Status Report on the World's Polar Bear Subpopulations

IUCN/SSC Polar Bear Specialist Group

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Status and Distribution

Polar bears are neither evenly distributed throughout the Arctic, nor do they comprise a single nomadic population, but rather occur in 19 relatively discrete subpopulations (Figure 1). There is uncertainty about the discreteness of the less studied subpopulations, particularly in the Russian Arctic and neighbouring areas, due to restricted capture and genetic data. The IUCN/SSC Polar Bear Specialist Group (PBSG) provided its first global population estimate in 1993: 21,470-28,370 polar bears (PBSG 1995). Although this was based on scientifically-derived estimates of abundance for most subpopulations, it also included estimates for some subpopulations that were based on knowledge of habitat quality or scientific opinion. Recognizing the false precision implied by this range and after further discussion, future global population estimates were rounded: 22,000-27,000 in 1997 (PBSG 1998), 21,500-25,000 in 2001 (PBSG 2002), and 20,000-25,000 in 2005 and 2009 (PBSG 2006, 2010). The variation in ranges reflects the absence of rigorous estimates of subpopulation abundance in several areas and the consensus desire to express a reasonable round number range that could not be interpreted as being more reliable than it really is.

Until 2005, PBSG status tables included estimates for 3 subpopulations (Chukchi Sea, Kara Sea, and Laptev Sea) where accepted methods had never been applied. These estimates were removed because including them in the table suggested they were more reliable than they really were. The PBSG has never provided estimates for two other regions (Arctic Basin and East Greenland). Bear numbers in the Arctic Basin are very low and those present may simply be passing through rather than representing a true subpopulation. East Greenland appears to have a resident group of polar bears but the PBSG has never attempted to estimate abundance.

The total number of polar bears worldwide is estimated to be 26,000 (95% CI=22,000–31,000; Regehr *et al.* 2016). The following subpopulation summaries and status are based on information presented and discussions at the 18th Working Meeting of the IUCN/SSC Polar Bear Specialist Group held in Anchorage, Alaska, 7–11 June 2016 (Durner *et al*. 2018) and review of new information that became available more recently. The information on each subpopulation is based on the status reports given by each nation. We present estimated subpopulation sizes and associated uncertainty in those estimates, subpopulation trends, changes in sea ice habitat, recent human-caused mortality, and summaries of subpopulation-specific concerns and vulnerabilities.

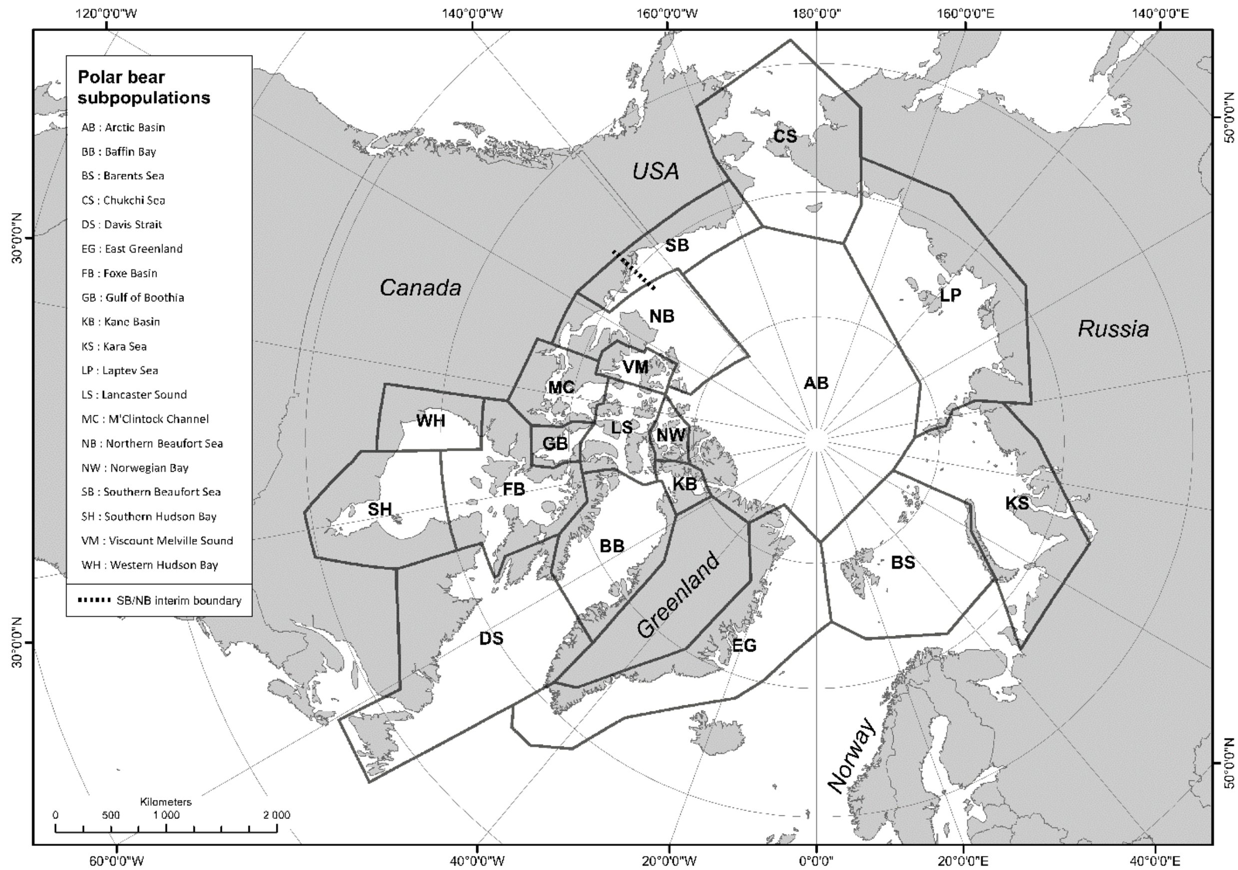

Figure 1. Distribution of the 19 polar bear subpopulations within the circumpolar Arctic. Also shown is the interim boundary (133° W) between the Southern Beaufort Sea and Northern Beaufort Sea subpopulations (i.e., SB/NB interim boundary).

Polar Bear Subpopulations

Arctic Basin (AB)

The Arctic Basin subpopulation is a geographic catchall to account for polar bears resident in northern areas of the circumpolar Arctic that are not clearly part of other subpopulations. Polar bears occur at very low densities here, in part because of deep, cold, stratified, and less biologically productive waters and, formerly at least, extensive coverage by multiyear ice. It is known that bears from several subpopulations may use the area (Durner and Amstrup 1993). As climate warming continues, it is anticipated that areas where some ice may still remain over the continental shelf may become important for polar bears as a refuge but a large part of the area is over the deepest waters of the Arctic Ocean and biological productivity is thought to be low. Polar bears with cubs have recently been observed from icebreakers in this region (Ovsyanikov 2010), although it is not possible to determine whether or not these cubs were born in the Arctic Basin, or make an assessment of possible total numbers on the basis of these anecdotal observations. Ovsyanikov (pers. comm.) reported that in 2015-16 very few polar bears were seen along this route in July – August (from Svalbard to Chukotka). The northernmost documented observation was made at 89°46 5'N, which is 25 km from the North Pole (van Meurs and Splettstoesser 2003).

Baffin Bay (BB)

Based on movements of adult females with satellite radio-collars and recaptures of tagged animals, the Baffin Bay subpopulation is bounded by the North Water Polynya to the north, Greenland to the east and Baffin Island, Canada, to the west (Taylor and Lee 1995; Taylor *et al*. 2001; Laidre *et al*. 2012). A distinct southern boundary at Cape Dyer on Baffin Island in Nunavut, Canada is evident from the movements of tagged bears (Stirling *et al*. 1980; Peacock *et al*. 2012) and from polar bears monitored by satellite telemetry (Taylor *et al*. 2001). This boundary overlaps with the northern boundary of the Davis Strait subpopulation. Studies of microsatellite genetic variation have not revealed significant differences between polar bears in BB and neighboring Kane Basin, although there was significant genetic variation between polar bears in BB and those in Davis Strait (Paetkau *et al*. 1999; Peacock *et al*. 2015; Malenfant *et al*. 2016; SWG 2016). However, polar bears in BB cluster with bears in northern Davis Strait (Peacock *et al*. 2015).

An initial subpopulation estimate of 300 – 600 bears in BB was based on mark-recapture data collected in spring (1984 – 1989) in which the capture effort was restricted to shore-fast ice and the floe edge off northeast Baffin Island. However, work in the early 1990s showed that an unknown proportion of the subpopulation was typically offshore during the spring and, therefore, unavailable for capture. A second study (1993 – 1997) was carried out during September and October, when all polar bears were thought to be ashore in summer retreat areas on Bylot and Baffin islands (Taylor *et al*. 2005). Taylor *et al*. (2005) estimated the number of polar bears in BB at 2,074 ± 226 (SE). A 3-year genetic mark-recapture survey (via biopsy darting) was completed in 2014 resulting in a new population estimate, survival rates, and habitat use analyses (SWG 2016). The mean estimate of total abundance of the BB subpopulation in 2012-2013 was 2,826 (95% CI = 2,059-3,593) polar bears. Due to evidence that the sampling design and environmental conditions resulted in an underestimate of abundance in the 1990s, these two estimates are not directly comparable and trend in abundance cannot be determined.

Satellite telemetry data and habitat selection studies in the 2000s indicate a number of ecological changes related to sea ice loss in Baffin Bay. There has been a significant reduction in the range of the subpopulation in all months and seasons when compared to the 1990s. The most marked reduction is a 60% decline in subpopulation range size in summer. Emigration from Baffin Bay has declined since the 1990s, especially with a reduction of bears moving from BB into Davis Strait and Lancaster Sound. The total number of bears marked during studies in 2011-2012 in BB was equivalent to ~34% of the estimated population size. Despite this, instances of emigration were ≤ 1% of the recaptures and recoveries of marks for the BB subpopulation.

Compared to the 1990s, adult female BB bears now use significantly lower sea-ice concentrations in winter and spring and spend 20-30 more days on land on Baffin Island in the summer ice-free season. Changes in maternity denning have been observed; entry dates into maternity dens are >1 month later in the 2000s than the 1990s. Furthermore, the first date of arrival on land by pregnant females is significantly earlier in the 2000s. Maternity dens in the 2000s occurred at higher elevations and steeper slopes than the 1990s, likely due to reduced snow cover.

Barents Sea (BS)

The size of the Barents Sea subpopulation was estimated to be 2,650 (95% CI, 1900 – 3600) in August 2004, using mark-recapture distance-sampling (MRDS) with data collected from aerial surveys (Aars *et al*. 2009). This analysis suggests that earlier estimates based on den counts and ship surveys (Larsen 1972) may have been too high. Ecological data supports that BS grew steadily during the first decade after all hunting ceased in 1973, and then either continued to grow or stabilized. A new survey in the Norwegian extent of BS was conducted in August 2015. The ice edge was located beyond an ice-free gap north of the Svalbard Archipelago. The number of bears encountered in Svalbard indicates that there is a local stock of ~200-300 bears (preliminary results), which did not differ much from the number detected in 2004. The results (J. Aars *et al*., *in prep*.) also indicate, in accordance with the results from 2004, that more bears are off-shore in the pack ice in autumn. The total estimated for the Norwegian Arctic was just under 1000 bears, considerably higher than the total for the Norwegian side in 2004, but with a confidence interval overlapping with the earlier estimate. During the new survey, the distribution of bears was clumped along the ice edge with most bears close to the Russian border, but access to the Russian portion of BS, for aerial survey, was not permitted, so no current reliable estimates exist for bear abundance in the Russian part of the Barents Sea subpopulation. Because of the overlapping confidence intervals, it cannot be concluded that the BS subpopulation has grown.

It is believed that excess hunting in the area before 1973 led to a population size far below the carrying capacity. Thus, it is unclear what the trajectory of the subpopulation will be in near future; we do expect that habitat loss will continue. There have not been any dramatic time trends in reproduction or condition parameters in BS, although poor ice years seem to influence these parameters.

Subpopulation boundaries based on satellite telemetry data indicate that BS is a natural subpopulation unit, albeit with some overlap to the east with the Kara Sea (KS) subpopulation (Mauritzen *et al*. 2002). Overlap between BS and the East Greenland (EG) subpopulation may be limited (Born *et al*. 1997), although to some degree home ranges of bears from the EG overlap with those of bears from Svalbard in Fram Strait (Born *et al*. 2012). Genetically, polar bears from BS are similar to those in the EG, KS, and Laptev Sea (LP) subpopulations (Paetkau *et al*. 1999; Peacock *et al*. 2015). At a global level, polar bears in BS belong to the Eastern Polar Basin genetic cluster (one of four global genetic clusters); substantial directional gene flow occurs from the Eastern Polar Basin to the Western Polar Basin (Peacock *et al*. 2015).

At a finer scale, there is evidence to support sub-structuring of polar bears within BS.

Studies on individual movement using satellite telemetry and mark-recapture have been conducted in the Svalbard area since the early 1970s (Larsen 1972, 1985; Wiig 1995; Mauritzen *et al*. 2001, 2002). These data show that some bears associated with Svalbard are very restricted in their movements, but bears specifically from the Barents Sea range widely between Svalbard and Franz Josef Land in the western Russian Arctic (i.e., a 'pelagic' type;' Wiig 1995; Mauritzen *et al*. 2001). Within the BS boundaries, substructure between local Svalbard bears and pelagic bears is likely increasing as sea ice around the islands disappears for longer durations. Fewer of the pelagic bears use maternity dens in the eastern part of Svalbard (Derocher *et al*. 2011; Aars 2013), in traditionally important denning areas, and it is likely that many of these bears now den more frequently on Franz Josef Land. Some bears of the pelagic-type from northern Svalbard, move north to the Arctic Ocean in the summer, and return to northern Svalbard in the winter, whereas bears from southeast Svalbard follow retreating ice to the east. Capture-recapture data also show that movement between northwest and southeast Svalbard is rare between springs of different years (Lone *et al*. 2013).

In 2016, the Russian Federation expanded its Russian Arctic National Park with the inclusion of Franz Josef Land, which is an important summering area for polar bears.

Chukchi Sea (CS)

Studies in the late 1980s and early 1990s revealed that polar bears in the Chukchi Sea (CS) subpopulation, also known as the Alaska-Chukotka subpopulation, are widely distributed on the pack ice of the northern Bering, Chukchi, and eastern portions of the East Siberian seas (Garner *et al*. 1990, 1994, 1995). Based upon these telemetry studies, the western boundary of the subpopulation was set near Chaunskaya Bay in northeastern Russia. The eastern boundary was set at Icy Cape, Alaska, which is also the western boundary of the Southern Beaufort Sea (SB) subpopulation (Amstrup *et al*. 1986; Amstrup and DeMaster 1988; Garner *et al*. 1990; Amstrup *et al*. 2004, 2005).

The first quantitative estimate of subpopulation size (2,937 95%CI = 1,552-5,944) was obtained from capture-recapture research in the U.S. portion of the subpopulation's range (Regehr *et al*. 2018*a*). Population abundance was previously estimated to be between 2,000 and 5,000 animals based on the number of maternity dens observed on Wrangel and Herald islands and the Chukotkan coast, and the assumed proportion of females in the subpopulation (Belikov 1993). In recent years, sea ice has retreated farther north in the area occupied by the CS subpopulation resulting in more days in which the biologically productive waters of the continental shelf are ice-free (Durner *et al*. 2009; Rode *et al*. 2013). Sea-ice loss is expected to continue (Douglas 2010). Rode *et al*. (2013) documented stable or improving body condition and reproduction for polar bears captured in the U.S. between 1986-1994 and 2008-2011, a period during which substantial sea-ice loss occurred. This suggests some resiliency of the subpopulation to summer habitat loss. Autumn-based observations on Wrangel Island for the period 2004-2010, however, may have indicated declining cub production and maternity denning (Ovsyanikov 2012).

A quantitative harvest risk assessment has been completed using new estimates of abundance and vital rates (Regehr *et al*. 2018*b*). Estimates of illegal take of polar bears in Russia are based on village interviews conducted 2010-2012. The current take level in Russia appears to be significantly lower than in the 1990s although up-to-date and accurate estimates are lacking (Kochnev and Zdor 2016). Uncertainty in previous estimates of abundance and other subpopulation parameters (e.g., levels of human-caused removals) result in a designation of "Data deficient" for the long-term change in subpopulation size. The designation of "Likely stable" for short-term subpopulation trend is based on estimates of population growth rate using vital rates for the period 2008-2016 (Regehr *et al*. 2018*b*).

New studies have found that CS polar bears have increased land use during the summer, primarily on Wrangel Island and the Chukotkan peninsula in Russia (Rode *et al*. 2015). Further, Wilson *et al*. (2014, 2016) found that habitat selection preferences of polar bears on the sea ice in the Chukchi Sea have not changed over time despite declines in the availability of their preferred habitats. This suggests that CS bears are not adapting their habitat choices and that climate warming will continue to reduce the availability of preferred sea-ice habitat. The observed relationship between summer sea-ice availability and the duration of time and proportion of the CS subpopulation that comes to shore suggests that land use will increase as sea ice loss continues.

Davis Strait (DS)

Based on the recapture or harvest of previously tagged animals and tracking adult female polar bears with satellite collars, the Davis Strait subpopulation occurs in Canada within the Labrador Sea, eastern Hudson Strait, Davis Strait south of Cape Dyer, and along a portion of southwest Greenland (Stirling and Kiliaan 1980; Stirling *et al*. 1980; Taylor and Lee 1995; Taylor *et al*. 2001). A genetic study of polar bears (Paetkau *et al*. 1999) indicated significant differences between bears from southern DS and both Baffin Bay and Foxe Basin. Crompton *et al*. (2008, 2014) found that individuals from northern portions of DS and those from Foxe Basin share a high degree of ancestry. Peacock *et al*. (2015) used samples from both northern and southern DS in an updated circumpolar genetic analysis, and found that the two regions are so distinct as to belong to two different global genetic clusters (southern DS to *Southern Canada* and northern DS to the *Canadian Archipelago*).

The initial subpopulation estimate of 900 bears for DS (Stirling and Kiliaan 1980; Stirling *et al*. 1980) was based on a subjective correction from the original mark-recapture estimate of 726 bears, which was thought to be too low because of possible bias in the sampling. In 1993, the estimate was again subjectively increased to 1,400 bears and to 1,650 in 2005. These increases were to account for bias as a result of springtime sampling, the fact that the existing harvest appeared to be sustainable and not having negative effects on the age structure, and TEK that suggested that more bears were being seen over the last 20 years. In addition, harp seals (*Pagophilus groenlandicus*), an important prey species for that population, had increased dramatically over the same period, providing a much-enhanced potential prey base. Polar bears were seen and radio-tracked in the large pupping areas off the coast of southern Labrador in spring. The most recent inventory of DS was completed in 2007 and the subpopulation estimate was 2,158 (95% CI: 1,833–2,542) (Peacock *et al*. 2013) and the subpopulation has been assessed as stable. Polar bear survival in DS varied with time and geography, and was related to factors that included reductions in sea ice habitat and increases of harp seal numbers (Peacock *et al*. 2013). It was suggested that the observed lowered reproductive rates and declines in body condition of polar bears in DS were likely a result of habitat changes and/or polar bear density (Rode *et al*. 2012; Peacock *et al*. 2013).

During the fall of 2017 and 2018, the field component of a genetic biopsy capture-mark-recapture study was completed.

East Greenland (EG)

Satellite-telemetry data show that polar bears range widely along the coast of eastern Greenland and in the pack ice in the Greenland Sea and Fram Strait (Born *et al*. 1997, 2009; Wiig *et al*. 2003; Laidre *et al*. 2013, 2015). Various studies have shown that there are resident groups in the region (Born 1995; Dietz *et al*. 2000; Sandell *et al*. 2001), and the East Greenland subpopulation (EG) is thought to have limited exchange with other subpopulations (Wiig 1995; Born *et al*. 2009). Although there is little evidence of genetic difference between subpopulations in the eastern Greenland and Svalbard-Franz Josef Land regions (Paetkau *et al*. 1999), satellite telemetry and movement of marked animals have detected minimal exchange between polar bears in EG and the Barents Sea subpopulation (BS) (Wiig 1995; Born *et al*. 1997, 2009; Wiig *et al*. 2003; Laidre *et al*. 2013). The polar bears in EG cluster with the Eastern Polar Basin genetic cluster, one of 4 global genetic clusters of polar bears (Peacock *et al*. 2015). Laidre *et al*. (2015) showed that due to multi-decadal sea ice loss within East Greenland, there have been changes in bears' habitat use between the 1990s and 2000s. Adult females tracked in the 2000s used areas with significantly lower sea ice concentrations (10-15% lower) than adult females in the 1990s during winter. They were also located significantly closer (100-150 km) to open water in all seasons and spent approximately 2 months longer in areas with <60% sea ice concentration than bears in the 1990s. No inventories have been conducted to determine the size of the polar bear subpopulation in EG, however pilot studies were initiated in southeast Greenland in 2015 to collect data to inform an assessment (Laidre, unpublished data).

Foxe Basin (FB)

Based on decades of mark-recapture studies and satellite tracking of female bears in Western Hudson Bay (WH) and Southern Hudson Bay (SH), the Foxe Basin subpopulation appears to occur in Foxe Basin, northern Hudson Bay, and the western end of Hudson Strait (Taylor and Lee 1995; Sahanatien *et al*. 2015). The most recent mapping of satellite telemetry data indicates substantial overlap with the WH and SH subpopulations and, to a lesser extent, with DS (Peacock *et al*. 2010; Sahanatien *et al*. 2015). During the ice-free season, polar bears are concentrated on Southampton Island and along the Wager Bay coast; however, significant numbers of bears are also encountered on the islands and coastal regions throughout the Foxe Basin area (Stapleton *et al*. 2016). A total subpopulation estimate of 2,197 ± 260 for 1994 was developed (Taylor *et al*. 2006*a*) from a mark-recapture analysis based on tetracycline biomarkers where the marking effort was conducted during the ice-free season, and distributed throughout the entire area. TEK suggested the subpopulation of polar bears had increased (GN consultations in villages in Foxe Basin 2004 – 2012). During a comprehensive summertime aerial survey in 2009 and 2010 (based on distance sampling and double-observer estimation) covering about 40,000 km each year, 816 and 1003 bears were observed, respectively (Stapleton *et al*. 2016). This most recent study yielded an abundance estimate of 2,585 (95% CI: 2,096 – 3,189) polar bears (Stapleton *et al*. 2016), which is not statistically different from the 1994 estimate indicating a stable population. Sea ice habitat for polar bears has decreased substantially for polar bears over the last several decades in FB (Sahanatien and Derocher 2012).

Gulf of Boothia (GB)

The boundaries of the Gulf of Boothia subpopulation are based on genetic studies (Paetkau *et al*. 1999; Campagna *et al*. 2013; Peacock *et al*. 2015; Malenfant *et al*. 2016), movements of tagged bears (Stirling *et al*. 1978; Taylor and Lee 1995), radio telemetry in GB and adjacent areas (Taylor *et al*. 2001), and interpretations by local Inuit hunters of how local conditions influence the movements of polar bears in the area. GB belongs in the Canadian Archipelago global genetic cluster (Peacock *et al*. 2015). An initial subpopulation estimate of 333 bears was derived from the data collected within the boundaries proposed for GB, as part of a study conducted over a larger area of the central Arctic (Furnell and Schweinsburg 1984). Although population data from this area were limited, local hunters reported that numbers remained constant or increased since the time of the central Arctic polar bear survey. Based on TEK, recognition of sampling deficiencies, and polar bear densities in other areas, an interim subpopulation estimate of 900 was established in the 1990s. Following the completion of a mark-recapture inventory in spring 2000, the subpopulation was estimated to number 1,592 ± 361 bears (Taylor *et al*. 2009). Natural survival and recruitment rates were estimated at values higher than the previous standardized estimates (Taylor *et al*. 1987). Taylor *et al*. (2009) concluded that the subpopulation was increasing in 2000, as a result of high intrinsic rate of growth and low harvest. Harvest rates were increased in 2005 based on the 2000 population estimate and the population was believed to be stable. A three-year, genetic mark-recapture population inventory study began in spring 2015.

Kane Basin (KB)

Based on the movements of adult females with satellite collars and recaptures of tagged animals, the boundaries of the Kane Basin subpopulation include the North Water Polynya to the south, the Kennedy Channel to the north and Greenland and Ellesmere Island to the east and west (Taylor *et al*. 2001). Polar bears in KB do not differ genetically from those in Baffin Bay (Paetkau *et al*. 1999; Peacock *et al*. 2015). The size of the subpopulation was estimated to be 164 ± 35 (SE) for 1994 – 1997 by Taylor *et al*. (2008*a*). The intrinsic natural rate of growth for KB polar bears was estimated to be low at 1.009 (SE, 0.010) (Taylor *et al*. 2008*a*), likely because of large expanses of multi-year ice and low population density of seals (Born *et al*. 2004). A genetic mark-recapture survey (via biopsy darting) and aerial survey were completed in 2014 resulting in a new population estimate, survival rates, and habitat use analyses (SWG 2016). Using genetic mark-recapture, the estimated abundance of the KB subpopulation was 357 polar bears (95% CI: 221 – 493) for 2013 – 2014. More bears were documented in the eastern regions of the KB subpopulation during 2012 – 2014 than during 1994-1997.The difference in distribution between the 1990s and 2010s may reflect differences in spatial distribution of bears, possibly influenced by reduced hunting pressure by Greenland in eastern KB but also some differences in sampling protocols. An estimate of abundance based on a springtime 2014 aerial survey in KB was 206 bears (95% lognormal CI: 83 - 510). However, due to insufficient coverage of offshore polar bear habitat, this estimate is likely negatively biased. The total number of bears marked during studies in 2012-2013 in KB was equivalent to ~25% of the estimated population size. Despite this, documented cases of emigration comprised < 4% of recaptures and recoveries in KB.

Changing sea-ice conditions have resulted in broad movement and habitat use patterns of KB bears that are more similar to those of bears in seasonal sea-ice ecoregions. The size of the subpopulation range has expanded since the 1990s in all seasons, especially in summer (June-September) where ranges doubled between the 1990s and the 2000s. Land use in KB during summer remains intermittent because some sea ice remains inside fjords and coastal areas. Reproductive metrics for KB were comparable between the 1990s and 2010s sampling periods. Body condition in KB appeared to have slightly improved between sampling periods (see SWG 2016). Overall, the data on abundance when considered with data on movements, condition, and reproduction, suggest evidence that the subpopulation has increased.

Kara Sea (KS)

The Kara Sea (KS) subpopulation overlaps in the west with the Barents Sea (BS) subpopulation in the area to the east of Franz Josef Land and includes the Novaya Zemlya archipelago. Data for KS and BS, in the vicinity of Franz Josef Land and Novaya Zemlya, are mainly based on dated aerial surveys and den counts (Parovshivkov 1965; Belikov and Matveev 1983; Uspenski 1989; Belikov and Gorbunov 1991; Belikov *et al*. 1991; Belikov 1993). Telemetry studies of movements have been done throughout the area, but data to define the eastern boundary are incomplete (Belikov *et al*. 1998; Mauritzen *et al*. 2002). Using polar bear samples from KS from the 1990s, at a global level, polar bears in KS belong to the Eastern Polar Basin genetic cluster (together with polar bears from Barents Sea, Laptev Sea); gene flow suggests substantial directionality (29-fold difference) from the Eastern Polar Basin to the Western Polar Basin (Peacock *et al*. 2015).

Lancaster Sound (LS)

Information on the movements of adult female polar bears monitored by satellite radio-collars, and mark-recapture data from past years, has shown that the Lancaster Sound subpopulation is distinct from the adjoining Viscount Melville Sound (VM), M'Clintock Channel (MC), Gulf of Boothia (GB), Baffin Bay (BB), and Norwegian Bay (NW) subpopulations (Taylor *et al*. 2001). Survival rates of the pooled NW and LS populations were used in the PVA to minimize sampling errors; the subpopulation estimate of 2,541 ± 391 is based on an analysis of both historical and current mark-recapture data to 1997 (Taylor *et al*. 2008*b*). This estimate is considerably larger than a previous estimate of 1,675 that included NW (Stirling *et al*. 1984). Taylor *et al*. (2008*b*) estimated survival and recruitment parameters that suggest this subpopulation has a lower renewal rate than previously estimated. However, what effect this may or may not have on the present population is not known, especially under changing sea-ice conditions. Currently, the population data are dated, but the population is thought to be stable based on local traditional information.

Laptev Sea (LP)

The Laptev Sea subpopulation area includes the western half of the East Siberian Sea and most of the Laptev Sea, including the Novosibirsk and possibly Severnaya Zemlya Islands (Belikov *et al*. 1998). The 1993 estimate of subpopulation size for LP (800 – 1,200) is based on aerial counts of dens on the Severnaya Zemlya in 1982 (Belikov and Randla 1987) and on anecdotal data collected in 1960–80s on the number of females coming to dens on Novosibirsk Islands and on the mainland coast (Kistchinski 1969; Uspenski 1989). At present these estimates are not actual, and population size is unknown.

M’Clintock Channel (MC)

The current population boundaries for the M’Clintock Channel (MC) subpopulation are based on recovery of tagged bears, movements of adult females with satellite radio-collars in adjacent areas (Taylor and Lee 1995; Taylor *et al*. 2001), and genetics (Paetkau *et al*. 1999; Campagna *et al*. 2013; Peacock *et al*. 2015; Malenfant *et al*. 2016). These boundaries appear to be a consequence of large islands to the east and west, the mainland to the south, and the multiyear ice in Viscount Melville Sound to the north. An estimate of 900 bears was derived from a 6-year study in the mid-1970s within the boundaries proposed for the MC subpopulation, as part of a study conducted over a larger area of the central Arctic (Furnell and Schweinsburg 1984). Following the completion of a mark-recapture inventory in spring 2000, the subpopulation was estimated to number 284 ± 59.3 (Taylor *et al*. 2006*b*). Natural survival and recruitment rates were estimated at values lower than previous standardized estimates (Taylor *et al*. 1987). As a consequence of the reduced population abundance, and after an initial harvest moratorium, harvest levels for MC were drastically reduced to levels that were expected to allow the population to recover and increase. A three-year genetic mark-recapture study began in 2014.

As with habitat in Gulf of Boothia, Barber and Iacozza (2004) found no trends in ringed seal habitat or sea ice condition from 1980 to 2000 for MC. A general trend has been detected for earlier break-up and delayed freeze-up (Markus *et al*. 2009; Stern and Laidre 2016), but multiyear ice is predicted to persist into the near future (Howell *et al*. 2008; Sou and Flato 2009; Maslanik *et al*. 2011). Habitat quality could be improved over the short-term and multi-year ice declines.

Northern Beaufort Sea (NB)

Studies of movements and abundance estimates of polar bears in the eastern Beaufort Sea have been conducted using telemetry and mark-recapture at intervals from the early 1970s to the present (e.g., Stirling *et al*. 1975; DeMaster *et al*. 1980; Stirling *et al*. 1988; Lunn *et al*. 1995; Stirling *et al*. 2011). From these studies, it became clear that there were two separate populations in the North and South Beaufort Sea (NB and SB) (Stirling *et al*. 1988; Amstrup *et al*. 1995; Taylor and Lee 1995) and not a single overall population. The density of polar bears using the offshore multi-year ice that predominated in much of the northernmost area of NB was lower than it was further south where most polar bear habitat consisted of annual ice over the biologically productive continental shelf (Lunn *et al* 1995; Stirling *et al*. 2011). The population estimate for polar bears in NB in 1988 was 1,200 (Stirling *et al*. 1988) although parts of the northwestern coast of Banks Island and M'Clure Strait were under-sampled because of local concern about potential disruption to guided polar bear sport hunters in the area at the same time. A subsequent study, limited to the most northerly region of the NB subpopulation (M'Clure Strait and the west coast of Prince Patrick Island) conducted in 1990–92 found that, although the ratio of marked to unmarked polar bears was similar to that in more southerly areas, densities of bears were recorded there were much lower than further south and few subadult bears were seen (Lunn *et al*. 1995). In other words, inadequate sampling of the furthest northern areas in earlier studies did not appear to have caused the overall population estimates to be biased too low. The last mark-recapture population study, completed in 2006, estimated the NB subpopulation to be 980 ± 155 (Stirling *et al* 2011). The apparent overall stability of the NB subpopulation at time was attributed to relatively stable ice conditions up to the time of completion of the field work and that the harvest had remained within sustainable limits (Stirling *et al*. 2011). Since then, sea ice conditions for polar bears in the eastern Beaufort Sea have declined dramatically (Stroeve *et al*. 2014; Stern and Laidre 2016).

More recently, based on preliminary data from satellite tracking of female polar bears, spatial modeling techniques (Amstrup *et al*. 2005), changing patterns of breakup and freeze-up resulting from climate warming, and TEK (Joint Secretariat 2015), the original boundary between NB and SB was moved west from its previous eastern limit at Pearce Point. For the purposes of the 2019 Subpopulation Status Assessment, the PBSG adopted interim use of the revised boundary between SB and NB used by management authorities in the Northwest Territories and Yukon Territory. In the future however, it is clear that the boundary issue needs to be resolved by a quantitative re-analysis of the vast amount of new data on movements from satellite tracking, mark-recapture, genetics, hunter harvest, and applicable TEK before reliable final independent population assessments and management of the two populations can be designed and carried out.

Even though a definitive assessment of population size and trend for polar bears in NB is not possible at this time, because of uncertainties over the reliability of current boundaries, possible issues of capture heterogeneity, and differing survey methods used over differing areas at different times, it is clear from the following indicators that the polar bear population of NB is currently declining and that trend will likely continue if the quality of the sea ice conditions continue to decline: 1) the highly quantified population assessments of population size of polar bears in SB, using the original PBSG boundaries (which include a significant amount of area now included in the interim boundary of NB), show a dramatic decline in the estimates of population size from 1,526 (95% CI = 1,211 – 1,841) polar bears in 2006 (Regehr *et al*. 2010) to 907 (95% CI = 548 – 1,270) in 2010 (Bromaghin *et al*. 2015); 2) polar bear body condition, stature, and reproduction have all declined between 1982 and 2006, trends which have been linked to multi-year trends of declining sea ice conditions (Rode *et al*. 2010); 3) the proportion of fasting polar bears more than doubled between 1985-1986 and 2005-2006, supporting the hypothesis that energy balance of polar bears has changed in the eastern Beaufort Sea and may at least partially explain observed declines in survival (Cherry *et al*. 2009); 4) hunter success in harvesting the allowed quota in the original area of SB in Canada declined from 81.5% (248/304) in the 1980s to 60% (231/385) in the 1990s (Brower *et al*., 2002) and, subsequently, has declined further in the overall interim NB area between 2013 and 2018 to 46.4% (62.4/134) see 2019 Status Table; and 5) in March 2012, an aerial survey of offshore areas in NB was carried out in which 7776 km of transects in polar bear habitat were surveyed a total of only two mother-yearling pairs were observed (McDonald 2012). All these results are consistent with a declining population of polar bears in NB.

Norwegian Bay (NW)

The Norwegian Bay subpopulation appears to be genetically unique (Malenfant *et al*. 2016). This subpopulation is bounded by heavy multi-year ice to the west, islands to the north, east, and west, and polynyas to the south (Stirling *et al*. 1993; Stirling 1997; Taylor *et al*. 2008*b*). Data collected during mark-recapture studies, and from satellite radiotracking of adult female polar bears, it appears that most of the polar bears in this subpopulation are concentrated along the coastal tide cracks and ridges along the northern, eastern, and southern boundaries (Taylor *et al*. 2001). The most current (1993 – 97) estimate is 203 ± 44 (SE; Taylor *et al*. 2008*b*). Survival rate estimates for the NW subpopulation were derived from pooled Lancaster Sound and NW data because the subpopulations are adjacent and the number of bears captured in NW was too small to generate reliable survival estimates. The 5-year mean harvest (2009/10 – 2013/14) has been well below a sustainable harvest level for that population size. Population data are dated.

Southern Beaufort Sea (SB)

Radio-telemetry and mark-recapture studies through the 1980s indicated that polar bears in the region comprised a single subpopulation, with an eastern boundary between Paulatuk and Baillie Island, Northwest Territories (NWT), Canada, and a western boundary near Icy Cape, Alaska, USA (Amstrup *et al*. 1986; Amstrup and DeMaster 1988; Stirling *et al*. 1988). Analyses of relocations of polar bears carrying satellite radio collars suggested that at Utqiağvik (formerly Barrow), Alaska, in the west, 50% of polar bears were from the SB subpopulation and 50% were from the Chukchi Sea (CS) subpopulation, and that at Tuktoyaktuk, NWT, to the east, there was a 50% probability of polar bears being either from the SB or the northern Beaufort Sea (NB) subpopulation. To address the issue of overlapping boundaries, resource managers in Canada shifted the eastern boundary westward to 133° W longitude (due north of Tuktoyaktuk) in 2014, and changed the allocation of harvest between the SB and NB. A similar boundary shift and change in the way harvest is allocated may be required on the western side of the SB subpopulation where it borders the CS subpopulation (Amstrup *et al*. 2005).

The size of the SB subpopulation was first estimated to be approximately 1,800 animals in 1986 (Amstrup *et al*. 1986). Survival rates of adult females and dependent young were estimated from radio-telemetry data collected from the early 1980s to the mid-1990s (Amstrup and Durner 1995) and observations suggested that abundance had increased (Amstrup *et al*.

2001). Results from a mark-recapture study conducted from 2001-2006 in both the USA and Canada indicated that the SB subpopulation included 1,526 (95% CI = 1,211 – 1,841) polar bears in 2006 (Regehr *et al*. 2006). That study and others found that the survival and breeding of polar bears were negatively affected by changing sea ice conditions, and that population growth rate was strongly negative in years with long ice-free seasons, such as 2005 when Arctic sea ice extent reached a former record low (Hunter *et al*. 2010; Regehr *et al*. 2010). The most recent analysis (covering the years 2001-2010) showed that survival estimates remained low through 2007 and increased through 2009, resulting in an abundance estimate of 907 (95% CI = 548 – 1,270) polar bears in 2010 (Bromaghin *et al*. 2015). However, it is important to note that there is the potential for un-modeled spatial heterogeneity in mark-recapture sampling, resulting from field crews being unable to sample the entire geographic reach of the population boundaries, which could bias both survival and abundance estimates. A recent Traditional Knowledge study from Canada concluded that the numbers of polar bears in regularly used hunting areas have remained relatively stable within living memory (Joint Secretariat 2015).

Declines in polar bear body condition, stature, and reproduction have been linked to multi-year trends of declining sea ice (Rode *et al*. 2010). Multiple assessments of temporal patterns of feeding ecology found that the number of bears that are in a physiological fasting state in April/May increased from the mid-1980s to the mid-2010s (Cherry *et al*. 2009, Rode *et al*. 2018). These data support the hypothesis that energy balance of polar bears has changed in the southern Beaufort Sea, which may explain declines in survival observed in the mid-2000s. The availability of sea ice habitat for polar bears (Durner *et al*. 2009) is reduced with declining sea ice extent (Stroeve *et al*. 2014), resulting from the continuing effects of climate warming. Atwood *et al*. (2016) and Pongracz and Derocher (2017) found that polar bears in the SB are spending significantly more time on land, which is correlated with the extent of ice retreat. Further, while on land, many polar bears feed on the subsistence-harvested bowhead whale remains aggregated at Cross Island near the Prudhoe Bay industrial infrastructure and Barter Island near the community of Kaktovik (Herreman and Peacock 2013, Rogers *et al*., 2015). Increased polar bear activity near human settlements may increase exposure to terrestrial-based pathogens (Atwood *et al*. 2017) and the risk of human-bear interactions.

For the purposes of the 2019 Subpopulation Status Assessment, the PBSG adopted interim use of the revised boundary between SB and NB used by management authorities in the Northwest Territories and Yukon Territory.

Southern Hudson Bay (SH)

Boundaries of the Southern Hudson Bay polar bear subpopulation are based on observed movements of marked and collared bears (Jonkel *et al*. 1976; Kolenosky and Prevett 1983; Kolenosky *et al*. 1992; Obbard and Middel 2012; Middel 2014). The range of the SH subpopulation includes much of eastern and southern Hudson Bay and James Bay and large expanses of the coastline of Ontario and Québec as well as areas up to 120 km inland (Kolenosky and Prevett 1983; Obbard and Walton 2004; Obbard and Middel 2012).

An initial estimate of population size of 763 ± 323 animals was derived through a 3-year

(1984–1986) capture-recapture study conducted in mainland Ontario (Kolenosky *et al*. 1992). This estimate was subsequently adjusted to 1000 for management purposes by the Canadian Polar Bear Technical Committee because areas away from the coast may have been under-sampled due to the difficulty of locating polar bears in the boreal forest and some areas in James Bay were not sampled (Lunn *et al*. 1998). A re-analysis of the 1984-1986 capture data produced an estimate for the study area of 641 (95% CI = 401–881 for those years (Obbard 2008; Obbard *et al*. 2007). A subsequent 3-year capture-recapture study conducted over the same geographical area and with similar capture effort (2003-05) produced an estimate of 673 (95% CI 396-950; Obbard 2008). An analysis of bears captured on Akimiski Island in James Bay during 1997 and 1998 resulted in the addition of 70–110 bears to the total subpopulation estimate (Obbard 2008). While the results of the two capture-recapture studies suggest that abundance was unchanged between 1984-86 and 2003-05, body condition declined and survival rates in all age and sex categories tended to decline between the two capture periods, although point estimates were not significantly different because of the overlap in confidence intervals (Obbard *et al*. 2006; Obbard 2008).

Intensive aerial surveys were conducted during the fall ice-free season over mainland Ontario (same geographic area as for the capture–recapture studies) and Akimiski Island in 2011, and over the remaining islands in James Bay, the coastal areas of Québec from Long Island to the SH–FB border, and the off-shore islands in eastern Hudson Bay in 2012. Results of this mark-recapture-distance-sampling (MRDS) analysis provided an estimate of 860 bears (95% CI: 580–1,274) in the mainland Ontario, neighboring islands, and Akimiski Island portions of the SH management unit during the 2011 ice-free season. The estimate for the 2012 survey was 83 bears (SE 4.5) in the 2012 study area. Thus, combining the aerial survey results from 2011 and 2012 yielded an overall estimate of 943 (SE: 174, 95% CI: 658–1350) for SH (Obbard *et al*. 2015). Overall, despite the difference in methodologies, assumptions, and biases between capture–recapture studies and aerial surveys, the evidence suggests it is likely that abundance of the subpopulation was unchanged between 1986 and 2012.

The ice-free season within the SH boundaries increased by about 30 days from 1980 to 2012 (Obbard *et al*. 2016; Stern and Laidre 2016). Concurrently, body condition declined in all age and sex classes, though the decline was less for cubs than for other social classes (Obbard *et al*. 2016).

The intensive aerial survey was repeated in September 2016 to assess recent trend in abundance. All areas in Ontario, Nunavut and Québec were sampled within a 3-week period to ensure complete coverage within the same year. Results suggest that abundance declined 17% from 943 bears (95% CI: 658–1350) in 2011/2012 to 780 (95% CI: 590–1029) in 2016. The proportion of yearlings declined from 12% of the population in 2011 to 5% in 2016, whereas the proportion of cubs remained similar (16% in 2011 vs. 19% in 2016) suggesting low survival of the 2015 cohort (Obbard *et al*. 2018).

Viscount Melville Sound (VM)

A five-year study of movements and subpopulation size, using telemetry and mark-recapture, was completed for polar bears inhabiting Viscount Melville Sound (VM) in 1992 (Messier *et al*. 1992, 1994; Taylor *et al*. 2002). Population boundaries were based on observed movements of female polar bears with satellite radio-collars and movements of bears tagged in and out of the study area (Bethke *et al*. 1996; Taylor *et al*. 2001). The most recent subpopulation estimate of 161 ± 40 (1992) (Taylor *et al*. 2002) is 25 years old and the PBSG now regards VM as a data deficient subpopulation. However, in spring 2014, the field component of a mark-recapture study to re-assess abundance and status of the VM subpopulation was completed; the results are not yet available.

Western Hudson Bay (WH)

Hudson Bay is a relatively shallow inland sea that is ice covered in winter and ice free in summer (Hochheim *et al*. 2010). Although three subpopulations of polar bears (Foxe Basin, Southern Hudson Bay, and Western Hudson Bay) occur on the sea ice in winter and spring, they appear to be largely segregated during the open-water season (Derocher and Stirling 1990; Peacock *et al*. 2010; Viengkone *et al*. 2016). During the ice-free period, Western Hudson Bay polar bears exhibit strong fidelity to terrestrial summering areas in northeastern Manitoba (Stirling *et al*. 1977; Derocher and Stirling 1990; Cherry *et al*. 2013; Stapleton *et al*. 2014; Lunn *et al*. 2016). The current Western Hudson Bay subpopulation boundary is based largely on capture, recapture, and harvest of tagged animals (Stirling *et al*. 1977; Derocher and Stirling 1990, 1995*a*; Taylor and Lee 1995; Lunn *et al*. 1997).

Although the size of the Western Hudson Bay subpopulation was unknown until the 1990s (Derocher and Stirling 1995*a*), Inuit have observed a larger number of bears in recent decades relative to the historic levels of the early 1900s to 1970s (McDonald *et al*. 1997; Tyrrell 2006, 2009; Nirlungayuk and Lee 2009; Henri *et al*. 2010; Kotierk 2012). A significant factor likely contributing to this observed increase was a population-level response to decreased hunting pressure that occurred in the 1950s and 1960s resulting from the closure of the fur trading post at York Factory, withdrawal of military personnel from Churchill, and the closure of hunting in Manitoba (Stirling *et al*. 1977; Derocher and Stirling 1995*a*).

Derocher and Stirling (1995*a*) estimated the mean population size for 1978-1992 to be 1,000 (SE = 51). However, this estimate was considered conservative because the study had not covered the southern portion of the range east of the Nelson River (Calvert *et al*. 1995; PBSG 1995) and, therefore, for management purposes the population size was adjusted to 1,200 (Calvert *et al*. 1998). In 1994 and 1995, Lunn *et al*. (1997) expanded the capture program to sample animals to the Western Hudson Bay/Southern Hudson Bay management boundary and estimated abundance to be 1,233 (SE = 209) in 1995. Regehr *et al*. (2007) reported a decline in abundance from 1,194 (95% CI = 1,020–1,368) in 1987 to 935 (95% CI = 794–1,076) in 2004 and also documented that the survival rates of cubs, sub-adults, and old bears (>20 years) were negatively correlated with the date of sea ice breakup.

A mark-recapture distance sampling study resulted in an abundance estimate of 1,030

(95% CI = 754–1,406) in 2011 (Stapleton *et al*. 2014). During this survey, 711 bears were observed and more bears, particularly adult males, were observed in the coastal areas east of the Nelson River towards the Western Hudson Bay/Southern Hudson Bay boundary than were documented during the late 1990s (Stirling *et al*. 2004). Stapleton *et al*. (2014) suggested that a distributional shift may have negatively biased abundance estimates derived from capture samples. Mean litter size (cubs-of-the-year, 1.43 ± 0.08; yearlings, 1.22 ± 0.10) and number of cubs observed as a proportion of total observations (cubs-of-the-year, 0.07; yearlings, 0.03) were lower than those recorded for the neighboring subpopulations of Foxe Basin and Southern Hudson Bay, which is consistent with Western Hudson Bay having low reproductive productivity (Regehr *et al*. 2007; Peacock *et al*. 2010; Stapleton *et al*. 2014). The body mass of solitary adult female polar bears has declined over the past 37 years, which has likely contributed to declining reproductive success (Derocher and Stirling 1995*b*; Stirling *et al*. 1999; Sciullo *et al*. 2016; Lunn and McGeachy 2018).

Lunn *et al*. (2016) evaluated the demography and status of the Western Hudson Bay subpopulation for the period 1984-2011, using a Bayesian implementation of multistate capture-recapture models, coupled with a matrix-based demographic projection model, to integrate several types of data and to incorporate sampling uncertainty as well as demographic and environmental stochasticity across the polar bear life cycle. Their analysis resulted in an estimate of 806 (95% CI = 653–984) for polar bears in the core area of study north of the Nelson River in 2011. Although the abundance estimates from the aerial survey and capture-recapture model are broadly similar with overlapping confidence intervals, it is difficult to make direct comparisons because the studies differed with respect to spatial and temporal perspectives and with the assumptions of each method (Lunn *et al*. 2016). The aerial survey provides a snapshot estimate of the total number of polar bears in the Western Hudson Bay management area at the time of the survey whereas the point estimate from the capture-recapture model is based on the number of bears that moved through the smaller, capture-recapture sampling area over multiple years.

The most recent estimate of abundance comes from a mark-recapture distance sampling study in 2016 to update subpopulation status (Dyck *et al*. 2017). Pre-survey consultations with Nunavut Hunters' and Trappers' Organizations, Kivalliq communities, and with the Manitoba Department of Sustainable Development were conducted in order to include local and traditional knowledge in the study design. Dyck *et al*. (2017) estimated there to be 842 bears (95% CI: 562–1121) that, although not statistically significant from the previous aerial survey estimate, represented an 18% decline in abundance between 2011 and 2016. Over the same period of time and using similar methods, Obbard *et al*. (2018) documented a 17% decline in abundance for the neighbouring Southern Hudson Bay subpopulation. Similar to observations from the 2011 survey, cubs-of-the-year and yearling cubs comprised a small proportion of the sample size (Dyck *et al*. 2017) and suggested that low reproductive performance of the Western Hudson Bay subpopulation has continued.

From the 1930s through the 1960s, Inuit report that encounters with polar bears in the interior of the Kivalliq mainland and along the Kivalliq coast of Hudson Bay were rare

(Nirlungayuk and Lee 2009; Tyrrell 2009). Within the last few decades more bear-human encounters have occurred resulting in increased concerns for human safety and property damage (Tyrrell 2006, 2009; Henri *et al*. 2010).

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