Species Status Assessment for the Polar Bear (*Ursus maritimus*)

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Executive Summary

This polar bear (*Ursus maritimus*) Species Status Assessment documents our use of the best available scientific information to characterize the biological status of polar bears. The polar bear is listed as threatened under the Endangered Species Act throughout their range. The purpose of the assessment is to inform the 5-year Review for the species as required under the Endangered Species Act and to inform future conservation efforts.

Polar bears occur in 19 subpopulations throughout the seasonally and permanently ice-covered marine waters and adjacent coastal areas of the northern hemisphere (Arctic and Subarctic), in Canada, Greenland, Norway, Russia and the United States (U.S.). The total circumpolar population of polar bears is estimated to be 26,000 (95% CI = 22,000–31,000), approximately 60% of which live in Canada. Abundance estimates exist for 15 of the subpopulations and range from <200 to ~3,000 individuals, but confidence intervals vary widely, and many estimates are decades old and not useful for informed management decisions.

The subpopulations are grouped into four ecoregions based on observed temporal and spatial patterns of ice formation and ablation, observations of how polar bears respond to those patterns, and how general circulation models forecast future ice patterns. In most of the Archipelago Ecoregion, heavy annual and multi-year sea ice fills the channels between the Canadian Arctic Islands, and subpopulations of polar bears in this ecoregion remain on the sea ice throughout the year. The Polar Basin Convergent Ecoregion is characterized by annual sea ice that converges towards the shoreline allowing bears to access nearshore ice year-round. Conversely, the Polar Basin Divergent Ecoregion is characterized by the formation of annual sea ice that is advected towards the Polar Basin. For subpopulations in the Seasonal Ice Ecoregion, the sea ice fully melts in the summer and bears are forced onshore for extended periods until the sea ice reforms. These four ecoregions are defined as recovery units under the Conservation Management Plan and are the analytical units in this document used for current and future conditions.

Polar bears are an ice-dependent species that rely on sea ice as a platform from which to hunt and feed; to seek mates, breed, and den; to travel to terrestrial maternity denning areas; and to make long-distance movements. Thus, all the individual-, subpopulation-, and species-level requirements necessitate adequate sea-ice conditions. To adapt to changing physical and biological conditions, the species needs to maintain a certain number or distribution across its range, as well as its ecological, behavioral, and genetic diversity to ensure viability.

We identified three major groups of stressors as having the potential to impact polar bears or their habitat throughout their range: 1) loss of sea ice due to climate change, including loss of denning habitat and access to prey, declining prey abundance, and increased movements/energy expenditure; 2) commercial activities, including industrial development, ecotourism, and shipping; and 3) overutilization, including harvest, human-bear conflict, and illegal take. Although other natural or anthropogenic threats that do not fit within these categories exist, they are less likely to impact polar bear persistence. We discussed how these stressors currently impact subpopulations, however, sea ice decline is the primary stressor affecting all aspects of polar bear life history.

Model projections for how stressors will change in the future and the polar bear response to those changes were conducted in a Bayesian network model. Three Representative Concentration Pathways (RCP 2.6, 4.5, and 8.5) and four time periods (2020–30, 2045–55, 2070–80, and 2090–2100) were considered. The results clearly demonstrate that stressor levels will increase in the future, and though the time period and RCP varied slightly, all ecoregions eventually will have greatly decreased polar bear abundance. Projections for the Polar Basin Divergent Ecoregion were the most pessimistic with abundance greatly decreased for all RCPs in all future time periods. By 2045–55, abundance is projected to be greatly decreased for both the Seasonal Ice Ecoregion (all three RCPs) and the Polar Basin Convergent Ecoregion (RCP 4.5 and 8.5 and uncertainty at 2.6). Polar bears in the Archipelago Ecoregion were projected to be the least impacted with outcomes of decreased or greatly decreased (RCP 8.5) by the period 2090–2100.

Whereas the near- and midterm impacts of sea-ice loss on polar bears will vary among subpopulations and ecoregions, over the long term, the impacts are anticipated to be significant for polar bears range-wide if global greenhouse gas (GHG) emission levels are not significantly reduced. The continued significant decline in annual sea ice extent will lead to range contraction, reduction in abundance, and/or extirpation of subpopulations by the end of this century. Based on the best scientific information currently available and our assessment of representation, redundancy, and resiliency (the 3Rs), the single most important act for polar bear conservation is decisive action to address Arctic warming, which is driven primarily by increasing atmospheric concentrations of greenhouse gases. Short of action that effectively addresses the primary cause of sea ice decline, it is unlikely that polar bears will be recovered.

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Chapter 1: Introduction

The polar bear (*Ursus maritimus*) is the largest of the extant bear species and is classified as a marine mammal. The polar bear was listed as a threatened species under the U.S. Endangered Species Act of 1973 (ESA), as amended (16 USC 1531 *et seq*.), on 15 May 2008 (73 FR 28212). As a result, it became a "depleted" species under the Marine Mammal Protection Act of 1972 as amended (MMPA). The global polar bear population was estimated to be 26,000 individuals (95% confidence interval = 22,000–31,000; Wiig et al. 2015, p. 5). Largely dependent on sea ice, their native range lies throughout the circumpolar Arctic, primarily within the Arctic Circle, which is one of the largest ranges for an extant large carnivore. Polar bears occur in 19 subpopulations throughout the seasonally and permanently ice-covered marine waters of Arctic and Subarctic regions of Canada, Greenland, Norway, Russia, and the United States (U.S.; Fig. 1). Population status varies for each subpopulation (Table 1). The U.S. contains portions of two subpopulations: Chukchi Sea (CS) and Southern Beaufort Sea (SB).

This Species Status Assessment (SSA) incorporates the best available scientific information and comprehensively reviews polar bear biology and threats to the species, evaluates the biological status, and provides an assessment of the conditions and resources required to maintain long-term viability across the global population. When available, future revisions of this document will also include updated stock assessment reports (SAR) for the Alaskan subpopulations of polar bears (as required by the MMPA). Additionally, the best management practices for activities occurring within the range of this species is included in the appendix (Appendix A). To be consistent with previous analyses, we conducted analyses within each of the four ecoregions and discussed individual subpopulations when data was sufficient and relevant. When available, we also included more specific and detailed information on the U.S. managed subpopulations to provide the required elements of SARs. The objective of the SSA is to determine what the species needs to remain viable, its current condition related to those needs, and its forecasted future conditions. We considered these ecological needs by characterizing the species' status in terms of its *Resiliency*, *Redundancy*, and *Representation* (the 3 Rs; Smith et al. 2018, entire):

- *Resiliency* is the ability of the species to withstand stochastic disturbance as well as annual environmental variation and is measured at the population level. Environmental variation includes normal variation in precipitation and temperatures, variation in summer sea-ice extent, or unusual weather events. Important metrics include population size and other demographic variables, population growth rate, and habitat quality. Typically, a more resilient species has multiple healthy, well-connected populations.
- *Redundancy* is the species ability to withstand catastrophic events by having multiple populations that are well distributed across its range. In a species with ample redundancy, catastrophic events are unlikely to result in species' extinction. Metrics of redundancy include the number and distribution of populations across the range of the species. More populations distributed more widely can better withstand catastrophic events.
- *Representation* reflects the species' "adaptive capacity" or ability to adapt to short-and long-term changes in the environment. Metrics include ecological or environmental variation and genetic diversity both within and among populations. A more diverse species has higher capacity for adapting to natural or anthropogenic changes in the environment.

Figure 1. Global distribution of subpopulations (as defined by the Polar Bear Specialist Group; Obbard et al. 2010, p. 33) and ecoregions (Amstrup et al. 2008, p. 216).

The 19 subpopulations have been further classified into four ecoregions based on temporal and spatial patterns of sea-ice dynamics, observations of the patterns of polar bear response to these dynamics, and forecasts of future sea-ice patterns (Fig. 1; Amstrup et al. 2008, p. 215). There are four ecoregions: the Seasonal Ice, Archipelago, Polar Basin Convergent, and Polar Basin Divergent Ecoregions. We use the four ecoregions (see Chapter 4) as our analytical units, which is consistent with the Polar Bear Conservation Management Plan (CMP; Service 2016, entire) and the existing future viability analysis (Chapter 5). Current detailed information (i.e., current conditions) on the status of each subpopulation is summarized herein through 2021 (Table 1) as well as available through the Polar Bear Specialist Group (PBSG; https://www.iucn-pbsg.org/wp-content/uploads/2021/11/July-2021-Status-Report-Web.pdf) and the Polar Bear Technical Committee (PBTC; https://www.polarbearscanada.ca/en/polar-bears-canada/canadas-polar-bear-subpopulations).

Many generations of polar bear hunters and members of Native coastal communities have accumulated extensive and important knowledge of polar bears and their habitat. Termed as Indigenous Knowledge (IK), Traditional Ecological Knowledge, or Local Traditional Knowledge, it is the cumulative body of knowledge about local natural resources accumulated by Indigenous people and often passed down through generations through practice and oral traditions (Polar Bear Range States 2021: https://polarbearagreement.org/index.php/polar-bear-management/involvement-of-Indigenous-peoples-and-incorporation-of-tek). While often under-recognized in western science, in recent decades, there has been increasing recognition of the value of this knowledge (e.g., Berkes et al. 2000, p. 1251; Huntington 2000, p. 1270; Huntington et al. 2004, p. 18; Ambrose et al. 2014, p. 1; Beaudreau and Levin 2014, p. 244; Mistry and Berardi 2016, p. 1274). We use the term IK in this SSA and recognize that there is an appropriate role for IK in science and management of polar bears, just as there is an appropriate role for the empirical methods of western science; indeed, these sets of knowledge can often enhance each other. When known and available, we included IK in relevant sections throughout the SSA, but most notably in Table 1 and Chapter 4. This SSA currently relies primarily on western science and secondarily on IK that was available through published reports. We recognize that this is not all the IK that could be useful to the current and prospective versions of this SSA. As part of the exploratory process of this SSA in 2021, the Service requested available IK through Tribal and comanagement (i.e., Alaska Nanuut Co-management Council; ANCC) partners in Alaska, and as of the publication of this version, the Service had not received any additional IK. The Service will continue to rely on international management bodies to provide IK outside of the U.S., while the Service will work with ANCC to strive to increase formal and informal opportunties to collect IK in Alaska that will be used to inform subsequent versions of this SSA.

Table 1. Ecoregion and managing countries for the 19 subpopulations. Abundance estimates, confidence intervals (CI), and subpopulation trends represent combined data and trends from Polar Bear Specialist Group (PBSG 2021, entire) and Polar Bear Technical Committee (PBTC 2021, entire) status tables as well as the Indigenous Knowledge (IK) reported therein, 2021.

Ecoregion	Subpopulation	Country	Abundance estimate (95% CI)	PBSG		PBTC		
				Long-term[a]	Short-term[b]	Historical[c]	Recent[d]	IK[i]
Archipelago	Gulf of Boothia	Canada	1525 (949–2101)	Data deficient	Likely stable (2000–2017)	Likely stable	Stable (2000–2017)	Increased
	Kane Basin	Greenland	357 (221–493)	Data deficient	Likely increased (1997–2014)	Likely reduced	Increased (1997–2014)	Increased
	Lancaster Sound	Canada	2541 (1759–3323)	Data deficient	Data deficient	Likely stable	Uncertain	Increased
	M'Clintock Channel	Canada	716 (545–955)	Data deficient	Likely increased (2000–2016)	Uncertain	Increased (2000–2016)	Stable
	Norwegian Bay	Canada	203 (115–291)	Data deficient	Data deficient	Uncertain	Uncertain	Stable
	Viscount Melville Sound	Canada	161 (93–229)	Data deficient	Data deficient	Likely reduced	Uncertain	Increased
Convergent	East Greenland[e]	Greenland	Unknown	Data deficient	Data deficient	NA	NA	NA
	Northern Beaufort Sea	Canada	980 (825–1135)	Data deficient	Data deficient	Likely stable	Likely stable (1987–2006)	Stable
Divergent	Barents Sea	Russia, Norway	2644 (1899–3592)	Data deficient	Likely stable (2004–2015)	NA	NA	NA
	Chukchi Sea	Russia, United States	2937 (1552–5944)	Data deficient	Likely stable (2008–2016)	NA	NA	NA
	Kara Sea	Russia	Unknown	Data deficient	Data deficient	NA	NA	NA
	Laptev Sea	Russia	Unknown	Data deficient	Data deficient	NA	NA	NA
	Southern Beaufort Sea	United States, Canada	~900 (606–1212)[f]	Likely decreased (1983–2015)	Likely decreased (2001–2015)	Uncertain	Likely declined (1998–2006)	Uncertain

Ecoregion	Subpopulation	Country	Abundance estimate (95% CI)	PBSG		PBTC		
				Long-term[a]	Short-term[b]	Historical[c]	Recent[d]	IK[i]
Seasonal	Baffin Bay	Greenland, Canada	2826 (2059–3593)	Data deficient	Data deficient	Uncertain	Likely stable (1997–2013)	Stable
	Davis Strait	Canada	2158 (1833–2542)[h]	Data deficient	Data deficient	Likely increased	Likely increased (1980–2007)	Increased
	Foxe Basin	Canada	2585 (2096–3189)	Data deficient	Likely stable (1994–2010)	stable	Stable (1997–2010)	Increased
	Southern Hudson Bay	Canada	780 (590–1029)	Very likely decreased (1986–2016)	Likely decreased (2012–2016)	Likely reduced	Likely declined (2012–2016)	Stable/likely increased[g]
	Western Hudson Bay	Canada	842 (562–1121)	Very likely decreased (1995–2016)	Likely decreased (2011–2016)	Likely reduced	Likely declined (2011–2016)	Increased
NA	Arctic Basin		Unknown	Data deficient	Data deficient	NA	NA	NA

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[a] Change in abundance over ≥2 polar bear generations [≥23 yr]; Regehr et al. 2016, p. 4)

[b] Change in abundance (~1 polar bear generation [11.5 yr]; Regehr et al. 2016, p. 4)

[c] Change in abundance since signing of 1973 Agreement on the Conservation of Polar Bears

[d] Trend in abundance during the past 15 years

[e] Subpopulation described in Laidre et al. (2022) is currently included herein, but ecoregion and subpopulation status will likely be re-evaluated by PBSG in 2023.

[f] 90% CI

[g] Stable in James Bay portion of subpopulation; likely increased in East Hudson Bay

[h] An updated abundance estimate of 2,015 bears (SD = 251; 95% Bayesian Credible Interval 1,603–2,588) is provided in Dyck et al. (2021a, entire) and will likely be evaluated by PBSG in 2023.

[i] Methods for IK-based assessment of status are provided by PBTC (2021, p. 4).

Chapter 2: Species Ecology

In this chapter we provide biological information on the polar bear including its range, taxonomy, physical characteristics, life history traits, and basic ecology. We drew much of this information from the CMP (Service 2016, entire) and the most recent 5-year Review (Service 2017a, entire). We also summarized the ecological requirements of the individual, subpopulation, and species, and based the subsequent analyses in later chapters on these requirements.

2.1 Species Taxonomy and Description

The polar bear was first described by Phipps (1774, p. 185) and is one of 4 species within the genus *Ursus* which also includes American black bears (*Ursus americanus*), brown (or grizzly) bears (*Ursus arctos*), and Asiatic black bears (*Ursus thibetanus*), but is the only bear considered to be a marine mammal. The scientific classification is:

Kingdom: Animalia
Phylum: Chordata
Class: Mammalia
Order: Carnivora
Family: Ursidae
Genus: *Ursus*
Species: *maritimus*

Polar bears are the largest living bear species (DeMaster and Stirling 1981, p. 1) and have a longer neck and proportionally smaller head than other ursids. Their hair is non-pigmented and different colors are expressed depending on various factors. Fur color varies between white, yellow, grey, or almost brown, and is affected by oxidation from exposure to the air, light conditions, and soiling or staining due to contact with fats obtained from prey items (Amstrup 2003, p. 588). They are sexually dimorphic with females weighing 181 to 317 kilograms (kg) and males up to 654 kg (Service 2016, p. 61).

Polar bears evolved in sea ice habitats and are evolutionarily well adapted to Arctic environments. Their unique physical adaptations include: 1) non-pigmented pelage with water-repellent guard hairs and dense underfur; 2) a short, furred snout; 3) small ears with reduced surface area; 4) teeth specialized for a carnivorous rather than an omnivorous diet; and 5) feet with tiny papillae (dermal bumps) on the underside, which increase traction on ice (Stirling 1988, p. 25). In addition, they have large, paddle-like feet (Stirling 1988, p. 24), and claws that are used primarily for clutching prey, thus are shorter and more strongly curved than brown bear claws, and larger and heavier than those of black bears (Amstrup 2003, p. 589).

2.2 Species Distribution and Genetics

Nineteen subpopulations are recognized worldwide (Fig. 1; Aars et al. 2006b, p. 33; Obbard et al. 2010, p. 1). Subpopulations have been further classified as occurring in one of four ecoregions (Fig. 1; Amstrup et al. 2008, p. 216) based on the spatial and temporal dynamics of sea ice in the subpopulation's range. Subpopulations classified as occurring in the Seasonal Ice Ecoregion share the characteristic that the sea ice in their range fully melts in the summer, during which time bears are onshore for extended periods of time until the sea ice reforms. The

Archipelago Ecoregion has heavy annual and multi-year sea ice that fills the channels between the Canadian Arctic Islands. Bears in this ecoregion remain on the sea ice throughout the year. The Polar Basin Divergent Ecoregion is characterized by the formation of annual sea ice that is advected towards the polar basin. Conversely, the Polar Basin Convergent Ecoregion has annual sea ice that converges towards the shoreline, which allows bears access to nearshore ice year-round. Current conditions of polar bears in each ecoregion are described in Chapter 4.

Genetic diversity is low among subpopulations due to extensive population mixing, and while genetic analyses support boundaries between some subpopulations, the genetic differences are small. Several studies have found genetic differences between some subpopulations and regions (Crompton et al. 2008, p. 2533; Campagna et al. 2013, pp. 3153; Peacock et al. 2015, p. 8; Malenfant et al. 2016, p. 11; Laidre et al. 2018a, pp. 2071–2072). However, demographic and genetic exchange has occurred (Paetkau et al. 1999, entire; Crompton et al. 2008, p. 2533; Peacock et al. 2015, p. 8), and this has masked evidence of genetic partitioning; there is no evidence of genetic discontinuities for polar bears that would be consistent with significant periods of genetic isolation. The Baffin Bay (BB) subpopulation is, however, becoming increasingly isolated due to a substantial (70%) contraction of summer range (Laidre et al. 2018a, p. 2067), and the potential for both physical and genetic isolation potentially threatens other subpopulations in the future (Laidre et al. 2018a, p. 2072).

Whereas polar bears within different ecoregions have some differences in demographic parameters, behavior, or life history strategies, there is no information suggesting morphological or physiological differences across the range of polar bears which would indicate local adaptations to environmental variations. Although information is limited, the global genetic structure of polar bears appears to reflect the four ecoregions (Paetkau et al. 1999, p. 1578; Amstrup et al. 2008, p. 215; Peacock et al. 2015, p. 1).

2.2.1 Subpopulation delineation

Five countries share management responsibilities for the 19 subpopulations: Canada, Greenland, Norway, Russia, and the U.S. (collectively, the Polar Bear Range States [PBRS]). The 2008 ESA listing, the 5-year Review (Service 2017a, entire), and this SSA are based on the PBSG delineation (Fig. 1), which usually, but not always, reflects ecological boundaries. In some cases, boundaries are practical delineations for management purposes. Several methods have been used for affirming boundaries of subpopulations including genetics (e.g., Dizon et al. 1992, p. 28; Cronin et al. 2006, p. 658; Peacock et al. 2015, pp. 8–12; Laidre et al. 2018a, p. 2072), satellite radiotelemetry and movements (e.g., Bethke et al. 1996, p. 312; Mauritzen et al. 2002, p. 82; Obbard and Middel 2012, p. 136; Scharf et al. 2019, entire), and stable isotopes (e.g., Smith et al. 2022, entire). Other data informing subpopulation delineation includes differing responses to sea ice loss (Rode et al. 2014b, p. 84), and contaminant loads and/or type of contaminant (Norstrom et al. 1998, p. 365; Evans 2004a, entire; Evans 2004b, entire; Kannan et al. 2005, entire; Kannan et al. 2007, entire). Of particular importance is proper delineation of subpopulation boundaries for managing harvest (Bethke et al. 1996, p. 313; Amstrup et al. 2004, pp. 676–677). Changing

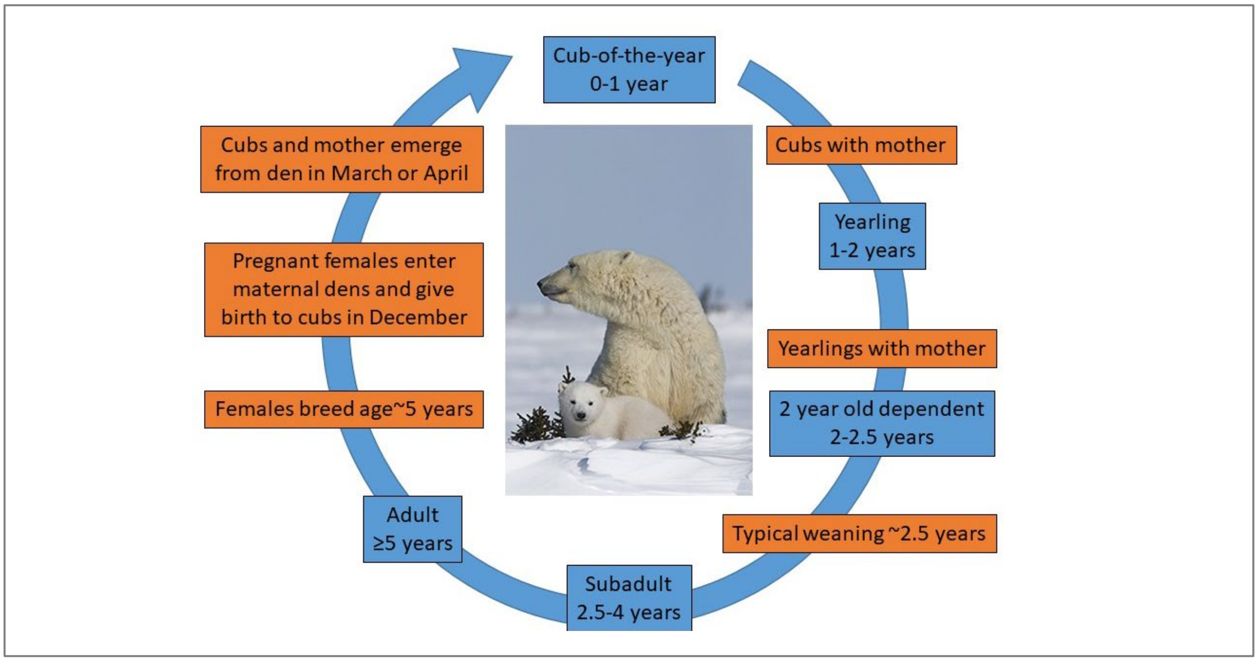

Figure 2. Lifecycle of the polar bear.

sea ice dynamics may alter subpopulation boundaries (Derocher et al. 2004, p. 172). Some subpopulations may experience more overlap than others during the ice-free season when the distribution and extent of sea ice is limited forcing bears to come together more than when ice is at its full extent. Ongoing research is necessary to ensure informed management decisions (Vongraven et al. 2018, pp. 19–22).

2.3 Life History

Polar bears are an ice-dependent species: they utilize sea ice to hunt and feed; to seek mates, breed, and den; to travel to terrestrial maternity denning areas; and to make long-distance movements (Stirling and Derocher 1993, p. 241).

2.3.1 Breeding and reproduction

Polar bears are a *K*-selected or “slow” species, characterized by late sexual maturity, small litter sizes, and extended parental investment in raising young. All these factors contribute to the species’ low reproductive rate (Amstrup 2003, pp. 598–601). Reproductive success is affected by numerous factors (e.g., nutritional condition, habitat quality, population density, lack of disturbance, etc.), although cub production and survival are strongly linked to a longer denning period (Rode et al. 2018a, pp. 22–24). Females generally mature and breed for the first time at 4–5 years and give birth at 5–6 years of age (Fig. 2). Litter size typically ranges between 1−3 cubs: litters of two cubs are most common, but 3-cub litters are seen on occasion (Amstrup 2003, p. 599). The minimum reproductive interval for adult females with a successful litter is 3 years. Most males reach sexual maturity around 6 years of age, although some may breed as young as 3 or 4 years old (Rosing-Asvid et al. 2002, p. 881; Cronin et al. 2009, p. 686; Zeyl et al. 2009, pp. 1198–1199).

Females enter a prolonged estrus between March and June when breeding occurs. Males actively seek mates during the breeding season and may travel >100 km in search of mates (Molnár et al 2008, pp. 221–222). Though female bears ovulate in the spring, implantation is delayed until autumn. The timing of implantation, and therefore the timing of birth, likely depends on body condition of the female, which is determined by many environmental factors. When foraging conditions are difficult, polar bears may delay reproduction in favor of survival (Derocher and Stirling 1992, p. 1155; Eberhardt 2002, pp. 2850–2851). Pregnant females that spend the late summer on land prior to denning may not feed for eight months (Watts and Hansen 1987, p. 311; Atkinson and Ramsay 1995, p. 560). This fasting period between early winter and spring coincides with the time when females give birth to and nourish new cubs in the den.

Denning is a critical period in polar bear life history. Females enter dens between September and December (Wiig 1998, p. 28; Laidre et al. 2015a, pp. 888–889; Rode et al. 2018a, p. 22). Phenology of den entrance varies, in part, with latitude, snow accumulation, and consolidation of sea-ice (Amstrup 2003, pp. 595–598). A successful denning period requires adequate thermal protection (e.g., sufficient snow accumulation; Harington 1968, entire; Lentfer and Hensel 1980, p. 101), time for cub maturation (Rode et al. 2018a, p. 23), a lack of natural or human disturbance (Linnell et al. 2000, entire), and security from predation (Derocher and Wiig 1999, entire). Most black and brown bears of all sex and age classes spend several months in winter inside a den in a state of metabolic dormancy to conserve energy. However, only pregnant female polar bears overwinter in dens (Ramsay and Stirling 1988, p. 605) and females are not in the same state of prolonged metabolic dormancy that other bear species experience (Amstrup 2003, pp. 598). Other sex and age classes are active throughout winter with limited short-term use of temporary dens (Messier et al. 1992, p. 228; Messier et al. 1994, p. 424–425), particularly in areas where sea ice is absent in autumn or at higher latitudes where the weather is harsher (Amstrup 2003, p. 597).

The amount of time females spend in dens varies (~106–167 days; e.g., Amstrup and Gardner 1994, p. 6; Escajeda et al. 2018, p. 93; Rode et al. 2018a, p. 24) and has been found to influence reproductive success (i.e., cub production and survival). Rode et al. (2018a, p. 24) found that females that denned through the end of March all produced and retained cubs that were observed later in the season. Conversely, roughly half of the females that emerged from dens before the end of February did not produce cubs or had cubs that did not survive. Therefore, later den emergence may increase the likelihood of cub survival (Rode et al. 2018a, p. 24).

Altricial, newborn polar bears are blind, have no teeth, and weigh approximately 0.6 kg at birth (Blix and Lentfer 1979, p. 2). Cubs grow rapidly and may weigh 10–12 kg by the time they emerge from the den in the spring. Young bears will stay with their mothers until weaning, which occurs most commonly in early spring when the cubs are 2.5 years old. Female bears are available to breed again after their cubs are weaned (Fig. 2).

2.3.2 Survival

Polar bears are long-lived with typical lifespans of approximately 25 years in the wild (Rode and Stirling 2018, pp. 743–746). Due to extended maternal care of young and low reproductive rates, high adult survival rates, particularly for females, are necessary to maintain population levels (Eberhardt 1985, p. 1008; Amstrup and Durner 1995, p. 1319). As is generally typical of ursids, survival rates are age dependent, with cubs-of-the-year (COY) having the lowest rates (approx. 40−65%; e.g., Derocher and Stirling 1996, entire; Larsen 1985, p. 323; Amstrup and Durner 1995, entire) and prime reproductive age adults (between approx. 5 and 20 years of age) having survival rates that can exceed 90% (Regehr et al. 2010, p. 121; Regehr et al. 2018, p. 6). Polar bear survival rates vary by subpopulation, however, adult female survival rates exceeding 90% are essential to sustain subpopulations (Amstrup and Durner 1995, p. 1313).

Changes in body condition have been shown to affect reproduction and survival, which in turn, can have population-level effects (Stirling et al. 1999 p. 304; Regehr et al. 2010, p. 125; Rode et al. 2010a, p. 779). Declines in body condition can occur before a statistically significant decline in abundance of the subpopulation is detected (Regehr et al. 2007, pp. 2678–2679). Declines in body size, body condition, and recruitment have also been associated with declining sea ice availability (Regehr et al. 2006, entire; Rode et al. 2010a, pp. 774–780). Additionally, multiple years of reduced sea ice has been associated with low breeding probability and survival, leading to negative population growth rate in some subpopulations (Regehr et al. 2010, p. 125). The survival of polar bear COY has been directly linked to their own and maternal body weights, with lower weights resulting in reduced survival (Derocher and Stirling 1996, p. 1250; Stirling et al. 1999, pp. 303–304).

2.3.3 Feeding

Polar bears are top predators in the Arctic marine ecosystem. On average, adult polar bears need to consume approximately 2 kg of fat per day to survive (Stirling 1988, p. 146), although fasting for up to 4 months is common during the open-water season in some subpopulations (i.e., ~July–mid-November), and denning females may go without food for longer periods (≥8 months; Watts and Hansen 1987, p. 311; Atkinson and Ramsay 1995, p. 560). They prey heavily on ice seals, principally ringed seals (*Phoca hispida*), and to a lesser extent, bearded seals (*Erignathus barbatus*). They also occasionally take larger animals such as walruses (*Odobenus rosmarus*) and belugas (*Delphinapterus leucas;* e.g., Kiliaan and Stirling 1978, p 199; Florko et al. 2020, p. 55). Research in the Canadian Arctic suggests that, in some areas and under some conditions, carrion or prey other than seals may be able to sustain polar bears when seals are unavailable (Stirling and Øritsland 1995, p. 2609; Smith et al. 2010a, p. 1152; Gormezano and Rockwell 2013, p. 544; Iles et al. 2013, p. 1376). However, across most subpopulations, use of alternate terrestrial-based prey sources does not prevent declines in body condition when seals are unavailable (Rode et al 2015b, p. 144). Similarly, bears in some subpopulations may be limited in their ability to meet energy requirements using alternate marine prey recourses when availability of ringed seals is reduced (Rode et al. 2023, p. 15).

The onshore remains of bowhead whales (*Balaena mysticetus*) from subsistence harvest, strandings, or orca (*Orcinus orca*) predation have been an important and seasonally reliable food source in some regions, including the southern Beaufort Sea, Svalbard, and Chukotka, Russia (Miller et al. 2015, p.1318; Galicia et al. 2016, p. 6006; Wilson et al. 2017, p. 292; Laidre et al. 2018b, p. 520; Lillie et al. 2019, entire). Although the nutritional equivalent of a whale varies with species, mass, and state of remains (i.e., whether or not it was harvested and butchered or a whole stranded carcass), a single whole whale carcass can provide the same nutrition as ~1,300 ringed seals (as determined from mass equivalents; Laidre et al. 2018b, p. 518). Field observations of polar bear body condition (see body condition index in Stirling et al. 2008, entire) when feeding on bowhead whale remains in the autumn suggest an improvement in condition over just a few weeks (Miller and Reed 2015, p. 2). However. these observations did not include marked bears, making it challenging to evaluate the real contribution of whale remains to individual body condition. Some research has suggested that the energetic costs associated with sea-ice decline could be mitigated by whale carcasses as a food source for some subpopulations, yet the reliability and state (i.e., whole, or partial) of whale carcasses in the future is uncertain (Laidre et al. 2018b, p. 522). Additionally, recent work has found that whale consumption in SB was unable to compensate for energy deficits during times of reduced seal availability (Rode et al. 2023, p. 15). Polar bears are opportunistic feeders and will also feed on human garbage (Lunn and Stirling 1985, p. 2295). In addition, when confined to land for long periods, they have been shown to consume plants and other terrestrial foods (Russell 1975, pp. 122–127; Derocher et al. 1993, p. 252; Smith et al. 2010a, pp. 1150–1152; Gormezano and Rockwell 2013, p. 3514; Jagielski et al. 2021a, entire), although the relevance of such foods to the long-term welfare of polar bears is limited by their patchy availability and relatively low nutritional content compared to marine food recourses (Derocher et al. 2004, p. 169; Rode et al. 2010b, p. 1520; Rode et al. 2015b, p. 143; Jagielski et al. 2021b, entire).

Body condition and size affect reproduction and influence subpopulation trajectories in polar bears. In SB from 1982–2006, average body size of polar bears >3 years old declined and the size of young, growing bears was smaller after years when sea ice availability was reduced (Rode et al. 2010a, p. 768). Litter mass (i.e., total mass of cubs in a litter) and cub recruitment also declined over that period (1983–2015; Atwood et al. 2021, pp. 8–9, 11). Additionally, in CS where there were half as many reduced ice days (i.e., days with lower-than-normal percent ice cover) over continental shelf waters from 2008–11 compared to SB, bears were larger, in better body condition, and had higher reproductive rates (Rode et al. 2014b, p. 81). Similar patterns were observed in BB, Davis Strait (DS), and Southern Hudson Bay (SH) subpopulations, where declining body condition likely resulted from reductions in sea-ice habitat (Rode et al 2012, p. 11; Obbard et al. 2016, entire). Additionally, Sciullo et al. (2017, entire) reported declines in body condition concurrent with declining abundance in Western Hudson Bay (WH). The significant relationship between several of these measures and sea ice cover over the continental shelf suggests that nutritional limitations are associated with changing sea-ice conditions.

2.4 Ecological Requirements

Ecological requirements for individuals, populations, and the species are discussed in detail in the sections following.

2.4.1 Individuals and populations

Subpopulations principally have the same requirements as individuals (see *2.3 Life History*, *2.4.3 Species*) but on a larger scale. Most importantly, sea ice conditions and primary prey (i.e., ringed seal) densities and body condition (Rode et al. 2021, entire) must be capable of supporting numerous bears with sufficient breeding opportunities and consistent survival and recruitment rates that exceed, or at least match, mortality rates (see *3.1.1 Loss of access to prey* and *3.1.2 Declining prey abundance*). Even when conditions are poor (e.g., a year of low ringed seal density or extraordinary sea ice loss) the habitat conditions must be adequate to rebound to levels where the population could recover through growth of the residential population or potentially immigration. Additionally, habitat needs to have a low likelihood of human-bear conflict (see section *3.3.3 Human-bear conflicts*) with opportunities to support other bears of the opposite sex with which to breed successfully (*2.4.3 Species*).

Adult female survival (and associated production of offspring) drives population growth and must average ≥90% for a population to remain stable (Amstrup and Durner 1995, p. 1319; Regehr et al. 2015, pp. 19–32, 38). The theoretical maximum population growth rate for the species is approximately 6–14% (Taylor et al. 2009, pp. 791–792), but may be less if habitat loss or other factors affect subpopulations negatively through density-independent effects. Several population viability analyses have been published for polar bears across their range, mostly in harvested subpopulations (Taylor et al. 2006, entire; Taylor et al. 2008, entire; Taylor et al. 2009, entire; Regehr et al. 2021a, entire, Regehr et al. 2021b, entire). Additionally, adult females need access to maternal denning habitat (see *Denning* below, and *3.1.4 Loss of denning habitat*), and their newly independent offspring (~2.5-years old) also need adequate prey and sea-ice habitat to support their dispersal and eventually reproduction.

2.4.2 Species

As a species, polar bears need multiple resilient subpopulations across their range (i.e., redundancy) with a wide range of ecological and genetic diversity (i.e., representation) for long-term species persistence. According to the Service's recovery criteria under the ESA, this means each ecoregion must maintain an abundance of >100 individuals or >15% of the ecoregion abundance (whichever is greater) at the time of listing (i.e., 2008; Service 2016, p. 25). For large mammals, the effects of demographic stochasticity become prominent at population sizes <100 (Wielgus 2001, pp. 298–300). Depending on population-specific demographic parameters and sex- and age-structure, mating success may decline with declines in subpopulation density and thus access to potential mates (i.e., Allee effect; Molnár et al. 2008, pp. 221–224; Molnár et al. 2014, pp. 5–11).

Habitat

Ensuring conservation of polar bears also means maintenance of the health and stability of the marine ecosystem, as well as maintaining polar bears as a significant functioning element of the ecosystem (Service 2016, entire). The individual-, subpopulation-, and species-level requirements necessitate adequate sea-ice conditions to facilitate all aspects of polar bear life history. Polar bears prefer certain sea-ice stages, concentrations, forms, and deformation types (Arthur et al. 1996, pp. 221–223; Mauritzen et al. 2001, p. 1710; Durner et al. 2009, pp. 51–52; Wilson et al. 2014, pp. 8–12), and have been shown to select for the floe ice edge, stable shore-fast ice with drifts, and moving ice (Stirling et al. 1993, pp. 18–19). Annual ice found over the continental shelf and surrounding islands are the most biologically productive and provide the highest ringed seal densities, making them preferred habitat for polar bears (Durner et al. 2009, p. 55; Stirling 2009, entire). Declines in survival have been linked to declines in the amount of sea ice over the continental shelf (Regehr et al. 2010, p. 121).

Although polar bears in much of their range have historically spent most of their life on the sea ice, land is increasingly important for denning and summer refugia (Kochnev 2002, entire; Ovsyanikov 2012, entire; Fischbach et al. 2007, p. 1402; Rode et al. 2015a, pp. 7–11; Atwood et al. 2016b, pp. 9–12). Given that the extent of summer sea ice is projected to decline through the 21st century (Overland and Wang 2013, p. 2100; Barnhart et al. 2016, entire; Douglas and

Atwood. 2022, entire), terrestrial habitat will become increasingly important for polar bears. Access to food sources and terrestrial denning areas before and after the denning period are important to minimize potential impacts to reproduction and cub survival from sea-ice loss (Derocher et al. 2004, pp. 165–167).

Access to prey

The formation and movement patterns of sea ice strongly influence the distribution and accessibility of ringed and bearded seals (Frost et al. 2004, pp. 120–126; Ferguson et al. 2005, pp. 126, 131–132; Cameron et al. 2010, p. 189). In some ecoregions, the shore-fast ice zone (i.e., ice that is attached to the shore or ocean floor) is important habitat (along with all pack ice) for ringed seals to construct subnivean (under the snow) birth lairs for pupping, and thus important foraging habitat for polar bears during spring (Stirling et al. 1993, pp. 18–22). Shore-fast ice is used by polar bears for feeding on seal pups, for movement, and occasionally for maternity denning (Stirling et al. 1993, pp. 18–22). In protected bays and lagoons, shore-fast ice typically forms in autumn and remains stationary throughout winter. Shore-fast ice usually occurs in a narrow belt along the coast and melts in the summer.

During the winter and spring when energetic demands are the greatest, lead systems (i.e., cracks in the ice where bears can hunt hauled-out seals) and polynyas (areas of open sea surrounded by sea ice) are important for seals and therefore important foraging habitat for polar bears (Trukhanova et al. In Review, entire). Availability and accessibility of prey during primary feeding periods is critical for survival through the winter months, although polar bears in different areas achieve their heaviest weight at different times of year. For example, bears in Hudson Bay reach their peak weights in summer (Fischbach et al. 2007, p. 1403) while bears in SB are estimated to reach their peak weights during autumn and early winter (Durner and Amstrup 1996, pp. 481–482).

Breeding

Breeding occurs between March and June (Schliebe et al. 2006, p. 17). Polar bears depend on sea ice as a habitat to seek mates and breed (Ramsay and Stirling 1986, pp. 2148–2149; Stirling et al. 1993, pp. 21–22). The probability that adult females will survive and produce COY has been shown to be negatively correlated with longer ice-free periods over the continental shelf (e.g., SB; Regehr et al. 2006, pp. 7–14). In addition, the variable nature of sea ice results in an ever-changing distribution of suitable habitat for polar bears and eliminates any benefit to defending individual territories (Schliebe et al. 2006, p. 34), thus territory defense does not occur in polar bears. Males must be free of the need to defend territories if they are to maximize their potential for finding mates each year (Ramsay and Stirling 1986, pp. 2148–2149; Schliebe et al. 2006, p. 34). Other barriers to successful breeding include Allee effects due to limitations on finding mates (Taylor et al. 2006, p. 1672) associated with sex-selective harvest *(*Molnár et al. 2008, pp. 223–224; Molnár et al. 2014, entire) or contaminant-induced reproductive failure in males (Pavlova et al. 2016, entire).

Denning

Throughout the polar bear’s range, pregnant females typically excavate dens in snow drifts located on land near the coastline in the autumn and early winter (Ramsay and Stirling 1990, entire; Amstrup and Gardner 1994, pp. 5–8; Durner et al. 2010, entire; Andersen et al. 2012, p.

500); however, some subpopulations still have a proportion of dens that occur on sea ice (Florko et al. 2020, pp. 618−619; Patil et al. 2022, p. 10). The key characteristic of snow drift denning habitat is a topographic feature that catches snow on its leeward side in the autumn and early winter as successful denning requires accumulation of sufficient snow for den construction and maintenance (Durner et al. 2003, pp. 58–59; Liston et al. 2016, pp. 126–133). Liston et al. (2016, p. 132) suggested that polar bears need snow drifts that are at least 2 m deep to successfully maintain a maternity den throughout the denning season.

Maternal dens typically occur on land (i.e., barrier islands, coast) as well as drifting pack ice (Ramsay and Stirling 1990, entire; Amstrup and Gardner 1994, p. 5; Amstrup 2003, pp. 595–596; Durner et al. 2003, pp. 58–59; Durner et al. 2006, entire; Durner et al. 2010, entire; Durner et al. 2013, pp. 201–204; Durner et al. 2020, entire). However, in Hudson Bay, female polar bears enter dens prior to the accumulation of significant snow and instead dig earthen dens (Ramsay and Stirling 1990, entire; Clark et al. 1997, entire; Richardson et al. 2005, entire) often >50 km from the coastline (Stirling et al. 1977, p. 30; Kolenosky and Prevett 1983, entire). Topographic features (i.e., bank height, slope, aspect), however, are similar at earthen dens and expand into drifted snow as winter progresses (Jonkel et al. 1972, p. 146; Ramsay and Stirling 1990, entire; Clark et al. 1997, p. 162).

In some regions, bears exhibit fidelity to denning areas on land (Ramsay and Stirling 1990, entire; Amstrup and Gardner 1994, p. 6; Scott and Stirling 2002, pp. 160–162; Zeyl et al. 2010, pp. 1142–1145). Although fidelity is more related to denning substrate (ice versus land) as opposed to spatial fidelity (Amstrup and Gardner 1994, p. 6; Amstrup 2003, p. 596). In some areas, most polar bear denning occurs in core areas (Harington 1968, p. 8; Stishov 1991, pp. 90–92; Ovsyanikov 2005, p. 171), which show high repeated use over time, while in other portions of the species' range, polar bears den in a more diffuse pattern with dens scattered over larger areas at lower density (Stirling and Andriashek 1992, pp. 364–365; Amstrup and Gardner 1994, p. 5; Ferguson et al. 2000, pp. 1122–1125). As sea ice declines and the availability of sea ice suitable for denning decreases, terrestrial denning habitat will become more important (Fischbach et al. 2007, p. 1403; Atwood et al. 2016b, pp. 9–12; Patil et al. 2022, p. 15).

2.5 Summary of Species Needs in Terms of the 3 "Rs"

To maintain resilient subpopulations, polar bears need sufficient resources (e.g., access to ice seals, denning habitat) to maintain or increase survival and reproductive success and support adequate numbers of bears across subpopulations. In order to adapt to changing physical and biological conditions, multiple resilient subpopulations (redundancy) representing ecological, behavioral, and genetic diversity (representation) are required (Fig. 3; discussed in Chapter 3).

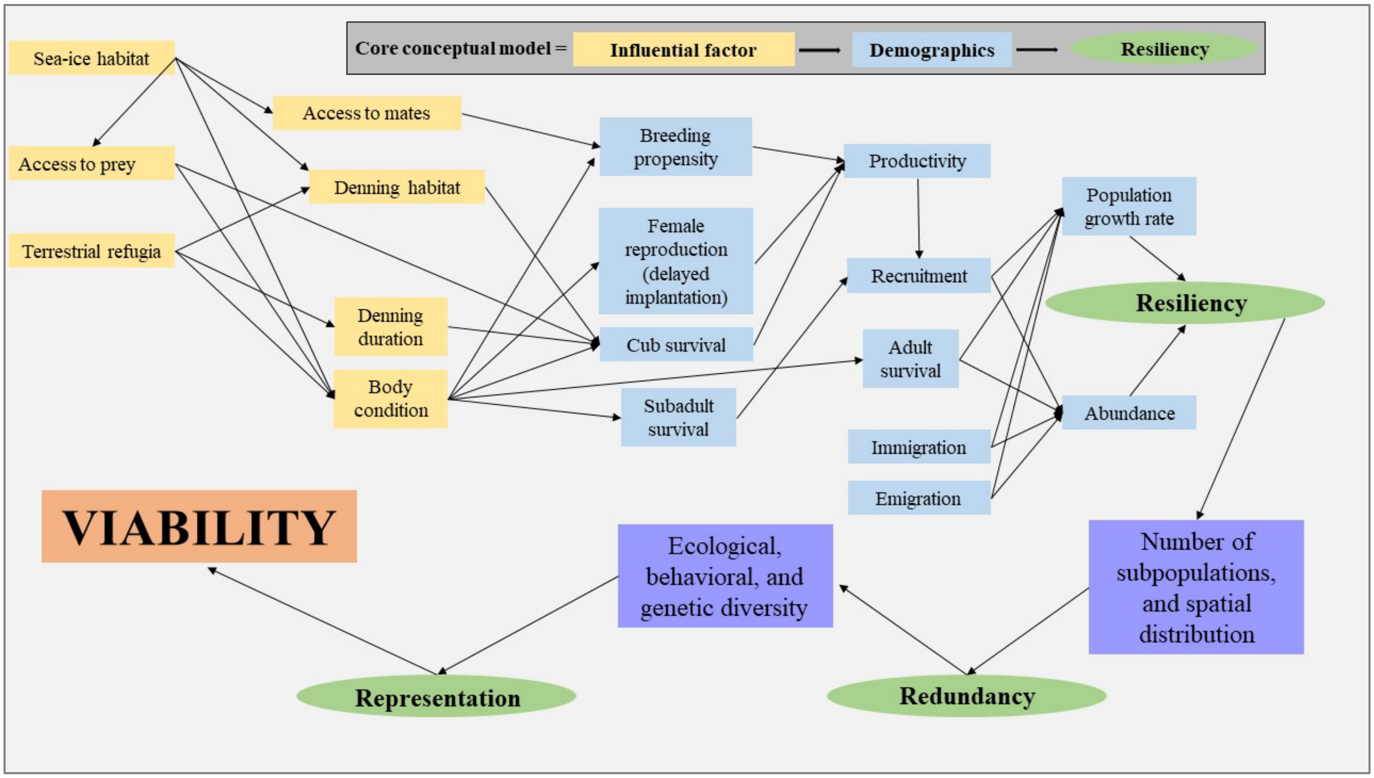

Figure 3. Conceptual diagram of the factors that influence polar bear demographics, and in turn, resiliency, redundancy, and representation (the three R's). The three R's ultimately influence the viability of the global polar bear population.

Chapter 3: Factors Influencing Viability of the Species

Polar bears evolved to use the Arctic sea-ice niche and are distributed throughout most ice-covered seas of the Northern Hemisphere. However, polar bear habitat, principally sea ice, is declining throughout the species' range and this decline is expected to continue (Douglas 2010, pp. 7–12; Stroeve et al. 2012, entire; Thackeray and Hall 2019, entire). In 2008, the Service determined that the polar bear was threatened throughout its range by habitat loss (i.e., sea ice recession; 73 FR 28212). Additionally, no known regulatory mechanisms are in place at the national or international level that directly and effectively address the range-wide loss of sea ice habitat. We determined that overutilization (i.e., harvest) did not threaten the species, but that it was exacerbating the effects of habitat loss for several subpopulations and may become a more significant threat within the foreseeable future. We also determined that contaminants, disease, and predation, in particular intraspecific predation, did not threaten the species, but again may become more significant threats for subpopulations within the foreseeable future, especially those experiencing nutritional stress or declining abundance. Research published since listing indicates the threats identified in the 2008 decision remain; this section will focus on those threats and any additional threats identified, as well as any conservation actions that may influence the species.

Multiple interrelated events with cumulative effects have changed the extent and characteristics of sea ice during all seasons, particularly during summer. Sea ice continues to rapidly thin and retreat throughout the Arctic (Douglas 2010, pp. 7−12; Maslanik et al. 2011, entire; Stroeve et al. 2012, entire; Stroeve et al. 2014, pp. 1217–1224; Stern and Laidre 2016, pp. 2032–2039) and there remain no mechanisms in place to address this threat. Sea ice cover is negatively correlated with surface temperature, which is increasing in the Arctic at about 3 times the global average (Comiso 2012, pp. 1186–1189). Sea ice loss in the Arctic has progressed faster than most climate models have predicted (Stroeve et al. 2007, entire), and the minima of sea ice extent in September has declined linearly at 14% per decade from 1979 through 2011 (Stroeve et al. 2012, pp. 2–3; Stroeve et al. 2014, pp. 1217–1224). In September 2021, the minimum sea ice extent was greater than in recent years but was still 8% lower (0.5 million km^2) than the 1991–2020 average (Copernicus Climate Change Service 2021). The fifteen lowest sea-ice extents ever recorded have been in the last 15 years (Meier et a. 2021, p. 32). The world's warmest years on record since 1880 were 2015–21 (World Meteorological Organization 2021, entire). Arctic warming is likely to continue for several decades given the current trends in global GHG emissions (IPCC 2021, p. SPM-17), the long persistence time of certain GHGs in the atmosphere (Moore and Braswell 1994, entire), and the lag times associated with global climate processes attaining equilibrium (Mitchell 1989, entire; Hansen et al. 2011, entire). Hence, climate change effects on sea ice, polar bears, and their prey will likely continue for several decades or longer unless GHG levels can be substantially lowered by reducing human-caused emissions.

The most influential driver of adverse outcomes for polar bears in the future will be declines in the sea-ice conditions and the subsequent impacts to the marine prey base (Atwood et al. 2016a, entire). Mortality from *in situ* anthropogenic factors such as, harvest and defense of life removals, will exert considerably less influence on future outcomes for polar bear populations, while stressors such as trans-Arctic shipping, industrial development, and point-source pollution

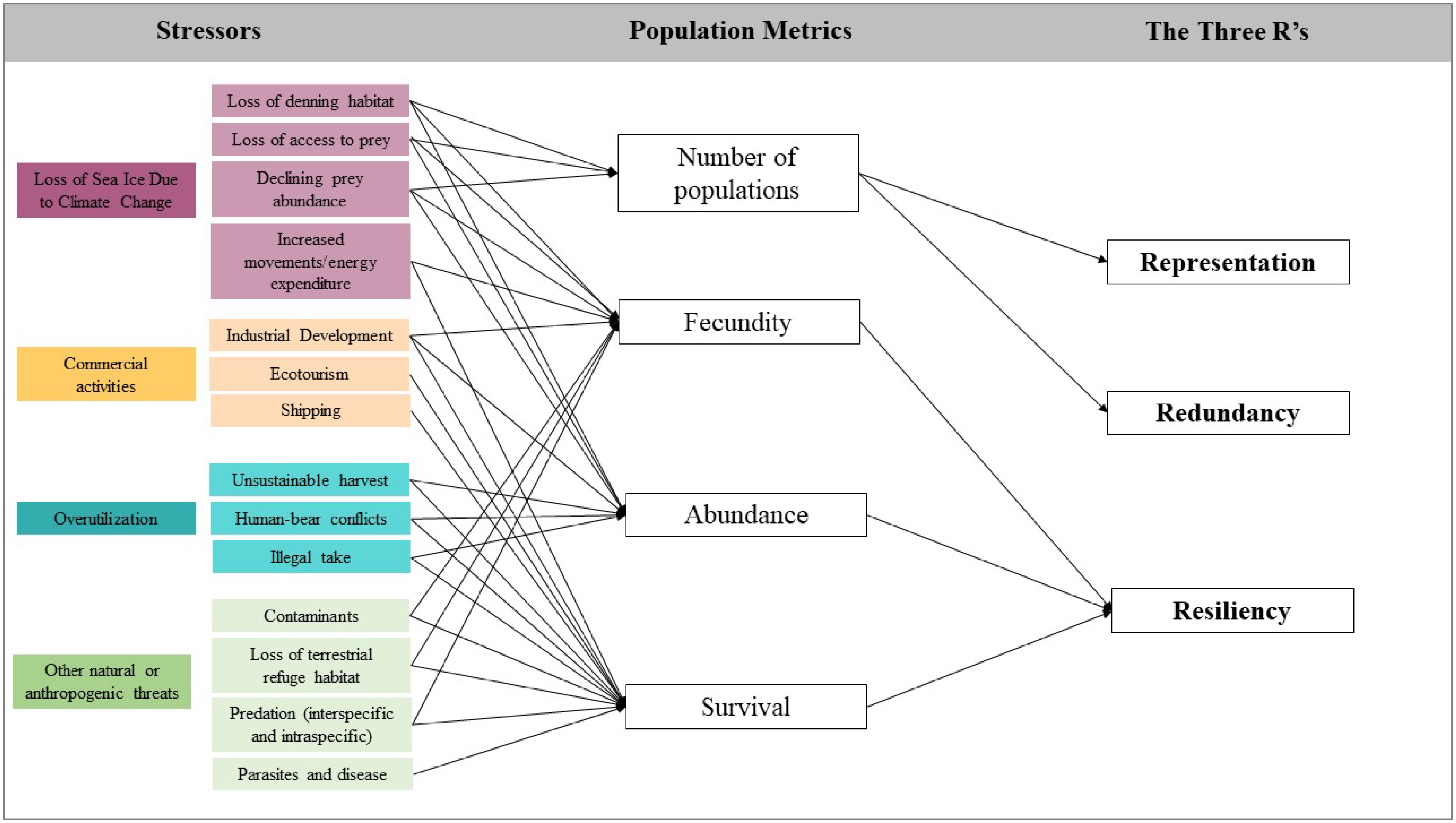

Figure 4. Interactions and relationships between the threats to polar bears [similar to Atwood et al. (2016a), pp. 5–8] and their influence on species viability relative to the 3Rs: representation, redundancy, and resiliency.

are predicted to have negligible effects. Below, we discuss the various factors that have been identified as currently or potentially affecting the species viability; specifically, the interactions and relationships between the threats and their influence on viability (Fig. 4).

3.1 Loss of Sea Ice due to Climate Change

As identified in the listing of polar bear as a threatened species under the ESA, the decline of sea ice habitat due to changing climate continues to be the primary threat (73 FR 28211). Additionally, at the international level, the PBRS identified climate change and its effects on the extent and composition of sea ice as the largest circumpolar threat to polar bears (PBRS 2015, p. 31). Sea ice is rapidly thinning and retreating throughout the Arctic. Changes in ice volume, extent, and fragmentation, and seasonal loss of sea ice of biologically productive waters, and reduction in heavy, stable, multi-year ice (e.g., Sahanatien and Derocher 2012, entire; Lindsay and Schweiger 2015, entire; Stern and Laidre 2016, entire) are all changes that will affect polar bear habitat. Although the thinning of thick, multi-year ice may result in transient improvement in sea ice habitat (e.g., Laidre et al. 2020b, entire), these combined and interrelated events change the extent and quality of sea ice during all seasons, but particularly during the spring-summer period (Service 2016, p. 11).

Polar bears evolved over thousands of years to life in a sea-ice environment, and they depend on the ice-dominated ecosystem to support essential life functions (Service 2016, p. 64). The sea-ice ecosystem supports ringed seals, the primary prey for polar bears, and other important marine food resources (Stirling and Archibald 1977, entire; Smith 1980, entire, 1985, entire; Iverson et al. 2006, entire). Polar bears continue to rely heavily on sea ice for essential functions (Laidre et al. 2020a, pp. 6–15), and there is no new information available suggesting that the threat of climate change on polar bears has been reduced. Further, climate change will continue to affect sea ice in the Arctic for the foreseeable future. Due to the long persistence time of certain GHGs in the atmosphere, the current and projected patterns of GHG emissions over the next few decades, and interactions among climate processes, climate changes over the next 20–30 years are already largely established (IPCC 2021, p. SPM-17). Detrimental effects of climate change on sea ice (Douglas and Atwood 2022, entire) and polar bears will continue during this time, and likely further into the future (Atwood et al. 2016a, entire).

The ultimate effect of reduced sea ice extent will be a decline, or continued decline, in abundance and distribution. With a diminished sea ice platform, polar bear distribution and seasonal proportion of the population onshore will change (Rode et al. 2015a, pp. 7–15; Rode et al. 2022, pp. 8–12). However, not all subpopulations will be affected equally in the level, rate, and timing of effects (Atwood et al. 2016a, pp. 10–18). In some subpopulations, the physiological and demographic effects of longer ice-free periods are already evident (Regehr et al. 2010, pp. 121–125; Rode et al. 2014b, pp. 80–86; Bromaghin et al. 2015, pp. 641–648) and polar bears have exhibited behavioral responses to longer ice-free periods, including spending more time on land during the summer (Schliebe et al. 2008, pp. 1005–1008; Rode et al. 2015a, pp. 7–15; Atwood et al. 2016b, p. 9–15; Pongracz and Derocher 2017, entire; Rode et al. 2022, pp. 8–12). Given the predicted growth of ice-free periods, these behavioral changes are anticipated to continue and are expected to lead to an increase in adverse population-level demographic effects in the future (e.g., Molnár et al. 2020, entire).

The continued retraction and fragmentation of sea ice habitat will also alter habitat use patterns, both seasonally and regionally. Polar bear movements and seasonal fidelity to certain habitat areas and/or substrates are changing in relation to simultaneous changes in sea ice (Rode et al. 2015a, pp. 7–14; Atwood et al. 2016b, pp. 9–15; Wilson et al. 2016, pp. 3–7). For example, bears in East and Southeast Greenland have been found to use glacial mélange as a platform to hunt seals during the ice-free season (Laidre et al. 2022, p. 1) .There is also the potential for large-scale shifts in polar bear distribution by the end of the 21st century (Durner et al. 2009, entire). Polar bears were noted in open water of SB and on land during surveys in 1997–2005, when sea ice was often absent from the study area, compared to 1979–96 surveys, when sea ice was predominant in the area (Gleason and Rode 2009, pp. 409–410). Additionally, the number of polar bears on land was higher during years (2000–05) when sea ice retreated further offshore (Schliebe et al. 2008, pp. 1005–1008). Similarly, distribution of polar bears in the Barents Sea subpopulation (BS) is changing as the distance between the pack ice and the islands of Svalbard increases (i.e., creating two ecotypes of bears; Aars et al. 2017, p. 11). This trend of increasing distance between land and sea ice over time will likely continue to be associated with an increase in the number or proportion of polar bears on land and/or an increase in the duration of time polar bears spend on land. Degrading sea ice habitat can also result in increased energetic demands due to increased movement and activity rates (Durner et al. 2017, entire; Pagano et al. 2020, entire).

Changes in movements and seasonal distributions associated with climate change can affect nutrition and body condition (Stirling and Derocher 2012, pp. 2697–2699). In the WH, sea ice break-up has occurred approximately 7–8 days earlier per decade since the late 1970s because of increasing spring temperatures (Stirling and Parkinson 2006, p. 265), which was also correlated with the time female bears came ashore and when they are able to return to the ice (Cherry et al. 2013, pp. 916–917, 919). Similarly, changes in summer sea ice conditions have resulted in an increase in the time spent on land during the summer and the proportion of the subpopulation on land in both SB and CS (Rode et al. 2015a, pp. 7–12; Atwood et al. 2016b, p. 9).

Declines in reproductive rates, subadult survival, body condition, and body mass have occurred because of longer fasting periods on land resulting from progressively earlier sea-ice break-up (Stirling et al. 1999, entire; Derocher et al. 2004, entire; Lunn et al. 2016, p. 1303; Galicia et al. 2020, pp. 843–847). In WH, the sea ice decline has led to a reduction in reproduction (e.g., number of yearlings produced per female) and abundance (Regehr et al. 2007, p. 2678). Similarly, Rode et al. (2010a, pp. 774–780) suggested declining sea ice has resulted in reduced body size and reproductive rates within SB. Earlier sea ice break-up also shortens the important period of spring feeding as access to prey becomes more limited, leading to declines in body condition. Galicia et al. (2020, pp. 843–847) noted the importance of spring and summer feeding in several Canadian subpopulations.

The increased use of land by polar bears has diverse implications. If polar bears spend more time on land during the ice-free season (late summer through early autumn), there is potential for increased disease transmission (Kirk et al. 2010, pp. 329; Wiig et al. 2015, pp. 8–9) due to exposure to terrestrial based pathogens or through increased exposure to marine pathogens when polar bears form aggregations at sites where the remains of subsistence harvested whales are deposited (e.g., Barter and Cross islands, Alaska; Atwood et al. 2017, entire). Such aggregations are also more susceptible to impacts from potential oil spills [Bureau of Ocean Energy Management (BOEM) 2015a, p. 298]. Increased use of onshore habitat by polar bears has also led to higher incidences of human-polar bear conflict (Dyck 2006, pp. 57–58; Towns et al. 2009, pp. 1534–1536). In northern Canada, the majority of polar bears killed in defense of life occurred during the ice-free season (Stenhouse et al. 1988, p. 277; Dyck 2006, p. 57). Thus, as more polar bears come onshore during summer where they have a greater spatial overlap with people, there is an increased risk of negative human-bear interactions and conflict-associated removals of bears (see *3.3.3 Human-bear conflicts*). Increases in human-caused removals associated with conflict not only have a negative impact on polar bears, but could also disrupt industrial, recreational, and/or subsistence activities. For example, polar bears in the SB removed due to conflict could impact the number of polar bears available for subsistence harvest and/or that could be permitted to be incidentally taken by industrial activities. Additionally, an increase in human-polar bear conflicts that result in the removal of polar bears could impact the daily activities of industry due to concerns for human safety. In the 2008 ESA listing (73 FR 28212), the Service reviewed existing regulatory mechanisms and determined that potential threats to polar bears from direct take, disturbance by humans, and incidental or harassment take are, for the most part, adequately addressed by existing regulatory mechanisms.

There are no regulatory mechanisms in place at the national or international level that directly and effectively address the primary threat to polar bears: the range-wide loss of sea ice habitat currently or in the foreseeable future. Since 2008 there have been no new mechanisms implemented that effectively regulate GHG emissions, which are contributing to global climate change and associated modifications to polar bear habitat. However, governments and concerned organizations are trying to address climate change impacts on a global level. At the Paris Climate Conference held in December 2015, 195 countries adopted the first universal, legally binding global climate agreement. This agreement presented a global action plan meant to limit global warming to below 2° C by the end of the century (European Commission 2016). On 22 April 2016, all five countries with subpopulations signed the Paris Agreement. On 1 June 2019, the U.S. announced their intent to withdraw from the Paris Agreement, and on 4 November 2019, the U.S. formally notified the United Nations that the U.S. would withdraw (effective 1 year later). However, on 20 January 2021, the U.S. rejoined the Paris Agreement. At the 2021 Convention on Climate Change in Edinburgh, Scotland, countries reaffirmed their commitment to limiting the increase in global temperature by pursuing the development of sources of renewable energy and curbing GHG emissions.

3.1.1 Loss of access to prey

Reduced duration of sea ice over shallow, productive waters of the continental shelf will likely have significant impacts on polar bears' ability to access prey (Durner et al. 2009, pp. 52–53; Castro de la Guardia et al. 2013, p. 2679; Hamilton et al. 2014, pp. 4–5; Galicia et al. 2020, pp. 843–847). Continued declines in sea ice are expected in the future and without sea ice polar bears lack a platform to access their primary prey. Longer melt seasons and reduced summer ice extent have forced polar bears to increase use of habitats where hunting success is reduced (Derocher et al. 2004, pp. 167–169; Stirling and Parkinson 2006, pp. 266–267, 270–271; Prop et al. 2015, p. 8). Summer sea ice habitat that is highly selected by polar bears in CS has declined by 75% in the past 30 years (Wilson et al. 2016, p. 5). Once sea ice concentration drops below 50%, polar bears have been documented to quickly abandon sea ice for land, where access to their primary prey is almost entirely absent. Alternatively, polar bears may also retreat northward with the more consolidated pack ice over the polar basin, which may be less productive foraging habitat. In both instances, polar bears are likely to find limited prey items and employ energy saving strategies such as limiting activity (Whiteman et al. 2015, p. 296; Ware et al. 2017, p. 96).

The northward retreat of some polar bears is most likely related to the tradeoffs associated with reduced hunting success in broken ice with significant open water, and the need to reduce energetic costs once prey availability and food intake drop below some threshold (Stirling et al. 1999, pp. 299–300, 303–304; Derocher et al. 2004, p. 167). Hamilton et al. (2017, pp. 1057–1063) documented a decrease in spatial overlap between ringed seals and polar bears with declining sea ice in Svalbard, Norway. They noted a concomitant increase in daily distance moved by polar bears between 2002–04 and 2010–13. Another study found that polar bears are increasingly found on ice over less productive waters in summer, with activity levels indicating they are not hunting (Ware et al. 2017, pp. 93–95). Similarly, Whiteman et al. (2015, p. 296) found that bears summering on sea ice had similar activity rates and internal temperatures to those on land, indicative of fasting. During summer, ice seals typically occur in open water and are therefore largely inaccessible to polar bears (Harwood and Stirling 1992, p. 897). Polar bears have occasionally been reported to capture ringed seals in open water (Furnell and Oolooyuk 1980, entire), although hunting in ice-free water will not likely compensate for the loss of sea ice and the hunting opportunities it affords (Stirling and Derocher 1993, p. 243; Derocher et al. 2004, pp. 167–169).

There is evidence that the potential for mortality from fasting may increase after 180 days (Pilfold et al. 2016, entire). Although, given sufficient access to prey during other times of year, polar bears may be capable of persisting with an average ice-free period of 4 months or less. Current data indicates progressively earlier sea-ice break-up and longer fasting periods have resulted in declines in reproductive rates, subadult survival, body condition, and body mass (Stirling et al. 1999, pp. 297–305; Derocher et al. 2004, entire; Regehr et al. 2007, pp. 2677–2681; Rode et al. 2012, pp. 4, 10-–12; Lunn et al. 2016, p. 1303; Galicia et al. 2020, pp. 843–847). Observations of polar bears eating terrestrial-based foods have been increasing (Rockwell and Gormezano 2009, entire; Dey et al. 2017, entire; Stempniewicz et al. 2021, pp. 2200–2203; Jagielski et al. 2021a, p. 64). However, with a few exceptions (i.e., remains of subsistence harvested bowhead whales; Rogers et al. 2015, pp. 1040–1046; Whiteman et al. 2015, pp. 296–297), research generally indicates consumption of terrestrial foods such as blueberries (*Vaccinium* spp.), snow geese (*Anser caerulescens*), and reindeer (*Rangifer tarandus*), likely cannot replace the energy-dense diet obtained from marine mammals (e.g., Derocher et al. 2004, pp. 167–169; Rode et al. 2010b, entire; Rode et al. 2015b, pp. 142–143), particularly during an extended ice-free period (Rode et al. 2010a, p. 780; Dey et al. 2017, entire). Another alternative prey source, muskoxen (*Ovibos moschatus*), have been successfully hunted by polar bears on Wrangel Island, Russia (Ovsyanikov 2011, p. 2), although they are not known to be regularly preyed upon (Brooks and Richardson 2002, p. 193).This may be attributed to their life history strategy of being a sit and wait predator when on the sea ice (Pagano et al. 2018, pp. 568–569), which results in the propensity to overheat during activity and may hinder their ability to chase down prey.

Reduced access to preferred prey (i.e., ice seals; Thiemann et al. 2008, entire) is likely to have demographic effects on polar bears. For example, in SB, the period when sea ice is over the continental shelf has decreased significantly over the past decade, resulting in reduced body mass and productivity (Rode et al. 2010a, pp. 774–777; Rode et al. 2014b, pp. 80–86) and likely reduced population size (Bromaghin et al. 2015, p. 647). It should be noted, however, that there is considerable variation and uncertainty in the status of subpopulations as demographic effects of sea ice loss have been documented in only a few of the 19 subpopulations (Table 1) with apparent differences between information types (i.e., western science and IK). For example, Rode et al. (2014b, entire; Rode et al. 2021, p. 14) found that even though sea ice loss during summer had been substantial in the Chukchi Sea, polar bears in that subpopulation have not exhibited concomitant declines in body condition or mass and productivity.

3.1.2 Declining prey abundance

Subpopulations are known to fluctuate with prey abundance (Stirling and Lunn 1997, p. 176). Regional declines in ringed and bearded seal numbers and productivity have resulted in marked declines in productivity in some subpopulations (Stirling and Øritsland 1995, p. 2607; Stirling 2002, entire). Ringed seal populations are known to exhibit natural fluctuations, but there is concern that longer-term population declines associated with reduced sea ice might be overlaid with natural fluctuations (Chambellant et al. 2012, p. 278). However, ringed seal population dynamics are a complex mix of biotic and abiotic factors (Ritchie 2018, pp. 27, 50), making it difficult to understand the direct influence of sea ice loss on population demography.

Accurate population estimates and trends for the many of Arctic seal species important to polar bears are unavailable. In 2012, the National Marine Fisheries Service (NMFS) listed two polar bear prey species, the Arctic subspecies of ringed seal (*Phoca hispida hispida*) and the Beringia Distinct Population Segment (DPS) of bearded seal (*Erignathus barbatus nauticus*) as threatened under the ESA due to climate change (77 FR 76706; 77 FR 76740).

Diminishing ice and snow cover are the greatest challenges to the persistence of ringed seals. In some populations, ringed seals are thought to be increasing their foraging efforts due to changing environmental conditions, and the resulting increased energy expenditure could potentially lead to population-level consequences (Hamilton et al. 2015, p. 5). Additionally, within the century, snow cover is projected to be inadequate for the formation and occupation of subnivean birth lairs over most of the species' range (Kelly et al. 2010a, pp. 41–48, 104–110; Iacozza and Fergusson 2014, pp. 818–819, 828–829). The thickness of the snow layer surrounding birth lairs is crucial for thermoregulation, and hence the survival of nursing pups when air temperatures are below freezing (Stirling and Smith 2004, p. 65). Stirling and Smith (2004, p. 66) postulated that should early season rain become more frequent and widespread in the future, mortality of ringed seal pups will increase, especially in more southerly parts of their range. Rain-on-snow events during the late winter have increased in terrestrial systems (Arctic Climate Impact Assessment 2005, pp. 43–44), and if similar trends occur in marine systems, this could damage or eliminate snow-covered birthing lairs and expose pups to the elements and elevate the risk of hypothermia. Pups in lairs with "thin" or damaged snow roofs or born in the open are more vulnerable to arctic fox (*Alopex lagopus*) and polar bear predation (Hammill and Smith 1991, entire; Smith and

Lydersen 1991, pp. 591–593; Stirling and Smith 2004, p. 65; Ferguson et al. 2005, pp. 132). Pupping habitat on landfast ice (McLaren 1958, pp. 55–56; Burns 1970, p. 447) and drifting pack ice can be affected by earlier warming and break-up in the spring, which shortens the length of time pups have to grow and mature before transitioning to the sea environment (Kelly 2001, p. 46; Smith and Harwood 2001, pp. 217–219).

Consistent and directional changes in ocean, snow, and sea ice conditions in the forthcoming decades will likely result in a net reduction in the abundance of prey species, such as bearded seals (Cameron et al. 2010, pp. 110–125). As a result, some subpopulations likely will not be able to compensate for the reduced availability of ringed seals by increasing consumption of other species (Derocher et al. 2004, pp. 168–169). However, Peacock et al. (2013, entire) documented increased survival and reproduction in DS with the concurrent increase in abundance of harp seals (*Pagophilus groenlandicus*). It should be noted, however, that the mechanism that resulted in an increase in harp seal abundance was a reduction in harvest, and thus this is unlikely to be a common situation for polar bears where a prey species suddenly becomes much more abundant. In addition to abundance, seal body condition can impact polar bears. Rode et al. (2021, entire) found that adult female bears and dependent young in the CS had improved body condition during years where ringed seals also saw increased body condition. Similarly, male bears body condition improved in during years where bearded seals had increased fat. These results suggest that the quality of prey is also an important factor in addition to abundance.

3.1.3 Increased movements and energy expenditure

Polar bears move inefficiently on land and expend approximately twice the average energy when walking compared to other mammals (Best 1982, pp. 64–72; Hurst et al. 1982, pp. 271, 274). Increased rate and extent of sea ice movements (i.e., drift) will require polar bears to expend additional energy to maintain their position near preferred habitats (Mauritzen et al. 2003, p. 123; Durner et al. 2017, p. 3471). This may be an especially important consideration for females with COY (Durner et al. 2017, p. 3467), who have higher energetic demands due to lactation (Ramsay and Dunbrack 1986, entire; Gittleman and Thompson 1988, entire).

As ice movement and areas of unconsolidated ice have increased, the speed of sea ice drift has accelerated (Zhang et al. 2012, p. 5) and polar bear habitat has become increasingly fragmented (Derocher et al. 2004, p. 167; Sahanatien and Derocher 2012, entire). In response, polar bears have increased the time spent moving, movement rate, and the frequency of short and long-distance swimming events, all of which increase energy expenditure (Pagano et al. 2012, entire; Sahanatien and Derocher 2012, p. 401; Durner et al. 2017, entire). These increased energetic costs are likely to result in reduced body weight and condition and a corresponding reduction in survival and recruitment rates (Regehr et al. 2010, pp. 121–125; Rode et al. 2010a, p. 777). Additionally, diminished sea ice cover has increased areas of open water and possibly wave action (i.e., larger waves). Both could result in increases in polar bear mortality associated with swimming long distances (Monnett and Gleason 2006, pp. 683–686; Durner et al. 2011, entire; Pagano et al. 2012, entire). Diminished sea ice cover could also result in hypothermia for young cubs that are forced to swim for longer periods, although maternal behavioral mechanisms may exist to reduce the risk to cubs (e.g., cubs riding on the back of the mother; Aars and Plumb 2010, entire).

3.1.4 Loss of denning habitat

While polar bears successfully den on both land and sea ice (Amstrup and Gardner 1994, p. 5; Fischbach et al. 2007, pp. 1399, 1402–1404), for most subpopulations, maternity dens are located on land (see Derocher et al. 2004, p. 166). In SB, the proportion of polar bears denning on sea ice has decreased with some disproportionately denning on land (Rode et al. 2015a, entire; Olson et al. 2017, p. 217). Additionally, female polar bears often return to specific terrestrial denning areas in some subpopulations (Harington 1968, p. 8; Ramsay and Stirling 1990, entire; Amstrup and Gardner 1994, p. 6).

Distance to the ice edge and the timing of when sea ice returns to the coast in the autumn may limit access to terrestrial denning areas (e.g., CS: Rode et al. 2015a, pp. 10–12). For polar bears to access denning areas on land from the sea ice, pack ice must drift close enough, or sufficiently freeze, by early November to allow pregnant females to walk or swim to the area (Derocher et al. 2004, p. 166). As distance increases between the pack ice edge and coastal denning areas, it will become increasingly difficult for females to access preferred denning locations unless they are already on or near land. Increased travel distances could impact denning success and ultimately population abundance (Aars et al. 2006a, p. 148). For most subpopulations under most climate change scenarios, the distance between the edge of the pack ice and land will increase during summer. Derocher et al. (2004, p. 166) predicted that under future climate change scenarios, pregnant female polar bears will not be able to reach many of the most important denning areas along the coast of the central Beaufort Sea. Bergen et al. (2007, pp. 6, 20) found the minimum distance traveled to denning habitats in northeast Alaska increased between 1979 and 2006 at an average linear rate of 6–8 km (3.7–5.0 mi) per year and almost doubled after 1992 with projected travel distances increasing threefold by 2060.

Climate change has also affected denning through changes in snow and sea-ice conditions (Fischbach et al. 2007, entire). Characteristics of dens have been well studied (Amstrup and Gardner 2004, entire; Durner et al. 2001, entire; Durner et al. 2003 entire) and indicate polar bears need a snowdrift of ~2 m deep to excavate a successful den (Liston et al. 2016, p. 132). Insufficient snow results in use of poor sites that have an increased chance of den roof collapse or could prevent den construction altogether (Derocher et al. 2004, p. 166–167). Changes in the amount and timing of snowfall could also impact the thermal properties of dens (Derocher et al. 2004, p. 167). Rain-on-snow events are projected to increase throughout the Arctic in winter (Liston and Hiemstra 2011, p. 5708), which could increase the possibility of den collapse in late winter and early spring (Stirling and Smith 2004, p. 64). Since polar bear cubs are altricial and need to nurse for ~3 months before emerging from the den, major changes in the thermal properties of dens could impact cub survival (Derocher et al. 2004, p. 166–167).

3.2 Commercial Activities

3.2.1 Industrial development

Onshore and offshore oil and gas activities occur throughout the range of polar bears. At the time of listing, the greatest level of oil and gas activity occurring within polar bear habitat was in the U.S. (Alaska). The Service has previously determined that direct impacts from oil and gas exploration, development, and production activities had been minimal and did not threaten the species overall (Service 2017a, p. 37). This conclusion was based primarily on 1) the relatively localized nature of the development activities; 2) existing mitigation measures that were in place; and 3) the availability of suitable alternative habitat for polar bears. The Service also noted that data on direct, quantifiable, and cumulative impacts to polar bear habitat from oil and gas activities was lacking. More recently, however, quantitative assessments of polar bears indicated industry-related icebreaker activity caused 79% ($n = 46$; Smultea et al. 2016, p. 181) and 100% (Lomac-MacNair et al. 2019, p. 282; $n = 3$) of polar bears to change their behavior (e.g., increased vigilance, fleeing). Polar bears are also sensitive to oiling and a worst-case scenario oil spill could have individual and population-level impacts (Mosbech et al. 2007, pp. 10, 21; Boertmann et al. 2009a, p. 191; Wilson et al. 2018, entire).

Petroleum development is cyclic in nature and susceptible to market demands. Currently, oil and gas exploration, development, and production throughout the Arctic has declined since the time of the listing; however, new areas have been opened to potential development in Russia (Lagutina 2021, entire) and the U.S. (Tax Cuts and Jobs Act 2017, entire; Wilson and Durner 2020, pp. 201−202). As rising Arctic temperatures and climate-mediated sea ice decline continue (Douglas 2010, pp. 7−12; Stroeve et al. 2012, entire; Thackeray and Hall 2019, entire), the Arctic may become more open to industrial activity (Prowse at al. 2009, entire; Peters et al. 2011, entire; Larsen and Fondahl 2015, entire), and polar bears will be increasingly impacted. This includes potential effects to maternal denning polar bears (Wilson and Durner 2020, entire), especially if the increasing trend in the number or proportion of bears denning on land continues (Derocher et al. 2011 pp. 276–278; Rode et al. 2015a, entire; Olson et al. 2017, p. 220).

Canada−Currently no oil and gas exploration is occurring in the Canadian Arctic and none is expected in the near future that is likely to affect polar bears. The construction of a natural gas pipeline from the Mackenzie Delta to southern Canada was approved and, if constructed, it could affect denning polar bears from SB (Obbard et al. 2010, pp. 23–24). The project has moved slowly due to environmental concerns and impacts to Indigenous People (Nuttall 2008, entire). However, in late 2017, the partnership funding the pipeline dissolved, effectively ending plans for development of the pipeline in the near future. Permits for offshore exploration activities in the Lancaster Sound region were relinquished in 2016 (Murray 2016). Also in 2016, Canadian Prime Minister Trudeau signed a moratorium on offshore oil and gas exploration in the Canadian Arctic to be reviewed every 5 years. In 2019, wildlife boards representing Indigenous hunters and trappers throughout the affected region recommended the moratorium continue for at least an additional 10 years to allow sufficient time to "…complete the research, planning, and consultation identified as necessary prior to undertaking a re-assessment by the minister to determine if the moratorium should be lifted" (Anselmi 2019). The deadline for completing the assessment was 31 December 2022 (Government of Canada 2021).

Greenland−In 2021, Greenland ceased all plans for oil and gas exploration citing the high cost of oil extraction in the Arctic and concerns for the environment. Previously, Greenland's government published a plan (Greenland's Oil and Mineral Strategy 2014–2018) that encouraged oil and gas development and mitigated environmental impacts (Government of Greenland 2014, entire). West Greenland waters were opened for hydrocarbon exploration in 2008; subsequent environmental assessments for oil and gas development in BB and DS areas concluded that development would have little to moderate effects on polar bears. Exploration has also occurred in waters offshore of northeast Greenland, potentially affecting the East Greenland subpopulation (EG). An environmental analysis concluded moderate effects of activities associated with exploration, but oil spills posed a more serious concern for EG (Boertmann et al. 2009b, pp. 199–205). Several licenses have been issued for prospecting ($n = 7$) and exploration and exploitation ($n = 4$), although no oil production (i.e., exploitation) has occurred and the recent decision to cease issuing licenses will likely limit any exploration.

Norway−Most oil and gas activities have occurred in the southern portions of the Barents Sea that is relatively ice free, however, in 2016 the government opened a previously unexplored area in the northern Barents Sea to oil development (Agence France-Presse 2016, entire) potentially affecting the BS. Since that time, the Government of Norway's Ministry of Petroleum and Energy has opened several new areas to oil exploration in both the Barents and Norwegian Seas (Nilsen 2020 entire; Nilsen,2021 entire). The country will begin issuing licenses for production in 2022 (Nilsen 2021).

Russia−Oil and gas exploration in Russia is ongoing and expected to continue into the future, particularly as sea ice melt continues to facilitate ease of travel in Arctic waters. Exploration has particularly been increasing in the Kara and Barents Seas, concurrent with exploration in the Norway region of the Barents Sea. Offshore production of the Prirazlomnoye field in the Pechora Sea began in 2013, also within the range of the Kara Sea subpopulation (KS). While significant environmental concerns have been raised about this project (Barents Observer 2015), no known effects to polar bears have yet to be identified or published. In early 2020, an executive order titled Basic Principles of Russian Federation State Policy in the Arctic to 2035 was enacted to encourage future economic growth in Russia's Arctic with the intent to "…develop the Russian Arctic as a strategic resource base and use it rationally to speed up national economic growth" (Lagutina 2021, p. 123). In late 2020, a Russian petroleum company announced the discovery of two large natural gas fields in the Kara Sea (The Arctic 2020a, entire; The Arctic 2020b, entire).

United States−All oil and gas activities are evaluated and regulated in the U.S. Potential effects on polar bears are evaluated and mitigated through 1) development of activity-specific human-bear interaction plans to prevent and mitigate negative interactions between bears and people; 2) safety and deterrence training for industry staff; 3) bear monitoring and reporting requirements; and 4) implementation of project-specific protection measures. In 2016, the Department of the Interior finalized additional regulations for future, offshore exploratory drilling activities in the Arctic (USDOI 2016, entire). These regulations are intended to improve operational standards from mobilization to transport, drilling, and emergency response. Additionally, a review of potential impacts is conducted every five years through the Service's Incidental and Intentional Take Authorization Program; the most recent reviews (in 2021 and 2018 for the Beaufort and Chukchi Seas, respectively) include "findings of no significant impact" to polar bears.
Since listing, lease sales have been held in both the Chukchi and Beaufort Seas. In 2008, a 2.7-million-acre lease sale occurred for exploration on the outer continental shelf of the Chukchi Sea. In 2010, however, a federal judge ruled to halt any industrial activities associated with the lease

as a result of several lawsuits citing environmental concerns. The lease area is noted for its valuable wildlife habitat, including high value polar bear habitat (Wilson et al. 2014, p. 9), some of which was designated as Critical Habitat in 2010 (75 FR 76086). Limited exploration was permitted beginning in 2012, however, exploration activities ceased in 2015 as a result of complications including grounding of a drilling rig and the failure to discover economically viable quantities of oil or natural gas (Eilperin and Mufson 2015). Ongoing oil and gas production continues in the central Beaufort Sea within the range of SB. Although since 2014, market mechanisms, such as a decline in the value of oil, have slowed the pursuit of petroleum development in both the Beaufort and Chukchi Seas. This resulted in the cancellation of future lease sales and the relinquishment of lease holdings by companies back to the federal government.

In 2017, Congress approved the Tax Cuts and Jobs Act (2017, Public Law 115-97), which included the requirement of at least one lease sale in the 1002 Area of the Arctic National Wildlife Refuge (Arctic NWR) by 21 December 2021 and a second lease sale by 21 December 2024. In January 2021, leases were issued by the Bureau of Land Management (BLM) on 9 of 22 available tracts (BLM 2021, entire), although bids were far lower than expected with no bids from major oil companies. In 2021, a hold was placed on the leasing process pending additional environmental review. No plans for next steps have been made public. Three offshore lease sales (2019, 2021, 2023) were also proposed in the Alaska portion of the Beaufort Sea in the 2019–24 National Outer Continental Shelf (OCS) Oil and Gas Leasing Draft Proposed Program, though the program has not been approved, and thus lease sales have not occurred. Pending actions from the current administration would bar drilling in the Beaufort Sea and limit new oil and gas leases in the National Petroleum Reserve – Alaska.

Oil Spills−Oil spills were identified as a primary concern for polar bears throughout their range when they were listed in 2008 (73 FR 28212). The primary threats to polar bears from an oil spill are 1) the inability to effectively thermoregulate when their fur is oiled; 2) ingestion of oil from eating contaminated prey or grooming; 3) habitat loss or precluded use of preferred habitat; and 4) oiling and subsequent reduction of primary prey. Spilled oil present in the autumn or spring during formation or breakup of ice presents a greater risk than in ice-free or ice-covered seasons because of the difficulties associated with oil spill clean-up in mixed, broken ice, and the presence of polar bears and other wildlife in prime feeding areas over the continental shelf during this period (Wilson et al. 2018, p. 655). Given the difficult Arctic conditions including minimal daylight and inclement weather, the likelihood of oil being removed in ice-covered Arctic waters is low.

At the time of listing and in subsequent 5-Year Reviews, the Service determined that the probability of a large-scale oil spill occurring in polar bear habitat that could affect the species range-wide was low. Since listing, no major oil spills have occurred in the marine environment within the range of polar bears. The Service also noted that in Alaska 1) past history has demonstrated that onshore oil and gas operations can be conducted safely and effects on wildlife and the environment minimized; 2) regulations are in place that provide for pollution prevention and control, as well as marine mammal monitoring and avoidance measures; and 3) plans are reviewed by both leasing and wildlife agencies prior to any activity so protective measures specific to polar bears can be put into place prior to any new activity. However, the Service also noted that increased circumpolar Arctic oil and gas development, coupled with a growth in shipping and potential offshore developments increase the potential for an oil spill. And, if a large spill were to occur, it could have significant impacts to polar bears and their prey, depending on the size, location, and timing of the spill, and the number of animals affected (Wilson et al. 2018, entire; Amstrup et al. 2006, entire).

Since the 2008 listing, the level of information and number of entities generating information about oil spill preparedness in the Arctic has increased (Holland-Bartels and Pierce 2011, pp. 109–164). Because a spill in Arctic waters may have consequences for multiple countries, several circumpolar and bilateral agreements about spill response have been developed. For example, at the circumpolar level, the Arctic Council's Protection of the Arctic Marine Environment (PAME) working group produced the Arctic Marine Shipping Assessment Report (Arctic Council 2009, entire), which identified oil spill prevention as the highest priority in the Arctic for environmental protection. The PAME working group is functioning to enhance cooperation in the field of oil spill prevention and support research and technology that helps prevent the release of oil into Arctic waters. Additionally, in 2014, the member nations of the Arctic Council (U.S., Canada, Greenland, Finland, Iceland, Norway, Russia, Sweden) signed a Cooperative Agreement to strengthen cooperation, coordination, and mutual assistance regarding oil pollution preparedness and response in the Arctic and to protect the marine environment from oil pollution. In 2017, the U.S. and Canada signed the 2017 Canada-United State (CANUS) Joint Marine Pollution Contingency Plan (JCP). This plan replaced the 2013 CANUS JCP and is consistent with the provisions of Article 10 of the International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990. In 2021, *the 2020 Joint Contingency Plan of the United States of America and the Russian Federation on Combating Pollution in the Bering and Chukchi Seas* was signed by the U.S. and Russia. Joint contingency plans promote a coordinated system for planning, preparing, and responding to pollutant substance incidents in the waters under the jurisdiction of the signatories. All these initiatives encourage countries to prepare for oil spills, thereby benefitting polar bears if a spill were to occur.

Several key reports have also been published since 2008 regarding oil spill response in the U.S. Arctic. An effort to assess risks, challenges, and potential consequences of oil spills in the U.S. Arctic was undertaken by the U.S. Arctic Program, Pew Environment Group (Pew 2010, entire). The authors noted that, while very large spills and well blowouts are low-probability events, the consequences can be disastrous, and even a moderate spill in a sensitive area could have devastating effects. Another report noted "a significant coordinated international effort by industry and governments is taking place to develop safe and effective infrastructure and technologies to access energy resources in ice-covered Arctic waters" (Holland-Bartels and Pierce 2011, p. 113). They also noted that while management, spill response, and science communities are actively engaged in developing essential decision-making and ocean-observing systems, most of these efforts are not fully funded, operational, or tested in Arctic waters. The report concluded that better data and better coordination of data are needed to optimize oil spill response in the Arctic.

In Alaska, the Oil Spill Risk Analysis process (Reich et al. 2014, pp. 1–102) continues to be used by federal managers to identify where natural resources might be exposed to oil under various spill scenarios. For example, as part of the lease sale process, the BLM, and BOEM modeled the likelihood of spills occurring during exploration and development in both the National Petroleum Reserve-Alaska (NPR-A; BLM 2012, entire) and in the Beaufort and Chukchi Sea planning areas (BOEMRE 2011, entire; BOEM 2015a, entire). Large (>1,000 barrels) or very large spills (>120,000 barrels) were considered unlikely to occur during oil and gas exploration (BOEM 2015a, pp. 151–160, 452–478). BOEM noted that while a very large oil spill is a highly unlikely event, if one did occur it could result in the loss of large numbers of polar bears and could have significant impacts on SB and CS (BOEM 2015a, pp. 521–570).

Wilson et al. (2018) developed a model to estimate how a worst-case discharge oil spill might affect CS during autumn (October). The study used data from simulated oil spill trajectories at two planned areas of development in the Chukchi Sea (McCay et al. 2016, entire; McCay et al. 2017, entire). Simulations modeled the effects of an underwater pipeline leak of 25,000 barrels/day for 30 days and tracked spill effects for an additional 46 days. Spill trajectories were overlain with biological data on annual movement patterns and habitat use patterns of polar bears (Wilson et al. 2014, entire) to help predict how many animals are likely to be exposed to oil during a spill event. Wrangel and Herald Islands, two areas highly important for polar bear maternal denning and summer terrestrial habitat, had the highest probability of being affected by the oil spills. While approximately only 10% of high-value polar bear habitat was affected, the number of polar bears potentially affected was 27–38% of CS.

McCay et al. (2018, entire) developed spill simulations at three locations along the 1002 area coastline where future development could occur. These spill simulations were similar to those conducted in 2016 (McCay et al. 2016, entire), however, they were slightly earlier (16 August–14 September) when large aggregations of polar bears were most likely to be onshore during late summer/autumn. Analysis of how this oil spill data may impact polar bears is ongoing and is expected to be published in 2022–23.

As a response measure, a planning tool known as the Net Environmental Benefit Analysis has been developed that can be used as a decision-making process to identify the spill response methods most likely to reduce environmental threats in the Arctic (Potter al. 2012, entire). Additionally, new tools, such as unmanned aircraft systems, have been tested and used to detect and track oil in snow and ice, and appear to have applications to minimize impacts to polar bears (EPPR 2015, pp. 115). Further, considerable research has been conducted on the use of in situ burning, dispersants, and chemical herders as response tools for cleaning up oil in the ice environment, some with promising results (Brandvik et al. 2010, p. 30; Sørstrøm et al 2010, pp. 17–23; Potter et al. 2012, pp. 33–76). Recent technological developments include improved fire-resistant booms, use of herding agents in conjunction with *in situ* burning, and improvements to dispersant formulas, equipment, and delivery systems (Potter et al. 2012, entire). However, significant data gaps still exist in terms of understanding the toxicity from chemical herders and dispersant to Arctic species (Holland-Bartels and Pierce 2011, pp. 141–142). Where testing of these technologies has been conducted in icy waters, it has been at small scales in controlled environments.

Minimizing risk of contamination from oil spills is identified as a high priority conservation and recovery action in the CMP (Service 2016, p. 92). In 2015, the Oil Spill Response Plan for Polar Bears in Alaska (Service 2015, entire) was updated. The plan classifies response activities for polar bear protection into primary, secondary, and tertiary strategies. Primary response involves keeping spilled oil away from polar bears and physical protection of areas most important to polar bears. Primary response strategies also include guidance on the removal of oiled carcasses from the environment to prevent scavenging and accidental ingestion of oil by polar bears. Secondary response is designed to prevent polar bears from entering oiled areas. Tertiary response involves the capture, handling, transport, and treatment of oiled bears, and either their return to the environment or placement in a designated facility. Additionally, an *ad hoc* Marine Mammal Working Group, sponsored by Alaska Clean Seas (i.e., the primary oil spill response organization for spills on the North Slope of Alaska; https://www.alaskacleanseas.org/), conducts annual meetings and field response exercises.

If a spill were to occur, steps have been taken to increase response capabilities to treat a small number of oiled polar bears in Alaska. This includes the design and construction of specialized equipment such as washing tables, transport cages, and a collapsible polar bear holding pen (Miller 2016, entire). Additionally, experiments were conducted in 2012 to determine how best to remove oil from polar bear fur (Miller 2016, entire). Results indicated oil can be readily removed from polar bear fur using a 10% soap solution and warm salt or fresh water between 15−32° C (60−90° F; Service 2015, p. 56). While the Service's response strategy emphasizes preventative measures, significant steps have been taken to improve response capabilities for treating a small number of oiled polar bears.

Although the risk of a large enough oil spill affecting a significant portion of the global polar bear population remains unlikely, the potential consequences warrant continued monitoring and mitigation of industries that have the potential to spill oil into the Arctic environment. Additionally, with limited ability to sufficiently clean up spills in icy, Arctic waters, even a small spill would be detrimental to polar bears.

3.2.2 Ecotourism

Polar bear viewing and photography are popular forms of tourism that occur primarily on the north coast of Alaska (the communities of Kaktovik and Utqiaġvik), in Churchill, Manitoba and portions of Nunavut, Canada; Svalbard, Norway; and Wrangel Island, Russia (Lemelin and Dyck 2008, entire). The Service noted that while it is unlikely that properly regulated tourism will have a negative effect on subpopulations (Service 2008, entire), increasing levels of public viewing and photography in polar bear habitat may lead to increased human-polar bear interactions (Service 2016, p. 77). Tourism can also result in inadvertent displacement of polar bears from preferred habitats or alter natural behaviors (Dyck and Baydack 2004, pp. 345–348; Eckhardt 2005, p. 23). Since listing, the role of stakeholders in polar bear viewing has increased. It has been noted that wildlife tourism conservation activities have a greater potential for success if local people take part in developing and implementing programs (Lemelin and Dyck 2008, p. 374).

Churchill, Manitoba, Canada is considered the "the polar bear viewing capital of the world", providing tourists the opportunity to easily observe polar bears in the wild (Dawson et al. 2010, pp. 321–322; Peacock et al. 2010, pp. 104–105). Although polar bear viewing is a well-established industry in Churchill, tourism is also growing in new areas, such as Torngat

Mountains National Park in northern Labrador (DS; Lemelin and Maher 2009, p. 153). Polar bear viewing management includes use of Indigenous guides, attractant management, passive and active deterrents, and education/codes of conduct that minimize human-bear interactions and facilitate understanding of the unique viewing situation in the area (Lemelin and Maher 2009, p. 153). In 2008, polar bears from WH were recognized as threatened under the Manitoba Endangered Species Act, and since then, all tourism flights into core maternity denning areas have been discontinued (Lunn et al. 2010, p. 92).

Tourism activities are increasing in Svalbard, Norway and there is concern that polar bears may be disturbed in important areas during sensitive periods (Ekker et al. 2016, p. 113). Although operators in Svalbard are restricted from using polar bears in the marketing of their trips due to the environmental law and tourism regulations, it is assumed the motivation for tourists to visit certain destinations is the probability of observing polar bears (M. Keyser, Svalbard Science Forum, personal communication). Andersen and Aars (2008, p. 504) evaluated snowmobile disturbance in Svalbard (a common activity for tourists in the area) and found that polar bears moved away when snowmobiles were at an average distance of 843 m. This avoidance effect was strongest for females with dependent young.

Prior to 2020, tourism was increasing in Alaska due to of the opportunity to observe high concentrations of polar bears near the community of Kaktovik during autumn (Hallo et al. 2019, p.1). However, viewing opportunities in Kaktovik have been suspended since 2020 due to Covid-19-related travel restrictions to the community, and the Arctic NWR is not currently issuing permits to polar bear viewing guides as per directions from a Secretarial Order 3392 from the Department of the Interior (2021). Since listing, the Service has worked with the community of Kaktovik to reduce human-bear conflicts by establishing professional viewing practices that promote human safety and polar bear conservation as well as the development and enactment of quantitative tools to evaluate viewing activities to ensure compliance with the MMPA. Additionally, community-based guidelines request that visitors use trained guides and obey local laws and ordinances related to polar bear viewing.

Tourism associated with polar bears is not established in Greenland. Accompanying a polar bear hunter and viewing polar bears are both illegal by Executive Order (Government of Greenland 2005, entire).

Polar bear-related tourism in Russia currently occurs in relatively low numbers compared to other countries. Beginning in 2009, 2–3 cruise ships per year have visited Chukotka and Wrangel Island during the summer season. However, in early 2020 the aforementioned executive order (Government of Russia, entire) outlined measures to increase cruise tourism, which included reducing restrictions on foreigners and establishing priority tourism zones in each Arctic region. Recent geopolitical events involving Russia and Ukraine will likely reduce number of cruise ships to Wrangel Island, however, the actual impacts to cruises in this region are unknown.

Increasing polar bear tourism does not appear to have emerged as a significant threat to the circumpolar population of polar bears (Rode et al. 2018c, pp. 126–129; Miller 2019, entire). In the January 2020 midterm review of the Circumpolar Action Plan (CAP), tourism was identified as a low-level threat (PBRS 2020, pp. 7–10); however, negative effects may occur in areas where regulations and involvement from local stakeholders are lacking. Cooperative relationships that develop between managers and community residents will become increasingly important if tourism to observe polar bears continues to grow.

3.2.3 Shipping

A decline in Arctic sea ice has resulted in an increase in the navigation season within Arctic waters, thus increased shipping has been identified as an emerging issue for polar bear conservation (73 FR 28212). Previously ice-covered sea routes are now opening up in summer, allowing access for commercial shipping (Saul 2020). Vessel traffic may increase by mid-century when sea-ice conditions are predicted to allow for open water vessel traffic along the Northern Sea Route, new routes for ice-strengthened ships over the Arctic Basin, and new routes through the Northwest Passage for both open-water and ice-capable ships (Smith and Stephenson 2013, entire). Increased shipping along the Northern Sea Route, part of the Northeast Passage following the coasts of Norway and Russia into the Chukchi and Bering Seas, and the Northwest Passage, which follows Canada's eastern coast north along the coasts of Canada and Alaska's Beaufort Sea, could result in increased fragmentation of sea ice habitat and disturbance or injury to marine mammals, increased human-bear encounters, and the introduction of waste, litter, and/or toxic pollutants into the marine environment (PBRS 2015, p. 37). A primary concern associated with increased shipping is the increased potential for oil spills.

While no population level effects from increased shipping were identified at the time of listing, the PBSG recommended that each PBRS take appropriate measures to monitor, regulate, and/or mitigate effects of ship traffic to subpopulations and their habitat (Aars et al. 2006b, p. 58). Currently, the PBRS recognize shipping as a low-level threat to polar bears (PBRS 2020, pp. 7–10.

Increased attention on shipping as an emerging Arctic issue has occurred at the circumpolar level. The Arctic Council drafted the Arctic Marine Shipping Assessment Report that focused on shipping in the Arctic Ocean and the potential impacts on humans and the Arctic marine environment (Arctic Council 2009, entire). This report included a comprehensive estimate of how many ships operated in the Arctic during 2004 to function as a baseline and identified natural resource development and regional trade as the key drivers of future Arctic marine activity. The release of oil was identified as one of the most significant environmental threats related to shipping. The report included a specific recommendation for Arctic countries to address impacts on marine mammals from shipping and work with the International Maritime Organization (IMO) to develop and implement mitigation strategies.

Since publication of the Arctic Council report (2009, entire), significant advancements have been made to implement the recommendations therein. For example, several other publications have been produced that identified Arctic marine areas of special ecological and cultural importance (Smith et al. 2010b, entire), and provided guidelines to reduce underwater noise to avoid adverse impacts on marine biota (Arctic Council 2015, entire). Additionally, vessel routing and speed restrictions were recognized as effective measures to mitigate impacts on marine mammals (Brigham and Sfraga 2010, p. 11). In 2014, the IMO drafted the "International code of safety for ships operating in polar waters (Polar Code) [which] covers the full range of design, construction, equipment, operational, training, search and rescue and environmental protection matters relevant to ships operating in the inhospitable waters surrounding the two poles.” In 2015, the IMO adopted the environmental provisions of the Polar Code and includes standardized safety procedures such as use of designated ship lanes, both of which are significant achievements for addressing marine environmental protection. The Polar Code was enacted on 1 January 2017 (IMO 2016). In the U.S., steps are being taken to establish designated shipping routes in the Bering Strait and Chukchi Sea (79 FR 72157), areas known for their biological and cultural importance (Huntington et al. 2015, pp. 119–120). Additionally, in 2020 Russia enacted an executive order that would create new shipping and transport routes in Russia’s Arctic (Government of Russia 2020, entire).

Potential impacts from shipping on polar bears continue to warrant attention. At present, ongoing circumpolar efforts to improve marine safety and environmental protection are positive steps toward addressing potential impacts on marine mammal species, including polar bears.

3.3 Overutilization

Reviews of circumpolar management of polar bears developed by the IUCN PBSG (Obbard et al. 2010, entire), TRAFFIC North America and World Wildlife Fund Canada (Shadbolt et al. 2012, entire), the Animals Committee of the Convention on the International Trade of Endangered Species of Fauna and Flora (CITES) 2015 Review of Significant Trade (CITES 2015, entire), and the IUCN Red List Authority (Wiig et al. 2015, pp. 7, 10–12) generally agree that overutilization in the form of human-caused removals (e.g., unsustainable harvest, removals in defense of human life, illegal take) is not currently a major threat to the global population throughout all or a significant portion of its range. However, during the midterm CAP review, the PBRS elevated the current level of threat for unsustainable harvest from “low” to “medium to low” due to a lack of current population data for many subpopulations (PBRS 2020, pp.7–10) and, thus the potential for unintentional overharvest. Additionally, an updated review of polar bear harvest in the Arctic circumpolar indicates overharvest has occurred in most subpopulations (Vongraven et al. 2022, pp. 9–10). Additional concerns exist regarding the cumulative effects of climate change on subpopulations and how to incorporate that knowledge into harvest quotas. The PBRS also acknowledged the challenge of aligning Western science-based perspectives and IK when determining sustainable harvest levels (PBRS 2020, pp. 7–10). Despite elevating the level of threat of unsustainable harvest, the PBRS acknowledged sea-ice loss due to climate change remains the predominant threat to polar bears and unsustainable harvest is a comparably low-level threat (PBRS 2020, pp. 7–10).

In forecasting the future status of polar bears worldwide, research concluded *in situ* human activities (including human-caused removals) exert considerably less influence on subpopulation outcomes compared to sea-ice loss due to anthropogenic climate change (Atwood et al. 2016a, p. 12). Another rigorous assessment of harvest risk similarly concluded there is currently minimal overall risk to subpopulations from well monitored and managed harvest (Regehr et al. 2017b, entire). However, increased mortality from human-bear conflicts or other forms of mortality may become a more significant threat in the future, particularly for subpopulations experiencing nutritional stress or declining numbers because of habitat change (Vongraven et al. 2022, entire). Management is necessary to ensure that human-caused removals do not reduce abundance to unacceptable levels or reduce the viability of subpopulations (Regehr et al. 2015, entire; Regehr et al. 2017b, entire; Regehr et al. 2023, entire).

Subsistence harvest, conflict-management removals (defense of life, mercy killings, and removal of bears involved in conflicts with humans), and sport harvest (Canada only, using a proportion of subsistence-allocated tags) are currently types of human-caused removals that are allowed throughout all or parts of the polar bear's range. Harvest, mainly for subsistence, occurs in most subpopulations [with the exception of the Laptev Sea (LV), KS, BS, and the Arctic Basin (AB)]. Subsistence harvest accounts for the majority of human-caused removals (Obbard et al. 2010, p. 31; Vongraven et al. 2022, entire): an estimated 39,049 polar bears were harvested from 1970–2018 (yearly mean = 797 bears, SE = 16, range: 629–1,285; Vongraven et al. 2022, p. 6). Subsistence harvest is important to Indigenous people in many parts of the Arctic for nutritional and cultural purposes (Schliebe et al. 2006, p. 127; Born et al. 2011, throughout; Voorhees et al. 2014, entire), and in some regions harvest provides economic revenue from the sale of polar bear parts or handicrafts. Concerns persist about subsistence harvest levels for several subpopulations, particularly those with poor or outdated population data (Obbard et al. 2010, entire; Vongraven et al. 2012, pp. 2–4; Vongraven et al. 2022, entire). The three Range States with subpopulations that allow legal harvest—Canada, Greenland, and the U.S.—have made progress on the management systems and scientific information used to ensure that harvest does not threaten the species.

Ensuring species persistence includes managing the rate of direct human-caused removals to maintain subpopulation size above the maximum net productivity level (*mnpl*) relative to carrying capacity (Service 2016, pp. 19–23; Regehr et al. 2023, entire). Carrying capacity is determined by the availability of limiting resources, which vary naturally and via anthropogenic influences, and the *mnpl* will vary in proportion to carrying capacity. Likewise, the intrinsic growth rate can vary over time as a function of the health of the ecosystem, also affecting the *mnpl*. Both the changing carrying capacity and the changing intrinsic rate of growth need to be considered when evaluating the maximum number of removals permitted to maintain a population above *mnpl*. In long-lived mammal populations where removals are unbiased with regard to age or sex, *mnpl* occurs at some population size greater than 50% of carrying capacity; for polar bears, demographic analysis suggests that this level occurs at approximately 70% of carrying capacity (Regehr et al. 2015, p. 19).

Estimating the size of a subpopulation at carrying capacity, and by extension the *mnpl*, is challenging because factors limiting population growth are difficult to measure and vary over time. Nonetheless, if human-caused removal levels are based on an estimate of current population size and a harvest rate (h) that is designed to maintain a population above its *mnpl*, polar bears can be managed to maintain the health and stability of the marine ecosystem and to maintain polar bears as a functioning element of the ecosystem. The removal rate (h_{mnpl}) that achieves *mnpl* at equilibrium is likely 79–84% of the intrinsic population growth rate for polar bears (Regehr et al. 2015, p. 19). Thus, to ensure overall species viability, total human-caused removals in each subpopulation must not exceed h (relative to the subpopulation size), which maintains the subpopulation above its *mnpl* relative to carrying capacity.

On a circumpolar level, a primary concern is the potential for future overutilization due to interactions between human-caused removals and negative effects of climate change (Regehr et al. 2017b, p. 1535). For example, if habitat loss leads to an increased number of nutritionally stressed polar bears on land, human-bear conflicts and resulting human-caused removals are expected to increase (PBRS 2015, p. 60; Wilder et al. 2017, entire; Rode et al. 2022, entire). Consequently, to facilitate sustainable harvest for subpopulations affected by climate, harvest management should consider the following: 1) change in the current and future potential effects of habitat loss; 2) the quality of data used to inform management decisions, and 3) the possibility of delineating population thresholds below which conservation efforts would be increased to reduce human-caused disturbance and removals (Regehr et al. 2015, p. 42; Regehr et al. 2017b, p. 1542; Service 2016, pp. 69–70).

3.3.1 Management systems and agreements

Human-caused removals are managed in accordance with numerous laws, legislation, and regulations among and within the PBRS. The transfer and trade of polar bear parts is regulated by CITES, under which the polar bear is currently listed on Appendix II, which "…includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival". The 1973 Agreement on the Conservation of Polar Bears (hereafter, the 1973 Agreement) calls for cooperative international management of subpopulations based on sound conservation practices, prohibits polar bear hunting except by local people using traditional methods, calls for protection of females and denning bears, and bans use of aircraft and large motorized vessels for polar bears hunting (PBRS 1973, entire; Prestrud and Stirling 1994, entire). Reviews of international and national management of human-caused removals of polar bears are available in several documents (73 FR 28212; Schliebe et al. 2006, entire; Obbard et al. 2010, entire; Shadbolt et al. 2012, p. 30) and are briefly described below.

Canada−Polar bears are managed under federal, provincial, and territorial legislations. On the federal level, the Species at Risk Act is an important law for managing polar bears, while multiple land claims agreements play a critical role in polar bear management at the provincial and territorial levels (Shadbolt et al. 2012, p. 32). Except for Ontario and Quebec, most provinces and territories with polar bears have harvest quotas. There is no legal harvest in Manitoba, although polar bears are legally removed in defense of life incidents. Based on evidence for declines due to sea-ice loss (Regehr et al. 2007, entire; Lunn et al. 2016, pp. 1303, 1309–1310), the quota for WH in Nunavut was reduced from 56 (2005) to 24 bears per year (2014). However, in 2019, Nunavut changed the managed harvest sex ratio from a 2:1 sex ratio (i.e., 2 males for every 1 female) to up to one female bear harvested for every male bear harvested (i.e., 1:1 sex ratio; Government of Nunavut 2019b, entire). Initial concerns regarding this change included the potential impact to population growth (i.e., to negative population growth) and thus population viability. This ratio change was conducted without a scientific assessment of the implications or clearly articulated management objectives.

A negative non-detriment finding under CITES was issued in 2009 for BB. This was primarily due to concerns about overharvest and an incremental reduction in harvest of 10 bears per year (2010–2014; Obbard et al. 2010, pp. 36–37), and completion of a joint population assessment by

Canada and Greenland. However, the effect of harvest reduction on abundance of bears in BB is currently undetermined. A harvest risk assessment that includes considerations of the effect of climate change was recently published (Regehr et al. 2017a, entire) and informed the current BB quota. In response to the removal of 74 bears in 2011 and the lack of harvest quotas in Nunavik, Quebec, an agreement between Nunavut, Quebec, and Ontario was developed for harvest from SH. A recent reassessment of total allowable harvest (TAH) indicated that prior to the current evidence for demographic declines, SH supported relatively high and likely sustainable harvest levels over the past 30 years (Regehr et al. 2021a, entire).

Greenland−Polar bear management is governed by The Greenland Home Rule Act No. 12 of 29 October 1999, on Hunting and Game. Harvest is primarily for subsistence purposes and is permitted only for resident, full-time hunters registered with the government. Quotas for polar bear harvest were implemented in 2006 along with an improved reporting system (Lønstrup 2006, p. 133; Born et al. 2011, entire). A phased quota reduction over three years followed due to concerns about overharvest of BB and Kane Basin (KB), and lack of current scientific data for EG. In 2008 a negative non-detriment finding under CITES was issued for all polar bears in Greenland. No abundance estimate currently exists for EG, however, new population studies in western and eastern Greenland were initiated in 2011 and 2015, respectively, and data collection is ongoing (PBSG 2021, p. 20).

Norway−The Svalbard Environmental Protection Act (2002) is the main legal framework for polar bear management in Norway. Because there are no Indigenous people in Svalbard, polar bear harvest has been prohibited since enactment of the 1973 Agreement.

Russia−Russia has prohibited the harvest of polar bears since 1956. Polar bears can be killed legally only in conflict situations or for scientific purposes. Further, the only permitted removal of polar bears from their natural environment is the removal of cubs for education (Shadbolt et al. 2012, p. 55). Since 2008, new amendments have been added to the Criminal Code of the Russian Federation to penalize destruction of critical habitat for animals and plants listed in the Red Data Book of the Russian Federation, including the polar bear.

Russia and the U. S. signed the Agreement between the Government of the United States of America and the Government of the Russian Federation on the Conservation and Management of the Alaska-Chukotka Polar Bear Population (Bilateral Agreement; see *3.5.1 International Conservation Agreements and Plans*) in 2000 and held the first Bilateral Commission meeting in 2009. In 2018, the Commission established a sustainable harvest level (or quota) of 85 polar bears per year evenly split between the U.S. and Russia, of which no more than one-third are female. Russia intends to implement a legal subsistence harvest for Indigenous people in accordance with these limits once the necessary monitoring and management infrastructures have been established.

United States−In 1972, the U.S. passed the MMPA ending polar bear hunting in the U.S. except by coastal dwelling Alaska Native People for subsistence purposes, provided the harvest is not wasteful. The import of sport-hunted polar bear trophies from Canada to the U.S. became illegal with the polar bear listing under the ESA (73 FR 28211). In the coming years, the U.S. intends to implement the sustainable harvest limits for CS, as identified under the Bilateral Agreement, through a co-management framework between the federal government and the Alaska Nannut Co-Management Council (ANCC). Subsistence harvest in SB is addressed through an agreement between the Inuvialuit and Iñupiat peoples in Canada and Alaska, respectively (I-I Agreement; Brower et al. 2002, entire). The harvest quota for SB is voluntary within the U.S. side of SB subpopulation and currently set at 56 bears (Alaska = 35, Canada = 21).

Polar bear harvest in the U.S. is monitored by the Service's Marking, Tagging, and Reporting Program (MTRP; 75 FR 76086) with the assistance of local taggers in Alaska's villages. A review of past and current harvest, and other forms of lethal take, and recommendations for harvest monitoring and management have been developed for CS (Schliebe et al. 2016, entire) and updated for CS and SB (Woodruff et al. 2021, entire).

Circumpolar−The 1973 Agreement was established in recognition of the significant impacts that unregulated and unsustainable non-subsistence harvest were having on polar bears, causing many subpopulations to be considered substantially depleted (PBRS 1973, entire; PBRS 2015, pp. 41–42). Measures outlined in the 1973 Agreement, such as regulated harvest management, have contributed to an increase in abundance in subpopulations that were experiencing unsustainable harvest (PBRS 2015, entire). In recent years, the PBRS have become active in addressing the emerging threat of climate change, with multilateral meetings held every 2–3 years from 2009–20 (5 meetings since 2009). In 2014, the PBSG was identified as the scientific advisor to the PBRS. The CAP was developed to synthesize and coordinate management and conservation activities among countries, in conjunction with national action plans developed by individual countries (PBRS 2015, entire). A midterm review of the CAP was conducted in 2020, halfway through the CAP implementation period (2015–25).

In 2015, the Trade Working Group of the PBRS produced six recommendations to explore mechanisms to 1) counter the threat of poaching and illegal trade in polar bear parts, 2) enhance cooperation among law enforcement agencies, 3) improve the clarity of legal trade data, and 4) improve identification of legally traded specimens. In 2015, the CITES Animals Committee removed the polar bear from a Review of Significant Trade on the basis that the level of harvest and trade in polar bear parts was not detrimental to the survival of the species (CITES 2015, entire. This action resulted in no change to the polar bear's listing under Appendix II of CITES. In 2015, the IUCN Red List Authority categorized the polar bear as "vulnerable" (Wiig et al. 2015, p. 1) due to the primary threat of habitat loss due to climate change.

Laidre et al. (2015b, pp. 732–736) published a circumpolar assessment of the status of Arctic marine mammals, including the polar bear, and recommended the following considerations for effective management and conservation: maintain and improve co-management by local, federal, and international partners; recognize spatial and temporal variability in marine mammal subpopulations responses to climate change; implement monitoring programs with clear goals; mitigate cumulative impacts of increased human activity; and recognize the limits of current protected species legislation.

3.3.2 Unsustainable harvest

Polar bear harvest remains an important nutritional, cultural, and economic resource for Indigenous people in many parts of the Arctic (e.g., Schliebe et al. 2006, p. 127; Born et al. 2011, throughout; Voorhees et al. 2014, entire). The U.S., Canada, and Greenland are currently the only countries that allow polar bear harvest by Indigenous people, and management regimes vary within these countries (73 FR 28212; Obbard et al. 2010, entire; Shadbolt et al. 2012, pp. 29–62). Canada is the only country that allows sport hunting through guided hunts in Nunavut and the Northwest Territories that use a portion of the tags allocated for subsistence harvest under existing management agreements.

All forms of human-caused removals are generally included in harvest statistics, however some types of removals, such as subsistence harvest and defense-of-life kills, are interrelated and often difficult to separate. The statistics in this section reflect all reported human-caused removals unless otherwise noted.

Shadbolt et al. (2012, p. 30) reported 735 polar bears per year were killed globally on average from 2006−07 to 2010−11 (winter years), which was 3–4% of their estimated global population of 20,000–25,000 polar bears (noting that Wiig et al. [2015, p. 5] suggested a global population size of 26,000 polar bears [95% CI = 22,000–31,000]). For polar bears, removing 4.5% of a subpopulation annually has historically been considered sustainable (Taylor et al. 1987, entire). Regehr et al. (2015, p. 42; 2017b, p. 1538) corroborated that a 4.5% removal rate is generally reasonable, although some subpopulations may support higher rates under favorable environmental conditions, and under some circumstances lower rates may be necessary to avoid accelerating population declines caused by habitat loss due to climate change. Shadbolt et al. (2012, p. 30) indicated that Canada harvested the highest number of bears of any Range State during this period, with an average of 554 bears per year. Greenland, the U.S., and Norway removed an average of 136, 45, and one bear per year, respectively. Information on bears removed in Russia was not available for their analysis, although the results of a study published in 2015 provided updated information of the current and historic number of polar bears removed from communities in Chukotka (Kochnev and Zdor 2015, entire; see *3.3.4 Illegal take*). Similarly, but spanning a longer time period (1970–2018), Vongraven et al. (2022, p. 6) reported 26,570, 7,018, 4,591, and 870 bears removed in Canada, Greenland, USA, and Norway, respectively.

The mean level of human-caused removal by subpopulation for the most recent 5 years is updated by the IUCN PBSG every 2 years (PBSG 2021, p. 52; Table 4). Recent harvest levels are thought to be sustainable in most subpopulations (Obbard et al. 2010, pp. 62–67; Table 1), although concerns exist for some subpopulations due to poor or outdated scientific data, poor or incomplete reporting of human-caused removals, or differences between scientific population data and IK. The PBSG categorized knowledge on the current trend of 8 subpopulations as “data deficient”, largely due to outdated demographic information (Table 1). Vongraven et al. (2012, entire) indicated polar bear harvest is closely monitored in most regions where it occurs but noted several subpopulations for which improvements to baseline harvest data and sampling were needed. Subsistence harvest levels are based on factors including scientific assessments of status, IK, and the level of local interests in harvesting polar bears for nutritional, cultural, and economic purposes (Vongraven et al. 2012, p. 29; Regehr et al. 2015, entire; Regehr et al. 2017b, entire). Subpopulations may respond differently to various levels of harvest pressure depending on multiple factors, and flexible harvest systems that can adapt to changing conditions may be necessary to mitigate and minimize the relative threat legal harvest poses to subpopulations (Vongraven et al. 2012, entire; Regehr et al. 2015, entire; Regehr et al. 2017b, entire).

Regehr et al. (2015, pp. 19–42) provided a modeling and management framework for harvesting wildlife affected by climate change, specifically polar bears. The framework uses state-dependent (i.e., dependent on current subpopulation condition) management to identify harvest levels that consider the effects of factors including changes in environmental carrying capacity (e.g., due to sea-ice loss), changes in intrinsic growth rate, the sex and age of harvested animals, the quality of population data (e.g., what are the accuracy and precision levels), timing of management decisions, and risk tolerance. The research evaluates the ability of the harvest management strategy relative to its ability to achieve two objectives: (1) maintain a subpopulation above its *mnpl* relative to a potentially changing carrying capacity, and (2) minimize the effect of harvest on subpopulation persistence.

Regehr et al. (2015, entire) demonstrated that harvest adhering to this framework is unlikely to accelerate subpopulation declines resulting from habitat loss due to climate change, recognizing that both the annual harvest level and rate (i.e., percent of the subpopulation removed annually) may decline for subpopulations negatively affected by climate change.

We provide more specific information on human-caused removal of polar bears for the U.S. portion of the CS and SB (Fig. 5). Since listing, the total human-caused removal was 540 bears, 275 and 265 from CS and SB, respectively. Of the 540 bears removed, 513 were subsistence kills. Cause of death for the remaining mortalities were: struck and lost (n = 13), defense of human life (n = 4), industry (n = 3), unknown human-caused (n = 3), research (n = 1), and euthanasia (n = 1). Also, 2 cubs were removed from the wild and placed in zoos (see *3.3.5 Other Removals*; Table 2). The average sex composition of removals since listing was 20.2% female, 63.9% male, and 15.9% unknown (Fig. 5).

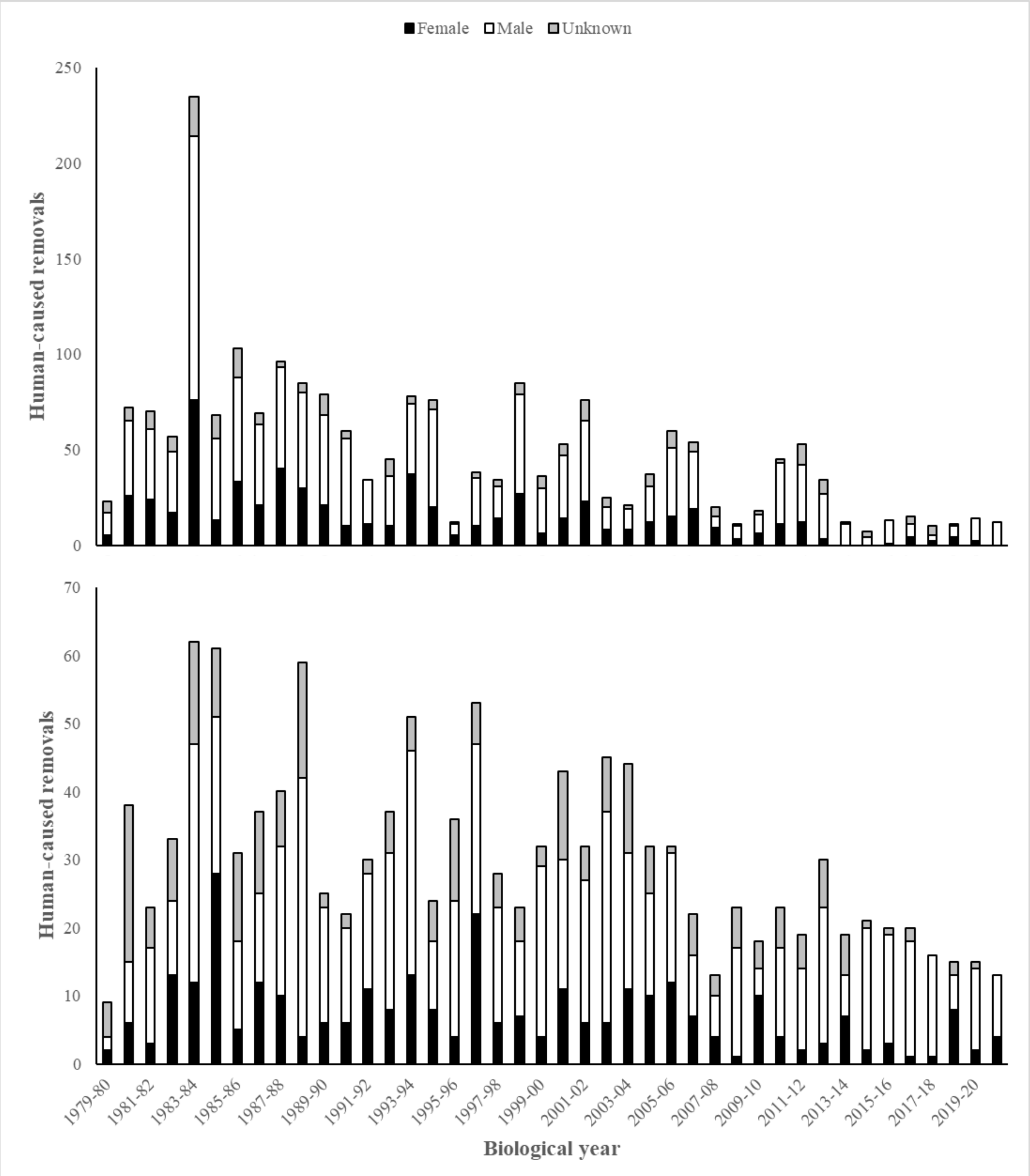

Figure 5. Human-caused removals by biological year (July 1−June 30 as defined by Canada relative to seasonal harvest) and sex for the Chukchi (upper panel) and Southern Beaufort Sea (lower panel) polar bear subpopulations, Alaska, 1979−2021 (data accessed 16 November 2022).

Table 2. Human-caused polar bear removals (*n* = 540) since listed as Threatened under the Endangered Species Act in Chukchi Sea and Southern Beaufort Sea subpopulations, Alaska, for biological year as defined by Canada relative to seasonal harvest, 1 Jul 2007–30 Jun 2021 (as of 16 November 2022).

Biological year	Type of removal							
	Subsistence	Defense of Life	Industry	Struck and Lost	Zoo	Research	Euthanized	Unknown human-caused
2007−08	32						1	
2008−09	33							1
2009−10	34			1		1		
2010−11	67				1			
2011−12	68		1	3				
2012−13	60		2	1	1			
2013−14	31							
2014−15	24	2		2				
2015−16	33							
2016−17	33			2				
2017−18	26							
2018−19	20	1		4				1
2019−20	28							1
2020−21	24	1						
Total	513	4	3	13	2	1	1	3

3.3.3 Human-bear conflicts

Human-bear conflicts and/or defense-of-life kills may increase under projected climate change scenarios (Derocher et al. 2004, pp. 169–170; Dyck 2006, p. 59; Towns et al. 2009, pp. 1535–1536; Wilder et al. 2017, p. 545; Rode et al. 2022, entire). Since the late 1990s, freeze-up in the autumn has been occurring progressively later in the year. This has resulted in polar bears spending a longer amount of time on land in some areas (Rode et al. 2015a, pp. 9–14; Atwood et al. 2016b, pp. 9–15; Laidre et al. 2020a, pp. 4–5; Rode et al. 2022, pp. 8–13), which could increase the probability of interactions between bears and people. With projections indicating that the Arctic Ocean may be largely ice free in the summer in the coming decades (Overland and Wang 2013, entire), human-polar bear conflicts are expected to increase as bears are forced onshore in close proximity to people (Dyck 2006, pp. 57–59; Regehr et al. 2007, p. 2681; Towns et al. 2009, pp. 1535–1536). Polar bears are inquisitive animals and often investigate novel odors or sights. This trait can lead to polar bears being killed when they investigate human activities (Dyck 2006, p. 58), and can cause concerns for human safety. Therefore, understanding and implementing measures to proactively prevent human-bear conflicts is vital to help reduce polar bear mortality due to conflicts with humans.

Reducing human-polar bear conflicts has become an increasingly important issue for many communities across the Arctic. In recent years, multi-stakeholder efforts have increased. Government agencies, non-governmental organizations (NGOs), and local communities throughout the Arctic have been working together to provide resources to remove and/or secure attractants in villages (e.g., bear-resistant containers, and electric fencing), and fund polar bear patrols (Voorhees and Sparks 2012, pp. 23, 65, 109; Voorhees and Sparks 2019, pp. 21–23; York et al. 2014, pp. 31–32). These initiatives strive to minimize human-bear conflicts and create safe communities; however, much work remains. Reducing human-bear conflicts through attractants management, such as managing natural attractants (i.e., harvested marine mammals) and human food and garbage in or near human settlements continues to be an important and challenging issue for Arctic communities and wildlife managers (Koopmans 2011, pp. 20–27; Aerts 2012, entire; Alaska Nanuuq Commission 2013, entire; York et al. 2014, pp. 31–32).

Polar bear patrols in coastal communities are an effective technique to reduce human-bear conflicts through detection, deterrence, and education. These structured programs enable trained, local residents to deter polar bears from entering communities using a variety of less-lethal techniques (Alaska Nanuuq Commission 2013, entire; Service 2017b, entire). Since 1992, there have been successful efforts in Alaska by the North Slope Borough (NSB) Department of Wildlife Management as well as individual tribal governments to implement patrol programs. Beginning in 2010, the NSB and the Service have worked together to fund and carry out patrols in the North Slope villages of Utqiaġvik (formerly Barrow), Kaktovik, Nuiqsut (Cross Island), Point Hope, Point Lay, and Wainwright. This program has been very successful in limiting the number of bears killed due to public safety concerns. Efforts to formalize training and deterrence programs have been an important step in making the program successful. Continued efforts are needed to implement training programs annually and to provide funds needed to support the program (Rode et al. 2021, p. 253). Established polar bear patrols now occur in the U.S., Canada, Greenland, and Russia. In addition to community patrols, there are a number of active deterrence programs across the Arctic implemented by industry, academic institutions, and other private organizations to address human-bear conflicts (PBRS 2022, entire).

While deterrence may not be effective for every polar bear, it does provide an option other than lethal removal for keeping polar bears out of communities or developed areas in the majority of cases. Despite the thousands of interactions where polar bears have been deterred in the U.S., accidental mortalities of polar bears have occurred as part of deterrence activities (*n* = 3). One mortality occurred in 2011 when a bear died from injuries sustained when shot with a cracker shell by an industry bear guard. Two bears were accidentally killed by community polar bear patrols in 2012 and 2021 during hazing events when a lethal round was mistaken for a non-lethal round (2021 incident not included in mortality numbers reported above because it was after the cutoff date of 30 June 2021).

3.3.4 Illegal take

Wiig et al. (2015, p. 7) reported that range-wide illegal hunting of polar bears was not considered a major concern, although given the remoteness of human settlements throughout the PBRS, poaching is hard to record and quantify. During the 2008 listing review (73 FR 28212), the Service found limited evidence to suggest that poaching is a concern in the subpopulations within Canada, Norway, Greenland, and the U.S. However, poaching may be an issue for the subpopulations within Russia. Polar bear hunting has been prohibited in Russia since 1956, but the level of poaching is unknown in KS and LV (Vongraven et al. 2012, p. 30). Poaching appeared to increase in northeast Russia (Chukotka) after the collapse of the Soviet Union. The level of illegal killing was estimated to be high enough to be unsustainable and pose a threat to CS in the 1990s (Obbard et al. 2010, p. 186). Based on community interviews conducted in 2010−11, illegal hunting of polar bears in CS removed approximately 32 bears per year (Kochnev and Zdor 2015, p. 101). This represented a likely decline from the estimated 209 bears killed annually in 1994−2003. Illegal hunting in Canada is reportedly a rare event (Environment Canada 2010, p. 4). There is little documentation of illegal hunting in Greenland, although two men were charged with hunting polar bears with illegal equipment in 2011 (Shadbolt et al. 2012, p. 51). No documented cases of illegal hunting exist for Norway (Svalbard). Like Canada, illegal takes in the U.S. are rare: in 2008−21, two bears were known to be illegally taken: one each in 2013 (CS; harvest of female with cub, violation of Bilateral Agreement and Title V, MMPA), and 2018–19 (SB; wasteful harvest as defined in MMPA).

3.3.5 Other removals

Other forms of removal include take associated with accidental mortality during scientific research, industrial activities, and placement of orphaned cubs into public display facilities. In 2008, these levels of take were sufficiently low that we determined they were insignificant and had no effect on population status. New information summarized below indicates this is still an accurate assessment.

Research. Research activities may cause short-term effects to individual polar bears targeted in survey and capture efforts (Thiemann et al. 2013, pp. 390–392, Whiteman et al. 2022, entire; Stirling et al. 2022, entire) and may incidentally disturb those nearby. In rare cases, research efforts may lead to injury or death of polar bears. Between 1967 and 2017, there were >4,500 capture events of polar bears in Alaska with an overall capture mortality rate of ~ 0.5%. In 2001, the USGS began an intensive capture-mark-recapture project for SB that is ongoing (note this changed to biopsy darting instead of physical capture in 2016), and mortality has been low (~0.24%). Polar bear capture in SB has not been shown to result in any long-term effects on body condition, reproduction, or cub survival (Rode et al. 2014a, pp. 316–319).

Industrial Activities. Climate change is expected to increase accessibility to natural resources in the Arctic, effectively increasing industrial activities and related support infrastructure in the circumpolar regions. Industries, such as mineral extraction, shipping, and petroleum exploration and development, are all expected to increase in the future (Peters et al. 2011, entire; Larsen and Fondahl 2015, entire). Three polar bear mortalities have been recorded in SB since the listing as a result of industry activities. In 2011, a security guard for an oil company accidently shot and killed a female polar bear during a deterrence action (same incident noted above in human-bear conflicts). In 2012, an adult female and her two-year old male cub were found dead on an island near industry facilities. Their deaths are assumed to be related to the chemical substances found in and on the bears. Industrial activities are further discussed below.

Orphaned Cubs. Two orphaned COY were removed from the wild in the U.S. during the period 2008–21. In 2011, an orphaned female cub from SB was recovered in an industrial area after apparently being separated from its mother and was subsequently sent to a zoo. In 2013, an orphaned male COY was recovered from CS as a stranded animal after its mother was harvested. It was subsequently sent to a public display facility for long term care and maintenance. In Russia, several orphaned cubs (no specific number provided) are removed from the wild annually (Ministry of Natural Resources of Russia 2010, pp. 11–12). No other recent information on orphaned cubs has been documented from other countries.

3.4 Other Natural or Anthropogenic Threats

3.4.1 Contaminants

The topic of contaminants is complex and highly specialized. Many studies, including several comprehensive reviews, have been published on the effects of contaminants on marine mammals, including polar bears (e.g., Letcher et al. 2010, pp. 2998–3015; Sonne 2010, entire; McKinney et al. 2011, entire; Routti et al. 2019a, entire; Routti et al. 2019b, entire). The adverse effects of contaminants on polar bears can include neurotoxicity as well as impacts to the immune system, corticosteroids, sex hormones, thyroid health, energy metabolism, liver and kidney function, reproduction, bone density, and skeletal system (Sonne 2010, p. 5; Routti et al. 2019a, entire). Current contaminant concentrations are not believed to have population-level effects on most subpopulations, although they may become a more significant threat in the future, especially for subpopulations experiencing declines related to nutritional limitations associated with sea ice loss and environmental changes (PBRS 2015, pp. 36–37; Service 2016, pp. 73–74; Arctic Monitoring and Assessment Programme 2018, pp. 13, 17); Routti et al. 2019a, entire; Hoondert et al. 2021, pp. 6–11).

Understanding the potential effects of contaminants on polar bears in the Arctic is confounded by the wide range of contaminants present, each with different chemical properties and biological effects, and their differing geographic, temporal, and ecological exposure regimes. Three main groups of contaminants in the Arctic present the most significant potential threats to polar bears and other marine mammals: legacy persistent organic pollutants (POPs; i.e., chemicals that "leave a legacy" by remaining in the environment for a long period of time), heavy metals, and petroleum hydrocarbons (73 FR 28212; Service 2016, pp. 73–76). The predominant compounds found in polar bears are polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), brominated flame retardants (FRs), perfluoroalkyl substances (PFAS) including perfluoroalkyl acids and perfluorooctane sulfonic acids (PFOS), and mercury (Dietz et al. 2013a, entire; Dietz et al. 2013b, entire; Routti et al. 2019, p. 1064). Contamination from petroleum hydrocarbons is discussed in *3.2.1 Industrial development*.

Concentrations of POPs have generally declined in polar bears since the adoption of the Stockholm Convention, which imposed regulations or bans on POP use (UNEP 2001, entire). However, due to the propensity of POPs to bioaccumulate and biomagnify in fatty tissues, they are of particular concern to species, such as polar bears, that are at a high trophic level and consume a lipid-rich diet (Letcher et al. 2010, pp. 3014–3015; Routti et al. 2019a, entire; Hoondert et al. 2021, pp. 1, 8–11). The presence and persistence of these contaminants is dependent on factors such as transport routes, distance from source, and quantity of the contaminant in the environment (Service 2016, pp. 73–76). Therefore, contaminant exposure and subsequent assimilation vary among subpopulations. For example, concentrations of PCBs in KS and EG were found to be approximately twice as high as those in WH, SH, and BS, whereas concentrations in CS and SB were considerably lower than other subpopulations (Routti et al. 2019b, pp. 1066–1067). A recent study evaluated the relationship between legacy POPs and projected population growth rate for 15 subpopulations with available contaminant data under three different species-risk scenarios (low, medium, and high-risk; Hoondert et al. 2021, entire). Levels of POP chemicals in seal species (ringed, spotted [*Phoca largha*], harp, ribbon, and bearded) and walrus were used as correlates to polar bears. Their results suggested a negative population growth rate for 10 of 15 subpopulations under the medium-risk scenario, and all subpopulations showed a negative trajectory in population growth rate under the high-risk scenario (Hoondert et al. 2021, p. 6).

Data on the biological effects on Arctic biota, including polar bears, of a subgroup of POPs known as organohalogen contaminants (OHC) indicated polar bears in SH, WH, EG, and BS have the highest potential risk of POP/OHC exposure (Letcher et al. 2010, pp. 3006–3007). Increasing OHC levels have been related to decreasing sizes of sexual and reproductive organs, which could eventually lead to population-level impacts (Sonne et al. 2018, entire). Contaminant exposure has also led to declines in bone mineral density for most sex and age classes, which could manifest as osteoporosis and/or other bone-related diseases (Sonne et al. 2004, p. 1714; Sonne et al. 2012, p. 3).

Similarly, analysis of samples collected from polar bears in 11 subpopulations (2005–08) indicated levels of FRs and legacy contaminants were highest in bears from these same four subpopulations (McKinney et al. 2011, entire). Subsequently, Dietz et al. (2015, entire) conducted a risk assessment of OHC levels found in polar bears from 11 subpopulations (1999–2008) to assess reproductive effects, immunotoxicity, and carcinogenicity. Results indicated that all examined subpopulations were at risk for additive effects from OHC, and that PCBs were the highest contributor to risk. PCBs and PCB metabolites, in combination with natural stressors and other contaminants, can also affect polar bear reproductive potential (Gustavson et al. 2015, entire; Sonne et al. 2015, entire) and thyroid health (Grønning 2013, pp. 43–51).

Shifts in contaminant burdens in polar bears may be a result of dietary shifts resulting from climate-induced sea ice changes. Reduction in the length of the sea-ice season can also influence bio-accumulative contaminant concentrations in polar bears due to prey switching behavior (McKinney et al. 2009, entire). Higher contaminant levels are possibly due to increased feeding on high trophic level prey found in sea-ice habitats, rather than terrestrial food sources or fasting (Tartu et al. 2017, p. 22). The polar bears in this study with higher contaminant levels generally had larger home ranges, and thus higher energy requirements, potentially adding to the level of contaminant intake via on-ice prey consumption (Tartu et al. 2018, pp. 16–17).

The ecological impacts of climate change on mercury exposures in bears are a complex interplay of sea ice dynamics, atmospheric loading of contaminants, permafrost melt, and predator-prey dynamics (McKinney et al. 2015, pp. 619–621, 625). Mercury levels in marine mammals often exceed levels that have caused effects in terrestrial mammals (Arctic Monitoring and Assessment Programme 2021, p. 176). Mercury levels are expected to continue to increase over time in the Arctic due to several climate-related factors. The release of mercury from thawing permafrost is likely to accelerate as a result of warming of the climate (Rydberg et al. 2010, entire). Carbon isotope data and mercury levels in the livers of polar bears from Canada, Alaska, and Greenland, suggested polar bear food webs rich in river-exported carbon may lead to elevated total mercury concentrations (Routti et al. 2012, p. 1070). In the Yukon River Basin in Alaska, a large amount of organic-carbon associated mercury (a particularly bioavailable form of mercury) was "exported" to the marine environment; this was attributed, in part, to permafrost thaw and other climate-related factors (Schuster et al. 2011, entire).

The effects of mercury on neurological health and reproduction have been well studied in a few mammalian species and in human epidemiological studies, but less is known about dose-response relationships in polar bears. Studies of neurochemical parameters related to mercury in brains of polar bears in northern Canada indicated current environmental exposure levels of mercury do not appear to have an effect (Krey et al. 2014, pp. 2466–2469), although this could change with increasing levels of mercury in the environment. In SB, high concentrations of mercury due to differing prey consumption was associated with decreased abundance and diversity of gut microbiota, both of which are important for overall health and immune response (Watson et al. 2021, entire). However, McKinney et al. (2017b, p. 7818) documented a decline in methyl mercury concentrations of SB bears over a short period of time (2004–11). Environmental mercury loads are expected to continue to increase in subpopulations over time, thus mercury should continue to be an important focus of future monitoring efforts and toxicological research.

International regulations have likely been effective in reducing some contaminants in the environment. However, slow declines of some legacy pollutants (e.g., PCBs) coupled with exposure to "new" chemicals continues to be a concern to polar bear health (McKinney et al. 2009, entire). Population-level effects are still widely undocumented for most subpopulations but should continue to be closely monitored given increasing exposure to contaminants may become a more significant threat in the future, especially for declining or nutritionally stressed subpopulations.

3.4.2 Parasites and disease

Historically, it has been assumed that the spread of pathogens among polar bears has been limited due to minimal host-to-host interactions between bears on the sea ice; therefore, disease and parasites are considered low level threats (73 FR 28212; Vongraven et al. 2012, pp. 37, 40–41; PBRS 2015, pp. 33; PBRS 2020, pp. 7–10). However, data on the exposure of polar bears to disease agents and parasites are limited (i.e., restricted almost entirely to SB and BS), and there is no information on putative links between disease status and population vital rates. In a recent study investigating the prevalence of helminths on ice seal species (i.e., polar bear prey species) in the Bering and Chukchi Seas, there was no increase in prevalence of, and no new, helminths during the period 2006–15 (Walden et al. 2020, entire). However, the lack of polar bear specific information is a concern given that climate change is expected to have both direct and indirect effects on disease dynamics in the Arctic due to changes in host-pathogen associations, altered transmission dynamics, and host and pathogen resistance (Burek et al. 2008, entire; Atwood et al. 2017, entire; Pilfold et al. 2021, entire).

There is limited information on the health effects of infectious diseases in polar bears (e.g., exposure to various bacteria, fungi, parasites, and viruses; Fagre et al. 2015, pp. 533–534). Additionally, the majority of diseases found in captive polar bears do not occur in the Arctic environment and may have limited value for understanding the importance of these diseases in wild populations (Fagre et al. 2015, pp. 534–536). As the effects of climate change become more prevalent, there are concerns with the expansion of existing pathogens within polar bear range (Weber et al. 2013, entire). New pathogens may expand northward from southerly areas under projected climate change scenarios (Harvell et al. 2002, p. 2161), although the susceptibility of bears to new pathogens due to their lack of previous exposure to diseases and parasites is unknown. Increased time on land during ice-free summers may increase exposure to pathogens (Atwood et al. 2017, entire). Further concerns include the potential for pathogens crossing human-animal boundaries (e.g., giardia) and new threats from existing pathogens that may be able to establish in immuno-compromised/stressed individuals. Several pathogens and viruses have been found in seal species that are polar bear prey, so the potential also exists for transmission of these diseases to bears.

The potential for disease outbreaks, exposure to novel pathogens, or increased susceptibility to existing pathogens all warrant continued monitoring and may become more significant threats as subpopulations decline and/or experience nutritional stress (73 FR 28212). Due to the synergistic impacts of warming and pollutants potentially compromising the resistance of bears to disease and parasites, collecting baseline data on common diseases in different subpopulations and tracking temporal trends in prevalence could help future research and monitoring (Patyk et al. 2015, entire). The best available science currently indicates that disease is a low threat, although periodic monitoring of polar bear exposure to, and the effects of, disease agents, pollutants, and contaminants is warranted.

3.4.3 Competition and predation

Interspecific competition, such as hybridization and for food resources, has been documented between polar and grizzly bears. The ranges of these species overlap in portions of northern Canada, eastern Russia, and northern and western Alaska. The first documented case of hybridization in the wild was a first-generation male hybrid harvested on Banks Island, Canada in 2006 (Doupé et al. 2007, p. 273). Two additional hybrids were harvested on Victoria Island and multiple sightings were confirmed in Canada, one of which was considered a second-generation hybrid, the result of a female grizzly-polar hybrid mating with a male grizzly bear (Species at Risk Committee [SARC] 2012, p. 108; Pongracz et al. 2017, entire). An adult female polar bear with two older first-generation hybrid cubs was harvested in April 2012. Pongracz et al. (2017, entire) reported two additional probable hybrids from photos and 4 hybrids during capture in April 2014 (1 first- and 3 second-generation individuals). Hybridization in the wild is thought to be rare but warrants monitoring for potential increases in occurrence. Based on the harvest and sighting locations, polar bears affected by hybridization with grizzly bears are likely from the Northern Beaufort Sea (NB) and Viscount Melville Sound (VM) subpopulations. Regarding food resources, polar bears apparently competed with brown bears for localized food resources in Barter Island, Alaska (2005–07). Brown bears were socially dominant and frequently displaced polar bears from bowhead whale remains left after subsistence harvest (Miller et al. 2015, entire). The effects of these interactions to individual polar bears were unknown.

Intraspecific competition (i.e., cannibalism and infanticide by male bears) among polar bears has been documented. However, cannibalism (Derocher and Wiig 1999, entire; Amstrup et al. 2006, entire; Stirling and Ross 2011, entire) and infanticide (Taylor et al. 1985, entire; Derocher and Wiig 1999, entire; Stone and Derocher 2007, entire) have not resulted in population-level effects. However, anecdotal findings suggest cannibalism may be increasing in portions of Russia due to increasing nutritional stress (Ivanov 2020, entire).

3.4.4 Loss of terrestrial habitat

Though ice habitat is critical to the ability of polar bears to access their prey, protection of terrestrial denning and summering habitats is, and will likely be, important to supporting the long-term persistence of polar bears (Service 2016, p. 30). Durner et al. (2009, entire) demonstrated marked reductions of polar bear habitat (i.e., sea ice) in spring and summer for SB, CS, BS, and EG between 1985–1995 and 1996–2006. Projected changes during the 21st century estimated additional habitat losses in LV and KS. Erosion associated with reduced sea ice also cause concerns for loss of important maternal denning habitat on barrier islands and along the coast (Zimmermann et al. 2022, entire). Minimal habitat losses were projected for areas north of the Canadian archipelago and Greenland, suggesting these regions could serve as refugia under future climate scenarios (Durner et al. 2009, p. 55; Service 2016, p. 43).

An expanding anthropogenic footprint has the potential to influence the spatial distribution, connectivity, and quality of lands that might serve as terrestrial habitat for polar bears. Access to terrestrial habitats is likely not compromised currently for polar bears, yet further monitoring is needed of any potential threats to polar bear terrestrial habitat use and availability and the effects those threats may have on population vital rates. In particular, increased use of land is likely to heighten the risk of human-bear interactions and conflicts, particularly if anthropogenic activity in the Arctic increases as projected (e.g., Vongraven et al. 2012, p. 8), the human population in the Arctic grows, and management of attractants is not improved.

3.5 Regulatory Mechanisms and Conservation Efforts

The ongoing threats to the long-term viability of polar bears is of international interest, and many governmental agencies, NGOs, institutions, and Indigenous organizations are currently involved in polar bear conservation. These entities are integral to the conservation of the species and are working around the world to mitigate the severity of threats to polar bears. Because most of the threats are a direct or indirect result of anthropogenic climate change (Atwood et al. 2015, entire; Atwood et al. 2016a, entire), **the foremost conservation action is limiting atmospheric levels of GHGs via a reduction in global GHG emissions**. Domestic and international conservation agreements and plans are described below.

3.5.1 International conservation agreements and plans

Agreement on the Conservation of Polar Bears (1973 Agreement)

All five PBRS are parties to the 1973 Agreement. The 1973 Agreement requires the signatories to take appropriate action **to protect the ecosystem of which polar bears are a part, with special attention to habitat components, such as denning and feeding sites, and migration patterns, and to manage subpopulations in accordance with sound conservation practices based on the best available scientific data**. The 1973 Agreement relies on the efforts of each party to implement conservation programs and does not preclude a party from establishing additional controls (Lentfer 1974, p. 1). In 2009, the PBRS agreed to initiate a process that would lead to a coordinated approach to conservation and management strategies between the parties. Subsequently, the CAP was developed (see *Circumpolar* section of *3.3.1 Management systems and agreements*).

Inuvialuit-Iñupiat Agreement for the Management of Polar Bears of the Southern Beaufort Sea (I-I Agreement)

In January 1988, the Inuvialuit of Canada, and the Iñupiat of Alaska, two groups of Indigenous peoples that harvest polar bears for cultural and subsistence purposes, signed a management agreement for SB (I-I Agreement; Brower et al. 2002, entire). **This agreement is based on the understanding that the two groups harvest animals from a single subpopulation shared across the international boundary and establishes expectations on management, and conservation priorities with an emphasis on harvest**. The I-I Agreement provides joint responsibility for conservation and harvest practices (Treseder and Carpenter 1989, pp. 2–4; Brower et al. 2002, entire). In Canada, recommendations and decisions from the I-I Commissioners are implemented through Community Polar Bear Management Agreements, Inuvialuit Settlement Region Community Bylaws, and Northwest Territories Big Game Regulations. In the U.S., the I-I Agreement is implemented at the local level, and adherence to the agreement's terms is voluntary.

Agreement between the United States of America and the Russian Federation on the Conservation and Management of the Alaska-Chukotka Polar Bear Population (Bilateral Agreement)

On 16 October 2000, the U.S. and the Russian Federation signed a bilateral agreement for the conservation and management of the polar bear subpopulation shared between the two countries. The Bilateral Agreement expands upon the progress made through the multilateral 1973 Agreement **by implementing a unified conservation and harvest program for this shared subpopulation** (i.e., CS or commonly referred to the Alaska-Chukotka population). The U.S. domestic implementing statute of the Bilateral Agreement is Title V of the MMPA (2007). Beginning in 2007, parties to the treaty established a joint U.S.-Russia Commission responsible for making management decisions concerning polar bears in the Alaska-Chukotka region. The Commission is composed of a Native and Federal representative from each country. The Commissioners appointed the Scientific Working Group (SWG), which is tasked with numerous objectives; however, the top priority was, and still is, to identify and evaluate a sustainable harvest level for CS. In response to this initiative, the SWG provided the Commission with a peer-reviewed report of their recommendations regarding harvest and future research. In June 2010, the Commission placed an upper limit on annual harvest from CS of 19 female and 39 male polar bears to be split evenly between Native peoples of Alaska and Chukotka. At the 2018 Commission meeting, the SWG presented an updated abundance estimate and harvest risk assessment for CS (2,937; 95% C.I. = 1,552–5,994; Regehr et al. 2018, p. 7; Regehr et al. 2021b, entire). Based on this new demographic data and analyses, the harvest risk assessment indicated that an annual sustainable harvest level of 80−90 bears represented a moderate degree of risk of reducing the population below *mnpl* and was unlikely to have significant negative population effects (Regehr et al. 2021b, entire). The SWG also presented an updated model (Scharf et al. 2019, entire) suggesting the eastern biological boundary between CS and SB should be located between Icy Cape and the western edge of Smith Bay, Alaska (as opposed to Point Barrow). **Following the recommendations from the SWG, the Commission adopted an annual removal level of 85 polar bears, of which no more than one-third may be female, to be split equally between the countries; this is the only enforceable removal level in the U.S.** The Commission also agreed to pursue the exchange of diplomatic notes to modify the area to which the Bilateral Agreement applies (i.e., the eastern biological boundary was to be Icy Cape). Formal modification of the eastern boundary of the Bilateral Treaty has not been completed.

The extent of the impacts of the Russian invasion of Ukraine in February 2022 on bilateral efforts to manage and conserve polar bears in CS as well as implementation of the Bilateral Agreement are currently undetermined. In the near term, bilateral monitoring efforts (i.e., instrument-based aerial surveys and autumn research and monitoring operations on Wrangel Island) and implementation of the Bilateral Agreement are on hold until diplomatic relations are resumed with the Russian Federation.

Memorandum of Understanding between Environment Canada and the United States Department of the Interior Concerning the Conservation and Management of Shared Polar Bear Populations

In May 2008, the Canadian Minister of Environment and the U.S. Secretary of the Interior signed a Memorandum of Understanding (MOU) **to facilitate and enhance coordination, cooperation, and the development of partnerships between the two countries, and with other associated and interested entities, regarding polar bear conservation and management**. The MOU also provides a framework for the development and implementation of mutually agreeable immediate, interim, and long-term actions that focus on specific components of polar bear conservation.

Bilateral Environmental Agreement between the Government of Russia and the Government of Norway, including Provisions on Polar Bear Conservation

The bilateral environmental agreement between the Government of the Russian Federation and the Government of Norway was signed 24 December 1992. As part of this agreement, **a MOU was signed between the two governments in 2015 to cooperate with regard to research, monitoring, and management of the BS**.

MOU between the Government of Canada, the Government of Nunavut, and the Government of Greenland for the Conservation and Management of Polar Bear Populations

This was created to aid in conservation and sustainable management of the shared subpopulations in KB and BB. It also **outlines the creation of a joint commission that recommends a harvest quota and division of the shared harvest between Canada (the Government of Nunavut and Environment and Climate Change Canada) and Greenland**. The Joint Commission also coordinates science, IK, and outreach.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

CITES is a treaty designed to protect animal and plant species at risk from international trade (CITES 1963, entire). CITES regulates international wildlife trade by listing species in one of its three appendices; the level of monitoring and regulation to which an animal or plant species is subject depends on the appendix in which it is listed. Polar bears were listed in Appendix II of CITES on 1 July 1975 (CITES 2021a); "Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled" (CITES 2021b, entire). As such, CITES parties (i.e., any party agreeing to be bound by the CITES convention) must determine, among other things, that any polar bear, polar bear part, or product made from polar bear is legally obtained and the export will not be detrimental to the survival of the species, prior to issuing a permit authorizing the export of the animal, part, or product. All PBRS are CITES signatories and have the required Scientific and Management Authorities, which determine "…whether or not the proposed trade would be detrimental to the survival of the species …" (Description of designation and role of the Scientific Authorities) and ensures legal trade through the issuance of permits (Description of the designation and role of Management Authorities).

In 2010 and 2013, the US proposed up-listing polar bears to CITES Appendix I, an up-listing unsupported by the other PBRS. Listing under Appendix I requires that a species must meet one of three biological criteria: 1) a small wild population (the CITES guideline is <5,000 individuals; Annex 1A); or 2) a restricted area of distribution (Annex 1B); or 3) a marked decline in the population size in the wild (Annex 1C). Trade criteria must also be met: a species must be "affected by trade" (defined as "trade has or may have a detrimental impact on the status of the species") or "there is a demonstrable potential international demand for the species, that may be detrimental to its survival in the wild". Polar bears were not up-listed to Appendix I and remain an Appendix II species. In Canada, more recent analyses were conducted and concluded "trade does not currently constitute a significant driver of harvest in Canada and appears to be a low threat to conservation of polar bears" (Cooper 2015, entire; Cooper 2022, entire). **CITES is effective in regulating the international trade in polar bear parts and products and provides conservation measures to minimize that potential threat**.

3.5.2 Domestic regulatory mechanisms

Marine Mammal Protection Act of 1972 (MMPA)

The MMPA was enacted on 21 October 1972. All marine mammals, including polar bears, are protected under the MMPA. The MMPA prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters and by U.S. citizens and the importation of marine mammals and marine mammal products into the U.S. (MMPA, as amended; 16 U.S.C. §§ 1361 et seq.). Passage of the MMPA in 1972 established a moratorium on sport and commercial hunting of polar bears in Alaska. However, the MMPA exempts harvest, conducted in a non-wasteful manner, of polar bears by coastal dwelling Alaska Natives for subsistence and handicraft purposes. The MMPA and its implementing regulations also prohibit the commercial sale of any marine mammal parts or products except those that qualify as authentic articles of handicrafts or clothing created by Alaska Natives. The MMPA was amended in 1981 to allow for monitoring of Alaska Native subsistence harvest and the Service revised 50 CFR Part 18 to include regulations for harvest reporting of marine mammals as authorized under section 109(i) of MMPA (i.e., MTRP). In 1994, the Service, in partnership with the National Marine Fisheries Service, the Marine Mammal Commission, the Indigenous People's Council for Marine Mammals, and its member Alaska Native organizations (ANO) worked with Congress to amend the MMPA to include a new section (119) that provided for the co-management of subsistence use of marine mammals. Section 119 of the MMPA allows the Secretary to "…enter into cooperative agreement with Alaska Native organizations to conserve marine mammals and provide co-management of subsistence use by Alaska Natives." This also authorizes grants to be made to the ANOs to carry out agreements made under section 119. The Service may regulate harvest for species or stocks considered depleted (i.e., listed under the ESA); the Service has not determined that polar bear harvest should be limited under this provision. The MMPA Incidental and Intentional Take Program (IITP) allows for the incidental nonintentional take of small numbers of marine mammals during specific activities. The MMPA also allows for intentional "take by harassment" of marine mammals for deterrence purposes. The Service administers an IITP that allows polar bear managers to work cooperatively with stakeholders (i.e., oil and gas industry, mining industry, military, local communities, and researchers) working in polar bear habitat to minimize impacts of their activities on bears. The IITP has been an integral part of the Service's management and conservation program for polar bears in Alaska since its inception in 1991. The MMPA was further amended in 2007 to include Title V, which applies to the harvest of polar bears from CS and is the domestic implementing statute of the Bilateral Agreement.

Endangered Species Act of 1973 (ESA)

The ESA, as amended (16 USC 1531 *et seq*.), was passed to provide a mechanism to conserve threatened and endangered plants and animals, and their habitat. Listing under the ESA implements prohibitions on the take of the species. Under section 7 of the ESA, all Federal agencies must ensure that any action they authorize, fund, or carryout "…is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species…". Consultations occur with Federal action agencies under section 7 of the ESA to avoid and minimize impacts of proposed activities on listed species.

A status review and subsequent 12-month finding on the polar bear were completed in 2007 with the finding announced in the Federal Register on 9 January 2007 (72 FR 1064) when the Service published a proposed rule to list the polar bear as threatened on the Federal List of Endangered and Threatened Wildlife in 50 CFR 17.11(h). On 15 May 2008 the global polar bear population was listed under the ESA as a threatened species (73 FR 28212). Critical habitat (see section below) designation became effective 6 January 2011 (75 FR 76086), and a special rule for the polar bear under section 4(d) of the Act was finalized on 20 February 2013 after completion of appropriate National Environmental Policy Act (42 U.S.C. 4321 et seq.; NEPA) analysis (78 FR 11766).

The CMP (see below; Service 2016, entire) serves the dual purpose of a recovery and a conservation plan as required by the ESA and MMPA, respectively. A 5-year status review was completed and published in 2017.

The Alaska National Interest Lands Conservation Act of 1980 (ANILCA)

The Alaska National Interest Lands Conservation Act of 1980 (16 U.S.C. 3101 et seq.) created or expanded National Parks and National Wildlife Refuges (NWR) in Alaska, including the expansion of the Arctic NWR. One of the establishing purposes of the Arctic NWR was to conserve polar bears. Section 1003 of ANILCA prohibited production of oil and gas in the Arctic NWR, with no leasing or other development leading to production of oil and gas permitted unless authorized by an Act of Congress. In 2017, the Tax Cuts and Jobs Act (Public Law 115-97) authorized oil and gas leasing to occur in a portion of the coastal plain within the Arctic NWR known as the 1002 Area (see *United States* section of *3.2.1 Industrial Development*).

Critical Habitat Designation

The Service designated critical habitat for subpopulations in the U.S. effective 6 January 2011 (Service 2010, entire; 75 FR 76086). The critical habitat designation identified geographic areas containing features essential for the conservation of the polar bear within Alaska. Polar bear critical habitat includes barrier island and sea ice (both habitats are described in geographic terms), and terrestrial denning habitats (described as a functional determination). Barrier island habitat includes coastal barrier islands and spits along Alaska's coast, and is used for denning, refuge from human disturbance, access to maternal dens, feeding habitat, and travel along the coast. Sea ice habitat is located over the continental shelf and includes water ≤300 m (~984 ft) deep. Terrestrial denning habitat includes lands within 32 km (~20 mi) of the northern coast of Alaska between the Canadian border and the Kavik River and within 8 km (~5 mi) of the northern coast of Alaska between the Kavik River and the community of Utqiaġvik. The total designated area covers approximately 484,734 km2 (~187,157 mi2) and is entirely within the lands and waters of the U.S.

Polar Bear Conservation Management Plan (CMP)

In 2016, the Service published the CMP that was developed as a practical guide to implementation of polar bear conservation in the U.S. The CMP delineates reasonable actions that the Service believes will contribute to the conservation and recovery of polar bears (Service 2016, entire). From a legal perspective, the purpose of the CMP is to articulate the conditions whereby polar bears would no longer need the protections of the ESA and to lay out a collective strategy to achieve those conditions. A parallel path is laid out for improving the status of polar bears under the MMPA. Although the CMP satisfies the statutory requirements of the ESA and the MMPA, it is more broadly focused than a typical recovery or conservation plan and reflects the diverse input of regional stakeholders. The Fundamental Goals focus on conservation of polar bears while recognizing values associated with Indigenous cultures (e.g., harvest), human safety, and economic activity. The plan emphasizes engagement with the Alaska Native peoples who have lived with and depended on polar bears for thousands of years and the oil and gas industry on the North Slope of Alaska to keep employees safe and minimize defense-of-life kills, all of which are integral to polar bear conservation.

Chapter 4: Current Conditions

In this chapter, we present our understanding, based on the best available science, of the current conditions of polar bears in terms of the 3 Rs (summarized in **Chapter 1**; Figs. 3, 4). Current Conditions for each subpopulation are summarized (Table 1) and presented in detail herein. We provide a brief summary of Current Conditions at the end of this chapter (***4.3 Current Conditions Summary***).

Across their range, polar bears exhibit variation in genetics, behavior, and life-history strategies. The four ecoregions (Table 1, Fig. 1) represent our current knowledge of the ecological diversity of polar bears and their future responses to climate change. Ecoregions are the recovery units under the ESA in the CMP (Service 2016, entire). The ecoregions were defined based on observed temporal and spatial patterns of ice formation and ablation, observations of how polar bears respond to those patterns, and how general circulation models forecast future ice patterns (Amstrup et al. 2008, pp. 215–217). They also capture broad patterns in genetic and life-history of polar bears. As such, they provide an important tool for predicting effects of declining sea ice on different subpopulations. However, because the current information is incomplete, it may be important to conserve a finer-scale representation of current polar bear diversity (i.e., subpopulations). Therefore, we present the current conditions for each ecoregion separately, and present or discuss apparent differences among subpopulations within an ecoregion when they exist. We recognize that this categorization of polar bears, especially at larger temporal scales, reflects a number of assumptions and uncertainties due to the dynamic nature of climate change and its effects on ecosystems. However, ecoregions do share some similar conditions in regard to trends in sea ice metrics (1979–2019): all ecoregions exhibited shrinking summer sea-ice area, an earlier spring ice retreat, and later autumn ice advance (PBSG 2021; Table 3); continued changes in sea ice characteristics may lead to changes in subpopulation boundaries (Derocher et al. 2004, pp. 171–172) as areas become more or less suitable for polar bears.

4.1 Global Abundance

Accurate estimates of polar bear subpopulation sizes and trends are difficult to obtain due to the species' low densities, the vast and inaccessible nature of their sea-ice habitat, the movement of bears across international boundaries, and limited budgets. The most recent global population estimate was approximately 26,000 individuals (95% CI = 22,000–31,000) across the circumpolar Arctic (Wiig et al. 2015, p. 5). Over the past decade, international efforts have been conducted or planned to more accurately quantify subpopulation sizes to continue to assess the effects of climate change on the species. Based on new criteria for status assessments developed in 2019, PBSG updated the status for all 19 subpopulations (PBSG 2021, entire). The PBTC provides annual updates to the status of subpopulations managed (or co-managed) by Canada when new data is available (e.g., see PBTC 2021, entire). The PBTC also provides status based on IK (PBTC 2021, p. 4). Western science (PBTC and PBSG) and IK generally differ on the recent or short-term status of subpopulations (Table 1), with complete alignment among these information sources found for only one subpopulation (KB). However, differences between IK and other sources could be attributed to differences in spatial-temporal inferences such as failure to adequately document IK across individuals throughout the geographic area of the subpopulation. Population estimates exist for 15 subpopulations, but confidence intervals vary widely, and many estimates are sufficiently outdated to be useful for informed management decisions. Population growth rates have also been estimated or projected in several subpopulations with some projected to exhibit short-term positive growth rates as biological productivity increases (e.g., increased prey; DS: Peacock et al. 2013, p. 472; GB: Dyck et al. 2023, p. 168), while most other subpopulations are currently exhibiting, or projected to exhibit, a negative population growth rate (Hunter et al. 2010, entire; Lunn et al. 2016, p. 1313; Atwood et al. 2016a, entire; Hoondert et al. 2021, pp. 6–11). We provide a compilation of the most recent subpopulation estimates and population trends (Table 1), although more comprehensive status information is directly available from the PBSG (2021, entire) and PBTC (2021, entire), which includes IK.

4.2 Current Conditions in Each Ecoregion

4.2.1 Archipelago

Management framework

The six subpopulations included in this ecoregion are GB, KB, Lancaster Sound (LS), M'Clintock Channel (MC), Norwegian Bay (NW), and VM (Fig. 1; Table 1). These subpopulations mostly fall under Canada's management, with the exception of KB which is jointly managed by Greenland and Canada (Nunavut). Greenland and Nunavut established the Canada-Greenland Joint Commission in 2009 with the signing of a Memorandum of Understanding between Canada, Nunavut, and Greenland to conserve and managed shared polar bear populations (ECCC 2009, entire). The goal of the agreement is "…to manage polar bear within the Kane Basin and Baffin Bay subpopulations to ensure their conservation and sustainable management into the future." This includes coordination on research of shared subpopulations, which includes subpopulation demographics (e.g., abundance) and harvest levels. In the Canadian portion of this ecoregion, all subpopulations are solely under the jurisdiction of the territory of Nunavut with the exception of VM, which is also under the jurisdiction of the Northwest Territories. Guiding principles and management objectives for VM are detailed in the Polar Bear Management Agreement for the North[ern] Beaufort Sea and Viscount Melville Sound Polar Bear Populations between Inuit of the Kitikmeot West Region in Nunavut and the Inuvialuit (2006) and the Nunavut Polar Bear Co-management plan (Government of Nunavut 2019a, see Appendix A XI).

Habitat conditions

Heavy annual and multi-year sea ice fills the channels between the Canadian Arctic Islands, and polar bears in most of this ecoregion remain on the sea ice throughout the year. Historically, the annual ice-free season was short, and polar bears had potential access to seals year-round. Decline in area of summer sea ice from 1979–2019 has been moderate compared to other regions although the declines have been markedly different between subpopulations (mean percent change/decade = −7.9%, SD = 4.2, range = −2.2 – −14.1; Table 3). Gulf of Boothia (GB) lost more summer sea ice (14.1% loss/decade) than NW (2.2% loss/decade). The date of ice retreat (spring) has become earlier by an average of 5.1 days/decade (SD = 2.13, range = −2 – −8.2).

The date of sea ice advance (autumn) is also now later (mean number days/decade = 5.3, SD = 1.3, range = 4.1 – 7). The ice-free season was more than 2.5 times greater in GB compared to NW (PBSG 2021, p. 52; Table 3). In KB (Scientific Working Group to the Canada-Greenland Joint Commission on Polar Bear 2016, pp. 443–453) and LS (COSEWIC 2018), annual sea ice conditions are becoming more similar to that of the neighboring Seasonal Ice Ecoregion where the ice-free season is longer. The range of KB has expanded since the 1990s, particularly during sea ice minima (Laidre et al. 2020b, p. 6259). Changes in denning habitat are projected with continued sea-ice loss, yet except for KB, little recent published data exists on denning habitat in this ecoregion. Polar bear denning habitat and phenology in KB and BB (discussed below) has apparently changed little between the 1990s and early 2010s, although sample size was inadequate to compare differences (Escajeda et al. 2018, p. 93). It is important to note that the presence of fine-scale fjords in the Archipelago ecoregion can make it difficult to evaluate sea ice conditions from imagery at the spatial resolution that is currently available. Due to these constraints, some researchers have chosen not to project future conditions in this region until higher-resolution imagery is available.

Abundance and harvest

All subpopulations in this ecoregion have been assessed with physical mark-recapture methods in addition to some genetic mark-recapture (*n* = 3), although half have demographic estimates that are ≥20 years old (Table 1). The most recent estimate for GB (2015–17) indicated stability (Dyck et al. 2023, p. 162; PBSG 2021, pp. 21–23) and was similar to previous estimates (Taylor et al. 2009, p. 791). Low precision and lack of power (i.e., due to low sample size) to estimate temporary emigration, however, make it likely that the estimate represents the "super-population" (i.e., bears using both GB and adjacent subpopulations) and is biased high (Dyck et al. 2023, p. 168). Similarly, the abundance estimate for MC was also likely biased high but indicated an increase (Dyck et al. 2021b, pp. 515–518; PBSG 2021, pp. 25–26). The KB likely increased from previous analyses (PBSG 2021, pp. 23–24; PBTC 2021, p. 17), however, a change in sampling methods (i.e., switch to genetic mark-recapture) and an eastward shift in distribution in KB complicate this interpretation (PBSG 2021, pp. 23–24). Previously, Taylor et al. (2008) reported low population growth rates in KB, likely due to low ringed seal density (Born et al. 2004, entire) and heavy multi-year ice. Three other subpopulations (LS, NW, VM) are deemed data deficient, though IK suggests that NW subpopulation is stable and LS and VM have increased in abundance (Table 2). Population reassessments are planned in both LS and NW, and a 2013–14 mark-recapture study was conducted in VM, although that data has not yet been compiled; low densities of polar bears and ringed seals were noted during capture operations (PBSG 2021, pp. 24–25, 28, 33).

Harvest varies across the ecoregion. Harvest is low in the smaller subpopulations (KB, MC, NW, and VM: 5-year mean harvest = 2–9 bears or 0.06–2.5%) compared to the average number of bears harvested during the same period in GB and LS (65 [4.3%] and 78 [3.1%], respectively; Table 4). Harvest level in NW was unsustainable in the early 2010s (PBSG 2021, p. 28), although current harvest level is low (PBTC 2021, p. 28). Percent of the total subpopulation harvested in this ecoregion ranges from <1−4% (NW−GB), however, these harvest rates are from old population estimates (e.g., abundance estimate in LS is from 1995–97 and 5-year mean harvest is based on 2015–16 to 2017–18). KB is the only subpopulation in this ecoregion with a harvest risk assessment (Regehr et al. 2017a, entire). The assessment evaluated the implications of different harvest rates into the future according to managers' risk-tolerance under the assumption that demographic parameters and carrying capacity projections would be updated every 10–15 years (Regehr et al. 2017a, entire). The assessment concluded the current harvest rate of 2.8% (~10 bears harvested annually) is sustainable (Regehr et al. 2017a, p. 57). Implementation of a harvest quota has reduced harvest pressure in Greenland, which may have contributed to the eastward shift and presumed growth in this subpopulation (PBSG 2021, pp. 23–24).

In Nunavut in 2019, the Wildlife Management Board changed the TAH from a 2:1 male to female sex ratio to a 1:1 sex ratio in GB, MC, and LS. This change was to reduce abundance and was partially in response to increasing human-bear conflicts, which included two separate polar bear attacks on people in 2018 that resulted in human fatalities. If this ratio change is reflected in actual bears harvested, and the number of bears harvested does not change, this could affect the trajectory of population growth and become a concern for population viability in these subpopulations (PBTC 2021, pp. 6–8, 13–15, 17–19, 22, 28, 38). Kills in defense of life or property are more common in LS compared to other subpopulations in this ecoregion (COSEWIC 2018), particularly in Resolute Bay. Guided polar bear sport hunting is allowed in Canada, and approximately 40% of polar bear sport-hunting in Nunavut is in LS (M. Dyck, Government of Nunavut, unpublished data) providing significant income to some communities (PBAC undated). From 1990–2007, there was a male-skewed sex ratio (~76.5% male) of bears harvested in LS due in part to sport hunting. However, with the ban on imports of polar bear trophies to the U.S. the percent of males harvested decreased to ~72% (data through 2016).

Nutrition, health, and reproduction

The decline of multi-year ice (Howell et al. 2008, entire; Markus et al. 2009, entire; Sou and Flato 2009, entire) could mean short-term increases in biological productivity improved habitat conditions for polar bears (Derocher et al. 2004, p. 167; Stirling and Derocher 2003, p. 243; Stirling and Derocher 2012, pp. 2700–2701). For example, body condition of bears in MC improved between 1998–2000 and 2014–16 and this was likely due to increased biological productivity (Dyck et al. 2021b, pp. 516, 519). Similarly in KB and GB, body condition of polar bears improved since the 1990s due to changes in sea ice and biological productivity (Scientific Working Group to the Canada-Greenland Joint Commission on Polar Bear 2016, p. 563; Laidre et al. 2020b, pp. 6257–6258; Dyck et al. 2023, p. 168). However, harvested polar bears from 2010–17 indicated that insufficient prey availability in autumn and winter in GB contributed to declining adipose tissue lipid content (an indicator of body condition; Galicia et al. 2020, p. 844), though different sampling methods (i.e., mark-recapture and harvest) and time periods make the results difficult to compare. Biological productivity varies within some subpopulations. For example, the western LS boundary with VM has low productivity (i.e., low seal densities, Taylor et al. 2002, p. 198) and heavy multi-year ice in contrast to the central and western portion of LS with high ringed seal and bear densities. In VM, IK identified stable body condition but few large, fat bears (Joint Secretariat 2015, entire).

Litter size (Derocher and Stirling 1994, entire) and ratio of adult females to yearlings (Vongraven et al. 2012, pp. 19–21, 47; Regehr et al. 2015, p. 13; Rode et al. 2010a, p. 773) are parameters indicative of the reproductive health of polar bears. The most recent estimate (2014–16) of mean litter size in MC and GB have generally remained stable since 1998–2000 (Dyck et al. 2021b, p. 516; Dyck et al. 2023, p. 162). The ratio of yearlings to females in GB was stable between the periods (Dyck et al. 2023, pp. 164–165), but was lower in MC during the recent period (0.28 vs. 0.39), though small sample size limited conclusions (Dyck et al. 2021b, pp. 518–519). Results of comparisons of litter size and ratio of yearlings to females in KB between the 1990s and 2012–14 (Scientific Working Group to the Canada-Greenland Joint Commission on Polar Bear 2016, p. 545) also indicated no significant change. However, concern for the potential contribution of contaminants to the decline in reproductive success, and eventually population health, is increasing (Sonne 2010, entire; McKinney et al. 2013, p. 2361; McKinney et al. 2014, pp. 523–524; Dietz et al. 2015, pp. 52–53; Dietz et al. 2018, entire). In particular, mercury is known to adversely affect reproduction (see *3.4.1 Contaminants*), and the amount of mercury in polar bear hair in Northwest Greenland (primarily KB bears) increased 1.6–1.7% per year from 1892 to 2008. Median concentrations were 23–27 times higher than the pre-industrial baseline level in the same region (Dietz et al. 2011, p. 1460).

Other stressors

Genetic structure has been demonstrated between some of this ecoregion's subpopulations (Paetkau et al. 1999, pp. 1576–1579; Peacock et al. 2015, pp. 10−17; Malenfant et al. 2016, pp. 8, 11; Laidre et al. 2018a, pp. 2069–2072) and some research indicates NW is genetically unique (Malenfant et al. 2016, pp. 5, 8−9, 11, 15, 19). Research also shows evidence of both significant long-term (mitochondrial DNA) and more contemporary (nuclear DNA) differentiation, although gene flow does still occur (Campagna et al. 2013, p. 3154). Both the Boothia Peninsula and Bellot Strait separate the populations and are potential geographic barriers to physical movement and thus gene flow (Campagna et al. 2013, p. 3153). This ecoregion has been identified as a potential refugia for polar bears (Derocher et al. 2004, p. 171; Peacock et al. 2015, p. 19; Atwood et al. 2016a, p. 15). Indeed, Peacock et al. (2015, pp. 13, 15, 17) cite directional gene flow towards this ecoregion in the past 1–3 generations as support for this hypothesis; other research, however, refutes the notion of strong directional gene flow (Malenfant et al. 2016, pp. 14, 16, 18–19).

Declining ice means a likely increase in shipping traffic and ecotourism with potential impacts to marine mammals, including polar bears (Kerr 2002, p. 1492; Service 2016, pp. 76–77; Hauser et al. 2018, p. 7618; Palma et al. 2019, entire). Subpopulations within this ecoregion lie within the Northwest Passage and therefore bears are possibly at risk of threats from shipping. At this time, however, shipping is currently perceived to have a negligible effect on polar bears in this region (PBRS 2015, 2020, entire; Service 2016, p. 32). Additional threats exist from exploitation of oil and gas reserves found within NW, LS, and VM, although the timeframe for exploration is unknown given the cost associated with drilling conditions in the Arctic environment and the long distances from petroleum markets (COSEWIC 2018).

4.1.2 Polar Basin Convergent

Management framework

The two subpopulations of this ecoregion (EG and NB) are managed by Greenland and Canada, respectively. Nunavut and Northwest Territories share management of NB. The potentially third subpopulation recently described by Laidre et al (2022, entire; Southeast Greenland, SG) will likely be assessed for its status and ecoregion assignment by the PBSG in the near future. Guiding principles and management objectives for NB are detailed in the Polar Bear Management Agreement for the North[ern] Beaufort Sea and Viscount Melville Sound Polar Bear Populations between Inuit of the Kitikmeot West Region in Nunavut and the Inuvialuit (2006). The purpose of the agreement is to enable coordinated management of sustainable harvest including ensuring a 2:1 male to female harvest ratio and protection of denning bears and family groups from harvest.

Habitat conditions

This ecoregion is characterized by annual sea ice that converges towards the shoreline allowing bears to access nearshore ice year-round. Polar bears here have historically had potential to access seals throughout the year with a short ice-free season. Recently, however, this region has experienced significant sea-ice loss with slightly higher declines in percent of summer sea ice area in EG (7.7% loss/decade) compared to NB (7.0% loss/decade; Table 3) from 1979–2019; this has contributed to changes in habitat use (Laidre et al. 2015a, pp. 884–889). The date of ice retreat has become earlier by 8.2 and 2 days/decade in EG and NB, respectively. The date of sea ice advance comes 7.6 and 3.1 days/decade later in EG and NB, respectively. Bears in the SG, however, rely on shore-fast ice that is available in winter and spring, and ice provided from marine terminating glacial fronts in fjord systems in the summer and autumn as a platform to hunt seals (Laidre et al. 2022, p. 1333).

Abundance and harvest

NB is relatively well-studied with long-term data on abundance and movement dating to the 1970s. The most recent abundance estimate suggested the population was stable from 1971–2006 (Stirling et al. 2011, p. 869). Although both the PBTC and IK report this subpopulation is currently stable, PBSG reports that the subpopulation is currently data deficient (Table 1) and previously reported both long- and short-term decline. Evidence for the decline include harvest levels at <50% of the quota and the fact that polar bears formerly included in NB were actually from SB (see *4.1.3 Polar Basin Divergent Ecoregion*; PBSG 2021, pp. 27–29). Changing ice conditions, difficulty accessing bears, and hide prices have influenced the reduction in harvest levels in Nunavut (PBTC 2021, p. 26; Cooper 2022, pp. 79–80). Annual harvest levels are relatively low in NB (i.e., below 4.5% total harvest rate). Movement data from collared bears and IK resulted in a shift of the western NB boundary further west (from 125° W near Pearce Point to 133° W near Tuktoyaktuk, NWT). Recognizing the boundary shift and implication to abundance estimates, the capture-recapture data (Regehr et al. 2006, entire; Stirling et al. 2011, entire) was reanalyzed and increased the abundance estimate by 311 bears to 1,291 (Griswold et al. 2017, entire). A large-scale genetic mark-recapture effort to estimate abundance in NB was initiated in 2019 and is ongoing.

EG is deemed data deficient by PBSG (2021, p. 20) and abundance has never been estimated in this subpopulation, although research was initiated in 2015 to determine the feasibility of collecting data to estimate abundance. Data collection is ongoing. Compared to the early 2000s, IK indicated an increasing number of polar bears coming into communities (Laidre et al. 2018c, p. 6). Polar bear hunters in Greenland also noted that the timing of polar bear hunting has changed with later sea-ice freeze-up, and most hunters indicated that because of open water, they do some hunting by boat as opposed to solely by dog sled as they did in the past (Laidre et al. 2018c, p. 14).

The minimum number of bears in the SG is estimated to be 234 bears (95% CRI = 111–462) with little to no human harvest (Laidre et al. 2022, supplemental material p. 25).

Nutrition, health, and reproduction

Body condition of female bears within NB is strongly affected by sea ice conditions (Florko et al 2020, p. 56), and progressively earlier sea ice breakup and a longer ice-free season could result in a decline of body condition for NB polar bears. Scientific (Florko et al. 2021, p. 57) and IK data (Joint Secretariat 2015, entire) both indicate body condition of bears in NB has remained stable. Whereas bears in some subpopulations are experiencing increased foraging success and a (likely temporary) improvement in body condition as a result of declining sea ice (e.g., MC, BB, KB; see Archipelago Ecoregion section above), this is not the case for polar bears in NB (Florko et al. 2021, p. 1454).

Body condition of EG, as measured by lipid content, improved from 1984–2010 possibly due to better access to subarctic seals including harp seals (McKinney et al. 2013, p. 2370; McKinney et al. 2014, pp. 519–521). However, increasing contaminants in prey species (Hoondert et al. 2021, pp. 2, 7) and dietary shifts as a result of climate induced sea ice changes may be increasing contaminant burdens in polar bears (McKinney et al. 2009, entire). Increasing contaminant loads in EG polar bears (McKinney et al. 2013, p.2370) are likely attributed to consumption of subarctic seals, which may have higher contaminant loads than Arctic seal species.

Contaminants in EG have been heavily studied and polar bears here are purportedly among the "…most contaminated species on the globe…" (Sonne et al. 2012, pp. 1, 6; Dietz et al. 2018, entire). Due to these contaminant loads, compromised immune and reproductive systems are likely resulting in negative short- and long-term health effects in EG (Sonne 2010, entire; Sonne et al. 2012, p. 6; Dietz et al. 2018, entire). Additionally, bears here are among the highest for potential risk of exposure to organohalogen contaminants (OHC; Letcher et al. 2010, p. 2998). PFAs at levels in EG bears are high enough to potentially affect cognitive processes and motor functions (Pederson et al. 2015, entire), while brominated contaminants (i.e., flame retardants) are also increasing in this subpopulation (Dietz et al. 2013a, pp. 495–499; Vorkamp et al. 2015, entire). Projections of population growth were negative for both EG and NB based on POP levels in seal blubber (Hoondert et al. 2021, pp. 6–11). NB also has one of the highest mercury levels observed in polar bears (Norstrom et al. 1986, pp. 202–203, 208–210; Rush et al. 2008, p. 622; 73 FR 28212; Routti et al. 2011, p. 1071). Whereas levels of 18 out of 19 legacy organochlorides (including PCBs) decreased between 1983 and 2010 in EG bears, the contaminants are still present at relatively high levels (Dietz et al. 2013a, pp. 495–499). Despite that many of these chemicals are now prohibited, they can persist and impact polar bears for decades.

In SG, litter sizes were similar to the remainder of EG (95% CI = 1.52–1.70). Alternatively, the number of COY (0.30) and yearling cubs (0.26) produced per adult female was lower than in northeast Greenland (0.56 and 0.43, respectively; Laidre et al. 2022, supplemental material p. 23). Female bears in SG were approximately 7–27% lighter than females in other North American subpopulations (Laidre et al. 2022, supplemental material p. 24).

Recognizing there have been significant declines in sea-ice availability, recent research in EG comparing habitat use indicated bears selected habitat >100 km from open water in all seasons except summer in the 1990s (Laidre et al. 2015a, p. 886). Comparatively, bears in the 2000s were 50–100 km closer to open water. All known maternal dens were on land during both time periods (Wiig et al. 2003, pp. 510–512; Laidre et al. 2015a, p. 887) with little use of terrestrial habitat outside of the denning period. Although not significantly different, bears entered maternity dens earlier and had a longer duration of denning in 2007–10 (Laidre et al. 2015a, p. 888) compared to 1993–97 (Born et al. 1997, p. 70). IK from NB also suggests shifts in denning distribution (i.e., bears are not denning in areas where dens were historically found) due to lack of suitable denning habitat (i.e., sufficiently deep snowbanks are no longer forming); earlier den emergence was also noted (Joint Secretariat 2015, pp. 189–190). With earlier ice breakup in spring, there is declining availability of fast ice feeding habitat in NB (Joint Secretariat 2015, pp. 175, 183; PBSG 2019, pp 14–15).

Other stressors

Substantial oil and gas reserves exist within the boundaries of NB but have largely been unexploited due to sea ice cover (Chen et al. 2004, entire; Gautier et al. 2009, pp. 1176–1178), thus exploration could increase with declining sea ice. As of 2021, Greenland will no longer issue new licenses for oil and gas exploration, although there currently are four active licenses for oil and gas exploration in Greenland (Battersby 2021, entire).

Similar to other ecoregions, an increase in shipping traffic and ecotourism as a result of sea-ice loss could occur with impacts to polar bears. Thus far, however, there are no published accounts of impacts to polar bears in this region from increased shipping or ecotourism.

4.1.3 Polar Basin Divergent

Management framework

There are five subpopulations in this ecoregion (BS, CS, KS, LV, and SB), including two of which are managed by the Service (CS and SB; Fig. 1). Two subpopulations (KS and LV) are wholly within Russia, BS is shared between Russia and Norway, and CS is shared between Russia and the U.S, while SB is shared between the U.S. and Canada. The BS is managed according to the Bilateral Environmental Agreement between the Government of Russia and the Government of Norway, including Provisions on Polar Bear Conservation. The Bilateral Agreement directs management of CS (also known as the Alaska-Chukotka population). The boundaries of this subpopulation are described differently in the Bilateral Agreement and by the PBSG. The Bilateral Agreement describes the subpopulation with a line extending north from the mouth of the Kolyma River (west boundary) and a line extending north from Point Barrow (east boundary), whereas the PBSG describes the eastern boundary near Icy Cape, Alaska to a western boundary near Chaunskaya Bay, Russia, in the Eastern Siberian Sea (Obbard et al. 2010, pp. 38–39). Efforts are currently under way to formally change the boundary recognized by the Bilateral Agreement to be consistent with the PBSG boundary at Icy Cape. SB is shared between Alaska and Canada and partially managed under the I-I Agreement (Brower et al. 2002, entire).

CS and SB have a shared boundary and some overlap in distribution (Garner et al. 1990, entire; Amstrup et al. 2000, p. 962; Amstrup et al. 2004, pp. 668–677; Amstrup et al. 2005, pp. 251–258; Scharf et al. 2019, entire), though the environmental conditions and overall subpopulation conditions are remarkably disparate (Rode et al. 2012, entire, 2014, entire; Table 1). The original delineation between the subpopulations was determined by: (a) movement information collected from capture-recapture studies (Lentfer 1983, entire); (b) physical oceanographic features (Lentfer 1974, entire); (c) morphological characteristics (Lentfer 1974, pp. 326–327; Wilson 1976, entire); and (d) variations in levels of contaminants of organ tissues (Lentfer 1974, p. 327; Lentfer 1976, entire; Lentfer and Galster 1987, entire). Additionally, while substantial genetic substructure is not evident between the subpopulations, indicating some level of gene flow (Paetkau et al. 1999, entire; Cronin et al. 2006, pp. 658–659), individuals showed significant fidelity to their respective regions in their movements (Amstrup 1995, pp. 73, 91–93, 115, 117; Amstrup et al. 2004, pp. 668–677; Amstrup et al. 2005, pp. 251–258). Support for the current delineation was further supported by more recent data on contaminant levels (Evans 2004a, entire; Evans 2004b, entire; Kannan et al. 2007, entire), stable isotope analysis (Smith et al. 2022, entire), response to sea ice loss (Regehr et al. 2010, entire; Rode et al. 2014, entire), and fidelity of general denning locations (Durner et al. 2010, entire).

Habitat conditions

This ecoregion is characterized by the formation of annual sea ice that is advected towards the polar basin and has seen some of the largest reductions in summer sea ice extent in the Arctic from 1979–2019 (mean percent change/decade = −22.3%, SD = 4.0, range = −17.9 – −26.5; Table 3). The BS has experienced the most rapid decline of sea ice in the Arctic (Stern and Laidre 2016, p. 2033). The date of ice retreat in the ecoregion has become earlier by an average of 9.9 days/decade (SD = 3.5, range = −6.9 – −15.4). The date of sea ice advance has also come later (mean number days/ decade = 11.2, SD = 7.0, range = 7.1–23.5; Table 3).

CS has seen large reductions in summer sea ice extent (Laidre et al. 2015b, p. 730), and sea-ice loss is expected to continue (Douglas 2010, pp. 7−12; Overland and Wang 2013, entire; Wei et al. 2020, entire). The number of ice-free days has increased by approximately 14 days since 1979 (PBSG 2021, p. 52, Table 3), which led to a 75% decline in highly selected summer sea ice habitat in the past 30 years (Wilson et al. 2016, p. 5). Bears in CS spend an additional 30 days/year on land compared to the 1990s, with much of that increased time spent on Wrangel Island, Russia (Rode et al. 2015a, pp. 13–14). Wrangel and Herald Islands and the Chukotkan coast are important maternal denning areas for CS bears as 84% of dens were on Wrangel Island from 2008−13 (Rode et al. 2015a, p. 8).

Changing ice type and percent cover have altered polar bear distribution in SB. As ice has thinned, sea ice transport rates (i.e., drift) have increased (Durner et al. 2017, pp. 3464–3471) and use and availability of high-quality habitat has declined in all seasons except winter when ice is at its maximum (Durner et al. 2019, pp. 8630–8633). A decrease in sea ice in SB has led to more bears on land and in open water in the recent two decades compared to 1979–96 when sea ice was predominant in the area (Gleason and Rode 2009, pp. 409–410; Pagano et al. 2021, entire). Whereas SB bears historically followed the multiyear ice to the north through spring and summer (Stirling and Lunn 1997, p. 170; Stirling 2002, p. 61), an estimated 24% of SB polar bears now stay on shore to scavenge subsistence harvested whale remains in autumn (Rogers et al. 2015, p. 1044). For bears that follow the sea ice (i.e., do not go to land in summer), data from collared bears indicated annual utilization distributions have increased by 64% in the period 1999–2016 compared to 1986–1998 when there was more sea ice present (Pagano et al. 2021, pp. 10, 12). This was coupled with a north-northeast shift of 193 km in the annual utilization distribution centroid in the same time periods (Pagano et al. 2021, p. 7). An association between sea ice loss and locomotor costs (Pagano and Williams 2021, entire) and apparent increase in long-distance swimming events (>50 km) has also resulted from an increase in open water in SB (Pagano et al. 2012, entire), with potential implications for survival (Monnett and Gleason 2006, entire; Durner et al. 2011, entire). Changing habitat conditions (i.e., availability and distribution of sea ice) has also led to a marked increase in land-based denning (Olson et al. 2017, p. 217; Patil et al. 2022, pp. 10–19).

Abundance and harvest

Little is known about the two subpopulations (KS and LV) wholly managed by Russia. Outside of the AB (see *4.1.5 Arctic Basin*), they are the least monitored and researched of the subpopulations, and, thus, both are deemed data deficient by PBSG with no current estimates of abundance or other demographic parameters (Table 1). Similarly, the Russia portion of the BS is under-surveyed, and some overlap exists between KS, LV, and BS according to satellite telemetry data (Mauritzen et al. 2002, pp. 84–88). Projections for this ecoregion indicate polar bears have a relatively high probability (50%) of substantial reductions in numbers and distribution as early as mid-century, with increasing probabilities through the end of the century under even the most optimistic emissions and warming scenarios (Atwood et al. 2016a, pp. 11–15; Molnár et al. 2020, pp. 732–737).

As a result of 100 years of overharvest in the BS, a dramatic decline in abundance occurred that has since rebounded due to the cessation of harvest in Russia (1956) and Norway (1973; Andersen and Aars 2016, pp. 4, 7–8). There is currently no legal polar bear harvest in Russia or Norway, although illegal harvest may be occurring (Vongraven et al. 2012, pp. 2, 30, 50; see *3.3.4 Illegal take*). Aerial surveys in 2015 on the Norwegian portion of the BS indicated little change and a likely stable population (Aars et al. 2017, pp. 11–12). Movement data from collared bears suggests there may be some sub-structuring within the BS, as nearshore/coastal bears limit their movements to areas close to Svalbard as opposed to pelagic or offshore bears which have a much larger annual range size and move between Svalbard and offshore pack ice (Mauritzen et al. 2001, pp. 1709–1710; Aars et al. 2017, pp. 11; Blanchet et al. 2020, pp. 6–16). The change in movement patterns has contributed to a decline in genetic diversity and a possible genetic substructure occurring in BS (Maduna et al. 2021, pp. 4–6). If separation of the subpopulation continues, separate abundance estimates may be warranted in the future (Aars et al. 2017, p. 3).

A new abundance estimate for CS was provided in 2018, which was the first estimate since the 1990s. The 1990s-era estimate (2,000–5,000 bears; Belikov 1993, p. 470) was based on denning surveys in Russian portions of the Chukchi Sea, where most of the maternal dens in this subpopulation were located (Stishov 1991, pp. 90–92; Ovsyanikov 2005, p. 171; DeBruyn et al. 2010, p. 187; Rode et al. 2015a, pp. 9–10). There have been two recent abundance estimates: one integrated multiple data sources in a Bayesian framework that improved accuracy and precision

(Regehr et al. 2018, entire: 2,937 bears, 95% CI: 1,552–5,944) and another that was a joint U.S.-Russian effort that used a combination of thermal imagery, digital photography, and human observations and provided estimates with varying proportions of bears "missed" in Russian-conducted surveys [Conn et al. 2021, entire: estimates ranged from 3,435 (95% CI: 2,300–5,131) to 5,444 (95% CI: 3,636–8,152)]. It remains uncertain how long positive productivity will occur in CS given the expected continued reduction in the extent and duration of sea ice (Regehr et al. 2018, p. 8; Rode et al. 2021, p. 2698). In regard to future estimates of abundance, deteriorating ice conditions have compromised the Service's ability to conduct regular monitoring (i.e., capture and collaring) off the Alaskan coast in spring. Indeed, due to lack of suitable sea ice, annual radio-collaring operations have not been conducted since 2017. In recent years, the only data collected on this subpopulation was a U.S.-Russia collaboration on Wrangel Island (2017–21) as well as annual harvest information in Alaska. That data has not yet been analyzed and any participation by U.S. government scientists on Wrangel Island has been suspended indefinitely due to the Russian invasion of Ukraine in February 2022. However, the Service is hoping to implement monitoring efforts in the next few years to facilitate another abundance estimate before 2027.

In CS, average reported annual harvest has declined in the past 3 decades from an average of approximately 55 bears/year from 1990–99 to 22 bears/year from 2010–19. Prior to 2018, the shared quota was 58 bears, 29 of which were allowed to be harvested in Alaska. At the 2018 Bilateral Commission meeting, the SWG presented an updated abundance estimate (Regehr et al. 2018, entire) and harvest risk assessment (Regehr et al. 2021b, entire) to the Commission. Based on the new demographic data, the harvest risk assessment indicated an increased harvest of 80–90 bears per year (of which no more than a third are female) represented a moderate degree of risk of reducing the population below *mnpl* and was unlikely to have significant negative population effects (Regehr et al. 2021b, p. 11). This sustainable harvest level of 85 bears/year remains in effect for CS. The 5-year average annual reported human-caused mortality was approximately 12.4 in the U.S. and an estimated 32 in Russia (Kochnev and Zdor 2015, pp. 97–103; Table 4).

SB has experienced declining survival and abundance, and reduced body mass and condition and recruitment (Bromaghin et al. 2015, p. 644; Bromaghin et al. 2021, p. 14260; Regehr et al. 2010, entire; Rode et al. 2010a, entire; Rode et al. 2014b, entire). Both short- and long-term abundance trends for SB indicate a likely decrease (Table 1) alongside substantial decreases in sea ice over the continental shelf (4% per decade; Durner et al. 2009, p. 45). The most recent estimate (2010) for the entire SB was ~900 individuals (Bromaghin et al. 2015, p. 644), with a more recent estimate (2015) for the Alaska portion of 573 individuals (95% Bayesian credible interval = 232–1,140 (Bromaghin et al. 2021, p. 14257). A direct correlation between ice and population dynamics had been demonstrated in SB with reduced sea ice and reduced survival and breeding from 2001–05 (Regehr et al. 2010, pp. 121–122). Demographic data through 2010 found similar evidence of low survival of all sex and age classes of polar bears in the mid-2000s (Bromaghin et al. 2015, pp. 641–643). However, this research also found an increase in survival of most sex and age classes in SB during 2007–10, despite continued declines in the availability of sea ice. Relationships between sea ice and status of this subpopulation likely reflect a combination of ecological variation and density effects (Bromaghin et al. 2015, p. 647), highlighting that reduced availability of sea ice is expected to be an increasingly important factor in affecting population dynamics as the climate continues to warm. An instrument-based aerial survey of SB was conducted in spring 2021, while a joint U.S.-Canada genetic mark-recapture effort to produce an updated abundance estimate is in progress (PBSG 2021, pp. 28–31); these data will inform a forthcoming integrated population model for the SB that also incorporates IK (Braund et al .2022, entire). Collaring of polar bears in SB stopped in 2016 at the request of the Inuvialuit-Iñupiat Joint Polar Bear Committee (I-I Commission) due to concerns about collar performance (i.e., failure of collar drop-off mechanisms [pre-programmed mechanism releasing the collars from the bear]). The I-I Commission requested a temporary moratorium on deploying collars until improvements were made to the collar-release mechanism. The USGS led a joint US-Canada aerial survey in 2017, captured and biopsied bears in 2018, and biopsied bears from 2019–23 as part of a joint US-Canada effort. The Service initiated a management- and monitoring-oriented capture (culvert trapping) and marking (ear tags and glue-on transmitters) of small numbers of SB bears in the oilfield (i.e., Endicott Island) in autumn 2022. The USGS may resume larger-scale monitoring efforts in 2023 and beyond.

Harvest in SB is divided between the U.S. and Canada with an annual quota of 56 bears (U.S.: 35; Canada: 21) and managed through the I-I Agreement (Brower et al. 2002, entire; see *3.5 Regulatory Mechanisms and Conservation Efforts*). Adherence to the quota is mandatory in Canada but voluntary in the U.S. Average annual harvest reported in the U.S. portion of SB has declined from an average of 33 bears/year (1990–2000) to 19 bears/year (2011–21). In the last 5 biological years (1 Jul 2016–30 Jun 2021 as defined by Canada relative to seasonal harvest), the average reported removals in Alaska (15.0) and Canada (3.4) from harvest was approximately 19 bears.

Nutrition, health, and reproduction

Consumption of terrestrial food sources has been well documented in coastal BS polar bears and could increase as sea ice concentration continues to decline (Iversen et al. 2013, p. 562; Prop et al. 2015, pp. 4–10; Tartu et al. 2018, pp. 6, 16; Stempniewicz et al. 2021, entire). Terrestrial food sources are primarily comprised of protein and carbohydrates which are less calorically dense and provide lower energy content (Derocher et al. 2004, p. 169; Rode et al. 2010b, entire; Rode et al. 2015b, p. 143) than fat rich marine prey (Rode et al. 2010b, entire; Rode et al. 2015b, p. 143–144). Polar bears that used higher quality sea-ice habitat were in better body condition than coastal bears, however, they also had higher contaminant levels (Routti et al. 2017, p. 1070; Tartu et al. 2017, p. 22; Tartu et al. 2018, pp. 13–14), which was likely due to increased feeding on high trophic level prey found in sea-ice habitats (Tartu et al. 2017, p. 22). The use of coastal, open water habitat may be a tradeoff as declining or later arrival of sea ice makes reaching maternal denning areas more difficult, or impossible, in some years (Derocher et al. 2011, p. 276). Some BS bears also den in Franz Josef Land, Russia, and maternal denning is likely to increase there, particularly in pelagic bears as loss of sea ice prevents them from reaching other denning areas (Andersen et al. 2012, p. 503; Aars et al. 2017, p. 11).

The Chukchi Sea has high biological productivity partially due to the majority of the area being over the continental shelf (Hill et al. 2018, entire; Schourup-Kristensen et al. 2018, pp. 75–77). Results of capture-based studies in the U.S. indicated stable or improving body condition (likely related to seal health; Rode et al. 2021, entire) and high indices of recruitment (i.e., mean litter size) from 1986–94 and 2008–11 in the U.S. portion (Rode et al. 2014b, pp. 80, 85; Rode et al.

2021, pp. 2690–2691). IK states that body condition in CS is good and polar bears are "…fat, healthy, and large" (Voorhees et al. 2014, p. 528; Braund et al. 2018, pp. 48–49). These data suggest stable or positive growth in CS (Braund et al. 2018, p. 39; Regehr et al. 2018, pp. 8–9; PBSG 2021, pp. 17–18), though uncertainty remains in the level of human-caused mortality in Russia (Belikov et al. 2018, p. 142).

Although the percent loss of sea ice has been greater in CS compared to SB, differences in the timing and rate of sea ice loss may partially explain differences in subpopulation health (Rode et al. 2014b, pp. 84–86). Additionally, compared to SB, sea ice loss in CS has not led to the same level of increase in time spent over deeper polar basin waters (i.e., less productive waters) because the ice still remains over the continental shelf (i.e., more productive waters). Sea ice decline has been occurring since the mid-1990s in SB whereas notable declines in CS began within the last 20 years. Declining sea ice also limits access to prey (Rode et al. 2010a, p. 769; Rode et al. 2014b, pp. 84–86), another factor likely contributing to differences between the subpopulations. Unlike SB (see *2.3.3 Feeding*), bears in CS did not exhibit concomitant declines in body mass or productivity (Rode et al. 2014b, pp. 80–86), even though sea ice loss has been substantial for CS (Durner et al. 2009, p. 49; Braund et al. 2018, p. 39). During the spring when sea ice extent is not typically limiting, polar bears in the SB have been increasingly fasting (Rode et al. 2018, pp. 417–418) and bears that fast lose body mass during this time (Pagano et al. 2018, entire). Thus, bears in SB are experiencing declines in body condition due to reduced access to prey, decreased hunting success, and/or abundance of prey given the changing ice conditions. Long-term declines (1983–2015) have been documented in litter mass of COY (−23%) and yearlings (−3 kg per 10 kg loss of maternal body mass) in SB (Atwood et al. 2021, p. 8).

In SB, onshore bowhead whale remains from subsistence harvest, strandings, or orca predation are an important and seasonally reliable food source (Miller et al. 2015, p.1318; Galicia et al. 2016, p. 6006; Wilson et al. 2017, p. 292; Laidre et al. 2018b, p. 520; Lillie et al. 2019, entire). Field observations of polar bear body condition (see body condition index in Stirling et al. 2008, entire) in the autumn when feeding on whale carcasses suggest an improvement in condition over just a few weeks (Miller and Reed 2015, p. 2) and may allow bears to remain in better body condition through spring (McKinney et al. 2017a, p. 11). It may be possible for bears to mitigate the energetic costs associated with sea-ice decline through scavenging whale carcasses, but the future reliability of whale carcass availability is uncertain and can likely only partially offset the energetic losses associated with sea ice declines (Laidre et al. 2018b, p. 522). Additionally, recent work has found that whale consumption in the SB was unable to compensate for energy deficits during times of reduced seal availability (Rode et al. 2023, p. 15).

Contaminant load in CS has generally been of little concern, albeit research has not been extensive. CS has had some of the lowest concentration of PCBs, chlorinated pesticides, and flame retardants of all subpopulations (McKinney et al. 2011, pp. 369–371). Alternatively, concentrations of organohalogen contaminants (OC) in CS exceeded a toxic effect threshold (Dietz et al. 2015, pp. 50–52), and concentrations of hexachlorocyclohexanes (β-HCH) in CS were higher than many other subpopulations (Routti et al. 2019a, p. 1067). Similarly, polar bears in Alaska tended to have higher levels of DDT contamination than other regions (McKinney et al. 2011, pp. 371–372).

Like CS, SB has some of the lowest concentration of PCBs, chlorinated pesticides, and flame retardants of all subpopulations (McKinney et al. 2011, pp. 369–371). However, concentrations of trans-nonachlor in SB were higher than many other subpopulations (Routti et al. 2019a, p. 1067), and concentrations of OC also exceeded a toxic effect threshold (Dietz et al. 2015, pp. 50–52). Some of the highest mercury levels in polar bears have been reported in SB (Rush et al. 2008, p. 622; Routti et al. 2011, p. 2262), though mercury levels decreased by 13% annually from 2004–11 in SB (McKinney et al. 2017b, p. 7818). The marked decrease was likely due to increased use of onshore habitats, and in turn, reduced feeding on high trophic level, ice-based prey, though higher contaminant concentrations occur in leaner bears and those using sea ice in summer (Bourque et al. 2020, entire). A recent study (using most of the same data as McKinney et al. 2017b, entire) found that gut microbiota of polar bears decreased in abundance and diversity with higher levels of accumulated mercury (Watson et al. 2021, entire). Alterations in the gut microbiome have been associated with shifting foraging habitats (Franz et al. 2022, entire). Gut microbiota is essential for several physiological functions, including nutrient processing, proper immune function, and protection against pathogens (Hooper et al. 2012, entire; Kamada et al. 2013, entire).

Other stressors

Human activity, mainly tourism (see *3.2.2 Ecotourism*), camping, and snowmobile use, has been increasing in recent years in Svalbard (Overrein 2002 [cited in Andersen and Aars 2016, p. 8]; Lemelin and Dyck 2008, entire; Hagen et al. 2012, entire). Conflict between polar bears and humans during tourism activities has led to several human fatalities and serious injuries, and the subsequent killing of the bears (Andersen and Aars 2016, p. 9; Jørgensen 2018, p. 1; Jonassen 2020, p. 1).

Tourism has been minimal in the past for bears in CS, as few cruise ships visited Wrangel Island and coastal Chukotka, Russia on an annual basis. In recent years, boat-based tourism has expanded, and an increasing number of ships visit the area each year. Land-based polar bear viewing excursions on snowmobiles and all-terrain vehicles were recently available on Wrangel Island (WISNR 2021, entire).

Two communities (Kaktovik and Utqiaġvik, Alaska) in SB have experienced increasing popularity in polar bear viewing over the past decade. The Service's jurisdiction over management of viewing programs is limited to activities on Arctic NWR lands and waters. However, all polar bear viewing in the U.S. must be compliant with the MMPA in that they must ensure unauthorized disturbance to polar bears does not occur. The majority of polar bear viewing has taken place in Kaktovik, where the Arctic NWR manages a boat-based viewing program on Refuge waters adjacent to the community. Despite the apparent economic benefits of tourism associated with viewing polar bears, residents remain divided in supporting tourism and managing visitors to their community. However, viewing opportunities in Kaktovik have been suspended since 2020 due to Covid-19-related travel restrictions to the community and the Arctic NWR is not currently issuing permits to polar bear viewing guides as per directions from Secretarial Order 3392 from the Department of the Interior (2021).

Oil and gas exploration and development in the Russian Arctic are increasing (Staalesen 2021, p. 1) with potential implications for LS, KS, and BS. In August 2021, oil drilling began in the Gulf of Ob, Kara Sea, a region designated an ecologically or biologically significant area (UNE 2015, entire) of great importance to marine life, including polar bears and their prey species. In the BS, however, mining activities have decreased in recent decades with Norway planning to close its last coal mine on Svalbard in 2023 (Haram 2021, entire).

In SB, land-based industrial activity is anticipated to increase in the U.S. portion, with activities largely occurring during winter months to minimize impacts to sensitive tundra habitats. Correspondingly, there has been a marked shift in denning distribution, where the frequency of land-based denning increased from ~34% (1985–95) to ~55% (1996–2013; Amstrup and Gardner 1994, pp. 5–8; Fischbach et al. 2007, p. 1399; Olson et al. 2017, p. 217). Based on the projections of continued sea-ice decline, the use of onshore habitats by polar bears will continue to increase during the open-water season. The overlap in land-based denning habitat and industrial activity will likely result in increased potential for disturbance to maternal dens (Wilson and Durner 2020, entire; Patil et al. 2022, entire). Conversely, in the Canadian portion of SB, land-based denning habitat is protected by Ivvavik National Park, Herschel Island Qikiqtaruk Territorial Park, and the land withdrawal on the Eastern Yukon North Slope, which prevents the area from industrial development (PBTC 2021, p. 31).

4.1.4 Seasonal Ice

Management framework

The five subpopulations included in this ecoregion are BB, DS, Foxe Basin (FB), SH, and WH (Fig. 1). Most subpopulations fall solely under Canada's management authority except BB and DS, which are shared between Canada and Greenland. The Memorandum of Understanding between Canada, Nunavut, and Greenland to conserve and managed shared polar bear populations guides management of BB. The two subpopulations in Hudson Bay (SH and WH) are two of the most well-studied large carnivore populations in the world.

Habitat conditions

Much of this ecoregion is at the southern extent of the global range of polar bears (Fig. 1). Sea ice completely melts in summer, during which time bears are onshore for extended periods until sea ice reforms. Polar bears have experienced reduced access to prey during the ice-free season, and the reduced summer sea ice extent and lengthening of the ice-free season has contributed to declines in survival and body condition (Obbard et al. 2016, p. 29). Percent decline per decade in the area of summer sea ice averages 15.9% (SD = 5.3) and ranges from 7.2% (SH) to 20% (WH; Table 3). Reduced sea ice extent has resulted in range contraction and declining average monthly movement rates in BB (Scientific Working Group to the Canada-Greenland Joint Commission on Polar Bear 2016, pp. 183–184; Laidre et al. 2018d, p. 8): adult females had smaller ranges and the overall range of BB polar bears shifted to the north during "on-ice" season in the 2000s compared to the 1990s (Laidre et al. 2018a, pp. 2067–2068). The date of ice retreat is earlier by an average of 4.6 days/decade (SD = 1.8, range = −1.6 – −6.4). The date of sea ice advance also comes later (mean number days/ decade = 4.2, SD = 1.4, range = 2.9–6.2). Bears in BB arrive onshore earlier and spend 20–30 more days on land (i.e., Baffin Island) compared to the 1990s

(Scientific Working Group to the Canada-Greenland Joint Commission on Polar Bear, p. 184; Laidre et al. 2020a, p. 8). The occurrence of swims >100 km from offshore sea ice increased from the 1990s to the 2000s in BB (Scientific Working Group to the Canada-Greenland Joint Commission on Polar Bear, pp. 179–180).

Contrary to previous analysis (Paetkau et al. 1999, entire; Peacock et al. 2015, entire; Malenfant et al. 2016, p. 8), BB exhibited signs of genetic substructure compared to surrounding subpopulations (i.e., KB, LS, and DS; Laidre et al. 2018a, p. 2069).

Abundance and harvest

All subpopulations in this ecoregion have been assessed with mark-recapture methods, although several are considered either outdated or insufficient to determine a trend (Table 2). Several efforts to estimate abundance in BB have been carried out since the 1990s, however, differences in sampling methods (i.e., improved study methods in recent surveys) and survey area have resulted in an inability to compare these estimates (PBSG 2021, p. 14; PBTC 2021, p. 7). The most recent abundance estimate for BB was in 2013 (Atkinson et al. 2021, entire) and the long-term trend is considered data deficient or uncertain (Table 1). While in the near-term, BB is identified as either data deficient or likely stable or stable (Table 1). Analysis from a genetic biopsy mark-recapture effort in DS was recently published and abundance in DS was estimated (Dyck et al. 2021a, entire) for the period 2017–18 as 2,015 bears (SD = 251; 95% Bayesian Credible Interval 1,603–2,588), however this estimate has not yet been incorporated into the PBSG status table (Table 1). Previously, abundance was estimated in 2007 (Peacock et al. 2013, p. 470) and was considered data deficient in the near- and long-term by PBSG, although both PBTC and IK (York et al. 2015, p. 31) report the subpopulation has increased (Table 1). In FB, the short-term trend is considered likely stable, but data deficient in the long-term (Table 1). IK reports an increase in FB, while PBTC considers the subpopulation trend stable in both the near- and long-term (Table 1).

SH has been declining over the near- and long-term (Table 1). Abundance estimates indicated the subpopulation was stable from the mid-1980s (Obbard et al. 2018, p. 635) through the early 2010s (Obbard et al. 2015, p. 1721), although declining body condition and survival during this period suggested a decline in abundance was imminent (Obbard et al. 2007, p. 16; Obbard et al. 2015, p. 1714; Obbard et al. 2018, pp. 648–650). A re-assessment of the subpopulation indicated a 17% decline from 2011–12 to 2016 (Obbard et al. 2018, p. 650; Dyck et al. 2019, p. 6). IK reports a stable polar bear population, as well as increasing human-bear conflicts at the southern end of SH subpopulation's range (i.e., James Bay) and an increase in abundance in eastern Hudson Bay (NMRWB 2018, pp. 29–39; Table 1). WH has been declining in the near and long-term (Lunn et al. 2016, p. 1313; Dyck et al. 2017, pp. 14, 37–38; Table 1) with an 18% decline between 2011 and 2016 (PBSG 2021, p. 36), although IK reports WH has increased (Table 1).

Survival rates for female polar bears in BB ≥2 years (2011–13) were concerning (Scientific Working Group to the Canada-Greenland Joint Commission on Polar Bear 2016, p. 267), although the short time period of the study precluded a comprehensive assessment of the trajectory of the subpopulation relative to survival rates (Atkinson et al. 2021, p. 115). Estimates of survival in female bears ages 2–20 years in DS (2008) differed by geography and associated harp seal abundance and distribution within the subpopulation (Peacock et al. 2013, p. 471), but were comparable to neighboring subpopulations (BB and WH; Regehr et al. 2007, p. 2677). Adult male survival in these subpopulations was lower than survival of adult females (Peacock et al. 2013, p. 471; Regehr et al. 2007, p. 2677). Survival estimates in SH were based on data collected from 1984–2005 and indicated declining survival across all sex and age classes (Dyck et al. 2019, p. 7). There are no recent survival estimates for FB.

Harvest occurs in all subpopulations in this ecoregion and ranges from a 5-year mean harvest of 30 (3.5% harvest rate) to 143 (5.0%) bears in WH and BB, respectively (Table 4). Harvest risk assessments have been completed for BB (Regehr et al. 2017a, entire) and SH (Regehr et al. 2021a, entire). According to the risk assessment, the recent potential harvest in SH (>48 bears; Table 4) was likely not sustainable, although actual reported harvest was lower and deemed sustainable. Incomplete harvest reporting, however, limits the capacity to assess harvest risk, so the quota is currently being reevaluated (PBTC 2021, p. 8). The number of polar bears killed in conflict or defense of life or property has risen in SH. For all subpopulations in this ecoregion, the change in TAH in Nunavut (see *4.1.1 Archipelago Ecoregion*) has the potential to reduce the population growth rate (PBTC 2021, pp. 7–9).

Nutrition, health, and reproduction

Changing sea ice conditions is facilitating near-term increases in biological productivity and higher diversity of prey species (Thiemann et al. 2008, p. 599; Galicia et al. 2015, p. 1989). Nevertheless, polar bears in most subpopulations in this ecoregion have shown declines in body condition concomitant to sea ice loss. Polar bears in BB exhibited a long-term decline in body condition that began as early as the 1990s (Dowsley and Wenzel 2008, p. 182; Rode et al. 2012, pp. 10–11; Laidre et al. 2020a, p. 13), likely as a result of reduced access to prey due to the lengthened ice-free period (Scientific Working Group to the Canada-Greenland Joint Commission on Polar Bear 2016, pp. 343–345). There were indications of improved body condition in BB in winter, which was possibly due to access to prey along the ice edge in western Greenland (Laidre et al. 2018d, p. 12), yet this trend was not documented in other adjacent subpopulations (Galicia et al. 2020, p. 844). Due to higher prey abundance from reduced human harvest, particularly harp seals, polar bear density in DS was higher than any other subpopulation in this ecoregion (Peacock et al. 2013, p. 472). However, even with an increased population of harp seals, body condition in DS declined with density-dependent effects and/or decreased availability of high-quality habitat (Peacock et al. 2013, p. 475). Body condition has also reportedly declined in polar bears in SH (Obbard et al. 2016, pp. 23–24). However, IK reports no decline in body condition for DS (York et al. 2015, p. 68; NMRWB 2019, pp. 73–74) or SH polar bears (NMRWB 2018, pp. 43–44). In WH, long-term declines in body condition preceded declines in abundance (Stirling et al. 1999, p. 300; Regehr et al. 2007, pp. 2678–2679; Stapleton et al. 2014, p. 45; Sciullo et al. 2016, pp. 49–50). FB actually had improved body condition with later freeze-up, perhaps because freeze-up occurred more slowly there, which gave bears access to seals along the ice edge (Galicia et al. 2020, p. 847). FB also has increased access to bowhead whale carcasses from orca predation; orcas have expanded their range due to sea ice loss (Galicia et al. 2016, p. 6006).

DS and WH have lower litter sizes and COY:female and yearling:female ratios compared to the surrounding subpopulations (Peacock et al. 2013, pp. 472–473; Stapleton et al. 2014, p. 46). In

SH, cub production remains high, although COY recruitment is declining (i.e., lower yearling:female ratios) likely due to poor maternal body condition (Obbard et al. 2016, p. 27). COY recruitment in BB also declined from 1993 to 2013 (Scientific Working Group to the Canada-Greenland Joint Commission on Polar Bear 2016, p. 310; Laidre et al. 2020a, p. 9). In BB, FB, and SH, litter sizes are similar but higher than DS and WH; WH polar bears have the lowest litter sizes and yearling:female ratios of the three subpopulations in Hudson Bay (Dyck et al. 2017, p. 40).

Several protected areas important for maternal denning habitat exist within this ecoregion. Primary denning habitat in Wapusk National Park, Manitoba is protected for WH (Lunn et al. 2002, p. 46; Richardson et al. 2005, p. 861). Ontario's Polar Bear Provincial Park was established in 1970 to protect maternal denning and coastal habitats used by SH during the ice-free season (Obbard and Walton 2004, p. 106). Because snow drifts have not reached sufficient depth by the time pregnant females are denning, bears in WH and SH typically dig earthen dens in frozen peat banks, which sometimes are expanded into the snowdrift as snow accumulates (Jonkel et al 1972, p. 146). The increase in melting permafrost (Gough and Leung 2002, entire) and collapse of peat banks once conducive to maternal denning (Richardson et al. 2007, p. 374) increase the importance of protected denning habitat (e.g., Polar Bear Provincial Park; Obbard and Walton 2004, p. 113). In Labrador's Torngat National Park, a portion of onshore and denning habitats are protected for DS. For BB, Auyuittuq and Sirmilik National Parks on Baffin Island protect denning and summer resting habitats, and the Melville Bay Nature Reserve in Greenland also has areas protected specifically for denning. Den phenology and habitat in BB have changed from the 1990s to 2000s: bears enter dens later yet emerge at the same time, which was coincident with an upward shift in elevation and a preference for more southerly aspects on steeper slopes for denning (Escajeda et al. 2018, p. 93). No recent data or analysis on maternal denning of FB is available.

Research from fatty acid analysis indicates that increasing contaminant burdens in polar bears may be a result of dietary shifts resulting from climate induced sea ice changes. In WH, in years where earlier sea ice break-up occurred, a higher proportion of bears' diets consisted of harbor seals (*Phoca vitulina*) rather than ice associated seals (ringed seals; McKinney et al. 2009, p. 4337). Polar bears in SH and WH were at high risk of potential POP/OHC exposure (Letcher et al. 2010, p. 3006), and levels of flame retardants (i.e., brominated compounds). Also, when compared to other subpopulations, legacy contaminants were high in SH and WH (McKinney et al. 2011, pp. 369–370).

Other stressors

Substantial oil and gas reserves exist within the boundaries of DS and BB but have largely been unexploited due to sea-ice cover. Increasing accessibility with sea ice loss has increased industrial activity in the Greenland portion of DS, with potential negative implications for bears (Canada-Newfoundland and Labrador Offshore Petroleum Board 2018, p. 15). Current threats from oil and gas are not apparent for other subpopulations in this ecoregion.

Bears in WH are subject to high levels of tourism as visitors gather in Churchill, Manitoba each autumn. In Churchill an estimated 10,000 people visit during the approximately 6-week prime viewing period (Dawson et al. 2010, p. 321). Polar bear tourism is lower in other subpopulations, though limited opportunities do exist in Polar Bear Provincial Park in Ontario and Torngat National Park in Labrador.

4.1.5 Arctic Basin

The Arctic Basin subpopulation is not classified as part of an ecoregion and is deemed a "geographic catchall" and data deficient (Table 1). Bears not belonging to another subpopulation are grouped into this subpopulation. Geographically this region is thought to be a potential refugium as the climate warms and sea ice declines (Peacock et al. 2015, p. 19). There is no estimate of abundance and there are no known human-caused removals (Table 4).

4.3 Current Conditions Summary

Of the 3 Rs, resiliency continues to remain the factor most difficult to evaluate for recovery units and subpopulations therein. Resiliency is the ability to withstand stochastic disturbance as well as annual environmental variation and is typically measured by the presence of multiple healthy, and well-connected populations. Important metrics include population size and other demographic variables, population trajectory, and habitat quality. For polar bears, examples of stochastic disturbances that may affect subpopulations and/or ecoregions include climatic factors, such as continued increasing global temperature and associated sea ice loss, decreased or later onset of snowfall, and increased rain-on-snow events. Given that polar bears rely on sea ice as a platform for hunting, breeding, denning, and long- and short-distance movements, loss of sea ice threatens every aspect of their life history. Further, due to the inherently low reproductive output of this strongly K-selected or "slow" species (e.g., 1–2 cubs every 3 years), any stochastic climatic anomalies could result in species-wide reductions in reproductive success. Examples include decreased or later onset of snowfall (Hezel et al. 2012, pp. 2–4) or more frequent rain-on-snow events (Clarkson and Irish 1991, entire) that could impact maternal denning conditions (Olson et al. 2017, p. 212) as well as pupping lairs of prey species (e.g., ringed seals; Stirling and Smith 2004, entire).

Population demographics of many subpopulations are unknown, out of date, and/or uncertain, making it difficult to evaluate the current resiliency of subpopulations (Hamilton and Derocher 2019, entire; Table 1). Some subpopulations have demonstrated resiliency by likely increased abundance in response to lower harvest pressure (e.g., KB and MC; PBSG 2021, pp. 23–26), higher survival rates due to increases in prey abundance (e.g., DS when harp seal abundance dramatically increased after harvest restrictions; Peacock et al. 2013, pp. 469–470), or apparently stable population productivity during periods of sea ice loss (e.g., CS; Rode et al. 2021; entire; Table 1). The likely decrease of three subpopulations (i.e., SB, SH, and WH; Table 1) along with range-wide decline in sea ice extent (Table 3), however, indicate a lower level of resiliency in some subpopulations. Additionally, western science (PBTC and PBSG) and IK generally differ on the recent or short-term status of subpopulations (Table 1), with complete alignment among these information sources found for only one subpopulation (KB). However, differences between IK and other sources could be attributed to differences in spatial-temporal inferences such as failure to adequately document IK across individuals throughout the geographic area of the subpopulation. In the Archipelago Ecoregion, the PBTC and PBSG stated that one subpopulation was likely stable/stable, 2 subpopulations likely increased/increased, and 3 were data deficient or uncertain. Alternatively, IK noted that 4 subpopulations increased while 2 remained stable. In the Convergent Ecoregion, PBSG determined both subpopulations were data deficient, while PBTC and IK assessments on trend aligned: one subpopulation was data deficient or unknown and the other was likely stable/stable. In the Divergent Ecoregion, the PBSG determined that 2 subpopulations were likely stable (one was CS), and 2 were data deficient. The PBSG and PBTC stated that SB likely decreased or declined; IK was not available or uncertain in this ecoregion. Finally, in the Seasonal Ice Ecoregion, the PBTC and PBSG stated that one subpopulation was likely stable/stable, 2 subpopulations likely decreased/declined, while PBSG determined that 2 subpopulations were data deficient. PBTC and IK stated that one subpopulation was likely stable/stable, and one likely increased/increased. Alternatively, IK assessed that 3 subpopulations were stable/likely increased-increased.

Representation is the adaptive capacity of the species, or the ability of the species to adapt to current and future physical and biological stressors and is characterized by the breadth of both ecological and genetic diversity within and among populations. Currently, genetic diversity and differentiation is low across the global population due to overlap and mixing of subpopulations. While demographic and genetic exchange does occur, there is still evidence of genetic structure among some subpopulations and regions that reflects the four ecoregions (Paetkau et al. 1999, entire; Crompton et al. 2008, pp. 2532–2533; Campagna et al. 2013, p. 3155; Peacock et al. 2015, pp. 10–17; Malenfant et al. 2016, entire). Across their range polar bears occupy a narrow ecological niche defined largely by sea-ice habitat and availability of ice seals, indicating little ability to adapt to changing environmental conditions. Currently, hybridization with grizzly bears, while documented (Doupé et al. 2007, pp. 273, 275; SARC 2012, p. 33; Pongracz et al. 2017, entire) is not deemed a substantial threat to the species, yet the extent of future crossbreeding and resulting introgression of grizzly bear genes is unknown.

In terms of redundancy, or the ability of the species to withstand catastrophic events, the current broad distribution of polar bear subpopulations across a large geographic area, makes the polar bear at minimal risk to extirpation from a single catastrophic event. Their range spans the circumpolar Arctic. While anecdotal evidence indicates polar bears once ranged south to St. Matthew Island (Hanna 1920, pp. 121–122) and the Pribilof Islands (Ray 1971, entire) in the Bering Sea, we lack evidence that polar bears have been lost from any large geographic areas indicating no major decline in redundancy from historical levels.

In summary, **current conditions since listing (2008) and the last 5-yr review (2017) have remained largely unchanged within recovery units**. While polar bears currently roam large areas of the Arctic, the species is at risk as their sea-ice habitat shrinks and the climate continues to warm. The ecological diversity and genetic health across polar bear range suggest representation is adequate, and the global polar bear population exhibits redundancy sufficient to preclude extirpation as a result of a catastrophic event.

Table 3. Change in sea ice metrics, which includes the dates of spring sea ice retreat and autumn sea ice advance (days per decade) and the area of summer sea ice (percent change/decade; PBSG 2021, p. 52), and projected future conditions for Representative Concentration Pathways 4.5–8.5 by Ecoregion (data from Fig. 6, Atwood et al. 2016a, p. 13) and subpopulation (adapted from Fig. 4, Molnár et al. 2020, p. 737) at the end of the century for the global population of polar bears, 2022.

Ecoregion	Abundance[a]	Subpopulation	Change in sea-ice metrics (1979–2019)			Future conditions	
			Date of spring sea-ice retreat	Date of autumn sea-ice advance	Summer sea ice area	Atwood et al[b]	Molnár et al[c]
Archipelago	~5,500	Gulf of Boothia	−8.2	7.0	−14.1	Decreased–greatly decreased	NA
		Kane Basin	−6.6	5.2	−10.3		NA
		Lancaster Sound	−5.0	4.1	−7.2		NA
		M'Clintock Channel	−4.1	4.6	−9.0		NA
		Norwegian Bay	−2.0	4.3	−2.2		NA
		Viscount Melville Sound	−4.5	6.8	−4.7		NA
Convergent	≥1,000	East Greenland	−6.7	7.6	−7.7	Greatly decreased–greatly decreased	Likely–inevitable
		Northern Beaufort Sea	−7.7	3.1	−7.0		Possible–very likely
Divergent	≥6,500	Barents Sea	−15.4	23.5	−18.5	Greatly decreased–greatly decreased	Likely–inevitable
		Chukchi Sea	−6.9	7.1	−25.8		Likely–inevitable
		Kara Sea	−9.5	8.5	−22.7		Likely–inevitable
		Laptev Sea	−7.0	7.2	−17.9		Possible–likely
		Southern Beaufort Sea	−10.9	9.6	−26.5		Very likely–inevitable
Seasonal	~9,200	Baffin Bay	−6.4	4.4	−19.3	Greatly decreased–greatly decreased	Possible–likely
		Davis Strait	−5.2	6.2	−18.6		Very likely–inevitable
		Foxe Basin	−4.6	4.6	−14.2		Likely–very likely
		Southern Hudson Bay	−1.6	2.9	−7.2		Very likely–inevitable
		Western Hudson Bay	−5.4	3.0	−20.0		Very likely–inevitable
NA	Unknown	Arctic Basin	−9.6	14.6	−7.5		NA

[a] Summed mean abundance estimate (Table 1) by Ecoregion rounded to the nearest 100 bears.

[b] The population outcome probability for normative results for RCPs 4.5–8.5

[c] The risk of demographic effects to cub recruitment for RCPs 4.5–8.5

Table 4. Reported human-caused removals (primarily harvest) by subpopulation. The majority of the data is for biological years (1 Jul–30 Jun, as defined by Canada relative to seasonal harvest) 2015−16 to 2019−20 (PBSG 2021, p. 52) with the exception of the Chukchi and Southern Beaufort Sea subpopulations, which spans the most recent 5-year period (2016−17 to 2020−21).

Ecoregion	Subpopulation	5-year mean potential removals (bears/yr)	5-year mean removals [bears/yr (% of subpopulation)]
Archipelago	Gulf of Boothia	74.0	65.2 (4.3%)
	Kane Basin	2015–17: 11 2018–20: 15	9.0 (2.5%)
	Lancaster Sound	85	77.8 (3.1%)
	M'Clintock Channel	12	9.8 (1.4%)
	Norwegian Bay	4	1.2 (0.6%)
	Viscount Melville Sound	7	2.2 (1.4%)
Convergent	East Greenland	65	68.0 (N/A)
	Northern Beaufort Sea	77	37.8 (3.9%)
Divergent	Barents Sea	N/A	N/A
	Chukchi Sea	2015–18: 58 2018–21: 85	U.S.: 12.4 (0.4%)[e] Russia: ~32 (1.1%)[f]
	Kara Sea	N/A	N/A
	Laptev Sea	N/A	N/A
	Southern Beaufort Sea	56	18.4 (2.0%)[e]
Seasonal	Baffin Bay	160	142.4 (5.0%)
	Davis Strait	76 + Quebec[a]	67.6 (3.1%)
	Foxe Basin	123 + Quebec[b]	109.0 (4.2%)
	Southern Hudson Bay	48 + Quebec + Ontario[c]	34.6 (4.4%)
	Western Hudson Bay	424[d]	29.8 (3.5%)
NA	Arctic Basin	NA	NA

[a] Currently, Quebec has no quota or harvest reporting requirements. Annual reported harvest levels averaged 27 bears/year (range 12–59) from 2012−13 to 2019−20 although actual harvest is unknown.

[b] Currently, Quebec has no quota or harvest reporting requirements. Annual reported harvest levels averaged 4 bears/year (range 0–12) from 2008−09 to 2019−20 although actual harvest is unknown.

[c] Currently, only part of Quebec has a quota (23 bears, which is included in the 48) or harvest reporting requirements. There is no quota or harvest reporting requirements in Ontario.

[d] Included 38 in Nunavut and 4 in Manitoba where only accidental or defense kills are legal.

[e] Estimates from 2016−17 to 2020−21.

[f] Estimate from Kochnev and Zdor (2015; entire).

Chapter 5: Future Conditions

In the future, climate warming will continue to impact sea ice, and the decline of sea ice habitat will remain the primary threat to polar bears. Due to the long persistence time of certain GHGs in the atmosphere, the current and projected patterns of GHG emissions over the next few decades, and interactions among climate processes (IPCC 2021, p. SPM-17), **the associated impacts to sea ice are already largely determined until at least mid-century** (Douglas and Atwood 2022, pp. 7, 22–25). Climate change effects on sea ice and polar bears will continue during this time and further into the future (Atwood et al. 2016a, entire). The levels that global GHG emissions reach in the coming decades will have substantial influence on the abundance and distribution of polar bears by the end of the century.

Given the uncertainty of the future condition of polar bear habitat and the lack of current reliable estimates of demographic parameters for many of the subpopulations, it is difficult to predict the precise future conditions for many subpopulations. However, **the likely effect of continued warming will be that most polar bear subpopulations will decline or continue to decline** (Table 3). With a diminished sea-ice platform, the distribution and seasonal onshore abundance of bears will change. The shorter duration of sea ice over shallow, productive waters of the continental shelf is likely to have significant impacts on access to prey and continued declines in sea ice characteristics are expected (Durner et al. 2009, pp. 36–37; Castro de la Guardia et al. 2013, p. 2679; Hamilton et al. 2014, pp. 4–5; Douglas and Atwood 2022, pp. 7, 22–25).

5.1 Modelled Future Conditions

This section contains summaries of three peer-reviewed publications that provide projections of the responses of polar bears or their primary habitat by ecoregion (polar bears: Atwood et al. 2016a, entire; sea ice: Douglas and Atwood 2022, entire) or subpopulation (Molnár et al. 2020, entire). These papers did not include the potentially additional subpopulation (SG) described by Laidre et al. (2022, entire); however, given its unique life history, and likely small abundance estimate, the absence of this potential subpopulation in these forecasting efforts does not change the expected future conditions for the global population of polar bears (Table 3). The following summaries of these works use language, whole or in part, that was included in the original publications.

5.1.1 Forecasting the relative influence of environmental and anthropogenic stressors on polar bears (Atwood et al. 2016a, entire)

This work projected the likelihood of polar bear persistence through the end of the 21st century as a result of sea ice loss and human influence (which includes stressors listed in Fig. 4). Using ecoregions as the analysis unit, the authors updated an earlier Bayesian network model (Amstrup et al. 2008, entire) to include data collected post-2007 (i.e., not included in the earlier model). Outcomes were projected for each ecoregion in three Representative Concentration Pathways (RCP; IPCC 2014, entire; Table 5) and four time periods (2020–30, 2045–55, 2070–80, and 2090–2100). The possible outcomes for each ecoregion and RCP in each time period included: increased, same as recent (i.e., 2007–12), decreased, or greatly decreased (Atwood et al. 2016a, p. 8).

Table 5. General overview of the three Representative Concentration Pathways (RCPs) included in Atwood et al. (2016a, p. 3) when evaluating future conditions.

RCP	Description	Emissions
2.6	Global temperatures do not increase by >2 °C above pre-industrial levels by 2100. Emission levels decline after a peak in ~2020.	Low
4.5	Assumes a goal to limit emissions is invoked and emission levels decline after a peak in ~2040. Radiative forcing is stabilized at 4.5 W/m^2 in 2100.	Intermediate
8.5	Emission levels continue to rise throughout this century. The average global temperature is expected to increase 4–5 °C.	High

Their results substantiate the climate threat by **determining that the most influential driver of adverse polar bear outcomes in the future will likely be declines in sea-ice conditions, followed by declines in the marine prey base**. On the other hand, mortality from hunting; defense of life; trans-Arctic shipping; oil and gas exploration, development, and production; and point-source pollution appear to impose little risk to the long-term persistence of polar bears. Although the time period and RCP differed, all ecoregions eventually had outcomes of greatly decreased populations (Table 3). **Projections for the Polar Basin Divergent Ecoregion were the most pessimistic with populations being greatly decreased for all RCPs in all future time periods** (Atwood et al. 2016a, p. 12). Outcomes of greatly decreased were projected by 2045–55 for both the Seasonal Ice (all three RCPs) and the Polar Basin Convergent Ecoregion (RCP 4.5 and 8.5 and uncertainty at 2.6). Polar bears in the Archipelago Ecoregion were projected to be the least impacted with outcomes of decreased or greatly decreased (RCP 8.5) by 2090–2100.

5.1.2 Comparisons of Coupled Model Intercomparison Project Phase 5 (CMIP5) and Coupled Model Intercomparison Project Phase 6 (CMIP6) sea-ice projections in polar bear (Ursus maritimus) ecoregions during the 21st century (Douglas and Atwood. 2022, entire)

The CMIP3 and CMIP5 models used for sea-ice projections were previously used in a Bayesian network assessment of how climate change could affect the persistence of polar bears for each ecoregion (Atwood et al. 2016a, entire). Since the publication of Atwood et al (2016a, entire), CMIP6 was released and has been used in the most recent IPCC analysis. Thus, Douglas and Atwood (2022, entire) compared sea-ice projections between CMIP6 and CMIP5 models and sources of variability that affected the uncertainties of model projections within each ecoregion for the 21st century. Natural variability and variability associated with the CMIP models dominated uncertainties in sea-ice projections in all months and ecoregions during the first half of this century, while emissions scenarios dominated uncertainties for late in this century (Douglas and Atwood. 2022, p. 9). **Relative to sea-ice projections, they found general continuity between the CMIP5 and CMIP6 models** (e.g., Fig. 6; Douglas and Atwood. 2022, pp. 7, 11, 22–25): in the Divergent and Seasonal Ecoregions, model averages for CMIP5 and 6 ensembles projected complete ice loss during July–November under the high emissions scenario by century's end, while in the Divergent Ecoregion, CMIP6 projected slightly less ice than CMIP5 during the remaining months. Similarly, in the Convergent Ecoregion, model averages projected complete ice loss during August–October under the high emissions scenario by the end of the century. All models projected the Archipelago Ecoregion will remain completely ice-covered during December–May until century's end, except under the highest GHG emissions scenario. Models projected notable ice declines during summer and autumn (Jul–Nov), however, a lack of congruency between CMIP5 and CMIP6 projections during summer months was evident. **Similar to other works, both models confirmed that the current trajectory of sea-ice loss will likely continue through mid-century regardless of the emissions scenario** (Fig. 6; Douglas and Atwood. 2022, pp. 7, 11, 22–25). Finally**, incorporating CMIP6 instead of CMIP5 sea-ice projections in Atwood et al. (2016a, entire) would not qualitatively change the population status outcomes published therein**.

5.1.3 Fasting season length sets temporal limits for global polar bear persistence (Molnár et al. 2020, entire)

This effort used length of fasting period to project when polar bear subpopulations in three of the four ecoregions (13 of 19 subpopulations) would begin to decline. The six subpopulations in the Archipelago ecoregion were excluded from the analysis because of low resolution data for sea ice concentration. Sea ice concentration (30%) was used as a metric of ice availability to determine number of fasting days. Number of days fasting (i.e., on shore) was estimated from movement data of radio-collared polar bears in WH as the time between the arrival from and departure to the sea ice. The number of fasting days as indicated by number of ice-free days were projected using RCP 4.5 and RCP 8.5. Because recruitment and survival are directly linked to metabolic requirements and body mass, they determined a threshold fasting period that can occur prior to a decline in cub recruitment and eventually adult survival. Each year, the threshold fasting period fluctuated with body mass and length in a subpopulation at the start of the fasting period, and hence also varied by subpopulation. Notably, hindcasts indicated SB, CS, KS, and BS have likely been experiencing declining cub recruitment and/or adult survival related to fasting for several decades. Under RCP 8.5, nearly all subpopulations are projected to experience significant declines in cub recruitment and possibly adult survival by 2100 (Table 3). **In agreement with Atwood et al. (2016a), mitigation of GHGs (i.e., RCP 4.5) would likely prolong persistence of some subpopulations, although recruitment would still be impacted and lead to ongoing demographic declines**.

5.2 Future Conditions Summary

Projected future conditions for polar bear ecoregions (Table 3) are largely the same since the last 5-year review (Atwood et al. 2016a, entire), with some potential mechanistic clarity on how subpopulation declines may occur throughout the 21st century (Molnár et al. 2020, entire). However, as the years go by without a significant societal choice to alter the trajectory of GHG emissions, the primary factor affecting polar bear subpopulations continues, the spatial and temporal scope of those impacts increase and become more certain, and recovery becomes less likely.

By the end of this century polar bears are expected to experience different pressures throughout their range, resulting in increasing probabilities of extirpation (e.g., in some parts of the Polar Basin Divergent Ecoregion; Table 3) to moderate probabilities of persistence (e.g., in the Archipelago Ecoregion; Amstrup et al. 2008, pp. 224–240 Amstrup et al. 2010, entire; Atwood et al. 2016a, pp. 10–18; Molnár et al. 2020, pp. 732–737). This SSA characterizes the viability of polar bears in all four ecoregions. The continued significant decline in annual sea ice extent will lead to range contraction, and reductions in abundance by the end of this century (Table 3). Numerous reports investigating the future status of polar bear subpopulations have been published (Amstrup et al. 2007, entire; Amstrup et al. 2008, entire; Hunter et al. 2010, entire; Castro de la Guardia et al. 2013, entire; Atwood et al. 2016a, entire; Hamilton and Derocher 2019, entire; Molnár et al. 2020, entire), all of which predict a significant decline in the global abundance of bears, and the possible extirpation of some subpopulations. Not all subpopulations will be affected uniformly in the level, rate, and timing of effects (Atwood et al. 2016a, entire; Molnár et al. 2020, entire), however, only a few subpopulations may remain in the high-Arctic by 2100 (Molnár et al. 2020, entire). Indeed, polar bear abundance will be reduced from much of their present-day range by the end of the century if emissions continue at current rates (Amstrup et al. 2008, entire; Atwood et al. 2016a, entire; Regehr et al. 2016, entire; Molnár et al. 2020, p. 735). However, if the rise in global mean temperature can be kept below 2° C, which could be accomplished only by prompt and very aggressive reductions in worldwide GHG emissions, the probability of greatly reduced polar bear subpopulations could be substantially lowered (Atwood et al. 2016a, p. 18; Molnár et al. 2020, p. 735).

Based on the best scientific information currently available and our assessment of the 3Rs, the single most important act for polar bear conservation is decisive action to address Arctic warming, which is driven primarily by increasing atmospheric concentrations of GHGs. Indeed, the largest source of uncertainty for sea-ice conditions and their impact on global populations of polar bears lies in GHG emissions trajectory (Douglas and Atwood 2022, p. 9). Addressing the increased atmospheric levels of GHGs that are resulting in Arctic warming will require a societal choice and decisive global action. Short of action that effectively addresses the primary cause of sea ice decline, it is unlikely that polar bears will be recovered.

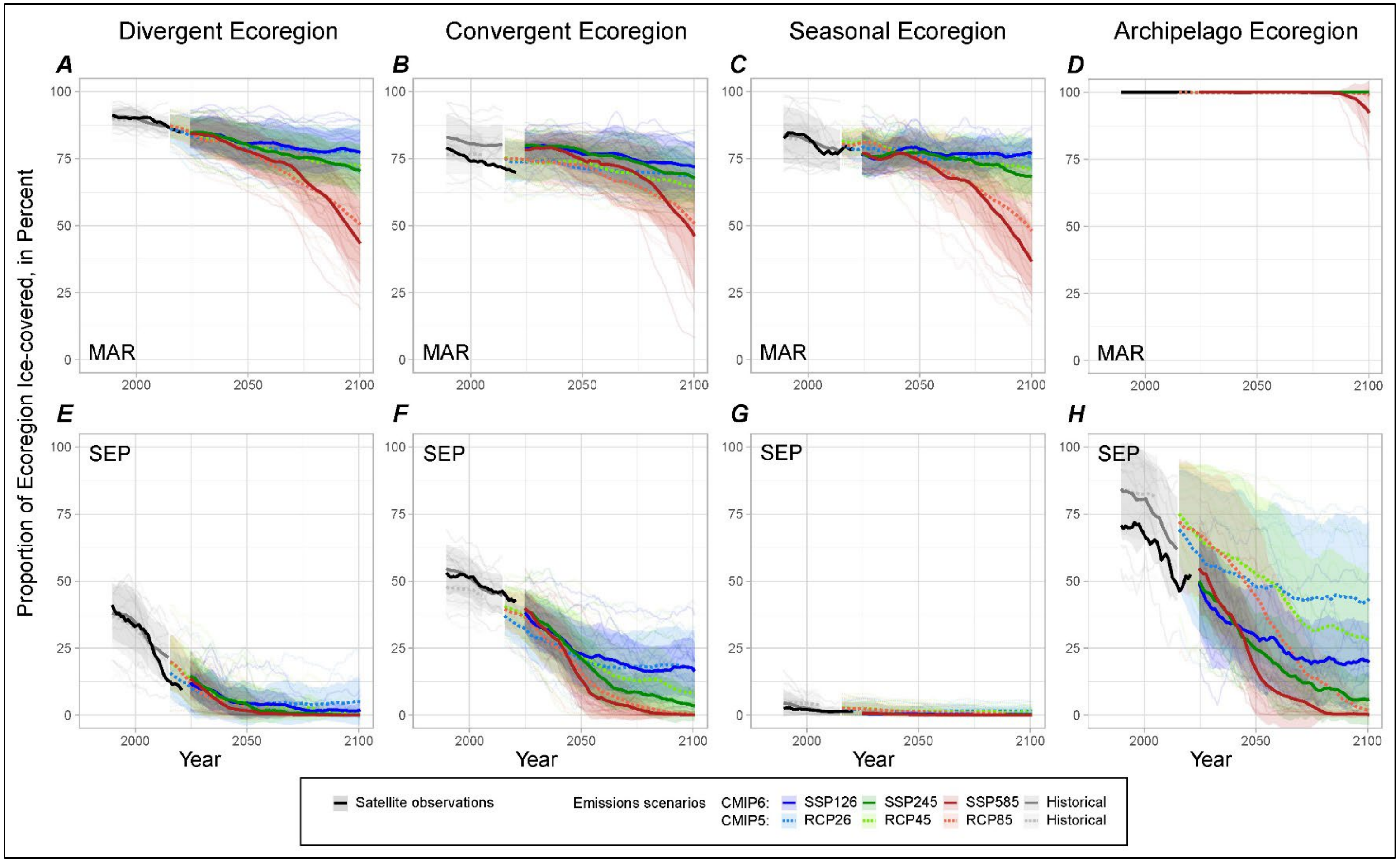

Figure 6. As in Douglas and Atwood (2022, p. 7; reproduced here with permission, with caption edited for length), percentage of ecoregions (Divergent, Convergent, Seasonal, Archipelago; fig. 1) covered by sea ice (>15% ice concentration) in March (A, B, C, D) and September (E, F, G, H) as recorded by satellite observations (black line), as simulated (historical forcing) for recent decades by selected Coupled Model Intercomparison Project Phase 5 (CMIP5, broken lines) and CMIP6 (solid lines) models (Douglas and Atwood 2022, p. 5) through 2004 and 2014 (gray lines), and as projected through 2100 when forced by different greenhouse gas emissions scenarios (colored lines) named “representative concentration pathways (RCP; CMIP5)” and “shared socioeconomic pathways (SSP; CMIP6).” Bold gray and colored lines are multimodel averages shaded by ±1 SD; all lines plot 10-year running means.

Abbreviations and Acronyms

AMSA	Arctic Marine Shipping Assessment
ANCC	Alaska Nannut Co-Management Council
ANILCA	Alaska National Interest Lands Conservation Act of 1980
BB	Baffin Bay
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
CAP	Circumpolar Action Plan
CI	Confidence interval
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMP	Polar Bear Conservation Management Plan
CS	Chukchi Sea
DPS	Distinct Population Segment
DS	Davis Strait
EG	East Greenland
ESA	Endangered Species Act
FB	Foxe Basin
FR	Federal Register
GB	Gulf of Boothia
GHG	Greenhouse Gas
I-I	Inuvialuit-Iñupiat Agreement
IITP	Incidental and Intentional Take Program
IK	Indigenous Knowledge
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
KB	Kane Basin
KS	Kara Sea
LS	Lancaster Sound
LV	Laptev Sea
MC	M'Clintock Channel
MMPA	Marine Mammal Protection Act
MTRP	Marking, Tagging, Reporting Program
NB	Northern Beaufort
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPRA	National Petroleum Reserve-Alaska
NSB	North Slope Borough
NW	Norwegian Bay
NWR	National Wildlife Refuge
NWT	Northwest Territories

PAME	Protection of the Arctic Marine Environment
PBDEs	Polybrominated diphenyl ethers
PBRS	Polar Bear Range States
PBSG	Polar Bear Specialist Group
PBTC	Polar Bear Technical Committee
POP	Persistent Organic Pollutants
PVA	Population Viability Analysis
SB	Southern Beaufort
Service	U.S. Fish and Wildlife Service
SH	Southern Hudson Bay
SSA	Species Status Assessment
SWG	Scientific Working Group
TAH	Total Allowable Harvest
U.S.	United States
USDOI	U.S. Department of Interior
USGS	U.S. Geological Survey
VM	Viscount Melville Sound
WH	Western Hudson Bay

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Appendix A. Best Management Practices to Minimize Impacts to Polar Bears

Polar bears are protected under the Marine Mammal Protection Act (MMPA) and were listed as a threatened species under the Endangered Species Act (ESA) in 2008. The MMPA and ESA both prohibit the “take” of polar bears with limited exceptions, such as for authorized incidental take and when necessary for human safety. Take includes disturbing, injuring, and killing polar bears.

Polar bears use sea ice, marine waters, and terrestrial areas in northern and northwestern Alaska for resting, feeding, denning, and seasonal movements. They are most likely to be encountered within 25 miles of the coastline, especially along barrier islands during July−October. Polar bears may also be encountered farther inland, especially females during the denning period (November−April). Be aware that polar bears also occur within human settlements such as villages, camps, and work areas.

This document lists best management practices the Service recommends to minimize the risk of human activities causing adverse impacts to polar bears, as well as polar bear encounter guidelines and reporting procedures. Following as many relevant measures as possible through the development and implementation of a polar bear avoidance and encounter plan will help protect both human and bear safety. Adherence to measures does not, however, absolve personnel of responsibility if they take (harass, harm, capture, or kill) a polar bear in violation of the MMPA. If you have questions about any best management practices or how they might be implemented in specific scenarios, please contact the Service’s Marine Mammals Management (MMM) at FW7 AK_Marine_Mammals@fws.gov or 907-786-3844.

Best practices for avoiding polar bear encounters and impacts to bears

Project siting and timing

- Avoid siting projects in polar bear high-use areas to the maximum extent practicable. High-use areas include all land within 2 km (1.2 miles) of the Chukchi and Beaufort Sea coasts. Polar bears are most likely to be encountered along coastal movement corridors along the Beaufort Sea coast between July and October. Polar bears may congregate near coastal communities in September and October when remains of subsistence-harvested whales are present. If coastal siting is unavoidable, maintain an open transit corridor for bears that is free of human presence and activity to help avoid conflict.
- Avoid establishing infrastructure in or near polar bear denning habitat (see USGS habitat maps: https://alaska.usgs.gov/data/polarBear/denHabitat/polarBear_denHabitat_allACP) and avoid undertaking activities in or near polar bear denning habitat between November and April.
- Be vigilant for sows with cubs during the den emergence period (March–May) in inland as well as coastal areas.
- Polar bears typically rest during day and become more active during dusk, night, or dawn. Plan activities with this in mind.

Den detection and avoidance

- Although efficacy is poor to moderate (see Woodruff et al. 2022), aerial infrared (AIR) surveys can locate polar bear dens that need to be avoided between November and April to prevent disturbance to denning bears. Anyone planning industrial operations or other activities involving large human presence or equipment between November and April and within 25 miles of the Bering, Chukchi, or Beaufort Sea coasts (outside of communities) should contact Marine Mammals Management to determine if completing one or more AIR surveys is necessary to lower the risk of impacts to denning bears.
- Avoid any activities within one mile of known polar bears dens, including dens encountered during the course of activities. Locations of known polar bear dens can be obtained from MMM. Report any observed polar bear dens to the MMM Regulatory Program at FW7_MMM_Reports@fws.gov as soon as possible and within 24 hours of discovery. Should occupied dens be identified within one mile of activities, cease work in the immediate area and immediately contact MMM for guidance before proceeding with activities. The Service will evaluate these instances on a case-by-case basis and determine the appropriate action.
- During transit off of ice roads and established tundra travel routes, personnel in potential denning areas should constantly be on the lookout for signs of denning (e.g., piles of snow from den excavation, tracks) between November and April. Use vehicle-based forward-looking infrared cameras to scan for dens when possible. Personnel should avoid crossing topographic features suitable for denning, such as riverbanks and along bluffs.

Avoiding impacts to sows and cubs after den emergence

- If a sow and cubs of the year are seen, cease operations within a 1.6 km (1 mi) exclusion zone and notify the Service at 1-800-362-5148 and FW7_MMM_Reports@fws.gov. Any operations in between the sow/cubs and the shoreline must be notified, and the bears must be provided a clear and unimpeded path to the sea.

Attractants management

- Be aware that garbage, food, deliberate feeding, animal carcasses, chemicals, petroleum products, sewage, and grey water can attract polar bears. Polar bears are curious and may also be attracted to novel or unfamiliar items (e.g., plastic objects, snowmachines)
- Incinerate garbage and food waste at work sites as frequently as possible. Locate incinerators outside of living areas. If incineration is not an option, store wastes as described below and remove them from site (e.g., fly them out) as frequently as possible.
- Store attractants in a manner that minimizes odors and prevents access by bears. Use bear-resistant storage containers and waste receptacles. Containers should be approved and certified by the Interagency Grizzly Bear Committee as "bear-resistant" (see information at http://www.igbconline.org/html/bear-resistant-products). Always store food away from living quarters.
- Maintain clean work areas and/or camps.
- Clean any fuel spills or spills/leaks of other chemicals or toxic materials properly and immediately, even if they are small.
- When travelling, avoid carrying strongly scented attractants or store them in air-tight containers to minimize odor transmission, and consume food in enclosed and secure areas whenever possible.

Bear avoidance, detection, and deterrence protocols

- Establish specific protocols to minimize the risk of encounters and maximize human and animal safety if an encounter does occur. These should include such measures as:
  - regular on-site safety discussions
  - using the buddy system for activities away from buildings or outside fences
  - being vigilant, traveling in groups, and making noise to avoid surprise encounters
  - using bear detection tools/methods including human monitors or “bear guards”, physical barriers, trip wire systems, alarms, and/or motion detectors/cameras
  - establishing a notification system/communication plan (e.g., using radio, blow horns, or sirens) to alert workers of a polar bear in the area and contact outside help if needed (e.g., by satellite phone)
  - designating safe area(s) to gather if a bear approaches work areas

  Additional precautions should be taken on barrier islands, in river drainages, along bluff habitat or ice leads/polynyas, near whale or other marine mammal carcasses, or in the vicinity of fresh tracks. For example, prior to landing/docking on barrier islands or other coastal areas, survey the area to ensure polar bears are not present.
- Prepare bear deterrence plans to implement if a polar bear approaches and must be hazed to protect workers and property. The Service has issued Polar Bear Deterrence Guidelines (link to notice: https://www.federalregister.gov/documents/2010/10/06/2010-25044/marine-mammal-protection-act-deterrence-guidelines) that describe passive and

preventative deterrence measures that do not require advance training. These include tools such as loud acoustic devices, air horns, electric fencing, or using a vehicle or boat to block an approaching bear. Bear spray is another effective preventative deterrence tool for individuals informed in its proper use. Use of more advanced deterrence methods, such as projectiles from a firearm (e.g., pepper balls, cracker shells, bean bags, rubber bullets) requires appropriate specialized training, and the Service may provide a Letter of Authorization for Intentional Harassment for projects intending to use advanced deterrence. Contact MMM for additional information on the Service's Bear Safety and Bear Deterrence Specialist training and intentional harassment authorization.

  - If deterrence plans include use of a firearm by a Service-approved bear deterrence specialist, make sure plans identify how rounds will be handled to prevent mixing of lethal and less-lethal rounds.
- If working near a North Slope Borough community, reach out to the North Slope Borough Department of Wildlife Management (phone: 907-852-0350) for information on recent polar bear activity in the area to inform avoidance plans.

Information and measures in the Polar Bear Encounter Guidelines section of this document should be incorporated into encounter and deterrence protocols

Personnel training materials and procedures

- Ensure all personnel working in polar bear habitat receive appropriate safety training, including education on site-specific protocols. Depending on individual duties and activities, this may include Bear Safety Training from the Service or the Alaska Department of Fish and Game.
- Any personnel that may need to deter an approaching polar bear should receive training in use of deterrents, including hands-on practice. Training from the Service or Service-approved trainers is critical for individuals planning to use advanced hazing tools (e.g., projectiles from a firearm or approaches with vehicle).
- Share or publicly post materials on bear safety and encounter protocols at work sites.
- Complete on-site polar bear safety drills.

Industrial infrastructure: site design and snow and lighting management

- For industrial infrastructure, ensure good visibility in all work site locations though facility layout and lighting. All personnel areas, including entrances, should be illuminated during working hours. Waste-management areas and pedestrian traffic areas should be particularly well-lit.
- Exterior doors should open outward, and there should be windows in or near exterior doors so personnel can look for polar bears before exiting a building. To limit risk of bears entering buildings, use oval-shaped versus handle-type knobs on exterior doors. Prevent snow from piling up below windows if it could allow a bear to climb and enter the building through the window. Grates on windows (in compliance with fire codes) are recommended to limit potential entry by bears.
- Take measures to prevent snow drifts from forming around elevated structures (including roads and pads), as they may obstruct visibility or attract bears as denning habitat.

Prevailing wind directions and resulting drift should be considered when placing barriers or storing materials. Establish protocols to remove accumulated snow from infrastructure, as needed, and consider placement of snow berms to increase visibility.

- Minimize the potential for polar bear concealment. Arrange any objects outdoors in a way that reduces or eliminates spaces where a polar bear could be concealed. Where practicable, install skirting under elevated buildings, cap off stored pipes, block culverts in the winter, surround equipment storage areas with fencing, and place of gates or other barriers on stairwells.
- Avoid creating corners and areas where bears may feel trapped or workers may become trapped by a bear.
- Minimize outdoor storage and rearrangement of outdoor objects, which may attract curious polar bears.
- If work and camp activities are co-located (e.g., on a pad) ensure living quarters are centrally located.
- Use electric or other fences that exclude bears from work and living areas, but recognize that fences are not fail-safe and awareness within or outside fences is necessary.
- If full illumination of a work site is not possible, monitoring by a bear guard using infrared night-vision cameras or binoculars may be sufficient to detect approaching bears. Contact MMM if you are considering infrared night-vision monitoring.

Remote field camp safety practices

- Minimize and prevent access to attractants. Store food, garbage, and other attractants in a manner that minimizes odors and prevents access by bears. Do not allow any bears to receive a food reward in a camp. Use containers approved and certified by the Interagency Grizzly Bear Committee as "bear-resistant" to store food, garbage, and other attractants (see attractant section above).
- Use an electric fence or alarm system as additional campsite protection.
- Avoid camping or lingering in bear high-use areas such as river drainages, coastal bluffs and barrier islands, or along ice leads/polynyas. Do not camp within one mile of river drainages with steep banks and bluffs during denning season (November-April).
- Along the Beaufort and Chukchi coasts, locate overnight camps inland. Based on known patterns of land use by polar bears, camping >1 mile (1.6 km) inland will dramatically decrease the chance a camp will be in the path of a polar bear. Be aware, however, that camping inland or along the coast can result in an encounter with a brown bear, so take bear conflict-avoidance precautions regardless of camping location.

Watercraft operations

- Be especially vigilant for swimming bears when vessels are underway. If one or more swimming bears are encountered, allow it to continue unhindered. Never approach, herd, chase, or attempt to lure a swimming bear.
- Reduce speed and avoid sudden changes in travel direction when visibility is low.

Aircraft operations (including unmanned systems/drones):

- Pilots of all aircraft types (fixed wing, helicopters, and drones) should fly at the maximum distance possible from polar bears. Aircraft should maintain an altitude of 1500 ft (457 m) above ground level when operationally possible. Under no circumstances, other than an emergency, should aircraft operate at an altitude lower than 1500 ft within 0.5 mi (805 m) of polar bears observed on ice or land.
- When weather conditions do not allow a 1500 ft flying altitude, such as during severe storms or when cloud cover is low, aircraft may be operated below this altitude. However, when lower flight is necessary, the operator should avoid areas of known concentrations of polar bears and should take precautions to avoid flying directly over or within 0.5 miles (805 m) of these areas. Operators should stay aware of bear congregation sites near their work areas through communication with the Service and regional and local bodies (e.g., the North Slope Borough Department of Wildlife Management, community councils). Note that Barter Island and Cross Island are consistent bear concentration areas.
- Aircraft should avoid performing any evasive and sudden maneuvers, especially when traveling at lower altitudes. Avoid circling, turning, or hovering aircraft within 0.5 mi (805 m) of polar bears or in known polar bear concentration areas.
- If a polar bear is spotted within a landing zone or work area while an aircraft is in flight, aircraft operators should travel away from the site, and if flying at a lower altitude, slowly increase altitude to 1500 ft (or a level that is safest and viable given current traveling conditions). Do not land aircraft within 0.5 mile of a polar bear.
- If a polar bear is observed while an aircraft is grounded, personnel should board the aircraft and leave the area. The pilot should also avoid flying over the polar bear.
- Do not operate aircraft in such a way as to separate individual members of a group of polar bears from each other.

Polar bear encounter guidelines

The general strategy for minimizing human-bear conflicts is to: 1) be prepared; 2) avoid encounters; and 3) know how to respond if an encounter occurs. Preparation and avoidance measures—which include avoiding high-use areas, minimizing attractants, developing a human-bear safety plan, preventing surprise encounters, carrying deterrents and practicing using them—are all described above. Guidelines for encounters are listed in this section. These encounter guidelines are based on up-to-date, expert assessment of polar bear incidents and practices that minimize negative outcomes.

Note that polar bears react differently to human presence depending on a variety of biological and environmental factors, as well as their previous experience with humans. Hungry (skinny) bears can be particularly dangerous.

If a polar bear is encountered:

- Prepare deterrent(s). Do not run from or approach polar bears. If the bear is unaware of human presence, allow it to continue what it was doing before it was encountered. Move to safe shelter (e.g., vehicle or building) if available, and wait until it is safe to proceed.

- Group up. If no safe shelter is available, group up with others and stand positioned to allow for safe deployment of deterrents (e.g., firearm, pistol launcher, bear spray) – until the bear leaves.

- Observe bear behavior. Polar bears that stop what they are doing to turn their head or sniff the air in your direction have likely become aware of your presence. These animals may exhibit various behaviors:

  - ➢ C*urious* polar bears typically move slowly, stopping frequently to sniff the air, moving their heads around to catch a scent, or holding their heads high with ears forward. They may also stand up.
  - ➢ *A threatened or agitated* polar bear may huff, snap its jaws together, stare at you (or the object of threat) and lower its head to below shoulder level, pressing its ears back and swaying from side to side.
  - ➢ A *predatory* bear may sneak up on an object it considers prey. It may also approach in a straight line at constant speed without exhibiting curious or threatened behavior.

If a polar bear approaches you or your camp:

- Defend your group/camp. Any bear that approaches within range of your deterrents should be deterred. Stand your ground; do not run. Defend your group or camp, increasing the intensity of your deterrence efforts as necessary. Start with the least aggressive options, such as using noisemakers, yelling or clapping, or deploying air horns. Recent work has found bear spray to be an effective deterrent against polar bears, even under high wind scenarios. With wise use of deterrents, your group may be able to de-escalate the incident by keeping bears from making contact with site items, and by eventually increasing distance between you and the bear. Be aware that lethal take of polar bears is permissible if such taking is imminently necessary in defense of human life. Defense of life kills must be reported to the Service within 48 hours.

- If bear makes physical contact, fight back. If deterrence/lethal efforts have failed and a polar bear attacks (makes physical contact), **do not "play dead"**. Fight back using any deterrents available, aiming fists or objects at the bear's nose and face.

If defense of life becomes necessary:

- ▪ Defense of life kills are only allowed in self-defense or to save the life of a person in immediate danger. All defense-of-life kills of polar bears must be reported to the Service within 48 hours. Report to USFWS Marine Mammals Management (email

FW7_MMM_Reports@fws.gov and/or call 1-800-362-5148). Events in the Arctic National Wildlife Refuge may alternatively be reported by calling the Arctic National Wildlife Refuge Manager at 1-800-362-4546 or by calling (907) 883-9409 and speaking to a law enforcement officer. If you send an email or leave a message, provide your name, contact info, and location so you can be reached to provide additional information about the incident.

- You will be required to document the circumstances leading up to, and immediately surrounding, the death of the bear, including documentation of the preventative methods you used to de-escalate the conflict in advance of killing the bear.
- The shooter may be required to transfer the carcass (including hide and skull) to a law enforcement officer or designated local representative. The shooter is responsible for the carcass once the bear is killed (it cannot be abandoned).
- The shooter may not keep any parts of the animal unless authorized by the US Fish and Wildlife Service.

Reporting

The Service requests that any polar bears sighted during activities are reported to FW7_MMM_Reports@fws.gov. Reports are mandatory if polar bears are harassed or harmed in an incident, and all sighting reports are helpful. Any injury or death of a bear related to human activities must be reported as soon as possible and no later than 48 hours after occurrence, as described in the defense of life section above. Please include as much of the following information as possible in reports:

- Date, time, and location of the polar bear observation
- Number of individual polar bears by sex and age, if possible
- Observer name and contact information
- Weather, visibility, and ice conditions at the time of the polar bear observation
- Estimated closest point of approach for the polar bear from personnel and facilities/equipment
- Project activity at time of the polar bear observation and possible attractants if present
- Polar bear behavior
- Description of the encounter with the polar bear. A full written description, including the duration of encounter and all actions taken to minimize harassment or harm to the bear, is required when a human-bear interaction occurs.
- In cases involving aircraft or vessels:
    a. Aircraft or vessel heading
    b. Aircraft or vessel speed
    c. Aircraft altitude
    d. Initial behaviors of the polar bear before responding to the aircraft or vessel
    e. A description of any apparent reactions from the polar bear to the aircraft or vessel
- If injured, distressed, or dead polar bears are observed that not associated with project activities (e.g., found outside the project area, previously wounded polar bears, or carcasses), please report this information to the Service as soon as possible at 1-800-362-5148 and FW7_MMM_Reports@fws.gov. The following website has instructions for reporting found polar bear remains: https://www.fws.gov/alaska/pages/marine-

mammals/polar-bear/carcass-found. Photographs, video, location information, or any other available documentation is very helpful for all reports.