in interpretation of population growth' was necessary.[100] However, traditional knowledge says numbers have increased and the PBSG assessment for 2019 concluded that the population had 'likely increased'.[101]

M'Clintock Channel – Archipelago

The first population size estimate generated for M'Clintock Channel (MC) was about 900 bears in the mid-1970s and a mark-recapture study in 2000 generated an estimate of 284±59 bears, a significant decline blamed on over-hunting.[102] Hunting was subsequently halted but later resumed at a much-reduced level, after which the population was presumed to be increasing. Results of a three-year genetic mark-recapture study were published in 2020 and showed the population had more than doubled, from 284 in 1998–2000 to 716 (range 545–955) in 2014–2016. Numbers of both males and females increased between the study periods due to reduced hunting and 'improved habitat quality' (i.e. less thick multiyear ice).[103] While traditional knowledge in 2018 considered this subpopulation had declined in recent years due to overhunting, the PBSG assessed it as 'very likely increased' in 2019.[104]

Viscount Melville – Archipelago

The first survey of the Viscount Melville (VM) subpopulation was completed in 1992 and generated an estimate of 161±40.[105] This estimate is now over 25 years old; while a new genetic mark-recapture survey was completed in 2014, the results had still not been made public by the end of 2020; traditional knowledge indicates

the population is stable or increasing, while the PBSG in 2019 considered it 'data deficient'.[106]

Gulf of Boothia – Archipelago

The Gulf of Boothia (GB) is one of the smallest polar bear subpopulation regions. The first survey in 1986 generated an estimate of about 900 bears, but by 2000 this had risen to 1,592±361 bears, a significant increase, and a very high population density.[107] A new estimate for the area based on genetic mark-recapture published in 2020 showed the population has been stable since the last assessment. The mean abundance estimate was 1,525 (range 1231–1819) for 2015–2017, a statistically non-significant change from the earlier survey.[108] Mean litter sizes showed no trend between study periods but body condition (i.e. fatness) in the spring increased (see Section 7), while overall population survival indicators suggested 'a good potential for growth'. The PBSG in 2019 list this subpopulation as 'likely stable' while traditional knowledge considers it to have increased.[109]

Lancaster Sound – Archipelago

The Lancaster Sound (LS) subpopulation, in the middle of the Canadian Arctic archipelago, has one of the highest population counts of polar bears anywhere, although it is one of the smaller regions. The latest population surveys in LS were conducted from 1995 to 1997, giving an estimate of 2,541±391 bears, a significant increase over the previous estimate (from 1977) of 1,675.[110] Traditional knowledge says numbers in the region have increased while the Polar Bear Technical Committee assessed it as 'likely stable' in 2018.[111] In 2017, the PBSG considered the population to be stable but change this to 'data deficient' in 2019.[112]

Norwegian Bay – Archipelago

The last population count for Norwegian Bay (NB) was done in 1993–1997 in conjunction with the Lancaster Sound survey, and is therefore well out of date.[113] It generated a population estimate of 203±44.[114] The PBSG in 2019 listed this subpopulation as 'data deficient' while traditional knowledge considered it stable.[115]

4. Population trends

In 2018, the Government of Canada published a global polar bear population status and trend map (unchanged at 31 December 2020), based primarily on 2017 PBSG data,[116] and in 2019, the PBSG posted an updated assessment. Since these figures are now out of date, Figure 2 shows a more realistic representation of current polar bear population trends based on all available information (survey results as well as studies on health and habitat status published up to 31 December 2020). This gives the following classification totals at 2020: [117]

- three 'increasing' or 'likely increasing' [KB, DS, MC]
- three 'stable' or 'likely stable' [SB, WH, SH]
- twelve 'presumed stable or increasing' [EG, LS, VM, NB, GB, LS, BB, BS, KS, CS, FB, NW]

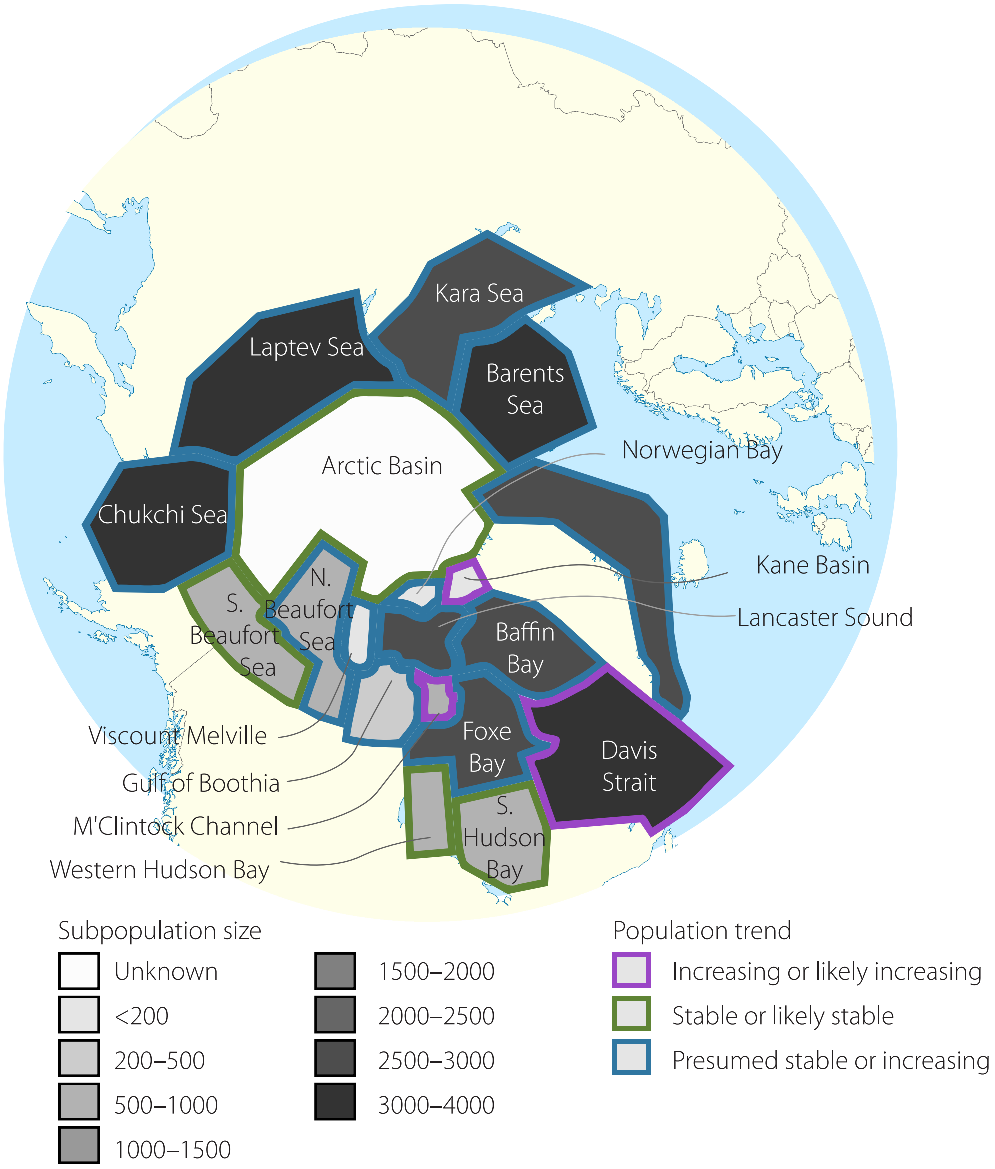


Figure 2: Trends in polar bear subpopulations at 2020.

Number of bears per subpopulation. Former 'data deficient' regions are marked 'likely stable or increasing' to reflect current research on studied populations.

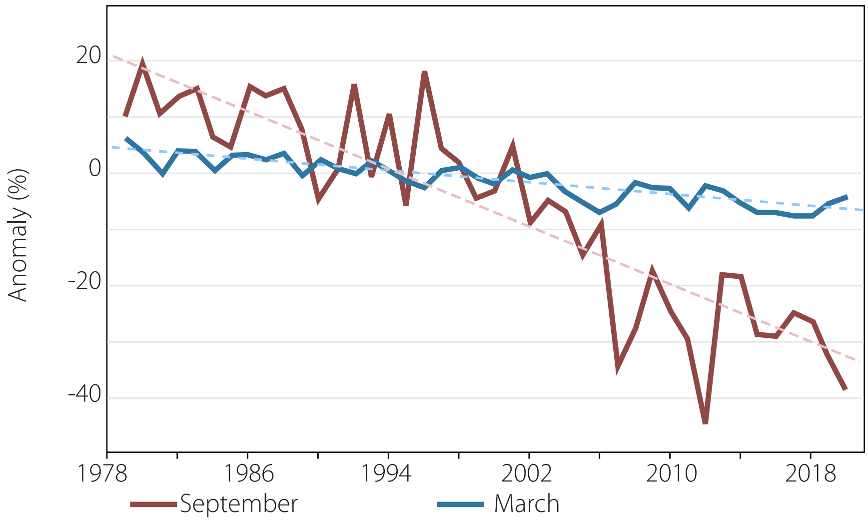
5. Habitat status

Global sea ice

Summer sea-ice extent (at September) has declined markedly since 1979, but winter ice levels (at March) have declined very little. Moreover, there has been essentially no trend in March sea ice coverage since 2004 and no trend in summer ice since 2007 (Figure 3).[118] March extent in 2020 (15.05 mkm^2 at March 5), was the highest since 2013, and the extent in September dropped to the second lowest (after 2012) since 1979 (3.74 mkm^2 at 21 September).[119] As far as is known, record low extents of sea ice in March 2015, 2017 and 2018,[120] which were so similar to 2006, had no impact on polar bear health or survival (ice cover at March 2019 and 2020 were higher than all three of those years).

Figure 3: Sea-ice extents, 1979–2019.

Anomalies against 1981–2010 mean. Source: Arctic Report Card.



Sea ice extent in June has declined, on average, from just over 12 mkm^2 in the 1980s to just under 11 mkm^2 in 2019 and 2020.[121] However, this still leaves a great deal of ice throughout the Arctic to act as a feeding and mating platform for polar bears (see Section 6). Moreover, despite September 2020 having the second-lowest ice cover since 1979, there were no media or community reports of polar bear phenomena commonly blamed on lack of summer sea ice: no reports of widespread starvation amongst polar bears that spent the ice-free season on shore, no incidents of cannibalism, and no deaths by drowning.[122] Nor does the lack of sea ice seem to have led to an increase in fatal polar bear attacks (see Section 9).

It will be at least another year (and maybe two in some regions) before field researchers can properly assess the impact of the low ice levels of summer 2020, but the experience of 2012, when sea ice dropped even lower (Figure 3), suggests there will be few problems. For example, polar bears in the Chukchi Sea were thriving in 2012 and 2013, as were those in the Barents Sea (despite the most summer ice loss of any subpopulation).[123] And in the Southern Beaufort, the slight decline in numbers from 2012 to 2013 was negligible compared to the aftermath of the thick spring ice episodes of the 1970s and 2000s (discussed below in more detail).[124]

Increased primary productivity due to reduced summer sea ice

One of the most important lessons of the profoundly low extent of summer ice in 2020 in particular (and less summer ice in general since 2002) is that a longer ice-free season has been a net benefit to most animals in the Arctic and peripheral seas because less ice means more sunlight and more upwelling, which increases the ocean's primary productivity. In simple terms, less ice means ideal conditions for phytoplankton, the single-celled plants that are the basis for all life in the ocean.

Primary productivity during the ice-free season has been on the increase since 2002, but hit record highs in 2020, especially in the Laptev, East Siberian and Kara Seas, the Chukchi and Barents Seas, and Hudson Bay (Table 1).[125] One study published in 2020 found primary productivity across the Arctic had increased by 57% between 1998 and 2018, and the authors refer to this dramatic change as a 'regime shift'.[126] Such changes have also been documented in several Arctic regions during the warm period of the early Holocene that began about 9000 years ago.[127]

All the way up the food chain – where polar bears hold the top spot – more primary productivity means more food (fat newborn seals) for bears in the spring when they need it most, a fact that has been documented conclusively in the Chukchi Sea. Besides ringed seals, bearded seals, and polar bears, bowhead whales have also been shown to have benefitted from this increased primary productivity and the large recent population size and health of Pacific walrus suggest they are another species that has been the beneficiary of less summer sea ice since 2003.[128] Reports of markedly increased primary productivity in the Barents Sea between 2003 and 2019, as well as documented increased body condition of adult female bears over the same time period, suggest polar bears in that region, like bears in the Chukchi Sea, have benefitted from reduced summer sea ice.[129] As a consequence, given that a marked increase in primary productivity was documented across the Arctic in the summer of 2020, it is reasonable to expect that even if it has not been documented, Laptev Sea polar bears are also thriving as a result. This conclusion is in marked contrast to one polar bear researcher, who suggested that 'no ice = no ice bears'.[130]

Table 1: Changes in primary productivity 2020 vs 2003–19

Region	Change %
Eurasian Arctic (East Siberian, Laptev, Kara Seas)	117.2
Amerasian Arctic (Chukchi, Beaufort, Canadian Archipelago)	107.9
Barents Sea	102.5
Hudson Bay	107.1

Source: Frey et al. 2020, Table 1.

Ironically, although sea ice coverage has been below average in the summer in the Laptev Sea, the region continues to act as the primary 'sea ice generator' for the Arctic: during fall and winter, the severe continental weather in Siberia blows offshore into the shallow Laptev Sea, creating the upwelling conditions necessary for almost constant sea ice formation from October to April.[131]

Long term variability of Arctic sea ice

Sea ice varies between seasons, of course, but it is often highly variable from year to year within a sea ice ecoregion and across the Arctic as a whole. Over longer periods (decades, centuries, millennia), Arctic sea ice has also been quite variable, at times more extensive than today and at others, less extensive.[132] Polar bears and their prey species – ringed and bearded seals, walrus, beluga, and narwhal – have survived these and other changes with no apparent negative effects.[133] Their inherent flexibility in dealing with changing ice conditions past and present (see Section 8) mean that evolutionary adaptation, as it is usually defined, has not been necessary.

An important study published in 2020 provided strong evidence that the Northern Hemisphere cold period known as the Little Ice Age (ca. 1300–1850 AD) was initiated by a spontaneous, century-long increase in Arctic sea ice flowing into the North Atlantic in the early 1300s that had no apparent external trigger; it also found evidence for another spontaneous pulse of sea ice lasting nearly a century off east Greenland in the 15th century that coincided with the abandonment of Norse colonies.[134] Lead author Giff Miles stated: "we do have physical, geological evidence that these several decade-long cold sea ice excursions in the same region can, in fact do, occur."[135] Similarly, another paper published in 2020 found evidence that the Laptev and East Siberian Seas were often ice-free in summer during the early to middle Holocene warm period, as they have been in recent years, but that the lack of summer ice in the past was due to natural causes.[136]

Sea ice by subpopulation

Regehr and colleagues in 2016[137] provide details of the amount of sea ice loss (number of days with ice cover of >15% concentration) per year for the period 1979–2014 per polar bear subpopulation. This metric varied from a high of 4.11 days per year in the Barents Sea to a low of 0.68 in the southern-most region, Southern Hudson Bay. Most subpopulations have lost about one day per year since 1979, although a few have lost somewhat more or less.[138]

Variable ice levels in Barents Sea

Surprisingly, despite the Barents Sea having the greatest loss of ice since 1979, polar bear numbers have been increasing. In 2019, litter counts were as high as in 1993 (Section 7).[139] In 2020, winter ice in the Svalbard region of the Barents Sea was unusually extensive: by late February 2020, it was well above average for that time of year – higher than it had been in two decades – with extensive

ice present on the west coast of the archipelago for the first time since February 2000.[140] By 3 April, ice extent around Svalbard was the sixth highest since 1967, only slightly less than it had been in 1988, and Bear Island (Bjørnøya) to the south of the Svalbard Archipelago was surrounded by ice between late February and mid-May, a most unusual occurrence this century.[141] Ice north of Svalbard was also unusually thick and remained so into May, which presented some logistical problems for marine traffic in the area and resupply for MOSAiC researchers deliberately stuck in ice aboard the *Polarstern* icebreaker just north of Svalbard.[142] However, in May there was a remarkable reversal: ice extent declined abruptly and by 25 August ice extent was the lowest it had been on that date since records began in 1967[143] and extent remained below average for the rest of the year.[144] Although there were no negative impacts on polar bears reported, researchers were not allowed into the field to investigate because of Covid-19 concerns and so could not assess the condition of bears in a systematic way.

Freeze-up and breakup date changes for Hudson Bay

Contrary to predictions, freeze-up of sea ice along Western and Southern Hudson Bay came as early in 2017, 2018, 2019, and 2020 as it did in the 1980s; in addition, summer breakup in 2019 and 2020 was as late as it was in the 1980s – making 2019 and 2020 phenomenally good years for Hudson Bay polar bears – even though this information has not yet been incorporated into the scientific literature.[145] These ice conditions allowed most WH and SH bears to resume seal hunting four weeks earlier than in 2016 (when freeze-up was quite late) and has meant six good seasons in a row for these bears (with the last two being very good).[146] Although year-to-year variability is quite normal for Hudson Bay, a return to 1980s-like freeze-up dates four years in a row was not only unexpected but could not be explained by external forcing, such as the June 1991 volcanic eruption of Mount Pinatubo that seemed to cause a later-than-average breakup in 1992 and earlier-than-usual freeze-ups in 1991 and 1993.[147] Polar bear specialists have implied natural variation was to blame.[148]

Despite the overall drop in ice-covered days since 1979, several polar bear studies have demonstrated that there has been no statistically significant change in either breakup or freeze-up dates for WH since the mid-1990s and recent data is unlikely to change that.[149] Most of the change, an increase in the total ice-free period of about three weeks, came about 1998.[150] Note that is three weeks total, not three weeks at breakup and another three weeks at freeze-up, as is sometimes claimed.[151] As discussed in Section 8, many WH bears have been staying out on the melting ice long past the time they would have done a decade ago, which implies that breakup dates no longer mean what they once did for polar bears. Perhaps because of this, WH polar bear papers published in recent years have only presented sea ice data since 2015 as part of an index or correlation, not as simple data that can be compared to previous studies or to reports by observers of dates of polar bears' arrival onshore.[152]

There is less data, both formal and informal, for SH than there is for WH. However, sea ice charts show the pattern is similar for both, with breakup and freeze-up dates for SH coming a bit later than for WH. The ice-free season has increased in SH by about 30 days since the 1980s, but, as for WH, most of that change came in the late 1990s, with much yearly variation in breakup and freeze-up dates since then.[153]

Since 2017, the time polar bears are spending onshore has not increased as expected with declining ice levels. It is almost exactly the same as it was in the 1980s, before sea ice changes were evident. Even more astonishing is that some bears that left the ice in late August and then returned in late November 2020 would have spent only three months onshore – about one month less than in the 1980s and two months less than in the 1990s and 2000s.[154]

6. Prey base

Polar bears, seals, and sea ice

Ringed and bearded seals, and particularly their pups, are the primary prey of polar bears worldwide.[155] In some regions, other seal species, walrus, beluga, and narwhal are consumed too,[156] and bears may also scavenge whale carcasses.[157]

Seal numbers

Ringed and bearded seals

While ringed seals and bearded seals were both listed as 'threatened' under the US Endangered Species Act (ESA) in 2012, there is no evidence that either species has declined in number or registered any other negative impact due to reduced summer sea ice.[158] The 'threatened' status is based exclusively on the presumption that future harm with be caused by further reductions in summer sea ice.[159] However, no other Arctic nation has taken this conservation step for ringed and bearded seals, and neither has the IUCN Red List, which lists both as 'Least Concern'.[160]

In October 2020, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) released their 2019 assessment of the ringed seal, which changed the conservation status from 'not at risk' to 'special concern' due to 'reductions in area and duration of sea ice due to climate warming' and because the Canadian population is 'predicted to decline over the next three generations and may become threatened'.[161] The designation 'special concern' is the same status COSEWIC have assigned to the polar bear and is meant to indicate concerns that a species *may* qualify as 'threatened' in the near future (i.e. is predicted to decline but has not done so already).

The report cites as its primary evidence a study by Steven Ferguson and colleagues published in 2017 on Western Hudson Bay that assumed, but did not conclusively demonstrate, that a very warm year in 2010 was the cause of poor ringed seal body condition and birth of fewer pups in the few years following (2011–

2013).[162] Noting a correlation of ovulation rate in 2011 with the length of the open-water season in 2010, the authors blamed low ice levels for the decline in population, although they conceded that longer open-water periods in summer should actually allow ringed seals to feed for longer. Moreover, other explanations were possible. The authors also conceded that a recent unexplained shift in fish availability and abundance noted by other authors[163] could have been to blame, as could a respiratory illness, of which there was anecdotal evidence. In addition, the authors noted that heavy ice or snow in spring could also have reduced population health.[164]

Despite these compelling caveats, the COSEWIC ringed seal assessment for 2019 summarily concluded that a 'warm year' was the cause of the poor health and short-term population decline of WH ringed seals 2010–2013, without mention of any other possible factors.

Harp seals

Harp seals are an important alternate prey for polar bears in Davis Strait, Foxe Basin, Hudson Bay, southern Baffin Bay, East Greenland, and the Barents Sea.[165] A survey in 2012 determined there were an estimated 7.4 million harp seals in Atlantic Canada (range 6.5–8.3 m), an order-of-magnitude increase over the early 1980s when perhaps only half a million remained.[166] The results of a 2017 count of harp seal pups off Newfoundland and Labrador was published in 2020. Numbers had increased to 7.6 million (range 6.6–8.9 m).[167] This abundant prey base is likely to have resulted in a modest increase in polar bear numbers in Davis Strait and/or increased body condition since the last count in 2007 and, therefore, improved overall bear health and survival.[168]

7. Health and survival

Body condition

There were no images of starving polar bears circulated in 2020, although video footage of a lean young bear that boarded a Russian cargo ship got a small amount of international attention in April.[169] In August, a young male bear killed a camper in Svalbard, but its condition was not reported and no photographs of the bear were permitted (more details below).[170] As has been the case for several years, in 2020 most problem bears shown in photographs have been fat and healthy.[171]

Female body condition of polar bears has been reported to be somewhat worse in a few areas (SB, SH, DS, BB), but not below threshold levels necessary for reproduction.[172] The connection between body condition and reproductive success is, however, somewhat obscure. Laidre and colleagues note that:[173]

> the functional and temporal relationships between declines in body condition and recruitment, and declines in subpopulation size, are poorly understood….

New metrics of body condition

A study published in 2020 by Amy Johnson and colleagues used a new metric for comparing the health of WH bears between 1985 and 2018.[174] It combined estimates of the number of bears onshore in summer with estimates of 'energy density' and 'storage energy' (based on body-condition data). The results were then correlated with sea ice loss over time. Such a novel metric cannot be compared to previous studies but at this time is the only published paper which considers individual body condition data collected between 2007 and 2018. Their conclusion, that energy density and storage energy had declined significantly over the 34-year study, was followed by a shockingly obvious caveat that this result was due, in part, to the decline in population size over time.[175] As a consequence, it cannot be concluded with any confidence that body condition of WH bears had, in fact, declined.

In contrast, shore-based observers in WH, including polar bear specialists and officials at the *Churchill Polar Bear Alert Program*, have noted that from 2017 through 2020, virtually all WH bears have been in excellent condition and in 2020 a mother with a triplet litter (an indicator of a bear in very good condition, seen commonly in the 1970s and 1980s but rarely in recent years) was observed outside of Churchill on multiple occasions between September and November.[176] A triplet litter was also reported in the fall of 2017.[177] As noted in Section 5 with regard to WH sea ice breakup and freeze-up dates, none of this recent information on body condition for WH bears has made its way into the scientific literature in a format comparable to previous studies.[178]

Another recent study also used a novel 'index' of body condition rather than raw body condition data, to try to determine the effect of changing sea ice levels.[179] Melissa Galicia and colleagues based their index on adipose lipid content in fat samples collected from individual bears harvested by Inuit hunters from 2010 to 2017 in BB, DS, FB, GB, and LS.[180] Their results suggest that the body condition of the bears increased long past local dates of ice breakup. This implies that they were hunting successfully despite rapidly deteriorating ice conditions, and suggests that the decision of WH bears in 2017–2020 to stay out on the ice long past the breakup may represent common behaviour (Section 5). That said, this study presents a real conundrum: the lipid content data suggests that bears in all subpopulations were in good or very good condition in January–March (i.e. before the seal pupping season), contradicting previous studies (using body measurement data) that indicated bears were generally in their worst condition at that time of year.[181] This contradiction does not prove the Galicia study is flawed, but does call the results into question.

Improvements in some areas

A report on GB bears published in 2020[182] found that, contrary to expectations, body condition of all bears captured in spring increased between the 1998–2000 and 2015–2017 study periods despite a marked decline in sea ice; evidence from survey

counts indicated the population had remained stable (but not increased) over time (see Section 3). In neighbouring MC, body condition of all bears was found to have increased between the 1998–2000 and 2014–2016 study periods despite a profound change in sea ice; evidence from survey counts indicated the population had more than doubled over time (from about 325 to 716).[183]

Surprisingly, in the Svalbard region of the BS, the body condition of both male and female bears has increased despite a marked decline in sea ice. In-progress reports of field results showed that most male bears in 2019 were in better condition than they had been since 1995.[184] Similarly, a peer-reviewed study published in 2019 found that adult female bears captured from 2005 to 2017 around Svalbard were in significantly better condition than they had been in the 1990s and early 2000s, despite the most dramatic declines of summer and early winter (Dec-Feb) ice of all polar bear regions:[185]

> Unexpectedly, body condition of female polar bears from the Barents Sea has increased after 2005, although sea ice has retreated by ~50% since the late 1990s in the area, and the length of the ice-free season has increased by over 20 weeks between 1979 and 2013. These changes are also accompanied by winter sea ice retreat that is especially pronounced in the Barents Sea compared to other Arctic areas.

In summary, it is clear that recent data collected from across the Arctic do not support the assumption stated repeatedly by polar bear specialists that sea ice loss inevitably leads to reduced body condition of polar bears.[186]

Hybridization

There were no reports or published papers on additional hybridization events in 2020, although a news report about grizzlies in Wapusk National Park, Manitoba again raised the issue of potential hybridization with polar bears, since some WH polar bears spend the summer or make maternity dens in the park.[187] A blonde grizzly shot in 2016 north of the park, near Arviat, was initially thought to have been a hybrid but this was disproven by DNA analysis.[188] The increase in reported grizzly numbers in Manitoba[189] (all of which have been lone animals, probably males since male tundra grizzlies are known to travel thousands of kilometres) was blamed on climate change by one researcher. However, not mentioned was the obvious alternative explanation – that hunting restrictions have led to a population increase and an expansion of their range.[190] As far as we know, hybridization in the wild has been between female polar bears and male grizzlies: as a result, the offspring are raised as polar bears and live on the sea ice (true also for second generation grizzly × polar bear crosses); the opposite cross (male polar bear × female grizzly) is so far only known from captive animals.[191]

Effect of contaminants

Contaminants have been shown to be present in polar bears, but have not been shown to have done any harm. All of the so-called 'evidence' for negative effects is currently circumstantial and inconclusive.[192] In 2020, a review of all 'new and/or emerging' contaminants across Hudson Bay, East Greenland, and Svalbard was simply a list of potentially nasty compounds found in polar bears but did not show any documented harm.[193] Despite this, a study published in early 2021 (but accepted in September 2020) assumed that a number of organic contaminants would have profound negative health and reproductive effects on polar bears across the Arctic. The authors' computer model indicated that 10 out of 15 polar bear subpopulations were likely to decline as a consequence.[194]

Denning on land vs. sea ice

Many polar bear females den on land across the Arctic but denning on the sea ice is also a viable option. In Seasonal ice ecoregions, including WH, SH, FB, and DS, all bears make their dens on land because sea ice melts completely in the summer. But in other ecoregions, including SB, CS, and BS, bears can choose between land dens or sea ice dens.

In 2020, Kristin Laidre and Ian Stirling documented, for the first time, polar bears denning on or around grounded icebergs in northern and northeastern Greenland.[195] Another paper published in 2020 updated previous studies and summarized known land den areas in Canada, using information from a variety of sources, including traditional ecological knowledge.[196] A number of major and minor terrestrial polar bear denning areas have also been recorded in other regions, including Wrangel Island, Franz Josef Land, Svalbard, and the Laptev Sea.[197]

In 2020 the issue of SB bears denning on land became an issue due to intensified efforts to thwart oil exploration and extraction in Alaska (details below).

Ice-free period on land

In recent years, the Southern Beaufort has been virtually 100% covered by sea ice between November and June, and the majority of bears stay on the ice as it retreats north in the summer; only 17.5% stay on land.[198] SB bears that spend all or a part of the summer on land seem to benefit from scavenging on the carcasses of bowhead whales that have been legally harvested by aboriginal residents,[199] although it is primarily males and mothers with cubs (not pregnant females) that use these resources. In 2020, the ice-free period in the SB was shorter than it has been for years, making this a good ice year for polar bears there. There was not extensive open water off Alaska until the end of June and extensive ice had returned by the third week in October, although it is unknown if this made a difference to the health of bears that had spent the season on shore.[200] However, 2020 was also a shorter than usual ice-free period for polar bears in WH –

for the fourth year in a row (see Section 5) – and bears there were reported to be in excellent condition.[201]

Threats from oil exploration and extraction in Alaska

In 2018, renewed concerns were expressed regarding the risks to polar bears from planned oil exploration and extraction activities in the Arctic National Wildlife Refuge Area of Alaska (ANWR).[202] However, less than half of SB females make maternity dens in this area,[203] and biologists have found that while females are generally loyal to either land or sea for denning, as well as to a particular stretch of coast, they are not loyal to a specific place. Such flexibility is probably necessary because of annual variations in weather, sea ice conditions and prey availability.[204] In other words, there is strong evidence to suggest that if drilling or other activities were to disturb a pregnant female at a particular den location one year, she simply would not try to den in that spot again. Moreover, it is unlikely she would den in the same spot even if she was *not* disturbed. In addition, the small proportion of the polar bear population that spends some part of the summer on land are concentrated at the whale bone piles at Kaktovik and a few lesser known beach sites, which should be easy for drilling and exploration crews to avoid.[205]

Surprisingly, oil exploration and extraction activities – from the 1990s in the Eastern Beaufort (around Tuktoyaktuk in Canada) and from the 1970s in the Canadian High Arctic – were expected to cause a marked increase in the number of defense kills and unacceptable disruptions to denning but they did not.[206] However, in 2020 increased efforts to stop oil exploration and extraction resulted in two new studies that purported to assess possible threats to survival of SB polar bear cubs. One modelled the probable effectiveness of a variety of seismic survey designs that might be used by oil industry teams.[207] Another study assessed probabilities of disturbance to denning polar bears, but the authors were surprised to find that bears were less reactive to disturbance than expected:

> We found significant probabilities for disturbance among all stimulus classes, with aircraft showing the highest potential for initiating den abandonment. However, while all human activities elicited varying degrees of response, the overall response intensity was less than anticipated, even under high-use scenarios. Our data indicate that the current guideline of a 1.6 km (1 mile) buffer zone effectively minimizes disturbance to denning polar bears.[208]

Public commentaries regarding this issue continued in 2020.[209] However, in September a US government report combined the results of the recent SB population survey with a count of polar bear dens: it showed that the population in fact had not declined since 2010 as expected (see Section 2), but that few dens could be expected in the area scheduled for oil exploration. The report concluded that an estimated 123 dens (range

69–198) could be expected in the entire SB population (about 908 bears) every year and, of those, a little more than half (66 dens, range 35–110) would be situated on land. The number of dens expected in the Arctic Coastal Plain, where oil exploration has been proposed, was 14 (range 5–30).[210] In other words, only about 11% of dens were at risk of *possible* disturbance due to oil exploration and extraction activities, and females are not particularly disturbed by such activities anyway. This result seems at odds with the claim that this area is critical denning territory for the survival of polar bears in Alaska and that the risk posed by oil exploration is unacceptably high.[211] However, because this is a highly political issue in the US, the controversy continues.[212]

Litter sizes

Litter sizes are one way to assess the reproductive success of polar bears. Recent litter size counts have given no cause for concern, including those reported during 2020.

8. Evidence of flexibility

Polar bears do not maintain territorial home ranges like grizzly and black bears and this is one of the most distinctive aspects of the species.[213] Since Arctic sea ice changes almost constantly from timescales of days, seasons, years, decades and millennia, one of the polar bear's most critical evolutionary adaptations is the ability and willingness to move around as sea ice and prey availability changes. Researchers are only documenting some of this flexibility now because marked changes in sea ice coverage did not routinely happen between the 1970s and the start of the 21st century.

Sea ice preferences

While polar bear specialists have for years insisted that polar bears prefer sea ice of 50% or more over continental shelves, regardless of season, recent research has shown bears utilize sea ice well below this threshold. In the Southern Beaufort Sea and Western Hudson Bay, bears were found to use ice of 0–20% concentration; in some cases SB bears were tracked to areas registered by satellites as open water.[214] Similar behaviour has been observed among WH bears in 2017–2020. Perversely, they have also been staying onshore for an extra two weeks or more in the fall despite ice levels being adequate for them to leave. Researcher Andrew Derocher calls this 'behavioural plasticity'.[215] In fact, this phenomenon had been observed before 2017, but its significance was not addressed.[216]

This ability to adapt to low ice concentrations during summer and a reticence to leave in the fall, even when ice is available offshore for hunting, indicates inherent flexibility in the polar bear, one that probably always existed but was not evident until sea ice changes became so pronounced.[217]

9. Human/bear interactions

Attacks on humans

A major 2017 scientific summary of polar bear attacks on humans (1880–2014), authored by biologist James Wilder and colleagues,[218] concluded that such attacks are extremely rare and that the threat to human safety from polar bears is exaggerated. However, this may be because they essentially ignored attacks on Inuit and other indigenous people that live and hunt in the Arctic. By attempting to generate information that could be assessed with statistical methods, the authors ended up with data so skewed and incomplete that it does not provide a plausible assessment of the risk to humans of attacks by polar bears. Acknowledging that well-reported attacks on Europeans (or recorded by them) make up the bulk of the data used in the paper does not adequately address the weakness of the authors' conclusion that polar bears are not particularly dangerous.

This means that, except for well-reported incidents in the last few decades, virtually all attacks on the people most likely to encounter polar bears were not included in this study and the authors discount the almost perpetual danger from predatory polar bear attacks that Inuit and other indigenous people endured — and still endure in many areas — because those people in the past existed in 'relatively low numbers.'[219]

In 2020, an important paper was published that showed traditional bear spray – used routinely outside the Arctic for protection against brown and black bears – is more effective than assumed at relatively low temperatures and might be a useful option at close range for protection against polar bears.[220]

Unusual sightings, problem bears and attacks in 2020

Winter/spring

Winter is the leanest time of year for polar bears, since fat Arctic seal pups won't be available for another 2–3 months and meals for polar bears are hard to come by; this makes the bears especially dangerous when they come into contact with humans.[221] By spring, bears are in hunting-mode, as they pack on as much fat as possible to aid their survival over the summer months of fasting, and humans do well to avoid being the focus of these hunts.[222] Even well-fed bears continue to seek out sources of food.

Svalbard 2020 problem bears winter/spring

On 15 January 2020, just east of Longyearbyen, a bear ran at a dog sled tour group as they neared home in the winter darkness at the end of a six-hour trip. The driver stopped the sled but said there was not enough time to reach his rifle, so he smacked the bear several times across the nose with the heavy noose-shaped brake rope that hung on the front of his sled. This assault caused the bear to run off and it was eventually chased away from the

area by helicopter.[223] On 20 January 2020, a 62-kg female bear that had been prowling the area across the fjord from Longyearbyen for weeks was tranquilized after being chased for almost an hour by helicopter. She unfortunately died on the flight to a remote area of northeast Svalbard, of undetermined causes.[224] On 1 May 2020, a bear was sighted in an area of recreational cabins west of Longyearbyen but caused no trouble before moving off.[225]

Labrador and Newfoundland 2020 problem bears winter/spring

Oddly, in 2020 there was only one media report of polar bears onshore in Labrador: the community of Cartwright noted on 15 February that one or more bears had recently been spotted in the area.[226] According to Canadian Ice Service charts, sea ice was less extensive along the Labrador coast in early 2020, but there was certainly ice present from late January until early May. So either bears were not going ashore or sightings were not being reported.

There were also surprisingly few reports of bears onshore in Newfoundland between January and April 2020. Several sightings of bears and/or their tracks were reported near the town of St. Anthony in Newfoundland in mid-March, but no specific problems were noted; a bear was sighted on Fogo Island, Newfoundland on 6 April, but again there were no conflicts.[227] According to Canadian Ice Service charts, sea ice was less extensive than usual off the north coast of Newfoundland in 2020 but there was definitely some off the coast from at least late February until mid-April.

Summer/autumn

Where all or a portion of the subpopulation comes ashore during the ice-free season, there is a different human–bear dynamic than what is seen in winter. For five months or so in some regions, but less in others, encounters between bears and people are much more likely in summer and autumn. Compared to sixty years ago, when hunting restrictions were put in place, there are many more bears and also more people. While serious attacks have always been relatively rare in summer, the number of bears shot or removed before tragedy strikes (especially in remote regions) have only recently been closely tracked.[228] For example, since polar bears have been protected in Canada, defence kills in Nunavut have been counted as part of the yearly quota of bears that a community is allowed to hunt, so they were rarely reported as something other than a legal harvest. The same may be true in Greenland, where bears are also hunted by native residents. In contrast, in the 1960s and early 1970s, many 'problem' bears in the community of Churchill, Manitoba were shot every year in defence of life or property, but presumably all were officially reported.[229]

Russia 2020, problem bears in summer/autumn

In late October 2020, at a location in the Kara Sea (the exact location is not confirmed, but it is probably Novaya Zemlya), ten fat polar bears – including at least two mothers with cubs – besieged a stalled garbage truck stuck on a road. The bears climbed into

the open truck to get at the food scraps inside. Luckily, no one was hurt, but the driver was shaken up (a driver in another truck called for help).[230] In the Russian Far East in 2020, the residents of Ryrkaypiy on the Chukchi Sea apparently came up with a solution with assistance from the World Wildlife Fund (WWF): although more than 30 polar bears were seen near town in late December, guards placed around the town kept the bears from entering the community and causing problems as they had in 2019.[231]

Western Hudson Bay problem bears in summer/autumn

All Western Hudson Bay polar bears are forced ashore by melting ice in the summer, and Churchill, Manitoba is located near a primary staging area for the many bears that wait for the ice to form in the autumn. Churchill's problems with polar bears extend back to the 1960s and took time and money to become as well-managed as they are today.[232] Table 2 shows the tallies of problem bears recorded by the Polar Bear Alert Program for the years 2015–2020.

Although correlations between an increase in the ice-free season over time and increased problems with bears in Churchill have been attempted several times ('less ice = more problem bears'),[233] a study published in 2020 by Sarah Heemskerk and colleagues found that the number of problem bears increased between 1970 and 1998 but showed no trend between 1999 and 2018; overall, however, there were remarkably fewer problems with bears after 2001 than there were before (601 vs. 1409). Their data show the years with highest number of polar bear incidents were 1983 (when there was also a fatal attack) and 2003 (the highest for the entire 1970–2018 period); 2017 and 2018, as noted above, had relatively few and the years with the fewest number of conflicts were 1980 through 1982. [234] The paper stated that 'after 2011 there was a continued decrease in abundance' (i.e. a further population decline) but cite only 'unpublished data' to corroborate such a claim; they also claim a correlation over time with an increase in the ice-free season but the fit with that trend line is less than convincing, since there were fewer attacks in the one year with longest ice-free season (>190 days) than there were in three years when the season was much shorter (<150 days).[235] Also,

Table 2: Polar bear problem bears in Churchill, Manitoba

Year	Period	Number of incidents
2020	16–22 Nov	116
2019	11–17 Nov	138
2018	5–11 Nov	246
2017	20–26 Nov	148
2016	5–11 Dec	386
2015	16–22 Nov	333

Source: Polar Bear Alert Program, Churchill, Manitoba

while other authors, including polar bear specialists, acknowledge that a step-change in summer sea ice added about three weeks to the ice-free season in 1998 but has not changed since, Heemskerk and colleagues present a continuing increase in the ice-free season since 1979.[236] In other words, they note a step-change in polar bear incident data but not the sea ice data. Ultimately, however, they conceded that changes in management protocols (such as the increased vigilance after the near-fatal attack in 2013) meant that none of the trends over time they identified – including an apparent decrease in problems due to documented or implied declines in population size – were reliable: none of their correlations were scientifically valid because the way that 'problem' bears were defined and dealt with changed over time.

In Arviat to the north, increased attention to managing bears in the immediate area of town since 2014 continues to be successful at avoiding serious incidents with bears.[237] In the fall of 2020 in Arviat, a whale carcass blown onshore near town by a storm attracted a mother and two cubs, so to reduce any danger to residents community 'bear monitors' dragged the carcass out to sea and sank it. According to social media reports by one resident, there were many bears around Arviat in 2020 but bear monitors drove them away before they could cause any trouble.[238] However, the fatal attacks that have occurred north of Churchill have taken place well outside communities, where it is almost impossible to predict where bears will be or how they will behave.

Baffin Bay sightings summer/autumn

There was a probable polar bear sighting on 6 July 2020 near the city of Iqaluit (on southeastern Baffin Bay) in Sylvia Grinnel Territorial Park. However, there were no further sightings of the bear and no problems were reported.[239]

Svalbard fatal bear attack summer/autumn

In 2020, Svalbard had its first fatal polar bear attack since 2011, in the early hours of 28 August 2020, just outside the main town of Longyearbyen, at a camping site along a beach beside the Longyearbyen airport. The camping site provided low-cost accommodation for visitors, but did not have a guard posted or an electric fence installed to protect against polar bears. About 4 a.m., a bear grabbed a Dutch camper as he slept in his tent and his screams brought others to his aid; someone managed to shoot the bear but not before the man was fatally mauled. The bear was a three-year-old male but his condition was not described: historically, subadult bears are responsible for most attacks on people and they are known to be especially dangerous.[240] This bear was one of at least four that had been seen in the area that week. Apparently, supplies to build an electric fence had arrived in March but construction was delayed when Covid-19 restrictions shut down the arrival of all visitors; by the time visitors were allowed, the ground was too soft to install the fencing.[241] Lack of sea ice cannot be blamed for this attack – or for the numerous reports of bears in the area at the time – since Norwegian Ice Service charts showed

ice coverage around the archipelago had been better in the spring of 2020 than they have been for decades.[242] While there was no ice off Svalbard at the time of the attack, that is not unusual for late August, and most bears onshore at that time should have been in excellent condition.

Labrador and Newfoundland problem bears summer/autumn

In 2020, in late September, a Canadian search and rescue helicopter left out overnight at the remote airstrip in Saglek on the northern coast of Labrador was damaged by a polar bear. The bear pushed in the side door, popped out an emergency exit window and ripped the cover off the nose cone, but did not enter the helicopter and no one was injured.[243] The damage to the helicopter happened very near where a near-fatal polar bear attack took place in late July 2013, when a bear grabbed a camper – tent and all – and headed off down the beach. The victim was only saved by a fellow camper who shot flares at the bear until he dropped the man and ran off. Several accounts of the incident unfairly blamed lack of sea ice due to climate change for the attack, and most failed to acknowledge the rather dramatic increase in polar bear numbers that had been documented in the region.[244]

10. Discussion

Even in 2020, polar bears continue to be described as 'canaries in the coal mine' for the effects of human-caused climate change, despite evidence that far from being a highly-sensitive indicator species, it is thriving across the Arctic, even in regions that have had the most dramatic recent declines in sea ice.[245]

The current health and abundance of polar bears is also markedly at odds with a new model that attracted worldwide media attention in 2020 because it predicted the near extinction of the species by 2100 due to climate change.[246] This model depended on one critically flawed assumption: it used the RCP8.5 carbon dioxide emissions scenario, which most observers consider so extreme as to be discredited as scientifically implausible.[247] In addition, although the model estimated theoretical 'fasting thresholds' expected to limit the number of cubs produced and adult survival, it did not take into account the increased primary productivity recorded across the Arctic as a result of reduced summer sea ice, which we know from regional studies means that many bears have more to eat in the spring, so that they enter the summer fast period in excellent condition. Nor did the study take into account the documented willingness of bears to adjust their denning and feeding locations as sea-ice changes occur. Fortunately for the authors, they did not make specific claims for future effects of sea-ice loss on polar bear abundance that would encourage scientific hypothesis testing, as their colleagues did in 2007: they stuck to vague descriptors, such as 'possible' and 'likely', to describe future negative impacts, knowing that all of their predicted 'inevitable' effects were half a century or more from critical scrutiny.[248]

Despite the fact that in 2020, summer sea-ice levels declined to the second lowest levels since 1979 – but still no further than about 3 mkm^2 – there were no reports of widespread starvation of bears, acts of cannibalism, or drowning deaths that might suggest they were having trouble surviving the ice-free season. In general, there were no more reports of problem bears than normal.

Studies that presented data up to and including 2020 showed that primary productivity in the Arctic has increased because of longer ice-free periods. A report on the abundance of harp seals off Newfoundland and Labrador suggested that this important food source for polar bears had increased since 2012. Other surveys have been delayed, some because of Covid-19 or for other reasons that are less clear. The increase in primary productivity explains in part why polar bears in the Chukchi and Barents Seas have been thriving in recent years –and suggests that bears in the Laptev, East Siberian and Kara Seas, as well as Hudson Bay, are likely also doing well, although a lack of recent studies means documentary evidence is wanting. Recent body-condition surveys give more grounds for optimism, although polar bear specialists tend to cite decades-old data,[249] or to use new metrics of body condition in order to present a pessimistic view.

The long-predicted decline in polar bear populations still hasn't happened. Results of three polar bear population surveys were published in 2020 and all were found to be either stable or increasing. Importantly, Southern Beaufort polar bear numbers were found to have been stable since 2010 at about 907 bears, not reduced as expected. Overall, studies published between 2016 and 2020 suggest that the most up-to-date global population total should be about 30,000 (and could be even higher), up from about 26,000 in 2015.[250] Reports in progress may increase this further.

Overall, 2020 appears to have been another good year for polar bears.

Bibliography

Aars, J. 2013. Variation in detection probability of polar bear maternity dens. *Polar Biology* 36:1089–1096.

Aars, J. 2018. Population changes in polar bears: protected, but quickly losing habitat. *Fram Forum Newsletter 2018*. Fram Centre, Tromso.

Aars, J., Lunn, N.J. and Derocher, A.E. 2006. *Polar Bears: Proceedings of the 14th Working Meeting of the IUCN/SSC Polar Bear Specialist Group, Seattle, Washington, 20–24 June 2005.* Occasional Paper of the IUCN Species Survival Commission 32. IUCN, Gland, Switzerland.

Aars, J., Marques, T.A., Buckland, S.T., Andersen, M., Belikov, S., Boltunov, A., et al. 2009. Estimating the Barents Sea polar bear subpopulation. *Marine Mammal Science* 25: 35–52.

Aars, J., Marques,T.A, Lone, K., Anderson, M., Wiig, Ø., Fløystad, I.M.B., Hagen, S.B. and Buckland, S.T. 2017. The number and distribution of polar bears in the western Barents Sea, *Polar Research* 36:1, 1374125.

ACIA 2005. *Arctic Climate Impact Assessment: Scientific Report*. Cambridge University Press.

AC SWG 2018. Chukchi-Alaska polar bear population demographic parameter estimation. Eric Regehr, Scientific Working Group (SWG. Report of the Proceedings of the 10th meeting of the Russian-American Commission on Polar Bears, 27–28 July 2018), pg. 5. Published 30 July 2018. US Fish and Wildlife Service. https://www.fws.gov/alaska/fisheries/mmm/polarbear/bilateral.htm.

Allen, K. 2020. Polar bears may be extinct by 2100 if Arctic ice melts at projected rate, according to new study. *ABC News*, 22 July. https://abcnews.go.com/US/polar-bears-extinct-2100-arctic-ice-melts-projected/story?id=71895289.

Amstrup, S.C. 1993. Human disturbances of denning polar bears in Alaska. *Arctic* 46:246–250.

Amstrup, S.C. 2003. Polar bear (*Ursus maritimus*). In *Wild Mammals of North America*, G.A. Feldhamer, B.C. Thompson and J.A. Chapman (eds), pg. 587–610. Johns Hopkins University Press, Baltimore.

Amstrup, S.C. 2018. Proposed oil exploration plan would put polar bear population at an unacceptable risk. Opinion, 25 September, *The Hill*. https://thehill.com/blogs/congress-blog/energy-environment/408225-proposed-oil-exploration-plan-would-put-polar-bear.

Amstrup, S.C. 2019. Written Testimony of Dr. Steven C. Amstrup Chief Scientist, Polar Bears International before the Subcommittee on Energy and Mineral Resources of the Committee on Natural Resources United States House of Representatives. Legislative hearing on "The Need to Protect the Arctic National Wildlife Refuge Coastal Plain" 26 March 2019 https://naturalresources.house.gov/download/testimony-polar-bears-international-amstrup.

Amstrup, S. 2020. Polar bear dens at risk. *Polar Bears International News*, 2 March. https://polarbearsinternational.org/news/article-research/polar-bear-dens-at-risk/.

Amstrup, S.C., Durner, G.M., Stirling, I. and McDonald, T.L. 2005. Allocating harvests among polar bear stocks in the Beaufort Sea. *Arctic* 58:247–259.

Amstrup, S.C. and Gardner, C. 1994. Polar bear maternity denning in the Beaufort Sea. *The Journal of Wildlife Management* 58:1–10.

Amstrup, S.C., DeWeaver, E.T., Douglas, D.C., Marcot, B.G., Durner, G.M., Bitz, C.M., and Bailey, D.A. 2010. Greenhouse gas mitigation can reduce sea-ice loss and increase polar bear persistence. *Nature* 468:955–958.

Amstrup, S.C., Marcot, B.G. and Douglas, D.C. 2007. Forecasting the rangewide status of polar bears at selected times in the 21st century. Administrative Report, US Geological Survey. Reston, Virginia.

Amstrup, S.C., Marcot, B.G., Douglas, D.C. 2008. A Bayesian network modeling approach to forecasting the 21st century worldwide status of polar bears. Pgs. 213–268 in *Arctic Sea Ice Decline: Observations, Projections, Mechanisms, and Implications,* E.T. DeWeaver, C.M. Bitz, and L.B. Tremblay (eds.). Geophysical Monograph 180. American Geophysical Union, Washington, D.C.

Amstrup, S.C., Stirling, I. and Lentfer, J.W. 1986. Past and present status of polar bears in Alaska. *Wildlife Society Bulletin* 14:241–254.

Amstrup, S.C., Stirling, I., Smith, T.S., Perham, C. and Thiemann, B.W. 2006. Recent observations of intraspecific predation and cannibalism among polar bears in the Southern Beaufort Sea. *Polar Biology* 29:997–1002.

Andersen, M. and Aars, J. 2016. Barents Sea polar bears (*Ursus maritimus*): population biology and anthropogenic threats. *Polar Research* 35: 26029.

Andersen, M., Derocher, A.E., Wiig, Ø. and Aars, J. 2012. Polar bear (*Ursus maritimus*) maternity den distribution in Svalbard, Norway. *Polar Biology* 35:499–508.

Anonymous. 1968. Proceedings of the First International Scientific Meeting on the Polar Bear, 6–10 September 1965 at Fairbanks, Alaska. U.S. Dept. of the Interior (Resource Publication 16) and the University of Alaska (International Conference Proceedings Series, No. 1). http://pbsg.npolar.no/en/meetings/.

Arctic Council. 2020. The impact of Covid-19 on Indigenous peoples in the Arctic. *Arctic Council*, 16 July 2020. https://arctic-council.org/en/news/the-impact-of-covid-19-on-indigenous-peoples-in-the-arctic/.

Arrigo, K.R., Perovich, D.K., Pickart, R.S., Brown, Z.W., van Dijken, G.L., Lowry, K.E., Mills, M.M., Palmer, M.A., Balch, W.M., Bahr, F., Bates, N.R., Benitez-Nelson, C., Bowler, B., Brownlee, E., Ehn, J.K., Frey, K.E., Garley, R., Laney, S.R., Lubelczyk, L., Mathis, J., Matsuoka, A., Mitchell, B.G., Moore, G.W.K., Ortega-Retuerta, E., Pal, S., Polashenski, C.M., Reynolds, R.A., Schieber, B., Sosik, H.M., Stephens, M., and Swift, J.H. 2012. Massive phytoplankton blooms under Arctic sea ice. *Science* 336:1408.

Atwood, T.C., Marcot, B.G., Douglas, D.C., Amstrup, S.C., Rode, K.D., Durner, G.M. et al. 2016a. Forecasting the relative influence of environmental and anthropogenic stressors on polar bears. *Ecosphere* 7(6): e01370.

Atwood, T.C., Peacock, E., McKinney, M.A., Lillie, K., Wilson, R., Douglas, D.C., and others. 2016b. Rapid environmental change drives increased land use by an Arctic marine predator. PLoS ONE 11(6): e0155932. doi:10.1371/journal.pone.0155932.

Atwood, T.C., Bromaghin, J.F., Patil, V.P., Durner, G.M., Douglas, D.C., and Simac, K.S., 2020. Analyses on subpopulation abundance and annual number of maternal dens for the U.S. Fish and Wildlife Service on polar bears (*Ursus maritimus*) in the southern Beaufort Sea, Alaska. U.S. Geological Survey Open-File Report 2020–1087.

Barton, K. 2016. Grolar or pizzly? Nope, just a blond grizzly. *CBC News*, 21 June. http://www.cbc.ca/news/canada/north/blonde-grizzly-hybrid-polar-1.3645547.

Beaumont, P. 2020. Polar bear kills man at campsite on Norwegian archipelago of Svalbard. *The Guardian* (UK), 28 August. https://www.theguardian.com/world/2020/aug/28/polar-bear-kills-man-norway-svalbard-longyearbyen.

Brewster, M. 2020. 'Polar bear damages RCAF search and rescue chopper.' *CBC News*, 30 September. https://www.cbc.ca/news/politics/air-force-helicopter-bear-1.5744778.

Bromaghin, J.F., McDonald, T.L. and Amstrup, S.C. 2013. Plausible combinations: An improved method to evaluate the covariate structure of Cormack-Jolly-Seber mark-recapture models. *Open Journal of Ecology* 3:11–22 doi: 10.4236/oje.2013.31002.

Bromaghin, J.F., McDonald, T.L., Stirling, I., Derocher, A.E., Richardson, E.S., Regehr, E.V., Douglas, D.C., Durner, G.M., Atwood, T. and Amstrup, S.C. 2015. Polar bear population dynamics in the southern Beaufort Sea during a period of sea ice decline. *Ecological Applications* 25(3):634–651.

Brown, T.A., Galicia, M.P., Thiemann, G.W., Belt, S.T., Yurkowski, D.J. and Dyck, MG. 2018. High contributions of sea ice derived carbon in polar bear (*Ursus maritimus*) tissue. *PLoS One* 13(1):e0191631. https://doi.org/10.1371/journal. pone.0191631.

Brown, Z.W., van Dijken, G.L. and Arrigo, K.R. 2011. A reassessment of primary production and environmental change in the Bering Sea. *Journal of Geophysical Research* 116:C08014. doi:10.1029/2010JC006766.

Burns, J.J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. *Journal of Mammalogy* 51(3):445– 454.

Burns, J.J., Fay, F.H., and Shapiro, L.H. 1975. The relationships of marine mammal distributions, densities, and activities to sea ice conditions (Quarterly report for quarter ending September 30, 1975, projects #248 and 249). *In* Environmental Assessment of the Alaskan Continental Shelf, Principal Investigators' Reports, July-September 1975, Volume 1. NOAA Environmental Research Laboratories, Boulder, Colorado. pp. 77–78.

Calvert, W. and Stirling, I. 1990. Interactions between polar bears and overwintering walruses in the Central Canadian High Arctic. *Bears: Their Biology and Management* 8:351–356.

Cameron, M.F., Bengtson, J.L., Boveng, J.K., Jansen, J.K., Kelly, B.P., Dahle, S.P., Logerwell, E.A., Overland, J.E., Sabine, C.L., Waring, G.T. and Wilder, J.M. 2010. Status review of the bearded (Erignatha barbatus). NOAA Technical Memorandum NMFS-AFSC-211.

Castro de la Guardia, L., Myers, P.G., Derocher, A.E., Lunn, N.J., Terwisscha van Scheltinga, A.D. 2017. Sea ice cycle in western Hudson Bay, Canada, from a polar bear perspective. *Marine Ecology Progress Series* 564: 225–233.

CBC News 2020. Polar bear kills Dutch citizen on Norway's remote Svalbard Islands. *Associated Press*, 28 August. https://www.cbc.ca/news/world/norway-fatal-bear-attack-1.5703320.

Chambellant, M. 2010. Hudson Bay ringed seal: ecology in a warming climate. In S.H. Ferguson et al. (eds.), *A Little Less Arctic: Top Predators in the World's Largest Northern Inland Sea, Hudson Bay*, Springer Science+Business Media B.V. DOI 10.1007/978-90-481-9121-5_7.

Chambellant, M., Stirling, I., Gough, W.A. and Ferguson, S.H. 2012. Temporal variations in Hudson Bay ringed seal (*Phoca hispida*) life-history parameters in relation to environment. *Journal of Mammalogy* 93: 267–281.

Clark, D. 2003. Polar bear-human interactions in Canadian National Parks, 1986–2000. *Ursus* 14:65–71.

Clark, D.A., Stirling. I, and Calvert, W. 1997. Distribution, characteristics, and use of earth dens and related excavations by polar bears on the Western Hudson Bay lowlands. *Arctic* 50:158–166.

Coupel, P., Michel, C. and Devred, E. 2019. Case study: The Ocean in Bloom. In: *State of Canada's Arctic Seas*, Niemi, A., Ferguson, S., Hedges, K., Melling, H., Michel, C., et al., Canadian Technical Report Fisheries and Aquatic Sciences 3344.

COSEWIC. 2012. COSEWIC assessment and status report on the Grizzly Bear *Ursus arctos* in Canada. *Committee on the Status of Endangered Wildlife in Canada*. Ottawa.

COSEWIC. 2018. COSEWIC assessment and status report on the Polar Bear *Ursus maritimus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa.

COSEWIC. 2019. COSEWIC assessment and status report on the Ringed Seal *Pusa hispida* in Canada. *Committee on the Status of Endangered Wildlife in Canada*. Ottawa. https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments-status-reports/ringed-seal-2019.html.

Crawford, J. and Quakenbush, L. 2013. *Ringed seals and climate change: early predictions versus recent observations in Alaska*. Oral presentation by Justin Crawford, 28th Lowell Wakefield Fisheries Symposium, March 26–29. Anchorage, AK. http://seagrant.uaf.edu/conferences/2013/wakefield-arctic-ecosystems/program.php.

Crawford, J.A., Quakenbush, L.T. and Citta, J.J. 2015. A comparison of ringed and bearded seal diet, condition and productivity between historical (1975–1984) and recent (2003–2012) periods in the Alaskan Bering and Chukchi seas. *Progress in Oceanography* 136:133–150.

Crockford, S.J. 1997a. *Osteometry of Makah and Coast Salish Dogs*, Archaeology Press #22, Simon Fraser University, Burnaby, B.C.

Crockford, S.J. 1997b. Archaeological evidence of large northern bluefin tuna, *Thunnus thynnus*, in coastal waters of British Columbia and northern Washington. *Fishery Bulletin* 95:11–24.

Crockford, S.J. (ed.) 2000. *Dogs Through Time: An Archaeological Perspective.* Proceedings of the 1st ICAZ Symposium on the History of the Domestic Dog. Oxford, British Archaeological Reports (B.A.R.), Archaeopress S889.

Crockford, S.J. 2002. Animal domestication and heterochronic speciation: the role of thyroid hormone. pg. 122–153. *In:* N. Minugh-Purvis and K. McNamara (eds.) *Human Evolution Through Developmental Change*. Baltimore, Johns Hopkins University Press.

Crockford, S.J. 2003a. Commentary: Thyroid hormones in Neanderthal evolution: A natural or a pathological role? *Geographical Review* 92(1):73–88.

Crockford, S.J. 2003b. Thyroid hormone phenotypes and hominid evolution: a new paradigm implicates pulsatile thyroid hormone secretion in speciation and adaptation changes. *International Journal of Comparative Biochemistry and Physiology Part A* 135(1):105–129.

Crockford, S.J. 2004. Animal Domestication and Vertebrate Speciation: A Paradigm for the Origin of Species. Ph.D. dissertation. University of Victoria, Canada.

Crockford, S.J. 2006. *Rhythms of Life: Thyroid Hormone and the Origin of Species.* Trafford, Victoria.

Crockford, S.J. 2008a. *Some Things We Know – and Don't Know – About Polar Bears.* Science and Public Policy Institute (SPPI).

Crockford, S.J. 2008b. Be careful what you ask for: archaeozoological evidence of mid-Holocene climate change in the Bering Sea and implications for the origins of Arctic Thule. In *Islands of Inquiry: Colonisation, Seafaring and the Archaeology of Maritime Landscapes,* 113–131. G. Clark, F. Leach and S. O'Connor (eds.). Terra Australis 29 ANU EPress, Canberra.

Crockford, S.J. 2009. Evolutionary roots of iodine and thyroid hormones in cell-cell signaling. *Integrative and Comparative Biology* 49:155–166.

Crockford, S.J. 2012a. *A History of Polar Bears, Ringed Seals, and other Arctic and North Pacific Marine Mammals over the Last 200,000 Years.* A report Prepared for The State of Alaska Department of Commerce, Community and Economic Development and The University of Alaska Fairbanks. Pacific Identifications Inc., Victoria, British Columbia.

Crockford, S.J. 2012b. *Annotated Map of Ancient Polar Bear Remains of the World.* Spotted Cow Presentations Inc., Victoria, British Columbia. Available at http://polarbearscience/references/.

Crockford, S.J. 2014a. On the beach: walrus haulouts are nothing new. *Global Warming Policy Foundation Briefing Paper 11*. http://www.thegwpf.org/susan-crockford-on-the-beach-2/.

Crockford, S.J. 2014b. The walrus fuss: walrus haulouts are nothing new. Global Warming Policy Forum. http://www.thegwpf.org/gwpftv/?tubepress_item=cwaAwsS2OOY&tubepress_page=2.

Crockford, S.J. 2014c. Healthy polar bears, less than healthy science. *Global Warming Policy Foundation Note 10.* London.

Crockford, S.J. 2015a. Twenty good reasons not to worry about polar bears. *Global Warming Policy Foundation Briefing Paper 14*. London.

Crockford, S.J. 2015b. The Arctic fallacy: sea ice stability and the polar bear. *Global Warming Policy Foundation Briefing Paper 16*. London. Available at http://www.thegwpf.org/susan-crockford-the-arctic-fallacy-2/.

Crockford, S.J. 2015c. A harrowing encounter: polar bear vs. lawyer in Labrador. *Range Magazine* Spring issue, pp. 42–43.

Crockford, S. 2016. Prehistoric mountain goat *Oreamnos americanus* mother lode near Prince Rupert, British Columbia and implications for the manufacture of high-status ceremonial goods. *Journal of Island and Coastal Archaeology.*

Crockford, S. 2017a. Testing the hypothesis that routine sea ice coverage of 3–5 mkm^2 results in a greater than 30% decline in population size of polar bears (Ursus maritimus). *PeerJ Preprints* 2 March 2017. Doi: 10.7287/peerj.preprints.2737v3.

Crockford, S. 2017b. *Polar bear scare unmasked: the saga of a toppled global warming icon.* Video, February. Global Warming Policy Forum, London. https://www.youtube.com/watch?v=z6bcCTFnGZ0.

Crockford, S. 2017c. *The death of a climate icon.* Video, August. Global Warming Policy Forum, London. https://www.youtube.com/watch?v=XCzwFalI8OQ.

Crockford 2017d. Twenty good reasons not to worry about polar bears: an update. *Global Warming Policy Foundation Briefing Paper 28*. London.

Crockford, S.J. 2017e. *Polar Bears: Outstanding Survivors of Climate Change*. Amazon CreateSpace https://www.amazon.com/dp/1541139712/.

Crockford, S.J. 2018a. State of the Polar Bear Report 2017. *Global Warming Policy Foundation Report* #29. London.

Crockford, S.J. 2018b. 'Polar bears keep thriving even as global warming alarmists keep pretending they're dying.' 27 February opinion, National Post/*Financial Post*. http://business.financialpost.com/opinion/polar-bears-keep-thriving-even-as-global-warming-alarmists-keep-pretending-theyre-dying.

Crockford, S.J. 2018c. 'The real story behind the famous starving polar bear video reveals more manipulation.' 29 August opinion, *National Post/Finacial Post*. https://business.financialpost.com/opinion/the-real-story-behind-the-famous-starving-polar-bear-video-reveals-more-manipulation.

Crockford, S.J. 2018d. *White lie: the cruel abuse of a starving polar b*ear. Video, August. Global Warming Policy Forum, London. https://www.youtube.com/watch?v=Z7KTfPlCrgY.

Crockford, S.J. 2019a. State of the Polar Bear 2018. *Global Warming Policy Foundation Report* #32. London.

Crockford, S.J. 2019b. *The Polar Bear Catastrophe That Never Happened*. Global Warming Policy Foundation, London.

Crockford, S.J. 2019c. 'Netflix is lying about those falling walruses. It's another 'tragedy porn' climate hoax.' 24 April opinion, *National Post/Financial Post*. https://business.financialpost.com/opinion/netflix-is-lying-about-those-falling-walruses-its-another-tragedy-porn-climate-hoax.

Crockford, S.J. 2019d. 'Netflix, Attenborough and cliff-falling walruses: the making of a. false climate icon.' Video, May. Global Warming Policy Forum, London. https://www.youtube.com/watch?v=I-atVKZZcPG0.

Crockford, S.J. 2019e. 'The truth about Attenborough's falling walruses' Video, September. Global Warming Policy Foundation, London. https://www.youtube.com/watch?v=tFcwAKZEnHY.

Crockford, S.J. 2019f. 'No climate emergency for polar bears.' Video September. Global Warming Policy Foundation, London. https://www.youtube.com/watch?v=jQRle6pgBCY.

Crockford, S.J. 2019g. 'Falling walrus: Attenborough tacitly admits Netflix deception.' Video December. Global Warming Policy Foundation, London. https://www.youtube.com/watch?v=U5Ji6ME3Vlo.

Crockford, S.J. 2020a. 'New footage reveals Netflix faked walrus climate deaths.' Video, 19 November. Global Warming Policy Forum, London. https://www.youtube.com/watch?v=kV8d26oziVM.

Crockford, S.J. 2020b. State of the Polar Bear 2019. *Global Warming Policy Foundation* Report 39.

Crockford, S., and Frederick, G. 2007. Sea ice expansion in the Bering Sea during the Neoglacial: evidence from archaeozoology. *The Holocene* 17:699– 706.

Crockford, S.J. and Frederick, G. 2011. Neoglacial sea ice and life history flexibility in ringed and fur seals. pg. 65–91 In, T. Braje and R. Torrey, eds. *Human and Marine Ecosystems: Archaeology and Historical Ecology of Northeastern Pacific Seals, Sea Lions, and Sea Otters.* U. California Press, LA.

Crockford, S.J., Frederick, G. and R. Wigen. 1997. A humerus story: albatross element distribution from two Northwest Coast sites, North America. *International Journal of Osteoarchaeology* 7: 378.1–5.

Crockford, S.J. and Kuzmin, Y.V. 2012. Comments on Germonpré et al., Journal of Archaeological Science 36, 2009 'Fossil dogs and wolves from Palaeolithic sites in Belgium, the Ukraine and Russia: osteometry, ancient DNA and stable isotopes', and Germonpré, Lázkičková-Galetová, and Sablin, Journal of Archaeological Science 39, 2012 'Palaeolithic dog skulls at the Gravettian Předmostí site, the Czech Republic.' *Journal of Archaeological Science* 39:2797–2801.

Crockford, S.J., Moss, M.L., and J.F. Baichtal. 2011. Pre-contact dogs from the Prince of Wales archipelago, Alaska. *Alaska Journal of Anthropology* 9(1):49–64.

Cronin, T.M. and Cronin, M.A. 2015. Biological response to climate change in the Arctic Ocean: the view from the past. *Arktos* 1:1–18.

Cronin, M.A., Rincon, G., Meredith, R.W., MacNeil, M.D., Islas-Trejo, A., Cánovas, A. and Medrano, J.F. 2014. Molecular phylogeny and SNP variation of polar bears (*Ursus maritimus*), brown bears (*U. arctos*), and black bears (*U. americanus*) derived from genome sequences. *Journal of Heredity*105:312–323.

Department of Fisheries and Oceans Canada (DFO). 2020. 2019 Status of Northwest Atlantic Harp Seals, *Pagophilus groenlandicus*. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/020.

Derocher 2005. Population ecology of polar bears at Svalbard, Norway. *Population Ecology* 47:267–275.

Derocher, A.E., Andersen, M., Wiig, Ø., Aars, J., Hansen, E. and Biuw, M. 2011. Sea ice and polar bear den ecology at Hopen Island, Svalbard. *Marine Ecology Progress Series* 441:273–279.

Derocher, A., Garner, G.W., Lunn, N.J., and Wiig, Ø. (eds.) 1998. Polar Bears: Proceedings of the 12th meeting of the Polar Bear Specialist Group IUCN/SSC, 3–7 February, 1997, Oslo, Norway. Gland, Switzerland and Cambridge UK, IUCN.

Derocher, A.E. and Stirling, I. 1992. The population dynamics of polar bears in western Hudson Bay. pg. 1150–1159 in D.R. McCullough and R.H. Barrett, eds. *Wildlife 2001: Populations.* Elsevier Sci. Publ., London, U.K.

Derocher, A.E. and Stirling, I. 1995. Temporal variation in reproduction and body mass of polar bears in western Hudson Bay. *Canadian Journal of Zoology* 73:1657–1665.

de Vernal, A., Hillaire-Marcel, C., Le Duc, C., Roberge, P., Brice, C., Matthiessen, J., Spielhagen, R.F. and Stein, R. 2020. Natural variability of the Arctic Ocean sea ice during the present interglacial. *Proceedings of the National Academy of Sciences USA* 117(42):26069–26075.

Devyatkin, P. 2020. Vulnerable Communities: How has the COVID-19 Pandemic affected Indigenous People in the Russian Arctic? *The Arctic Institute*, 10 December 2020 https://www.thearcticinstitute.org/vulnerable-communities-covid-19-pandemic-indigenous-people-russian-arctic/.

Dickie, G. 2020. Most polar bears to disappear by 2100, study predicts. *The Guardian (UK)*, 20 July. https://www.theguardian.com/environment/2020/jul/20/most-polar-bears-to-disappear-by-2100-study-predicts-aoe.

Dietz R., Rigét, F.F., Sonne, C., Born, E.W., Bechshøft, T., McKinney, M.A. and Letcher, R.J. 2013a. Three decades (1983–2010) of contaminant trends in East Greenland polar bears (*Ursus maritimus*). Part 1: Legacy organochlorine contaminants. *Environment International* 59:485–493.

Dietz R., Rigét, F.F., Sonne, C., Born, E.W., Bechshøft, T., McKinney, M.A., Drimmie, R.J., Muir, D.C.G., and Letcher, R.J. 2013b. Three decades (1984–2010) of contaminant trends in East Greenland polar bears (*Ursus maritimus*): Part 2 Brominated flame retardants. *Environment International* 59: 494–500.

Dominique, M., Letcher, R.J. Rutter, A. and Langlois, V.S. 2020. Comparative review of the distribution and burden of contaminants in the body of polar bears. *Environmental Science and Pollution Research* 27:32456–32466.

Doran, T. 2020. Emails from the edge: Svalbard's polar bears are sending messages to scientists. *CNN*, 9 Dec 2020. https://www.cnn.com/2020/12/09/europe/polar-bears-svalbard-jon-aars-norwegian-polar-institute-spc-intl-c2e/index.html.

Doupé, J.P., England, J.H., Furze, M. and Paetkau, D. 2007. Most northerly observation of a grizzly bear (*Ursus arctos*) in Canada: photographic and DNA evidence from Melville Island, Northwest Territories. *Arctic* 60:271–276.

Durner, G.M., and Amstrup, S.C. 1995. Movements of a polar bear from northern Alaska to northern Greenland. *Arctic* 48(4):338–341.

Durner, G.M., Douglas, D.C., Nielson, R.M., Amstrup, S.C. and McDonald, T.L. 2007. *Predicting 21st-century polar bear habitat distribution from global climate models.* US Geological Survey. Reston, Virginia.

Durner, G.M., Douglas, D.C., Nielson, R.M., Amstrup, S.C., McDonald, T.L., et al. 2009. Predicting 21st-century polar bear habitat distribution from global climate models. *Ecology Monographs* 79: 25–58.

Durner, G.M., Laidre, K.L, and York, G.S. (eds). 2018. *Polar Bears: Proceedings of the 18th Working Meeting of the IUCN/SSC Polar Bear Specialist Group, 7–11 June 2016, Anchorage, Alaska*. Gland, Switzerland and Cambridge, UK: IUCN.

Dyck, M. 2017. Re-estimating the abundance of the Davis Strait polar bear subpopulation via genetic mark-recapture sampling. Interim Field Report to Nunavut Wildlife Boards. Government of Nunavut, Igloolik, 27 November. https://www.gov.nu.ca/environment/documents/re-estimating-abundance-davis-strait-polar-bear-sub-population-genetic-mark.

Dyck, M., Campbell, M., Lee, D., Boulanger, J. and Hedman, D. 2017. 2016 Aerial survey of the Western Hudson Bay polar bear subpopulation. Final report, Nunavut Department of Environment, Wildlife Research Section, Iglolik, NU.

Dyck, M., Lukacs, P., and Ware, J.V. 2020a. Re-estimating the abundance of a recovering polar bear subpopulation by genetic mark-recapture in M'Clintock Channel, Nunavut, Canada. Final Report, Government of Nunavut, Department of Environment, Iglulik. 29 July 2020. https://www.gov.nu.ca/environment/documents/re-estimating-abundance-recovering-polar-bear-subpopulation-genetic-mark.

Dyck, M., Regehr, E.V. and Ware, J.V. 2020b. Assessment of Abundance for the Gulf of Boothia Polar Bear Subpopulation Using Genetic Mark-Recapture. Final Report, Government of Nunavut, Department of Environment, Iglulik. 12 June 2020. https://www.gov.nu.ca/environment/documents/assessment-abundance-gulf-boothia-polar-bear-subpopulation-using-genetic-mark.

Elfström, M., Zedrosser, A., Støen, O.-G., and Swenson, J.E. 2014. Ultimate and proximate mechanisms underlying the occurrence of bears close to human settlements: review and management implications. *Mammal Review* 44:5–18.

Falconer, R. 2020. Research flashes new warnings of polar bear survival due to climate change. *Axios*, 20 July. https://www.axios.com/polar-bears-greenhouse-gas-survival-threat-c73e52d6-d722-4ed0-bef4-daa4defba4e8.html.

Ferguson, S.H. 2019. Case study: Ringed seals and the decline of sea ice. In *State of Canada's Arctic Seas*, Niemi, A., Ferguson, S., Hedges, K., Melling, H., Michel, C., et al., Canadian Technical Report Fisheries and Aquatic Sciences 3344.

Ferguson, S.H., Stirling, I. and McLoughlin, P. 2005. Climate change and ringed seal (*Phoca hispida*) recruitment in Western Hudson Bay. *Marine Mammal Science* 21: 121–135.

Ferguson, S.H., Taylor, M.K., Rosing-Asvid, A., Born, E.W. and Messier, F. 2000. Relationships between denning of polar bears and conditions of sea ice. *Journal of Mammalogy* 81:1118–1127.

Ferguson, S.H., Young, B.G., Yurkowski , D.J., Anderson, R., Willing, C. and Nielsen, O. 2017. Demographic, ecological, and physiological responses of ringed seals to an abrupt decline in sea ice availability. *PeerJ* 5:e2957.

Fischbach, A.S., Amstrup, S.C. and Douglas, D.C. 2007. Landward and eastward shift of Alaskan polar bear denning associated with recent sea ice changes. *Polar Biology* 30: 1395–1405.

Florko, K.R.N., Derocher, A.E., Breiter, C-J.C., Ghazal, M., Hedman, D., Higdon, J.W., Richardson, E.S., Sahanatien, V., Trim, V. and Petersen, S. 2020. Polar bear denning distribution in the Canadian Arctic. *Polar Biology* 43:617–621.

Fountain, H. 2020. 'Arctic Seismic Work Will Not Hurt Polar Bears, Government Says.' *New York Times*, 7 December. https://www.nytimes.com/2020/12/07/climate/arctic-refuge-polar-bears.html.

Frey, K.E., Comiso, J.C., Cooper, L.W., Grebmeier, J.M. and Stock, L.V. 2020. Arctic Ocean primiary productivity: the response of marine algae to climate warming and sea ice decline. *2020 Arctic Report Card,* NOAA. DOI: 10.25923/vtdn-2198 https://arctic.noaa.gov/Report-Card/Report-Card-2020/ArtMID/7975/ArticleID/900/Arctic-Ocean-Primary-Productivity-The-Response-of-Marine-Algae-to-Climate-Warming-and-Sea-Ice-Decline.

Fritts, R. 2020. 'Trump officials rush plans to drill in Arctic refuge before Biden inauguration.' *The Guardian* (UK), 17 November. https://www.theguardian.com/environment/2020/nov/17/trump-oil-drilling-arctic-wildlife-refuge-alaska.

Furnell, D.J. and Schweinsburg, R.E. 1984. Population-dynamics of central Canadian Arctic island polar bears. *Journal of Wildlife Management* 48:722–728.

Gabrielson, K.M., Krokstad, J.S., Villanger, G.D., Blair, D.A.D., Obregon, M.-J., Sonne, C., Dietz, R., Letcher, R.J. and Jenssen, B.M. 2015. Thyroid hormones and deiodinase activity in plasma and tissues in relation to high levels of organohalogen contaminants in East Greenland polar bears (Ursus martimus). *Environmental Research* 136: 413–423.

Galicia, M.P., Theimann, G.W. and Dyck, M.G. 2020. Correlates of seasonal change in the body condition of an Arctic top predator. *Global Change Biology* 26:840–850.

Garner, G.W., Knick, S.T., and Douglas, D.C. 1990. Seasonal movements of adult female polar bears in the Bering and Chukchi Seas. *Bears: Their Biology and Management* 8:219–226.

George, J.C., Moore, S.E. and Thewissen, J.G.M. 2020. Bowhead whales: recent insights into their biology, status, and resilience. *2020 Arctic Report Card*, NOAA. DOI: 10.25923/cppm-n265.

Gjertz. I ., Aarvik, S. and Hindrum, R. 1993. Polar bears killed in Svalbard 1987–1992. *Polar Research* 12:107–109.

Gjertz. I . and Persen. E. 1987. Confrontations between humans and polar bears in Svalbard. *Polar Research* 5:253–256.

Gosselin, M., Levasseur, M., Wheeler, P.A., Horner, R.A., and Booth, B.C. 1997. New measurements of phytoplankton and ice algae production in the Arctic Ocean. *Deep-Sea Research II* 44:1623–1644.Government of Canada (no author), 2020. 'Polar bears: the very large canary in the coalmine for our generation.' *'Science behind the scenes' blog*, 17 November. http://www.ic.gc.ca/eic/site/063.nsf/eng/98181.html.

Grebmeier, J.M., Frey, K.E., Cooper, L.W. and Kedra, M. 2018. Trends in benthic macrofaunal populations, seasonal sea ice persistence, and bottom water temperatures in the Bering Strait region. *Oceanography* 31(2):136–151.

Griswold, J., McDonald, T., Branigan, M., Regehr, E.V. and Amstrup, S.C. 2017. Southern and Northern Beaufort Sea polar bear subpopulation estimates under a proposed boundary shift. Report 265 to the Government of the Northwest Territories.

Grove, C. 2020. 'Alaska polar bear den disturbances part of 'death by a thousand cuts,' researcher says.' *Alaska Public Radio*, 14 July. https://www.alaskapublic.org/2020/07/14/listen-alaska-polar-bear-den-disturbances-part-of-death-by-a-thousand-cuts-researcher-says.

Hamilton, S.G. and Derocher, A.E. 2019. Assessment of global polar bear abundance and vulnerability. *Animal Conservation* 22:83–95.

Hammill, M.O. and Smith T.G. 1991. The role of predation in the ecology of the ringed seal in Barrow Strait, Northwest Territories, Canada. *Marine Mammal Science* 7:123–135.

Harington, R.C. 1968. Denning habits of the polar bear (*Ursus maritimus* Phipps). Canadian Wildlife Service Report Series No. 5.Ottawa.

Harris, R.B. 2012. Preface to 'A circumpolar monitoring framework for polar bears.' *Ursus* 23 (sp2):fmiii.

Harwood, L.A., Smith, T.G., Melling, H., Alikamik, J. and Kingsley, M.C.S. 2012. Ringed seals and sea ice in Canada's western Arctic: harvest-based monitoring 1992–2011. *Arctic* 65:377–390.

Hausfather, Z. and Peters, G.P. 2020. Emissions – the 'business as usual' story is misleading ["Stop using the worst-case scenario for climate warming as the most likely outcome — more-realistic baselines make for better policy"]. *Nature* 577: 618–620.

Heemskerk, S., Johnson, A.C., Hedman, D., Trim, V., Lunn, N.J., McGeachy, D. and Derocher, A.E. 2020. Temporal dynamics of human-polar bear conflicts in Churchill, Manitoba. *Global Ecology and Conservation* 24:e01320. https://doi.org/10.1016/j.gecco.2020.e01320.

Hench, D. 2013. Polar bear attack victim's thought: 'Dude, you're going to die.' *Portland Press Herald* (Maine), 2 September 2013. http://www.pressherald.com/2013/09/02/bear-attack-victim-thought-dude-youre-going-to-die_2013-09-02.

Herreman, J. and Peacock, E. 2013. Polar bear use of a persistent food subsidy: Insights from non-invasive genetic sampling in Alaska. *Ursus* 24(2):148–163.

Hoondert, R.P.J., Ragas, A.M.J. and Hendriks, A.J. 2021. Simulating changes in polar bear subpopulation growth rate due to legacy persistent organic pollutants – temporal and spatial trends. *Science of the Total Environment* 754:142380.

Hunter, C.M., Caswell, H., Runge, M.C., Regehr, E.V., Amstrup, S.C. and Stirling, I. 2007. *Polar bears in the Southern Beaufort Sea II: Demography and population growth in relation to sea ice conditions.* US Geological Survey. Reston, Virginia.

Hunter, C.M., Caswell, H., Runge, M.C., Regehr, E.V., Amstrup, S.C. and Stirling, I. 2010. Climate change threatens polar bear populations: a stochastic demographic analysis. *Ecology* 91:2883–2897.

International Human-Bear Conflicts Workshop. 2009. Polar bear focus day summary (compiled by Colleen Matt). November 17, Canmore, Alberta.

Johnson, A.C. and Derocher, A.E. 2020. Variation in habitat use of Beaufort Sea polar bears. *Polar Biology* 43:1247–1260.

Johnson, A.C., Reimer, J.R., Lunn, N.J., Stirling, I., McGeachy, D. and Derocher, A.E. 2020. Influence of sea ice dynamics on population energetics of Western Hudson Bay polar bears. *Conservation Physiology* 8(1): coaa132; doi:10.1093/conphys/coaa132.

Joint Secretariat. 2015. Inuvialuit and Nanuq: A Polar Bear Traditional Knowledge Study. Joint Secretariat, Inuvialuit Settlement Region, Inuvik, Northwest Territories, Canada.

Joint Secretariat. 2017. Inuvialuit Settlement Region Polar Bear Co-Management Plan. Joint Secretariat, Inuvik, NT.

Kaufman, M. 2019. Village of the Sea Bears: Churchill's famed polar bear population is plunging. 20 November, *Mashable*. https://mashable.com/feature/polar-bears-churchill-population-decline/.

Kearney, S.R., 1989. The Polar Bear Alert Program at Churchill, Manitoba. In: Bromely, M. (Ed.), *Bear–People Conflict: Proceedings of a Symposium on Management Strategies,* Yellowknife, Northwest Territories Department of Renewable Resources, pp. 83–92.

Kelly, B.P., Bengtson, J.L., Boveng, P.L., Cameron, M.F., Dahle, S.P., Jansen, J.K., Logerwell, E.A., Overland, J.E., Sabine, C.L., Waring, G.T. and Wilder, J.M. 2010. Status review of the ringed seal (*Phoca hispida*). NOAA Technical Memorandum NMFS-AFSC-212.

Kochnev, A.A. 2002. Factors Causing Pacific Walrus Mortality on the Coastal Haulouts of Wrangel Island. In Aristov, A.A. et al (eds.) *Marine Mammals (Results of research conducted in 1995–1998).* Collection of articles. Moscow 2002. pp.191–215.

Kolenosky, G.B. and Prevett, J.P. 1983. Productivity and maternity denning of polar bears in Ontario. *Bears: Their Biology and Management* 5:238–245.

Koop, B.F., Burbidge, M., Byun, A., Rink, U, and Crockford, S.J. 2000. Ancient DNA evidence of a separate origin for North American indigenous dogs. pg. 271–286. *In:* S.J. Crockford (ed.) *Dogs Through Time: An Archaeological Perspective.* Oxford*,* U.K., Archaeopress S889.

Kovacs, K.M. 2015. *Pagophilus groenlandicus*. The IUCN Red List of Threatened Species 2015: e.T41671A45231087. http://dx.doi.org/10.2305/IUCN.UK.2015–4.RLTS.T41671A45231087.en.

Kovacs, K.M. 2016. *Erignathus barbatus*. The IUCN Red List of Threatened Species 2016: e.T8010A45225428. Available online http://www.iucnredlist.org/details/full/8010/0.

Laidre, K.L. and Stirling, I. 2020. Grounded icebergs as maternity denning habitat for polar bears (*Ursus maritimus*) in North and Northeast Greenland. *Polar Biology* 43:937–943.

Laidre, K.L, Atkinson, S.N., Regehr, E.V., Stern, H.L, Born, E.W., Wiig, Ø., Lunn, N.J. and Dyck, M. 2020a. Interrelated ecological impacts of climate change on an apex predator. *Ecological Applications* 30(4): e02071. https://doi.org/10.1002/eap.2071.

Laidre, K.L., Atkinson, S.N., Regehr, E.V., Stern, H.L., Born, E.W., Wiig, Ø., Lunn, N.J., et al. 2020b Transient benefits of climate change for a high-Arctic polar bear (*Ursus maritimus*) subpopulation. *Global Change Biology* 26:6251–6265.

Laidre, K.L., Regehr, E.V., Akcakaya, H.R., Amstrup, S.C., Atwood, T., Lunn, N., Obbard, M., Stern, H.L., Thiemann, G. and Wiig, Ø. 2016. AGU 2016. Fall Meeting, San Francisco, presentation of Regehr et al. 2016 paper results. 12 December 2016. https://agu.confex.com/agu/fm16/meetingapp.cgi/Paper/119105 'GC13I-01: Conservation status of polar bears (*Ursus maritimus*) in relation to projected sea-ice declines (Invited).

Laidre, K.L., Born, E.W., Gurarie, E., Wiig, Ø., Dietz, R. and Stern, H. 2013. Females roam while males patrol: divergence in breeding season movements of pack-ice polar bears (*Ursus maritumus*). *Proceedings of the Royal Society B* 280:20122371. http://dx.doi.org/10.1098/rspb.2012.2371.

Laidre, K.L., Born, E.W., Atkinson, S.N., Wiig, Ø., Andersen, L.W., Lunn, N.J., Dyck, M., Regehr, E.V., McGovern, R. and Heagerty, P. 2018a. Range contraction and increasing isolation of a polar bear subpopulation in an era of sea-ice loss. *Ecology and Evolution* DOI: 10.1002/ece3.3809.

Laidre, K.L., Northey, A.D. and Ugarte, F. 2018b. Traditional knowledge about polar bears (*Ursus maritimus*) in East Greenland: changes in the catch and climate over two decades. *Frontiers in Marine Science* 5 (article 135). https://doi.org/10.3389/fmars.2018.00135.

Laidre, K.L., Stern, H., Born, E.W., Heagerty, P., Atkinson, S.N., Wiig, Ø., Lunn, N.J., Regehr, E.V., McGovern, R. and Dyck, M. 2018c. Changes in winter and spring resource selection by polar bears *Ursus maritimus* in Baffin Bay over two decades of sea-ice loss. *Endangered Species Research* 36:1–14.

Larsen, T. 1972. Norwegian polar bear hunt, management and research. *Bears: Their Biology and Management* 2:159–164. http://www.jstor.org/stable/3872579.

Larson, W.G., Smith, T.S. and York, G. 2020. Human interaction and disturbance of denning polar bears on Alaska's North Slope. *Arctic* 73(2):141–277.

Lawrynuik, S. 2020. Black bears and grizzlies and polar bears. Oh, my! *Winnipeg Free Press*, 30 October. https://www.winnipegfreepress.com/special/bearingnorth/black-bears-and-grizzlies-and-polar-bears-oh-my-572905861.html.

Lee, S.H. and Whitledge, T.E. 2005. Primary and new production in the deep Canada Basin during summer 2002. *Polar Biology* 28:190–197.

Letcher, R.J., Morris, A.D., Dyck, M., Sverko, E., Reiner, E.J., Blair, D.A.D., Chu, S.G. and Shen, L. 2018. Legacy and new halogenated persistant organic pollutants in polar bears from a contamination hotspot in the Arctic, Hudson Bay Canada. *Science of the Total Environment* 610–611:121–136.

Lewis, K.M., van Dijken, G.L. and Arrigo, K.R. 2020. Changes in phytoplankton concentration now drive increased Arctic Ocean primary production. *Science* 369(6500):198–202.

Lillie, K.M., Gese, E.M., Atwood, T.C. and Conner, M.M. 2019. Use of subsistence-harvested whale carcasses by polar bears in the Southern Beaufort Sea. *Arctic* 72(4):404–412.

Limoges, A., Weckström, K., Ribeiro, S., Georgiadis, E., Hansen, K.E., Martinez, P., Seidenkrantz, M.-S., Giraudeau, J., Crosta, X. and Massé, G. 2020. Learing from the past: impact of the Arctic Oscillation on sea ice and marine productivity off northwest Greenland over the last 9,000 years. *Global Change Biology* 26:6767–6786.

Lippold, A., Bourgeon, S., Aars, J., Andersen, M., Polder, A., Lyche, J.L., Bytingsvik, J., Jenssen, B.M., Derocher, A.E., Welker, J.M. and Routti, H. 2019. Temporal trends of persistent organic pollutants in Barents Sea polar bears (*Ursus maritimus*) in relation to changes in feeding habits and body condition. *Environmental Science and Technolog*y 53(2):984–995.

Liu, Y., Richardson, E.S., Derocher, A.E., Lunn, N.J. and others. 2018. Hundreds of unrecognized halogenated contaminants discovered in polar bear blood. *Angewandte Chemie International Edition* 57:16201–16406.

Lowry, L. 1985. Pacific Walrus – Boom or Bust? *Alaska Fish & Game Magazine* July/August: 2–5.

Lowry, L. 2015. *Odobenus rosmarus ssp. divergens*. The IUCN Red List of Threatened Species 2015, e.T61963499A45228901. Available online http://www.iucnredlist.org/details/full/61963499/0.

Lowry, L. 2016. *Pusa hispida*. The IUCN Red List of Threatened Species 2016, e.T41672A45231341. Available online http://www.iucnredlist.org/details/full/61382318/0.

Lunn, N.J., Schliebe, S., and Born, E.W. (eds.). 2002. Polar Bears: Proceedings of the 13th meeting of the Polar Bear Specialist Group IUCN/SSC, 23–28 June 2001, Nuuk, Greenland. Gland, Switzerland and Cambridge UK, IUCN.

Lunn, N.J., Servanty, S., Regehr, E.V., Converse, S.J., Richardson, E. and Stirling, I. 2016. Demography of an apex predator at the edge of its range – impacts of changing sea ice on polar bears in Hudson Bay. *Ecological Applications* 26(5):1302–1320.

Matishov, G.G., Chelintsev, N.G., Goryaev, Yu. I., Makarevich, P.R. and Ishkulov, D.G. 2014. Assessment of the amount of polar bears (*Ursus maritimus*) on the basis of perennial vessel counts. *Doklady Earth Sciences* 458 (2):1312–1316.

McIver, K. 2020. Polar bear season: week 3. *Polar Bears International News*, 2 November. https://polarbearsinternational.org/news/article-polar-bears-international/polar-bear-season-week-3/.

McKinney, M.A., Iverson, A.J., Fisk, A.T., Sonne, C., Rigét, F.F., Letcher, R.J., Arts, M.T., Born, E.W., Rosing-Asvid, A. and Dietz, R. 2013. Global change effects on the long-term feeding ecology and contaminant exposures of East Greenland polar bears. *Global Change Biology* 19:2360–2372.

Mauritzen, M., Derocher, A.E. and Wiig, Ø. 2001. Space-use strategies of female polar bears in a dynamic sea ice habitat. *Canadian Journal of Zoology* 79:1704–1713.

Meier, W.N. and Stewart, J.S. 2019. Assessing uncertainties in sea ice extent climate indicators. *Environmental Research Letters* 14:035005. https://doi.org/10.1088/1748-9326/aaf52c.

Meier, W. 2019. September monthly mean extent and trends for 1979–2019, showing overall trend and trends for the most recent 13 years, and the steepest 13 years in the 41-year record. Figure 3b, in 'Falling Up' [sea ice conditions for September 2019], *NSIDC Arctic Sea Ice News & Analysis*, 3 October. http://nsidc.org/arcticseaicenews/2019/10/falling-up/.

Mercer, G. 2018. 'They're everywhere': has the decline of the seal hunt saved the polar bear? *The Guardian (UK)*, 24 May. https://www.theguardian.com/world/2018/may/24/canada-polar-bears-labrador-rigolet-seal-hunt.

Messier, F., Taylor, M.K. and Ramsay, M.A. 1994. Denning ecology of polar bears in the Canadian Arctic Archipelago. *Journal of Mammalogy* 75(2):420–430.

Miles, M.W., Andresen, C.S. and Dylmer, C.V. 2020. Evidence for extreme export of Arctic sea ice leading the abrupt onset of the Little Ice Age. *Science Advances* 6:eaba4320.

Miller, S., Schliebe, S. and Proffitt, K. 2006. Demographics and behavior of polar bears feeding on bowhead whale carcasses at Barter and Cross Islands, Alaska, 2002–2004. Alaska Outer Continental Shelf (OCS) Study MMS 2006–14, US Dept. of the Interior, Minerals Management Service, Anchorage.

Miller, S., Wilder, J. and Wilson, R.R. 2015. Polar bear-grizzly bear interactions during the autumn open-water period in Alaska. *Journal of Mammalogy* 96(6):1317–1325.

Molnar, P.K., Bitz, C.M., Holland, M.M., Kay, J.E., Penk, S.R. and Amstrup, S.C. 2020. Fasting season length sets temporal limits for global polar bear persistence. *Nature Climate Change*. https://doi.org/10.1038/s41558-020-0818-9.

Moore, C.R., West, A., LeCompte, M.A., Brooks, M.J., Daniel Jr., I.R., Goodyear, A.C., Ferguson, T.A., Ivester, A.H., Feathers, J.K., Kennett, J.P., Tankersley, K.B., Adedeji, A.V. and Bunch, T.E. 2017. Widespread platinum anomaly documented at the Younger Dryas onset in North American sedimentary sequences. *NATURE Scientific Reports* 7:44031.

National Snow and Ice Data Center (NSIDC). 2020. 'Steep decline sputters out.' *NSIDC Arctic Sea Ice News*, 4 August. http://nsidc.org/arcticseaicenews/2020/08/steep-decline-sputters-out/.

Nilsen, T. 2020. Man killed by polar bear near Longyearbyen airport. *The Barents Observer*, 28 August. https://thebarentsobserver.com/en/arctic/2020/08/man-killed-polar-bear-near-longyearbyen-airport.

Norwegian Polar Institute (NPI). 2019. Polar Bear (*Ursus maritimus*). Presentations and interpretations of monitoring data from Svalbard and Jan Mayen. Last updated 4 June 2019. http://www.mosj.no/en/fauna/marine/polar-bear.html.

Obbard, M.E. 2008. Southern Hudson Bay polar bear project 2003–2005: Final report. Unpublished report, Wildlife Research and Development Section, Ontario Ministry of Natural Resources, Peterborough, ON.

Obbard, M.E., Cattet, M.R.L., Moody, T., Walton, L.R., Potter, D., Inglis, J., and Chenier C. 2006. Temporal trends in the body condition of Southern Hudson Bay polar bears. *Climate Change Research Information Note, No. 3*. Ontario Ministry of Natural Resources, Applied Research and Development Branch, Sault Ste. Marie, Ontario, Canada.

Obbard, M.E., Cattet, M.R.L., Howe, E.J., Middel, K.R., Newton, E.J., Kolenosky, G.B., Abraham, K.F. and Greenwood, C.J. 2016. Trends in body condition in polar bears (*Ursus maritimus*) from the Southern Hudson Bay subpopulation in relation to changes in sea ice. *Arctic Science* 2:15–32.

Obbard, M.E., Stapleton, S., Middel, K.R., Thibault, I., Brodeur, V. and Jutras, C. 2015. Estimating the abundance of the Southern Hudson Bay polar bear subpopulation with aerial surveys. *Polar Biology* 38:1713–1725.

Obbard, M.E., Stapleton, S., Szor, G., Middel, K.R., Jutras, C. and Dyck, M. 2018. Re-assessing abundance of Southern Hudson Bay polar bears by aerial survey: effects of climate change at the southern edge of the range. *Arctic Science* 4:634–655.

Obbard, M.E., Theimann, G.W., Peacock, E. and DeBryn, T.D. (eds.) 2010. Polar Bears: Proceedings of the 15th meeting of the Polar Bear Specialist Group IUCN/SSC, 29 June-3 July, 2009, Copenhagen, Denmark. Gland, Switzerland and Cambridge UK, IUCN.

Olesiuk, P.F., Bigg, M.A., Ellis, G.M., Crockford, S.J. and Wigen, R.J. 1990. An assessment of the feeding habits of harbour seals (Phoca vitulina) in the Strait of Georgia, British Columbia, based on scat analysis. *Canadian Technical Reports on Fisheries and Aquatic Sciences* 1730, 135 p.

Olson, J.W., Rode, K.D., Eggett, D., Smith, T.S., Wilson, R.R., Durner, G.M., Fischbach, A., Atwood, T.C. and Douglas, D.C. 2017. Collar temperature sensor data reveal long-term patterns in southern Beaufort Sea polar bear den distribution on pack ice and land. *Marine Ecology Progress Series* 564:211–224.

Ovodov, N.D., Crockford, S.J., Kuzmin, Y.V., Higham, T.F.G., Hodgins, G.W.L., and van der Plicht, J. 2011. A 33,000 year old incipient dog from Altai Mountains of Siberia: evidence for the earliest domestication disrupted by the Last Glacial Maximum. *PLoS One* 6(7):e22821. doi:10.1371/journal.pone.0022821.

Ovsyanikov, N. 1998. Den use and social interactions of polar bears during spring in a dense denning area on Herald Island, Russia. *Ursus* 10:251–258.

Ovsyanikov, N. 2010. Polar bear research on Wrangel Island and in the central Arctic Basin. In, Proceedings of the 15th meeting of the Polar Bear Specialist Group IUCN/SSC, 29 June-3 July, 2009, edited by Obbard, M.E., Theimann, G.W., Peacock, E. and DeBryn, T.D., pp. 171–178. Gland, Switzerland and Cambridge UK, IUCN.

Ovsyanikov, N.G. and Menyushina, I.E. 2015. Demographic processes in Chukchi-Alaskan polar bear population as observed in Wrangel Island region. pg. 37–55, In: *Marine Mammals of the Holarctic,* Collection of Scientific Papers. Vol. 2. Moscow.

Parfitt, T. 2019. 'A polar bear might be around the corner thanks to climate change.' 14 December, *The Times* (UK). https://www.thetimes.co.uk/article/climate-change-means-a-polar-bear-may-be-around-next-corner-6zb9899gd.

Peacock, E., Taylor, M.K., Laake, J., and Stirling, I. 2013. Population ecology of polar bears in Davis Strait, Canada and Greenland. *Journal of Wildlife Management* 77:463–476.

Perovich, D., Meier, W., Tschudi, M., Hendricks, S., Petty, A.A., Divine, D., Farrell, S., Gerland, S., Haas, C., Kaleschke, L., Pavlova, O., Ricker, R., Tian-Kunze, X., Webster, M. and Wood, K. 2020. Sea ice. *2020 Arctic Report Card*, NOAA.Petrov, A.N., Hinzman, L.D., Kullerud, L, Degai, T.S., Holmberg, L., Pope, A. and Yefimenko, A. 2020. Building resilient Arctic science amid the COVID-19 pandemic. *Nature Communications* 11 (6278). https://www.nature.com/articles/s41467-020-19923-2.

Pielke, Jr., R. and Ritchie, J. 2021. Distorting the view of our climate future: the misuse and abuse of climate pathways and scenarios. *Energy Research & Social Science* 72:101890.

Pilfold, N.W., McCall, A., Derocher, A.E., Lunn, N.J., and Richardson, E. 2017. Migratory response of polar bears to sea ice loss: to swim or not to swim. *Ecography* 40:189–199.

Polar Bears International (PBI). 2020. 'Arctic Refuge Lease Sales Threaten Polar Bears'. *PBI News*, 19 November. https://polarbearsinternational.org/news/article-polar-bears-international/arctic-refuge-lease-sales-threaten-polar-bears/.

Pomeroy, L.R. 1997. Primary production in the Arctic Ocean estimated from dissolved oxygen. *Journal of Marine Systems* 10:1–8.

Pongracz, J.D. 2014. Viscount Melville Sound polar bear subpopulation survey. *2014 Annual Report of Wildlife Research in the NWT*, Northwest Territories Environment and Natural Resources Department, pp. 60–63.

Pongracz, J.D., and Derocher, A.E. 2017. Summer refugia habitat of polar bears (Ursus maritimus) in the southern Beaufort Sea. *Polar Biology* 40(4):753–763.

Pongracz, J.D., Paetkau, D., Branigan, M. and Richardson, E. 2017. Recent hybridization between a polar bear and grizzly bears in the Canadian Arctic. *Arctic* 70:151–160.

Pope, K. 2020. 'If you're a polar bear, your location may foretell your future'. *Yale Climate Connections*, 6 November. https://yaleclimateconnections.org/2020/11/if-youre-a-polar-bear-your-location-may-foretell-your-future.

Preuß, A., Gansloßer, U., Purschke, G. and Magiera, U. 2009. Bear-hybrids: behaviour and phenotype. *Der Zoologische Garten* 78(4):204–220. https://doi.org/10.1016/j.zoolgart.2009.08.005.

Prigg, M. 2016. "'Pizzly' bear was NOT a hybrid: DNA tests find slaughtered animal was a 'blonde grizzly' and not part polar bear." *Daily Mail* (UK), 23 June. http://www.dailymail.co.uk/sciencetech/article-3657142/Pizzly-bear-NOT-hybrid-DNA-tests-slaughtered-animal-blonde-grizzly-not-polar-bear.html.

Ramsay, M.A. and Stirling, I. 1988. Reproductive biology and ecology of female polar bears (*Ursus maritimus*). *Journal of Zoology London* 214:601–624.

Regehr, E.V., Amstrup, S.C., and Stirling, I. 2006. *Polar bear population status in the Southern Beaufort Sea.* US Geological Survey Open-File Report 2006–1337.

Regehr, E.V., Lunn, N.J., Amstrup, S.C. and Stirling, I. 2007. Effects of earlier sea ice breakup on survival and population size of polar bears in Western Hudson Bay. *Journal of Wildlife Management* 71:2673–2683.

Regehr, E.V., Laidre, K.L, Akçakaya, H.R., Amstrup, S.C., Atwood, T.C., Lunn, N.J., Obbard, M., Stern, H., Thiemann, G.W., and Wiig, Ø. 2016. Conservation status of polar bears (*Ursus maritimus*) in relation to projected sea-ice declines. *Biology Letters* 12: 20160556.

Regehr, E.V., Hostetter, N.J., Wilson, R.R., Rode, K.D., St. Martin, M., Converse, S.J. 2018. Integrated population modeling provides the first empirical estimates of vital rates and abundance for polar bears in the Chukchi Sea. *Scientific Reports* 8 (1) DOI: 10.1038/s41598–018–34824–7 .

Richardson, E. 2019. Case study: Polar bears and the decline of sea ice. In *State of Canada's Arctic Seas*, Niemi, A., Ferguson, S., Hedges, K., Melling, H., Michel, C., et al., Canadian Technical Report Fisheries and Aquatic Sciences 3344.

Rockwell, R., Gormezano, L. and Hedman, D. 2008. Grizzly bears, *Ursus arctos*, in Wapusk National Park, Northeastern Manitoba. *Canadian Field Naturalist* 122(4):323–326.

Rode, K.D., Douglas, D., Durner, G., Derocher, A.E., Thiemann, G.W., and Budge, S. 2013. *Variation in the response of an Arctic top predator experiencing habitat loss: feeding and reproductive ecology of two polar bear populations*. Oral presentation by Karyn Rode, 28th Lowell Wakefield Fisheries Symposium, March 26–29. Anchorage, AK.

Rode, K.D., Olson, J., Eggett, D., Douglas, D.C., Durner, G.M., Regehr, E.V., Wilson, R.R., Smith, T. and St. Martin, M. 2018a. Den phenology and reproductive success of polar bears in a changing climate. *Journal of Mammalogy* 99(1):16–26.

Rode, K.D., Peacock, E., Taylor, M., Stirling, I., Born, E.W., Laidre, K.L., and Wiig, Ø. 2012. A tale of two polar bear populations: ice habitat, harvest, and body condition. *Population Ecology* 54:3–18.

Rode, K.D., Wilson, R.R., Douglas, D.C., Muhlenbruch, V., Atwood, T.C., Regehr, E.V., Richardson, E.S., Pilfold, N.W., Derocher, A.E., Durner, G.M., Stirling, I., Amstrup, S.C., St. Martin, M., Pagano, A.M. and Simac, K. 2018b. Spring fasting behavior in a marine apex predator provides an index of ecosystem productivity. *Global Change Biology* 24(1):410–423.

Rode, K.D., Regehr, E.V., Douglas, D., Durner, G., Derocher, A.E., Thiemann, G.W., and Budge, S. 2014. Variation in the response of an Arctic top predator experiencing habitat loss: feeding and reproductive ecology of two polar bear populations. *Global Change Biology* 20(1):76–88.

Rode, K.D., Robbins, C.T., Nelson, L. and Amstrup, S.C. 2015a. Can polar bears use terrestrial foods to offset lost ice-based hunting opportunities? *Frontiers in Ecology and the Environment* 13(3): 138–145, doi:10.1890/140202.

Rode, K.D., Wilson, R.R., Regehr, E.V., St. Martin, M., Douglas, D.C. and Olson, J. 2015b. Increased land use by Chukchi Sea polar bears in relation to changing sea ice conditions. *PLoS ONE* 10(11):e0142213.

Rogers, M.C., Peacock, E., Simac, K., O'Dell, M.B. and Welker, J.M. 2015. Diet of female polar bears in the southern Beaufort Sea of Alaska: evidence for an emerging alternative foraging strategy in response to environmental change. *Polar Biology* 38(7):1035–1047.

Rolland, N. and Crockford, S.J. 2005. Late Pleistocene dwarf *Stegodon* from Flores, Indonesia? *Antiquity* 79 (June #304 Project Gallery). http://antiquity/ac.uk/projgall/rolland/.

Routti, H., Atwood, T.C., Bechshoft, T. and 13 others. 2019. State of knowledge on current exposure, fate, and potential health effects of contaminants in polar bears from the circumpolar Arctic. *Science of the Total Environment* 664:1063–1083.

Russell, C. 2020. The COVID-19 pandemic has halted most US Arctic field research for 2020. *Arctic Today*, 25 May 2020. https://www.arctictoday.com/the-covid-19-pandemic-has-halted-most-us-arctic-field-research-for-2020/.

Savikataaq Jr., J. 2015. Operation Arviat polar bear summary report for 2014. Government of Nunavut, 27 October. https://www.gov.nu.ca/environnement/information/wildlife-research-reports.

Schliebe, S., Rode, K.D., Gleason, J.S., Wilder, J., Proffitt, K., Evans, T.J., and S. Miller. 2008. Effects of sea ice extent and food availability on spatial and temporal distribution of polar bears during the fall open-water period in the southern Beaufort Sea. *Polar Biology* 31:999–1010.

Scott, J.B.T. and Marshall, G.J. 2010. A step-change in the date of sea-ice breakup in western Hudson Bay. *Arctic* 63:155–164.

Sha, L., Jiang, H., Seidenkrantz, M-S., Muscheler, R., Zhang, X., Knudsen, M.F., Olsen, J., Knudsen, K.L. and Zhang, W. 2016. Solar forcing as an important trigger for West Greenland sea-ice variability over the last millennium. *Quaternary Science Reviews* 131:148–156.

Shankman, S. 2014. *Meltdown: Terror at the Top of the World*. Inside Climate News [aka 'Lost Light Projects Inc.'] New York.

Siberian Times. 2020. 'Ten polar bears – six adults and four cubs – besiege a stalled rubbish truck in Russian Arctic. *Siberian Times*, 20 October. https://siberiantimes.com/other/others/news/ten-polar-bears-six-adults-and-four-cubs-besiege-a-stalled-rubbish-truck-in-russian-arctic/.

Smart, A. 2019. Grizzly bears move north in High Arctic as climate change expands range. CBC News, 16 December. https://www.cbc.ca/news/canada/north/grizzlies-move-north-1.5397274.

Smith, P., Stirling, I., Jonkel, C., and Juniper, I. 1975. Notes on the present status of the polar bear (*Ursus maritimus*) in Ungava Bay and northern Labrador. *Canadian Wildlife Service, Progress Notes 53*.

Smith, T.G. and Stirling, I. 1978. Variation in the density of ringed seal (*Phoca hispida*) birth lairs in the Amundsen Gulf, Northwest Territories. *Canadian Journal of Zoology* 56:1066–1071.

Smith, T.G. and Stirling, I. 2019. Predation of harp seals, *Pagophilus groenlandicus,* by polar bears, *Ursus maritimus,* in Svalbard. *Arctic* 72:197–202.

Smith, T.S., Wilder, J.M., York, G., Obbard, M.E. and Billings, B.W. 2021. An investigation of factors influencing bear spray performance. *Journal of Wildlife Management* 85(1):17–26.

Sonne C. 2010. Health effects from long-range transported contaminants in Arctic top predators: an integrated review based on studies of polar bears and relevant model species. *Environment International* 36:461–91.

Sonne, C., Dyck, M., Rigét, F.F., Jens-Erik Beck Jensen, J.-E.B., Hyldstrup, L., Letcher, R.J., Gustavson, K., Gilbert, M.T.P., Dietz, R. 2015. Penile density and globally used chemicals in Canadian and Greenland polar bears. *Environmental Research* 137:287–291.

Stapleton S., Atkinson, S., Hedman, D., and Garshelis, D. 2014. Revisiting Western Hudson Bay: using aerial surveys to update polar bear abundance in a sentinel population. Biological Conservation 170:38–47.

Stapleton S., Peacock, E., and Garshelis, D. 2016. Aerial surveys suggest long-term stability in the seasonally ice-free Foxe Basin (Nunavut) polar bear population. *Marine Mammal Science* 32:181–201.

Stein, R., Fahl, K., Schade, I., Manerung, A., Wassmuth, S., Niessen, F. and Nam, S-I. 2017. Holocene variability in sea ice cover, primary production, and Pacific-Water inflow and climate change in the Chukchi and East Siberian Seas (Arctic Ocean). *Journal of Quaternary Science* 32:362–379. DOI: 10.1002/jqs.2929.

Stern, H.L. and Laidre, K.L. 2016. Sea-ice indicators of polar bear habitat. *The Cryosphere* doi:10.5194/tc-10–2027–2016.

Stirling, I. 2002. Polar bears and seals in the eastern Beaufort Sea and Amundsen Gulf: a synthesis of population trends and ecological relationships over three decades. *Arctic* 55 (Suppl. 1):59–76.

Stirling, I. 2011. *Polar Bears: The Natural History of a Threatened Species.* Fitzhenry & Whiteside, Markham Ontario.

Stirling, I. and Derocher, A.E. 2012. Effects of climate warming on polar bears: a review of the evidence. *Global Change Biology* 18:2694–2706 doi:10.1111/j.1365–2486.2012.02753.x.

Stirling and Kiliaan. 1980. Population ecology studies of the polar bear in northern Labrador. *Canadian Wildlife Service Occasional Paper No. 42.*

Stirling, I. and Lunn, N.J. 1997. Environmental fluctuations in arctic marine ecosystems as reflected by variability in reproduction of polar bears and ringed seals. In *Ecology of Arctic Environments,* Woodin, S.J. and Marquiss, M. (eds), pg. 167–181. Blackwell Science, UK.

Stirling, I. and Øritsland, N.A. 1995. Relationships between estimates of ringed seal (*Phoca hispida*) and polar bear (*Ursus maritimus*) populations in the Canadian Arctic. *Canadian Journal of Fisheries and Aquatic Sciences* 52: 2594–2612.

Stirling, I. and Parkinson, C.L. 2006. Possible effects of climate warming on selected populations of polar bears (Ursus maritimus) in the Canadian Arctic. *Arctic* 59:261–275.

Stirling, I. and Andriashek, D. 1992. Terrestrial maternity denning of polar bears in the eastern Beaufort Sea area. *Arctic* 45:363–366.

Stirling, I., Calvert, W., and Andriashek, D. 1980a. Population ecology studies of the polar bear in the area of southeastern Baffin Island. *Canadian Wildlife Service Occasional Paper* No. 44. Ottawa.

Stirling, I., Calvert, W., and Andriashek, D. 1984. Polar bear ecology and environmental considerations in the Canadian High Arctic. Pg. 201–222. In Olson, R., Geddes, F. and Hastings, R. (eds.). *Northern Ecology and Resource Management*. University of Alberta Press, Edmonton.

Stirling, I., Jonkel, C., Smith, P., Robertson, R., and Cross, D. 1977a. The ecology of the polar bear (*Ursus maritimus*) along the western coast of Hudson Bay. *Canadian Wildlife Service Occasional Paper No. 33.*

Stirling, I., Lunn, N.J. and Iacozza, J. 1999. Long-term trends in the population ecology of polar bears in Western Hudson Bay in relation to climate change. *Arctic* 52:294–306.

Stirling, I., Lunn, N.J., Iacozza, J., Elliott, C., and Obbard, M. 2004. Polar bear distribution and abundance on the southwestern Hudson Bay coast during open water season, in relation to population trends and annual ice patterns. *Arctic* 57:15–26.

Stirling, I., Richardson, E., Thiemann, G.W. and Derocher, A.E. 2008. Unusual predation attempts of polar bears on ringed seals in the southern Beaufort Sea: possible significance of changing spring ice conditions. *Arctic* 61:14–22.

Stirling, I., Schweinsburg, R.E., Calvert, W. and Kiliaan, H.P.L. 1977b. Polar bear population ecology along the proposed Arctic Islands gas pipeline route, preliminary report. Indian and Northern Affairs Publication QS-8160–015-EE-A1 and ESCOM No. AI-15.

Stirling, I., Schweinsburg, R.E., Kolenasky, G.B., Juniper, I., Robertson, R.J., and Luttich, S. 1980b. Proceedings of the 7th meeting of the Polar Bear Specialist Group IUCN/SSC, 30 January-1 February, 1979, Copenhagen, Denmark. Gland, Switzerland and Cambridge UK, IUCN., pg. 45–53.

Stroeve, J., Holland, M.M., Meier, W., Scambos, T. and Serreze, M. 2007. Arctic sea ice decline: Faster than forecast. *Geophysical Research Letters* 34:L09501.

Stroeve, J., Markus, T, Boisvert, L., Miller, J. and Barrett, A. 2014. Changes in Arctic melt season and implications for sea ice loss. *Geophysical Research Letters* 41:1216–1224.

Strong, W. 2020. 'It's no surprise for Inuit — Baffin Bay polar bears defy past assumptions with stable population'. *CBC News*, 3 March. https://www.cbc.ca/news/canada/north/baffin-bay-polar-bears-nunavut-1.5472492.

SWG Executive Summary [Scientific Working Group to the Canada-Greenland Joint Commission on Polar Bear Executive Summary]. 2016a. Re-Assessment of the Baffin Bay and Kane Basin Polar Bear Subpopulations: Executive Summary for the Final Report to the Canada-Greenland Joint Commission on Polar Bear.

SWG [Scientific Working Group to the Canada-Greenland Joint Commission on Polar Bear]. 2016b. Re-Assessment of the Baffin Bay and Kane Basin Polar Bear Subpopulations: Final Report to the Canada-Greenland Joint Commission on Polar Bear.

TASS. 2020. 'Around 30 polar bears approached Russia's west Chukotka, says WWF.' *TASS (Moscow)*, 16 December. https://tass.com/society/1235879.

Taylor, K.C., Mayewski, P.A., Alley, R.B., Brook, E.J., Gow, E.J., Grootes, P.M., Meese, D.A., Salzman, E.S., Severinghaus, J.P., Twickler, M.S., White, J.W.C., Whitlow, S. and Zielinski, G.A. 1997. The Holocene-Younger Dryas transition recorded at Summit, Greenland. *Science* 278(5339):825–827.

Taylor, M.K., Laake, J., McLoughlin, P.D., Cluff, H.D., and Messier, F. 2006. Demography parameters and harvest-explicit population viability analysis for polar bears in M'Clintock Channel, Nunavut, Canada. *Journal of Wildlife Management* 70:1667–1673.

Taylor, M.K., Laake, J., McLoughlin, P.D., Cluff, H.D., and Messier, F. 2008. Mark-recapture and stochastic population models for polar bears of the High Arctic. *Arctic* 61:143–152.

Taylor, M.K., Laake, J., McLoughlin, P.D., Cluff, H.D., and Messier, F. 2009. Demography and population viability of polar bears in the Gulf of Boothia, Nunavut. *Marine Mammal Science* 25:778–796.

Tempel, J.T.L. and Atkinson, S. 2020. Pacific walrus (*Odobenus rosmarus divergens*) reproductive capacity changes in three time frames during 1975–2010. *Polar Biology* 43:861–875.

Thiemann, G.W., Iverson, S.J., and Stirling, I. 2008. Polar bear diets and Arctic marine food webs: insights from fatty acid analysis. *Ecological Monographs* 78: 591–613.

Todd, F.S., Headland, R.K., and Lasca, N. 1992. Animals at the North Pole. *Polar Record* 28:321–322.

Tollit, D.J., Schulze, A., Trites, A.W., Olesiuk, P., Crockford, S.J., Gelatt, T., Ream, R., and K. Miller, K. 2009. Development and application of DNA techniques for validating and improving pinniped diet estimates. *Ecological Applications* 19:889–905.

Towns, L., Derocher, A.E., Stirling, I., Lunn, N.J. and Hedman, D. 2009. Spatial and temporal patterns of problem polar bears in Churchill, Manitoba. *Polar Biology* 32(10):1529–1537.

US Fish and Wildlife Service (USFWS). 2008. Determination of threatened status for the polar bear (*Ursus maritimus*) throughout its range. *Federal Register* 73:28212–28303.

US Fish and Wildlife Service (USFWS). 2012a. Threatened status for the Arctic, Okhotsk and Baltic subspecies of the ringed seal. *Federal Register* 77:76706–76738.

US Fish and Wildlife Service (USFWS). 2012b. Threatened status for the Beringia and Okhotsk distinct population segments of the *Erignathus barbatus nauticus* subspecies of the bearded seal. *Federal Register* 77:76740–76768.

US Fish and Wildlife Service (USFWS). 2013. Polar Bear News 2013–2014, pp. 17–18. US Fish and Wildlife Service Newsletter, Anchorage, AK.

US Fish and Wildlife Service (USFWS). 2016. Polar bear (*Ursus maritimus*) conservation management plan, final. USFWS, Region 7, Anchorage, Alaska.

US Fish and Wildlife Service (USFWS). 2017. *'Endangered and Threatened Wildlife and Plants; 12-Month Findings on Petitions to List 25 Species as Endangered or Threatened Species'*. *Federal Register* 82(192), 5 October, 50 CFR Part 17. ['listing…Pacific walrus…not warranted at this time'].

US Geological Survey (USGS). 2007. Executive Summary, USGS Science Strategy to Support U.S. Fish and Wildlife Service Polar Bear Listing Decision. Administrative Report, US Geological Survey. Reston, Virginia.

Van Meurs, R. and Splettstoesser, J.F. 2003. Farthest North Polar Bear (Letter to the Editor). *Arctic* 56:309.

Vibe, C. 1965. The polar bear in Greenland. In, *Proceedings of the First International Scientific Meeting on the Polar Bear.* Fairbanks, Alaska 6–10 September 1965, IUCN Polar Bear Specialist Group. University of Alaska International Conference Proceedings Series, No. 1. pg. 17–25. Washington, DC.

Vibe, C. 1967. *Arctic animals in relation to climatic fluctuations.* Meddelelser om Grønland. 170(5). C.A. Reitzels Forlag, Copenhagen.

Vongraven, D., Aars, J., Amstrup, S., Atkinson, S.N., Belikov, S., Born, E.W., DeBruyn, T., Derocher, A.E., Durner, G., Gill, M., Lunn, N., Obbard, M., Omelak, J., Ovsyanikov, N., Peacock, E., Richardson, E., Sahanatien, V., Stirling, I., Wiig, Ø. 2012. A circumpolar monitoring framework for polar bears. *Ursus 23 (sp2)*: 1–66.

Vongraven D. 2013. Circumpolar monitoring framework for polar bears. Presentation 5.1 at the International Polar Bear Forum, December 3–6, Moscow.

Wakefield, R. 2020. 'The birthplace of Arctic ice'. *Alfred-Wegener Institute*, 20 November. https://www.awi.de/en/focus/sea-ice/in-the-arctic-sea-ices-kindergarten.html.

Walker, M. 2009. Polar bear plus grizzly equals? *BBC Earth News*, 30 October. http://news.bbc.co.uk/earth/hi/earth_news/newsid_8321000/8321102.stm accessed 2 Nov. 2011.

Wiig, Ø., Born, E.W., and Garner, G.W. (eds.) 1995. Polar Bears: Proceedings of the 11th working meeting of the IUCN/SSC Polar Bear Specialist Group, 25–27 January, 1993, Copenhagen, Denmark. Gland, Switzerland and Cambridge UK, IUCN.

Wiig, Ø., Amstrup, S., Atwood, T., Laidre, K., Lunn, N., Obbard, M., et al. 2015. *Ursus maritimus*. *The IUCN Red List of Threatened Species 2015*: e.T22823A14871490. Available from http://www.iucnredlist.org/details/22823/0 [accessed Nov. 28, 2015].

Wilder, J.M., Vongraven, D., Atwood, T., Hansen, B., Jessen, A., Kochnev, A., York, G., Vallender, R., Hedman, D. and Gibbons, M. 2017. Polar bear attacks on humans: implications of a changing climate. *Wildlife Society Bulletin* DOI: 10.1002/wsb.783.

Wilson, R.R., and G.M. Durner. 2020. Seismic survey design and effects on maternal polar bear dens. *Journal of Wildlife Management* 84(2):201–212.

Yang, Z., Wang, J., Yuan, L., Cheng, W., Wang, Y., Xie, Z. and Sun, L. 2019. Total photosynthetic biomass record between 9500 and 2200 BP and its link to temperature changes at a High Arctic site near Ny-Ålesund, Svalbard. *Polar Biology* 42:991–1003.

York, G. 2019. Working in remote Arctic Russia. Polar Bears International News/Research Article, 9 December. https://polarbearsinternational.org/news/article-research/working-in-remote-arctic-russia/.

York, J., Dowsley, M., Cornwell, A., Kuc, M. and Taylor, M. 2016. Demographic and traditional knowledge perspectives on the current status of Canadian polar bear subpopulations. *Ecology and Evolution* 6(9):2897–2924.

Young, B.G., and Ferguson. S.H. 2013. Seasons of the ringed seal: pelagic open-water hyperphagy, benthic feeding over winter and spring fasting during molt. *Wildlife Research* 40(1):52–60.

Young, B.G., and Ferguson. S.H. 2014. Using stable isotopes to understand changes in ringed seal foraging ecology as a response to a warming environment. *Marine Mammal Science* 30(2):706–725.

Young, B.G., and Ferguson. S.H. and Lunn, N.J. 2015. Variation in indices of ringed seal density and abundance in western Hudson Bay determined from aerial surveys, 1995 to 2013. *Arctic* 68(3):301–309.

1 The author has published original research results in related fields (Crockford 1997a,b, 2016; Crockford et al. 1997, 2011; Koop et al. 2000; Olesiuk et al. 1990, Tollit et al. 2009; Wilson et al. 2011), research on evolutionary theory that includes polar bears (Crockford 2003a-b, 2004, 2006), research on evolutionary theory that includes geological and atmospheric processes (Crockford 2009), reviews, critiques, and synthesis reports on polar bears and walrus (Crockford 2008a, 2012a,b, 2014a,b, 2017a–e), reviews and synthesis reports on Arctic climate and seals (Crockford 2008b, 2015, Crockford and Frederick 2007, 2011), critiques/commentaries in related fields (Crockford 2002, Crockford and Kuzmin 2012; Rolland and Crockford 2005), and edited a volume of original research in a related field (Crockford 2000).

2 https://susancrockford.com, all available through *Amazon*.

3 Crockford, S. 2017a. Testing the hypothesis that routine sea ice coverage of 3–5 million km2 results in a greater than 30% decline in population size of polar bears (*Ursus maritimus*). PeerJ Preprints 2 March 2017. Doi: 10.7287/peerj.preprints.2737v3.

4 Crockford 2014a–c, Crockford 2015a,b, Crockford 2017b–d; Crockford 2018; and Crockford 2019a,d–g.

5 Obbard et al. 2010.

6 Durner et al. 2018.

7 Amstrup et al. 2007; US Fish and Wildlife Service 2008.

8 Wiig et al. 2015; Regehr et al. 2016.

9 Aars et al. 2017; Crockford 2017a; Crockford and Geist 2018; Dyck et al. 2017; SWG 2016b; AC SWG 2018; Obbard et al. 2018; Regehr et al. 2018; Dyck et al. 2017; SWG 2016b; Dyck et al. 2020a, b; Atwood et al. 2020; Crockford 2019b; Larsen 1972; see also Crockford 2020b ('The problem of statistical confidence').

10 ACIA 2005; Amstrup et al. 2007, 2008; Hunter et al. 2007, 2010; Crockford 2017a; Crockford and Geist 2018.

11 Crockford 2017a; Crockford and Geist 2018.

12 Wiig et al. 2015; Regehr et al. 2016; Akçakaya et al. 2006; Crockford 2017a; Aars et al. 2006; Laidre et al. 2016.

13 USFWS 2008; USFWS 2016.

14 COSEWIC 2018; see also https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments-status-reports/polar-bear-2018.html.

15 Anonymous 1968; IUCN/SSC Polar Bear Specialist Group 2019; PBSG 2019; Laidre et al. 2016; Regehr et al. 2016; Wiig et al. 2015 http://pbsg.npolar.no/en/news/archive/2019/2019-StatusTable.html and http://pbsg.npolar.no/en/status/pb-global-estimate.html [accessed 31 Dec 2020].

16 It has been argued that a plausible and scientifically defensible 'best-guess' estimate at 2018, extrapolated from 'known' to 'unknown' subpopulations within sea ice ecoregions, would be about 39,000 (range 26,000-58,000), although a more pessimistic best-guess based on a greater variety of ecosystem traits (including prey diversity and sea ice cover) came out much lower, at 23,315 (range 15,972-31,212); see Crockford 2019a; Hamilton and Derocher 2019.

17 Stroeve et al. 2007, 2014.

18 Amstrup et al. 2007; Durner et al. 2007; USGS 2007.

19 https://arctic.ru/ecology/20200212/906958.html.

20 Petrov et al. 2020; Russell 2020; Arctic Council 2020; Devyatkin 2020; Lawrynuik 2020a.

21 Vongraven et al. 2012; Vongraven 2013.

22 Atwood et al. 2016a; Regehr et al. 2016; Vongraven et al. 2012; Vongraven et al. 2013; but see Harris 2012; Molnar et al. 2020; Pope 2020.

23 Crockford 2017a, 2019b.

24 COSEWIC 2018, pp. 46; http://pbsg.npolar.no/en/status/populations/baffin-bay.html; SWG 2016a, b; Laidre et al. 2018a.

25 Laidre et al. 2020a; Strong 2020.

26 http://pbsg.npolar.no/en/status/populations/davis-strait.html.

27 Peacock et al. 2013; Rode et al. 2012.
28 DFO 2020; Kovacs 2015.
29 COSEWIC 2018; https://www.canada.ca/en/environment-climate-change/services/biodiversity/maps-sub-populations-polar-bears-protected.html#_fig02.
30 DFO 2020.
31 Dyck 2017.
32 http://pbsg.npolar.no/en/status/populations/davis-strait.html.
33 Stapleton et al. 2016; Taylor et al. 2006.
34 COSEWIC 2018, pp. 47-48; http://pbsg.npolar.no/en/status/populations/foxe-basin.html.
35 Regehr et al. 2007; Derocher and Stirling 1995; see also Lunn et al. 2016; Stapleton et al. 2014; Dyck et al. 2017; Durner et al. 2018;COSEWIC 2018, p. 49.
36 USFWS 2008; Aars et al. 2006.
37 Rose, D. (30 December 2018): 'Why all you've been told about these polar bears could be WRONG.' https://www.dailymail.co.uk/news/article-6539067/Why-youve-told-polar-bears-WRONG-Inuits-different-story.html.
38 Nunavut Polar Bear Co-Management Plan 2018. Also https://www.highnorthnews.com/en/too-many-polar-bears; https://nsidc.org/data/masie/; https://www.facebook.com/polarbearblog/posts/3629263777163820; https://twitter.com/AEDerocher/status/1321503486232518657; https://twitter.com/AEDerocher/status/1334212354951716864; https://twitter.com/AEDerocher/status/1154049472508284929; https://www.canada.ca/en/environment-climate-change/services/ice-forecasts-observations/latest-conditions/archive-overview/information-about-data.html.
39 http://pbsg.npolar.no/en/status/populations/western-hudson-bay.html.
40 Obbard et al. 2006, 2008; see also Obbard et al. 2015.
41 Obbard et al. 2018; Durner et al. 2018. See also https://www.canada.ca/en/environment-climate-change/services/biodiversity/maps-sub-populations-polar-bears-protected.html#_fig02.
42 Obbard et al. 2016.
43 see references in note 69 above.
44 COSEWIC 2018; http://pbsg.npolar.no/en/status/populations/southern-hudson-bay.html.
45 Aars et al. 2006, 2009.
46 Aars et al. 2009.
47 Aars et al. 2017, Table 3.
48 Crockford 2017a.
49 Regehr et al. 2018.
50 http://polarview.met.no/.
51 Durner et al. 2018; See also http://pbsg.npolar.no/en/status/populations/barents-sea.html [accessed 27 Jan 2019].
52 Durner at al. 2018; See also http://pbsg.npolar.no/en/status/populations/barents-sea.html.
53 Matishov et al. 2014.
54 Wiig et al. 2015 supplement; Regehr et al. 2016.
55 Amstup et al. 2007; Crockford 2017a.
56 Durner et al. 2018; http://pbsg.npolar.no/en/status/populations/kara-sea.html [accessed 27 Jan 2019].
57 Derocher et al. 1998.
58 Aars et al. 2006.
59 SJC personal archive of online PBSG status table updates.
60 Durner et al. 2018; http://pbsg.npolar.no/en/status/populations/laptev-sea.html [accessed 27 Jan 2019].
61 Wiig et al. 2015 supplement; Regehr et al. 2016.
62 Durner et al. 2018; Stern and Laidre 2016.

63 Crockford 2019b.
64 http://pbsg.npolar.no/en/status/populations/laptev-sea.html.
65 Obbard et al. 2010.
66 SJC personal archive of online PBSG status table updates; Durner et al. 2018; http://pbsg.npolar.no/en/status/populations/chukchi-sea.html.
67 Wiig et al. 2015 supplement; Regehr et al. 2016.
68 Regehr et al. 2018:2.; Aars et al. 2006:34; Belikov 1993; Wiig et al. 1995:24.
69 Regehr et al. 2018 supplementary data.
70 Rode et al. 2014; Rode et al. 2015b; Rode et al. 2018b.
71 Ovsyanikov and Menyushina 2015; http://www.dailymail.co.uk/news/article-5110801/Polar-bears-scramble-mountain-feast-whale.html.
72 York 2019; see also https://polarbearsinternational.org/news/article-research/life-on-wrangel-island/.
73 Rode et al. 2015b.
74 Durner et al. 2018; AC SWG 2018; See also https://arctic.ru/environmental/20180220/719437.html.
75 Bromaghin et al. 2013, 2015; Amstrup et al. 1986, 2005.
76 Durner et al. 2018; http://pbsg.npolar.no/en/status/populations/southern-beaufort-sea.html.
77 Atwood et al. 2020; Pope 2020; Polar Bears International 2020.
78 Atwood et al. 2020:13.
79 COSEWIC 2018, pg. 39.
80 COSEWIC 2018, pg. 40-41; Joint Secretariat 2017; Griswold et al. 2017; Regehr et al. 2006; see also https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments-status-reports/polar-bear-2018.html.
81 Griswold et al. 2017; Joint Secretariat 2017, pg. 12.
82 http://pbsg.npolar.no/en/status/populations/southern-beaufort-sea.html.
83 COSEWIC 2018; Durner et al. 2018; Joint Secretariat 2015, 2017.
84 Stirling 2011.
85 Durner et al. 2018; http://pbsg.npolar.no/en/status/populations/northern-beaufort-sea.html.
86 https://www.canada.ca/en/environment-climate-change/services/biodiversity/maps-sub-populations-polar-bears-protected.html#_fig02.
87 Joint Secretariat 2017; http://pbsg.npolar.no/en/status/populations/northern-beaufort-sea.html.
88 Larsen 1972; Lunn et al. 2002; see also Courtland 2008, fig. 1.
89 SJC personal archive of online PBSG status table updates.
90 'East Greenland appears to have a resident group of polar bears but the PBSG has never ventured an estimate of their abundance.' 11 July 2014. http://pbsg.npolar.no/en/status/pb-global-estimate.html [accessed 16 Jan 2020].
91 Laidre et al. 2018b.
92 http://arcticjournal.com/climate/773/hunters-5-polar-bears-0 [H. Martin, 10 July 2014].
93 http://pbsg.npolar.no/en/status/populations/east-greenland.html.
94 http://www.cbc.ca/news/canada/north/east-greenland-polar-bears-1.4668180.
95 http://pbsg.npolar.no/en/status/populations/arctic-basin.html.
96 Durner and Amstrup 1995; van Meurs and Splettstoesser 2003; Ovsyanikov 1998, 2010; Todd et al. 1992.
97 COSEWIC 2018; Arrigo et al. 2012; Gosselin et al. 1997; Lee and Whitledge 2005; but see Pomeroy 1997.
98 Obbard et al. 2010; SWG 2016b; York et al. 2016.
99 SWG 2016a: 21; Taylor et al. 2008.
100 SWG 2016a: 14.

101 Durner et al. 2018; COSEWIC 2018, pp. 45. http://pbsg.npolar.no/en/status/populations/kane-basin.html.
102 Furnell and Schweinsburg 1984; Taylor et al. 2006.
103 Dyck et al. 2020a.
104 COSEWIC 2018, pp. 42-43; http://pbsg.npolar.no/en/status/populations/mclintock-channel.html.
105 Taylor et al. 2008.
106 COSEWIC 2018; Pongracz 2014; Durner et al. 2018; http://pbsg.npolar.no/en/status/populations/viscount-melville-sound.html.
107 Taylor et al. 2009.
108 Dyck et al. 2020b.
109 COSEWIC 2018, pp. 43; Dyck et al. 2017; Durner et al. 2018; http://pbsg.npolar.no/en/status/populations/gulf-of-boothia.html.
110 Lunn et al. 2002; Stirling et al. 1984; Taylor et al. 2008.
111 COSEWIC 2018, pp. 44.
112 Durner et al. 2018; http://pbsg.npolar.no/en/status/populations/lancaster-sound.html.
113 Durner et al. 2018; http://pbsg.npolar.no/en/status/populations/norwegian-bay.html.
114 Taylor et al. 2008.
115 COSEWIC 2018, pp. 44-45; http://pbsg.npolar.no/en/status/populations/norwegian-bay.html.
116 https://www.canada.ca/en/environment-climate-change/services/biodiversity/maps-sub-populations-polar-bears-protected.html#_fig02.
117 Crockford 2018, 2019b updated and corrected here.
118 Meier and Stewart 2019; Perovich et al. 2020; Meier 2019.
119 https://scripps.ucsd.edu/programs/keelingcurve/wp-content/plugins/sio-bluemoon/graphs/mlo_one_year.png and http://nsidc.org/arcticseaicenews/2020/03/no-record-breaker-maximum/; https://www.co2.earth/monthly-co2 and http://nsidc.org/arcticseaicenews/2020/09/arctic-sea-ice-decline-stalls-out-at-second-lowest-minimum/.
120 http://nsidc.org/arcticseaicenews/2017/04/another-record-but-a-somewhat-cooler-arctic-ocean/ and http://nsidc.org/arcticseaicenews/2018/04/2018-winter-arctic-sea-ice-bering-down/.
121 http://nsidc.org/arcticseaicenews/.
122 Stirling and Derocher 2012; USFWS 2008.
123 Rode et al. 2014, 2018a; Lippold et a. 2019; USFWS 2013.
124 Atwood et al. 2020 (Fig 4); Burns 1970; Burns et al. 1975; Crockford 2019b; Stirling 2002, Stirling and Lunn 1997; Stirling et al. 1980b, 2008.
125 Frey et al. 2020; Coupel et al. 2019; Brown et al. 2011; NSIDC 2020;.
126 Lewis et al. 2020; see also https://www.sciencedaily.com/releases/2020/07/200709141558.htm.
127 de Vernal et al. 2020; Yang et al. 2019; Limoges et al. 2020.
128 George et al. 2020; Crawford and Quakenbush 2013; Crawford et al. 2015; Crockford 2014a,b; Rode et al. 2013, 2014, 2018; Lippold et al. 2019; Lowry 1985, 2015; MacCracken et al. 2017; USFWS 2017; Grebmeier et al. 2018; Tempel and Atkinson 2020; see also https://www.fws.gov/alaska/pages/endangered-species-program/candidates-esa-listing.
129 Frey et al. 2020; Coupel et al. 2019; Lippold et al. 2019.
130 Frey et al. 2020; but see https://twitter.com/AEDerocher/status/1318288825349677056 (19 October 2020).
131 Wakefield 2020.
132 Cronin et al. 2014; Vibe 1965, 1967; Crockford 2012b; Moore et al. 2017; Taylor et al. 1997; Limoges et al. 2020; Yang et al. 2009.
133 Cronin and Cronin 2015; Sha et al. 2016; Stein et al. 2017; de Vernal et al. 2020.
134 Miles et al. 2020.

135 University of Colorado at Boulder press release, 17 Sept 2020, https://phys.org/news/2020-09-sea-ice-triggered-age.html.
136 de Vernal et al. 2020.
137 Regehr et al. 2016.
138 Stern and Laidre (2016) calculated similar metrics using a threshold of 50% ice cover, which is presumed to be ideal polar bear habitat, but the overall trends are the same.
139 Aars et al. 2017; Aars 2018; Lippold et al. 2019; NPI 2019.
140 See https://cryo.met.no/en/sea-ice-index and https://cryo.met.no/archive/ice-service/ice-charts/quicklooks/.
141 https://cryo.met.no/archive/ice-service/icecharts/quicklooks/ and https://twitter.com/lstjenesten/status/1258774573056737280 (8 May 2020).
142 https://www.maritime-executive.com/article/icebreaker-needs-fuel-after-record-north-pole-voyage (3 April 2020); https://www.awi.de/en/about-us/service/press/press-release/alternative-resupply-plan-for-polarstern-now-in-place.html (24 April 2020); https://www.highnorthnews.com/en/arctic-mosaic-expedition-overcomes-logistical-challenges-covid-19 (28 April 2020).
143 https://twitter.com/lstjenesten/status/1298232572091215876 (25 August 2020).
144 https://twitter.com/lstjenesten/status/1335958661563379712 (7 December 2020).
145 Kaufman 2019; 'Brian Keating: Polar bears in Churchill Manitoba' (13 November 2017, CBC Radio episode 300312418) http://www.cbc.ca/player/play/1095183939998 and https://twitter.com/AEDerocher/status/1144015795598454784 (26 Jun 2019); https://twitter.com/AEDerocher/status/1200529054677340160 (29 Nov 2019); https://twitter.com/AEDerocher/status/1331626671858860034 (25 Nov 2020); https://twitter.com/AEDerocher/status/1292104338425303040 (7 Aug 2020); https://twitter.com/AEDerocher/status/1066051762379837440 (19 Nov 2018); https://twitter.com/AEDerocher/status/887035084326305792 (17 Jul 2017); See also http://churchill.ca/p/polar-bear-safety-stats; https://polarbearscience.com/2017/11/13/w-hudson-bay-freeze-up-one-of-earliest-since-1979-not-closer-to-average/ and http://polarbearscience.com/2018/11/10/w-hudson-bay-freeze-up-earlier-than-average-for-2nd-year-in-a-row-polar-bear-hunt-resumes/ and http://polarbearscience.com/2019/09/05/western-hudson-bay-polar-bears-in-great-shape-after-five-good-sea-ice-seasons/; http://polarbearscience.com/2020/08/09/many-w-hudson-bay-polar-bears-still-offshore-at-7-august-despite-apparent-low-ice-levels/.
146 http://polarbearscience.com/2019/09/05/western-hudson-bay-polar-bears-in-great-shape-after-five-good-sea-ice-seasons/.
147 Stirling et al. 1999; Stirling and Parkinson 2006. See also https://www.cbc.ca/news2/background/polarbears/ and https://pubs.usgs.gov/fs/1997/fs113–97/.
148 'Polar bears return to the ice' (10 November 2017, Polar Bears International) https://polarbearsinternational.org/news/article-polar-bears/polar-bears-returning-to-the-ice/; 'Back on the sea ice!' (20 November 2018, Polar Bears International), https://polarbearsinternational.org/news/article-polar-bears/back-on-the-sea-ice/.
149 Castro de la Guardia et al. 2017; Lunn et al. 2016; Regehr et al. 2016; Stern and Laidre 2016.
150 Scott and Marshall 2010; Castro de la Guardia et al. 2017;.
151 https://polarbearsinternational.org/news/article-polar-bears/western-hudson-bay-polar-bears/.
152 Johnson et al. 2020; Galicia et al. 2020; Heemskerk et al. 2020 compared to Castro de la Guardia et al. 2017; Lunn et al. 2016; Regehr et al. 2016; Stern and Laidre 2016.
153 Obbard et al. 2016; Stirling et al. 2004.
154 Polar Bear Alert Program weekly reports, http://churchill.ca/p/polar-bear-safety-stats; Canadian Ice Service charts archive, https://www.canada.ca/en/environment-climate-change/services/ice-forecasts-observations/latest-conditions/archive-overview/information-about-data.html; https://polarbearscience.com/2020/11/03/western-southern-hudson-bay-polar-bears-ex-

perience-earliest-freeze-up-in-decades/; https://polarbearscience.com/2017/09/10/problem-bear-reports-confirm-churchill-polar-bears-are-in-excellent-condition/ ; https://polarbearscience.com/2017/11/07/problem-bear-report-for-churchill-might-be-second-last-one-this-year/.

155 Brown et al. 2018; Thiemann et al. 2008.

156 e.g. Calvert and Stirling 1990.

157 Atwood et al. 2016b; Herreman and Peacock 2013; Miller et al. 2006; Miller et al. 2015; Rode et al. 2015a; Rogers et al. 2015; Lillie et al. 2019; See also http://www.dailymail.co.uk/news/article-5110801/Polar-bears-scramble-mountain-feast-whale.html.

158 Kelly et al. 2010; Cameron et al. 2010.

159 USFWS 2012a-b.

160 COSEWIC 2018; Lowry 2016; Kovacs 2016.

161 COSEWIC 2019.

162 Ferguson et al. 2017; Ferguson 2019.

163 e.g. Chambellant et al. 2012.

164 Ferguson et al. 2005; Harwood et al. 2012; Chambellant et al 2012; Young and Ferguson 2013, 2014; Young et al. 2015;.

165 Laidre et al. 2013; Laidre et al. 2018c; Smith and Stirling 2019; Thiemann et al. 2008.

166 DFO 2020; Kovacs 2015.

167 DFO 2020; see also http://polarbearscience.com/2020/05/14/new-report-harp-seal-population-critical-to-davis-strait-polar-bears-is-still-increasing/.

168 Peacock et al. 2013; Mercer 2018; See also https://www.canada.ca/en/environment-climate-change/services/biodiversity/maps-sub-populations-polar-bears-protected.html#_fig02.

169 http://icepeople.net/2020/04/11/bear-on-board-crew-of-russian-cargo-ship-forced-to-take-refuge-on-roof-as-polar-bear-climbs-on-deck-in-search-of-food/ see also https://vk.com/club23578257?w=wall-23578257_295%2Fall.

170 Barents Observer 2020; Beaumont 2020; CBC News 2020; Icepeople 2020.

171 e.g. Siberian Times, 10 Oct 2020 https://siberiantimes.com/other/others/news/ten-polar-bears-six-adults-and-four-cubs-besiege-a-stalled-rubbish-truck-in-russian-arctic/.

172 Obbard et al. 2016, 2018; Peacock et al. 2013; Rode et al. 2014, 2018b; SGW 2016; Laidre et al. 2020b.

173 Laidre et al. 2020b:last sentence.

174 Johnson et al. 2020.

175 Lunn et al. 2016; Johnson et al. 2020:11.

176 See note 222 and 226; also McIver 2020 and http://churchill.ca/p/polar-bear-safety-stats and https://www.youtube.com/watch?v=tVktO2Ld_3g&feature=emb_logo.

177 Churchill Wild photo, 30 September 2017, https://www.churchillwild.com/polar-bear-triplets-highlight-summer-at-seal-river-heritage-lodge/ (7 October 2017).

178 e.g. Johnson et al. 2020 and Galicia et al. 2020 compared to Ramsay and Stirling 1988; Stirling and Parkinson 2006; Stirling and Derocher 2012.

179 Johnson et al. 2020.

180 Galacia et al. 2020.

181 Stirling and Oritsland 1995:2603; Ramsay and Stirling 1988:613; Stirling 2002:68; see also Hammill and Smith 1991:132.

182 Dyck et al. 2020b.

183 Dyck et al. 2020a.

184 http://www.mosj.no/en/fauna/marine/polar-bear.html [accessed 3 Feb 2021].

185 Lippold et al. 2019:988.

186 Amstrup et al. 2007, 2008, 2010; Doran 2020; Molnar et al. 2020; Richardson 2019; Stirling and Derocher 2012.

187 Lawrynuik 2020.

188 Barton 2016; Prigg 2016.
189 Rockwell et al. 2008; Smart 2019.
190 COSEWIC 2012; Doupé et al. 2007; McLaughlin et al. 2003.
191 Pongracz et al. 2017; Preuß et al. 2009; Walker 2009.
192 Dietz et al. 2013a, 2013b; Gabrielson et al. 2015; McKinney et al. 2013; Sonne 2010; Sonne et al. 2015; Liu et al. 2018; Letcher et al. 2018; Routti et al. 2019.
193 Dominique et al. 2020.
194 Hoondert et al. 2021.
195 Laidre and Stirling 2020.
196 Florko et al. 2020; Harington 1968; Stirling and Andriashek 1992; Kolenosky and Prevett 1983; Clark et al. 1997; Mauritzen et al. 2001; Ferguson et al. 2000; Van de Velde et al. 2003.
197 Aars 2013; Amstrup and Gardner 1994; Andersen et al. 2012; Derocher et al. 2011; Fischbach et al. 2007; NPI 2019; Obbard et al. 2010; Olson et al. 2017; Ovsyanikov 1998, 2010; Ovsyanikov and Menyushina 2015.
198 Atwood et al. 2016b; Johnson and Derocher 2020; Olson 2017:213.
199 Atwood et al. 2016b; Heereman and Peacock 2013; Rode et al. 2015a; Rogers et al. 2015; Lillie et al. 2019.
200 Canadian Ice Service Archive https://iceweb1.cis.ec.gc.ca/Archive/page1.xhtml?lang=en; https://twitter.com/AEDerocher/status/1285686350969282563.
201 McIver 2020; https://twitter.com/AEDerocher/status/1285686350969282563.
202 Amstrup 2018; https://polarbearsinternational.org/news/article-polar-bears/arctic-national-wildlife-refuge/ and https://www.nytimes.com/2018/12/03/us/alaska-oil-drilling-polar-bears.html and https://www.motherjones.com/environment/2018/12/anwr-polar-bears-trump/ and https://polarbearsinternational.org/news/article-polar-bears/arctic-refuge-dens-at-risk/.
203 Amstrup 1993; Fischbach et al. 2007; Stirling and Andriashek 1992.
204 Amstrup and Gardner 1994; Garner et al. 1990.
205 Atwood et al. 2016b; Heereman and Peacock 2013; Miller et al. 2015; Rogers et al. 2015; Schliebe et al. 2008.
206 Amstrup and Gardner 1994; Stirling et al. 1977b; An employee was mauled by a bear at the Imperial Oil exploration site in January 1975 and the bear was later shot and killed (Montreal Gazette, 8 January 1975, pg. 2: 'Man mauled by polar bear'); in August 2011, a bear was shot by a security guard at a BP oil field, see https://polarbearsinternational.org/news/article-polar-bears/polar-bear-death-at-oil-field-investigated/.
207 Wilson and Durner 2020.
208 Larson et al. 2020: abstract.
209 Amstrup 2020; Grove 2020; PBI 2020.
210 Atwood et al. 2020.
211 Amstrup 2019, 2020.
212 Fountain 2020; Fritts 2020.
213 Amstrup 2003; Stirling 2011; Laidre et al. 2013; Durner and Amstrup 1995; Matishov et al. 2014; Crockford 2015b; Vibe 1967; Cronin and Cronin 2015.
214 Amstrup et al. 2007; Durner et al. 2007, 2009; Pilfold et al. 2017; Pongracz and Derocher 2017.
215 Castro de la Guardia et al. 2017 and tweets by polar bear researcher Andrew Derocher on the 'behavioural plasticity' of movement of WH bears at breakup and freeze-up: at 17 July 2017, https://twitter.com/AEDerocher/status/887035084326305792; 23 Nov 2018, https://twitter.com/AEDerocher/status/1066051762379837440; 18 July 2018, https://twitter.com/AEDerocher/status/1284490240116224001; 29 July 2019, https://twitter.com/AEDerocher/status/1155870820478013441; 29 Nov 2019, https://twitter.com/AEDerocher/status/1200529054677340160; 29 July 2020, https://twitter.com/AEDerocher/status/1288603934831984640; 22 Aug 2020, https://twitter.com/

AEDerocher/status/1297193992891768833; 23 Nov 2020, https://twitter.com/AEDerocher/status/1331626671858860034.
216 Molnar et al. 2020; Castro de la Guardia et al. 2017.
217 Crockford 2017a, 2019b; Cronin and Cronin 2015.
218 Wilder et al. 2017.
219 Wilder et al. 2017; e.g. https://www.adn.com/arctic/2017/07/11/as-sea-ice-gets-scarcer-polar-bear-attacks-on-people-become-more-frequent/.
220 Smith et al. 2021.
221 Stirling and Lunn 1997; Fleck and Herrero 1988; Gjertz et al. 1993; Gjertz and Persen 1987; International Human-Bear Conflicts Workshop 2009; Stenhouse et al. 1988.
222 Crockford 2015c; http://www.pressherald.com/2013/09/02/bear-attack-victim-thought-dude-youre-going-to-die_2013–09–02/.
223 http://icepeople.net/2020/01/16/fending-off-a-polar-bear-with-a-rope-dogsled-guide-says-bear-approached-tour-group-too-quick-to-use-weapon-scared-it-off-by-hitting-it-with-brake-rope-on-sled-without-incident/; http://icepeople.net/2020/01/15/alert-another-polar-bear-near-town-governor-sends-helicopter-to-monitor-bear-seen-wednesday-afternoon-in-bolterdalen-tracks-also-seen-on-longyearbreen-on-tuesday/.
224 http://icepeople.net/2020/01/31/polar-bear-drugged-but-dies-on-flight-north-officials-stun-bear-near-longyearbyen-investigating-why-it-died-on-helicopter-to-northeast-svalbard/; https://www.newsinenglish.no/2020/02/05/polar-bear-died-under-sedation/; http://icepeople.net/2020/06/18/unnecessary-risk-by-officials-in-polar-bears-death-lack-of-equipment-and-failure-to-assess-animals-health-among-faults-by-governor-and-science-experts-report-states/.
225 http://icepeople.net/2020/05/01/polar-bear-brings-early-morning-may-day-call-helicopter-tracks-animal-for-four-hours-as-it-wanders-from-bjorndalen-and-past-cabins-before-heading--north/.
226 https://vocm.com/2020/02/15/polar-bear-warning-issued-for-cartwright-area/.
227 https://www.thetelegram.com/news/provincial/several-polar-bear-sightings-reported-in-st-anthony-area-of-the-northern-peninsula-425584/ and http://www.townoffogoisland.ca/home/blog-678.
228 Clark 2003; Wilder et al. 2017.
229 Stirling et al. 1977a; Kearney 1989; https://www.cbc.ca/news/canada/north/polar-bear-management-arviat-1.4904164.
230 Siberian Times 2020; see also https://www.youtube.com/watch?v=5486VAM7WLM&feature=youtu.be.
231 TASS 2020; see also Crockford 2019g; Kochnev 2002; Parfitt 2019; and https://www.bbc.co.uk/programmes/articles/4zh2Dd3JC8gprNZcGY6BbHB/walrus-on-the-edge.
232 Kearney 1989; Stirling et al. 1977a; https://www.cbc.ca/archives/entry/operation-bear-lift-saves-churchills-polar-bears [from 1971] and https://www.theguardian.com/world/2019/feb/13/churchill-canada-polar-bear-capital.
233 Stirling and Parkinson 2006; Towns et al. 2009; also Stirling et al. 1977a; Kearney 1989 for historical perspective.
234 Heemskerk et al. 2020, Table 1 and Figure 2.
235 Heemskerk et al. 2020, page 5 and Figure 5.
236 Scott and Marshall 2010; Lunn et al. 2016; Castro de la Guardia et al. 2017.
237 Savikataaq Jr. 2015. see also Crockford 2019a for details of 2018 attacks in the area.
238 https://nunatsiaq.com/stories/article/its-that-time-of-year-again-in-arviat-when-polar-bears-start-moving-north/; see also https://twitter.com/Irngutaq2/status/1309258774373265408 (24 Sept 2020); https://twitter.com/Irngutaq2/status/1309666670487760896 (25 Sept 2020);.
239 https://www.cbc.ca/news/canada/north/polar-bear-iqaluit-sylvia-grinnell-1.5639627.
240 Elfström et al. 2014; Wilder et al. 2017; Heemskerk et al. 2020.
241 Nilsen 2020; Beaumont 2020; https://www.facebook.com/SysselmannenSvalbard/

posts/3531144113570840; https://www.bbc.com/news/world-europe-53945950; http://icepeople.net/2020/08/28/man-killed-by-polar-bear-at-longyearbyen-camping-attack-shortly-before-4-a-m-is-svalbards-first-such-fatality-since-2011/ ; http://icepeople.net/2020/08/25/two-polar-bears-flown-away-two-new-ones-arrive-well-known-female-bear-and-her-cub-removed-from-cabin-area-at-hiorthhamn-but-new-ones-near-town-separately-hours-later/; http://icepeople.net/2020/08/30/there-are-no-stupid-questions-faq-about-fatal-polar-bear-attack-at-campsite-why-is-camping-allowed-why-isnt-there-a-fence-was-killing-the-bear-necessary-and-other-answers/.

242 https://cryo.met.no/archive/ice-service/icecharts/quicklooks/.

243 Brewster 2020; Crockford 2015.

244 Hench 2013; Crockford 2015; Peacock et al. 2013; Shankman 2014.

245 Government of Canada 2020 (feature on polar bear biologist Evan Richardson).

246 Molnar et al. 2020; Allen 2020; Dickie 2020; Falconer 2020; see also http://icepeople.net/2020/07/21/no-polar-bears-by-2100-svalbard-faces-most-drastic-threat-to-entire-population-even-if-climate-change-impacts-are-reduced-in-new-global-study/ and https://www.nytimes.com/2020/07/20/climate/polar-bear-extinction.html.

247 Hausfather and Peters 2020; Pielke Jr, R. and Ritchie, J. 2021; see also https://www.bbc.com/news/science-environment-51281986.

248 Amstrup et al. 2007; Crockford 2017a, 2019b.

249 Galacia et al. 2020; Johnson et al. 2020; Molnar et al. 2020; see also Molnar et al. 2010; Richardson 2019; Weber 2020;.

250 Wiig et al. 2015; Crockford 2019a; Atwood et al. 2020; Dyck et al. 2020a, 2020b; Regehr et al. 2018; AC SWG 2018; SWG 2016a, b; Aars et al. 2017; COSEWIC 2018 ('Total Abundance' section); https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments-status-reports/polar-bear-2018.html.

About the Global Warming Policy Foundation

The Global Warming Policy Foundation is an all-party and non-party think tank and a registered educational charity which, while openminded on the contested science of global warming, is deeply concerned about the costs and other implications of many of the policies currently being advocated.

Our main focus is to analyse global warming policies and their economic and other implications. Our aim is to provide the most robust and reliable economic analysis and advice. Above all we seek to inform the media, politicians and the public, in a newsworthy way, on the subject in general and on the misinformation to which they are all too frequently being subjected at the present time.

The key to the success of the GWPF is the trust and credibility that we have earned in the eyes of a growing number of policy makers, journalists and the interested public. The GWPF is funded overwhelmingly by voluntary donations from a number of private individuals and charitable trusts. In order to make clear its complete independence, it does not accept gifts from either energy companies or anyone with a significant interest in an energy company.

RECENT GWPF REPORTS

13	Lewis and Crok	A Sensitive Matter
14	Montford, Shade	Climate Control: Brainwashing in Schools
15	De Lange, Carter	Sea-level Change: Living with Uncertainty
16	Montford	Unintended Consequences of Climate Change Policy
17	Lewin	Hubert Lamb and the Transformation of Climate Science
18	Goklany	Carbon Dioxide: The Good News
19	Adams	The Truth About China
20	Laframboise	Peer Review: Why Scepticism is Essential
21	Constable	Energy Intensive Users: Climate Policy Casualties
22	Lilley	£300 Billion: The Cost of the Climate Change Act
23	Humlum	The State of the Climate in 2016
24	Curry et al.	Assumptions, Policy Implications and the Scientific Method
25	Hughes	The Bottomless Pit: The Economics of CCS
26	Tsonis	The Little Boy: El Niño and Natural Climate Change
27	Darwall	The Anti-development Bank
28	Booker	Global Warming: A Case Study in Groupthink
29	Crockford	The State of the Polar Bear Report 2017
30	Humlum	State of the Climate 2017
31	Darwall	The Climate Change Act at Ten
32	Crockford	The State of the Polar Bear Report 2018
33	Svensmark	Force Majeure: The Sun's Role in Climate Change
34	Humlum	State of the Climate 2018
35	Peiser (ed)	The Impact of Wind Energy on Wildlife and the Environment
36	Montford	Green Killing Machines
37	Livermore	Burnt Offering: The Biomess of Biomass
38	Kelly	Decarbonising Housing: The Net Zero Fantasy
39	Crockford	The State of the Polar Bear Report 2019
40	Darwall	The Climate Noose: Business, Net Zero and the IPCC's Anticapitalism
41	Goklany	The Lancet Countdown on Climate Change: The Need for Context
42	Humlum	The State of the Climate 2019
43	Alexander	Weather Extremes: Are they caused by Global Warming?
44	Constable	Hydrogen: The Once and Future Fuel?
45	Kessides	The Decline and Fall of Eskom: A South African Tragedy
46	Goklany	Impacts of Climate Change: Perception and Reality
47	Constable	A Little Nudge with a Big Stick
48	Crockford	The State of the Polar Bear Report 2020