Fisheries and Oceans Canada
Pêches et Océans Canada
Ecosystems and Oceans Science
Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat (CSAS)

Research Document 2024/030

Quebec Region

Recovery Potential Assessment for Beluga (*Delphinapterus leucas)* Stocks in Nunavik (Northern Quebec)

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May 2024

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1919-5044
ISBN 978-0-660-71870-5 Cat. No. Fs70-5/2024-030E-PDF

Correct citation for this publication:

Sauvé, C., Caissy, P., Hammill, M.O., Mosnier, A., St-Pierre, A. P., and Gosselin, J.-F. 2024. Recovery Potential Assessment for Beluga (*Delphinapterus leucas*) Stocks in Nunavik (Northern Quebec). DFO Can. Sci. Advis. Sec. Res. Doc. 2024/030. v + 70 p.

Aussi disponible en français :

*Sauvé, C., Caissy,P., Hammill, M.O., Mosnier, A., St-Pierre, A. P., et Gosselin, J.-F. 2024. Évaluation du potentiel de rétablissement pour les stocks de béluga (*Delphinapterus leucas*) du Nunavik (nord du Québec). Doc. de rech. 2024/030. v + 77 p.*

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ABSTRACT

In 2020, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the eastern Hudson Bay (EHB) and Ungava Bay (UB) beluga designatable units (DUs) as Threatened and Endangered, respectively. These two DUs are currently under ministerial review for listing under the *Species at Risk Act* (SARA). DFO Science has been tasked to undertake a Recovery Potential Assessment (RPA) for these two DUs to help inform the listing decision and, if the listing is confirmed, the future development of recovery documents. Since the last beluga DU review by COSEWIC in 2016, a distinct genetic population has been identified in the Belcher Islands (BEL), within the EHB DU's geographic summer distribution area. Therefore, this RPA is not specific to the EHB genetic population alone, but rather to the joint BEL-EHB stock. Beluga aggregations are observed during summer in the estuaries and along the coast of the eastern Hudson Bay arc. In the fall, beluga from this area undertake a northward seasonal migration along the Nunavik coast to reach wintering areas in Hudson Strait and along the Labrador coast. While UB beluga were historically abundant in southern Ungava Bay, no large beluga aggregation has been seen during surveys conducted over the past 40 years. However, continued sightings and occasional harvests either suggest that the Ungava Bay DU persists at a very low level, or that neighbouring DUs frequent Ungava Bay. Most recent data indicates a continuous decline in BEL-EHB beluga since the 1970s, with an abundance estimate of 2,900-3,200 beluga in 2021. Management of subsistence beluga harvest is the main challenge for BEL-EHB and UB beluga survival and recovery. Other threats from human activities in the habitat of BEL-EHB and UB beluga include anthropogenic noise, industrial development, vessel traffic, chemical pollution, commercial fisheries, and climate change. A long-term (i.e., over > 100 years) distribution objective would be to recover the historical distribution of beluga in eastern Hudson Bay estuaries and within southern Ungava Bay and its estuaries.Three recovery abundance objectives are proposed for BEL-EHB beluga: 1) attain an abundance equal to or exceeding the 2015 abundance estimate in ten years, 2) attain an abundance equal to or exceeding the Precautionary Reference Level (PRL = 5,300 individuals) in 86 years, and 3) attain an abundance corresponding to the demographic growth given no harvest from this stock. The current harvest levels are incompatible with any of these recovery targets. Two recovery targets for abundance are proposed for UB beluga: 1) maintain population size at or above the 2022 abundance estimate, and 2) attain a population size corresponding to the demographic growth given no harvest from this DU. Perpetuating current harvest levels for UB beluga would lead to population decline and extirpation of any remaining stock in this area within 4 to 21 years. The Potential Biological Removal for BEL-EHB and UB beluga was estimated at 5 and 0 whales per year, respectively based on 2022 abundance estimates. Projections indicate that it is feasible for the BEL-EHB stock to reach the PRL in 86 year with an annual harvest level of 20 beluga.

CONTEXT

In 2016, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has identified eight recognized designatable units (DUs) of beluga in Canada, including the Eastern Hudson Bay (EHB) and the Ungava Bay (UB), populations. In 2020, COSEWIC assessed the EHB DU as Threatened and the UB DU as Endangered. These two DUs are currently under ministerial review for listing under the *Species at Risk Act* (SARA). In support of listing recommendations for EHB and UB beluga populations, DFO Science has been asked to undertake a Recovery Potential Assessment (RPA) for these two DUs.

Since the last COSEWIC beluga DU review, a distinct genetic population has been identified in the Belcher Islands (BEL), within the EHB DU's geographic summer distribution area. Accordingly, this RPA is not specific to the EHB genetic population alone, but rather to the joint BEL-EHB stock, and hereafter referred to as BEL-EHB beluga to better reflect the composite nature of the beluga aggregations occurring in this area during summer (see Caution section below for details).

The information presented as part of the current report has been reviewed during the February 20-24, 2023 National marine mammal peer review committee meeting (Appendix A), and updates and/or consolidates any existing advice regarding both EHB and UB beluga. The current RPA may be used to inform both scientific and socio-economic aspects of the listing decision, the development of a recovery strategy and action plan, or the actions undertaken by DFO following SARA listing.

CAUTION

Since the last COSEWIC beluga designatable unit (DU) review, a genetic re-analysis of beluga samples by DFO has identified a distinct population in the Belcher Islands (BEL), i.e., within the geographic summer distribution area of the EHB DU (Parent et al. 2023; COSEWIC 2016). Aerial surveys in eastern Hudson Bay showed that there was a continuous distribution of beluga from the coast between Kuujjuarapik and Inukjuak, which extends as far offshore as the Belcher Islands (Smith and Hammill 1986; Kingsley 2000; Gosselin et al. 2002, 2009, 2013; St-Pierre et al. 2024). In addition, most beluga equipped with satellite transmitters in estuaries of the eastern Hudson Bay performed repeated inshore-offshore movements extending out to the Belcher Islands during summer (Bailleul et al. 2012a). Therefore, there is likely a spatial overlap between the BEL and EHB genetic population distributions, and beluga summering in this area are considered together throughout this report, and referred to as the BEL-EHB management stock (DFO 2022). The conclusions from this report should be interpreted with caution as the potential for recovery and the recovery targets are not specific to the EHB genetic population alone, but rather based on the abundance and distribution of the joint BEL-EHB stock.

In addition, there is uncertainty as to whether the Ungava Bay beluga DU still exists or whether is has been extirpated. Beluga in this DU were defined by a summer aggregation centered near the Marralik River estuary, with concentrations at other rivers in southern Ungava Bay (COSEWIC 2016). However, COSEWIC (2004) defines the Ungava Bay area as the range for this DU, and it is generally recognized that beluga from other DUs occur in Ungava Bay from spring to fall, but not in summer (Lewis et al. 2009; Cuerrier et al. 2012; Cardinal 2013). Consequently, aerial surveys conducted in summer over the full extent of Ungava Bay provide an abundance estimate for the entirety of the bay (Sauvé et al. 2023; Smith and Hammill 1986; Kingsley 2000; Hammill et al. 2004; Gosselin et al. 2009). Although beluga were detected during the 2022 summer survey of Ungava Bay, none were observed in the historical aggregation areas in the south of the bay (Sauvé et al. 2023). Therefore, there is uncertainty as to whether beluga sighted during the 2022 survey represent beluga from the UB DU itself or animals from other stocks that interrupted their summer migration the central Ungava Bay area. Nevertheless, a small number of beluga continue to be sighted and harvested in estuaries in southern Ungava Bay (e.g., Durkalec et al. 2020). The present assessment of the potential for recovery for the UB DU is based on the most recent, 2022 survey, which covered the entirety of Ungava Bay. For consistency with the surveyed area, we considered harvest levels occurring throughout Ungava Bay when estimating threats and potential biological removals.

INTRODUCTION

The beluga (*Delphinapterus leucas)* has a nearly circumpolar distribution in Arctic and subarctic waters (NAMMCO 2018). Only one species is recognized worldwide, with no recognized subspecies. A significant proportion of the species' global range is distributed in Canadian waters. Populations are defined based on summering aggregations (Richard 2010; COSEWIC 2016; NAMMCO 2018), informed by lines of evidence underlining that beluga show strong intra- and inter-annual site fidelity based on behavioural (Caron and Smith 1990), as well as telemetry (Bailleul et al. 2012a), genetic (Brown Gladden et al. 1999; de March and Postma 2003; Postma et al. 2012; Turgeon et al. 2012; Colbeck et al. 2013; Parent et al. 2023), isotopic and trace element (Rioux et al. 2012) studies.

There are eight recognized DUs of beluga in Canada, namely the Eastern Beaufort Sea (EBS), Eastern High Arctic – Baffin Bay (EHA-BB), Cumberland Sound (CS), Ungava Bay (UB), Western Hudson Bay (WHB), Eastern Hudson Bay (EHB), St. Lawrence Estuary (SLE), and James Bay (JB) populations (Figure 2). Among all eight recognized beluga DUs, the CS, EHB and UB DUs are currently under ministerial review for listing, while the SLE DU is listed under the *Species at Risk Act* (SARA).

The COSEWIC first assessed the EHB and UB beluga DUs in 1988, affording them a status of Threatened and Endangered, respectively (Reeves and Mitchell 1988). The status of UB beluga has remained Endangered throughout COSEWIC's reassessments (COSEWIC 2004, 2020a). EHB beluga were reclassified as Endangered in 2004 based on a declining demographic trend and overharvesting, but their status was revised to Threatened in 2020 after stabilisation of the demographic trend and harvest removals (COSEWIC, 2004, 2020a).

After the COSEWIC assesses an aquatic species as Threatened, Endangered, or Extirpated, DFO undertakes a number of actions required to support implementation of the SARA. Many of these actions require scientific information on the current status of the wildlife species, threats to its survival and recovery, and the feasibility of recovery. Formulation of this scientific advice is typically developed through a RPA that is conducted shortly after the COSEWIC assessment. This timing allows for consideration of peer-reviewed scientific analyses into SARA processes, including recovery planning.

In 2005, DFO conducted a RPA for EHB and UB beluga conjointly with the CS and SLE beluga (DFO 2005). Since then, various research projects have been undertaken by DFO Science to increase the understanding of EHB and UB beluga populations. The advice generated via the present process updates and/or consolidates any existing advice regarding both the BEL-EHB and UB beluga stocks.

ASSESSMENT

SPECIES INFORMATION

Element 1*: Summarize the biology of EHB and UB Beluga.*

***Element 2**: Evaluate the recent species trajectory for abundance, distribution and number of populations.*

***Element 3**: Estimate the current or recent life-history parameters for EHB and UB Beluga*

Biology

The beluga is a medium-sized, toothed whale inhabiting Arctic and sub-Arctic waters. Along with the narwhal, it is one of two cetacean species of the *Monodontidae* family, and the only member of the *Delphinapterus* genus. They have a round head adorned with a melon which they use for echolocation. They lack a dorsal fin, which is probably an adaptation to life in partially ice-covered waters, and have an unfused cervical vertebrae which allows flexibility in the neck. Beluga calves are born dark grey or brown in colour and measure around 1.5 m at birth (Lesage et al. 2014; COSEWIC 2020a). They gradually transition to white between 10-20 years of age (COSEWIC 2020a). Mature individuals are white in colour and are sexually dimorphic, with a size ranging between 2.6 and 4.5 m, and adult female lengths nearing 80% the length of adult males (Lesage et al. 2014; COSEWIC 2020a). Size at sexual maturity may vary among populations. Beluga sampled in Hudson Bay were of relatively small size at maturity compared to other regions (see Lesage et al. 2014 for review), with estimated asymptotic length for mature males and females of 3.5 and 3.3 meters, respectively (Doidge 1990a). Whether this observed smaller size represents a phenotypic trait of Hudson Bay beluga populations or results from the long history of heavy exploitation that might have depleted older, bigger individuals from the area is unknown.

Gregarious in nature, belugas can form large aggregations (>300 individuals) throughout their habitat, and both closely related and unrelated individuals may group together (O'Corry-Crowe et al. 2020). They have a large repertoire of acoustic calls, such as clicks, burst pulses, whistles, and combined signals. Belugas mostly vocalize in the 0.1 to 12 kHz frequency range (Erbe et al. 2016), although they produce sounds up to 160 kHz (Southall et al. 2007). Their peak hearing frequency is situated between 0.5 and 130 kHz (Erbe et al. 2016). Vocalizations are used for communication, navigation, and foraging.

Beluga are generalists, with a diet which includes small pelagic, demersal, and riverine fish species, as well as invertebrates such as shrimps, squids, and sea worms (e.g., Doidge et al. 2002; Marcoux et al. 2012; Kelley et al. 2010; Quakenbush et al. 2015; Breton-Honeyman et al. 2016; Lesage et al. 2020). Beluga can dive to depths of hundreds of metres to forage, with dives generally lasting 8-15 minutes (Heide-Jørgensen et al. 1998; Kingsley et al. 2001; Martin et al. 2001).

Additional information on beluga biology can be found in the latest COSEWIC assessment and status report (COSEWIC 2020a).

Life history

Age at physical maturity was estimated at 15 and 10 years of age for females and males, respectively, using length-at-age curves from Doidge (1990a) and assuming deposition of one growth layer group (GLG) per year in teeth dentine (Table 1). Beluga longevity is unknown and likely underestimated given that old individuals systematically suffer from tooth wear, some losing their teeth altogether. Although the maximum age of sampled individuals mostly ranges between 45-60 years of age (Lesage et al. 2014; Hobbs et al. 2015; Ellis et al. 2018), the oldest free ranging beluga sampled was 89 years old(Ferguson et al. 2020). Generation time is defined as the average age of the parents of the current cohort (i.e., newborns), and reflects the turnover rate of breeding individuals in a population (Taylor al. 2007). Beluga generation time is estimated at 28.6 years (Lowry et al. 2017), although there are caveats associated with that estimate, and a generation time closer to 20-23 years may be more accurate (COSEWIC 2020a). Throughout this document, we use the 28.6 year generation time retained by COSEWIC (2020a) for consistency and because the difference between this and other suggested values did not affect the conclusions of this RPA for BEL-EHB and UB beluga.

On average, females give birth to one calf every three years (Vladykov 1944; Doidge 1990a; Suydam 2009), with a gestation period of 12.8 to 15 months (COSEWIC 2014; Matthews and Ferguson 2015). Therefore, approximately one-third of the sexually mature females are expected to become pregnant each year (Mosnier et al. 2015). Body size has been identified as a driver of reproductive activity in Hudson Bay beluga females (Ferguson et al. 2021). Perinatal mortality of the calf may result in decreased calving intervals as females may become available for mating one year earlier (Doidge 1990b; Mosnier et al. 2015). Lactation may continue for up to three years (Doidge 1990b; Matthews and Ferguson 2015), partially overlapping with the next gestation period. Ingestion of solid food starts during the calf's first to second year (Matthews and Ferguson 2015). The timing of mating and calving varies among populations, but mating generally occurs in late winter and spring, while calving takes place during summer. Beluga from eastern Hudson Bay are thought to mate in offshore areas in early May, with calving in late May of the following year (Doidge 1990b). There is no available information specific to Ungava Bay beluga. The beluga is one of the rare species with females showing signs of menopause (post-reproductive lifespan in females; Ellis et al. 2018). However, there is variability in age at sexual senescence, since pregnant females aged 60-70 years have been reported (Burns and Seaman 1986). Because of tooth wear in older beluga, age at senescence is difficult to assess.

Age-specific mortality rates differ among beluga populations and over time depending on the relative occurrence of the different causes of natural mortality (e.g., dystocia and peripartum complications, cancers, contaminants, predation) affecting the population. Beluga mortality rates were estimated based on individuals harvested on the eastern coast of Hudson Bay at 31% for young calves (age 0-1 year), and varied between 12-21% and 2-10% for beluga aged 2-9 years and ≥ 10 years, respectively (Doidge 1990b). There is no data available for UB beluga. However, Hammill and Lesage (2019) estimated similar trends in SLE and Alaska beluga: 14-29% for young calves (0-1 year), 2-7% for old calves/juveniles (1-8 years), 3-6% for young adults (9-44 years), and 8-17% for older adults (≥ 45 years). A recent model, which estimated median (± SE) mortality rates during 1980-2021 in SLE beluga, suggested lower mortality rates for most age classes: 49 ± 3% for young calves (0-1 year), 3 ± 1% in yearlings (1-2 years), 0.9 ± 0.1% in juveniles (4-7 years), and 0.8 ± 0.1% in young adults (8-11 years) (Tinker et al. 2024). The Hoenig's (1983) mean regression equation for teleosts and marine mammals, which is based on maximum age for populations and assumes a constant mortality rate after early life history stages, provided a mortality estimate ranging between 5.1-10.0% for a maximal age ranging between 45 and 89 years (Table 1).

Cultural significance

Beluga are deeply anchored in the Inuit culture and identity as a reliable source of nutritive food for families and communities (Inuit Tapiriit Kanatami and Inuit Circumpolar Council 2012; Lemire et al. 2015). The hunting, butchering, and sharing of beluga represent social and cultural practices that allow the perpetuation of Inuit knowledge, skills, and social bounds (Tyrrell 2007, 2008; Breton-Honeyman et al. 2021). Therefore, beluga are extremely important as a top predator in their ecosystem, and to the culture and lives of Nunavik (Northern Quebec) Inuit.

Number of populations, distribution and abundance

Sub-units of a species are defined as ‘populations’, ‘stocks’, and ‘DUs’ among other terms, and there is considerable debate as to how to differentiate these (Stewart 2008). See Appendix B for the definitions of species sub-unit terms, and how they apply to BEL-EHB and UB beluga.

Twenty-two putative stocks of beluga are recognized worldwide by the International Whaling Commission (IWC), totalling more than 150,000 animals, two-thirds of which are found in Canadian waters (NAMMCO 2018; Figure 3). Eight recognized DUs of beluga occur in Canada (Figure 2; COSEWIC 2016). There is a certain level of range overlap between the WHB, EHB, and UB DUs in Hudson Strait and between the WHB, EHB and JB DUs in the Belcher Islands region in eastern Hudson Bay. The newly identified BEL population also overlaps in its summer range with beluga from the WHB, EHB, and JB populations (Parent et al. 2023). The BEL population was genetically identified after the most recent definition of beluga DUs by COSEWIC (Parent et al. 2023; COSEWIC 2016), therefore, there is a mismatch between the current DU definitions and our understanding of population structure in the eastern Hudson Bay area. Moreover, there might be some interbreeding among animals from different DUs on shared wintering grounds.

BEL-EHB beluga summer in the estuaries of the eastern Hudson Bay arc, and can be seen up to 60 km west of the Belcher Islands (Figure 4; Bailleuil et al. 2012b). Historically, the largest aggregations were observed in July and August in Richmond Gulf, Little and Great Whale rivers, and the Nastapoka River (Smith and Hammill 1986; Caron and Smith 1990). Commercial over-harvesting decimated the beluga summering in Great Whale River which left Little Whale and the Nastapoka rivers as the main aggregation areas (Reeves and Mitchell 1987a). Although occasional sightings are still reported in the Nastapoka River estuary, no beluga have been observed there during aerial surveys since 2004, suggesting that it is no longer an important beluga summering area along the eastern coast of Hudson Bay (Gosselin et al. 2017; COSEWIC 2020a; St-Pierre et al. 2024). Consequently, the Little Whale River estuary appears to be the only remaining area in the eastern Hudson Bay Arc where significant numbers of animals occur (Figure 4). In the fall, beluga from the eastern Hudson Bay coast undertake a seasonal migration along the Nunavik coast and may sometimes travel in Ungava Bay to reach wintering areas in Hudson Strait and along the Labrador coast (Lewis et al. 2009; Bailleul et al. 2012a). The most recent population model abundance estimate for the BEL-EHB stock is 2,900 animals (95% CI= 1,500-4,200; Hammill et al. 2023).

UB beluga were historically abundant in southern Ungava Bay, mostly aggregating in the Koksoak, Leaf, Whale, Marralik (Mucalic), and George rivers, as well as in Hopes Advance Bay (near the community of Aupaluk) from mid-July to mid-August (Figure 1; Reeves and Mitchell 1987b). However, no large beluga aggregation has been seen during surveys conducted in the Ungava Bay area since the 1980’s (Boulva 1981; Finley et al. 1982; Smith and Hammill 1986; Hammill et al. 2004; Gosselin et al. 2009; Sauvé et al. 2023). Continued sightings and the occasional harvest of animals suggest that the Ungava Bay DU either persists at a very low level, or that neighbouring DUs frequent Ungava Bay (DFO 2005; Durkalec et al. 2020). Information on distribution and seasonal movements are fragmentary for this population. While assessments by COSEWIC present the Ungava Bay as the area of extent of the UB DU, traditional knowledge suggests some animals may leave the bay and overwinter in Hudson Strait and off the Labrador coast. It is not clear if these reported movements were from UB beluga and/or from animals from other stocks (e.g., BEL-EHB and WHB) known to be migrating through Ungava Bay (Lewis et al. 2009; Bailleul et al. 2012a; Cuerrier et al. 2012; Breton-Honeyman et al. 2013; COSEWIC 2016; Durkalec et al. 2020).

Summer samples collected since 1994 (n = 113) from northern Ungava Bay indicate no genetic structure suggestive of an isolated matrilineage in this area based on mitochondrial DNA haplotypes (Parent et al. 2023). There is limited possibility to collect genetic samples from historical aggregation sites in southern Ungava Bay during summer, which limits our ability to examine the genetic identity or define the characteristics of beluga summering in the area. An Inuit-led research project initiated in 2019 yielded four samples from a limited hunt in the Marralik (Mucalic) River and three biopsies, providing tissues which can be used to start building a sample library to address stock identity.

Recent Trajectory

Historically, BEL-EHB beluga were thought to number around 12,500 animals in the 1800s. Commercial whaling during the eighteenth, nineteenth, and early twentieth centuries resulted in a sharp decline in abundance (DFO 2005; Lawson et al. 2006; Hammill et al. 2017a), and continued high subsistence harvests have limited the recovery, with climate change and habitat modification being additional underlying factors. In 2001, a stock assessment estimated that if harvests were not reduced, the BEL-EHB stock would go extinct within two to three decades (Bourdages et al. 2002). A series of severe management measures to which a relatively high compliance was observed (Lesage et al. 2001a) slowed the population decline. Population models fitted to the aerial survey abundance estimates, and taking into account reported harvests, indicated that the population had declined from 6,600 animals in 1974 to a minimum of 3,100 in 2001. A reduction in harvest levels resulted in an increase to 3,400 (95% CI=2,200-5,000) in 2015 (Hammill et al. 2017a), which provided support for revising the DU status from Endangered to Threatened in 2020 (COSEWIC 2020a; Figure 5a). Since 2015, reported catches have exceeded recommended harvest levels. An assessment in 2022 that fitted the model to the updated survey time series, including the most recent survey flown in 2021, indicated that the population had probably been declining, albeit a very slow rate (approx. 1% per year) between 2001-2015. Since 2015, the rate of population decline had accelerated (approx. 3% per year), leading to a decline in abundance from 3,700-3,900 in 2015 to 2,900-3,200 in 2021, depending on model assumptions (Hammill et al. 2023; Figure 5b). This estimate reflects the combined abundance for the BEL-EHB stock, as defined by the most recent genetic analysis (Parent et al. 2023).

Beluga summering in Ungava Bay were estimated to have numbered over 1,900 whales in the late 1800s, i.e., prior to the active commercial whaling that occurred from 1867 to 1911, which severely depleted the DU (DFO 2005). Continued subsistence harvest during summer until the mid 1980s (mean annual takes 1974-1985: 83, CV= 19%; Smith 1998) likely contributed to further reductions in abundance (DFO 2005; Boulva 1981; Finley et al. 1982). Beginning in 1986, the Marralik (Mucalic) estuary was closed to hunting and quotas were implemented for Ungava Bay beluga (Lesage et al. 2001a). The Marralik estuary remained closed until a limited harvest of three beluga was allowed in 2021 and 2022. A series of four systematic visual surveys conducted between 1985 and 2008, and covering nearshore and offshore areas of Ungava Bay failed to detect beluga on transects, and yielded very low numbers of observations in nearshore areas (maximum daily count range: 0-36 beluga; Smith and Hammill 1986; Kingsley 2000; Hammill et al. 2004; Gosselin et al. 2009). Given the absence of beluga sightings on transects flown during these four consecutive surveys, Doniol-Valcroze and Hammill (2011) estimated a maximal population size of 32 (95% CI: 0-94) UB beluga. The last survey conducted in the summer of 2022 yielded an estimated abundance of 68 (95% CI: 23-202) individuals based on three sightings (for a total of four beluga; Sauvé et al. 2023). The 2022 abundance estimate is not significantly different from the previous zero-count derived estimate, suggesting little change in abundance over the last four decades. This is in agreement with the hunter's perception that there has been a lack of increase in beluga numbers in the southern UB estuaries (Durkalec et al. 2020).

HABITAT

***Element 4**: Describe the habitat properties that EHB and UB Beluga need for successful completion of all life-history stages.*

Beluga are highly mobile, tolerate a broad range of environmental conditions, and occupy a vast habitat spanning 221,000 and 51,000 km^2 for the BEL-EHB and UB DUs, respectively (COSEWIC 2020a). These factors led COSEWIC (2020a) to suggest that it may be more appropriate to refer to beluga habitat *preferences* rather than habitat requirements. Habitat preferences vary seasonally and between the sexes (Barber et al. 2001).

In summer, beluga generally occupy coastal and offshore waters within their summering distribution, but aggregate in large numbers in estuaries and river mouths (Sergeant 1973; Sergeant and Brodie 1975; Smith et al. 1985; Smith and Hammill 1986; Smith and Martin 1994; NAMMCO 2018). As discussed in the Distribution section above, Little Whale River estuary is currently the main aggregation in eastern Hudson Bay based on surveys conducted since 2004, but aggregations have been reported in the Richmond Gulf, the Little Whale River and the Nastapoka River during previous surveys (Smith and Hammill 1986; Gosselin et al. 2017; COSEWIC 2020a; St-Pierre et al. 2024). Beluga aggregation behaviour in estuarine habitat is incompletely understood, but estuaries are believed to serve multiple biological functions, including foraging on concentrations of anadromous fish, moulting, rearing of calves and predation avoidance (Frost and Lowry 1990; St. Aubin et al. 1990; Watts et al. 1991; Richard et al. 2001; Loseto et al. 2006; Smith et al. 2017). Females with young calves are seen in higher numbers in estuaries than large males, which are more likely to be observed offshore (Hauser et al. 2017; Loseto et al. 2006; Barber et al. 2001; Smith et al. 1994;). This spatial segregation of male and females in summering grounds raised the idea that estuaries might play an important role as calf-rearing grounds, notably by providing shelter from large-sized predators (most notably killer whales; Loseto et al. 2006; Smith et al. 2017).

In summer, BEL-EHB and UB beluga feed on various fish species notably capelin, salmonids, sculpin, Arctic cod, whitefish, and crustaceans (Kelley et al. 2010; Breton-Honeyman et al. 2016). To what relative extent estuaries and offshore waters contribute to beluga diet is for the most part undetermined: although traditional ecological knowledge (TEK), field observations, and isotopic evidence show that beluga feed on estuarine species (Kelley et al. 2010; Breton-Honeyman et al. 2016; Durkalec et al. 2020), most stomach contents from beluga harvested in the summer in estuaries were empty (Caron 1987; Kelley et al. 2010). However, beluga are reported to regurgitate their stomach content during the chase associated with harvesting (Vladykov 1944; Byers and Roberts 1995; Norton and Harwood 2001), indicating that food is ingested in summering grounds but that the reliability of dietary analyses based on stomach contents from harvested individuals is limited. Beluga tagged along the eastern Hudson Bay coast undertook frequent inshore to offshore movements during the summer, which are thought to represent foraging trips influenced by tidally-driven prey availability (Ezer et al. 2008; Bailleul et al. 2012a). A variety of factors are thought to influence beluga presence in estuaries, including winds and waves (Scharffenberg et al. 2020), bathymetry (Hornby et al. 2016), seabed composition (Whalen et al. 2020), currents and upwellings (Williams et al. 2006; Hauser et al. 2015), tides (Simard et al. 2014), and anthropogenic disturbances (Halliday et al. 2020). In the fall, females start making more frequent trips offshore (Barber et al. 2001), and increase their diving activity during the weeks preceding migration (Heide-Jørgensen et al. 1998; Bailleul et al. 2012a).

In late summer or early fall, most beluga populations migrate, generally in groups of related individuals (Colbeck et al. 2013), to various wintering sites that may be shared by several DUs. Wintering sites include offshore open water or loose pack ice close to sea ice edges (Jonkel 1969; Finley and Renaud 1980; McDonald et al. 1997; Lewis et al. 2009; Heide-Jørgensen et al. 2010). In the spring, beluga often follow the floe edge along their migration routes towards summering areas (Cardinal 2013). The pattern of seasonal migration varies among beluga populations and suggested environmental factors that could be directing these migrations include the distribution of prey species, climate indicators of ecosystem productivity, the risks of ice-entrapment and predation (Bailleul et al. 2012b; Hauser 2016). Summer movement of beluga tagged on the eastern Hudson Bay coast and the initiation of their fall migration has been linked to sea-surface temperature (Bailleul et al. 2012b). These satellite-tagged beluga were associated with a sea-surface temperature of around 3°C in both summer and winter (Bailleul et al. 2012a, 2012b). During their seasonal migration, tagged beluga remained close to the coastline, presumably to benefit from currents prevailing along the east side of Hudson Bay (Saucier et al. 2004; Bailleul et al. 2012a). Beluga from the eastern Hudson Bay area over-winter in partially ice-covered, open water (e.g., polynya) or deeper warmer water areas in offshore waters of eastern Hudson Strait, Ungava Bay and on the continental shelf along Labrador (Bailleul et al. 2012a; Durkalec et al. 2020; Babb et al. 2021).

Seasonal migration of UB beluga is not as well documented but the summer use of estuaries is recognized and they also require partially ice-covered, open water and deeper warmer open water areas in winter. Satellite telemetry and genetic information show that animals from different DUs, including EHB and WHB are present in Ungava Bay, Hudson Strait, and the Labrador Sea in winter. There is uncertainty on the potential extent of any seasonal migration of UB beluga (COSEWIC 2016; Cuerrier et al. 2012).

Little is known about foraging activities in wintering grounds: fish species that might be of interest to beluga in Hudson Strait and on the continental shelf of Labrador Sea include capelin, Arctic cod, Greenland halibut and American sand lance (Stewart and Lockhart 2004). Beluga are thought to forage extensively in their wintering habitats as they tend to be fatter at the end of the winter and thinner in the fall (Breton-Honeyman et al. 2016). Moreover, a greater proportion of beluga daily activity is spent diving 1-2 months prior to the fall migration and at wintering grounds compared to during the migration (Bailleul et al. 2012a).

Studies of beluga from other Canadian DUs and Alaska suggested that habitat selection is driven by bathymetry, ice cover, sea-surface temperature and turbidity (Barber et al. 2001; Hauser et al. 2017, 2018; Noel et al. 2022). However, habitat preferences are likely to differ among beluga populations. While seasonal satellite telemetry and summer systematic aerial survey data exist to document the distribution of BEL-EHB beluga, information on the distribution for UB beluga is not sufficient to develop habitat selection or preference models.

One important aspect of beluga habitat use and migration routes is that beluga exhibit strong philopatry to natal locations (Caron and Smith 1990; Smith et al. 1994; Turgeon et al. 2012; O'Corry-Crowe et al. 2018). Knowledge of summering grounds and migratory routes are considered to be transmitted culturally from older individuals to juveniles (Palsbøll et al. 2002; O'Corry-Crowe et al. 2020), and from mothers to their offspring (Brown Gladden et al. 1997; O'Corry-Crowe et al. 1997, 2018; Turgeon et al. 2012; Colbeck et al. 2013), resulting in genetic structures among beluga populations defined, at least partly, by their summering location.

Sources of uncertainty

- Migration patterns of BEL-EHB beluga were derived from 32 beluga tagged in the Nastapoka and Little Whale rivers in the summers of 1993 to 2004 (Bailleul et al. 2012a).

Our understanding of BEL-EHB beluga is therefore inferred from animals tagged at two aggregation sites along the eastern Hudson Bay coast, while no telemetry data is available from the Belcher Islands or for UB beluga. Moreover, tag battery life was insufficient to document the spring migration for tracked individuals. Migration phenology was derived from shoreline Inuit observations, which have a restricted spatial extent (Lewis et al. 2009). Further studies of beluga movement and distribution within, to, and from their summer and winter habitat would improve our understanding of habitat functions.

- Further studies examining BEL-EHB and UB beluga diving behaviour would help identify important foraging grounds, both in summering and wintering habitats.
- There is uncertainty related to habitat-specific carrying capacity limits (K) for the different habitats used by BEL-EHB and UB beluga. Pre-commercial whaling abundance can only be inferred from the quantities of oil recorded and the trade in skins, and there is a gap of > 100 years in harvest reports from the eastern Hudson Bay coast (Hammill et al. 2017b). It is therefore difficult to estimate catches over time, and thus K at the time of commercial exploitation of the stocks. Moreover, there have been changes in ecosystem conditions since the late 1800s, suggesting that an historic estimate of K might not be valid under current conditions (Hammill et al. 2017b). Although the BEL-EHB population model used for beluga provides a proxy of overall, population-specific K (see Recovery Target section), it does not provide any insight into which habitats used by beluga have the most limiting effect on population dynamics. Studies examining the bioenergetics of Nunavik beluga, compounded with habitat-specific prey availability studies, would improve our understanding of beluga habitat functions, and their relationship with fitness and population dynamics.

HABITAT SPATIAL EXTENT: NOT RELEVANT

***Element 5**: Provide information on the spatial extent of the areas in EHB and UB Beluga's distribution that are likely to have these habitat properties.*

Beluga matrilineages consistently return to the same estuaries in summer (Turgeon et al. 2012). This is considered to constrain the beluga's behavioural plasticity to environmental change and anthropogenic disturbance (Laidre et al. 2008; Smith et al. 2017). As such, areas where beluga used to aggregate in high numbers which were subsequently depleted by over exploitation have not been recolonized (e.g., Great Whale River in the eastern Hudson Bay arc, and the Marralik (Mucalic) Estuary in southern Ungava Bay). Beluga continue to occupy the Nelson and Churchill estuaries, where water flow has been modified by hydroelectricity development (Reeves and Mitchell 1987b, 1987c, 1989; Hammill et al. 2004; Smith et al. 2017), and they were observed consistently returning to the Nastapoka estuary within an average of 7.7 days following hunting or motor boat disturbance (Caron and Smith 1990). In eastern Hudson Bay, the Nastapoka River used to be an important aggregation area until the early 2000s, but no large aggregations has been observed during aerial surveys conducted over the last two decades (Gosselin et al. 2017; COSEWIC 2020a; St-Pierre et al. 2024). Whether this change in beluga distribution is due to undocumented local environmental changes altering the suitability of the habitat for beluga or to local extirpation due to unreported removals is unknown. A better understanding of the factors that led beluga to stop aggregating in the Nastapoka River could help the projection of important habitat use in other estuaries. Given current BEL-EHB and UB beluga demographic trends, the probability of beluga colonizing new estuaries in the next ten years is very low.

SPATIAL CONSTRAINTS: NOT RELEVANT

***Element 6**: Quantify the presence and extent of spatial configuration constraints, if any, such as connectivity, barriers to access, etc.*

Beluga move freely, inhabiting a wide vertical distribution in the water column as well as a broad geographical distribution in the Arctic and sub-Arctic waters. During winter, sea ice creates a spatial constraint to beluga distribution, movement, and habitat use since most of their summering habitat is covered. Changes in the timing of freeze-up and breakup, in sea ice coverage, as well as in icebreaker activity are expected to increase beluga wintering habitat availability and connectivity. Therefore, spatial constraints to beluga movements, if any, may weaken due to climate change and anthropogenic activity.

CONCEPT OF RESIDENCE: NOT RELEVANT

> ***Element 7:*** *Evaluate to what extent the concept of residence applies to the species, and if so, describe the species' residence.*

SARA defines "residence" as "a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating" (SARA s.2(1)). The concept of residence is not applicable to marine mammals, including beluga.

THREATS AND LIMITING FACTORS

> ***Element 8:*** *Assess and prioritize the threats to the survival and recovery of EHB and UB beluga.*
>
> ***Element 9:*** *Identify the activities most likely to threaten (i.e., damage or destroy) the habitat properties identified in elements 4-5 and provide information on the extent and consequences of these activities*
>
> ***Element 10:*** *Assess any natural factors that will limit the survival and recovery of EHB and UB beluga.*
>
> ***Element 11:*** *Discuss the potential ecological impacts of the threats identified in element 8 to the target species and other co-occurring species.*

THREATS SUMMARY

Important population declines in both BEL-EHB and UB stocks are attributable to intensive commercial hunting in the mid-19th and early 20th centuries. Since then, continued high levels of subsistence harvesting have contributed to further declines (DFO 2005). Management of subsistence beluga harvest remains the main challenge for BEL-EHB and UB beluga recovery, where short and long term harvest rights and long term conservation objectives must be balanced.

Threats from current human activities in the habitat of beluga include subsistence harvest, anthropogenic noise, potential industrial development, vessel traffic, chemical pollution, and commercial fisheries in Hudson Strait and Labrador Sea (Table 2). Climate change is also considered a threat to beluga through diverse effects on the ecosystem. Threats identified for BEL-EHB and UB beluga also affect other Canadian DUs, with some variation on the level of impact depending on respective distribution ranges. In Nunavik, whale carcasses are rarely retrieved from shores. Data from necropsies are thus unavailable for both BEL-EHB and UB beluga, limiting any quantification of the impact the threats detailed below pose to beluga recovery, except for subsistence harvest.

THREATS DESCRIPTION

Subsistence harvest – Beluga are an important source of nutrients (Lemire et al. 2015), are essential to Inuit food security and constitute an integral part of the Inuit culture (Alayco et al. 2007; Inuit Tapiriit Kanatami and Inuit Circumpolar Council 2012). Between the mid-19th and early 20th centuries, intensive non-Inuit commercial beluga exploitation substantially reduced some Canadian populations, notably those in Cumberland Sound, Ungava Bay, and eastern Hudson Bay. Beluga from the eastern Hudson Bay coast were mainly harvested between 1854 and 1877, with more than 8,000 individuals harvested between 1854 and 1863 (Reeves and Mitchell 1987a). Whaling in Ungava Bay occurred between the 1860's and early 1900's, but no total number of catches has been reported for that area (Reeves and Mitchell 1987b). By the 1960s and 1970s, all large-scale commercial beluga hunting had ceased (Sergeant and Brodie 1975; Kemper 1980; Reeves and Mitchell 1989).

Although local knowledge attributes the continued decline of BEL-EHB and UB beluga to increased vessel traffic (Johannes et al. 2000), this hypothesis is not supported by the available information. In areas such as Little Whale River, the Churchill River estuary (Manitoba), and the Mackenzie River estuary (Northwest territory) where vessel traffic, oil and gas exploration, and/or commercial whale watching take place, abundant concentrations of beluga are still seen (Norton et al. 1986; Hammill et al. 2004). In contrast, summering areas where beluga were seemingly extirpated have not been recolonized by large aggregations (Reeves and Mitchell 1987a, 1987b, 1989; Hammill et al. 2004). Severe local population reductions can therefore have long-lasting effects on beluga distribution (Wade et al. 2012).

The depletion of BEL-EHB and UB beluga due to excessive commercial exploitation and their failure to recover as a result of high subsistence harvest levels led DFO to establish management plans in the mid-1980s. Measures included a combination of quotas, and seasonal and area closures for subsistence beluga harvest. The Whale, Marralik (Mucalic), Tuctuc, and Tunulic river estuaries (all part of the Marralik (Mucalic) Estuary, Ungava Bay) were completely closed to harvesting in 1986, while seasonal closures were implemented in the Nastapoka and Little Whale River estuaries (eastern Hudson Bay) in 1990 and 1995, respectively. While the management of beluga was initially the sole responsibility of DFO, since the signature of the *Nunavik Inuit Land Claim Agreement* (NILCA) in 2006, beluga harvests in the Nunavik Marine Region waters have been co-managed by the Nunavik Marine Region Wildlife Board (NMRWB), DFO, and the Eeyou Marine Region Wildlife Board in areas where the land claims overlap (NILCA 2007). Since 2014, plans incorporate a flexible total allowable take (TAT) which uses available information on beluga migration timing and seasonal relative abundance of BEL-EHB beluga compared to WHB beluga to determine the number of beluga allocated for subsistence harvest in different Nunavik regions.

Management plans are renewed every three to five years and the current plan covers the 2021-2026 period (NMRWB and DFO 2021). The present management plan conservation objective is to maintain the BEL-EHB stock at or above the 2015 abundance estimate of 3,400 animals and that the probability of a decline due to harvesting must not exceed 50% (Hammill et al. 2017a, 2021). Management measures to meet this objective include combinations of harvest limits in the south-eastern Hudson Bay coastal area and seasonal closures in Hudson Strait and Ungava Bay (NMRWB and EMRWB 2020). The Marralik (Mucalic), Nastapoka and Little Whale River estuaries are still closed to hunting, but harvest may be authorised under certain circumstances. For example, the harvest of a low number of beluga in the Marralik (Mucalic) estuary has been approved for cultural purposes since 2021 (2 belugas taken in 2021 and in 2022). The killing of calves and of adults accompanied by calves is forbidden.

Management efforts to limit harvest of the BEL-EHB stock slowed the population declines to 1% or less between 2004 and 2014, but the rate of decline increased to > 3% annually since then (Hammill et al. 2023). These declines in abundance are not unexpected since harvests have consistently exceeded the recommended TAT levels (Figure 6), and previous assessments under-estimated the proportions of BEL-EHB beluga in Nunavik landings (DFO 2020; Hammill et al. 2023).

Anthropogenic noise – Anthropogenic noise is one of the most important threats to marine mammals worldwide since it can disturb normal behaviour, mask communications, interfere with feeding and diving patterns, and ultimately lead to hearing damage (Weilgart 2007). Due to their broad hearing frequencies, a variety of anthropogenic noise sources may disturb beluga. Beluga have been reported fleeing estuaries for up to 48h following acute sound disturbances (Reeves and Mitchell 1987a; Caron and Smith 1990). In addition, changes in vocal behaviour have been described, including reduction in calling frequency, suggesting predation avoidance mechanisms, and increases in the rate of repeated calls, similar to warning signals (Finley et al. 1990; Lesage et al. 1999; Halliday et al. 2019). In high circulation areas, notably the St. Lawrence river and Cook Inlet, vessel noise can mask beluga vocalization in the soundscape up to 94% of the time and impair mother-calf communication (Gervaise et al. 2012; Castellote et al. 2018; Vergara et al. 2021). Nevertheless, beluga are seen in high circulation areas such as Churchill (WHB DU – Manitoba), the St. Lawrence estuary (SLE DU – Québec), Longyearbyen (Svalbard beluga – Norway), Anadyr (Anadyr beluga – Russia) and Anchorage (Cook Inlet beluga – Alaska, United States). Yet, at least three of the five beluga stocks listed above are of concern (NAMMCO 2018), and anthropogenic noise is recognized as an important contributing factor to their decline (COSEWIC 2014; Castellote et al. 2018). Inuit consider that anthropogenic noise may have been an important contributing factor to the drastic reduction in population size for BEL-EHB and UB beluga (Doidge et al. 2002). Similarly, Inuit in Cumberland Sound consider that beluga are thinner than in the past due to increased energy expenditure devoted to boat traffic avoidance (Kilabuk 1998).

The main sources of anthropogenic noise that may affect BEL-EHB and UB beluga are from icebreakers, shipping vessels, sonars and seismic surveys in their wintering habitat, and recreational boats and aircraft in their summering habitats (Finley et al. 1990; Cosens and Dueck 1993; Lesage et al. 1999; Weilgart 2007; Moore et al. 2012; Halliday et al. 2017). Among these, large vessels (shipping vessels and icebreakers) are the most prominent sources of anthropogenic noise. Most large vessels circulate through Labrador Sea and Hudson Strait, although some enter Hudson and Ungava bays mainly to deliver goods to communities and for ore shipping. The increasing vessel traffic into and through the Northwest passage may change the soundscape in the eastern end of BEL-EHB and UB wintering distribution. Noise from vessels can last for hours due to ships' relatively slow travel speed (Castellote et al. 2018) and can be heard up to 80 km from the source underwater (Finley et al. 1990; Halliday et al. 2017). Other important sources of very loud underwater anthropogenic noise within BEL-EHB and UB habitat is seismic exploration, which is widespread in high latitudes. Since the western portion of the Hudson Bay, Hudson Strait, Ungava Bay and Labrador Sea are major hydrocarbons basins (Reeves et al. 2014), some seismic surveys have been completed throughout the Hudson Bay complex, including eastern Hudson Bay (Lavoie et al. 2019; Figure 7). Seismic airguns can generate up to 70 dB in noise at low frequency bands, and may still be heard at higher frequency bands past 48 kHz (Kyhn et al. 2019). Beluga usually tend to remain 20-30 km away from operating seismic survey vessels (Miller et al. 2005). Sound emitted from aircraft and recreational boats is of lower impact to beluga: emission duration is generally limited to a few seconds to minutes, and the number of events, even in high circulation areas, is considerably lower than shipping noise and hydrocarbon-related activities (Castellote et al. 2018). Nevertheless, controlled experiments in the St. Lawrence Seaway suggested that the vocal communication of beluga was altered both by low-frequency noise produced by a ferry moving along a predictable path and by high-frequency noises from a small outboard motorboat moving erratically (Lesage et al. 1999). Similarly, Inuit hunters report that beluga respond to the noise of small hunting vessels and snowmobiles (Kilabuk 1998). Despite these considerations, it is difficult to evaluate the relative impact of anthropogenic noise disturbance on BEL-EHB and UB beluga.

Industrial development – Industries that are a cause for concern in areas inhabited by BEL-EHB and UB beluga include offshore oil and gas development, port development related to mining, and the construction of hydroelectric dams. Industrial development can pose a threat to beluga via different mechanisms. It can cause acute and chronic underwater anthropogenic noise through seismic surveys, drilling, ship traffic, and construction of infrastructure such as pipelines and ports.

Industrial development also introduces the risk of toxic spills from maritime transport and gas exploitation, which can harm beluga through direct contamination, or through contamination of their prey (Meador et al. 1995; Wilson et al. 2005). Large oil spills can lead to recruitment failures of fish populations (Nahrgang et al. 2010; Laurel et al. 2019), potentially reducing prey availability for beluga. Moreover, hydrocarbons can persist in the environment for decades and be released by future dredging activities (Bagby et al. 2017). Spills are relatively rare in Canada (Marty and Potter 2014), and spill risk is particularly low in the Arctic given the limited vessel traffic in the area (Marty et al. 2016). Nevertheless, single spills vary largely in their severity depending on the substance involved, the volume, the spatial extent, the location, and the timing. Since the Hudson Bay complex is an inland sea, spills can remain enclosed for extended periods of time, increasing the severity of their impacts on wildlife (Tao and Myers 2021). Additionally, there are uncertainties related to the efficiency of the response in case of a spill in remote Arctic areas (AMAP 2007).

One project of concern identified in the last COSEWIC assessment was the construction of a port to support the operations of an iron mine projected for 2019-2021 near Aupaluk, southwest Ungava Bay. This project was not initiated, and the environmental assessment was terminated without being completed by Oceanic Iron Ore Corporation in 2022 (Impact Assessment Agency of Canada 2022). Nevertheless, the rich iron reserves in the soil of western Ungava Bay may lead to future interest in exploitation of the area (Oceanic Iron Ore Corp. 2012). The Raglan Mine is a nickel mining complex located ≈100 south of Deception Bay, between the Nunavik communities of Salluit and Kangiqsujuaq and has been operating since 1997. The ore produced is trucked to Deception Bay, were a 152 m icebreaking bulk carrier ensures shipping to Quebec City. The icebreaking activity and shipping lanes overlap with BEL-EHB migration routes and both BEL-EHB and UB wintering habitat.

Another project of industrial development of concern is the Mary River Iron Mine North of Baffin Island (DFO 2014b, 2019; Gavrilchuk and Lesage 2014) because the migration routes of BEL-EHB beluga (as well as those of other DUs which are not the focus of the present RPA) overlap with the shipping lanes associated with the port of Milne and the projected port at Steensby.

Hydroelectric dams modify water flow, salinity, sedimentation rates and turbidity, alter pelagic communities in favour of lake species, especially near reservoirs, and increase mercury levels in the environment for up to 15 years (Lawrence et al. 1992; Hayeur 2000). Resulting modifications to estuarine physical and biotic conditions represent alterations to beluga summering habitat, which may have consequences for their behaviour and/or fitness. For example, in the Nelson River estuary, WHB beluga aggregate further from the estuary when dam water discharges are higher (Smith et al. 2017). Local people in Waskaganish, QC, also report that beluga no longer swim upriver to feed and are observed in fewer numbers since the diversion of the Rupert River to support the Eastmain and La Grande Complex projects (Blackned 2019). More drastically, SLE beluga, which once occupied Manicouagan banks in the summer, never recolonized the area after the construction of dams up Manicouagan river (COSEWIC 2014), but over hunting may also have contributed to their extirpation of the area.

The development of the James Bay hydroelectric complex and the La Grande system induced changes in the Hudson Bay freshwater balance through the construction of reservoirs which retain water in the spring and release it in the winter. River inflow into Hudson Bay shifted from spring and summer, when most of river runoff, precipitation, and sea ice melt contributed to freshwater entering Hudson Bay, to winter, when river runoff used to be low as the land remained frozen and the formation of sea ice withdraws freshwater from the surface of the ocean (Eastwood et al. 2020). This freshwater input in the winter was noticed by Inuit in the Belcher Islands area, where polynyas representing eider duck wintering habitat experienced rapid freezing (Eastwood et al. 2020). These changes in ice coverage and dynamics may impact a portion of BEL-EHB beluga, since a fraction of the BEL population may overwinter in the Belcher Islands (Parent et al. 2023).

Most of the hydroelectric development in Nunavik occurred in the La Grande complex in James Bay (Hydro-Québec) and Churchill and Nelson Rivers in Hudson Bay (Manitoba Hydro). The Innavik Hydro project is currently building a run-of-river power plant on the Innuksuac River to supply the community of Inukjuak with hydroelectricity. The damn and turbines are being installed upriver and are not expected to directly affect beluga, although minor fish habitat loss and mortality (Pituvik Landholding Corporation 2010) may result in some indirect effects through changes in prey availability. Starting in 1970, Hydro-Québec planned another major hydroelectric development in the Great Whale River basin, which would have altered both Great Whale River and Little Whale River estuaries (Hayeur 2000). The project was abandoned in 1994, but discussions on revival of the project have been underway with the provincial government since 2022 (Bell and Stewart 2022). Hydro-Québec also assessed the hydroelectric potential of rivers from the Marralik (Mucalic) Estuary, but no hydroelectric development project was undertaken (Hayeur 2000). Any future hydroelectric development in Nunavik is likely to have significant impacts on BEL-EHB and/or UB beluga.

Chemical pollution – Beluga are apex predators with large lipid reserves, which make them highly vulnerable to persistent organic pollutants (POPs) which bioaccumulate in their tissues. High concentrations of POPs have been correlated to immunosuppression and endocrine malfunction in beluga (Letcher et al. 2010). Males tend to accumulate higher levels of POPs compared to females, a difference that can be attributed to elimination through pregnancy and lactation (Addison and Brodie 1987; Stern et al. 2005) and/or differential diets between males and females (Lesage et al. 2001b; Nozères 2006).

Nunavik is considered a pristine environment due to the low human and industrial occupation (14 communities along the coast of Hudson and Ungava Bay with c.a. 14,000 residents). Consequently, most pollutants arrive from the south via oceanic and atmospheric transport (Lohmann et al. 2007). Burdens of contaminants, organohalogens, perfluorinated compounds, mercury and other heavy metals are considerably lower in Canadian arctic and subarctic beluga populations than in SLE beluga (Muir et al. 1990; Ray et al. 1991; McKinney et al. 2006). While contaminants are thought to play a role in the non-recovery of SLE beluga (DFO 2005; COSEWIC 2014), their current impact on BEL-EHB and UB beluga is likely minor, yet difficult to assess. With the global ban of several POPs in 2004 (UNEP 2019), the concentration of POPs in arctic wildlife tissues is on a downward trend (Rigét et al. 2019). Nevertheless, because of its effects on contaminant cycling, sedimentation and processing, climate change may reintroduce some contaminants into the arctic food web (Noël et al. 2018).

Commercial fisheries – Beluga are not considered susceptible to entanglement in fishing gear due to their particularly acute echolocation abilities and their ability to swim backwards (NAMMCO 2018). Yet, entanglements account for 1% of deaths for SLE beluga (Lair et al. 2016), and netting is a traditional Inuit beluga harvest technique that is still practised. There is no existing entanglement or by-catch record for BEL-EHB and/or UB beluga. Beluga caught in fishing gear in areas where subsistence hunting occurs are likely reported as harvest rather than by-catch (NAMMCO 2018).

The other mechanism by which commercial fisheries might affect beluga is through competition for their prey. No important commercial fisheries are currently exploited in the summer range of BEL-EHB and UB beluga. There is a commercial shrimp fishery in Hudson and Davis Straits, and in the northern Labrador Sea. A bottom trawl Greenland halibut fishery is conducted in the Labrador Sea (Coté et al. 2019; Storey and Eibner 2021). The Greenland halibut fishery occurs in the Northwest Atlantic Fisheries Organization (NAFO) Subarea 0, which includes Baffin Bay (Division 0A) and Davis Strait (Division 0B; DFO 2014c; Figure 8). Fisheries for Greenland Halibut and shrimp were identified as a significant concern for narwhal (NAMMCO 2018), which lead to the closing of an area that overlaps the winter foraging range of narwhals in NAFO Division 0A (DFO 2007, 2014c; Figure 8). Beluga telemetry data suggested a main winter residency area at the southern junction between Hudson Strait and Labrador Sea (Bailleul et al. 2012b). Although tagged beluga remained close to the coast in that area, fisheries in the south-western portion of NAFO Division 0B may overlap with beluga winter foraging grounds. Since beluga also prey on Greenland Halibut and shrimp during the winter (Watt et al. 2016), there may be competition with fisheries in this area. However, information on beluga energetic requirements and foraging patterns in their wintering habitat is currently too sparse to evaluate the extent to which these fisheries may affect beluga. Bycatch of forage fish species by the shrimp fishery may be another source of competition for prey between beluga and fisheries (NMRWB 2019).

With climate change, productivity in Arctic regions is expected to increase, leading to the potential development of new or more intensive fisheries. However, current projections suggest that the enhanced productivity in the Canadian arctic ecosystem is unlikely to sustain profitable fisheries like those exploited in subarctic areas (Dunbar 1970; Slagstad et al. 2015; Tai et al. 2019). Further research on beluga foraging behaviour in wintering habitats and the extent of competitive pressure posed by fisheries is needed to better characterise the associated threat to BEL-EHB and UB beluga recovery.

Vessel traffic – The passage of large vessels, recreational boats, and aircraft can affect beluga. Such physical disturbances can increase stress, force beluga to flee a given area for extended periods of time (up to 48h; Caron and Smith 1990), and modulate their vocalization rates (Lesage et al. 1999; Halliday et al. 2019). This can, in turn, negatively affect the rearing of young, especially if the disturbance occurs in estuaries, result in increased energy expenditure, and interfere with beluga's ability to forage. Vessel traffic also increases collision risks. Strikes caused by small, high speed vessels can severely injure beluga which may reduce their fitness or be lethal. In the St. Lawrence estuary, where more than 8,000 vessels navigate the waterway every year, vessel strikes account for 2% of deaths in SLE beluga (Lair et al. 2016). Across BEL-EHB and UB beluga distribution, most small vessel traffic occurs along the coasts, surrounding Inuit communities. There is no available data on vessel strike-induced mortalities for BEL-EHB and UB beluga, but the relatively low traffic level suggests it likely minimal. Vessel traffic in Nunavik is most prominent during the open-water season (May through October). BEL-EHB and UB beluga are therefore most susceptible to vessel strikes in their summering habitat or during their migration.

Other effects of increased vessel traffic in Hudson Strait are related to the use of icebreakers. The passage of icebreakers creates artificial open-water channels which beluga can follow and get trapped in once ice re-forms. The noise generated by icebreakers may also delay fall migration through avoidance of the Hudson Strait area, resulting in whales being trapped in the ice before they can reach wintering grounds (Nacke 2017).

Climate change – Climate warming of the Arctic is two to three times faster than the rest of the globe (Holland and Bitz 2003), and Nunavik is particularly vulnerable to its effect, notably in the Hudson Bay area, which is warming two times faster than the rest of polar regions (Brand et al. 2014).

Among the first noticeable changes are the lengthening of the ice-free season and the increase in sea surface temperatures. Changes in beluga migration phenology in response to changes in the timing of autumn freeze-up and spring break-up differ across populations. In some populations, beluga delay their fall migrations, and initiate their spring migrations to match ice dynamics (Bailleul et al. 2012b; Hauser et al. 2017). In the case of beluga from the eastern Hudson Bay coast, observations between 1995 and 2010 indicated fall migration has been delayed by 18 days per decade, while spring migration has been occurring 8 days earlier every decade (Hammill 2013).

Changes in ice regimes also generate unpredictable conditions, possibly increasing the risk of ice entrapments. Ice entrapments occur when rapid shifts in wind direction and drops in temperature rapidly close breathing holes in the pack ice, leading to mass drowning or inability to escape predation by polar bears. Ice entrapments can lead to mass casualties of several hundreds of individuals. In 1955, more than 3,000 belugas died in Disko Bay, Greenland, due to an ice entrapment (Golodnoff 1956). In small populations such as BEL-EHB and UB beluga, the effect of mass mortalities associated with ice entrapment could be disproportionate since it could reduce the population to an abundance from which recovery would no longer be possible (Hobbs et al. 2015). Furthermore, because related beluga tend to travel together (Colbeck et al. 2013; O'Corry-Crowe et al. 2018), entire lineages could be lost in a single event. Yet, the reduction in sea ice may also decrease the risk of ice entrapments depending on the area. In Disko Bay, where sea ice coverage has decreased significantly over the last decades, there has been no large-scale ice entrapment of beluga since 1990 (Heide-Jørgensen et al. 2010).

Another change caused by climate change is the shift in species composition. Hudson Bay forage fish assemblages, where lipid-rich Arctic cod (*Boreogadus saida*) was once dominant, is shifting in favour of boreal taxa, notably sand lance (*Ammodytes hexapterus*) and capelin (*Mallotus villatus)* (Ponton et al. 1993; Watt et al. 2016; Schembri 2022). Changes in the distribution of predators are also expected, and killer whales are being sighted with increasing frequency in Hudson Strait, Ungava Bay, and Hudson Bay (Higdon and Ferguson 2009; Ferguson et al. 2010). The loss of sea ice coverage due to climate change may result in beluga being more accessible to killer whales. Killer whales and polar bears are the most prominent predators of beluga (Ferguson et al. 2012), and increased predation rates on small populations may lead to extirpation if abundance falls below a certain threshold (Hobbs et al. 2015).

Other impacts of climate change that may indirectly affect beluga include landslides and permafrost thaw, which may increase in frequency and intensity (Owczarek et al. 2020). For example, in 2021, an important landslide occurred up Great Whale River, with 45 million cubic meters of sediments spilled in the river. Two smaller landslides also occurred in Little Whale River in the fall of 2022. Such events may alter beluga in and surrounding estuaries by increasing turbidity, reducing oxygen levels for fish, and reducing river flow (Geertsema et al. 2009). Similarly, permafrost thaw, which is predicted to accelerate (Dagenais et al. 2020; Smith et al. 2022), is expected to change hydrologic flows (Connon et al. 2014; Walvoord and Kurylyk

2016) and could lead to the release of a wide variety of contaminants into the water (Miner et al. 2021), with consequences on physical and chemical characteristics of estuarine habitats, and thus potentially beluga health and fitness.

THREATS TO CO-OCCURING SPECIES

Other marine mammals found in the Nunavik Marine Region are also impacted by most of the threats listed above (Huntington 2009). If threats to BEL-EHB and UB DUs were abated, it would thus benefit multiple species, including some listed as of special concern by COSEWIC, notably the ringed seal, polar bear, bowhead whale, narwhal, and killer whale. Similarly, a reduction in the risk of spills and the implementation of mitigation measures for anthropogenic noise and pollution could benefit the whole ecosystem. Subsistence harvest pressure varies substantially among species and is managed differentially.

LIMITING FACTORS

Disease – Beluga in high latitudes are considerably less affected by infectious diseases than beluga living in other areas, for example SLE beluga (Martineau et al. 1999; Mikaelian et al. 1999; Lair et al. 2014). Nonetheless, climate change is expected to alter wildlife disease dynamics, including exposure and transmission, through changes in host-pathogen-environment interactions (Burek et al. 2008). The warming climate has been associated with a worldwide increase of diseases in marine species (Kuiken et al. 2006). Therefore, epidemiological monitoring in Arctic and subarctic beluga populations, integrated with demographic data and the relationship with environmental factors is needed to understand the effects of climate change on beluga health. Such baseline data could act as an early warning system to foresee potential consequences for Threatened and Endangered populations.

Allee effect – The Allee effect, also known as depensation in the field of fisheries sciences, is defined as positive density dependence (i.e., per capita population growth is slowed at very small population sizes; Allee and Bowen 1932). The mechanisms involved include reduced reproduction due to the inability to find a mate, inbreeding depression, and behavioural changes such as reduced foraging success or protection from predators (Wade 2018). A decline in population growth rates at low levels can increase the risk of extinction of small populations, or prevent their recovery despite relief from anthropogenic threats (Dennis 1989; Liermann and Hilborn 2001). The absence of recovery in severely depleted cetacean populations in spite of it being several decades since the cessation of commercial whaling suggests that Allee effects might play a role in the population dynamics of marine mammals (Clapham et al. 2008). There are substantial uncertainties related to the UB beluga population trend. The population size might have been lower than the 2022 abundance estimate and recovering over the last decades. Alternatively, the UB beluga population may be stagnating despite over three decades since the closure of the southern Ungava Bay and the Marralik (Mucalic) Estuary to hunting, as a result of reduced productivity in this very small population. Contrasting reproductive rates among beluga populations of various statuses, and monitoring temporal trends in reproductive rates within populations would be useful to explore the role of potential Allee effects in the dynamics of beluga populations, as well as their significance for the achievability of recovery targets.

RECOVERY TARGETS

Caution: All recovery target abundance numbers provided in the following sections of the document are subject to change as new survey and harvest data become available to input into the population model. The recovery objectives used prevail over the population sizes shown in

Tables 3 and 4, regardless of whether model demographic trends and estimates change in future BEL-EHB and UB beluga stock assessments. In addition, recovery targets identified in this section are not specific to EHB beluga but to the joint BEL-EHB stock.

Element 12: *Propose candidate abundance and distribution target(s) for recovery.*

The EHB DU was assessed as Threatened in 2020 according to COSEWIC's criteria A1: 'Decline in total number of mature individuals' based on the approximately 50% decrease in population size between 1974 and 2015. The causes of decline were deemed understood and ceased (Hammill et al. 2017a; COSEWIC 2020a). However, the most recent survey and modelling data suggest that the BEL-EHB stock is still declining (Hammill et al. 2023, St-Pierre et al. 2024). Therefore, we propose three possible objectives (recovery targets) for the BEL-EHB stock (see Table 3 for corresponding population size benchmarks):

1. Attain a population size at or exceeding the 2015 abundance estimate in ten years. It should be noted that this objective is similar to the conservation objective of the current 2021-2026 beluga management plan.
2. Attain a population size which meets or exceeds the Precautionary Reference Level (PRL; defined as 48% of the carrying capacity) in 86 years (3 generations). This is based on the DFO-Maximum Sustainable Yield framework (DFO 2006).
3. Attain a population size corresponding to the estimated maximal demographic growth given no harvest from this stock.

Under SARA, population and distribution recovery objectives are set at the best achievable condition for a species (SARA 2021). In this context, objective 3) represents the best achievable condition for BEL-EHB beluga. However, beluga management plans aim at balancing harvesting rights with conservation objectives as identified within the land-claim agreements. The current conservation objective identified in the 2021-2026 management plan is to maintain the population at or above an abundance of 3,400 animals and that the probability of a decline due to harvesting must not exceed 50% (Hammill et al. 2017a, 2021). This is considered a high risk management approach because it fails to establish any buffer for implementation errors and possible model bias, likely under-estimates parameter uncertainty, and does not consider possible recovery of the stock. In contrast, precautionary approach frameworks aim at managing threats of serious irreversible harm to stocks where there is scientific uncertainty by accounting for the risk of unknown errors in model parameters (Doniol-Valcroze et al. 2013; Hammill and Stenson 2013; Hammill et al. 2017b). Objective 2) above aims for the stock status to attain the Healthy Zone under the precautionary approach framework (DFO 2006), and thus represents an intermediate recovery target integrating Inuit rights and sustainability of harvests.

In addition to a targeted abundance and a timeframe to reach that abundance, recovery targets should identify a probability that the targeted population size is attained. The current 2021-2026 management plan identified 50% as the acceptable probability of meeting the conservation objective. This management approach is highly risky, as is equivalent to accepting a 50% chance of failure to maintain the population at its current, low level. Alternatively, management objectives aiming for a 80% or 95% probability of maintaining or reaching the target population size would provide good, or very good chances of reaching the recovery target, respectively (e.g., Hammill and Stenson 2003, 2007, 2010, 2013; Stenson et al. 2012).

Another aspect of the BEL-EHB recovery objectives include the stock distribution within its summering habitat. Given the philopatry to summering sites displayed by individual beluga, and the potential desertion or extirpation from a formally major beluga aggregation area along the coast of eastern Hudson Bay (c.a., the Nastapoka Estuary) over the last two decades, there would be interest in avoiding further loss from the current BEL-EHB beluga summering distribution. Additionally, a long-term objective (i.e., over > 100 years) would be to recover the historical distribution of beluga in eastern Hudson Bay estuaries previously frequented during the summer, including Richmond Gulf and the Nastapoka River.

The Ungava Bay population was assessed as Endangered in 2020 based on criteria A2: 'Decline in total number of mature individuals', with a decline > 50% over the last three generations, and criteria D1: 'Very small or restricted population. Total number of mature individuals < 250'. Although the last assessment suggests a population size of 68 whales in total in the Ungava Bay area, uncertainty remains whether these individuals are part of a remanent UB DU or migrants from other units. Therefore, the possibility that the UB DU may be extinct cannot be discarded. Because there is no carrying capacity (K) estimate available for UB beluga, it is not possible to compute a PRL for this DU (see Allowable Harm Assessment section). Thus, we propose two possible recovery targets for the UB beluga, assuming the DU still exists at very low levels (see Table 4 for corresponding population size benchmarks):

1. Maintain the population size at or above the 2022 abundance estimate. This represents the survival objective for this DU.
2. Attain a population size corresponding to the estimated maximal demographic growth given no harvest from this DU.

The main summering areas for UB beluga (south of Ungava Bay and the Marralik (Mucalic) Estuary) have been closed to hunting since 1986 to protect this small population. However, harvesting in UB has continued and, given the very small size of any remaining DU, any removals or unusual mortality event would substantially limit recovery. In addition, there is substantial uncertainty related to the UB demographic trend and its drivers. In this context, the survival target (objective 1) may be the most achievable recovery target for this DU. Alternatively, objective 2) aims for population growth under a no mortality, and no density-dependence assumptions (i.e., no Allee effect affecting population dynamics). Although aiming for population growth for UB beluga would be highly recommended, a better understanding of population distribution, abundance, and dynamics within this DU would be required to assess the feasibility of this recovery target.

A distribution objective for UB beluga could be to recover the historical distribution of the population within southern Ungava Bay and its estuaries. This includes the Koksoak, Leaf, Whale, Marralik (Mucalic), and George rivers, as well as Hopes Advance Bay. This objective can only be considered on the long term (i.e., > 100 years).

Sources of uncertainty

- Although recovery targets for UB beluga are presented in the document, research efforts are necessary to establish whether the UB DU still exists or is extinct.
- The population models (see Element 13 for description) used to determine maximal growth objectives assumes that the only source of density-independent mortality for beluga whales is harvest. Under the current harvest levels, this assumption is considered a valid simplification of beluga population dynamics, where population size would stabilize around the carrying capacity in the absence of harvests. However, other factors, such as disease epidemics, ice entrapments or environmental events may also be responsible for beluga mortality, which are not captured in the maximal growth rate abundance numbers. In addition, if UB beluga productivity were affected by an Allee effect, the stock would not grow at its maximal rate of 4%, and therefore projections from the exponential growth function would not apply. Thus, the corresponding recovery targets may be overly optimistic.

- Any remanent of the UB beluga DU is highly vulnerable to stochastic demographic and environmental events given its highly limited size. Therefore, unpredictable causes may lead to extirpation of this DU even in the absence of harvest.
- There has been compelling evidence that beluga display strong philopatry to their natal site, and tend not to recolonize suitable habitat that was previously used as aggregation areas once they are abandoned or the local population is extirpated (Reeves and Mitchell 1987b, 1987c, 1989; Hammill et al. 2004). However, high population density can lead to increased dispersal through intraspecific competition (Lambin et al. 2001). It is therefore conceivable that beluga may recolonize suitable habitats if populations substantially increase to a point where densities approach local carrying capacities. Beluga population sizes at which such density-dependent dispersal may arise in eastern Hudson Bay and Ungava Bay, and likewise the timeframe within which this may occur, are unknown because it has not yet been observed.

Element 13: *Project expected population trajectories over a scientifically reasonable time frame (minimum of 10 years), and trajectories over time to the potential recovery target(s), given current EHB and UB beluga population dynamics parameters.*

Population model structure – All BEL-EHB demographic trajectories described in the present document were generated using the stochastic stock-production population model described in Hammill et al. (2023). Briefly, Bayesian methods are used to fit a state-space model that considers survey abundance data to be the outcome of two stochastic processes: a state process and an observation process (De Valpine and Hastings 2002). The state process describes the underlying population dynamics and the temporal series for the true stock using the formulae:

$$\mathrm{N_t} = \mathrm{N_{t-1}} \cdot (1 + (\lambda_{max} - 1) \cdot \left[1 - (\mathrm{N_{t-1}}/\mathrm{K})^{\theta}\right]) \cdot \varepsilon_{\mathrm{p_t}} - \mathrm{R_t} \qquad \text{(Equation 1)}$$

$$\text{with } \varepsilon_{\mathrm{p_t}} \sim \mathrm{logN}\left(0, \tau_{\mathrm{p}}\right) \qquad \text{(Equation 2)}$$

where *N* is the abundance at time *t* or *t*-1, λ_{max} is the maximum rate of increase, *K* is the environmental carrying capacity, theta (θ) defines the shape of the density-dependent function, and ε_{p_t} is the process error. Removals (R_t) were calculated by adjusting reported catches (C_t) of whales for struck and loss (*SL*, i.e., the proportion of animals that were wounded or killed but not recovered), as well as non-reported catches:

$$\mathrm{R_t} = \mathrm{C_t} \cdot (1 + \mathrm{SL}) \qquad \text{(Equation 3)}$$

The observation process describes the relationship between the true population size (N_t) and the survey estimates (S_t) where

$$\mathrm{S_t} \sim \Gamma(\alpha, \beta) \qquad \text{(Equation 4)}$$

$$\text{with } \alpha = \mathrm{N_t} \cdot \beta \qquad \text{(Equation 5)}$$

$$\text{and } \beta = \mathrm{N_t} \cdot \varepsilon_{\mathrm{S_t}} \qquad \text{(Equation 6)}$$

And ε_{S_t} corresponds to the precision of the survey estimate.

Model parametrization – The BEL-EHB abundance estimates from the eight surveys conducted between 1985 and 2021 (St-Pierre et al. 2024) were used to fit the model. The runs used the same model and fitting as outlined in Hammill et al. (2023), with the exception that the reported harvests were updated to include harvesting reported to 27 November 2022 (see Appendix B).

Model output – Perpetuating current harvest levels (110 for BEL-EHB beluga; including landings from Nunavut and Nunavik, and derived from BEL-EHB proportions from most recent genetic data; Hammill et al. 2023) would result in BEL-EHB abundances having a 50% probability of being ≥ 2,300 in ten years, and most (> 97%) projections predicting extinction within 33 years (Figure 9). Therefore, the current population dynamic parameters, most notably harvest levels, are incompatible with any of the recovery targets, and have high probabilities of resulting in BEL-EHB beluga extinction within the next two generations.

Exponential growth function – The 2022 survey provided the first abundance estimate for the UB beluga distribution area, despite being the fifth of a series of systematic surveys covering Ungava Bay since 1985 (Sauvé et al. 2023). No beluga were detected on transect lines in any of the four previous surveys, yielding no abundance estimate, although a small number of animals were seen off transect (Smith and Hammill 1986; Kingsley 2000; Hammill et al. 2004; Gosselin et al. 2009). Therefore, no abundance time series was available to fit a population model for UB beluga. In addition, since the Marralik (Mucalic) Estuary has been closed to hunting since 1986, there has been no reported harvest in the area over the last decades, except for those resulting from the estuary hunt plans in 2021 and 2022 (2 landings each year). Finally, negative population-dependence is unlikely to affect the UB demographic growth at its current size. Therefore, an exponential growth function with an intercept corresponding to the 2022 survey estimate and a 4% growth rate was fitted to make projections for the UB beluga population size under different harvest levels. Harvests were subtracted from the total population following annual growth, and a struck and loss of 27% (median estimated by the population model for BEL-EHB beluga) was applied since no struck and loss data from Ungava Bay was available.

Estimating current UB harvest levels is challenging due to the lack of genetic data available to derive season-specific proportions of UB beluga harvested in Ungava Bay. Because Ungava Bay is frequented by beluga from other, larger DUs during migration, only beluga harvested in summer in Ungava Bay were considered taken from the UB DU. There is uncertainty relative to the timing of the end of the period during which migrants from other DUs leave Ungava Bay in the spring. Therefore, three alternative periods were used to estimate UB beluga harvest levels: 2022 harvests taken by the communities of Aupaluk, Tasiujaq, Kuujjuaq, and Kangiqsualujuaq between 1) August and September (harvest = 4), 2) Mid-July and September (harvest = 10), and 3) July and September (harvest = 22). Perpetuating any of these harvest levels for UB beluga would result in a population decline leading to extirpation of any remaining stock within 4 to 21 years. Therefore, both the growth and survival recovery objectives are unachievable under current harvest levels (Figure 10).

Sources of uncertainty other than those identified in Element 12

- Aerial survey estimates for beluga are known to be highly variable. The BEL-EHB 2021 aerial survey abundance estimate was very low, yet estimated to be more precise than other surveys of this DU (St-Pierre et al. 2024). Given the relatively few surveys that have been completed for this stock, our understanding of current trends is sensitive to changes in the last survey estimate used in the model.
- There is uncertainty relative to the estimation of the number of BEL-EHB beluga harvested annually. BEL-EHB and WHB annual takes are considered to represent a proportion of the total number of beluga landed in Nunavik and Sanikiluaq. These proportions are area- and season-specific, and introduced as priors informed by genetic studies into the population model (Annex A; Hammill et al. 2023; Parent et al. 2023). Recent genetic data indicated that BEL-EHB animals represent a greater proportion of total landings than initially thought (Parent et al. 2023; see Element 15). The TATs and management measures established in

the current beluga management plan (NMRWB and EMRWB 2020) rely on previous, less conservative EHB proportions of total landings. In this document, revised, more conservative proportions are used. Nevertheless, both previous and revised proportions result in beluga removals exceeding the Science advice (DFO 2022).

- Field observations of animals struck and killed but not recovered or reported is an important source of uncertainty in the BEL-EHB population model. Any nonreporting or underreporting of takes has a high impact on model fitting and derived predictions for the population trend. In addition, the median struck and lost level estimated from the BEL-EHB model (27%) was used in the UB beluga demographic projection because no estimate was available for the Ungava Bay harvest efforts. Given the small size of the UB beluga DU, under- or overestimations of the struck and lost level applied to UB beluga harvests are likely to have substantial consequences for the UB beluga demographic projections.
- The UB beluga demographic projection was based on an exponential growth function assuming a constant 4% growth rate, corresponding to the default maximum natural growth rate for cetaceans (Wade 1998). Considering that the stock is depleted, UB beluga could be expected to exhibit a rate of increase close to their intrinsic maximum, which is not well known for beluga specifically. Alternatively, it is possible that UB beluga are subject to an Allee effect, where population growth is negatively influenced by density at very low population sizes. The projections from the 4% growth curve should therefore be interpreted as maximal population sizes.

Element 15: *Assess the probability that the potential recovery target(s) can be achieved under current rates of population dynamics parameters, and how that probability would vary with different mortality (especially lower) and productivity (especially higher) parameters.*

Under current harvest levels, the probability of reaching any of the recovery objectives for BEL-EHB or UB beluga is null. Decreasing anthropogenic mortality (i.e., harvest) would increase chances of recovery for BEL-EHB and UB beluga (Figure 11).

There has been substantial changes in the BEL-EHB population model predictions since the COSEWIC evaluation (COSEWIC 2020a). The most recent assessment indicates that the BEL-EHB stock abundance is not stable as previously thought (Hammill et al. 2017a, 2021), but has been declining at a rate of 3% per year since 2015 (Hammill et al. 2023). This decline is due to high levels of harvests that have consistently exceeded sustainable levels and an under-estimation of the proportion of BEL-EHB animals in the harvest (Hammill et al. 2023). The latter results from a re-analysis of the genetic information that determined that the stock could be further subdivided into an EHB and a separate Belcher Island (BEL) components. In previous analyses using short haplotypes, many of the beluga from the newly identified Belcher Island component had been grouped with WHB animals (Parent et al. 2023). This has important consequences for model parametrization and projections, since a proportion of landings from Sanikiluaq (Belcher Islands) that were previously deemed non-EHB beluga, are now considered as BEL-EHB animals when calculating their proportion in the total Nunavik and Sanikiluaq landings.

Using these updated proportions, no harvest level can provide a 50% probability that the BEL-EHB stock will be > 3,700 in 2026 (current management objective for the beluga management plan; NMRWB and EMRWB 2020). In contrast, the probabilities of BEL-EHB stock abundance being ≥ 3,700 whales in ten years (recovery target 1 identified above) or in one, two, or three generation times given different annual harvest levels are presented in Figure 12.

Probabilities that the BEL-EHB beluga stock would be above the LRL and PRL (recovery target 2) listed above) are presented in the Allowable Harm Assessment section. The probability of attaining a growing population of 3,900 BEL-EHB whales in ten years or 10,200 whales in 86 years is 50% under no harvesting pressure and is unachievable under harvest levels ≥ 1 (by definition of this maximal growth recovery objective).

In the population model used, productivity is modulated via a density-dependent function and a maximum rate of population growth (Hammill et al. 2023). Although the maximum rate of population increase is not known, most studies have suggested a median estimate around 4%, with a range of 2–8% (Alvarez-Flores and Heide-Jørgensen 2004; Hobbs et al. 2006; Lowry et al. 2008; Doniol-Valcroze et al. 2012, 2013). The prior distribution used for λ_{max} in the current model is a Beta distribution with a range of 0.02 to 0.06 (Appendix C), while the median model estimate for λ_{max} was 0.035 (2.5%-97.5% quantiles = 0.021-0.055). It appears unrealistic that this number would increase, and the current model already accounts for density dependence on productivity. Therefore, no simulations of increased productivity were attempted.

Regarding UB beluga, the exponential growth function suggest that at a harvest level of 2 annual takes, the population would remain stable, while any higher harvest level would result in rapid population decline.

Sources of uncertainty

Sources of uncertainty identified in Elements 12 and 13 apply.

SUPPLY OF SUITABLE HABITAT: NOT RELEVANT

Element 14: *Provide advice on the degree to which supply of suitable habitat meets the demands of the species both at present and when the species reaches the potential recovery target(s) identified in element 12.*

Due to philopatry to natal sites and cultural and vertical transmission of migration routes, BEL-EHB and UB beluga distribution is considered restricted to the summering and wintering grounds they occupy. Their recovery is not limited by the supply of suitable habitat.

SCENARIOS FOR MITIGATION OF THREATS AND ALTERNATIVES TO ACTIVITIES

Beluga are non-commercially exploited by Inuit from Nunavik and Nunavut. Inuit have harvesting rights under land claim agreements (NILCA and NLCA), and therefore do not require permits to harvest beluga. At present, the main hunting method is the use of a rifle (Breton-Honeyman et al. 2021), although traditional methods are allowed, including harpooning first and netting. There are no hunting fleets, but rather small private motorboats that are used by groups of hunters (Breton-Honeyman et al. 2021). The main hunting locations include the coastal waters off the 14 Nunavik communities and the waters off Belcher Islands, but hunting camps are also set at more remote locations, including Long Island (southeast Hudson Bay) and Marralik (Mucalic) River.

Most Nunavik Marine Region waters are currently managed without a total allowable take (TAT), except within the Eastern Hudson Bay Arc Region where a TAT is shared among communities (Figure 13) to protect BEL-EHB beluga (NMRWB and EMRWB 2020). The Nastapoka, Little Whale River and Marralik (Mucalic) Estuaries are closed to harvesting, and other seasonal closures are in place to protect BEL-EHB beluga during their seasonal migrations (*Marine Mammal Regulations* SOR/93-56, 2018). There is no TAT in Sanikiluaq (Nunavut), but the municipality implements voluntary closures from July 15 to September 30 annually to protect BEL-EHB beluga (DFO 2016). Harvesters are required to report all beluga harvested to DFO and/or Uumajuit Wardens. Nunavik hunters report a struck and lost rate of 5.7% (NMRWB and

EMRWB 2020), but the population model's median estimate for BEL-EHB is 27.3%. This model estimate also includes non-reporting.

> ***Element 16:*** *Develop an inventory of feasible mitigation measures and reasonable alternatives to the activities that are threats to the species and its habitat (as identified in elements 8 and 10).*
>
> ***Element 17:*** *Develop an inventory of activities that could increase the productivity or survivorship parameters (as identified in elements 3 and 15).*

Table 5 proposes mitigation measures that would likely decrease mortality and/or stressors of BEL-EHB and UB beluga. It is difficult to directly increase productivity of beluga populations, as it is dependent on environmental conditions influencing prey availability and carrying capacity. Productivity can likely be indirectly influenced by reducing anthropogenic threats to reproductively mature females and calves. Likewise, there is very little available data on BEL-EHB and UB natural mortality, and harvesting is considered the most important source of mortality for both stocks. Under current conditions, precautionary management of subsistence harvests represents the most likely measure for increasing BEL-EHB, and possibly UB, beluga survival.

The primary threat to BEL-EHB and UB beluga is overharvesting. Under the amended provisions of the *Fisheries Act* (2019), there is renewed emphasis on the sustainability of fisheries through the development of a management framework based on the Precautionary Approach. Under the DFO-MSY approach, the BEL-EHB stock lies in what is considered the Cautious zone, below the PRL but slightly above the LRL (Figure 14). Harvest strategies should focus on rebuilding the BEL-EHB stock within a certain timeframe. This is important both from a conservation perspective, but also to meet the needs of a growing population of hunters in Nunavik. One of the recovery objectives identified in this RPA for the BEL-EHB stock is recovery above the PRL within three generations (86 years), and harvest levels that could achieve this objective are presented in the Allowable Harm Assessment section of this document. In addition, given the known strong philopatry to summering sites expressed by beluga, management of harvests at the estuary level would represent a precautionary approach to avoid depleting family groups of beluga who may be vulnerable to single, large harvest events.

In contrast, the UB population is in the critical zone, under the LRL which is considered a lower limit below which significant harm can occur to the stock, significantly jeopardizing its recovery (Stenson et al. 2012; Doniol-Valcroze et al. 2013; Hammill et al. 2017b). It is unknown whether the non-recovery of UB beluga despite four decades of harvest closure in their main summering habitat is due to the small size of the population altering productivity via Allee effects, to non-reported continued harvests, or to the fact that this population may be extinct, and that animals observed in southern Ungava Bay and its estuaries in the summer may be migrants from other populations. Growth curves indicate that any harvest on remaining UB beluga would be unsustainable and pose serious threats to the survival of any residual population.

The impacts of other threats on BEL-EHB and UB beluga survival and recovery are difficult to assess, mostly due to the restricted data available on migration routes and timing, distribution in wintering grounds, season-specific diet and energetic requirements, and the physiological and fitness effects of the different stressors. A better understanding of spatiotemporal overlap of beluga migration and winter distribution with fisheries efforts, vessel traffic, and seismic exploration is required to estimate the reduction in mortality and increase in productivity expected by proposed mitigation measures or alternatives. Additionally, the implementation of a marine mammal carcass reporting and sampling program in Nunavik could provide valuable data on natural and anthropogenic causes of beluga mortality other than hunting.

Element 19: *Estimate the reduction in mortality rate expected by each of the mitigation measures or alternatives in element 16 and the increase in productivity or survivorship associated with each measure in element 17.*

Element 20: *Project expected population trajectory (and uncertainties) over a scientifically reasonable time frame and to the time of reaching recovery targets, given mortality rates and productivities associated with the specific measures identified for exploration in element 19.*

The current Nunavik beluga population model is a surplus production model, characterized by no age structure, and no explicit mortality or reproductive rates. The maximum rate of increase parameter (λ_{max}) integrates total births and mortalities and is fitted for the entire time series. It is, therefore, difficult to predict what impact on population dynamics individual mitigation measures would have. However, the one cause of mortality that is explicitly included in the model is removals through harvesting. Any reduction in harvest levels represent mortalities that are avoided. How this reduction in anthropogenic mortality interacts with density-dependent effects depends on the relative population size and carrying capacity. Figures 15 and 16 show the projected population trends with varying harvest levels for the BEL-EHB and UB stocks, respectively.

Element 21: *Recommend parameter values for population productivity and starting mortality rates and, where necessary, specialized features of population models that would be required to allow exploration of additional scenarios as part of the assessment of economic, social, and cultural impacts in support of the listing process.*

The parameter values estimated by the model are presented in Table 6. One aspect that the current model does not account for is unusual mortality events (UME) due, for example, to ice entrapments or disease epidemics, that are likely to affect overall abundance and, if repeated over time, may impact the overall productivity estimate. We simulated occasional UME in the BEL-EHB stock where 60 whales are harvested per year to explore potential impacts on population dynamics (Figure 17). While events causing additional mortality of 10 whales every 20 years had little impact on population dynamics, events removing an additional 50 beluga every 20 years resulted in delayed population growth. This demonstrates that stochastic, punctual events causing the mortality of several tens of beluga should be accounted for when modelling population dynamics.

A recently developed progesterone titration method allows the calculation of female pregnancy rates from beluga blubber samples (Renaud et al. 2023). Moreover, genetic sexing of historic beluga samples from harvest suggest sex biases in removals (Parent and Sauvé, DFO, unpublished data). Sex-skewed harvest can have numerous effects on mammal population dynamics, including impaired fecundity in low reproductive potential species (e.g. Ginsberg and Milner-Gulland 1994; Langvatn and Loison 1999; McLoughlin et al. 2005; Taylor et al. 2008). Therefore, incorporating information on age-specific reproductive rates and age- and sex-specific harvest levels into a sex- and age-structured demographic model could represent a way to integrate the effects of environmental variability and harvest biases into beluga population dynamics.

Element 18: *If current habitat supply may be insufficient to achieve recovery targets (see element 14), provide advice on the feasibility of restoring the habitat to higher values.*

Habitat supply is unlikely to limit BEL-EHB and UB beluga to achieve recovery targets.

ALLOWABLE HARM ASSESSMENT

Element 22: *Evaluate maximum human-induced mortality and habitat destruction that the species can sustain without jeopardizing its survival or recovery.*

Currently, the Government of Canada does not have a standardized, quantitative definition of Allowable Harm. In contrast, the U.S. Government adopted the potential biological removal (PBR) level as a tool for quantifying the maximum annual number of animals that may be removed in addition to natural mortality while still allowing the target population to reach or maintain its optimum sustainable population size within 100 years (Wade 1998). The PBR therefore has an implicit management objective, which is to identify harvest levels that have a 95% probability of the population being above the Maximum Net Productivity Level, defined as 50% of the carrying capacity over a period of 100 years (Wade 1998). The PBR is calculated as:

$$PBR = 0.5\, R_{max} \times RF \times N_{min} \quad \text{(Equation 7)}$$

Where R_{max} is the maximum rate of population increase (by default set to 4% for cetaceans), *FR* is a recovery factor ranging between 0.1 and 1, and N_{min} is the estimated population size using the 20th percentile of the assumed log-normal distribution around the abundance estimate (Wade 1998). N_{min} is calculated using the equation:

$$N_{min} = \frac{N_{est}}{\exp\left(z\sqrt{\ln\left(1+CV(N_{est})^2\right)}\right)} \quad \text{(Equation 8)}$$

where N_{est} is the point estimate of the most recent population size, *z* is the standard normal variate (0.824 for the 20th percentile), and *CV(N)* is the coefficient of variation for N_{est}.

The median BEL-EHB abundance estimate for 2022 was 2,833 (CV = 22.73%), resulting in an N_{min} of 2,355. For UB, we calculated N_{min} using the most recent survey abundance estimate of 68 (CV = 61.85%; Sauvé et al. 2023), the estimate N_{min} was 43.

Recovery factor values < 1 allocate a proportion of the expected net production to demographic growth, while accounting for uncertainties hindering population recovery (National Marine Mammals Service 2016). Default values of 0.1 and 0.5 are recommended for Endangered and Threatened DUs, respectively (Barlow et al. 1995; Wade 1998). Nevertheless, Canadian criteria suggest a RF of 0.1 for small, declining populations or populations with unknown trends(DFO 2018) . We thus used a RF of 0.1 for both populations.

Using these parameters, the PBR for BEL-EHB was 4.71 whales per year, while the PBR for UB was 0.085 whales per year. These PBR values represent an estimate of total removals from the population, thus including harvests, struck and loss, non-reported harvest, and other sources of human-induced mortality such as bycatch and vessel strikes. The TAT should therefore be lower than the PBR to account for sources of human-induced mortality other than harvesting.

In the case of BEL-EHB beluga, a certain level of information on abundance, trend and population dynamics is available. Therefore, a precautionary approach framework, which is more structured and leads to the calculation of different harvest levels which would still meet management objectives, can be applied to this DU (Hammill et al. 2017b). International agreements have identified the MSY as a management objective. Estimating MSY requires information on ecosystem carrying capacity (*K*) and the shape of the density dependent relationship. For some species, historic catch data have been used to infer pre-commercial hunt population sizes, which is assumed to be an estimate of *K*. In the case of BEL-EHB beluga, there is important uncertainty in historical catch. Moreover, there has been a change in ecosystem conditions in the Hudson-James Bay complex, including a shortening of the ice-covered season and the construction of hydro-electric dams that modified waterflow within the Bay (Tsuji et al. 2009; Galbraith and Larouche 2011; Hammill and Stenson 2013). This suggests that *K* might have varied since the late 1800s, and that other proxies of K under current conditions should be used (Hammill and Stenson 2007).

The model fitted to the 1985-2021 aerial survey data and including the 1974-2022 catch data produced an estimate of *K* for the period of the modelling (Table 6) that could act as a proxy in setting the PRL and LRL under the MSY approach (Hammill et al. 2017b). Assuming that maximum productivity occurs at 60% of *K*, the PRL and LRL are set at 48% and 24% of this *K* estimate, respectively (Hammill et al. 2017b). This results in a BEL-EHB beluga PRL and LRL of 5,300 and 2,700 whales, respectively. The median current population estimated from the population model was 2,800 whales. The probability that the 2022 population is above the PRL is zero, while the probability that it is above the LRL is 60%. The DU, therefore, lies in the cautious zone, below the PRL but above the LRL. Thus, under the precautionary approach framework, BEL-EHB beluga harvest strategies should focus on rebuilding the stock above the PRL within a certain time frame, which represents recovery objective 2) identified in Element 13. A recommended management objective is to maintain a 95% probability that the population is above the LRL and 80% probability that the population is above the PRL (Hammill and Stenson 2003, 2007, 2010, 2013; Stenson et al. 2012). The probabilities that the BEL-EHB stock increases above the LRL and PRL in 10 years, and in one, two, and three generation times considering different harvest levels are presented in Figures 18 and 19.

Projections, therefore, suggest that attaining a BEL-EHB stock size above the PRL in one generation is relatively unlikely (<70% probability under no annual harvest), while attaining the PRL in three generations is feasible with reasonable probability (e.g., 80%) with annual harvest levels of 20 beluga. Annual harvest levels ranging between 20-30 beluga are compatible with a 90-95% probability that the population remains over the LRL over the next two to three generations.

Sources of uncertainty

- Because the relative sizes of the EHB and BEL populations are unknown, it is currently not possible to derive population-specific allowable harm levels within the BEL-EHB stock. Nevertheless, total allowable harm reported in this section may exceed the yet undetermined EHB- or BEL-specific allowable harm levels if harvests differentially target the EHB and BEL populations. Exceeding the population-specific allowable harm levels could lead to extirpation of matrilineages occurring on the eastern Hudson Bay coast or around the Belcher Islands. Avoiding harvesting several beluga from a same group and distributing harvest efforts across the BEL-EHB distribution range are practices that could contribute to avoiding differential targeting of the BEL and EHB populations. In addition, assessing the relative population sizes of BEL and EHB beluga would allow calculation of population-specific allowable harm levels.

RESEARCH RECOMMENDATIONS

Different aspects of beluga distribution, behaviour and population dynamics for which additional information is required to better characterize the level of impact of the different threats and provide a more meaningful Allowable Harm assessment have been highlighted throughout this document. The three main aspects which are of particular importance are: 1) whether the UB DU still persists or is extinct, 2) the strong influence of the 2021 BEL-EHB abundance estimate on demographic model trends and projections, and 3) the scarcity of information on BEL-EHB and UB beluga feeding behaviour and winter distribution.

To address the question of the persistence of the UB beluga DU, beluga tissue samples from the summer distribution area must be collected and contrasted with that of other populations.

The lack of samples from this area is attributable to the absence of harvest in the south of Ungava Bay and the Marralik (Mucalic) Estuary since 1986, before genetic sampling was instigated. Biopsies, which provide samples from live animals, would represent a potential way of increasing sampling in that area without promoting removals on this very small, if not extinct population. Environmental DNA (eDNA) also represents a non-invasive sampling method, however only mitochondrial DNA can be analysed from eDNA samples due to nuclear DNA degradation. Recent analyses suggest nuclear DNA is more promising for identifying beluga populations than mitochondrial DNA (Geneviève Parent, DFO, personal communication). Caution is however warranted, as the absence of a genetically-distinct population in Ungava Bay in summer would not represent unequivocal evidence that the DU is extinct. Many beluga DUs in Canada are defined based on philopatry to summering grounds. Therefore, collecting behavioural (e.g., telemetry) data on beluga summering in southern Ungava Bay to document movements and characterize the summer distribution of these animals may be necessary to determine if beluga frequenting the area are summer residents or migrating individuals.

The addition of the low and unusually precise 2021 survey estimate into the time series used to fit the BEL-EHB demographic model changed the estimated population trend and projections. The extent to which the 2021 abundance estimate exerts a disproportional effect on the population model is unknown, but derived model estimates and projection raise concern as to the DU’s status. Beluga aerial survey-derived abundance estimates from a same area are highly variable, which is thought to result from the small size of surveyed populations, coupled with the non-random or contagious distribution of individuals that spend most of their time under the surface (Kingsley and Gauthier 2002; Gosselin et al. 2007; Gosselin et al. 2014). Conducting repeated surveys allows to capture the variability associated with the contagious distribution of beluga (e.g., Gosselin et al. 2007). Repeating aerial surveys to obtain other recent BEL-EHB stock abundance estimates to input into the population model would therefore provide a better understanding of current population trends and may reduce uncertainty associated with individual survey estimates. Moreover, incorporating sex- and age-specific data related to harvest and reproductive as well as environmental factors into a stochastic, rather than deterministic population model would better capture aspects of beluga population dynamics that are unaccounted for with the model currently used.

Over the last decades, telemetry devices have improved drastically in terms of battery life and data storage. The deployment of modern satellite telemetry tags which could collect dive data from beluga on the eastern Hudson Bay coast and from the Belcher Islands would provide unprecedented information on Nunavik beluga foraging behaviour, as well as information on movements to and within wintering grounds. This, compounded with detailed information on fishing effort, shipping traffic, seismic exploration and environmental variables, would allow a better assessment of the level to which the different threats may affect BEL-EHB beluga recovery, and would allow the development of habitat selection models.

Finally, TEK has provided extremely valuable information on beluga diet, distribution, condition, and the timing of migration which has been presented in this RPA. Additional efforts are needed among hunters, researchers, and managers so that Inuit knowledge and values that have been gained over countless generations are passed on and integrated into meaningful collaborations contributing to our understanding of beluga biology, behaviour, and demographic trends.

CONCLUSIONS

Beluga have general life-history traits that result in a low intrinsic rate of population increase and relatively long generation time. In addition, they display strong philopatry to their summering areas and culturally transmitted migration routes. These characteristics makes their populations highly susceptible to harvesting pressure, the main threat identified for both the BEL-EHB and UB stocks.

There are important uncertainties relative to the threat assessment, estimated probabilities of reaching the different recovery targets identified, and to the current population trends for both BEL-EHB and UB beluga. Nonetheless, most recent data indicates a continuous decline in BEL-EHB beluga since the 1970s, interspersed with periods where the decline has slowed or the population briefly stabilised. The population size of UB beluga remains very small, assuming the DU is not extinct. Management objectives should, therefore, target the recovery of both stocks, not only from a conservation perspectives, but also to ensure the continuation of the socio-culturally important beluga harvesting practices along the coasts of Nunavik. Collaborative research efforts and community engagement are critical to increase our understanding of the interactions between beluga behaviour and population dynamics, its changing ecosystem, and human activities including, but not limited to, harvesting.

ACKNOWLEDGEMENTS

We extend our thanks to all participants of the February 20-24, 2023 national peer review meeting on Recovery Potential Assessment of Beluga Whale (Eastern Hudson Bay and Ungava Bay populations) who contributed to the improvement of this RPA (see Appendix A).

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FIGURES

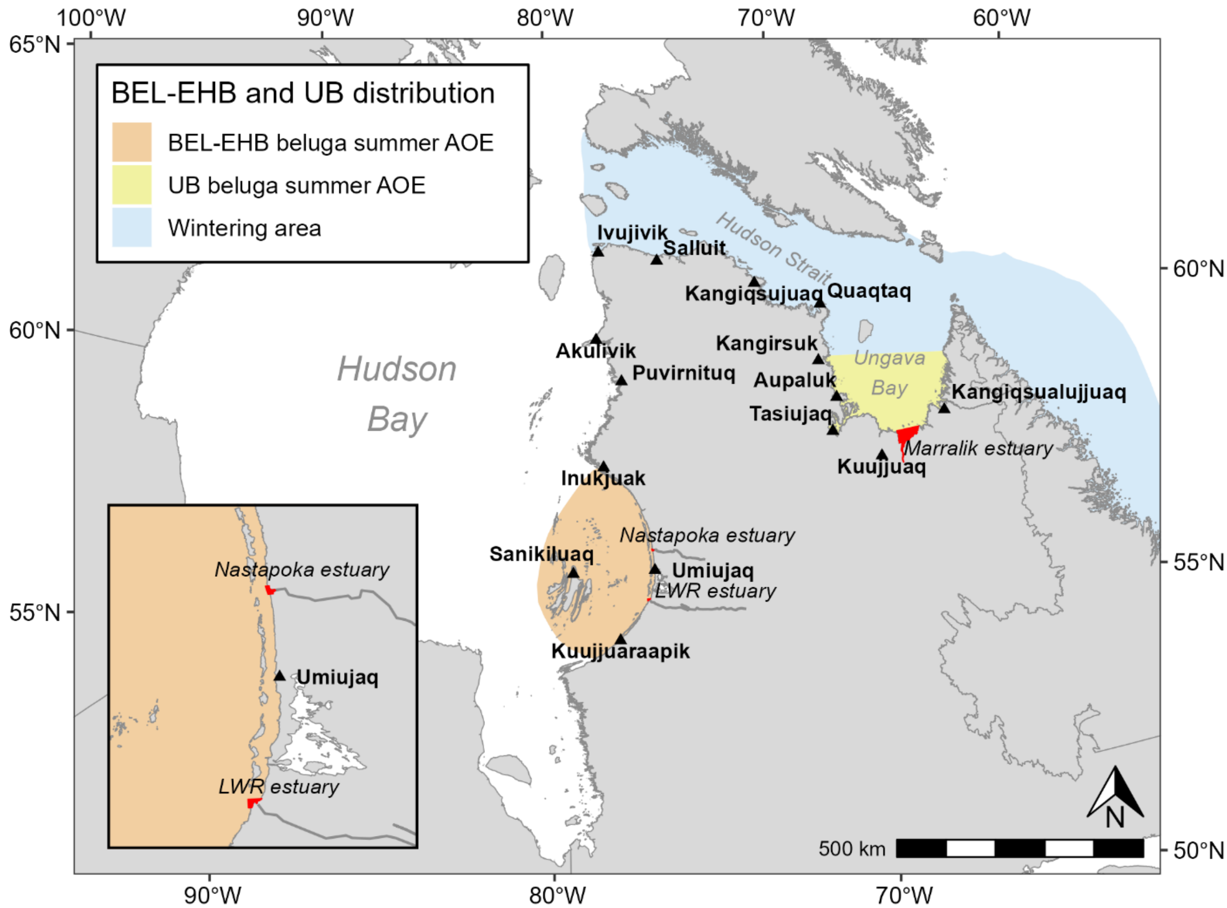

Figure 1. Geographic delimitation of summering and wintering areas of extent (AOE) for the Belcher Islands-Eastern Hudson Bay (BEL-EHB) beluga stock and the Ungava Bay (UB) beluga designatable unit. The red polygons represent the areas which are closed to harvesting year-round to protect BEL-EHB beluga (Nastapoka and Little Whale River (LWR) estuaries) and UB beluga (the south of Ungava Bay and Marralik Estuary).

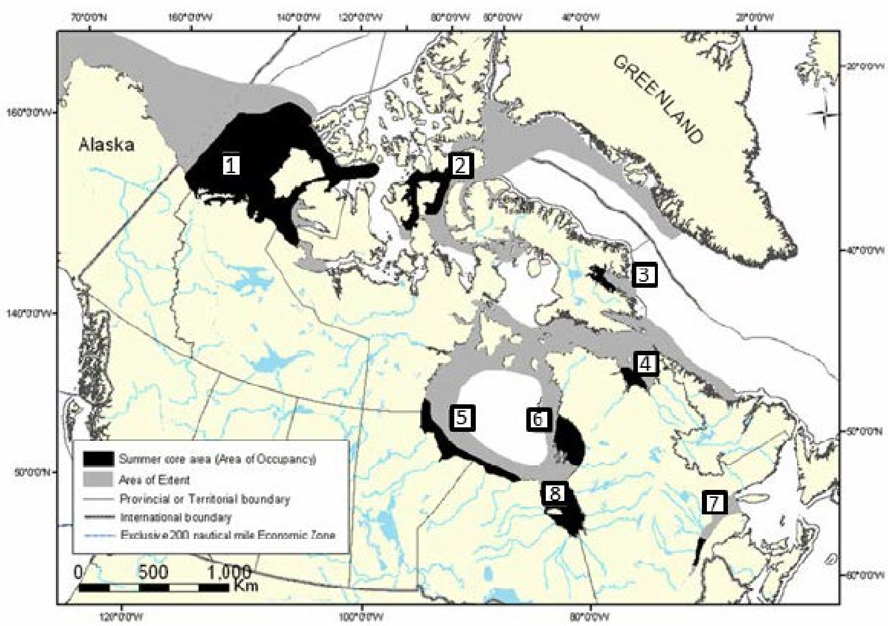

Figure 2. Distribution of beluga in Canada and recognized DUs: 1) Eastern Beaufort Sea (EBS); 2) Eastern High Arctic-Baffin Bay (EHA-BB); 3) Cumberland Sound (CS); 4) Ungava Bay (UB); 5) Western Hudson Bay (WHB); 6) Eastern Hudson Bay (EHB); 7) St. Lawrence Estuary (SLE); and 8) James Bay (JB). Source: COSEWIC (2020a).

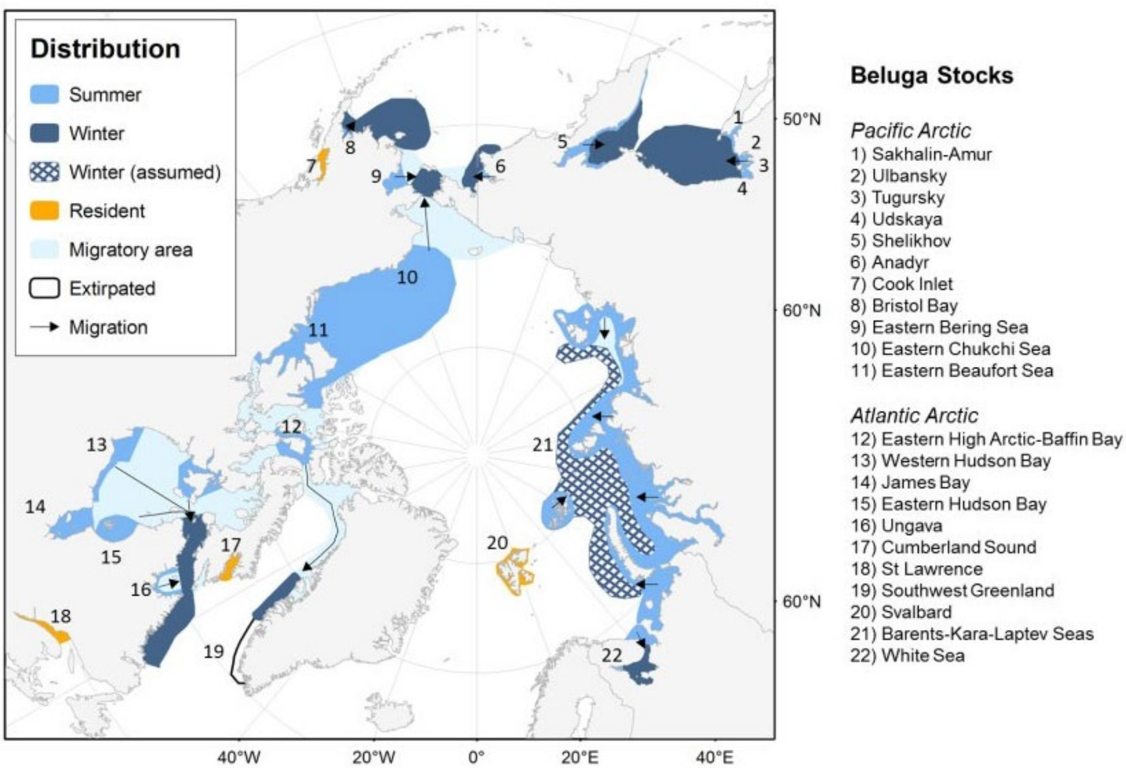

Figure 3. Global range of beluga, displaying currently recognized stock distribution and some indication of migratory movement. Source: NAMMCO (2018).

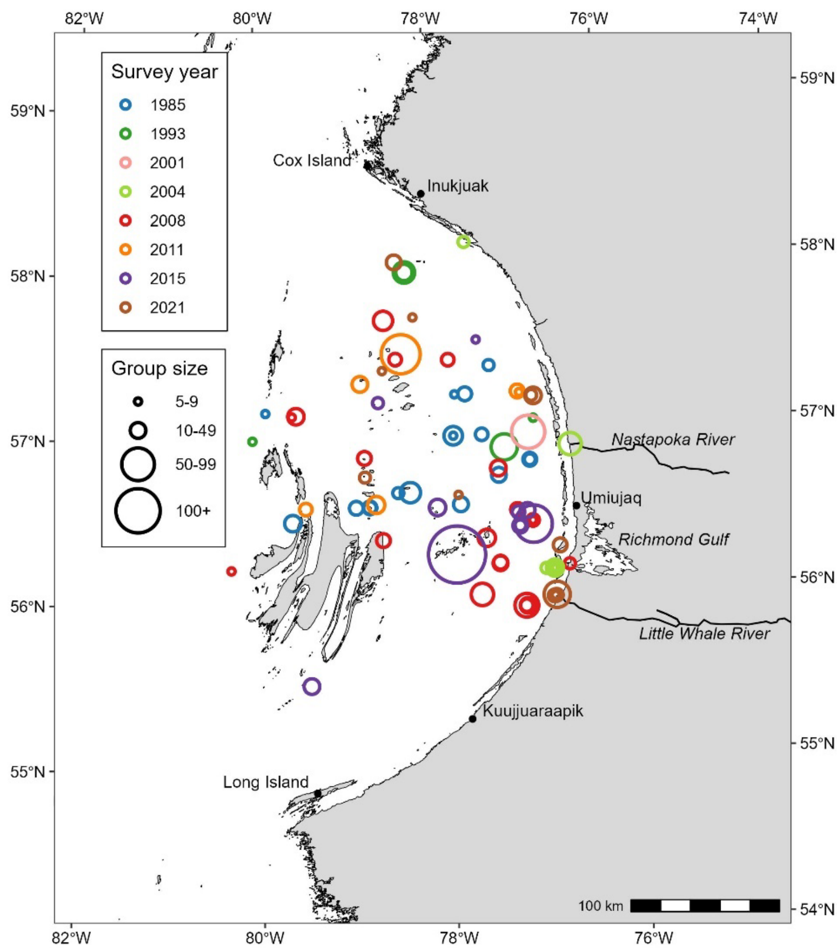

Figure 4. Spatial distribution of beluga aggregations (c.a., groups ≥ 5 individuals) detected during aerial surveys conducted from mid-July to September between 1985 and 2021. For the 2011, 2015 and 2021 surveys, which were flown using a double platform design, only the sightings from primary observers are depicted to avoid duplicates.

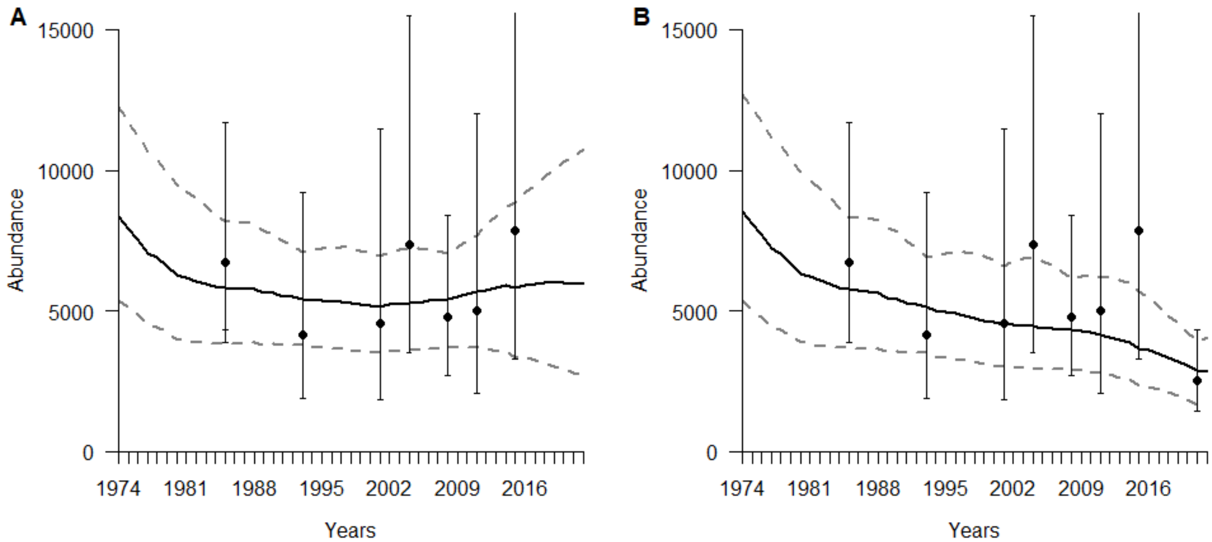

Figure 5. Estimated trajectory of the BEL-EHB beluga stock obtained by fitting a density dependent model to aerial survey abundance estimates, and accounting for reported harvests (1974-2022). Survey estimates (black circles ± 95% CI), median (black solid line) and 95% CI (grey dashed lines) are displayed. The model was fitted A) without and B) with the 2021 survey abundance estimate.

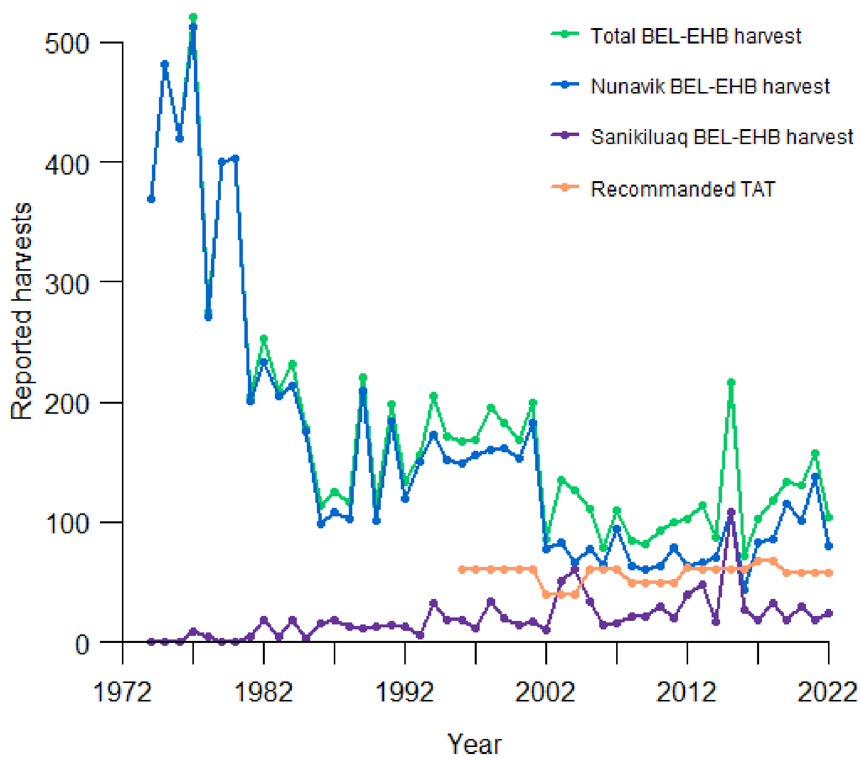

Figure 6. Harvest statistics derived using total reported harvest of beluga in Nunavik and revised season- and location-specific proportions of total landing representing BEL-EHB animals based on genetic data (Hammill et al. 2023; Parent et al. 2023). The total allowable take for BEL-EHB beluga is shown for reference.

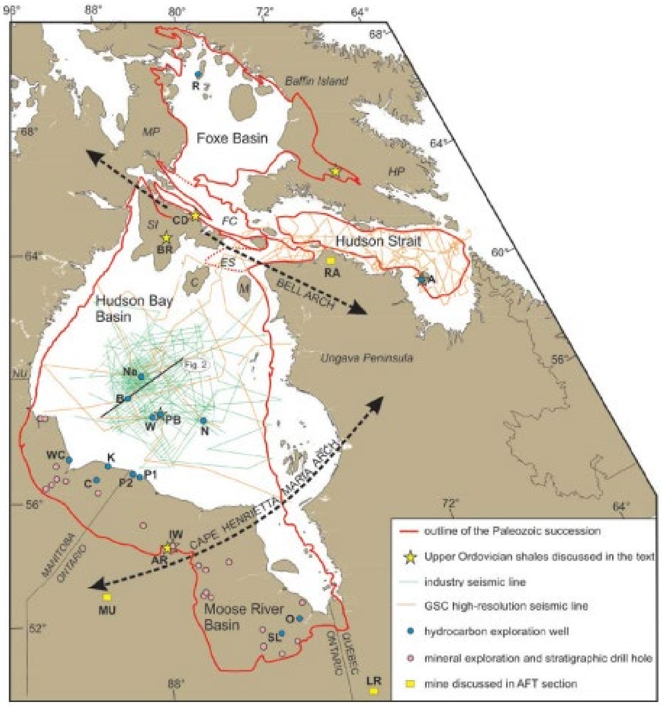

Figure 7. Distribution and extent of seismic research activities conducted under the Geomapping for Energy and Minerals programs between 2008 and 2018 in Hudson Bay Basin and adjacent basins. Multichannel industry seismic lines and Geological Survey of Canada (GSC) high-resolution seismic lines are depicted. Source: Lavoie et al. 2019.

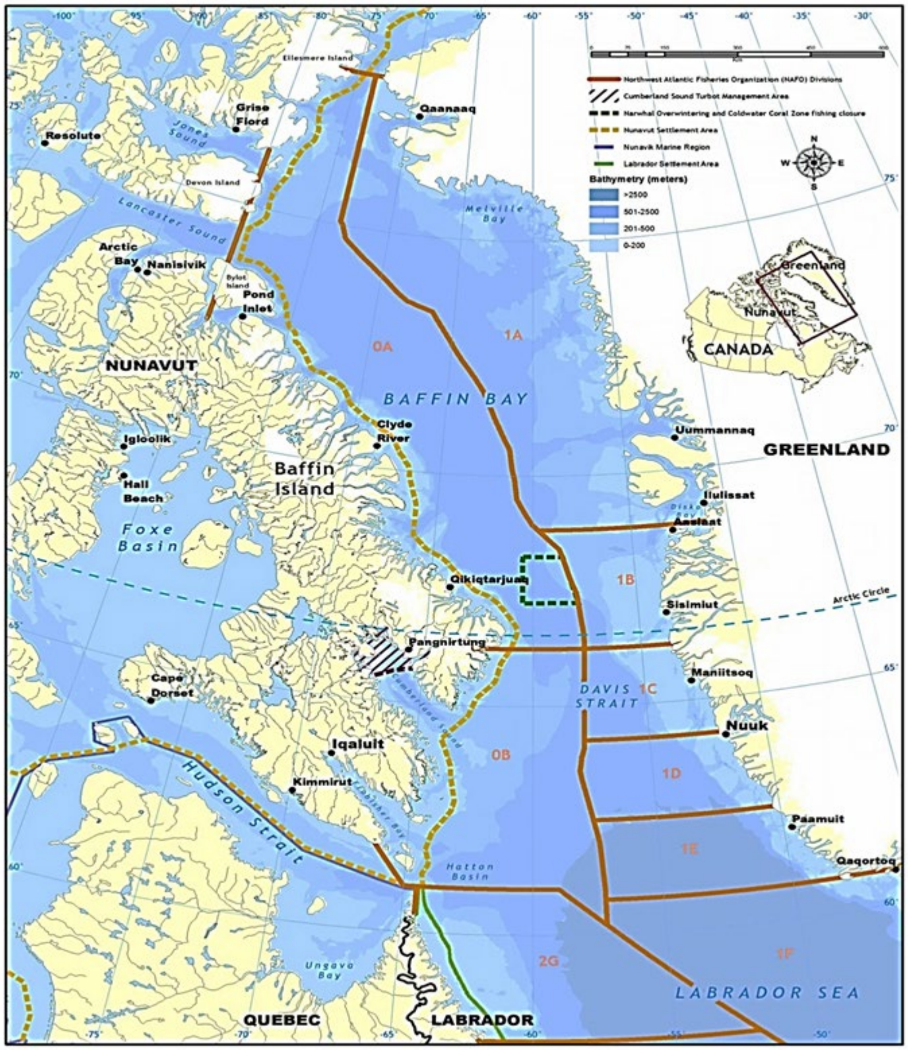

Figure 8. Northwest Atlantic Fisheries Organization Subareas and Divisions relevant to the Greenland Halibut fishery. Source: DFO (2014c).

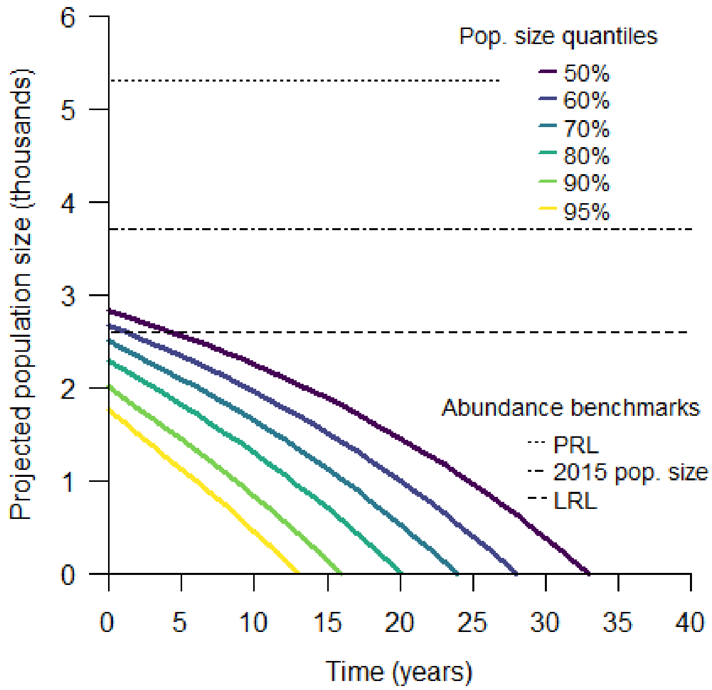

Figure 9. BEL-EHB stock abundance projected over the next decades under current harvesting levels (BEL-EHB: harvest = 110).

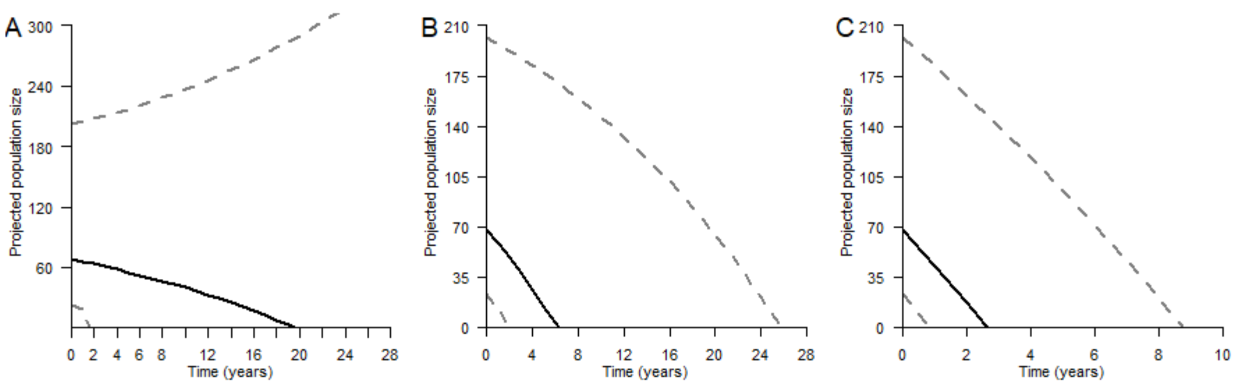

Figure 10. UB beluga population size projected over the next decades using a 4% exponential growth curve and the 2022 aerial survey estimate (full black line) and 95% confidence interval upper and lower limits (grey dashed curves) as initial population sizes under current harvest levels. Current harvest levels were estimated based on 2022 harvests taken in Ungava Bay between: A) August and September (harvest = 4), B) Mid-July and September (harvest = 10), and C) July and September (harvest = 22) of 2022.

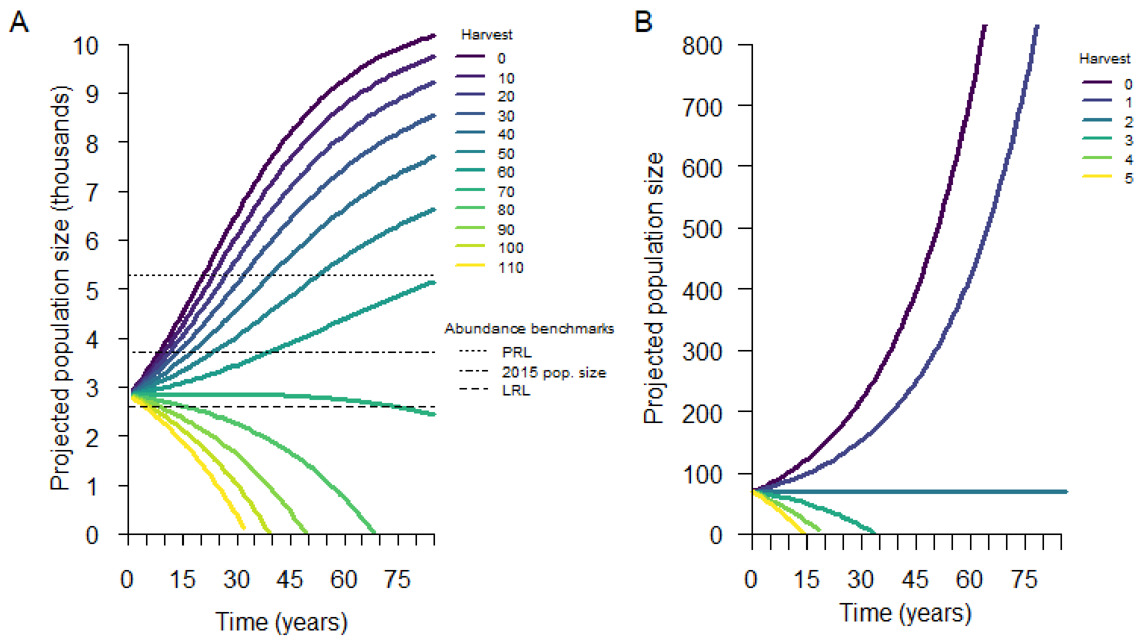

Figure 11. A) Median BEL-EHB and B) UB beluga stock abundance projected over the next three generations based on different harvest levels. Initial year is 2022. Projections are based on a population model for BEL-EHB and use a 4% exponential growth curve in the case of UB beluga. Colored curves refer to different annual harvest levels. Precautionary approach (PRL, dotted line) and limit reference (LRL, dashed line) levels are shown, as well as the 2015 abundance estimate (two-dashed line) as suggested recovery objectives.

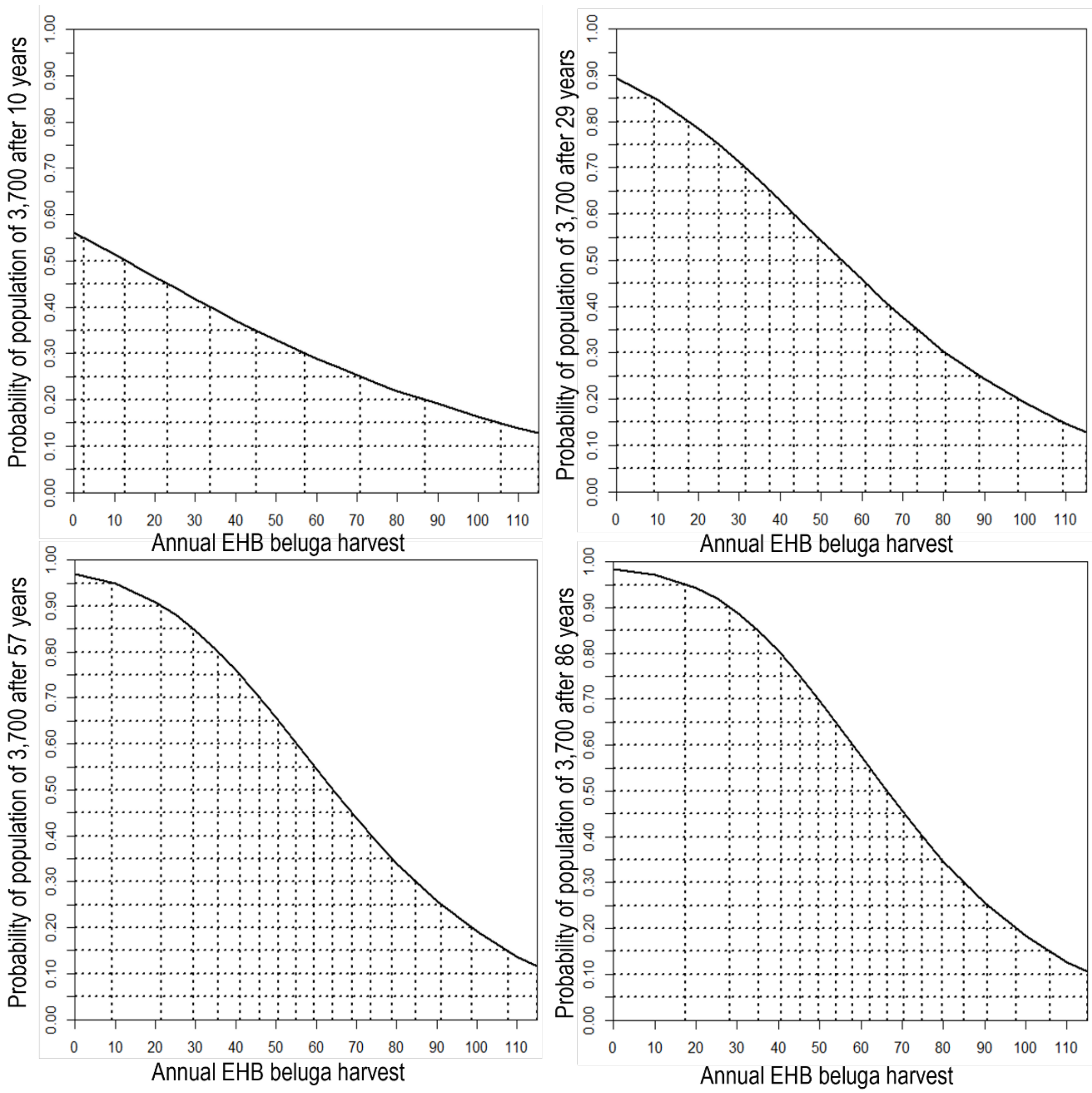

Figure 12. Probability that the BEL-EHB beluga stock would be greater than the 2015 abundance estimate after 10 years, or one, two or three generation times.

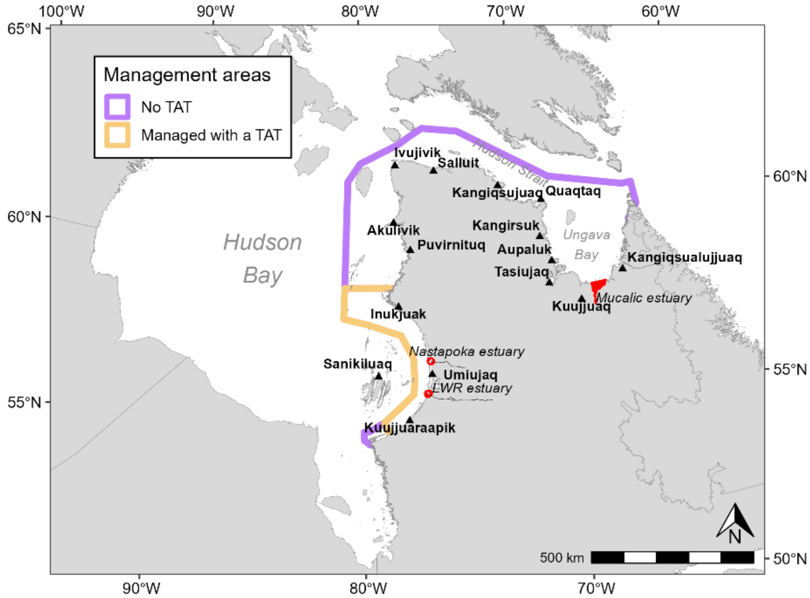

Figure 13. Nunavik beluga management areas, characterized by a total allowable take (TAT) and non-quota limitations (yellow contour), non-quota limitations only (purple contour), and estuaries closed to hunting (red zones).

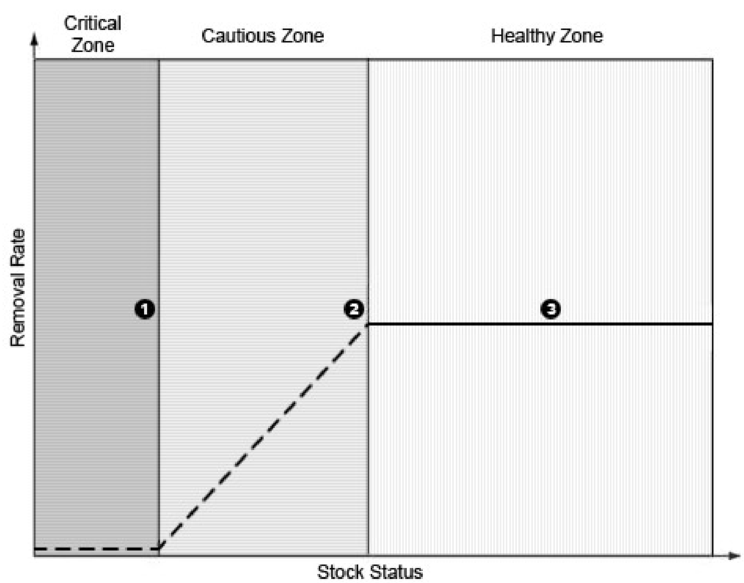

Figure 14. Suggested precautionary approach framework for Fisheries and Oceans Canada (DFO). 1) The limit reference level (LRL); 2) the precautionary preference level (PRL); and 3) a removal rate identified to maintain the resource within the Healthy zone (DFO 2006).

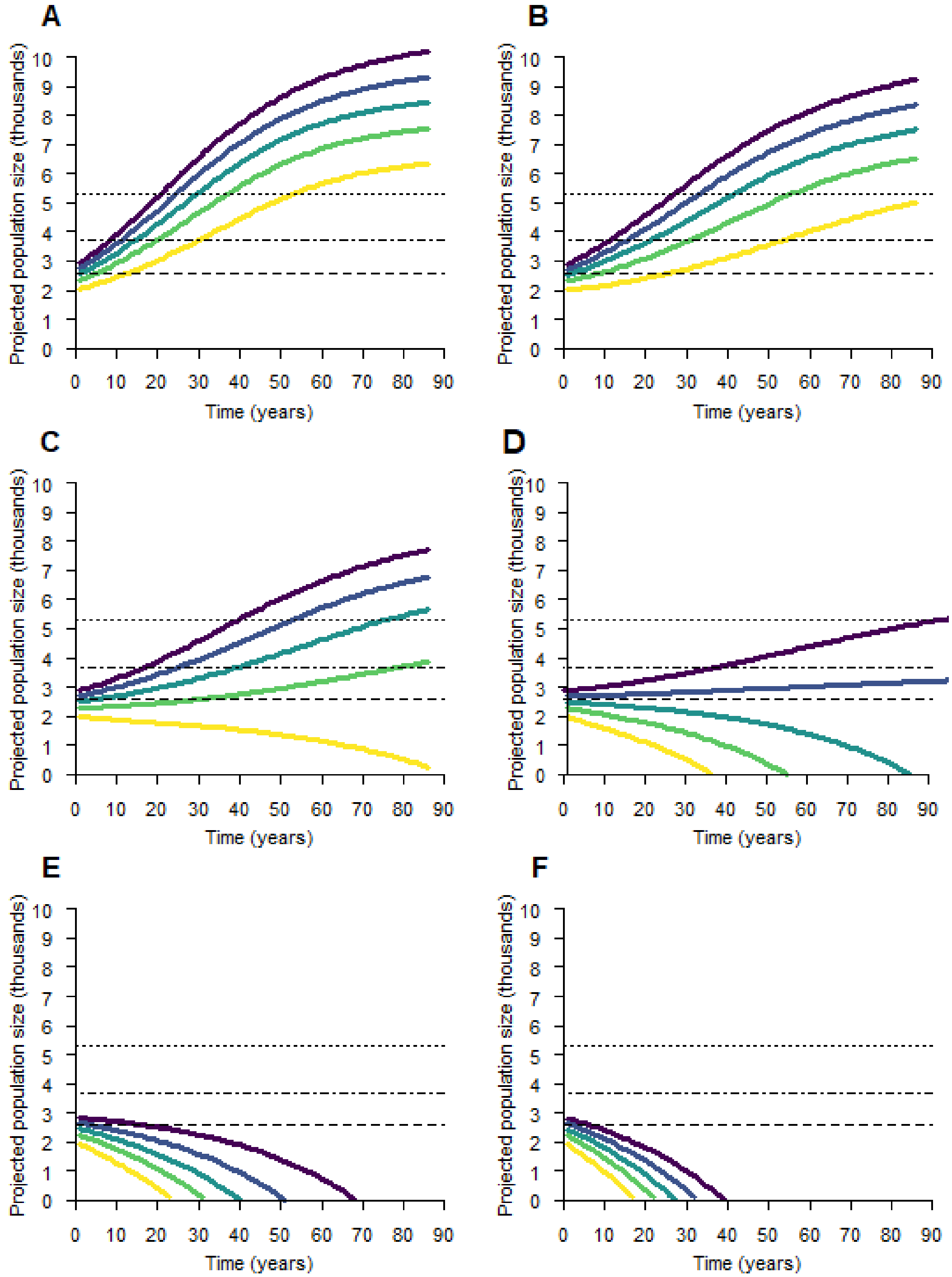

Figure 15. Population model projections for BEL-EHB beluga abundance over the next three generations (86 years). Initial year is 2022, and panels A, B, C, D, E, and F display projections assuming annual harvests of 0, 20, 40, 60, 80 and 100 whales, respectively. Dark purple, purple, blue, green and yellow lines represent > 50%, >60%, >70%, >80% and > 90% population percentiles, respectively. Precautionary approach (PRL, dotted line) and limit reference (LRL, dashed line) levels are shown, as well as the 2015 abundance estimate (two-dashed line) as a suggested recovery objective.

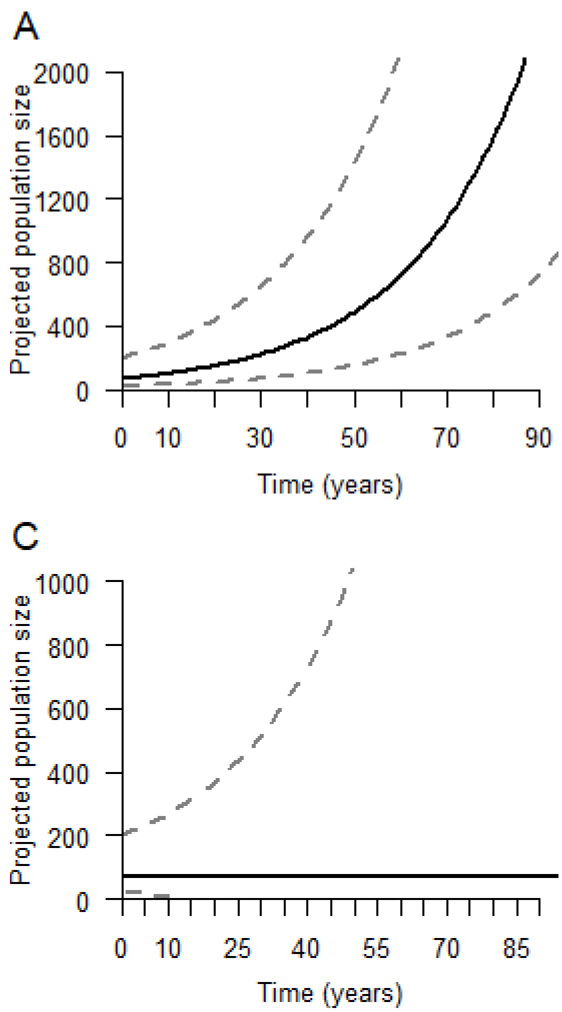

Figure 16. UB beluga population size projected over the next three generations using a 4% exponential growth curve and the 2022 aerial survey estimate (full black line) and 95% confidence interval upper and lower limits (grey dashed curves) as initial population sizes assuming annual harvests of 0, 1, 2 and 3 whales, for panels A, B, C and D, respectively. Note differences in y-axis scales between panels A-B and C-D.

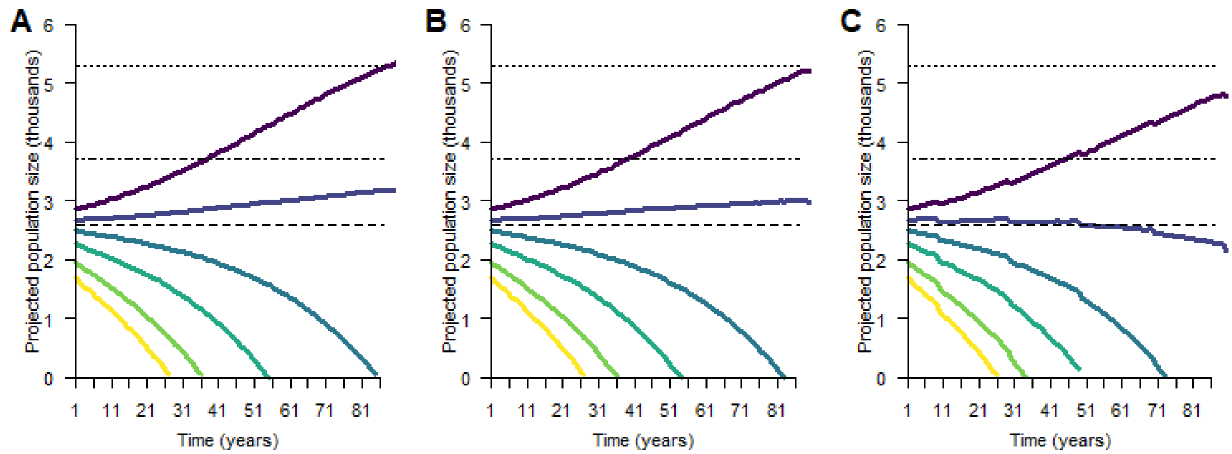

Figure 17. Exploration of the effects of UME on BEL-EHB beluga stock demography. Baseline harvest is set to 60 removals annually, and an UME occurs every 20 years of the simulation. A) No UME; B) An UME causing the mortality of 10 beluga every 20 years; C) An UME causing the mortality of 50 beluga every 20 years. Dark purple, purple, blue, turquoise, green and yellow lines represent > 50%, >60%, >70%, >80%, > 90%, and > 95% population percentiles, respectively. Precautionary approach (PRL, dotted line) and limit reference (LRL, dashed line) levels are shown, as well as the 2015 abundance estimate (two-dashed line) as a suggested recovery objective.

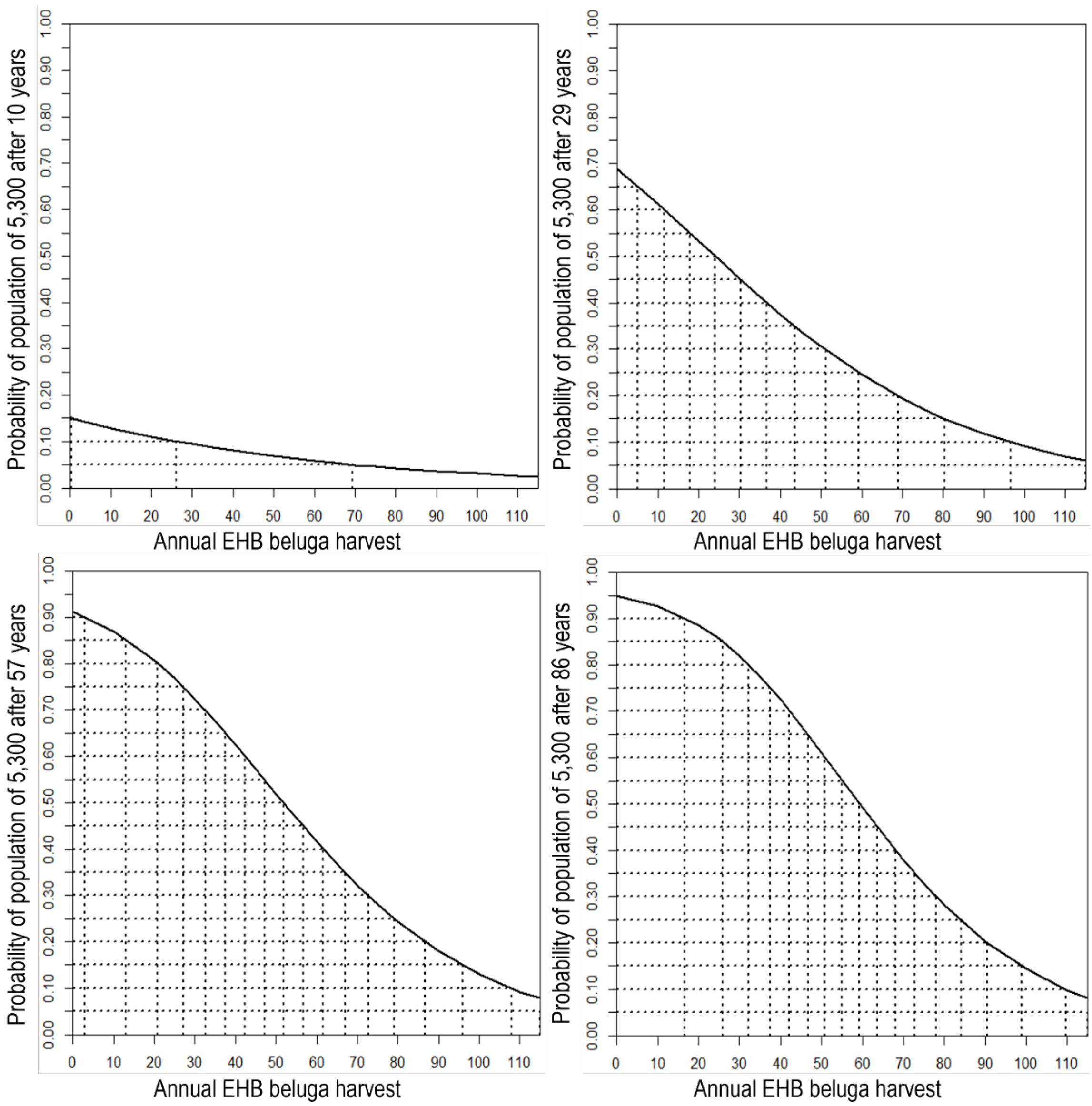

Figure 18. Probability that the BEL-EHB beluga stock would be greater than the PRL (5,300 whales) after 10 years, or one, two or three generation times.

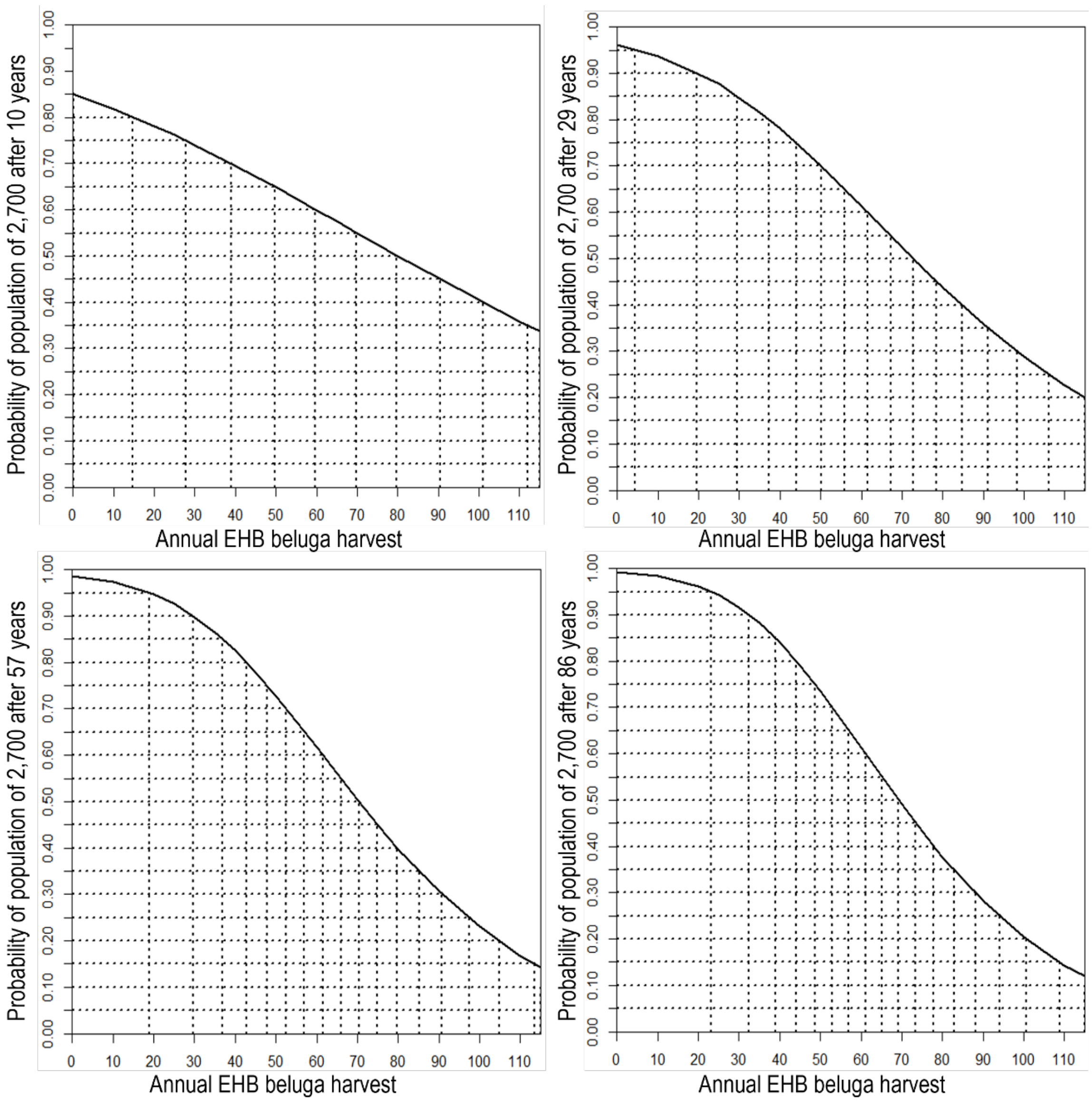

Figure 19. Probability that the BEL-EHB beluga stock would be greater than the LRL (2,700 whales) after 10 years, or one, two or three generation times.

TABLES

Table 1. Life history parameters for BEL-EHB and UB beluga. Parameters from studies where age was estimated assuming the deposition of two growth layer groups (GLG) per year were adjusted to reflect the fact that beluga deposit only one GLG per year. (F): female, (M): male.

Life-history parameter	Value	Reference
Age at sexual maturity	(F) 8-14 years (M) 8-22 years	Doidge 1990b; Sergeant 1973; Ferguson et al. 2020
Age at physical maturity (BEL-EHB only)	(F) 15 years (M) 10 years	Derived from Gompertz curves in Doidge 1990a
Age of reproductive senescence of females	35-50 years (but can be > 70 years)	Burns and Seaman 1986; Ellis et al. 2018; Ferguson et al. 2020
Longevity	45-89 years	McAlpine et al. 1999; Hobbs et al. 2015; Lesage et al. 2014; Ferguson et al. 2020
Gestation time	12.8-15 months	Doidge 1990b; Matthews and Ferguson 2015
No. of offspring per birth	1	Doidge 1990b; Matthews and Ferguson 2015
Lactation duration	2 years	Doidge 1990b; Matthews and Ferguson 2015
Inter-birth interval	3 years	Doidge 1990b; Matthews and Ferguson 2015
Generation time	26.8 years	Lowry et al. 2017
Adult natural mortality Young adults (9-44 years) Old adults (> 45 years)	 1-6% 8-17%	Hoenig 1983, Burns and Seaman 1986; Doidge 1990b; Hobbs et al. 2015; Mosnier et al. 2015; Hammill and Lesage 2019; Tinker et al. 2024

Table 2. Threat assessment for the BEL-EHB and UB belugas based on DFO (2014a) guidelines. H: Historical, C: Current, A: Anticipatory.

Threat	Likelihood of Occurrence	Level of Impact	Causal Certainty (Rank)	Population-Level Threat Risk	Population-Level Threat Occurrence	Population-Level Threat Frequency	Population-Level Threat Extent
Subsistence Harvest	Known	High (BEL-EHB), Extreme (UB)	Very high	High	H, C, A	Continuous	Extensive
Anthropogenic noise	Known	Medium-low	High-Medium	Unknown	C, A	Recurrent	Extensive
Chemical pollution	Unlikely	Low	Medium	Low	A	Continuous	Extensive-Narrow*
Industrial development	Likely	Unknown	Medium	Unknown	H, C, A	Continuous	Narrow
Vessel traffic	Likely	Unknown	Medium	Unknown	C, A	Recurrent	Broad
Commercial fisheries	Known	Unknown	Low	Unknown	C, A	Recurrent	Broad
Climate change	Likely	Unknown	Very low	Unknown	C, A	Continuous	Extensive

**Population-level threat extent may vary depending on the type of chemical pollution. A small restricted oil spill will only impact a fraction of the population in comparison to continuous inputs of chemicals widespread in the ecosystem which may affect the population as a whole.*

Table 3. Temporal population size benchmarks related to the recovery targets identified for BEL-EHB beluga. The total number of beluga are presented along with the number of mature individuals in parentheses. These numbers are subject to change based on future survey results and population model simulations informed by the latter.

Recovery target	Population in 10 years	Population in one generation (28.6 years)	Population in two generations (57.2 years)	Population in three generations (85.8 years)
1. Attain or exceed the 2015 abundance estimate.	3,700 (2,500)	3,700 (2,500)	3,700 (2,500)	3,700 (2,500)
2. Attain a population ≥ PRL in 3 generations	3,000* (2,000)	3,400* (2,300)	4,300* (2,900)	5,300 (3,600)
3. Attain a population size corresponding to the maximal demographic growth given no harvest	3,900 (2,600)	6,300 (4,300)	9,100 (6,200)	10,200 (6,900)

*Based on a harvest level of 60 beluga annually, which represents the highest harvest level compatible with this objective. Inter-annual variations in harvest levels would result in various scenarios to attain this recovery target.

Table 4. Temporal population size benchmark related to the recovery targets identified for UB beluga. The total number of beluga are presented along with the number of mature individuals in parentheses. These numbers are subject to change based on future survey results and population growth functions informed by the latter.

Recovery target	Population in 10 years	Population in one generation (28 years)	Population in 2 generations (57 years)	Population in 3 generations (86 years)
1. Maintain the population at or above the 2022 abundance estimate	70 (50)	70 (50)	70 (50)	70 (50)
2. Attain a population size corresponding to the maximal demographic growth given no harvest	100 (70)	200 (140)	640 (440)	1,980 (1,300)

Table 5. Overview of feasible mitigation measures and alternatives to activities considered as threats to the BEL-EHB and UB beluga in Canada.

Threat	Mitigation measures and/or alternatives to activities
Subsistence harvest	1) Continue to develop co-management strategies for traditional whaling, in support of treaty negotiated rights. 2) Implement precautionary approaches in co-management strategies. 3) Manage beluga harvest at the estuary level, and develop management measures to avoid over harvesting within family groups of beluga who may be vulnerable to single, large harvest events. 4) Public outreach and communication within eastern Hudson Bay and Ungava Bay communities on the status and population trends of BEL-EHB and UB beluga to improve support and compliance with management measures, and improve reporting of struck and loss.
Anthropogenic noise	1) Apply DFO standards for mitigation of seismic noise, regional implementation protocols (i.e., The Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment). 2) Ensure adequate enforcement of the Canadian *Marine Mammal Regulations* (MMR) regional guidelines. 3) Avoid, reduce or shift (geographically and/or temporally) underwater anthropogenic noise sources which overlap or are in close proximity to important habitat for BEL-EHB and UB beluga. 4) Promote development of quieting technologies for vessels.
Industrial development	1) Avoid coastal development, industrialization, or any other activity with the potential to disrupt or destruct costal summering habitat used by BEL-EHB and UB beluga. 2) Review project proposals with potential to impact to areas used by BEL-EHB and UB beluga (e.g., use of seismic or sonar surveying) and provide project-specific advice for mitigation or avoidance with respect to beluga habitat use.
Chemical pollution	1) Document and identify sources of marine pollution. Investigate how to reduce marine pollution at the source. 2) Ensure preventative measures are in place to avoid toxic spills of any nature. 3) Develop a comprehensive toxic spill response to mitigate or avoid impacts to beluga whales or their habitat in Canada. 4) Ensure those responsible for toxic spills have appropriate teams, training and materials to rapidly respond to and remediate spill events.
Fisheries	1) Initiate and promote a beluga entanglement reporting system in the Nunavik Marine Region and Labrador Sea. 2) Public outreach and communication on the importance of reporting beluga bycatches. 3) Undertake a spatial-temporal mapping exercise to document fishing efforts in the beluga wintering grounds. 4) Acquire more data on beluga distribution in wintering grounds, areas important for foraging, diet, and energetic requirements to quantify any competition between BEL-EHB and UB beluga and commercial fisheries.
Vessel traffic	1) Initiate and promote a vessel strike reporting system in the Nunavik Marine Region 2) Ensure adequate enforcement of the Canadian *Marine Mammal Regulations* (MMR) regional guidelines.

Threat	Mitigation measures and/or alternatives to activities
	3) Acquire more data on BEL, EHB and UB migration routes and timing, and undertake a spatial-temporal mapping exercise to identify high-risk areas and periods for vessel strikes, icebreaker-induced ice entrapments, and physical and noise disturbance caused by vessels. These high-risk areas and periods could be targeted for mitigation measures aimed at reducing the threat to BEL-EHB and UB beluga recovery posed by vessel traffic.
Climate change	Mitigation measures to limit climate change are global and non-specific to beluga populations. All efforts aiming at reducing emissions of greenhouse gases are susceptible to moderate the impacts of climate change on BEL-EHB and UB beluga.

Table 6. Posterior estimates of carrying capacity (K), maximum rate of increase (λmax), struck and loss, and population abundance in 2022 (N_{2022}) for the BEL-EHB stock.

Parameter	BEL-EHB estimate (95% CI)
K	11, 043 (6,437-19,410)
Lambda max	0.035 (0.021-0.055)
Struck and loss	0.273 (0.017-0.756)
N_{2022}	2,833 (1,541-4,073)

APPENDIX A – LIST OF MEETING PARTICIPANTS

Table A.1. This Research Document is from the February 20-24, 2023 national peer review on Recovery Potential Assessment of Beluga Whale (Eastern Hudson Bay and Ungava Bay populations).The authors which to acknowledge the meeting participants who contributed to the revision and improvement of the present RPA.

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APPENDIX B – TERMS USED TO DESCRIBE SUB-UNITS OF A SPECIES, AND APPLICATION TO BELCHER ISLANDS-EASTERN HUDSON BAY (BEL-EHB) AND UNGAVA BAY (UB) BELUGA

Sub-unit term	Definition	Application to BEL-EHB beluga	Application to UB beluga
Stock	A group of animals capable of independent exploitation or management (Royce 1972). A stock therefore refers to animals located within a management unit and may include more than one population, or only a subset of individuals from a population.	Aerial surveys conducted to estimate beluga abundance in the eastern Hudson Bay area extend from the Hudson Bay coast to the East, to West of Belcher islands. Population models and derived projections and harvest advices therefore encompass all beluga summering in that management unit. Based on most recent genetic data, beluga from this area form a genetically mixed BEL-EHB stock (Parent et al. 2023), and there is currently no data to inform the relative size of these two populations forming the stock.	Aerial surveys conducted to estimate abundance of beluga summering in Ungava Bay encompasses the entire bay, from bottom to 61.0ºN, as well as most estuaries in southern Ungava Bay. Harvest advices derived from this survey data thus apply to beluga harvested in summer throughout Ungava Bay, including its southern estuaries.
Population	A group of interbreeding individuals occurring together in time and space (Waples and Gaggiotti 2006). A population therefore captures the notion of genetic structure among geographically delineated areas. Beluga populations are geographically defined based on their summer habitat, as less is known about beluga winter distribution and there is potential spatial overlap among populations during winter.	In the Belcher Islands-eastern Hudson Bay area, two genetically distinct beluga populations are identified during summer: one harvested around the Belcher Islands (BEL), and one harvested along the coast of eastern Hudson Bay (EHB) (Parent et al. 2023). In previous genetic studies that used a shorter haplotype for genotyping, most BEL beluga were indistinguishable from Western Hudson Bay (WHB) individuals (Parent et al. 2023).	No endemic population summering in Ungava Bay could be identified based on mitochondrial DNA analyses (Parent et al. 2023). However, sample size for this area is very limited, especially for the south of the Bay where historical aggregations occurred. Obtaining addition samples from southern Ungava Bay and its estuaries in summer is necessary to assess whether beluga summering in the area form a genetically distinct population.
Designatable unit (DUs)	Discrete and evolutionarily significant units of the taxonomic species (COSEWIC 2020b). Discreteness refer to little or no transmission of heritable information between units, and encompasses genetic differentiation, natural disjunction between portions of the species range, or ecological isolation. Evolutionary significance refer to the importance of the unit to the evolutionary legacy of the species, and that if lost the individuals forming the unit would not be replaced through natural dispersion.	The EHB DU is defined by estuarine concentrations at the Nastapoka, Great Whale, and Little Whale rivers, with the main area of summer coastal occupation extending from Kujjuarapik to Inukjuak (COSEWIC 2016). Individuals perform repeated inshore-offshore movements extending out to the Belcher Islands (Bailleul et al. 2012a), where they mix with beluga from other DUs (WHB, JB) during summer (COSEWIC 2016). The genetic distinctiveness of EHB beluga was used to support the discreteness and evolutionary significance criteria in the last COSEWIC assessment (2016), before the identification of the BEL population. Therefore, the beluga DU structure in the eastern Hudson Bay and Belcher Islands area may eventually be redefined by COSEWIC.	The UB beluga DU is defined based on a historical aggregation centered near the Marralik River estuary, with additional smaller concentrations at the George, Soak, Leaf, and Whale river. The recognition of the UB DU is based primarily on TEK and historical harvest records. There are no genetic data to support or refute the discreteness or significance of this DU. However, COSEWIC considers that migrating beluga from other DUs occur in Ungava Bay in spring, fall and winter, but not summer. Hence, if the UB DU were to become extirpated, or has been already, much of southern Ungava Bay would remain unoccupied by beluga during summer (COSEWIC 2016).

APPENDIX C – PRIORS USED TO FIT BELUGA POPULATION MODELS

Table C.1. Prior distributions, parameters, and hyper-parameters used in the BEL-EHB beluga population models. Median and 0.025 and 0.975 quantiles are shown.

.Parameters	Notation	Prior distribution	Hyper-parameters	Parameter value	Prior median	0.025	0.975
Survey precision (t)	ε_{S_t}	Fixed		1 / (Survey standard error)^2	-	-	-
Process error (t)	ε_{pt}	Log-normal	μp / τp	0 / estimated	1 / inf	0	inf
Precision (Process)	τp	Gamma	αp / βp	1.5 / 0.005	236.6	21.6	934.8
Theta	θ	Fixed	-	-	2.39	-	-
Struck and loss 25%	SL	Beta	αsl / βsl	1.135 / 2.763	0.25	0.015	0.755
Initial population (BEL-EHB)	Start	Uniform	Nupp / Nlow	15,000 / 2,000	8,500	2,325	14,675
Carrying capacity (BEL-EHB)	K	Uniform	Nupp / Nlow	20,000 / 5,000	12,500	5,375	19,625
Maximum rate of increase	λ_{max}	Beta	αsl / βsl	15.618 / 373.015	0.039	0.023	0.062

Table C.2. Prior distributions used in the population model for the proportion of BEL-EHB animals harvested in Nunavik and Nunavut, by region. HSUB = prior to 2009 most samples were from the Hudson Bay-Ungava Bay area from the fall but harvest area is not known. These are assigned the same parameters as HS_F. Median and 0.025 and 0.975 quantiles are shown.

Nunavut

Parameters	Notation	Prior distribution	Hyper-parameters	Parameter value	Prior median	0.025	0.975
Sanikiluaq (Spring)	PSAN_S	Beta	αsan / βsan	45.778 / 27.164	0.629	0.515	0.734
Sanikiluaq (Fall)	PSAN_F	Beta	αsan / βsan	8.194 / 5.323	0.6113	0.344	0.837
Sanikiluaq (Winter)	PSAN_W	Beta	αsan / βsan	3.697 / 5.493	0.396	0.131	0.7151
Sanikiluaq (Summer)	PSAN_SU	Fixed	-	-	1	-	-

Nunavik

Parameters	Notation	Prior distribution	Hyper-parameters	Parameter value	Prior median	0.025	0.975
Hudson Strait (Spring)	PHS_S	Beta	Ahs_sp / βhs_sp	32.11 / 229.09	0.122	0.086	0.165
Hudson Strait (Fall)	PHS_F	Beta	Ahs_f / βhs_f	50.58 / 64.36	0.44	0.351	0.532
HSUB *	PHSF	Beta	αhs / βhs	50.58 / 64.36	0.44	0.351	0.532
Ungava Bay (Spring)	PUB_S	Beta	αub_s / βub_s	3.13 / 57.43	0.047	0.015	0.12
Ungava Bay (Fall, used HS Fall)	PUB_F	Beta	Aub_f / βub_f	50.58 / 64.36	0.44	0.351	0.532
Northeast Hudson Bay (used HS spring)	PNEHB_S	Beta	Anehb_s / βnehb_s	32.11 / 229.09	0.122	0.086	0.165
Northeast Hudson Bay (Fall)	PNEHB_F	Beta	Anehb_f / βnehb_f	6.228 / 6.20281	0.50	0.24	0.762