Options document for recommending the overall harvest level of the Southern Hudson Bay polar bear subpopulation considering the updated abundance estimate from the 2021 aerial survey

Prepared for the Southern Hudson Bay Advisory Committee

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Context and history

The Southern Hudson Bay (SH) subpopulation is shared between multiple governments, Wildlife Management Boards, and land claims organizations. Because of this complexity, there is a need to coordinate decision-making around harvest levels and gathering information. The SH Technical Working Group (TWG) was established to support management recommendations and decision-making processes by coordinating aerial surveys, analyses, synthesizing information, and providing a status report to the Advisory Committee.

Background on the 2019 SH harvest risk assessment

In 2019, Dr. Eric Regehr (Polar Science Center, University of Washington), in collaboration with the SH TWG performed a harvest risk assessment and prepared a report for the SH Advisory Committee (hereafter, 2019 harvest risk assessment). In 2021, a peer-reviewed paper was published based on results of the 2019 harvest risk assessment for the SH polar bear subpopulation (see Regehr et al. 2021). They considered population and harvest data through the 2016 aerial survey (Obbard et al. 2018). Given uncertainty about the magnitude of future climate warming and differing views on the influence on the bear population, the authors defined three scenarios for the current and future demographic status as a function of environmental conditions.

- The optimistic Scenario 1 assumed that the demographic status of the SH subpopulation in the next 34 years (i.e., three polar bear generations) will resemble its average status from 1986-2016, during which the subpopulation was capable of strong growth (maximum population growth rate [rmax] = 0.08) and supported a relatively high harvest. Scenario 1 assumes gradual declines in environmental carrying capacity (K) of 3% per decade going forward, informed by observed changes in sea-ice availability from 1980 through 2016.
- The middle-of-the-road Scenario 2 assumed that the demographic status of the SH subpopulation in the next 34 years will resemble its average status from 2005-2016, during which the subpopulation was capable of moderate growth (rmax = 0.05, which is close to the value of rmax = 0.06 that is often assumed for healthy subpopulations in the absence of climate effects) and could support a moderate harvest. Scenario 2 assumes gradual declines in both K and rmax of 3% per decade going forward, informed by observed changes in sea-ice availability.
- The pessimistic Scenarios 3a and 3b assumed that the demographic status of the SH subpopulation in the next 34 years will resemble its average status 2012-2016. Scenario 3a assumes a low capacity for growth followed by gradual declines in both K and rmax of 3% per decade going forward, representing the hypothesis of strong environmental limitation resulting from density-independent effects. Scenario 3b assumes a strong capacity for growth followed by a gradual decline in rmax of 3% per decade and a steep decline in K of 26% per decade going forward, representing the hypothesis of strong environmental limitation resulting from density-dependent effects.

The TWG recommended that to determine overall harvest level of SH, managers could focus on Scenario 2 at a “moderate” degree of risk tolerance, defined as having at least an 80% probability that harvest would not cause the subpopulation abundance to decline below its maximum net productivity level (i.e., the subpopulation abundance that produces the maximum sustainable yield). This results in an annual female harvest rate (h) of 0.02-0.03 of female abundance. Using a female harvest rate of 0.02-0.03 and the estimate of total (female and male) abundance of 781 bears from 2016 (Obbard et al. 2018), this corresponds to a total harvest of 16-23 bears per year at a 1:1 male-to-female harvest ratio, or a total harvest of 23-35 bears per year at a 2:1 male-to-female harvest ratio.

Overview of 2021 aerial survey, considerations, and uncertainties

In August 2021, the SH subpopulation was surveyed using nearly identical methods as in 2011/12 and 2016. The purpose of this survey was to obtain another, comparable estimate of the SH abundance to assess the status of the subpopulation. The results of this survey are outlined in detail by Northrup et al. (2022), yet some elements from the report are presented below as they relate to assessing a sustainable harvest level for SH. While the survey design for this latest survey was similar to previous surveys, Northrup et al. (2022) made use of recent advances in statistical techniques to try to more accurately estimate the abundance of bears within SH. This resulted in the best estimate of the number of bears in the SH subpopulation at the time of the survey in 2021 to be 1119 bears (95% CI 860-1454). However, this estimate was not directly comparable to the 2016 survey because of the difference in statistical analysis. The estimate obtained using the most comparable methods to the 2016 estimate was 1003 (95% CI 773-1302), equating to a 29% increase from 2016.

The greater number of bears within the limits of SH range in 2021 compared to 2016 has two plausible – not mutually exclusive – biological drivers, including 1) variation in the on-land distribution of bears in SH and Western Hudson Bay (WH) at different times, and 2) an increase in population growth rate due to reduced mortality, increased birth rate or both. We discuss each below.

Firstly, there appears to have been some movement of bears into SH from the adjacent WH subpopulation in 2021. Although the boundary between WH and SH, in northwestern Ontario, was based in part on movement and mark-recapture data, there is no major geographic feature that would limit movements across the boundary, and there are large aggregations of bears on offshore islands and peninsulas near the boundary. Thus, minor variation in the distribution of these bears could greatly influence the estimates of the abundance of bears present in WH and SH. Simultaneous with the 2021 aerial survey, research was underway by Environment and Climate Change Canada and the Ontario Ministry of Natural Resources and Forestry to examine broadscale movements of bears at the boundary of SH and WH. This work involved biopsy darting and genotyping individuals to compare annual distribution of bears, among other objectives. This work had been ongoing in WH and the far western portion of SH since 2018. In 2021, nearly the entirety of the Ontario coast of SH was also sampled. The results from this work indicated a potential large movement of WH bears that spend the onshore period near the management boundary into SH in 2021. Specifically, approximately 20% of the bears biopsied in SH in 2021 had been previously sampled exclusively in WH. Although there had been more sampling in WH in recent years, which could explain some of these results, these findings are suggestive of interannual variation in bear distribution in this area with greater movement into SH in 2021. We reiterate that this so-called movement of bears does not represent major influx of bears into SH from Nunavut or Wapusk National Park, but rather this is likely due to minor interannual variation in the on-land distribution of bears that primarily spend their summers near the management boundary.

It is also possible that the increased abundance of bears estimated in SH in 2021 was influenced in part by improved demographic rates of SH bears. The number of yearlings in 2021 was high and indicates increased recruitment compared to the particularly low numbers seen in 2016 (Obbard et al. 2018). Further, the two years preceding 2021 were two of the three years with the longest duration of sea-ice in Hudson Bay since 2011. These conditions would have been favorable for high reproductive output and survival of cubs in the previous two years. Further, according to reported harvest data, polar bear harvest in SH was lower between 2016 and 2021 than between 2010 and 2015 (37.8 bears per year compared to 58.8 bears per year). However, this decrease between the two time periods was partly driven by the exceptionally large harvest of 104 bears in the 2010/2011 harvest season. The high harvest in 2010/11 and higher average harvest early in the last decade, along with relatively poor ice years during that same period, could have driven a decline of SH between 2011 and 2016. In contrast, the observed increased abundance of bears in 2021 could be due to lower annual harvests, with the resulting downstream positive demographic effects, combined with better ice conditions that resulted in higher juvenile survival.

Ice conditions were on average more favorable for bears between 2016 and 2021, than 2011 and 2016, with bears often able to remain on the ice into August. These years of relatively good ice conditions, combined with reduced harvest, may have buffered the population against decline. At the time of the 2021 survey, reproduction appeared healthy with a high proportion of yearlings and cubs. However, 2021 was one of the shortest ice seasons of the past decade and survival of yearlings and cubs could be impacted. If the short ice season in 2021 equates to low survival of these bears, the current estimate could immediately become overly optimistic.

Currently, we do not have sufficient information to know whether movement or improved vital rates was more influential on the increase in abundance between 2016 and 2021. It is likely that some combination of the two drivers acted to increase bear abundance. The degree to which each of these factors was acting is unknown and critical to resolve. Continued monitoring of reproduction, survival, and inter-annual movements within and between both WH and SH will be critical to continue to inform management during the intervals between aerial surveys. We note that the major disadvantage of aerial surveys relative to other methods, such as genetic mark-recapture or physical mark-recapture is that no additional information is obtained to help understand changes in abundance over time.

Considerations for an updated harvest risk assessment

The SH aerial survey report has been completed and distributed to management authorities (December 2022). The TWG has considered whether there is a need to update the 2019 harvest risk assessment with the 2021 abundance estimate and latest harvest data. The harvest management framework in Regehr et al. (2021) was designed so that new biological information can be used to update decisions regarding overall harvest level of SH without requiring extensive analyses. Although it would be possible to perform an updated harvest risk assessment, patterned after Regehr et al. (2021) and directly including the 2021 estimate of abundance as well as recent harvest data, the TWG does not believe that approach would provide better information compared to the options below, which do not require extensive analyses. This is because the new biological information for the SH subpopulation consists primarily of the updated abundance estimate from the 2021 aerial survey, which includes several sources of uncertainty that cannot be fully resolved with the available data. The options presented here are also more cost effective than an updated harvest risk assessment, which would require approximately 30,000 CAD and at least a six-month period of performance.

The SH TWG has identified the following potential options to help identify an overall harvest level that could be recommended for the Southern Hudson Bay (SH) polar bear subpopulation considering the new and higher estimate of abundance from the 2021 aerial survey (Northrup et al. 2022) along with all the uncertainties surrounding that estimate which are outlined above. These options are described below (separately for the scenario and abundance estimate), along with brief explanations and statements of risk tolerance relative to the TWG's original recommendation on overall harvest level that was based on the SH harvest risk assessment (Regehr et al. 2021). In addition to providing these potential overall harvest level recommendations, the TWG recommends updated analyses that could help to resolve key sources of uncertainty regarding demographic status and sustainable harvest for the SH and adjacent WH subpopulations. The proposed analyses are described at the end of the document.

Options

Scenario

Three scenarios were defined in the 2019 harvest risk assessment for the current and future demographic status as a function of environmental conditions (see above), including the optimistic scenario 1, middle-of-the-road scenario 2, and pessimistic scenario 3 (Regehr et al. 2021). Out of the three potential scenarios presented in the 2019 harvest risk assessment, the TWG considers that Scenario 2 remains the most appropriate one to represent the long-term demographic status of SH. Despite the increase in abundance observed in SH according to the 2021 survey results, the TWG considers that this does not reflect a fundamental change in the long-term potential growth rate of SH, which would support the optimistic scenario (Scenario 1), but is rather the result of a combination of temporary movements of bears from WH to SH and a possible punctual increase in demographic growth from the favorable ice conditions and reduced harvest that occurred between 2016 and 2021. Furthermore, there is currently no sign supporting the pessimistic scenarios (Scenario 3a and 3b) which would have predicted a continuous decline in SH abundance at a rate similar to the decline observed between 2011 and 2016.

While support from a specific scenario (Scenario 2) to rely on for the establishment of an overall harvest level of SH seems relatively warranted, there remains important uncertainties regarding the actual abundance of SH to use when evaluating the rate of harvest that the population could sustain. We present below three options regarding abundance estimates that could be used to determine overall harvest levels, the rationale of these estimates and the corresponding risk of using each value to establish harvest levels.

Abundance estimate

OPTION 1: Update the recommendation of overall harvest level based on an estimate of 895 bears (i.e., female and male)

- **Rationale**: An abundance estimate of 1119 total bears is the most accurate reflection of the number of bears within the SH management boundary at the time of the 2021 aerial survey (Northrup et al. 2022). However, this estimate is subject to several sources of uncertainty. First, the estimate of 1119 bears likely included some animals that were previously attributed to the Western Hudson Bay subpopulation and had moved into the SH range at the time of the 2021 aerial survey. Setting an overall harvest level based on that population estimate could increase the risk of overharvest of SH considering the unknown proportion of those bears that are truly part of SH subpopulation. Second, approximately 35% of this estimate was comprised of cubs-of-the-year (C0s) and yearlings (C1s). This is an unusually high proportion of dependent young, though it is consistent with the 2011 and 2016 aerial survey estimates. Because dependent young are not harvested and generally have lower survival than other bears, calculating overall harvest level using an estimate of total abundance that includes so many dependent young may increase the risk of overharvest.

- Due to those uncertainties, Option 1 assumes that an abundance of 895 bears in 2021 is more suitable for determining overall harvest level. This abundance estimate is based on the fact that the combined abundance of SH and WH estimated in 2021 and 2016 are similar at approximately 1621 bears (Northrup et al. 2022; Atkinson et al. 2022), which supports a more or less stable abundance of bears within the whole Hudson Bay complex. Secondly, based on the genetic identification of individuals sampled along the coast of SH and WH through biopsy darting and genetic profiling, approximately 20% of the bears sampled in SH in 2021 had previously been sampled exclusively in WH (Northrup et al. 2022) and are therefore probably WH bears that were temporarily within the boundary of the SH population at the time of the aerial survey. Hence, this option considers that the actual abundance of SH is probably closer to 895 bears (80% of 1119) and that most of the increase in abundance of bears observed within the SH range in 2021 was due to temporary movements of bears from WH to SH that will not subsequently be subject to harvest in SH during the winter. This therefore reflects the assumption that 895 is a valid estimate of the number of bears subject to harvest in the SH subpopulation over a multiyear period.
- **Risk:** Option 1 likely reflects a similar, or slightly lower, risk of overharvest compared to the TWG's original recommendation.

OPTION 2: Update the recommendation of overall harvest level based on the estimate of 1119 total bears from the 2021 aerial survey (Northrup et al. 2022).

- **Rationale**: This option uses the most accurate estimate of the number of bears within the SH management boundary at the time of the 2021 aerial survey (Northrup et al. 2022). This number makes the assumption that all of the bears present in SH in 2021 during the aerial survey are actually SH bears and are subsequently subject to harvest by communities in SH. Telemetry data indicates that this is unlikely to be the case in many years, but substantial uncertainties remain. Further, this assumes that the high proportion of dependent young in 2021 does not compromise the subpopulation's ability to support harvest. This options thus considers that the increased abundance observed in SH in 2021 represents an actual growth of that population during the 2016-2021 period. Such an increase of the population could be possible given that harvest was lower during this time period than between 2011 and 2016 and three of the best ice years on record in the last decade occurred between 2016 and 2021. Considering that the combined abundance of SH and WH has remained more or less stable between 2016 and 2021, and if we consider that there was an actual increase of approximately 29% of the bears abundance in SH during that time period, this would therefore mean that there was an actual drastic decline in the abundance of the adjacent WH subpopulation.
- **Risk:** Option 2 reflects a moderately higher risk of overharvest compared to the TWG's original recommendation considering the chances of overestimating the actual abundance of SH.

OPTION 3: Update the recommendation of overall harvest level based on an estimate of 1000 bears.

- **Rationale**: This option uses the abundance estimate that has long been used for management purposes in SH. An abundance of 1000 bears is also the estimate that was used to develop the current overall harvest level. Under this overall harvest level, the abundance of bears in SH appears to have been more or less stable over the last 20 years, considering the overlaps in confidence intervals of the various abundance estimates. Using an abundance estimate of 1000 bears considers that some of the increased abundance observed during the 2021 aerial survey was partly due to temporary immigration of WH bears in SH at the time of the survey, and some of it was due to an actual demographic growth of the population. A modest increase in SH abundance between 2016 and 2021 is not unexpected given that harvest was lower during this time period than between 2011 and 2016 and three of the best ice years on record in the last decade occurred between 2016 and 2021.

- **Risk:** Option 3 reflects a similar risk of overharvest compared to the TWG's original recommendation considering 1000 is a compromise between 895 (assumes 20% of bears in SH in 2021 were temporary immigrants from WH) and 1119 (assumes all bears in SH in 2021 were actually part of SH subpopulation). Further, 1000 bears has long been the basis for the overall harvest level in SH and this number appears to have maintained general stability in the population over the last 20 years, albeit with some significant uncertainties.

Recommended option

Considering the current uncertainties regarding the abundance of SH, the TWG recommends Option 3, using an abundance of 1000 bears to determine overall harvest rate, to be the best option to limit the risk of overharvest of SH, while also limiting negative changes on current harvest limits in SH (and thereby also limiting potential negative changes on harvest limitations in WH).

The TWG further suggests orienting harvest levels towards a moderate degree of risk tolerance with respect to Management Objectives 1 and 2 presented in Regher et al. 2021 (Objective 1 = maintaining SH abundance above its maximum net productivity level; Objective 2 = maintain SH abundance above 90% of its starting value). Under the recommended Scenario 2, this approach would depend on a female harvest rate of h = 0.02-0.03, which corresponds to starting harvest levels of 10-15 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 sex ratio in the harvest, and a total harvest rate of approximately 3.0-4.5% assuming a 2:1 male-to-female sex ratio. Table 1 provides harvest levels for each of the three abundance estimate options and the Scenario 2 recommended female harvest rate of 0.02-0.03.

The TWG also notes that in their report, Northrup et al. (2022) presents evidence suggesting that the current adult sex ratio in SH is skewed towards females. At this time, there is insufficient evidence to conclude the exact degree to which the sex ratio is skewed, but caution is warranted to avoid potential overharvest of males. This should be taken into consideration when determining the recommended harvest sex ratio (1:1 or 2:1).

We also recommend that decisions on harvest levels in SH take into consideration the potential movements of bears between SH and WH subpopulations and the potential influence that this can have on the abundance estimate of each subpopulation, as well as the impacts on determining sustainable harvest level for each subpopulation.

Table 1: Recommended harvest rate under Scenario 2 of Regehr et al. 2021, considering a female harvest rate of 0.02 to 0.03, according to the three different abundance estimates options, and a 0.50 proportion of females in the SH subpopulation as per Regehr et al. 2021.

Total abundance estimate	Female abundance	Total female harvest	Overall population harvest level at 2:1 male-to-female ratio (harvest rate of population)	Overall population harvest level at 1:1 male-to-female ratio (harvest rate of population)
Option 1: 895	448	9-14	27-42 (3.0-4.7%)	18-28 (2.0—3.1%)
Option 2: 1119	560	12-17	36-51 (3.2 – 4.6%)	24-34 (2.1 – 3.0%)
Option 3: 1000	500	10-15	30-45 (3.0 - 4.5%)	20-30 (2.0 – 3.0%)

Future analysis for consideration

In light of the uncertainties raised by the latest aerial surveys of SH and WH, particularly regarding potential movements of bears between the two subpopulations near the SH/WH boundary, and the limits of aerial surveys to reflect the actual abundance of each population in such circumstances, the TWG recommends considering the development of a joint SH-WH integrated population model (IPM), which would provide managers with the most useful information for evaluating overall harvest level for future management decisions related to these two subpopulations.

A combined SH-WH IPM could make full use of all available data including aerial surveys, harvest monitoring, capture-recapture studies, biopsy darting, and radiotelemetry. The IPM could then provide estimates of abundance and vital rates for the SH and WH subpopulations, as well as rates of exchange between the two subpopulations. Furthermore, such an IPM could potentially be informed by both scientific data and by Indigenous Knowledge (IK) which could help resolve apparent discrepancies between scientific studies and IK. This would provide a more robust tool to evaluate a wide range of potential harvest strategies and provide managers with information on their likely demographic consequences. Considering the two subpopulations together will potentially lead to increased stability in management (i.e., by avoiding large changes in overall harvest level associated with temporary movements of bears) and a decreased likelihood of one subpopulation being negatively affected by management in the other subpopulation.

Time and cost: Very roughly, development of the SH-WH IPM would likely cost approximately 100,000 CAD (minimum) over a two-year period of performance. There are efficiencies given that an IPM is currently in development for the WH subpopulation, and the combined SH-WH model would build on that foundation. An accurate estimate of the time and cost of an SH-WH IPM will be possible once the TWG has developed an analytical outline.

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