STATE OF THE POLAR BEAR REPORT 2018

Susan J. Crockford

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Contents

Foreword **vii**

About the author **vii**

Executive summary **ix**

1 Introduction **1**

2 Conservation status **2**

3 Population size **3**
Global 3
Subpopulations by ecoregion 3

4 Population trends **12**
The problem of statistical confidence 14

5 Habitat status **16**
Global sea ice 16
Sea ice loss by subpopulation 19
Freeze-up and breakup date changes for Hudson Bay 19

6 Prey base **21**
Polar bears, seals, and sea ice 21
Seal numbers 22

7 Health and survival **23**
Body condition 23
Effect of record low winter ice 25
Hybridization 25
Effect of contaminants 25
Swimming bears 26
Denning on land 26
Ice-free period on land 26
Threats from oil exploration and extraction in Alaska 27
Litter sizes 27

8 Evidence of flexibility **28**
Den locations 28
Feeding locations 28
Genetics 29

9 Human/Bear interactions **30**

Attacks on humans 30
Problem bears and attacks in winter/spring 30
Problem bears and attacks in summer and autumn 33

10 Discussion 35

Notes 38

Bibliography 49

Foreword

From 1972 until 2010,[1] 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, 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 in the Arctic since 2014, relative to historical records, based on a review of the 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.

About the author

Dr Susan Crockford is an evolutionary biologist and has been working for 35 years in archaeozoology, paleozoology and forensic zoology.[2] She is an adjunct professor at the University of Victoria, British Columbia, but 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 and German), *Polar Bears Have Big Feet* (for preschoolers), and the fully referenced *Polar Bears: Outstanding Survivors of Climate Change,*[3] as well as a scientific paper on polar bear conservation status.[4] She has authored several earlier briefing papers and videos for GWPF on the subjects of polar bears and walrus.[5] Susan Crockford blogs at www.polarbearscience.com.

Executive summary

- Data published since 2017 show that global polar bear numbers have continued to increase slightly since 2005, despite the fact that summer sea ice in 2018 was again at a low level not expected until mid-century: the predicted 67% decline in polar bear numbers did not occur.
- Despite having to deal with the greatest change in sea ice habitat since 1979 of all Arctic regions, according to Norwegian biologists polar bears in the Svalbard area showed no negative impact from the low sea ice years of 2016 through 2018.
- Global sea ice extent was below average in March 2018, as it was in 2017, but this reduction in winter ice had no impact on polar bear health or survival, in part because most of the decline was in regions where polar bears don't live (like the Sea of Okhotsk and the Gulf of St. Lawrence).
- Unexpectedly, for the second year in a row, freeze-up of sea ice on Western Hudson Bay came earlier than the average date in the 1980s; no-one knows why.
- In Canada, where perhaps two-thirds of the world's polar bears live, the Committee on the Status of Endangered Wildlife (COSEWIC) decided in 2018 to continue to list the polar bear as a species of 'Special concern' rather than upgrade to 'Threatened.'
- Despite marked declines in summer sea ice, Chukchi Sea polar bears continue to thrive: reports from the first population-size estimate for the region, performed in 2016, show bears in the region are abundant (almost 3000 individuals), healthy and reproducing well.
- *National Geographic* received such a profound backlash from its widely viewed '*this is what climate change looks like*' starving polar bear video, released in late 2017, that in 2018 it made a formal public apology for spreading misinformation.
- Contrary to concerns about threats to polar bears from proposed drilling for oil in the National Wildlife Refuge in Alaska, polar bear females are quite tolerant of disturbances, and oil companies have an excellent track record of dealing responsibly with polar bears.
- Polar bear attacks made headlines in 2018: two fatal attacks in Nunavut, Canada and a narrowly averted death-by-mauling in northern Svalbard caught the world by surprise.
- The territory of Nunavut, where most polar bears in Canada live, is now poised to make human safety their priority in managing growing populations of bears.

1 Introduction

The US Geological Survey estimated the global population of polar bears at 24,500 in 2005.[6] In 2015, the IUCN Polar Bear Specialist Group estimated the population at 26,000 (range 22,000–31,000)[7] but additional surveys published 2015–2017 brought the total to near 28,500.[8] However, data published in 2018 brought that number to almost 29,500[9] with a relatively wide margin of error. This is the highest global estimate since the bears were protected by international treaty in 1973.[10] While potential measurement error means it can only be said that the global population has likely been stable since 2005 (but may have increased slightly), it is far from the precipitous decline polar bear experts expected given summer sea ice levels as low as they have been in recent years.[11]

Between 2007 and 2015, summer sea ice on average dropped about 38% from 1979 levels, an abrupt decline to within measurement error of the reduced coverage expected to occur by mid-century (Figure 1).[12]

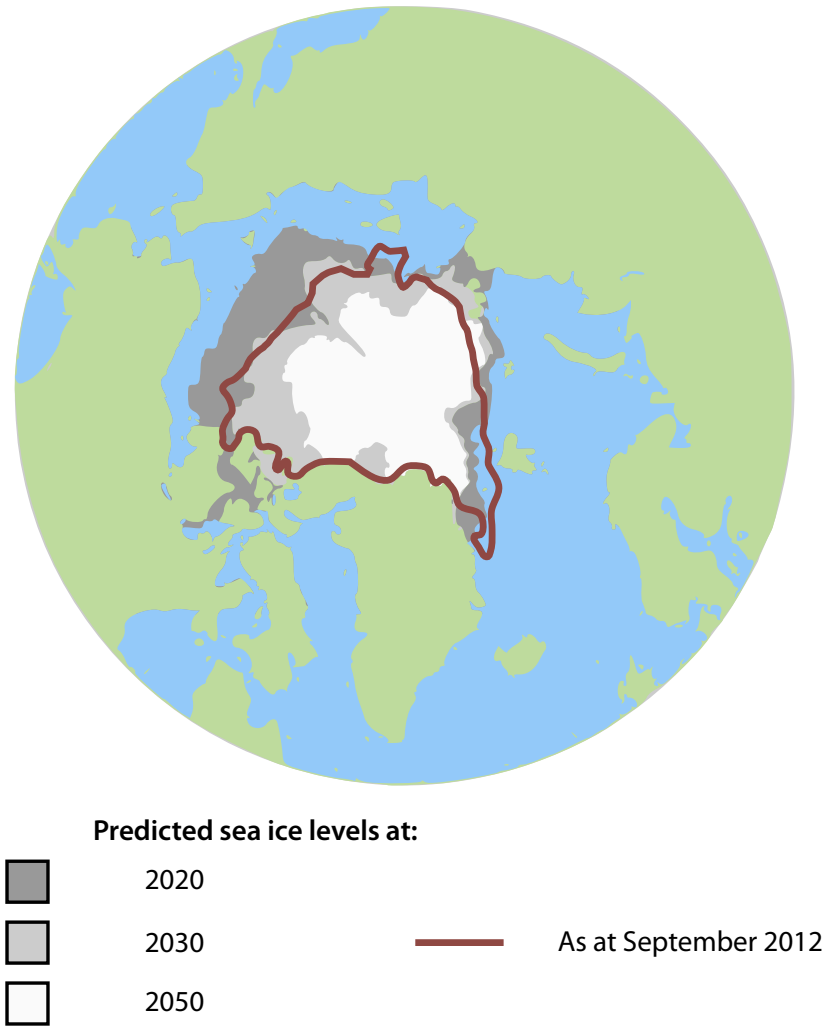


Figure 1: Predicted sea ice changes versus observations.

Sea ice predictions, based on 2004 data,[13] were used in 2007 to predict a 67% decline in global polar bear numbers. The red line indicates approximate situation as at 10 September 2012, an example of sea ice extent experienced since 2007.[14]

Christine Hunter and colleagues[15] proclaimed in 2007 that such reduced summer sea ice by 2050, if present for eight out of ten years (or 4 out of 5 years), would generate a massive drop in polar bear numbers: ten vulnerable subpopulations out of 19 would be extirpated, leaving fewer than 10,000 animals worldwide (a 67% decline). Even though summer sea ice from 2016–2018 has continued this pattern, recent research shows such a decline in polar bear abundance has not occurred. This indicates summer sea ice levels are not as critical to polar bear survival as USGS biologists assumed.[16]

Despite marked declines in summer sea ice, Chukchi Sea polar bears continue to thrive and reports from the first population size estimate for the region show bears in the region are abundant, healthy and reproducing well.[17] Similarly, according to Jon Aars, a senior Norwegian biologist, polar bears in the Svalbard area show no impact of the particularly low sea ice years of 2016–2018.[18]

2 Conservation status

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.[19] Similarly, in 2016, the US Fish and Wildlife Service (USFWS) upheld its 2008 conclusion that polar bears were 'threatened' with extinction under the US Endangered Species Act (ESA). [20] In both of these instances, polar bear conservation status is based on computer-modeled future declines predicted to exceed standard threshold levels (i.e. a population decline of 30% or more expected within three generations), not observed declines.

Polar bears currently have a relatively large population size and their historical range has not diminished due to habitat loss since 1979. If assessed on current observations, the polar bear would qualify for a status of 'Least Concern' by the IUCN Red List in 2015 (as they would have done in 2006) and the USFWS would not have included polar bears on the ESA list of threatened and endangered species in 2008.[21] Thus, concerns about the conservation status of polar bears are all about 'the potential response of the global population of polar bears to projected sea ice declines'[22] , not their current population size.

The polar bear was the first species assessed by the IUCN and under the ESA to use predicted population declines based on climate models – although all other species (with only a few recent exceptions) are assessed based on population declines already observed. As a consequence, the public and the media often logically assume that polar bear numbers must be currently declining because they have been listed as 'threatened' or 'vulnerable': this would be true for all other species listed by the IUCN or under the ESA, with only a few exceptions. This confusion is understandable because it appears contradictory. But the peculiar way in which polar bear conservation status has been defined by these organizations means it is entirely correct to state that polar bears are currently thriving, and to insist that such a statement is not at odds with a conservation status based on possible *future* declines in population size.

Similarly, in 2018, COSEWIC – the Committee on the Status of Endangered Wildlife in Canada – 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.'[23] Since roughly two thirds of the world's thriving polar bear population lives in Canada, the recent COSEWIC decision means that most of the species is still managed with an overall attitude of cautious optimism. This is a refreshing spark of rationality in the world of polar bear conservation assessment.

3 Population size

Global

Despite the fact that one of the primary objectives of the PBSG, when appointed in 1973, was to generate a global population estimate,[24] this portion of their mandate has proven particularly difficult to attain. Despite more than 50 years of dedicated research, several subpopulations have never been comprehensively surveyed for population abundance (East Greenland, Arctic Basin, Laptev Sea) and several others have had only one survey conducted over that time period (Chukchi Sea, Kara Sea, Viscount Melville, Lancaster Sound, M'Clintock Channel, and Norwegian Bay).

In 1993, the PBSG estimated polar bear abundance as about 21,470–28,370 (rounded to 22,000–27,000 in 1997). This number was 'adjusted' to 21,000–25,000 in 2001 and 'further simplified' to 20,000–25,000 in 2005; the apparent decline since 1993 comes from the fact that some estimates used prior to 2001 were deemed to be not scientific enough and were dropped from the totals.[25] In contrast, in 2005 the US Geological Survey put the global population of polar bears at 24,500, a mid-point estimate used to support the US Fish and Wildlife Endangered Species Act listing in 2008.

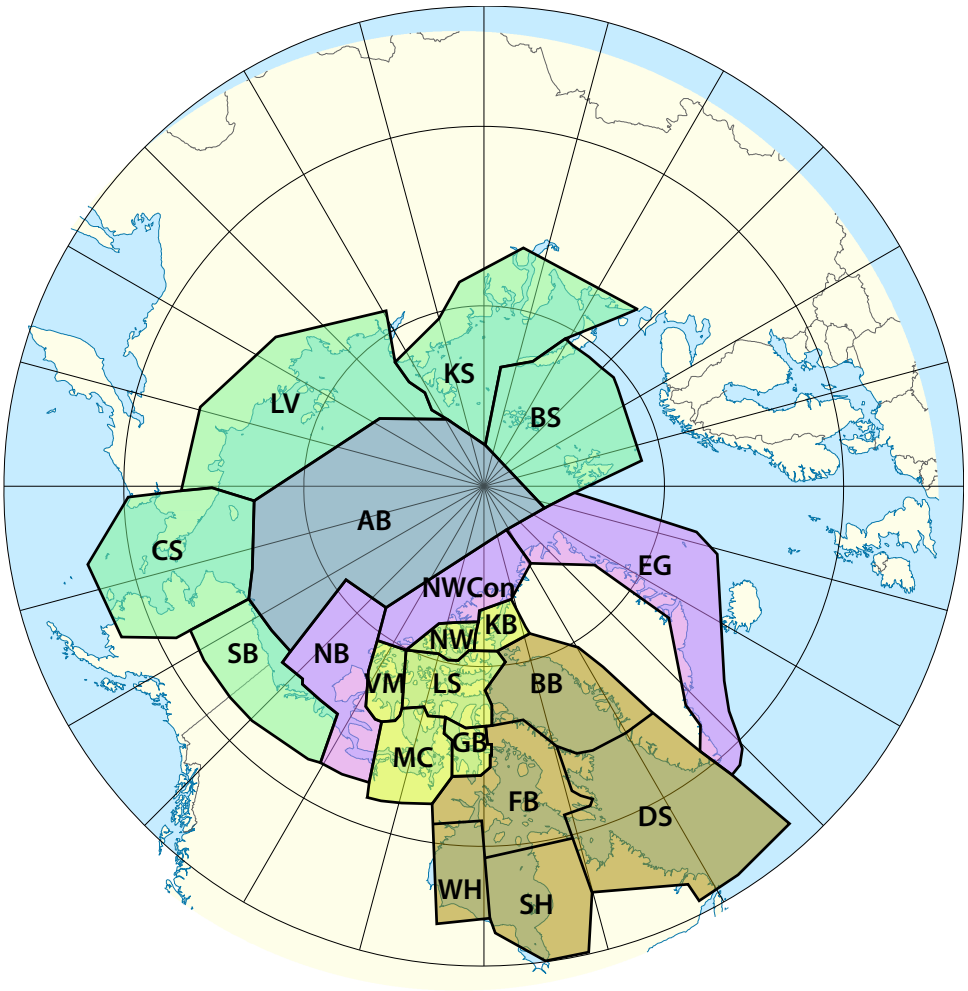
In 2014, the PBSG mid-point estimate was listed as 'approximately 25,000' (no range given), which was still the figure listed on their website at 26 January 2019.[26] This is rather odd, since the 2015 IUCN Red List assessment, written by PBSG members,[27] used a mid-point estimate of 26,000 (but not 26,500, the true mid-point of the stated 22,000–31,000 range, apparently due to potential estimate errors).

However, additional survey results published since the 2015 Red List assessment was prepared brought the mid-point total at 2015 to near 28,500, with a similar wide margin of error (see Section 4 for more detail). However, in 2018, new estimates for Southern Hudson Bay and the Chukchi Sea, completed in 2016, added about 1000 to that total. Moreover, surveys of the Gulf of Boothia, Viscount Melville, and M'Clintock Channel were completed by 2017 and although the results have not yet been published, their updated counts could put that global mid-point estimate above 30,000. While there is a wide margin of error attached to the most recent mid-point estimate of 29,500, this is a far cry from the 7,493 (6,660–8,325) bears we were assured would be all that would remain[28] given the sea ice levels that have prevailed since 2007.[29]

Subpopulations by ecoregion

In 2007, the US Geological Survey defined four Arctic sea-ice 'ecoregions' as part of their current and future assessments of polar bear population size and health (Figure 2).

- 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 those subpopulations in the Canadian Arctic archipelago.



AB Arctic Basin
BB Baffin Bay
BS Barents Sea
CS Chukchi Sea
DS Davis Strait
EG East Greenland
FB Foxe Basin
GB Gulf of Boothia
KB Kane Basin
KS Kara Sea
LV Laptev Sea
LS Lancaster Sound
MC M'Clintock Channel
NB Northern Beaufort
NW Norwegian Bay
SB Southern Beaufort
SH Southern Hudson Bay
VM Viscount Melville
WH Western Hudson Bay

Seasonal
Archipelago
Convergent
Divergent

Figure 2: 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.

Ecoregions now appear to have been accepted as a useful assessment methodology.[30] However, it is important to note that the inclusion of the Southern Beaufort (SB) in the 'Divergent' ecoregion is potentially misleading. Thick sea ice conditions occur in the SB every ten years or so, and persist for 2–3 years. They have a severe impact on polar bear health and survival, and thus population size. The most devastating and well-documented thick spring-ice events occurred in 1974–1976 and 2004–2006,[31] with evidence of perhaps less severe events in the early 1960s, mid-1980s, early 1990s, and the mid-2010s.[32] This makes the SB region almost unique, although something similar happens on a less regular basis off Greenland and in Hudson Bay due to thick ice and/or changes in snow depth over ice.[33] It might therefore be better thought of as an ecoregion of its own.

It should also be noted that Canada has recently changed the boundary between the Southern and Northern Beaufort regions. This step was meant to make management easier, but if the changes are adopted by the PBSG (and proceedings from their 2016 meeting indicated this has not yet been done),[34] accurately tracking long-term changes in population size and effects of thick spring ice events will become extremely difficult. Most of the population declines that occurred every ten years or so in the past were movements of bears away from thick ice areas,[35] rather than actual deaths and the boundary change means these movements will no longer happen within the SB but between SB and NB.

Baffin Bay – Seasonal

A comprehensive survey of Baffin Bay (BB) polar bears undertaken in 1993–1997[36] generated an estimate of 2,074±226. The government report for the latest survey, completed in 2013, confirmed what local Inuit and some biologists had been saying for years: contrary to the assertions of PBSG scientists, BB polar bear numbers have not declined since 1997 due to suspected over-hunting.[37] BB bear abundance in 2013 was found to be 'considerably larger' than the previous estimate, but the authors assert that differences in sampling design preclude direct comparison between the two. Still, the polar bear subpopulation estimate at 2013 for BB was 2,826±767 (95% CI = 2,059–3,593), a 36% increase over 1997 (2,074; 95% CI = 1,553–2,595). While all other metrics of life history and habitat were subject to statistical significance testing,[38] the abundance estimate was not, because of the claimed methodological issues (a position refuted by Mitchell Taylor, the author of the 1997 report).[39]

Davis Strait – Seasonal

The Davis Strait (DS) subpopulation include those bears that visit Newfoundland and southern Labrador in the spring. The first population count was completed in the late 1970s, and generated a figure of 726 bears. That figure has been subject to repeated post-hoc adjustments. The first was upwards, to 900.[40] That estimate was then subjectively increased by the PBSG to 1,400 bears and then, at the turn of the millennium, to 1,650 (without additional field surveys) to account for certain biases and assumptions in the original estimate as well as more sightings of bears and an increase in their harp seal prey.[41] A comprehensive survey completed in 2007 generated a new estimate of 2,158 (range 1,833–2,542), a substantial increase over the previous estimates.[42]

The density of Davis Strait bears in 2007 (5.1 bears/1,000 km^2) was found to be higher than other seasonal sea-ice subpopulations, such as the one in Hudson Bay. Rode and colleagues recorded a slight decline in body condition of DS polar bears between 1977 and

2010 but there was no indication this had affected survival or reproduction.[43] By 2012, the harp seal population had grown even further,[44] providing 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'.[45] As a consequence, it is highly likely that the actual population size at 2018 (eleven years after the last survey) is well above 2,500.

Foxe Basin – Seasonal

The first survey of Foxe Basin (FB) bears, conducted in 1994, generated an estimate of 2,197 bears (1,677–2,717), but in 2004 this was adjusted by the PBSG to 2,300 bears (1,780–2,820).[46] An aerial survey in 2009–2010 generated an estimate of around 2,580 bears, the first aerial surveys performed in Canada after mark-recapture studies were effectively banned by the Nunavut government.[47] While the two methods (aerial survey and mark-recapture) are not directly comparable, the population was considered stable by Environment Canada and the PBSG in 2014, and there is no recent evidence to conclude this is not still the case.[48]

Western Hudson Bay – Seasonal

The first comprehensive survey of Western Hudson Bay (WH) for the period 1978–1992 generated a population estimate of 1,000±51, which was adjusted by the PBSG in 1993 to 1,200 to account for areas not surveyed.[49] Regehr and colleagues estimated the abundance in 2004 as 935 (range 794–1,076), a statistically significant decline of 22% from the 1987 count of bears in the same core area of 1,194 (range 1,020–1,368).[50] This result was used as persuasive evidence that polar bears should be listed as 'vulnerable' and 'threatened' (by the IUCN Red List in 2006, and the US Fish and Wildlife Service in 2008, respectively). A mark-recapture study in 2011, again of the core region only because this was assumed to include all WH bears, generated an estimate of 806 (653–984) that looked like a further decline. But the same year, an aerial survey that encompassed the entire subpopulation area generated an estimate of 1,030 (range 754–1,406). This estimate of 1,030 was still the figure used by the PBSG in 2016 and 2017, which considered this subpopulation 'stable.'[51] Another aerial survey in 2016 generated an estimate of 842 (range 562–1,121).[52]

However, because the 2011 and 2016 WH aerial surveys used rather different methods and covered different portions of the region, the authors of the 2016 report emphasized that only two estimates can be reliably compared: for 2011, the estimate of 949 (range 618–1280) and for 2016, the estimate of 842 (range 562–1121). The slight decline between 2011 and 2016 of 11% was not statistically significant.[53] Therefore, it is not scientifically supportable to suggest that the estimate for 2016 of 842 bears is different from the 2011 estimate of 1,030 bears. Moreover, neither of these estimates is statistically different from the estimate of 935 calculated in 2004, which means there is no justification for suggesting the WH population has declined since 2004. Claims by polar bear specialists that the body mass of females, survival rates of cubs, and the frequency of triplet litters have all declined since 2004 due to sea ice changes have not been substantiated because no data of this nature have been published.[54] In a late 2018 interview with UK journalist David Rose, WH polar bear researcher Andrew Derocher would only concede that there has been 'a recent period of stability'.[55] But WH polar bears may be doing even better than just holding their own: the Nunavut Government insisted in late 2018 that several indicators point to the conclusion that the WH population has increased in size.[56]

Southern Hudson Bay – Seasonal

The first population size assessment for Southern Hudson Bay (SH) was made during 1984–1986, and generated an estimate of 763±323 bears.[57] Some adjustments, re-analyses and new surveys indicated that by 2005 the subpopulation had been stable since the mid-1980s at about 1000 animals.[58] A subsequent aerial survey in 2011–2012 generated an estimate of 943 bears (range 658–1350), a non-significant change from 2005 that further demonstrated that the body condition of SH bears had changed very little since the 1980s.[59] The small decline in body condition index found by SH researchers (no raw data provided) correlated only with very late freeze-up dates. Results of a more recent aerial survey, completed in 2016, showed a 17% decline in population size, from 943 to 780 (range 590–1029), which was not statistically significant.[60] 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' and 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, Martyn Obbard and colleagues also conceded that the decline in the percentage of yearling cubs they documented (from 12% in 2011 to 5% in 2016), which indicated low survival of cubs born in 2015, did not correlate with adverse fall or summer sea ice conditions because freeze-up was relatively early in 2015 and breakup was relatively late. They offered no alternative explanation for the poor survival of yearlings, which they noted was similar to that seen for Western Hudson Bay bears the same year. Furthermore, in contrast to their 2011/2012 survey, no additional information has yet been forthcoming on the body condition of bears they documented in 2016, nor have they reported sea ice conditions up to 2016.

Barents Sea – Divergent

The first count of Barents Sea (BS) polar bears was undertaken in August 2004 using a combination of mark-recapture and aerial survey over both Norwegian and Russian territories. This survey generated an initial estimate of 2,997, which was later amended to 2,650 (range 1900–3600) for the entire region.[61] Researchers found 2.87 times as many bears in the Russian sector of the Barents Sea as in the Norwegian sector in 2004.[62] In August 2015, a planned recount of the entire subpopulation had to be restricted to the Norwegian sector because Russian authorities refused to issue the necessary permits. However, while the published paper that reported the results of the Svalbard survey confirmed that a 42% increase in abundance had occurred (from 685 bears in 2004 to 973 bears in 2015), due to the large uncertainty (broad error ranges) in the estimates involved, that 42% increase was not statistically significant.[63] Authors Jon Aars and colleagues had this to say about the Svalbard survey:

> There is no evidence that the fast reduction of sea-ice habitat in the area has yet led to a reduction in population size. The carrying capacity is likely reduced significantly, but recovery from earlier depletion up to 1973 may still be ongoing.[64]

The same authors also concluded that only a few hundred bears now use Svalbard routinely as a denning area or summer refuge, and that most individuals seen around the area live in the pack ice offshore. This confirmed their previous finding that most Barents Sea polar bears live in the Russian sector of the region, around the archipelago of Franz Josef Land.[65]

Zoologist Susan Crockford pointed out in 2017[66] that if the results of the 2015 survey were extrapolated to the entire region using the ratio for the Russian and Norwegian sectors taken from the 2004 survey, the 2015 population size for the Barents Sea would likely be about 3,749 (an increase of about 1,109 bears). This extrapolated size increase might not be statistically significant but it accounts for the high probability that the polar bear population in the Russian sector increased between 2004 and 2015 by at least as much as the Norwegian sector (and perhaps by even more, because sea-ice conditions there have been less seasonally volatile).[67] However, the researchers who undertook the 2015 Svalbard survey did not extrapolate their estimate to the entire region. Even more oddly, both the 2017 online PBSG subpopulation description and the proceedings document from the 2016 PBSG meeting failed to even mention the 2015 Svalbard survey.[68] As a consequence, the official BS population size remains at 2,650 (range 1900–3600), which is now seriously out of date.[69]

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.[70] This estimate (range 2,700–3,500), derived by Russian biologists from ship counts, was added to the official global count published in 2015 by the IUCN Red List.[71] 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.[72] However, if it was accurate at the time, it may indicate a population increase has taken place. Despite this, the PBSG in 2016 and 2017 still listed the Kara Sea status as 'unknown' and did not mention the 2014 Russian estimate.[73]

Laptev Sea – Divergent

The Laptev Sea (LV) was given a population size of about 1,000 (range 800–1,200) based on den counts between the 1960s and 1980s.[74] The PBSG included this estimate in its 2005 assessment,[75] but the LV status was changed to 'data deficient' in 2013 and 'unknown' in 2014 due to the estimate being out of date.[76] 'Unknown' was also the LV status issued by the PBSG in 2016 and 2017.[77] In contrast, the 2015 IUCN Red List assessment required population size numbers for its models projecting future status and it used an estimate of 1,000 for LV.[78] However, there has not been legal hunting in the region since 1957, and sea ice declines in all seasons have been less than in the neighbouring Kara and Barents Seas,[79] which suggests the population size for LV is almost certainly three or more times as large as the estimate used for the latest Red List assessment.

Chukchi Sea – Divergent

An existing Russian estimate of 3,000–5,000 bears for the Chukchi Sea (CS) subpopulation, based on den counts and estimated numbers of females in the population, became 2,000–5,000 in the 1993 PBSG report and 2,000 in the 2005 report.[80] Considered 'declining' by the PBSG in 2009, based on existing and projected sea ice losses,[81] that changed to 'data deficient' in 2013 and 'unknown' in 2014–2017.[82] 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.[83]

However, a capture-recapture survey was conducted by US researchers over a small portion of the sea ice west of Alaska from 2008–2016 (during mid-March to early May). The

numbers of bears captured – 166 males and 135 females – were then extrapolated to provide a population estimate for the whole.[84] Even though the critical Wrangel Island denning region was not surveyed for the study, litter sizes of family groups found on the sea ice off Alaska were in spring found to be much higher than average for both cubs-of-the year (2.18) and yearling cubs (1.61). These large litter sizes were seemingly driven by an incidence of triplet litters (3/39 of yearling litters or 7.7%)[85] formerly seen only in Western and Southern Hudson Bay in the 1970s and 1980s.[86] This 2016 estimate supports evidence reported up to 2016 that suggested CS bears were in good condition and reproducing well.[87] For example, research conducted from 2008–2011 showed that CS polar bears were doing better than they were in the 1980s, and body condition was better than any other subpopulation except the bears of Foxe Basin (who were doing exceptionally well). It was also reported that bears spending the summer on Wrangel Island, the region's main terrestrial denning area, had increased dramatically, from about 200–300 individuals in 2012 and 2013 to 589 in the fall of 2017,[88] although about 550–600 were counted in 2007.[89] All indicators suggest the CS subpopulation is productive and healthy despite recent changes in summer sea ice, and poaching is no longer considered an issue.[90] Even though the Bering Sea is considered part of the range for CS bears, few individuals venture further south than St. Lawrence Island while hunting for seals in winter and early spring.[91]

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 took place in 1986, and generated an estimate of about 1,800 individuals. The survey attempted to take into account known movements of bears to and from the Chukchi Sea to the west and the Northern Beaufort Sea to the east.[92] Such movements were what prompted a change in the SB/NB boundary in 2014 by Canadian wildlife managers; a similar change in the western boundary (near Barrow, Alaska) has been discussed but not implemented.[93] Mark-recapture studies in 2001–2006 generated a statistically insignificant decline, to about 1,526 bears (range 1,211–1,841), which was subsequently blamed on reduced summer ice.[94] However, it was clear from other studies that a series of thick spring sea ice episodes from 2004–2006, as severe as had occurred in 1974–1976, was ultimately responsible for the poor survival of cubs, reduced body condition of adults and subadults, increased spring fasting, and the reduced abundance of ringed seals.[95]

Additional survey data from 2007–2010, analyzed using a totally new method, showed that survival picked up in 2007 (just as summer sea ice hit a record low) and increased through 2009, resulting in a revised estimate of 907 (range 548–1270) in 2010, a statistically significant decline of roughly 25–50% (often wrongly cited as '40%') over the 1980s count.[96] The PBSG point out in their 2016 meeting proceedings and their online summary (updated in 2017) that the latest survey may not have sampled the entire geographic range adequately, and that this may have negatively skewed the 2010 population estimate: they 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).[97] According to a set of interviews, many Inuit in the Canadian portion of the region feel that polar bear numbers have been stable within living memory.[98]

Northern Beaufort Sea – Convergent

The last population count for the Northern Beaufort Sea (NB) was made in 2006, generating an estimate of 980 (range 825–1,135).[99] The population appeared to have been relatively stable over the previous three decades, but this estimate is now more than ten years out of date. The boundary with Southern Beaufort has been moved east, to near Tuktoyaktuk, for Canadian management purposes, a change provisionally accepted by the IUCN PBSG in 2017.[100] Updated maps from Environment Canada now incorporate this boundary change.[101]

East Greenland – Convergent

Although there has been no comprehensive survey of the East Greenland (EG) subpopulation, in 2001 the PBSG gave it an estimate of 2,000 bears (in part based on harvest records that indicated a fairly substantial population must exist).[102] However, in 2013 the group credited the region with only about 650 bears, with no reason given for the change in opinion,[103] 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.[104] In fact, the 2001 estimate of 2,000 bears was considered adequate for the 2015 IUCN Red List assessment.[105] The first comprehensive population survey should be completed by 2022.[106] Traditional ecological knowledge (TEK) gathered from hunters in northeast Greenland in 2014 and 2015 suggested an increase in numbers of bears coming into communities compared to the 1990s,[107] but in southeast Greenland, one representative of the local hunters' association said that there are more healthy bears causing trouble in the area because abundant seals have meant abundant bears.[108]

Arctic Basin – a designated 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 were called 'Queen Elizabeth – Convergent' and the later, 'Northwest – Convergent' (NWCon; Figure 2), but that nomenclature now seems to have been abandoned, probably because it is not a distinct subpopulation region for polar bears.[109] 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.[110] The Arctic Basin 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.[111]

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.[112] Until recently, the KB polar bear subpopulation, located between north-west Greenland and Ellesmere Island, was assessed with confidence by the PBSG to be declining due to suspected over-hunting. In 2014, Environment Canada's assessments were 'data deficient' for the area. But the 2013 survey generated an estimate

of 357 (range 221–493), a 118% increase over the 1997 estimate of 164 (range 94–234) and a 59% increase over the estimate recalculated in 2016 as 224 (range 145–303), indicating a 'stable to increasing' population.[113] 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.[114] While all other metrics of life history and habitat were subject to statistical significance testing, the authors did not state conclusively whether the 59% increase was statistically significant or not. However, the PBSG assessment for 2017 concluded that the population has indeed increased.[115]

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.[116] Hunting was subsequently halted then resumed at a much-reduced level, after which the population was presumed to be increasing. Results of a three-year genetic mark-recapture study that began in 2014 have not yet been made available.[117]

Viscount Melville – Archipelago

The first survey to determine the population size of the Viscount Melville (VM) subpopulation was completed in 1992 and generated an estimate of 161±40.[118] This estimate is now 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 2018.[119]

Gulf of Boothia – Archipelago

The Gulf of Boothia (GB) is in the middle of the Canadian Arctic. In terms of geographic area, it is one of the smallest of all 19 subpopulations worldwide: at only 170,000 km2; only the Norwegian Bay and Kane Basin regions are smaller, at 150,000 and 155,000 km^2 respectively.[120] The first population survey was done in 1986 and generated an estimate of about 900 bears. This was updated in 2000 with an estimate of 1,592±361 bears, a significant increase.[121] The new density was calculated as 18.3 bears per 1000 km^2, well above the 5.1 bears per 1000 km^2 found in Davis Strait, the 1.9 bears per 1000 km^2 in M'Clintock Channel, and the 6.5 bears per 1000 km^2 found in the Northern Beaufort Sea.[122] A new estimate for the area has been completed based on genetic mark-recapture but, as of the end of 2018, the results have not been made public. However, the last preliminary report stated that 'polar bears remain relatively abundant and in good condition.'[123]

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, and in 1998 an estimate of 2,541±391 bears was generated, a significant increase over the previous estimate (from 1977) of 1,675 bears.[124] The eastern portion of LS is generally clear of ice by late summer (hence the Northwest Passage) but the western third of the region not only retains pack ice later in the season, but some multiyear ice remains throughout the year.

The proximity of LS to Baffin Bay and the eastern Northwest Passage undoubtedly exposed polar bears there to hunting by European whalers during the 1800s and early 1900s,[125] but the population appears to have recovered since then. In 2017, the PBSG considered the population to be stable, although the 1997 estimate is now seriously out of date.[126]

Norwegian Bay – Archipelago

The last population count for Norwegian Bay (NB) was done in 1993–1997 in conjunction with the Lancaster Sound survey and generated a population estimate of 203±44.[127] That figure is now well out of date.[128] Several studies suggest this may be a genetically distinct subpopulation.[129] Norwegian Bay is either part of, or adjacent to, what has been called the 'Last Ice': a refugium of sea ice over shallow continental shelf waters expected to remain even if summer sea ice drops to near-zero levels (<1 million km2), depending on the model used.[130]

4 Population trends

In 2018, the Government of Canada published a global polar bear population status and trend map, based primarily on IUCN PBSG data (Figure 3),[131] which showed the following classification totals:

- three 'likely declined'
- two 'increased' or 'likely increased'
- three 'stable' or 'likely stable'
- eleven 'data deficient'

New population surveys since then would likely change the classification for the Chukchi, Barents, and Kara Seas from data deficient to at least 'likely stable.' However, as noted in Section 3, the PBSG has so far refused to acknowledge either the Kara Sea or Barents Sea survey results in their status tables and the CS estimate was not available at the time the Canadian status table was published. In addition, given conditions over the last two decades, it is highly likely that bear numbers in the Laptev Sea (once estimated at 1,000) and in East Greenland (previously estimated at 2,000) have also increased or at least remained stable.

Inexplicably, Western Hudson Bay and Southern Hudson Bay both were considered to be 'likely declined' even though (as noted in Section 3), neither registered statistically significant declines at their most recent counts: both should have been considered 'stable.' Also, only the Southern Beaufort (SB, Divergent sea ice ecoregion) registered a statistically significant decline at its last population count, but, as noted above, this region has special circumstances that make it an outlier: and the proximate cause of the apparent decline was thick sea ice, which temporarily drove seals and therefore bears out of the region.[132] A more realistic assessment of the SB nine years after the last population survey would therefore be 'likely stable.'

Although the PBSG listed population trends in their population status table in 2014 (when they considered four populations to be declining), by early 2017 they no longer included this hitherto important metric.[133] Since no rationale for the removal of the trends assessment has been given, the PBSG appears to be exhibiting a reluctance to declare that stable or increasing polar bear populations are now the norm across the Arctic.

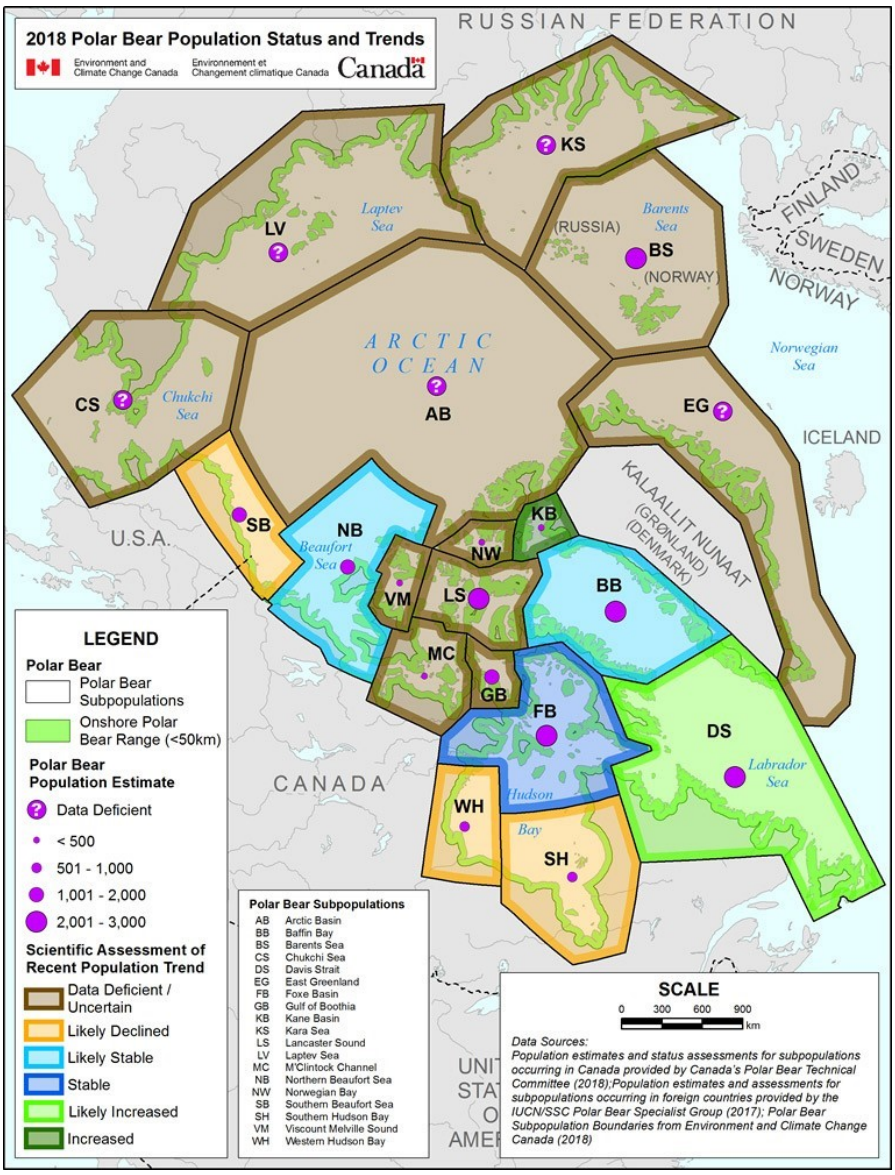


Figure 3: Trends in polar bear subpopulations at 2018, according to the Government of Canada.

The Canadian government considers the polar bear a species of 'Special Concern.' Note KB is 'increased', which is difficult to discern from 'data deficient' because of the color scheme chosen. The 'likely declined' status for WH and SH is not supported by statistically significant population declines.

Accordingly, Figure 4 shows a more realistic representation of current polar bear population trends, which gives the following classification totals as changed from 2017: [134]

- 2 increased or likely increased [KB, DS]
- 3 stable or likely stable [WH, SH, AB]
- 14 presumed stable or increasing [EG, LV, VM, NB, GB, MC, LS, BB, BS, KS, CS, SB, NB, FB].

The problem of statistical confidence

Virtually all recent population size estimates for polar bear subpopulations have such wide margins of error (statistical confidence intervals) that even quite large changes in size are unlikely to be statistically significant. For example, in its most recent population count in 2015, the Svalbard portion of the Barents Sea saw an increase of 42%, but this was not statistically significant.[135] The authors, Jon Aars and colleagues, could conclude only that recent large declines in sea ice habitat in the Svalbard area had not yet led to a reduction in population size and that recovery from previous overhunting might still be ongoing.

In addition, differences in survey methodology used to arrive at particular subpopulation estimates have led to numbers that are not considered comparable, so a trend cannot be established. Such problems have recently been claimed for the 2012–2013 estimate for Baffin Bay bears compared to one conducted in 1997, even though the more recent estimate was 36% larger.[136] Similarly, the most recent Western Hudson Bay surveys conducted in 2016 generated estimates 33% smaller than the estimate for 1987, but differences in methodology and areas surveyed mean the two figures cannot be used to derive a trend.[137] Two estimates for WH were generated that could be compared between 2004 and 2016, and these were found to have a statistically insignificant decline of about 11%.

In short, changes in survey methods and/or mathematical formulae used to derive population estimates over time have generally increased statistical confidence intervals to such an extent that a decline or increase in abundance would likely need to be 50% or more to be considered a real and valid change. This means that the ESA and Red List definitions of 'threatened' with or 'vulnerable' to extinction – based as they are on the likelihood of a population decline of 30% or more over the next three generations[138] – are using a mathematical threshold that is very likely statistically invalid for polar bears.[139] The IUCN Red List assessment for 2015 apparently dealt with this issue by concluding that there was a reduced probability (only 70%) that a decline of 30% or more would occur by 2050, which is a rarely discussed but significant caveat to their prediction.[140]

I have dealt with this issue in this report by replacing old subpopulation sizes with new ones generated since the 2015 Red List assessment was published (for Barents Sea, Baffin Bay, Kane Basin, Western Hudson Bay),[141] but acknowledge that the margin of error remains large and note the apparent increase in global population size is likely not statistically significant. The rationale for this approach is to emphasize that the anticipated decline in global numbers since 2005 has not taken place.

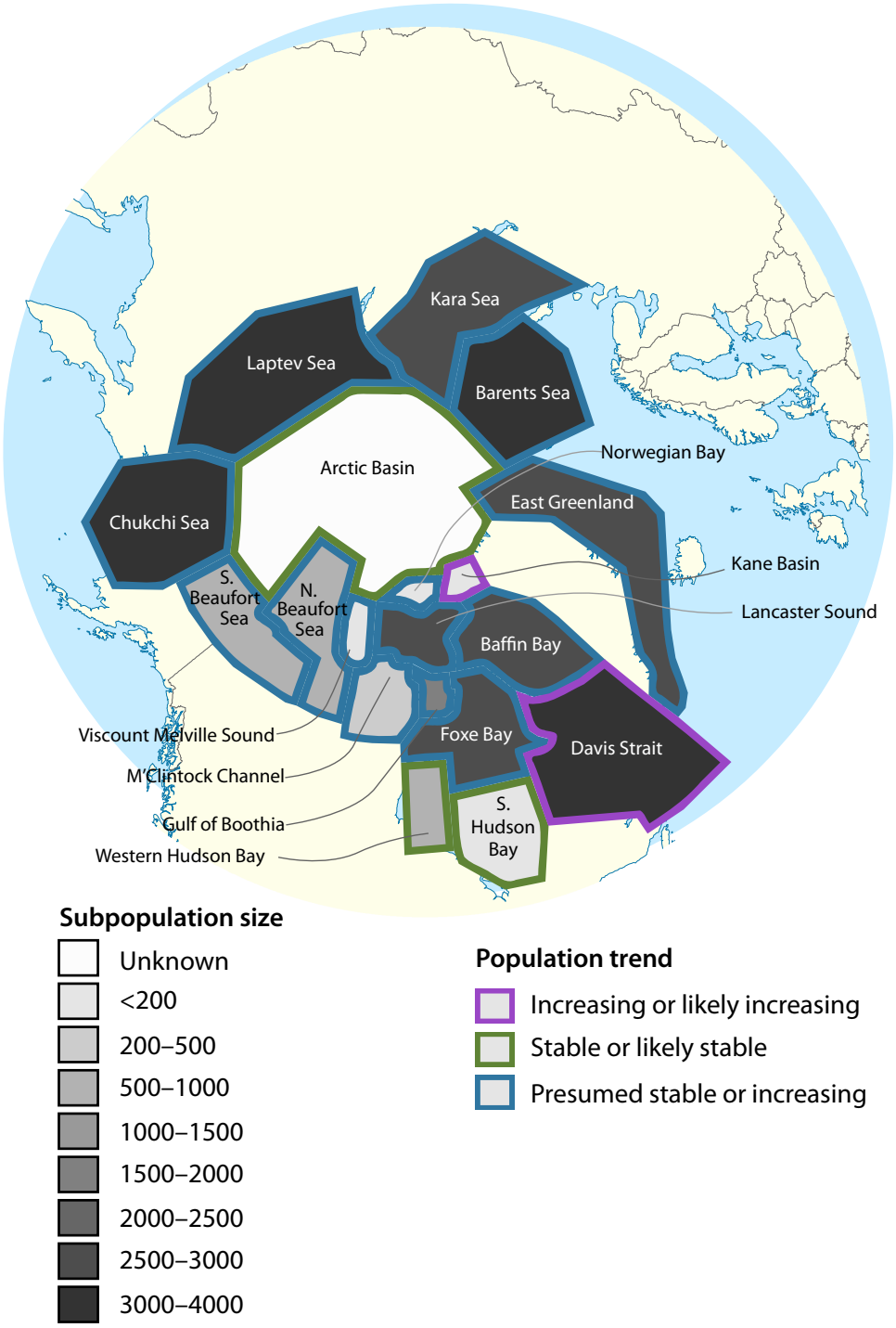


Figure 4: Trends in polar bear subpopulations at 2018.

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 (at September) has declined markedly since 1979, especially since 2007, but winter ice levels (at March) have declined very little (Figure 5). March extent in 2018 (when atmospheric CO2 levels were 410 ppm) was virtually identical to 2006 (when CO2 was 380 ppm).[142] There has been no research done on what effects, if any, the slight decline

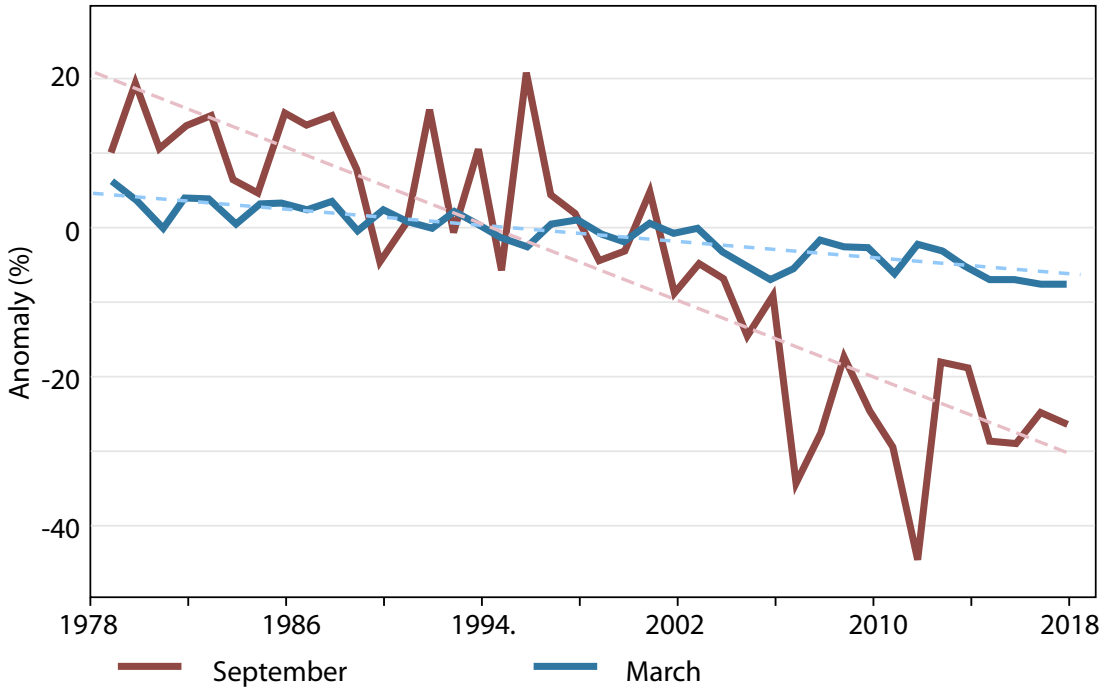
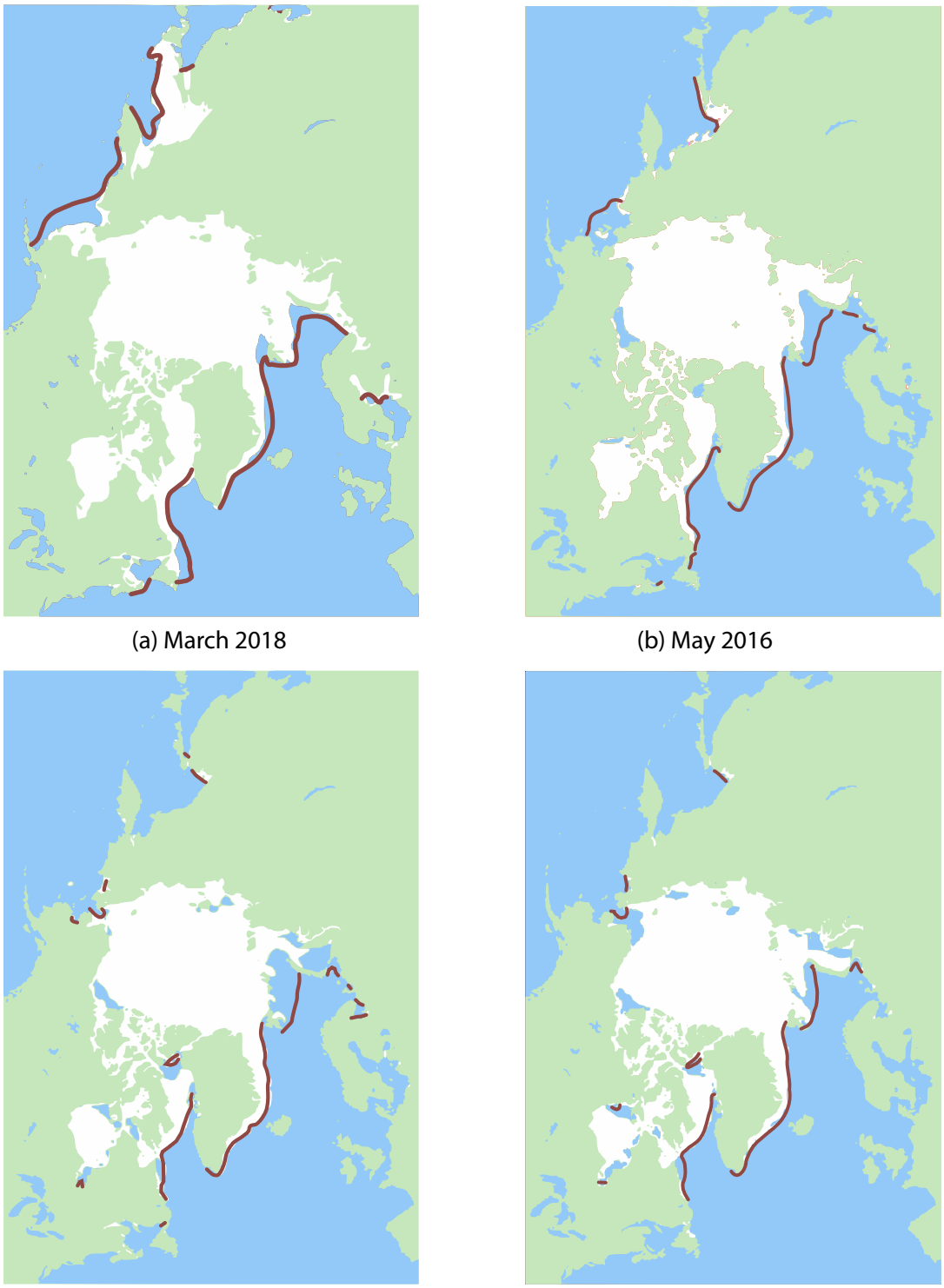


Figure 5: Sea ice extents, 1979–2018.

Anomalies against mean for 1981–2010. From NOAA's Arctic Report Card 2018.[143] A recent paper tracking sea ice levels back to 1850 shows a similar pattern.[144]

in winter ice extent has had on polar bears overall, but a cursory examination suggests that since 1979 there has been enough sea ice in winter to meet the needs of polar bears and their prey. In part, this is because most of the change in winter ice extent has occurred in the Sea of Okhotsk and the Gulf of St. Lawrence (where polar bears do not live) as well as in the southern Bering and southern Labrador Seas (where few polar bears venture in winter and early spring).[145] This was especially relevant in 2018 for the Bering Sea because of reports that the low extent of winter ice cover had broken historic records.[146] However, Bering Sea ice has been extraordinarily variable since 1979, and in 2012 reached by far the highest level since 1979 and broke the record at the other end of the range.[147]

As far as is known, record low extents of sea ice in March 2015, 2017 and 2018,[148] which were so similar to 2006, had no impact on polar bear health or survival (Figure 6a). For example, adult male bears captured around Svalbard, Norway showed no statistically significant change in condition from 2015 through 2018, compared to those captured since 1993.[149] High temperatures recorded at the northern tip of Greenland for a few days in February, 2018 ultimately did not impact local sea ice extent to any significant degree, although the media gave the phenomenon an abundance of attention.[150]



(a) March 2018

(b) May 2016

(c) June 2012

(d) June 2017

Figure 6: Average sea ice extents.
The red lines indicate the median extent. Courtesy US National Snow and Ice Data Center.

The most pessimistic predictions of March sea ice extent at the end of the 21st century is about 12.0m km^2, equal to the average extent of ice for May 2018 and May 2016 (Figure 6b).[151] Polar bears and their prey could survive without a precipitous decline in population size if March sea ice dropped this low, even before 2100, because there would be enough ice in all regions where these animals reside to meet their minimum spring requirements.

Sea ice extent in June has declined, on average, from just over 12m km^2 in the 1980s to just over 11m km^2 from 2004–2018.[152] By late May to early June, there is therefore lots of sea ice throughout the Arctic to act as a feeding platform for polar bears (Figure 6c, d). However, the young seals that form the bulk of polar bear diets in spring take to the water to feed and are no longer available on the ice, leaving only predator-savvy adults and subadults hauled out as potential prey.[153] This means few seals are actually caught and consumed by polar bears after about mid-June in Seasonal and Divergent sea ice ecoregions, or by mid-July in Convergent and Archipelago regions (see Section 6).

Sea ice thickness has declined in some regions of the Arctic but, by and large, this has been a net benefit for polar bears and their prey, whose preferred habitat is first-year ice less than two metres thick.[154] For example, during the 1980s, sea ice in Kane Basin, west of Northern Greenland, was predominantly multi-year ice, even in summer, and this poor seal habitat supported few polar bears. But now that the ice is mostly seasonal first-year ice, the population of bears has grown remarkably.[155]

In contrast, a 2016 report of Southern Beaufort Sea bears having difficulty finding prey in 2014–2016[156] indicated that the thick ice events that have impacted the region every ten years or so since the 1960s have continued despite reduced summer sea ice, although authors Anthony Pagano and colleagues did not draw that conclusion.[157] The scientific literature has many papers and reports that show what past episodes of thick spring sea ice have done to polar bears, ringed seals, and bearded seals that live in the Southern Beaufort Sea.[158] The Pagano study is evidence that the phenomenon occurred again in 2014–2016, right on schedule, ten years after the 2004–2006 episodes, although researchers and the media[159] blamed the effects on reduced summer sea ice.[160] The devastating effects that heavy ice cover has had on polar bears in the Beaufort Sea has been documented for 1974–1976, 1984–1986, and 2004–2006, with similar events inferred from anecdotal information for 1964 and 1992.[161] Susan Crockford argued a few years ago that Arctic sea ice is not the stable habitat that polar bear experts currently assume,[162] which means that population numbers in some regions will vary naturally in response. This was a conclusion reached by polar bear specialist Ian Stirling in 1982, and warrants repeating here:

> Until recently, management of marine mammals in the Canadian Arctic, to the extent that they are managed at all, seems to have been based on the assumption that ecological conditions show little variability. Thus, once populations are counted or quotas are established, little change in population management takes place for long periods. The results of this study have clearly shown that ice conditions in the eastern Beaufort Sea can be highly variable, can influence other ecological parameters, and can cause changes in the distribution and abundance of ringed and bearded seals. We expect that similar variability will be documented in other areas of the Arctic when comparable studies have been completed.
>
> What this means in terms of environmental assessment is that, because conditions are so variable, the consequences of possible man-made detrimental effects will vary depending on the status of the seal populations at the time.[163]

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 during the melt season that is 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.[164]

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.[165] For example, the abrupt decline in sea ice extent that came at the end of the Younger Dryas cold period (ca. 10,000–12,500 years ago), especially in the Eastern Arctic, where ice had extended into the North and Baltic Seas in summer, meant an abrupt contraction of range: most of the polar bear fossils of the Younger Dryas come from Denmark, southern Sweden and southern and western Norway.[166] The Younger Dryas ended abruptly, perhaps as a result of a comet strike,[167] over a 40-year period; the change took place in a series of steps of about five years' duration each.[168] Polar bears and their prey species (such as ringed and bearded seals, walrus, beluga, and narwhal) have survived these and other changes with no apparent negative effects.[169] Their inherent flexibility in dealing with changing ice conditions past and present mean that evolutionary adaptation, as it is usually defined, has not been necessary.

Sea ice loss by subpopulation

Eric Regehr and colleagues[170] 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.[171] Surprisingly, as Table 1 shows, despite having the greatest loss of ice since 1979, polar bear numbers in the Barents Sea in 2015 had grown over counts made in 2004, and bear numbers in Southern Hudson Bay, with the least amount of ice loss, have remained stable since the 1980s.[172]

Freeze-up and breakup date changes for Hudson Bay

Contrary to predictions, freeze-up for Hudson Bay came as early in 2017 and 2018 as it did in the 1980s, although this information has not yet been incorporated into the scientific literature.[173] This allowed most WH and SH polar bears to resume seal hunting four weeks earlier than 2016 (when freeze-up was quite late). Although year-to-year variability is quite normal for Hudson Bay, a return to 1980s-like freeze-up dates two years in a row was not only unexpected but could not be explained by an 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.[174] In fact, polar bear specialists have implied natural variation was to blame for these two very early freeze-up dates in a row for WH.[175]

WH bears leave the shore within about two days of sea ice concentration reaching 10% along the shore, although SH bears leave when it reaches about 5%.[176] In other words, the bears leave shore as soon as they possibly can. In 2017, there was enough ice by 8 November for many bears to leave shore and by 10 November most bears were on their way; in 2018,

Table 1: Sea ice loss per subpopulation.

Subpopulation by sea ice ecoregion	Days lost per year (1979–2014)
Seasonal	
Baffin Bay	1.27
Davis Strait	1.71
Foxe Basin	1.15
Western Hudson Bay	0.86
Southern Hudson Bay	**0.68**
Divergent	
Barents Sea	**4.11**
Kara Sea	1.70
Laptev Sea	1.35
Chukchi Sea	0.90
Southern Beaufort Sea	1.75
Convergent	
East Greenland	1.07
Northern Beaufort Sea	0.93
Archipelago	
Kane Basin	1.44
McClintock Channel	1.12
Viscount Melville	1.26
Gulf of Bothia	1.88
Lancaster Sound	1.08
Norwegian Bay	0.73

Change in number of days with ice cover of >15% concentration per year. From Regehr and colleagues (2016). Lowest and highest values in bold.

these same thresholds were reached on 12–14 November.[177] According to data for 1979–2015, in the 1980s the mean date that bears left the ice at freeze-up (10% sea ice coverage in WH) was 16 November ±5 days, while in recent years (2004–2008) the mean date of leaving was 24 November ±8 days, a difference of 8 days.[178] This also means that a freeze-up date of 10–12 November for 2017 and 12–14 November for 2018 were two of the earliest freeze-up dates since 1979 (the earliest being 6 November in 1991 and 1993), yet conservation organization *Polar Bears International* implied in their website report that freeze-up did not occur in 2018 until the 20th of November, even though the Churchill *Polar Bear Alert Program* reported that they released all bears in holding on the 13th November and remarked on the very early date of freeze-up.[179] Oddly, despite the early freeze-up, the number of 'problem bear' incidents reported by the Churchill *Alert* program was 251 in 2018, substantially more than the 148 reported in 2017 (but less than the 386 in 2016, when ice breakup was very late).[180]

Despite the overall drop in ice-covered days since 1979 there has been no statistically significant change in either breakup or freeze-up dates for WH since the mid-1990s.[181] Most

of the change, an increase in the total ice-free period of about three weeks, came about 1998. Note that is three weeks total, not three weeks at breakup and another three weeks at freeze-up, as is sometimes claimed.[182] The ice-free season has increased in SH by about 30 days 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.[183]

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.[184] In some regions, other seal species make up varying proportions of the diet: harp seals for Davis Strait and East Greenland bears, and ribbon seals for Chukchi Sea bears, for example. Walrus, beluga, and narwhal make up a small proportion of the diet in some areas. Polar bears also sometimes scavenge fat and meat remaining on beached whale carcasses (whether left due to natural death or aboriginal hunting),[185] and it has even been proposed that polar bears survived the Eemian Interglacial, a period of warmth about 115,000–130,000 years ago, by switching to feeding on whale carcasses in summer rather than Arctic seals in spring.[186] However, the authors, Kristin Laidre and colleagues, provided no evidence to support this idea.

Arctic seals have their pups in the spring on the sea ice. Most ringed and bearded seals, as well as several less-common species, are born from mid-March to mid-April or a bit later, depending on the location; harp seals are born earlier (February to mid-March) in less consolidated pack ice than the others.[187] While it is true that some Arctic ringed seals give birth in stable shorefast ice close to shore,[188] many others give birth well offshore in thick pack ice where polar bears also live and hunt in the spring.[189] Although not often mentioned, there is documented evidence of pack ice breeding ringed seals in the Bering Sea, Sea of Okhotsk, Chukchi Sea, Davis Strait, and the Barents Sea. This finding is supported by genetic evidence.[190] The presence of breeding ringed seals in the pack ice suggests strongly that polar bear spring hunting habitat includes all Arctic sea ice of suitable thickness over continental shelf waters, not just shorelines and fjords.[191]

Seal pups are preyed upon by polar bears from the moment they are born. However, those that survive gain weight rapidly and are weaned after a short nursing period. They can more than double their birth weight by the time they are weaned, and can reach 50% fat by weight. They then remain on the ice for three or four weeks, before taking to the water to feed. During this period, the pups are a particularly important food source for fat-craving polar bears. Polar bears consume two-thirds of their yearly food supply in the spring (Figure 7). In some areas, polar bears can kill up to 44% of new born seal pups each spring if conditions are right.[192]

From May to July, adult and subadult seals of all varieties haul out on sea ice while they moult their fur, but are harder for polar bears to catch than youngsters because they are predator-savvy.[195] However, even though summer sea ice has routinely declined to less than 5m km^2 in recent years, there has still been plenty of ice remaining to act as a hunting platform for polar bears until the middle or the end of June or later, depending on the location.

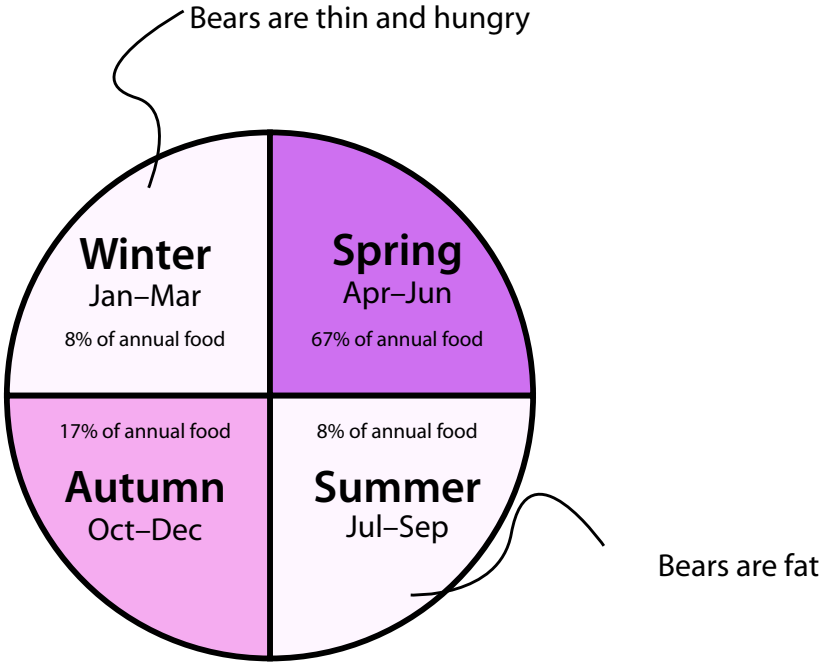


Figure 7: Polar bear feeding activity by season.

The most intensive feeding time is spring, followed by fall. Although some individuals have trouble eating enough in the spring due to inexperience, competition, old age, injury or disease, polar bears are usually hungriest in late winter, not summer as some people believe.[193] Based on data from the polar bear literature, seasons as defined by Pilfold and colleagues in 2015.[194]

Seal numbers

Ringed and bearded seals

While ringed seals and bearded seals were both listed as 'threatened' under the US Endangered Species Act 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.[196] The 'threatened' status is based exclusively on the presumption that future harm will be caused by further reductions in summer sea ice.[197] 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'.[198]

Chukchi Sea polar bears have been doing better in recent years, with an extended open-water season, than they did during the 1980s. This is because the ringed and bearded seals that are their primary prey do most of their feeding in ice-free summer waters. [199] More fat seals mean more fat seal pups the following spring for polar bears to eat. A recent study found that since 2007, with longer ice-free summers than occurred during the 1980s, the summer feeding period for seals was extended and they became extra fat. Well-fed female ringed seals produced fat healthy pups the next spring, which meant more food for polar bears when they needed it the most. It seems likely this is also the case in many other peripheral regions of the Arctic with wide continental shelves (such as the Laptev, Kara and Barents Seas) but not the Southern Beaufort. Oddly, in March 2013, less than six months after ringed and bearded seals were listed as 'threatened' with extinction in the USA, seal biologists were reporting to their peers that the results of their Chukchi Sea research contra-

dicted their dire predictions: less summer sea ice was actually better for ringed and bearded seals, not worse.[200]

Harp and hooded seals

Harp seals are an important alternate prey for polar bears in Davis Strait, Baffin Bay, East Greenland, and the Barents Sea. By 2015, there were an estimated 7.4 million harp seals in Atlantic Canada (range 6.5–8.3m), an exponential increase over the early 1980s when perhaps only half a million remained.[201] Relatively few harp seals give birth and breed in the Gulf of St. Lawrence (where there are no polar bears) but in some years they have suffered substantial mortality due to reduced spring ice conditions, which has happened more often in recent years.[202] However, the seals that whelp off Labrador and Newfoundland (where they are the main prey of polar bears) appear to have been less vulnerable to such changes, in the past and in recent years. From 1950–1990, poor ice conditions were present in the Gulf about one year in every ten but as in the past, most animals today likely move to the 'Front' ice off Newfoundland and Labrador to whelp when Gulf ice conditions are poor.[203] Although a count of harp seal pups off Newfoundland and Labrador was scheduled for March 2017 (the first since 2012) in order to estimate the current size of the population, the results of that study have not yet been published.[204]

In East Greenland, the current size of the harp seal stock is about three times as high as it was in the 1970s (estimated at more than 600,000 animals, range 470,540–784,280)[205] . So, as for polar bears in southern Davis Strait, there are lots of harp seal pups for East Greenland polar bears to eat in the spring. However, for unknown reasons, hooded seals in the same area (called the 'West Ice') appear to be declining (although those that live off Newfoundland and Labrador are doing well). There are only about half as many hooded seals in East Greenland now as there were in 1997, and much fewer than there were in the 1950s.[206] That's a huge *actual* decline, not a predicted one. The hooded seal in East Greenland was listed as 'vulnerable' to extinction by the IUCN in 2008 and again in 2015, but oddly, that fact hasn't been making headlines.

Walrus

As the USA stands out as the only nation that insists Arctic seals will be harmed by future declines in summer sea ice, as noted above, it was all the more surprising that in September 2017, the US Fish and Wildlife Service announced it would not pursue a plan to list Pacific walrus as 'threatened' with extinction under the Endangered Species Act. Walrus experts concluded there was no evidence of on-going harm or an imminent threat to walrus survival, which now concurs with the IUCN Red List assessment for this species.[207] Since then, the litigious environmental conservation organization *Center for Biological Diversity* has sued the USFWS for failing to protect the Pacific walrus but a court date has not yet been set.[208]

7 Health and survival

Body condition

There has been no increase in the percentage of starving or dying bears in recent years compared to the 1980s, despite the hungry bear photos and videos that have gone viral on the

internet. While such images have been used to make points about human-caused global warming and loss of Arctic sea ice, none of the photos circulated to date show bears that were unequivocally harmed due to reduced sea ice and lack of prey. One photo distributed in 2015 showed a Svalbard-area bear with a badly injured leg; a 2017 *National Geographic* video of an emaciated Lancaster Sound (Somerset Island) bear,[209] which later went viral, almost certainly showed an animal suffering from cancer or another malady that caused profound muscle wasting preventing it from hunting and thus causing it to starve. Bears in Lancaster Sound normally spend the summer fasting on land and there is no reason to expect that bears on the west side of Baffin Island, in Lancaster Sound, were doing any worse than bears on the east side of the island, which have recently been doing well.[210]

Indeed, by August 2018, strong pushback from viewers[211] apparently prompted *National Geographic* to make a well-publicized apology, on their website and in their magazine, for the misrepresentation in the video, saying it had gone too far with the claim that 'this is what climate change looks like'.[212] In fact, there was no factual basis to support a link between climate change or sea ice and the bear's condition: local sea ice had not been unusually low in 2017, most bears in that region come ashore in August, and no other starving bears were seen. Not only was the video seen as a blatant piece of propaganda, it made viewers angry that nothing had been done to help the bear. Activist Cristina Mittermeier, a colleague of videographer Paul Nicklen who shot the film, admitted the footage of the emaciated bear was specifically taken to convey a message about climate change, but blamed *National Geographic* for the bad publicity.[213] Mittermeier also revealed details about the event that showed an even greater indifference to the suffering of the animal than anyone had imagined. Apparently, Nicklen spotted the bear days before his camera crew arrived and told no one. In addition, after shooting the video, Nicklen and Mittermeier watched the bear swim away without alerting local conservation officers of its plight or the danger it presented to local residents (starving bears are desperate and extremely dangerous). Overall, the incident educated millions of people that starvation is the leading natural cause of death for polar bears and put the public on notice that even an organization they thought they could trust is willing to throw ethical practices out the window when climate change is involved.

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.[214] A recent mark-recapture survey for WH did not report female body condition, which means this metric has not been updated since 2007.[215] However, in SH, Martyn Obbard and colleagues determined that in the 2000s, females were on average about 31 kg lighter than they were in the 1980s and males 45 kg lighter. However, the number of bears in the population did not decline over the same period, which suggests that the small decline in body condition reported was not significant to survival. [216] Previous research on Western Hudson Bay bears captured between 1982 and 1990 stated that the critical weight for pregnant females was about 189 kg (below this weight, they lost the pregnancy).[217] Obbard and colleagues did not mention finding any SH mature females at or near this critical point in the 2000s, nor did any of the reports that documented a decline in body condition. Furthermore, a more recent SH survey (in 2016) that claimed to register a slight population decline (see details in SH section above) did not report data on body condition of SH females.[218] Considering that males can be over 500 kg and females over 300 kg by the time they come ashore in late summer,[219] it is doubtful that an average weight loss of 31–45 kg would have an appreciable effect on bear survival or reproduction in any subpopulation.

In contrast, a recent paper reported that Southern Beaufort Sea females were having difficulty catching prey and noted a lack of seal pups in their diet in 2014–2016, which resulted in uncharacteristic spring weight loss. However, as noted above, this is likely to be due to the continuation of the thick spring ice events that have impacted the region every ten years or so since the 1960s.

Effect of record low winter ice

As far as is known, the recent very low sea ice extents (the lowest on record in March 2017 and the second lowest in 2018[220]) had no impact on polar bear health or survival. Evidence for this position comes from ongoing research from the region around Svalbard, Norway by Norwegian Polar Institute biologists, who found no differences in body condition of adult male polar bears they caught in the springs of 2017 and 2018 (March–May) compared to those caught in previous years.[221]

Hybridization

Claims of recent widespread hybridization of polar bears with grizzlies, known for years from the Central Canadian Arctic,[222] were disproven in 2016 and 2017.[223] No further hybrids have been reported since 2014. This should have put to rest the hybridization-caused-by-global-warming myths, but it has not. For example, the January 2018 issue of *National Geographic* and the 10 February 2018 issue of *New Scientist* both repeated claims about grizzly/polar bear hybrids that disregarded new evidence.[224] At least one other online article along similar lines followed later in the year.[225]

Effect of contaminants

Contaminants have been shown to be present in polar bears, but have not been shown to have done any harm. Most of the data are from Eastern Greenland, where there has never been a polar bear population count. Even if harm could be shown to have occurred, no impact on population size could be inferred. One researcher undertook a long and extensive review of all the toxicology research done on polar bears to that date[226] and noted that:

> published polar bear data included in this review are correlative and descriptive and therefore do not directly demonstrate contaminant mediated cause and effect relationships.

While it is true that some biological effects have been recorded for a number of substances (e.g. sizes of male (but not female) skulls, changes in gene function, reduced penis bone density), it has not been demonstrated that any of the changes documented have negatively affected polar bear health or population size. For example, there is no evidence that any penis bones of polar bears in East Greenland have broken in recent years due to low bone density. There is only a suggestion that this could, theoretically, happen at some time in the future if the trend in density continues.[227] In short, all of the so-called 'evidence' for negative effects of organic pollutants on East Greenland polar bears is currently circumstantial and inconclusive.[228] Similarly, a report in 2018 that found 'hundreds' of previously unknown toxins in polar bear blood received much media attention but nevertheless provided no evidence that these chemicals had or would present health risks to bears (or to those who consume polar bear meat).[229]

Swimming bears

There have been no further reports of polar bear deaths due to drowning during the open water season since 2004, and no evidence has been presented to show that long-distance swims are detrimental to the health or survival of polar bears.[230] One group of researchers found that bears in Hudson Bay made few long-distance swims (>50 km) in 2007–2012, and 60% of those started on pack ice and ended on land during sea ice breakup in July; more Beaufort Sea bears undertook swims than Hudson Bay bears but 80% of BS swims took place before the September sea ice minimum, and bears started and ended their swims in the pack ice as they moved north with the retreating ice edge.[231] The media were impressed with the weight lost during a single long-distance swim made by a BS female and cub in 2008.[232] This feat was reported in 2011 and promoted again in 2017.[233] However, a comparison of the numbers show the female lost slightly less weight during her 63-day swim and subsequent walk over the ice (49 kg or 109 lbs) than a typical bear sitting on the shore of Western Hudson Bay in the summer (54 kg or 119 lbs or 0.85 kg per day).[234]

Furthermore, a study published in 2018 found that some Svalbard females made notable long-distance swims and had astonishing diving capabilities.[235] These new data called into question the prediction made by Ian Stirling just a few years ago that because of their apparently limited diving abilities, polar bears would be unable to evolve rapidly enough to deal with the abrupt sea ice changes predicted for the future.[236]

Denning on land

There has been no statistically significant change in proportion of Southern Beaufort females that make their dens on the sea ice (51%) versus on land or near-shore ice (49%) between the mid-1980s and 2013, despite marked increases in the length of the ice-free season.[237] Karyn Rode and colleagues[238] examined factors that might have been responsible for the higher reproductive success of both Southern Beaufort and Chukchi Sea females that made their dens on land rather than sea ice but considered only spring and fall snow fall amounts, autumn ice conditions, and spring and fall air temperatures: in other words, they looked at everything except sea ice thickness in spring and availability of newborn prey in spring, conditions which are known to have had a very strong negative effect on survival of bears in the Southern Beaufort from 2004–2006, almost certainly impacting near-shore or land-denning bears more than ice-denning bears.[239]

Ice-free period on land

In recent years, the SB has been virtually 100% covered by sea ice between June and November, and the majority of bears stay on the ice as it retreats north in the summer; only a small fraction (17.5%) stay on land.[240] 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,[241] although it is primarily males and mothers with cubs (not pregnant females) that use these resources.

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 (ANWR) area of Alaska.[242] However, less than half of the female portion of the Southern Beaufort Sea population makes maternity dens along this area of the coast,[243] where they would be most at risk of disturbance. 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 were not loyal to a specific place. Such flexibility is probably necessary because annual variations in weather, sea ice conditions and prey availability impact bears' choice of where to den.[244] 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.[245]

It is worth mentioning that oil exploration activities in the 1990s in the Eastern Beaufort (around Tuktoyaktuk in Canada) and in the Canadian High Arctic in the 1970s were expected to cause a marked increase in the number of defense kills and unacceptable disruptions to denning.[246] But impacts on polar bears have been so minimal that we've heard virtually nothing about them.[247] Similarly, there has been the potential for oil-related activities to cause disruption to denning outside the ANWR, a little further west along the Alaskan coast at Prudhoe Bay in the National Petroleum Reserve (the largest oil field in the USA). But since exploration began at this site in the 1960s, [248] there have been virtually no problems with polar bears (either from disruption of feeding and denning activities or due to excessive defense of life or property kills).[249] More specifically, biologist Steven Amstrup looked at 20 polar bear dens located within the ANWR between 1981 and 1992 and found that, contrary to expectations, virtually all females were exceptionally tolerant of the kind of human activities associated with oil exploration and drilling (including aircraft, snow machines, seismic surveys, and oil field operations).[250] Overall, the oil industry in Alaska and western Canada has a very good track record of dealing responsibly with polar bears through a combination of education and precautionary practices.[251] In conclusion, recent worries about potential threats to polar bears from oil exploration and extraction in the ANWR seem to have been overblown.

Litter sizes

Within the three Hudson Bay subpopulations, litter sizes estimated from recent autumn surveys of cubs-of-the-year varied only slightly up to 2016 (Table 2). No trends in autumn litter sizes over time were found for BB bears between 1997 and 2013, and the mean 2011–2013 litter size (1.55) was similar to FB and SH in 2011, where populations were considered stable.[252] For Kane Basin, mean autumn litter size in 2012–2014 was similar to WH in 1984–1986 and 2016. SH litter size had declined slightly between 2011 and 2016 by a lesser amount (1.56 to 1.46) than WH litter size had increased over the same period (1.43 to 1.63). Does this indicate WH could be increasing in size and SH decreasing? That is presently unclear, in part because there were about twice as many SH females with litters in both 2011 and 2016 as

there were in WH. No explanation for these differences in litter sizes have been suggested, but one point is abundantly clear: recent litter sizes have been nowhere as low as they were in WH in 1985–1992 (Table 2), except for WH in 2011.

Not included in Table 2 are data for Chukchi Sea litters reported by Eric Regehr and colleagues. This is because they were collected in the spring rather than autumn (2.18 for cubs-of-the-year and 1.61 for yearlings).[253] As noted in the CS status section, however, the rate of triplet litters in 2016 was almost 8%,[254] a frequency seen previously only in WH during the 1970s and 1980s (and rarely elsewhere). [255] Although polar bear specialist Nick Lunn claimed in 2018 that no triplet litters had been born since 1996 in WH,[256] in fact two photos of triplet litters have been posted on the internet in recent years: one in 2011 and another in 2018.[257] There are likely others that have not been seen or photographed. Nevertheless, there have been no published data reporting the incidence of triplet litters in WH since 1992, which means Lunn's claim is scientifically untenable.

8 Evidence of flexibility

Den locations

In the Barents Sea, where in some recent years the sea ice has not returned to the east coast of Svalbard in time for pregnant females to access traditional denning areas in fall, it appears that the bears affected have been sufficiently flexible to use the much colder, but still productive, islands of the Franz Josef Land archipelago instead.[258]

In Baffin Bay, females in 2009–2015 entered land dens a bit later in the autumn than they did in 1991–1997 (about 5 October vs 5 September) and made the dens at higher locations but emerged at similar times in both periods. However, no negative effects of these changes were noted.[259] According to one study conducted in 2013, while females that made maternity dens on land in the Southern Beaufort (about 51%) and the Chukchi Sea (about 84%) had a higher survival rate of cubs than those that made dens on the sea ice, it was not clear precisely why this was so.[260] Overall, however, flexibility in choosing where and when to enter a den is evidence that polar bear females have the biological plasticity necessary to survive changing environmental conditions.

Feeding locations

In 2013, fewer Baffin Bay females were traced moving south into Davis Strait in winter/spring to pursue harp and hooded seals than in 1997. Similarly, in summer, fewer bears visited Lancaster Sound, where there is often remnant sea ice to use as a hunting platform, than did so in the 1990s. More BB females in 2013 remained in the northern portion of their range during the ice-covered seasons than they did previously.[261] These changes in distribution of female bears appear to relate to feeding behaviour. While the authors of the study attempted to correlate changes in bear movements with changes in sea ice coverage between the early 1990s and the 2009–2015 period, there appeared to be no attempt to consider potential changes in prey availability that may have taken place over that time.[262]

An older example of this kind of flexibility was the documented movement of bears and seals into the Chukchi Sea during the catastrophic 1974 and 1975 episodes of thick spring ice in the Eastern Beaufort.[263] In the 1960s, Christian Vibe also described seals and bears moving in response to decadal cycles of change in sea ice cover along the Greenland coast.[264]

More recently, the small proportion of the subpopulation of polar bears that spend the summer on shore rather than on sea ice in the Southern Beaufort Sea have been shown to benefit from feeding on whale carcasses left from Inuit subsistence hunting.[265] However, aside from whale carcasses, there is little evidence that terrestrial foods make a difference to the body condition or survival of bears that spend all or part of the summer onshore in the ice-free season.[266] While polar bears have been documented eating a variety of foods while onshore, from ground-nesting birds and bird eggs to caribou, grasses, berries, and seaweed,[267] there is little evidence this makes any difference to body condition or survival over the short or long term.

Although the reasons for long-distance moves are often not clear, they do happen. A four-year-old female who had not yet given birth traveled from the Canadian area of the Southern Beaufort Sea to Wrangel Island in the Chukchi Sea after being captured and tagged in late April 2009.[268] Previously, another bear, an adult female with two cubs of the year who was tagged in late May 1992, moved from off Prudhoe Bay in the Southern Beaufort Sea, crossed the Arctic Basin to with 2 degrees of the North Pole, and ended up in northern Greenland.[269]

Genetics

One recent, widely publicized genetics paper suggested there is evidence that polar bears have already started moving from the periphery of the Arctic towards a sea ice 'refugium' in the Canadian Archipelago region in response to recent declines in summer sea ice. However, a follow-up analysis that did not get any media attention found 'methodological shortcomings' (including small and unbalanced sample sizes) and 'errors of interpretation' undermined the conclusions of the first study.[270] The second study did not find evidence of recent widespread movement towards the Canadian Archipelago, but did confirm the existence of a genetically unique cluster of bears in Norwegian Bay previously identified by other researchers.[271] Norwegian Bay is located at the north end of the Canadian Archipelago and, while it is dominated by multiyear ice, it has two large polynyas that have a few ringed seals and also support walrus and bearded seal populations.[272] Anecdotal accounts from local Inuit suggest that Norwegian Bay bears are 'different' from those in the surrounding area,[273] thus corroborating the two independent genetic studies. It is possible this subpopulation contains descendants of a previous population since gone into decline.[274]

One of the most recent genetic studies[275] emphasized that the polar bear, as a species, survived more than one previous warm period when there was virtually no summer sea ice.[276] Sea ice has varied both over the short term (i.e. decades-long climate oscillations) and the long term (glacial-to-interglacial cycles of thousands of years). Over the last 1.5 million years, for example, there have been periods of much less ice than today (including ice-free summers), but also periods with much more ice but no biological extinctions.[277]

Polar bear population numbers may have fluctuated somewhat in conjunction with these sea ice changes, but the polar bear as a species survived, and so did all of the Arctic seal species they depended on for food, including Pacific walrus.[278] The survival of polar bears through these large changes in sea ice cover indicates that these Arctic marine mammals, in an evolutionary sense, have the necessary built-in flexibility (called '*plasticity*' in biology jargon) to survive in their highly-variable habitat.[279] Although some have suggested that the low genetic diversity of polar bears makes them especially vulnerable to extinction,[280] there is little support for this notion in the scientific literature.[281]

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,[282] 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 polar bear attack that Inuit and other indigenous people endured – and still endure in many areas – because those people in the past existed in 'relatively low numbers.'[283] As discussed below, two Inuit hunters in Canada who were mauled to death by polar bears in 2018 are prime examples of these shortcomings.

The Wilder paper focused much attention on the potential for increases in polar bear attacks on humans due to sea ice loss blamed on human-caused global warming.[284] However, it did not consider the increased risk stemming from the relatively larger proportion of adult males in polar bear populations nowadays, a fact of life in growing populations, but also a function of hunting restrictions. Adult males dominate younger ones, and frequently steal their kills,[285] which can cause the young bears to become nutritionally stressed and at risk of attacking humans. In fact, Ian Stirling warned in the early 1970s that a complete hunting ban, such as Norway had just imposed in Svalbard, might increase polar bear–human conflicts.[286]

Problem bears and attacks in winter/spring

Winter (January–March) is the leanest time of year for polar bears (Figure 7), 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.[287] By early 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.[288]

Although over the last few decades, winter and early spring incidents have been relatively rare, there are now many more polar bears than there were in the 1970s, as well as more people living in many coastal Arctic communities. This means that problems with bears in the coldest months are likely to increase. More bears out on the ice in winter especially will almost certainly create more competition for the few seals that are available. As a result, some bears might look for alternative sources of food. On land in winter, bears are attracted by caches of frozen meat, cemeteries, odours of cooking food, food fed to dogs and the dogs themselves, stored food, garbage and sewage, as well as man-made petroleum prod-

ucts and other industrial material (such as oils and lubricants, vinyl seats and plastic-coated cables), antifreeze and insulation.[289]

The incidents mentioned in the following subsections are anecdotal, and are not part of a comprehensive survey that would make them scientifically significant. However, until such a survey is undertaken, they are noted here for perspective on the reports of summer incidents and attacks on humans that often garner more media attention.[290]

Svalbard 2017 and 2018

In late January 2017, a polar bear female with two cubs (possibly two-year-olds) were reported near the community of Longyearbyen on the west coast of Svalbard, where there was no sea ice. The bears probably traveled overland from the east coast where spare sea ice existed. The bears were not reported to have been thin, starving, or in poor condition, and had thus far not caused any problems aside from frightening people. Helicopters and snowmobiles were used to chase them away from the community but, even so, the bears remained in the vicinity for several weeks.[291]

In 2018, by early January, ice extended as far south as Hopen Island, a remote location used by females for denning in favourable ice years.[292] In March, a meteorologist stationed on Hopen reported seeing a total of fourteen bears within 24 hours during an overnight cross-country ski trip to a small cabin 7 km from where he worked, including females with cubs. Two bears looked into the window of the cabin while he was inside and another followed him as he skied back to his work station, coming so close to him and his two dogs that he had to fire a warning shot to make it move off.[293]

In late spring (3 June), a bear in good condition broke into the storage cabin of a remote luxury hotel about 90 km west of Longyearbyen (on the tip of the fjord) by pushing open a newly-installed garage door that somehow closed behind it. The bear ripped into garbage stored there and consumed bags and boxes of food and chocolate. He finally left through one of the many windows he had broken. According to the hotel manager, the garage door used to gain entry to the storage area needed replacing because a visit by another bear in February had destroyed the old one.[294]

Eastern Hudson Bay/Hudson Strait 2017 and 2018

A 'very fat' polar bear was reported outside the community of Inukjuak, Eastern Hudson Bay, on Saturday 25 February 2017.[295] This was a rare occurrence: according to the mayor, the community had not seen a bear onshore in nearly 30 years. The bear was a young, subadult female in excellent condition but it was shot for safety reasons. Its condition was surprising, as subadults are likely to be in poorer condition than adults at any time of year, due to their lack of hunting experience and competition with adult males.[296] Polar bears in Hudson Bay travel with the retreating ice to the western and southern shores so, with some exceptions, they usually only have access to the east coast during winter through spring.

Further up the east coast of Hudson Bay a few weeks later, in early March 2017, there was a late-night encounter with a thin and hungry polar bear in the northern Quebec community of Ivujivik on the edge of Hudson Bay. It was the fourth defence kill of 2017 (and the second that month) for this community, coming after a large number of bear sightings by residents that winter.[297] This bear was thin and obviously dangerous but was shot before anyone was hurt.

In 2018, on the 4 March, a young polar bear, perhaps only two years old, came ashore and wandered about the village of Puvirnituq, on the northwest coast of Hudson Bay in northern Quebec.[298] It was shot for safety reasons by a local hunter. This was the first time a bear had ever come into the community in living memory and residents suggested a big storm the night before may have caused the animal to become lost.

Labrador and Newfoundland 2017 and 2018

After only about a half dozen sightings in 2016, in 2017 there were well over a dozen reports of polar bears onshore in Newfoundland and Labrador.[299] In 2017, unusually cold conditions and heavy sea ice offshore persisted late into the season.[300] Considering Newfoundland alone, one or two bears have been reported every spring since about 2012,[301] but there were more than half a dozen sightings (involving at least nine bears) from March onward in 2017.[302] As a result, 2017 may have had the largest number of bears ashore in Newfoundland since about 1880.[303]

However, sightings and problems with bears in good condition were even higher in the spring of 2018, although there were fewer Labrador incidents (especially in January and February). March was particularly busy:

- on the 6th, a bear strolled through the streets of St. Lunaire-Griquet on the Northern Peninsula of Newfoundland;[304]
- on the 7th, police in Elliston (outside Bonavista in northeastern Newfoundland) found footprint evidence of an onshore visit;[305]
- on the 8th, four bears (likely a mother with a triplet litter of almost-grown cubs) were spotted on shore outside of Red Bay on the Labrador coast;[306]
- from the 10–14th, perhaps as many as seven (but at least four) bears were spotted in or around communities on the Northern Peninsula; [307]
- on the 14th a bear was spotted on Fogo Island off Newfoundland.[308]

On the 2nd of April, another bear in good condition was spotted onshore outside of Bonavista, Newfoundland.[309] After that incident, there were several others later in the season: assisted by an iceberg, a bear in good condition came ashore near St. Lunaire-Griquet on the 6th of June,[310] at least three bears including a mother and cub (and perhaps four altogether) were spotted around St. Anthony between 21–24 June,[311] and a bear was removed from the community of Makkovik on the coast of Labrador for safety reasons on July 5th.[312]

Therefore, a minimum of twelve polar bears were spotted onshore in Newfoundland in 2018 – and perhaps as many as sixteen– not counting those seen in Labrador (which may not always make the news). This figure surpassed the nine bears recorded in 2017. Sea ice was somewhat less extensive in 2018 than in 2017, although much of the ice was thicker in 2017. There was also ice off the northern peninsula of Newfoundland until late May in 2018, compared to about the middle of June in 2017. However, variable ice conditions are unlikely the reason for the marked increase in polar bear sightings over the last two years compared to previous years. It is known that the Davis Strait subpopulation was heavily impacted by commercial whalers in the late 1800s and early 1900s[313] and is still recovering.[314] Abundant prey in the form of harp and hooded seals,[315] as well as competition among a thriving population of bears for those seals, may only now be encouraging individuals to wander to the southern limits of the region.

Problem bears and attacks in summer and autumn

In areas where all of the subpopulation comes ashore during the ice-free season, the usual dynamic between polar bears and humans is changed. For five months or so in some regions, but less in others, encounters between bears and people become much more likely. While fatal attacks have always been relatively rare, the number of bears shot or removed before tragedy strikes (especially in remote regions) have only recently been closely tracked.[316] 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.[317]

Three events put polar bear attacks at centre stage in 2018.[318] Two fatal attacks occurred in the Canadian Arctic, with a third near-fatal mauling in Svalbard. The two Canadians killed were Inuit residents and the third attack victim (who lived) was from a tourist ship. However, the responses to these events were remarkably different.

The first fatal attack by a polar bear of 2018 occurred in early July outside the community of Arviat, an Inuit hamlet of more than 2,600 residents that sits 250 km (about 155 miles) north of Churchill on the northwest shore of Hudson Bay. On the evening of 3 July 2018 (about 7:30 pm), 31 year old Aaron Gibbons was mauled to death by a polar bear on Sentry Island, a barrier isle about 10 km offshore from Arviat ('Eskimo Point' on old maps). The attack occurred when a polar bear started to stalk one of Gibbons's three young children, who were on the island with their father to collect Arctic tern eggs. Gibbons put himself between the kids and the bear so they could run to the safety of their boat. Gibbons was subsequently mauled to death while his children watched and his terrified daughter called for help on the boat's radio. Unfortunately, he did not have his gun at hand at the time and died soon afterward from his injuries. Another person on the island heard the screams from Gibbons and his children and ran over to shoot the bear. It was an adult male and conservation officers who later examined the body described it as in 'fair' condition.[319]

In contrast, the last fatal attack in WH also happened in early July 1999, near Rankin Inlet. Two people were seriously injured and another mauled to death by a young bear, about one and a half years of age, that had probably just left the care of its mother.[320] Bears weaned in their second spring were less common in WH by 1998 compared to previous decades but still made up between 15–20% of all yearlings captured.[321] Young bears 2–4 years old are notoriously unpredictable and dangerous.[322]

And while the bear that killed Aaron Gibbons must have left the sea ice much earlier than usual, perhaps as early as the third week of May, he was not forced ashore by receding ice. There was still abundant ice remaining on Hudson Bay in late May. But for some reason, the bear chose to leave the ice near Arviat in the northwest portion of Hudson Bay rather than continue hunting seals until late June or early July as most other WH bears did that summer (when they left the ice near Churchill or points south).[323] According to local informants, perhaps as many as a dozen other bears were in the general area of Arviat at the time of the attack, suggesting some attractant – perhaps the tern eggs sought by the Gibbons family, perhaps eggs and fledglings of other waterfowl that nest in the area – gave these bears a reason to come ashore much earlier and much further north than the rest of the population.[324] Shortly after the fatal attack, another bear was shot because it repeatedly

approached a group staying in cabins outside Arviat and refused to be deterred by warning shots.[325] These two justified defence kills apparently used up all of the tags from Arviat's quota: any other kills made afterward would be considered illegal.

The second fatal attack occurred a bit further north, at the southwest edge of the Foxe Basin polar bear subpopulation region, on the morning of August 23. A party of three Inuit hunters from the community of Naujaat had boat trouble on the first day of a planned three-day hunting trip on 21 August. They took refuge on nearby White Island, but hours later, wind blew extensive ice onshore and they were prevented from leaving. On the morning of the attack, as they awaited rescue (knowing they would soon be reported overdue), the three were having their morning tea when an adult female polar bear accompanied by a yearling cub came at them. Leo Ijjangiaq fired a warning shot but the bear grabbed Laurent Uttak by the head. But when Darryl Kaunak tried to run away, the bear turned on him instead. She mauled Kaunak until he was nearly dead. Ijjangiaq's rifle had jammed after the warning shot but as soon as he found another rifle, he shot the bear dead, then the cub. His friends administered first aid, but Kaunak died a few hours later. Attracted by the carnage of three bodies on the ground, more bears came around and threatened the survivors; Ijjangiaq killed two of them. The Canadian Coast Guard icebreaker sent to rescue the men could not get through the thick ice to their location but they were eventually spotted by the ship's helicopter and taken to safety – three long days after the attack.[326]

Conservation officers later said three of the four bears found at the site after the rescue were in good condition (the carcass of the fourth could not be located). There had been an abundance of sea ice in the region at the time: the bears were not 'forced' off the ice, nor were any of them starving. The men were not near a community full of attractants, nor were they surrounded by meat or refuse from hunting activities (since they had not yet been hunting). The fact that this was an attack by an adult female made this incident especially disturbing, since most polar bear attacks are initiated by young males in poor condition.[327] This female appeared to be fearless, and the presence of a cub almost old enough to fend for itself was not likely a factor, since polar bears are not especially protective of cubs older than newborns just out of the den.[328]

Local Inuit blamed both attacks on an increased abundance of bears and perhaps bears habituated to the tourists that flock to the Churchill area to see bears up close. However, at least three polar bear specialists said the attacks were caused by lack of sea ice.[329] But trends of generalized sea ice decline do not explain local conditions at the times the attacks took place: state of the sea ice was not a plausible factor in either incident. However, because of the wide margins of error involved in estimating population sizes, it is entirely possible that the Inuit are right: that actual numbers of WH bears on the ground have increased since 2012 or so (about the time Arviat noticed more bears), even if the reported 'mean' of official counts had declined slightly (see Section 3). At the same time, or alternatively, a redistribution of WH bears may have occurred, with more bears now spending most of their time to the north of Churchill (and thus active close to Arviat and Rankin Inlet) than they did in 2004.[330]

The attack in Svalbard was quite different from the other two. It occurred on 28 July when a contingent of four polar bear guards from the German cruise ship *MS Bremen* went ashore on a remote island in the Sjuøyene group to check for the presence of bears before tourists from the ship would be allowed ashore; the shore leave was not for observing polar bears, as bears were only viewed from aboard the ship.[331] Although the guard was armed, he was ambushed and disabled by the bear before he could protect himself. Warning shots from his colleagues did not deter the bear, who was subsequently shot by one of the other guards

but not before the first guard suffered serious head injuries.[332] Pictures provided of the bear showed he was an emaciated adult male, age undetermined, in much the same condition as the Canadian bear promoted in the *National Geographic* video that caused so much trouble a year earlier – which shows just how dangerous a starving bear can be.

By January 2019, as far as is known, no report had been released regarding the necropsy on the bear. However, it seems likely that if he hadn't been shot, he would have died a natural death from starvation within weeks of the attack. Most bears are in their best condition at that time of year and the fact that he was so very thin suggested he had not been in good condition when he came ashore or had been ashore for many months. Lack of sea ice cannot be blamed for his pitiful condition (although some have tried),[333] because bears in this region can chose to remain on the ice throughout the summer and autumn months, where they can continue to try and hunt seals. The bear made a poor decision to leave the ice because he became stranded when the ice retreated.

The enormous hue-and-cry generated by environmentalists and anti-hunting factions on social and news media over the death of the Svalbard bear dwarfed the responses to the deaths of two Inuk hunters.[334] Most people who got angry about the Svalbard mauling were simply misinformed: based on early but incomplete reports of the incident, they thought, incorrectly, that ecotourists had come to the island to view polar bears and shot a bear that came too close. However, the accusation from some Inuit in Nunavut that people care more about polar bears than they do about people whose lives are threatened almost daily by their presence[335] seemed substantiated by the disproportionate outrage prompted by the death of the Svalbard bear. Inuit residents of Nunavut were angry that their lives were at risk all year round, here and now, while scientists continued to focus on protecting bears from becoming extinct sometime in the future.[336] This point of contention came on top of others that had been brewing between the two groups for years, and in late 2018, the government of Nunavut released a draft management plan for polar bears that gave voice to their indignation (see Discussion below).[337]

10 Discussion

In Canada, where perhaps two-thirds of the world's polar bears live, the Committee on the Status of Endangered Wildlife (COSEWIC) decided in 2018 to continue to list the polar bear as a species of 'Special Concern' rather than upgrade the status to 'Threatened.' Despite 2018 summer sea ice levels remaining around 3–5m km^2, as they have since 2007, polar bear numbers continued to increase, albeit slowly. Taking studies published in 2018 into account, the current mid-point estimate is about 29,500, with a wide margin of error.

It seems hard to believe that the sea ice models used in 2005 to predict ice coverage over the 21st century could have been so flawed and that the polar bear survival models that predicted a 67% decline in abundance could have been so far off the mark. However, sea ice and polar bear data published by 2018 confirm that this is so.[338] The most recent IUCN sea ice models (from 2015) used by polar bear specialists predicted nearly ice-free conditions in summer before mid-century, even without taking possible effects of CO_2 into account.[339] The polar bear survival models based on these forecasts suggested that by mid-century, a 30% decline or more in polar bear numbers could happen – or at least that there would be a 70% chance of such a decline.[340] In other words, experts now say we should expect an ice-free summer much earlier than previously predicted, regardless of CO_2 emissions, but

anticipate that 10,000 or so fewer polar bears will die because of it. That's a huge reversal since 2005 and a tacit admission that previous predictions were indeed unsound.

In 2018, the results of the first-ever population count of the Chukchi Sea were published. Western Hudson Bay inexplicably had an earlier-than-the-1980s freeze-up for the second year in a row, *National Geographic* apologized for promoting misinformation via its 'starving polar bear video,' and potential impacts of drilling for oil in Alaska got overblown.

Moreover, 2018 was the year that Inuit in the huge Canadian territory of Nunavut became truly fed up with scientists insisting that polar bear numbers were declining when their own experiences told them otherwise. Canadian Inuit have taken the necessary steps towards changing their wildlife management focus for polar bear from encouraging population growth and protecting bears to ensuring human safety and protecting human life.[341] This decision arose out of a long-standing conflict between Inuit and polar bear specialists,[342] but took on a new urgency in 2018 after so little change in the attitude of scientists,[343] and two residents killed by bears in as many months. The public outcry when a polar bear was killed for attacking a German polar bear guard from a tourist ship overwhelmed the reaction to the news, a few days later, that yet another Inuk hunter had been killed by a bear in Canada. The incident reinforced the impression held by Canadian Inuit that many people, including polar bear researchers, valued the life of a polar bear over a human life – especially an Inuit life. An editorial in a Nunavut newspaper that named polar bears the 'newsmaker of the year' for 2018 had some harsh words to say about the contentious situation:[344]

> But in Nunavut, the damage that environmentalists have inflicted on their cause will likely last for generations. Growing numbers of people in Nunavut not only believe polar bears are a threat to public safety. Growing numbers also believe that scientists and government wildlife managers are their enemy.
>
> On that last point, the condescending attitudes of some researchers and government officials has been rather less than helpful.
>
> For example, the federal Department of Environment and Climate Change said last fall, in a submission to the wildlife management board, that the Inuit position is 'inconsistent with the federal listing of the polar bear as a species of special concern in Canada.'
>
> That tone-deaf response simply reinforces the Inuit belief that governments value the lives of polar bears more than they value the lives of human beings.

The Nunavut Polar Bear Co-Management Plan presented in November 2018 to the Nunavut Government began with this basic premise:

> Over the last 50 years polar bear management has focused on recovery of polar bear numbers, which has largely been achieved. The focus of polar bear management now shifts to maintaining, or reducing numbers in areas where public safety is a concern and/or where there are detrimental effects on the ecosystem due to increased numbers of polar bears.

Inuit have the political power in Canada to legislate such game-changing polar bear management decisions whether or not scientists and federal (or international) government officials agree. This has huge implications for the species because perhaps as many as two-thirds of the world's polar bears live in Canada and most of them reside in Nunavut[345] – including the so-called 'Last Ice' region of Norwegian Bay that some think might be an important global warming refuge for polar bears if summer sea ice ever does decline to zero.[346] Ultimately, as Nunavut polar bear management plans prioritize keeping citizens safe, polar bear specialists in Canada and elsewhere may be forced to report honestly and openly on

the existing status and health of the animals they study, without the voice-of-doom overlay and anxiety for the future that has colored their reporting of research results over the last three decades.

Notes

1. Obbard *et al.* 2010.
2. 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).
3. https://www.amazon.com/s/ref=dp_byline_sr_book_1?ie=UTF8&text=Susan+J+Crockford&search-alias=books&field-author=Susan+J+Crockford&sort=relevancerank and https://susancrockford.com.
4. Crockford, S. 2017. Testing the hypothesis that routine sea ice coverage of 3–5 million km^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.
5. Crockford 2014a–c, Crockford 2015a,b, Crockford 2017b–d.
6. Amstrup *et al.* 2007; US Fish & Wildlife Service 2008.
7. Wiig *et al.* 2015; Regehr *et al.* 2016.
8. Aars *et al.* 2017; Crockford 2017a; Crockford and Geist 2018; Dyck *et al.* 2017; SWG 2016b.
9. AC SWG 2018; Obbard *et al.* 2018; Regehr *et al.* 2018.
10. Larsen 1972.
11. Crockford 2017a; Crockford and Geist 2018.
12. Amstrup *et al.* 2007; USGS 2017.
13. ACIA 2005.
14. Crockford 2017a
15. Hunter *et al.* 2007, 2010.
16. Crockford 2017a; Crockford and Geist 2018.
17. Regehr *et al.* 2018; AC SWG 2018; See also https://arctic.ru/environmental/20180220/719437.html.
18. Aars 2018.
19. Wiig *et al.* 2015; Regehr *et al.* 2016.
20. USFWS 2008; USFWS 2016.
21. Akçakaya *et al.* 2006; Crockford 2017a; Aars *et al.* 2006.
22. Laidre *et al.* 2016.
23. COSEWIC, 3 December 2018 press release. https://www.newswire.ca/news-releases/species-deeply-rooted-in-canadian-culture-are-at-risk-701805822.html.
24. Anonymous 1968.
25. http://pbsg.npolar.no/en/status/pb-global-estimate.html.
26. http://pbsg.npolar.no/en/status/pb-global-estimate.html.
27. Laidre *et al.* 2016; Regehr *et al.* 2016; Wiig *et al.* 2015.
28. Stoeve *et al.* 207.
29. Amstrup *et al.* 2007; Durner *et al.* 2007; USGS 2007.
30. Atwood *et al.* 2016a; Regehr *et al.* 2016; Vongraven *et al.* 2012; Vongraven *et al.* 2013; but see Harris 2012.
31. Burns *et al.* 1975; DeMaster *et al.* 1980; Ramseier *et al.* 1975; Stirling *et al.* 1975a, 1975b, 1980, 1981, 1982, 1985, 1988, Stirling and Archibald 1977; Stirling and Lunn 1997; Stirling 1997, 2002.
32. Pagano *et al.* 2018; Rode *et al.* 2018; Harwood *et al.* 2012, 2016.

33. Chambellant *et al.* 2012; Crockford 2014; Ferguson *et al.* 2005; Vibe 1965, 1967.
34. Durner *et al.* 2018.
35. Harwood *et al.* 2012; Cherry et al.2009; Pilfold *et al.* 2012, 2014.
36. Taylor *et al.* 2005, see also http://pbsg.npolar.no/en/status/populations/baffin-bay.html.
37. SWG 2016b; Obbard *et al.* 2010; York *et al.* 2016.
38. SWG 2016a.
39. Pers. Comm.
40. Stirling *et al.* 1980a; Stirling and Kiliaan 1980.
41. http://pbsg.npolar.no/en/status/populations/davis-strait.html.
42. Peacock *et al.* 2013.
43. Rode *et al.* 2012.
44. DFO 2012, 2014; Kovacs 2015.
45. https://www.canada.ca/en/environment-climate-change/services/biodiversity/maps-sub-populations-polar-bears-protected.html#_fig02.
46. Obbard *et al.* 2010; Taylor *et al.* 2006.
47. Stapleton *et al.* 2012.
48. http://pbsg.npolar.no/en/status/populations/foxe-basin.html.
49. Derocher and Stirling 1995; Wiig *et al.* 1995.
50. Regehr *et al.* 2007.
51. Lunn *et al.* 2016; Stapleton *et al.* 2014; Durner *et al.* 2018. See also http://pbsg.npolar.no/en/status/populations/western-hudson-bay.html. [accessed 27 January 2019]
52. Dyck et al.2017.
53. Dyck *et al.* 2017, pp. 3, 37.
54. Stirling and Derocher 2012; http://www.cbc.ca/news/multimedia/polar-bears-in-churchill-face-bleak-future-researchers-warn-1.4380568. [2 November 2017, Nick Lunn]; http://www.upworthy.com/a-scientist-who-has-studied-polar-bears-for-34-years-is-starting-to-get-really-worried [20 June 2017, Andrew Derocher]; https://uphere.ca/articles/he-speaks-polar-bears [1 February 2016, Ian Stirling].
55. 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.
56. Nunavut Polar Bear Co-Management Plan 2018. Also https://www.highnorthnews.com/en/too-many-polar-bears.
57. Lunn *et al.* 1998; http://pbsg.npolar.no/en/status/populations/southern-hudson-bay.html.
58. Obbard *et al.* 2006, 2008.
59. Obbard *et al.* 2015, 2016.
60. 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.
61. Aars *et al.* 2006, 2009.
62. Aars *et al.* 2009.
63. Aars *et al.* 2017, Table 3.
64. Aars *et al.* 2017.
65. Note that a frequent phrase used by the media, that 'polar bears outnumber people in Svalbard' or something similar, is quite wrong. It seems to have originated from a statement on the website of the Svalbard Tourism Board ('Visit Svalbard') that mistakenly equated the Barents Sea subpopulation region with the Svalbard study area.
66. Crockford 2017a.
67. http://polarview.met.no/.
68. Durner *et al.* 2018; See also http://pbsg.npolar.no/en/status/populations/barents-sea.html [accessed 27 Jan 2019].

69. Durner at al. 2018; See also http://pbsg.npolar.no/en/status/populations/barents-sea.html.
70. Matishov *et al.* 2014.
71. Wiig *et al.* 2015 supplement; Regehr *et al.* 2016.
72. Amstup *et al.* 2007; Crockford 2017a.
73. Durner *et al.* 2018; http://pbsg.npolar.no/en/status/populations/kara-sea.html [accessed 27 Jan 2019].
74. Derocher *et al.* 1998.
75. Aars *et al.* 2006.
76. SJC personal archive of online PBSG status table updates.
77. Durner *et al.* 2018; http://pbsg.npolar.no/en/status/populations/laptev-sea.html [accessed 27 Jan 2019].
78. Wiig *et al.* 2015 supplement; Regehr *et al.* 2016.
79. Durner *et al.* 2018; Stern and Laidre 2016.
80. Aars *et al.* 2006: 34; Belikov 1993; Wiig *et al.* 1995: 24.
81. Obbard *et al.* 2010.
82. SJC personal archive of online PBSG status table updates; Durner *et al.* 2018; http://pbsg.npolar.no/en/status/populations/chukchi-sea.html.
83. Wiig *et al.* 2015 supplement; Regehr *et al.* 2016.
84. Regehr *et al.* 2018: 2.
85. Regehr *et al.* 2018 supplementary data.
86. Derocher 1999; Derocher 2005; Ramsay and Stirling 1988; Derocher and Stirling 1995; Kolenosky and Prevett 1983; Stirling and Lunn 1997.
87. Rode *et al.* 2014; Rode *et al.* 2018b.
88. http://www.dailymail.co.uk/news/article-5110801/Polar-bears-scramble-mountain-feast-whale.html.
89. Ovsyanikov 2010; Ovsyanikov and Menyushina 2015.
90. AC SWG 2018; See also https://arctic.ru/environmental/20180220/719437.html.
91. Durner *et al.* 2006; Regehr *et al.* 2018.
92. Amstrup *et al.* 1986.
93. Amstrup *et al.* 2005; Durner *et al.* 2018.
94. Amstrup *et al.* 2007; Regehr *et al.* 2006; Regehr *et al.* 2010; Hunter *et al.* 2007, 2010.
95. Cherry *et al.* 2009; Harwood *et al.* 2012; Stirling 2002; Stirling *et al.* 2008.
96. Bromaghin *et al.* 2013; Bromaghin *et al.* 2015.
97. Durner *et al.* 2018; http://pbsg.npolar.no/en/status/populations/southern-beaufort-sea.html.
98. Durner *et al.* 2018; Joint Secretariate 2015.
99. Stirling *et al.* 2011.
100. Durner *et al.* 2018; http://pbsg.npolar.no/en/status/populations/northern-beaufort-sea.html.
101. https://www.canada.ca/en/environment-climate-change/services/biodiversity/maps-sub-populations-polar-bears-protected.html#_fig02.
102. Larsen 1972; Lunn *et al.* 2002.
103. SJC personal archive of online PBSG status table updates.
104. http://pbsg.npolar.no/en/status/pb-global-estimate.html [accessed 27 Jan 2019].
105. Wiig *et al.* 2015 supplement; Regehr *et al.* 2016.
106. http://www.cbc.ca/news/canada/north/east-greenland-polar-bears-1.4668180.
107. Laidre *et al.* 2018b.
108. http://arcticjournal.com/climate/773/hunters-5-polar-bears-0 [H. Martin, 10 July 2014].
109. http://pbsg.npolar.no/en/status/populations/arctic-basin.html.
110. Durner and Amstrup 1993; van Meurs and Splettstoesser 2003; Ovsyanikov 2010; Todd *et al.* 1992.
111. Arrigo *et al.* 2012; Gosselin *et al.* 1997; Lee and Whitledge 2005; but see Pomeroy 1997.

112. Obbard *et al.* 2010; SWG 2016; York *et al.* 2016.
113. SWG 2016 summary: 21; Taylor *et al.* 2008.
114. SWG 2016 summary: 14.
115. Durner *et al.* 2018; http://pbsg.npolar.no/en/status/populations/kane-basin.html.
116. Furnell and Schweinsburg 1984; Taylor *et al.* 2006.
117. Dyck 2016; Durner *et al.* 2018; http://pbsg.npolar.no/en/status/populations/mclintock-channel.html.
118. Taylor *et al.* 2002.
119. Pongracz 2014; Durner *et al.* 2018; http://pbsg.npolar.no/en/status/populations/viscount-melville-sound.html.
120. Vongraven and Peacock 2011.
121. Taylor *et al.* 2009.
122. Peacock *et al.* 2013; Taylor and Lee 1995.
123. Dyck 2017; Durner *et al.* 2018; http://pbsg.npolar.no/en/status/populations/gulf-of-boothia.html.
124. Lunn *et al.* 2002; Stirling *et al.* 1984; Taylor *et al.* 2008.
125. Honderich 2001.
126. Durner *et al.* 2018; http://pbsg.npolar.no/en/status/populations/lancaster-sound.html.
127. Taylor *et al.* 2008.
128. Durner *et al.* 2018; http://pbsg.npolar.no/en/status/populations/norwegian-bay.html.
129. Paetkau *et al.* 1999; Malenfant *et al.* 2016.
130. Amstrup *et al.* 2007; Folger 2018; Wang and Overland 2012.
131. https://www.canada.ca/en/environment-climate-change/services/biodiversity/maps-sub-populations-polar-bears-protected.html#_fig02.
132. Bromaghin *et al.* 2015; Burns *et al.* 1975; Harwood *et al.* 2012; Crockford 2017a; Stirling 2008.
133. http://pbsg.npolar.no/en/status/status-table.html [accessed 27 Jan 2019].
134. Crockford 2018, note some errors in that version are corrected here.
135. Aars *et al.* 2017.
136. SWG 2016.
137. Dyck *et al.* 2017; Lunn *et al.* 2016; Regehr *et al.* 2007; Stapleton *et al.* 2014.
138. Amstrup *et al.* 2007, 2008; Wiig et a. 2015; Regehr *et al.* 2016.
139. This problem is expected to remain as more subpopulations are surveyed or resurveyed with newer methods.
140. Wiig *et al.* 2015; Regehr *et al.* 2016.
141. See also Crockford 2017a
142. https://www.washingtonpost.com/news/energy-environment/wp/2018/05/03/earths-atmosphere-just-crossed-another-troubling-climate-change-threshold/.
143. Perovich *et al.* 2018; Online at https://www.arctic.noaa.gov/Report-Card/Report-Card-2018/ArtMID/7878/ArticleID/780/SeanbspIce.
144. Walsh *et al.* 2017.
145. Durner *et al.* 2006; Garner *et al.* 1990; USFWS 2010; Peacock *et al.* 2013.
146. Perovich *et al.* 2018; https://climate.nasa.gov/news/2726/historic-low-sea-ice-in-the-bering-sea/ and https://uaf-iarc.org/2018/04/09/new-summary-available-on-bering-strait-winter-2018-sea-ice-conditions/ See also http://nsidc.org/arcticseaicenews/2018/04/2018-winter-arctic-sea-ice-bering-down/.
147. Brown *et al.* 2011; Wendler *et al.* 2014. See also http://nsidc.org/arcticseaicenews/2012/04/arctic-sea-ice-enters-the-spring-melt-season/.
148. 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/.
149. Aars 2018; See also http://www.mosj.no/en/fauna/marine/polar-bear.html.

150. https://www.theweathernetwork.com/news/articles/arctic-temperatures-spike-to-above-freezing-even-in-darkness-of-winter-may-be-warmer-in-days-ahead/96258 and https://www.washingtonpost.com/?utm_term=.5de2741ee391. and https://twitter.com/AEDerocher/status/967133521893507072.
151. Stroeve *et al.* 2007, Stroeve *et al.* 2014.
152. http://nsidc.org/arcticseaicenews/.
153. Obbard *et al.* 2016.
154. Atwood *et al.* 2016a; Durner *et al.* 2009; Lang *et al.* 2017.
155. SWG 2017.
156. Pagano *et al.* 2018.
157. DeMaster 1980; Bromaghin *et al.* 2015; Ramseier *et al.* 1975; Stirling 2002, Stirling and Lunn 1997; but see Rode *et al.* 2018a, 2018b.
158. Burns *et al.* 1975; Bromaghin *et al.* 2015; Cherry *et al.* 2009; DeMaster 1980; Harwood *et al.* 2012, 2015; Pilfold *et al.* 2012, 2015; Rode *et al.* 2010, 2014; Smith 1987; Stirling 1997, 2002; Stirling *et al.* 1975a, 1975b, 1980, 1981, 1982, 1985, 1988, 1993, 2008; Stirling and Lunn 1997.
159. https://news.nationalgeographic.com/2018/02/polar-bears-starve-melting-sea-ice-global-warming-study-beaufort-sea-environment/.
160. Crockford 2017a; Crockford and Geist 2018.
161. DeMaster 1980; Bromaghin *et al.* 2015; Ramseier *et al.* 1975; Stirling 2002, Stirling and Lunn 1997.
162. Crockford 2015; Derocher *et al.* 2004; Vongraven *et al.* 2012; Laidre *et al.* 2008.
163. Stirling *et al.* 1982: 21.
164. Amstrup *et al.* 2007; Durner *et al.* 2007, 2009; Pilfold *et al.* 2017; Pongracz and Derocher 2007.
165. Cronin *et al.* 2014; Vibe 1965, 1967.
166. Crockford 2012b.
167. https://www.thegwpf.com/was-the-younger-dryas-cooling-event-caused-by-cosmic-impact-after-all/.
168. Moore *et al.* 2017; Young *et al.* 1997.
169. Cronin and Cronin 2015; Sha *et al.* 2016; Stein *et al.* 2017b.
170. Regehr *et al.* 2016.
171. 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.
172. Aars *et al.* 2017; Obbard *et al.* 2016.
173. 'Brian Keating: Polar bears in Churchill Manitoba' (13 November 2017, CBC Radio episode 300312418) http://www.cbc.ca/player/play/1095183939998; https://explore.org/livecams/polar-bears-international/polar-bear-lodge-cam#comment-4191075299; See also 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/.
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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.

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3	Hughes	The Myth of Green Jobs
4	McKitrick	What Is Wrong With the IPCC?
5	Booker	The BBC and Climate Change
6	Montford	Nullius in Verba: The Royal Society and Climate Change
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9	Lilley	What Is Wrong With Stern?
10	Whitehouse	The Global Warming Standstill
11	Khandekar	The Global Warming-Extreme Weather Link
12	Lewis and Crok	Oversensitive
13	Lewis and Crok	A Sensitive Matter
14	Montford and Shade	Climate Control: Brainwashing in Schools
15	De Lange and 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

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