EXECUTIVE SUMMARY

Harvest Risk Assessment for the Southern Hudson Bay Polar Bear Subpopulation

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The Southern Hudson Bay Technical Working Group (TWG) was formed to provide advice to the Southern Hudson Bay Polar Bear Subpopulation Advisory Committee. The TWG has recently compiled the available scientific data for the Southern Hudson Bay (SH) subpopulation, summarized historical removal levels, worked with an outside expert to construct a demographic model, performed a harvest risk assessment, and documented these steps in the current report to the Advisory Committee. Although the assessment was based primarily on scientific information, Indigenous Knowledge was considered when interpreting and modeling the status of the SH subpopulation. The TWG is not a decision-making body. Rather, it sought to draw upon the expertise of its membership to develop and provide advice to the responsible decision-making bodies for the SH subpopulation.

This report presents a quantitative harvest risk assessment for the SH polar bear subpopulation. The final results are a series of potential harvest strategies that can inform prospective management actions in conjunction with other sources of information and considerations. The assessment uses a custom demographic model that was developed to evaluate responses to different environmental conditions and management interventions. Population processes are represented by a discrete version of the theta-logistic equation, which is widely used in ecology. The model includes a single age class and is applied to female bears only. This approach is consistent with the limited demographic information available for the SH subpopulation. The model includes a nonlinear relationship between population density and population growth resulting in demographic patterns that are generally within the bounds of those documented for polar bears and similar species. The model can incorporate the potential effects of habitat change through both density-dependent mechanisms (i.e., changing environmental carrying capacity [*K*]) and density-independent mechanisms (i.e., changing maximum intrinsic growth rate [r_{max}]).

We estimated parameters of the theta-logistic equation using a Bayesian Monte Carlo approach to population reconstruction. This process used estimates of abundance and population growth rate from capture-recapture studies in the 1980s and 2000s (Obbard et al. 2007), estimates of abundance from aerial surveys in the 2010s (Obbard et al. 2015, 2018), and harvest data from Nunavut, Québec, and Ontario. It also allowed incorporation of prior information from other case studies of polar bears. Population reconstruction demonstrated that the demographic model can reproduce plausible trends for the SH subpopulation in recent decades.

The available data are not conclusive regarding the current demographic status of the SH subpopulation. Statistical uncertainty and methodological differences between capture-recapture studies and aerial surveys preclude estimation of long-term trends in abundance. Several lines of evidence suggest that the subpopulation was, on average, capable of strong growth during the period 1984-2016 and thus could support a relatively high harvest. However, there is also evidence for a decline from 943 bears in 2012 (Obbard et al. 2015) to 780 bears in 2016 (Obbard et al. 2018) based on aerial surveys with consistent methodology. Sea ice has declined in the SH management area, although to a lesser extent than other polar bear management areas (Stern and Laidre 2016), and the SH subpopulation has experienced declines in nutritional condition (Obbard et al. 2016). In the adjacent Western Hudson Bay (WH) subpopulation, similar declines in condition were detected prior to obtaining evidence from capture-recapture studies for declines in reproduction, survival, and abundance (Lunn et al. 2016). Recent aerial surveys for the WH subpopulation suggest a decline in numbers during the period 2011-2016 based on multiple lines of evidence, although the difference in abundance estimates was not statistically significant (Stapleton et al. 2014; Dyck et al. 2017).

We accounted for uncertainty in the current and future status of the SH subpopulation by developing three biological scenarios representing a plausible range of conditions, from optimistic to pessimistic, based on the available scientific data and documented Indigenous Knowledge. The scenarios were developed using different approaches to population reconstruction and different assumptions about the future effects of habitat loss. Scenario 1 reflected the optimistic hypothesis that the future will be similar to the past 30 years, with only gradual declines in *K* proportional to projected declines in the number of ice-covered days per year in the SH management area. Scenario 2 reflected the middle-of-the-road hypothesis that the future will be similar to the past decade, during which there is some evidence of demographic declines, and that both *K* and r_{max} will decline gradually in the future. Scenario 3 consisted of two pessimistic representations of the SH subpopulation. Scenario 3a included a strong density-independent decline in r_{max} followed by gradual declines in both *K* and r_{max}. Scenario 3b reflected a subpopulation that was theoretically capable of strong growth but experienced rapid and nonlinear declines in *K*.

For each biological scenario, we used the demographic model to project simulated polar bear subpopulations forward in time while being subject to a wide range of female harvest rates. Projections were run for 35 years, which corresponds to approximately three polar bear generations and is a common timeframe for conservation assessments (Regehr et al. 2016). We evaluated the effects of harvest against three potential alternatives for subpopulation Management Objectives: (1) maintain a subpopulation size that achieves maximum sustainable yield, with respect to a potentially changing *K*; (2) maintain a relatively stable subpopulation size; and (3) maintain a subpopulation size above a minimum threshold, below which the function and viability of the subpopulation are likely to be compromised. Management Objective 3 is not intended as a measure of sustainability, but rather to indicate whether the subpopulation could become depleted to the extent that emergency management measures might be warranted. We present the probabilities of achieving the three management objectives for multiple harvest strategies, rather than only presenting results for a smaller number of harvest strategies that correspond to predetermined levels of risk tolerance (i.e., that correspond to specific probabilities of meeting the objectives).

We can compare results for the three biological scenarios by looking at harvest strategies with an 80% probability of meeting Management Objective 1 (i.e., maintaining a subpopulation size that achieves maximum sustainable yield). Management Objective 1 is well suited to balancing subpopulation protection with continued opportunities for use, and an 80% probability falls between the "low" and "medium" levels of risk tolerances that have been subjectively used for Management Objective 1 in other harvest assessments (Regehr et al. 2017a, 2018a). Furthermore, harvest strategies that meet these conditions were associated with low probabilities of violating Management Objective 3 or reducing future sustainable yield through overharvest. For Scenario 1, the corresponding harvest strategy had a present-day harvest level of 21 female bears/year. This is similar to the mean observed harvest for the SH subpopulation of approximately 19 females/year for the period 1986-2016, which is logical given that Scenario 1 was based on the hypothesis that the future will be similar to the past. For Scenario 2, the starting harvest level was 10 female bears/year. Assuming that the proportion of females in the SH subpopulation is currently 0.50, this would correspond to a total (i.e., female and male) harvest rate of approximately 3.8% if harvest were implemented at a 2:1 male-to-female ratio. For reference, this is slightly below the 4.5% rate at a 2:1 male-to-female ratio that has been considered sustainable under favorable environmental conditions (Taylor et al. 1987). For Scenario 3a, the starting harvest level was 4 female bears/year. The probability of violating Management Objective 3 increased at a starting harvest level of 8 female bears/year, and the probability of extirpation increased at a starting harvest level of 18 female bears/year. Scenario 3a demonstrates the potential for overexploitation when a subpopulation's capacity for growth is compromised by severe density-independent limitation. In contrast, subpopulation outcomes for Scenario 3b were relatively insensitive to harvest. This is because the rapid and unidirectional decline in *K* guaranteed that abundance would decline as well, and natural mortality due to density effects could be largely replaced by harvest without accelerating subpopulation declines. Although Scenarios 3a and 3b are both oversimplifications of how sea-ice loss might impact the SH polar bear subpopulation, they demonstrate the importance of whether the effects of habitat change are primarily density independent or density dependent. Currently, the data are not available to differentiate between density-independent and density-dependent effects for SH bears, and this remains an area of research for polar bears in general.

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Our approach of considering multiple biological scenarios, management objectives, and harvest strategies has the advantage of clearly representing scientific uncertainty and providing management authorities with detailed information against which their goals can be evaluated. However, it does not lead to recommendation of a specific management strategy because that would require identifying a specific management objective, which to date has not occurred for the SH subpopulation. To evaluate the biological risks of harvest, we suggest initially orienting toward Scenario 2 at a moderate degree of risk tolerance with respect to Management Objective 1. This would suggest female harvest rates in the vicinity of h = 0.02-0.03, which correspond to starting harvest levels of 8-12 female bears/year. This is equivalent to a total (i.e., female and male) harvest rate of approximately 2.0-3.0% assuming a 1:1 male-to-female ratio in the harvest or approximately 3.0-4.5% assuming a 2:1 male-to-female ratio.

The female harvest rate is the primary determinant of whether a given harvest strategy is sustainable, because female bears are most important to population growth (Eberhardt 1990). Based on previous studies of sex-selective harvest (Taylor et al. 2008; Regehr et al. 2017b) we suggest that a female harvest rate in the range 0.02-0.03 together with a 2:1 male-to-female ratio would be unlikely to deplete males in the SH subpopulation, provided that the female harvest rate was indeed below maximum sustainable yield with respect to the female segment of the subpopulation (Taylor et al. 2008; Regehr et al. 2017b). However, we were not able to directly evaluate the biological effects of a sex-selective harvest because analyses in this report were limited to female bears only. This was necessary because aerial surveys, the primary study method for the SH subpopulation in the past decade, can provide accurate estimates of total abundance but do not provide the data on subpopulation composition or vital rates needed to model the females and males together.

The mid-range harvest strategies indicated above likely have the benefit of limiting lost opportunities for subsistence use if conditions are more like Scenario 1, while reducing the chances of severe overexploitation if conditions are more like Scenario 3a. Working from the starting point of a female harvest rate in the range 0.02-0.03, the information provided in this report can help the management authorities weigh the pros and cons of lower and higher harvests in terms of biological risk, opportunities for use, and other considerations (e.g., human safety). Furthermore, comparing future demographic data for the SH subpopulation against the biological scenarios in this report may help understand how habitat loss is affecting the subpopulation and, by extension, which scenario is most relevant to management.

All harvest strategies in this report follow a “state-dependent” harvest management approach (Regehr et al. 2017b), which is similar to the “adaptive management” approach recommended by the Polar Bear Range States (2015). State-dependent management means that harvest levels do not remain constant into the future, but rather are updated periodically using new data from scientific studies or other sources on the current status (i.e., “state”) of the subpopulation. This requires a coupled research-management framework and accurate harvest monitoring. Specifically, our analyses assumed that new aerial surveys will be completed every 5 years with a level of precision similar to the surveys in 2012 and 2016 (Obbard et al. 2015, 2018). If there is uncertainty in the ability to implement state-dependent harvest management with these conditions, a more conservative approach to harvest (i.e., a lower allowable harvest) will be necessary to mitigate risk.

Our findings should be interpreted with caution due to limited demographic data for the SH subpopulation, incomplete understanding of how sea-ice loss affects polar bear population dynamics, and use of a relatively simple demographic model that did not include male bears or a detailed mechanism of reproduction. Our modeling approach did not make purposefully conservative assumptions regarding the effects of harvest or climate change. Furthermore, the TWG received limited guidance from the responsible management authorities with respect to management objectives or risk tolerance. In the main report, we discuss several potential ways to mitigate the biological risks associated with human-caused removals. These include research and monitoring approaches to address data gaps for the SH subpopulation, and the concept of a multi-level system under which graduated management and conservation actions are tied to pre-established subpopulation thresholds.