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Ecological and Biophysical Overview of the Southampton Island Ecologically and Biologically Significant Area in support of the identification of an Area of Interest

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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.

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TABLE OF CONTENTS

ABSTRACT

The Government of Canada has committed to protect 10% of its coastal and marine areas. One means of protection is through the development of Marine Protected Areas (MPAs). In Nunavut, Regional Inuit Associations along with other stakeholders provided guidance to identify potential Areas of Interest (AOI) for a Marine Protected Area process. In the Kivalliq Region of Nunavut, the marine waters adjacent to Southampton Island (SI) were identified as one AOI. The Southampton Island Ecologically and Biologically Significant Area (SI EBSA) provides valuable migratory habitat for Beluga (*Delphinapterus leucas)*, Bowhead (*Balaena mysticetus*) and Narwhal (*Monodon monoceros)*, as well as feeding and calving areas for a proportion of these marine mammal populations. The SI EBSA is home to large aggregations of seabirds such as the two colonies of Thick-Billed Murres (*Uria lomvia*) on Coats Island and the largest single colony of Common Eiders (*Somateria mollissima*) in Nunavut. Resident marine mammals to the SI EBSA include Walrus (*Odobenus rosmarus*) and Polar Bear (*Ursus maritimus*) populations. In addition, migratory Arctic Char (*Salvelinus alpinus*) are the most abundant salmonid that is available for subsistence harvesting to Inuit communities living adjacent to the SI EBSA. The recurring polynya in Roes Welcome Sound provides approximately 52 km^2 of open water during winter and is believed to play an important role in deep water formation and nutrient cycling in Hudson Bay, which may support high benthic productivity, and in turn large numbers of migrating birds and marine mammals. The polynya also provides valuable overwintering habitat for Walruses, Bearded *Seals* (*Erignathus barbatus*), and small numbers of Belugas in some years. This document provides a summary and synthesis of existing information relevant to the SI EBSA which has been used to determine its ecological significance, as well as known knowledge gaps and vulnerabilities.

INTRODUCTION

Fisheries and Oceans Canada (DFO), under the authority of the *Oceans Act* (1996), and with Indigenous partners, is working to establish a national system of Marine Protected Areas (MPAs) to conserve and protect Canada's marine resources. In 2010, the Government of Canada signed Aichi Target 11 which committed Canada to conserving 10% of coastal and marine areas within Canada's jurisdictional boundaries by 2020. Marine conservation will be achieved through managed networks of protected areas (e.g., Tarium Niryutait and Anguniqvia niqiqyuam MPAs) and Other Effective Area-Based Conservation Measures (e.g., Disko Fan, Davis Strait and Hatton Basin fishery closures). The Government of Canada's approach to achieving marine conservation targets is guided by the foundational principles of science-based decision making, transparency, and advancing reconciliation with Indigenous peoples. The *Oceans Act* (1996) explicitly references land claims agreements, and MPA processes, and future MPAs within the Nunavut Settlement Area will respect obligations under the Nunavut Agreement.

The National Framework for Establishing and Managing MPAs (DFO 1999) outlines five major steps as follows:

1) selection of an Area of Interest (AOI);
2) conducting an ecological, social, cultural, and economic overview and assessment of the AOI;
3) determining activities that could and those that should not be allowed in the MPA;
4) developing the regulatory process and designation of the MPA; and
5) managing the MPA. Consultation with Indigenous partners occurs at all stages of the process.

In Nunavut, the second step of overview and assessment will also specifically include Inuit traditional knowledge.

In August 2016, an AOI Working Group comprising DFO, Nunavut Tunngavik Inc. and Regional Inuit Associations was established to guide the process of identifying potential AOIs in the three regions of Nunavut (Kitikmeot, Kivalliq, and Qikiqtani). Other stakeholders provided expertise to the AOI Working Group. The Working Group started with previously identified Ecologically and Biologically Significant Areas (EBSAs). In March and April of 2017, consultations were conducted with communities in the vicinity of nine potential AOIs, three in each Nunavut region. Southampton Island (SI) EBSA was one of three potential AOIs for the Kivalliq Region of Nunavut. In June 2018, a letter of support to move forward with advancing marine protection was received from the Kivalliq Inuit Association (KIA). KIA and DFO re-engaged communities regarding a proposed Southampton Island AOI, and consultations to confirm the support of community members for a Southampton Island AOI were conducted in September 2018 in three communities: Coral Harbour, Naujaat, and Chesterfield Inlet, NU.

The SI EBSA is located in southern Foxe Basin, west of Hudson Strait (Figure 1). The area was identified as an EBSA in 2011 based on marine mammal and seabird use (DFO 2011a). The EBSA provides valuable migratory habitat for Bowhead and Narwhal, as well as aggregation areas for Polar Bear, Walrus and large numbers of seabirds (Cobb 2011). The marine portions of a migratory bird sanctuary extend into the SI EBSA and these areas support large numbers of nesting seabirds during spring and summer. The SI EBSA supports the largest single colony of Common Eiders (*Somateria mollissima*) in Nunavut. In 2013, the SI EBSA was identified by the International Maritime Organization as meeting several criteria for Particularly Sensitive Sea Area (or PSSA) designation (AMAP et al. 2013).

This document is intended to 1) summarize existing and new scientific information and Inuit Qaujimajatuqangit (IQ) relevant to the SI EBSA, and 2) identify ecological importance of the region, to help inform the conservation objectives in the development process of the MPA.

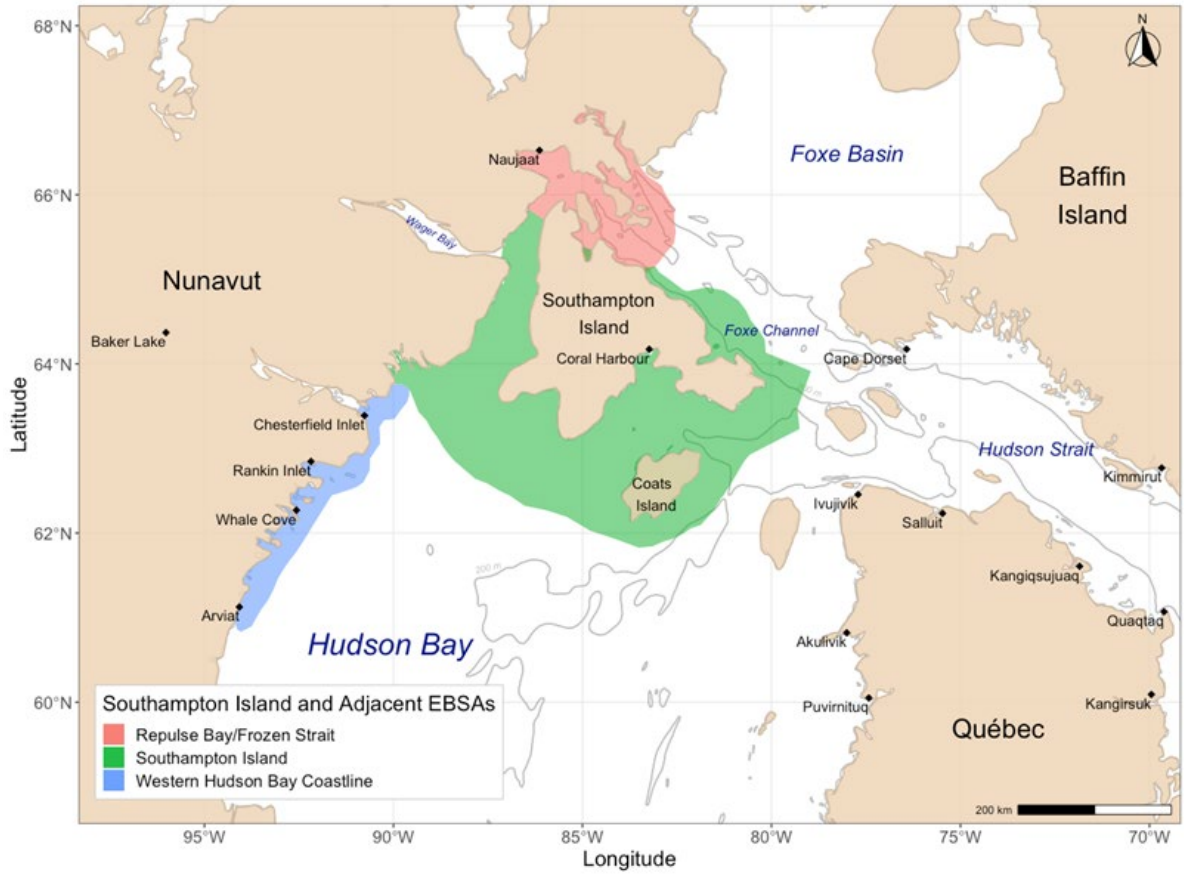

Figure 1. The Southampton Island Ecologically and Biologically Significant Area (EBSA; green shading) within the Hudson Bay Complex (Hudson Bay, Hudson Strait and Foxe Basin) biogeographic region of the Canadian Arctic.

ENVIRONMENTAL AND ECOLOGICAL INFORMATION

REGIONAL CONTEXT

The SI EBSA is located west of Hudson Strait and is situated between northwestern Hudson Bay and southwestern Foxe Basin (Figure 1). Southampton Island is the largest island occurring in the Hudson Bay/Foxe Basin region, is roughly triangular in shape, and encompasses an overall area of 41,214 km^2 (Bird 1953). The EBSA is part of the Hudson Bay Complex (Hudson Bay, Hudson Strait and Foxe Basin) biogeographic region (DFO 2009), which is located in the Kivalliq Region of Nunavut. The community of Coral Harbour (Salliq) is located on southern Southampton Island in South Bay.

SI EBSA boundaries extend approximately 40 km off its northeastern shore, south to include waters surrounding Coats Island, and all of Roes Welcome Sound to the west (Figure 1). Coats Island is located about 130 km south of Coral Harbour, has an area of 5,600 km^2 (Gaston and Ouellet 1997), and is separated from Southampton Island by Fisher and Evans straits in Hudson Bay (Figure 2). Waters bordering northern Southampton Island (including Frozen Strait and

Repulse Bay) are not included as part of the SI EBSA. Rather, these waters are considered as a separate EBSA (Repulse Bay/Frozen Strait) based on marine mammal and seabird foraging (DFO 2011a).

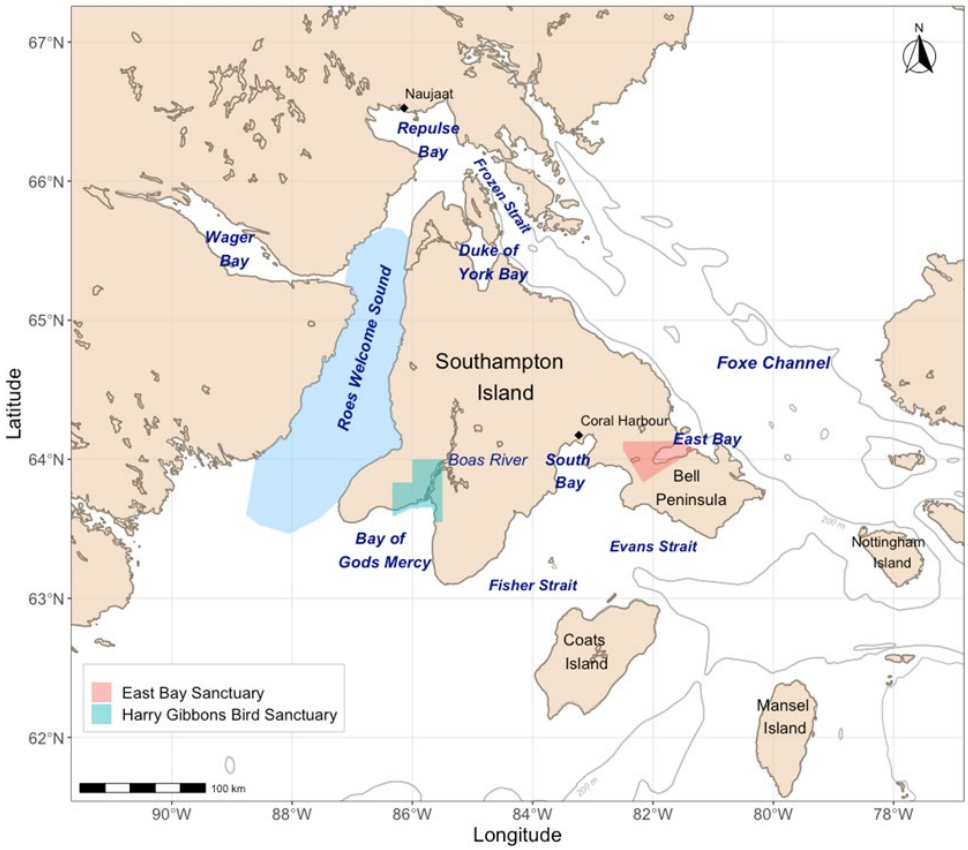

Figure 2. Map of waterbodies and important locations around the Southampton Island EBSA identified within this document.

Within the SI EBSA, a recurring coastal polynya occurs in Roes Welcome Sound between the northwestern shore of Southampton Island and the western Hudson Bay coast (Figure 2; Stirling 1980, Barber and Massom 2007, Hannah et al. 2009). This polynya provides approximately 52 km^2 of open water during January and about 107,107 km^2 during July (Barber and Massom 2007). A coupled ice-ocean model (Saucier et al. 2004) showed that wind forcing was the dominant mechanism responsible for the opening and maintenance of the polynya (Barber and Massom 2007). Mean opening date occurs around the beginning of December and mean merging date with other open water occurs at the end of June (Barber and Massom 2007). Strong currents maintain the polynya throughout the winter, making it a desirable habitat for Walrus, birds and other marine mammals (i.e., Belugas and Bowhead Whales). The importance of this polynya to distribution and movement of marine mammals will be discussed in more detail in the sections below.

CLIMATE

The SI EBSA falls within the Arctic climate zone and is characterized by long, cold, dry winters and short, cool summers. At Coral Harbour, the duration of daylight ranges from a maximum of 21 hours in late June to a minimum of about 4.5 hours during late December . The island itself has prevailing northwesterly winds for most of the year, resulting in a subsiding air flow from

continental Melville Peninsula, except for July and August when the eastern coastlines are influenced by maritime conditions. Annual precipitation in the region is generally higher than areas to the west or north in the Canadian Arctic Archipelago (CAA) with nearly half falling as rain.

Average daily air temperatures in this region range from 10°C in July to -30°C in January and February and remain below zero for much of the year (Figure 3). Precipitation is generally highest in August (59 mm or more) and lowest in February (Figure 4). These temperatures have been increasing in recent decades. For example, from 1950–2007, Zhang et al. (2011) identified relatively large increases in mean annual air temperature and precipitation throughout the Arctic, including a 1.5–3°C increase for Coral Harbour. Using a variety of data sources, Galbraith and Larouche (2011) identified a general warming trend in the Hudson Bay Complex since the 1930s and 40s, with a significant warming trend from 1992–2011. Twelve of the 19 warmest summers on record in Hudson Bay and Hudson Strait occurred between 1991 and 2009. A 10–40% significant increase in precipitation was noted for Coral Harbour from 1950–2007 with much of that increase occurring during winter (Zhang et al. 2011).

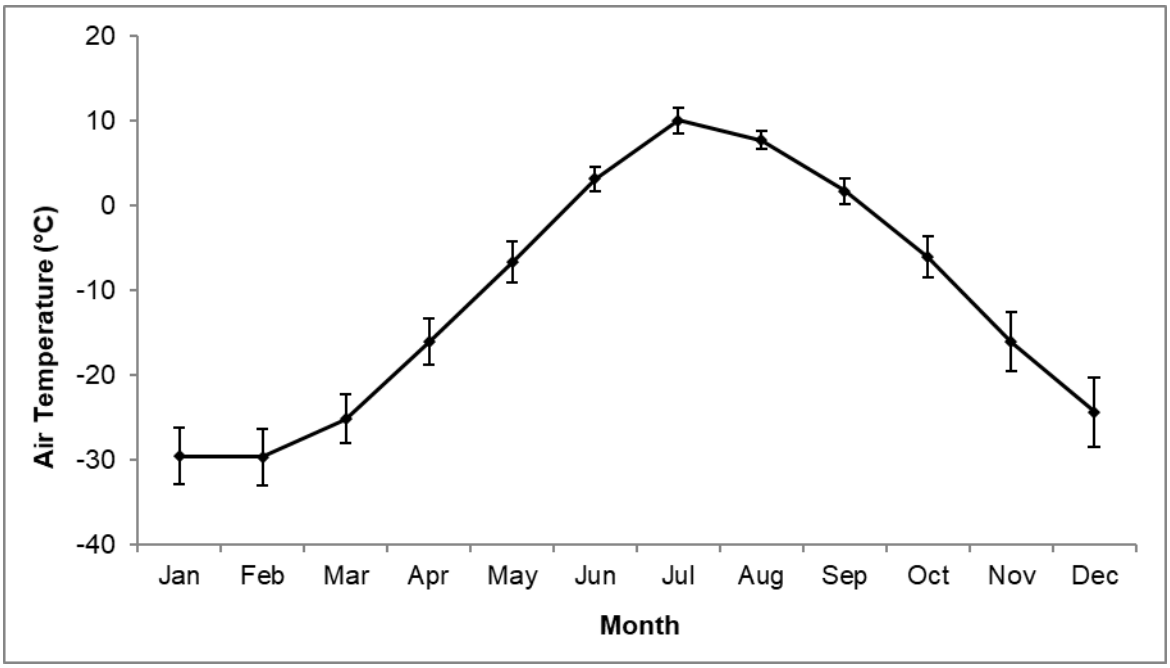

Figure 3. Average air temperatures ± standard deviation by month (1981-2010) collected from the Environment and Climate Change Canada (ECCC) meteorological station located at Coral Harbour, NU (Source: ECCC 2017).

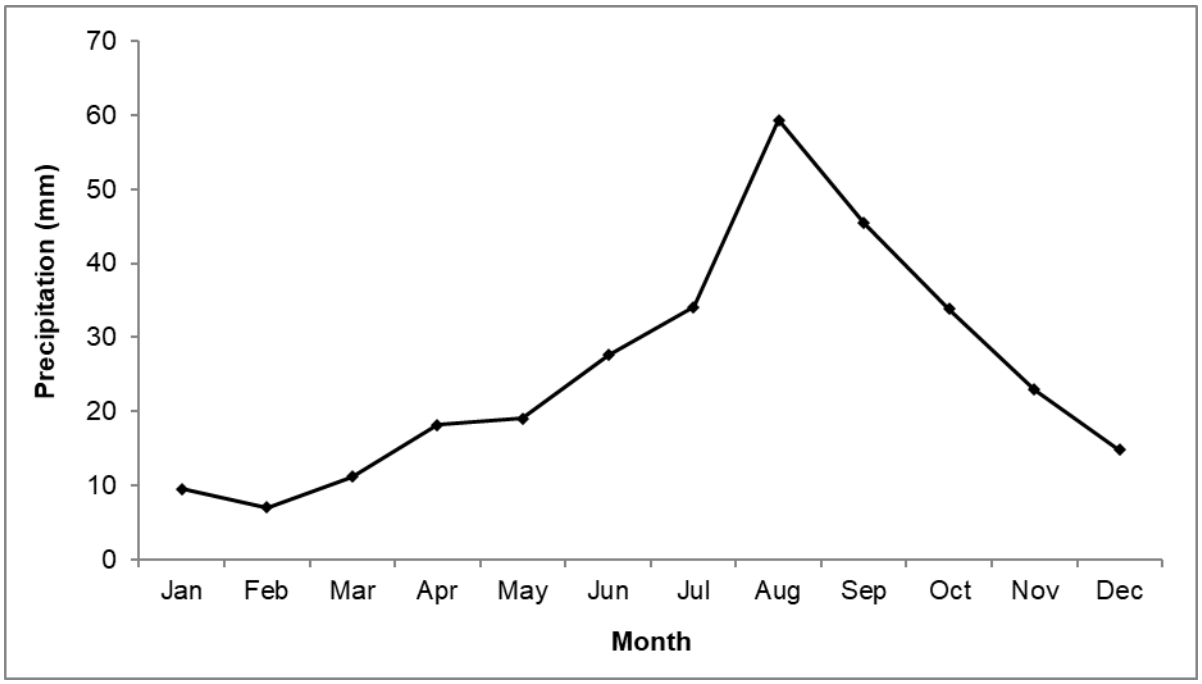

Figure 4. Average accumulations of precipitation by month (1981–2010) collected from the ECCC meteorological station located at Coral Harbour, NU (Source: ECCC 2017).

GEOLOGY AND BATHYMETRY

The geology of Southampton Island is complex but can be separated into two distinct geological regions. The northeast area of SI is an exposed highland of Precambrian basement rock that consists of a complex of high-grade plutonic gneiss, along with intrusive and metasedimentary rocks (LaFlamme et al. 2014, Sanborn-Barrie et al. 2014). These rocks belong to the Rae Craton of the Churchill Province and exhibit evidence of tectonic activity due to the Trans-Hudson Orogen collision during the Paleoproterozoic (Berman et al. 2013, Sanborn-Barrie et al. 2014). These Precambrian formations form a generally rugged topography with steep-sided coastal cliffs rising abruptly 300–500 m ASL along the northern coastline of Southampton Island (Campbell 1959, Stewart and Lockhart 2005). Raised marine beaches from post-glacial uplift, are prominent features along the north coast of Southampton Island (Stewart and Lockhart 2005).

Paleozoic (Upper Ordovician to Lower Silurian) carbonate rocks are characteristic of the southern and western portion of Southampton Island (Lavoie et al. 2013, Sanborn-Barrie et al. 2014) and this is the most southerly area in Arctic Canada in which these rocks can be found (Bird 1953). The carbonate strata are between 180 to 300 m thick and consist mostly of dolomitized fossiliferous limestone (Sanborn-Barrie et al. 2014). Three oil-shale intervals occur in the Cape Donovan area (Heywood and Sanford 1976, Zhang 2008, 2011, Lavoie et al. 2013, Zhang and Lavoie 2013). Large Upper Ordovician reef structures belonging to the Red Head Rapids formation have been studied for hydrocarbon potential (Lavoie et al. 2015, Lavoie et al. 2016). These reefs represent a sponge-microbe-synsedimentary cement framework (Castagner et al. 2016). Southampton Island may also serve as a potential source of industrial limestone (Zhang et al. 2014). Well-preserved Ordovician trilobite fossils occur in the Cape Donovan lower oil shale interval and the “Boas River shale” (Zhang 2008). These Paleozoic formations generally produce low-lying relief characterized by sandy beaches, lagoons, and extensive tidal mud flats along much of the south and west coast of the island (Bird 1953, Campbell 1959, EAG

1984 in Stewart and Lockhart 2005). Southampton Island coastal beaches, storm ridges and marine bars are wave-built with sand around the low water mark and mainly pebbles, cobbles, and boulders farther onshore (Bird 1953). In Bay of God's Mercy, the tidal mud flats give way to extensive low-lying marshes that are part of the Harry Gibbons Migratory Bird Sanctuary (EAG 1984 in Stewart and Lockhart 2005). With continuing isostatic rebound since the last glacial period, these mudflats are still emerging in some areas of the Hudson Bay coast (Stewart and Lockhart 2005). For the Hudson Bay lowlands generally, it is about 1m per 100 years (i.e., an extremely fast rate) (Stewart and Lockhart 2005).

The geology of Coats Island is similar to Southampton Island. The underlying rocks in the northeast consist of Precambrian metamorphics (gneiss), while Paleozoic sedimentary rocks (limestone and sandstone) predominate elsewhere (Heywood and Sandford 1976, St-Onge et al. 2015). General topography consists of rocky upland in the Precambrian northeast and low-lying marshes elsewhere (Campbell 1959, Gaston and Ouellet 1997, Stewart and Lockhart 2005).

Fisher and Evans straits, which separate Southampton and Coats islands (Campbell 1959, Stewart and Lockhart 2005), have depths that can reach up to 220 m but the area is overall relatively shallow (<100 m). Bottom topography in this area is typically smooth and unbroken. Bay of God's Mercy and South Bay (Figure 2) both slope gently from land reaching maximum depths of 40–60 m (Stewart and Lockhart 2005). Northeast of Coats Island, the bottom deepens considerably towards Hudson Strait reaching 300–400 m off Digges Island (Campbell 1959). The north end of the Winisk Trough (Figure 5), a deep, trench-like feature extending northward from offshore the Winisk River estuary, lies off the south end of Coats Island where it is about 1.6 km wide with steep walls that drop to a depth of about 370 m (Josenhans and Zevenhuizen 1990, Stewart and Lockhart 2005).

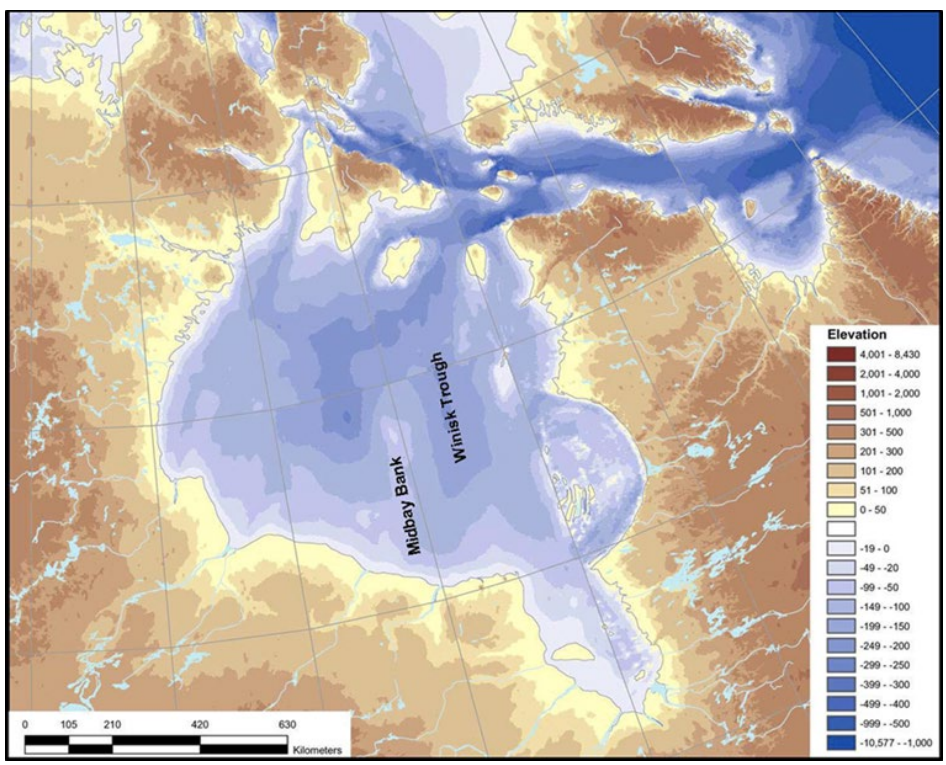

Figure 5. Topography and bathymetry (m) of the Hudson Bay Complex (Source: Stewart and Howland 2009).

North towards Foxe Channel, depths decrease to form a narrow ridge extending from Bell Peninsula to Nottingham Island that starts broad and flat, becoming narrow and uneven as Palaeozoic substrate transitions to Precambrian material. Nearshore areas on the north side of the Bell Peninsula and to the northeast have uneven bottom topography and sharp decreases in depth, reaching greater than 150 m only a few kilometers from the coast and a deep northwest-southeast trending trough that lies along the north side of Southampton Island in Foxe Channel (Campbell 1959, Stewart and Barber 2010). Depths in this trough are approximately 350 m in the southeast and nearly 400 m to the northwest where Frozen Strait begins (Stewart and Barber 2010). Although Repulse Bay is at present poorly mapped, current unpublished CTD cast data from 2018 and 2019 reveal that this region does reach approximately 250 m in depth. Near the mouth, at the flow edge region, Repluse Bay does become increasingly shallow (approximately 90 m) and forms a sill (M. Kamula, University of Manitoba, pers. comm.). Along the west side of Southampton Island in Roes Welcome Sound depths are approximately 55–85 m where gently sloping, smooth terrain similar to the south end of the island is more typical. General bathymetry of the SI EBSA is illustrated in Figure 5 and 6.

To our knowledge, the Winisk Trough area (Figure 5) is where glaciomarine sediment deposits are thickest in the region Marine deposits around Southampton and Coats islands consist largely of Phanerozoic sediments of the Hudson Platform, which in turn unconformably overlie and are surrounded by Precambrian basement rock (Lavoie et al. 2013). Much of the Hudson Bay seafloor between 72 and 175 m is marked by ice keel scours (1–5 m deep) with glacial till ridges (up to 15 m high) in nearshore areas deposited at the end of the last glacial period (Josenhans and Zevenhuizen 1990, Stewart and Lockhart 2005).

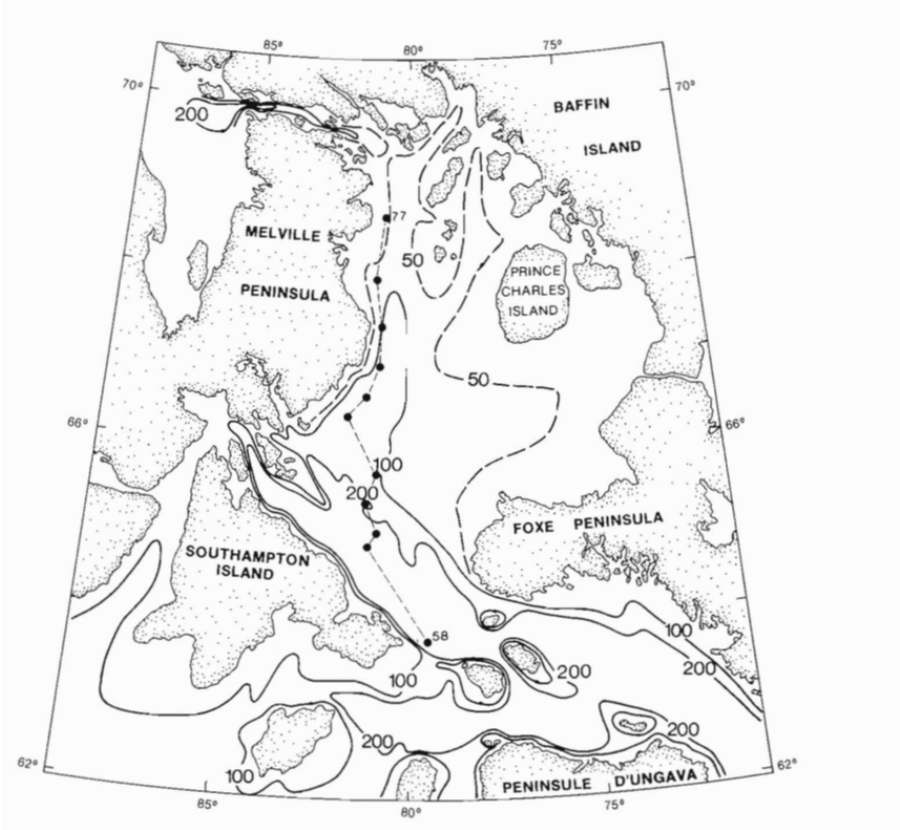

Figure 6. Bathymetry (in meters) of the Southampton Island region of Foxe Basin (Stewart and Lockhart 2005).

OCEANOGRAPHIC SYSTEMS

WATER MASSES AND GENERAL CIRCULATION

Foxe Basin, Hudson Bay, and Hudson Strait make up a large Canadian inland sea system, of which Southampton and Coats islands lay at the center. Arctic seawater from the northwest flows into the system through Fury and Hecla Strait, and from the east into northern Hudson Strait (via the Baffin Island Current), and outflow is to the Atlantic Ocean via southern Hudson Strait (Sadler 1982, Jones and Anderson 1994, Straneo and Saucier 2008, Stewart and Barber 2010). The amount of Arctic water that reaches Hudson Bay is relatively small compared to the amount that moves directly into Hudson Strait (Ingram and Prinsenberg 1998), but it strongly influences oceanographic conditions in the bay (Tan and Strain 1996, Stewart and Lockhart 2005). The net volume flux through Hudson Strait was measured at 0.17 Sv towards the Labrador Sea (McGeehan and Maslowski 2012). However, there was a net freshwater flux (fresher Arctic waters and sea ice transport) of 10.25 Sv towards the north Atlantic via Hudson Strait surface waters (McGeehan and Maslowski 2012). Sea ice production and melting together with physical mixing produce a range of water masses. Although freshwater input is very high along the south and eastern coasts of Hudson Bay (beyond the southern boundary of the SI EBSA), sea ice meltwater is the more significant source of fresh water in the SI EBSA (Jones and Anderson 1994, Stewart and Barber 2010).

Summer circulation patterns for the Hudson Bay Complex are shown in Figure 7. Arctic water from the CAA flows through Fury and Hecla Strait and then south through western Foxe Basin. This water creates a current that moves south along the eastern coast of the Melville Peninsula and then branches upon arrival at the northern end of Southampton Island. This current extends as much as 50 km offshore of the Melville Peninsula, flowing at a maximum of 0.6 m/s (Figure 8; Saucier et al. 2004, Prinsenberg 1986a). Upon reaching the north coast of Southampton Island, the southward flowing current splits with the majority, heading southeast towards Nottingham Island and Hudson Strait, and a smaller proportion moving northwest then southwards through Frozen Strait at speeds of up to 0.35 m/s (Prinsenberg 1986a, Saucier et al. 2004, Stewart and Barber 2010). The strong flow in Foxe Channel along Southampton Island is broad, extends to substantial depths, and parallels the coast until it reaches the ridge between Bell Peninsula and Nottingham Island where the deep portion is deflected towards Hudson Strait (Campbell 1959). The cold Arctic water that enters Frozen Strait continues through Roes Welcome Sound and then flows into northwestern Hudson Bay (Prinsenberg 1986a, Tan and Strain 1996, Stewart and Lockhart 2005). Some of the Arctic water that passes through Roes Welcome Sound circulates around the south end of Southampton Island towards Coats Island, where it joins warmer water flowing north from James Bay before rejoining the bulk flow moving eastwards into southern Hudson Strait. The water entering northern Hudson Bay also joins a cyclonic circulation before exiting and joining with the remaining Arctic water from Foxe Basin to form a southeast surface flow in Hudson Strait (Ingram and Prinsenberg 1998, Stewart and Barber 2010).

The northeast shore of Southampton Island, within Foxe Basin and Foxe Channel, are considered an important region for the development of a dense water mass and bottom water renewal within the Hudson Bay Complex. Multi-year oceanographic data from from three moorings located in Foxe Channel and Basin in 2003–2006, recorded a yearly spring pulse of cold, dense water to the bottom water of the north side of Southampton Island (Defossez et al. 2008). The gravity flow of cold, dense bottom water produced by western Foxe Basin polynyas was observed moving southeastward along Foxe Channel, reported lasting approximately three months and renewing nearly two-thirds of the deep water in the channel (Defossez et al. 2008 and Defossez et al. 2010). This deep water renewal is considered to have a significant role in

the Foxe Basin circulation, while at the same time expectedly plays an important biological role through the renewal of oxygen and nutrients to the bottom waters. This deep, cold, relatively high salinity water mass also appears to extend into Evans Strait (Campbell 1959). This deeper water mass from Foxe Basin and Channel that curves around the southeastern end of Southampton Island into Evans Strait is largely prevented from entering Hudson Bay by a 130 m-deep sill between Southampton Island and Coats Island (Prinsenberg 1986a). The currents in Evans Strait were much higher on the Southampton Island side than the Coats Island side of the strait in summer and fall of 1955 (Campbell 1959). These circulation patterns and the low volume of river runoff in the SI EBSA have been identified as factors producing regional waters with higher dissolved inorganic carbon content, pH, total alkalinity, and calcium carbonate saturation rates, particularly along the south coast of the island when compared with Hudson Bay (Azetsu-Scott et al. 2014). Water chemistry in southern and southeastern Southampton Island is most similar to that of Foxe Channel and western Hudson Strait.

Within Foxe Basin, the Arctic salinity distribution and the pattern of ice break-up suggest that the southward current along the Melville Peninsula is part of a cyclonic (counter clockwise) circulation in the northern and shallower part of the basin (Ingram and Prinsenberg 1998). This cyclonic pattern continues into Hudson Bay where currents are predominantly to the south and east with mean speeds in the range of 0.04–0.06 m/s (Prinsenberg 1986b, Prinsenberg 1987, Stewart and Lockhart 2005). The freshwater flux, primarily from sea ice melt, from Foxe Basin into Hudson Bay creates a buoyancy-driven current (Csanady 1982) that contributes to a nearly continuous cyclonic nearshore coastal current. Total volume transport in Hudson Bay was estimated at 0.55 Sv with 0.20 from inflow/outflow, 0.23 from wind, and 0.12 buoyancy-driven (Wang et al. 1994a, Stewart and Lockhart 2005). Temperature and salinity modeling carried out by Saucier et al. (2004) confirmed that circulation within Foxe Basin is cyclonic during both the ice cover period (in the spring) and the ice-free period (in the fall) (Figure 9). Their data also indicated that this cyclonic circulation applies to both surface and deeper water within the basin. However, data from western Hudson Bay indicated that ice-free current velocities are stronger overall and decrease with depth (as influenced by bottom topography) (Prinsenberg 1987, Stewart and Lockhart 2005). Current velocities are weaker with minimal vertical stratification during ice-covered periods (Prinsenberg 1987, Stewart and Lockhart 2005). This strong cyclonic force is responsible for Arctic oceanographic conditions occurring much farther south than elsewhere in North America, which is a key feature of this ecosystem (Stewart and Lockhart 2005, Stewart and Barber 2010).

Surface outflow from Hudson Bay joins part of the Foxe Basin surface outflow via Southampton Island, exiting the Hudson Bay Complex along the south shore of Hudson Strait (Prinsenberg 1986a, Azetsu-Scott et al. 2010). Mean daily and monthly velocities for this Hudson Bay flow component were measured at approximately 0.2 m/s, but can be obscured at times by strong wind forcing, which can reach magnitudes of 0.1–0.2 m/s (Prinsenberg 1986a). Sea ice melt and river runoff of about 900 km^3/y lead to a stratification of the Hudson Bay outflow into Hudson Strait with lower surface salinities than nearby areas (Azetsu-Scott et al. 2010).

Although summer water circulation is relatively well-known for the Hudson Bay Complex, it is highly variable and direct current meter measurements are uncommon (Prinsenberg 1986a, b). Circulation during freeze-up may differ. The northwestern Foxe Basin Polynya creates denser water through ice formation and results in a negative estuary circulation effect. In contrast, during the summer, ice melt and freshwater runoff force a surface outflow and a deep, saline inflow, creating a positive estuary in Foxe Basin.

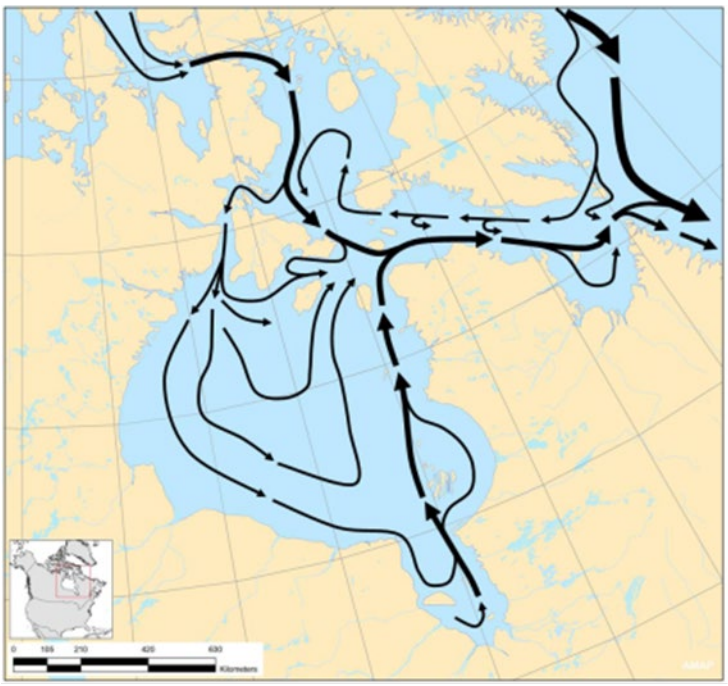

Figure 7. Water mass circulation patterns in the Foxe Basin Marine Region (Source: Stewart and Howland 2009).

Figure 8. Summer surface circulation, measured by currents as staight arrows (current meter) and curved arrows (dynamic height), in Foxe Basin (Source: Prinsenberg 1986a).

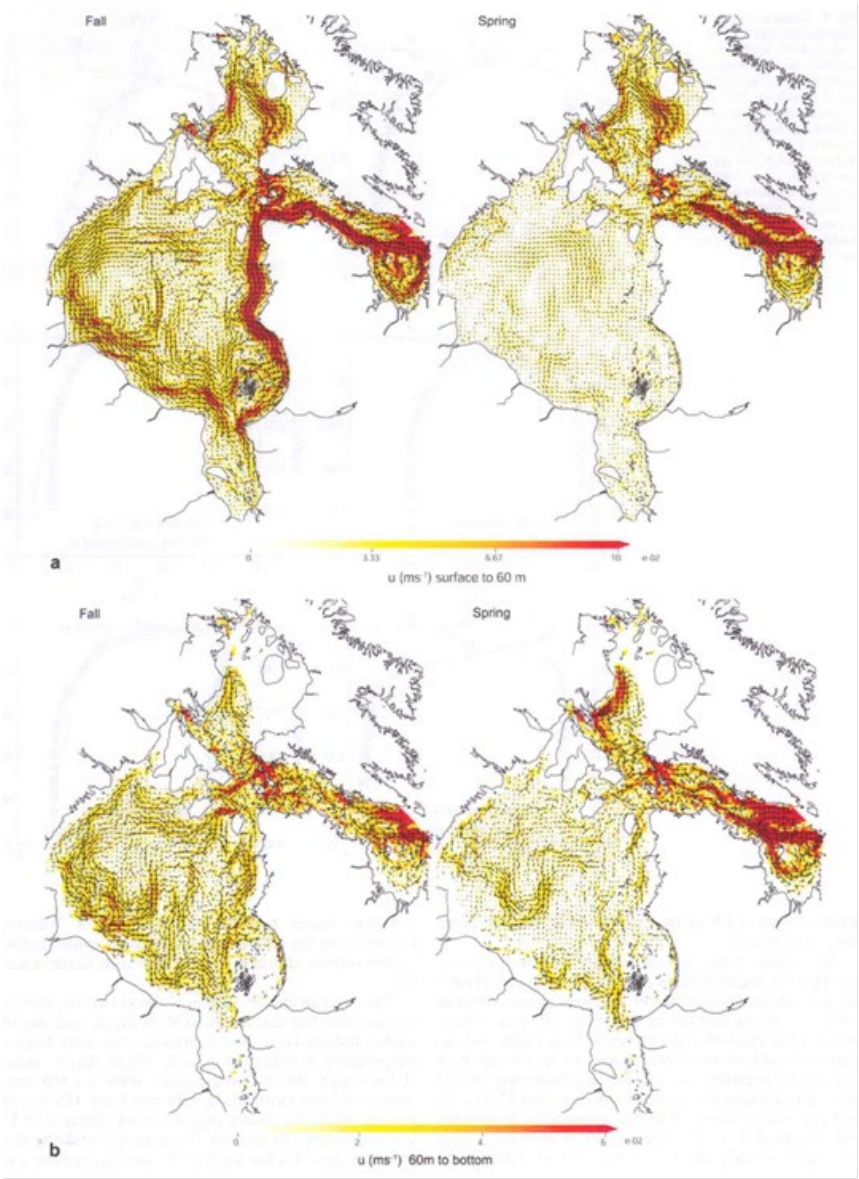

Figure 9. Seasonally averaged horizontal currents for fall and spring: (a) vertically averaged currents from the surface to 60 m depth; and (b) vertically averaged currents from 60 m depth to the bottom (Source: Saucier et al. 2004).

UPWELLING AND DOWNWELLING

The salt rejection associated with sea ice formation in Foxe Basin causes a penetrative convection to occur (Ingram and Prinsenberg 1998), resulting in a pulse of cold, dense water that sinks and flows south along the coast of Melville Peninsula. This water continues moving in a southeast direction to Foxe Channel, where it mixes with dense water from the previous winter along the bottom (Figure 10). The bottom waters of southern Foxe Basin are thus produced during winter because of ice production in the northern Foxe Basin polynyas. The extent of this bottom layer depends upon the ice production per unit area, which is related to the severity of the preceding winter (Ingram and Prinsenberg 1998). It is for this reason that the deep-water properties of Foxe Basin are highly variable from year to year. Turbulence on the east side of Foxe Channel, off Foxe Peninsula brings some of its deep, highly saline water to the surface,

thereby increasing subsurface salinities relative to the Southampton Island side of the channel (Campbell 1959).

A sill separating Hudson Bay and Foxe Channel generally prevents the intrusion of the deep (> 185 m), saltier and colder water of Foxe Channel into Hudson Bay (Campbell 1964, Prinsenberg 1986a). However, when the volume of dense water present within Foxe Channel becomes too large, it overflows into Hudson Bay (Prinsenberg 1986a, Jones and Anderson 1994).

TEMPERATURE AND SALINITY

Water temperature and salinity in the SI EBSA is heavily influenced by water circulation patterns.The influx of water through Fury and Hecla Strait, which is greater in summer than in winter, greatly affects circulation and temperature and salinity profiles within Foxe Basin (Prinsenberg 1986a, Ingram and Prinsenberg 1998). Water entering Foxe Basin is vertically homogeneous due to intense tidal mixing in Fury and Hecla Strait and is less dense than the water present in Foxe Basin, and thus flows along the surface (Ingram and Prinsenberg 1998).

In Foxe Basin and Hudson Bay, salinities are generally higher at northern latitudes in association with lower temperatures (Roff and Legendre 1986). The melting of isolated ice floes also causes large surface variations in the salinity and temperature distributions, which obscure the spatial variations caused by cyclonic circulation (Campbell 1964). The average summer surface water temperature within Foxe Basin in 1955/1956 was 0.3°C, with a range of -1.77˚C to 3.10°C (Campbell 1964, Prinsenberg 1986a). Colder surface temperatures (below 0°C) were observed concurrently in Evans Strait, decreasing gradually with depth (Campbell 1959). Temperatures adjacent to Southampton Island ranged from 2–7°C in August/September 1975 (Roff and Legendre 1986). Surface salinity in Foxe Basin ranged from 4 psu at sites where melt water or freshwater runoff diluted sea water, to 29 to 33 psu at most other sites (Campbell 1964, Prinsenberg 1986a). In Evans Strait, summer salinities were relatively high (31.75 psu) at the surface, and increased with depth (Campbell 1959). Mean salinity adjacent to Southampton Island in August/September 1975 ranged from 28 to 31 psu (Roff and Legendre 1986). Monthly subsurface temperatures in northern Foxe Basin ranged from an average of -1.2°C in July to -0.5°C in October, with average salinities ranging from 32 psu in July to 30.9 psu in October (Campbell 1964, Prinsenberg 1986a).

In late winter, the water coming in Foxe Basin has a temperature of approximately -1.71°C and a salinity of between 32.0 and 32.1 psu, while in summer it has a temperature of 0.5–0.75°C and a salinity of 31.0–32.0 psu (Ingram and Prinsenberg 1998). Winter 1955/56 subsurface temperatures in Evans Strait off of Southampton Island showed a smaller range, from -0.10 to -0.80°C, which decreased sharply to -1.50°C or colder starting at 20 m depth (Campbell 1959). In nearby Hudson Strait, surface temperatures in winter 1955/56 were much warmer (approximately 1.0°C) with colder water evident only at 75 m or deeper. Winter 1955/56 surface salinities in Evans Strait were 31.5 psu, increasing to a relatively high 33.0 psu at 30 m (Campbell 1959). These lower salinities that were confined to the surface near Southampton Island were distributed throughout the upper 150 m in western Hudson Strait. Once water has entered Foxe Basin, the two main drivers affecting water temperature and salinity are the formation and melting of sea ice (which occur as a result of changes to air temperature) and freshwater input from river runoff (Ingram and Prinsenberg 1998). Similar factors influence the warmer, less saline water in western Hudson Strait, which receives flow from southern Hudson Bay (Campbell 1959). The cold, saline waters in Evans Strait during winter are most similar to those found in Foxe Channel with origins in northern Foxe Basin. Although mixing was more evident during summer, Campbell (1959) noted the persistence of this water mass in Evans Strait through all seasons.

As ice begins to form in Foxe Basin in late autumn, salt is rejected, creating a layer of cold, dense water at the ice-ocean interface (Prinsenberg 1988). Salt is continually rejected as the ice cover thickens, causing the salinity to increase from 32.2 to 32.5 psu, while temperature decreases from -1.70°C to -1.74°C (Prinsenberg 1986a). In the shallower portions of the basin, the strong influence of the tides leads to a thorough mixing of the water under the ice (Figure 10; Ingram and Prinsenberg 1998).

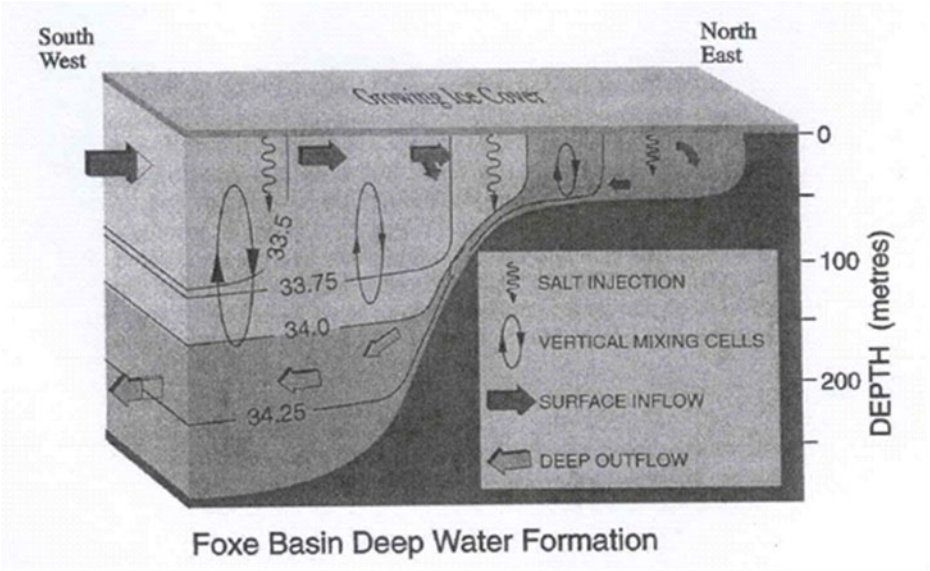

Figure 10. Foxe Basin circulation (Source: Ingram and Prinsenberg 1998).

In spring, melting of sea ice, as well as snow and ice on land, provides an acute input of fresh water into the system. The in situ ice melt contributes more fresh water (volume per unit time) than the combined input of the rivers (Prinsenberg 1988) over the May–June period. This input comprises a large portion of the freshwater content of northern Hudson Bay and, in particular, southern Foxe Basin, both of which include waters in the SI EBSA (Tan and Strain 1996). The ice melt input reduces the salinity and increases the temperature of the surface water, which suppresses mixing by creating a more uniform temperature and salinity gradient (Prinsenberg 1988). River runoff heavily influences near-coastal water salinities (Prinsenberg 1988).

In summer (open water), the central region of Hudson Bay is characterized by higher salinities and lower temperatures (Ingram and Prinsenberg 1998). Under the sea ice cover, a similar pattern is thought to occur (Prinsenberg 1986b, Prinsenberg 1987, Wang et al. 1994b, c). Deeper waters show little variation from year to year and seasonally (Ingram and Prinsenberg 1998). Due to the large amount of fresh water discharged into Hudson Bay, a strong vertical stratification occurs during the summer months, with a strong pycnocline at 15–25 m effectively preventing vertical exchange between surface and deep water layers (Anderson and Roff 1980). The sea-surface salinity shows a nearshore (or boundary) region that gradually freshens in a counter clockwise direction from north to south and a saltier interior region (Prinsenberg 1986c, Lapoussière et al. 2009). The freshening of the boundary is particularly evident at locations where river discharge is important. The counter clockwise trend corresponds to the general direction of the surface circulation (Prinsenberg 1986b). Surface temperatures reach 12°C, while deep waters remain close to freezing at -1.7°C. Upper layer mixing is mainly driven by wind and wave action (Ingram and Prinsenberg 1998), which causes distinct inshore-offshore differences in physio-chemical variables (Anderson and Roff 1980). Typically, inshore and estuarine areas of the Hudson Bay have lower salinities and lower temperatures. The lower

temperatures inshore are attributed to mixing processes, which result in colder deeper water being brought to the surface. During the winter months, a complete ice cover causes physical uncoupling of wind and water that dampens the circulation pattern (Freeman et al. 1982). In southeastern Hudson Bay, the reduced upper-layer mixing associated with the nearly complete ice cover leads to a much greater influence of river plume surface water dilution in winter than in summer (Ingram and Prinsenberg 1998). Overall, the upper-layer low salinity flux to Hudson Strait is balanced by the input of more saline seawater advancing at depth to the interior of the Hudson Bay (Ingram and Prinsenberg 1998). The under ice river plume has a low influence of the oceanography in the northwest region of Hudson Bay. The large northwestern Hudson Bay polynya plays a greater role in the northwestern region and results in a relatively well mixed water column (M. Kamula, University of Manitoba, pers. comm.).

Saucier et al. (2004) numerically simulated the distribution of sea surface temperature (SST) and salinity (SSS) in the Hudson Bay Complex (Figure 11). Results indicated that SST and SSS in the SI EBSA remain relatively constant year-round.

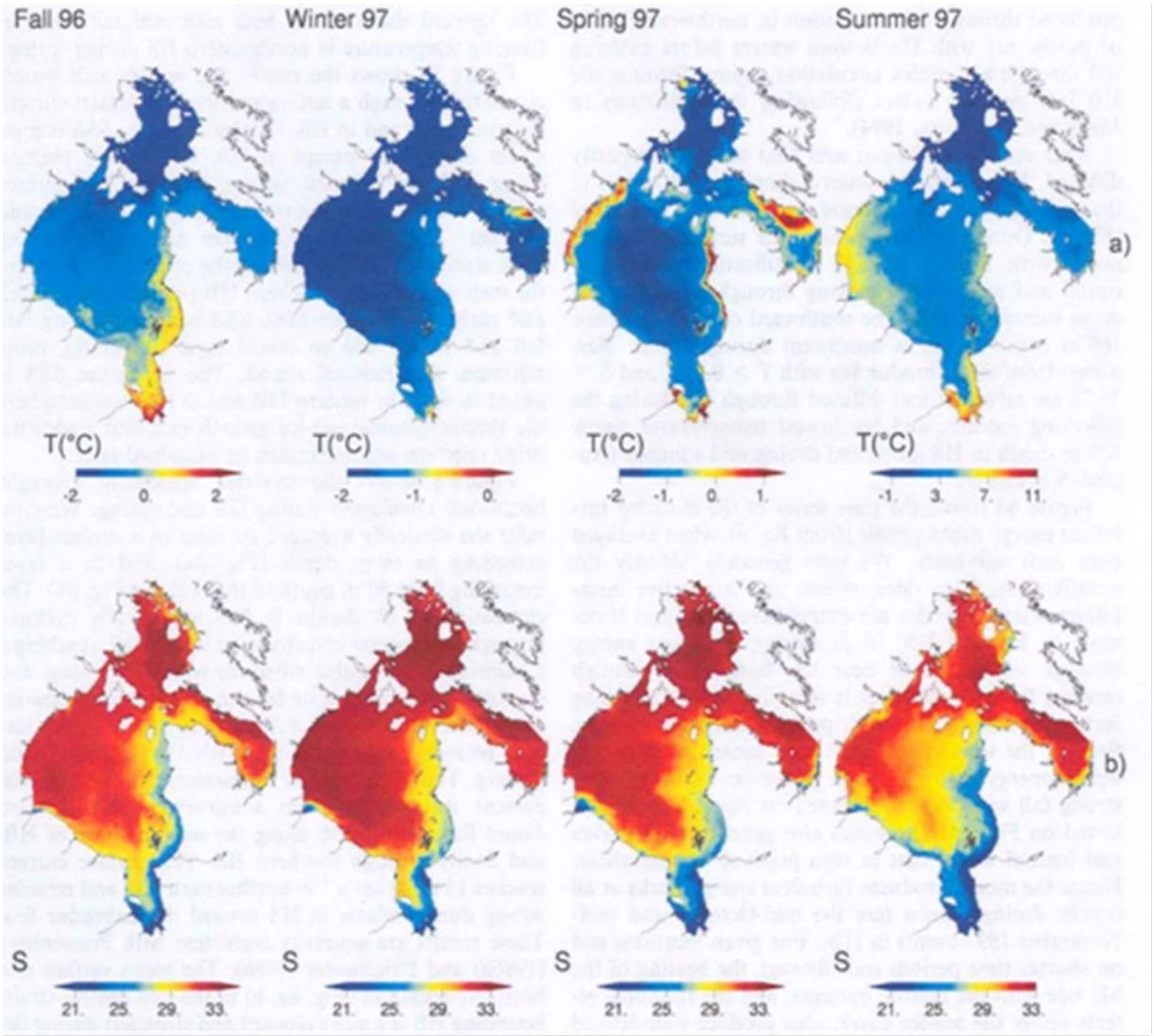

Figure 11. Seasonally-averaged (for three successive month periods starting with the fall season defined by October, November and December): (a) sea surface temperature (SST, °C), and (b) sea surface salinity (SSS) (Source: Saucier et al. 2004).

TIDES

The Hudson Bay Complex is globally important for dissipating tidal energy (Webb 2014). In particular, there are strong M_2 semidiurnal tides in the vicinity of Southampton Island (Killett et al. 2011, Webb 2014). Modeling demonstrated that the strong, local semidiurnal M_2 tides are dominated by four overlapping resonances, one of which lies to the north of Southampton Island. The geography of the region strongly influences the extreme tidal amplitudes observed in Ungava Bay, Hudson Strait, and Repulse Bay/Roes Welcome Sound. The amplitudes predicted by Webb (2014) using models at Repulse Bay (1.63 m) compared well with an actual tide gauge, which recorded an M_2 amplitude of 1.88 m.

Additional modeling demonstrated that seasonal variations in tidal currents and amplitude are caused by the presence of sea ice (Saucier et al. 2004) and under-ice friction in Hudson Bay, southern Foxe Basin and the western edge of Hudson Strait (St-Laurent et al. 2008).

In 2015, the Bedford Institute developed a WebTide modelling program to predict tides in Canada. This tool indicated that tides around the coastal region of Southampton Island are strongly semidiurnal, with the M_2 constituent being the most important (Table 1). The greatest tidal amplitudes were modeled in Roes Welcome Sound and declined slightly as they propagated southwards. The tidal elevation range lessened along the southwestern coast of Southampton Island through Fisher and Evans straits. The tidal evelvation range along the northern coastline is weakened as the tides propagate towards the southeast. The east and west coasts of Coats Island had similar tidal amplitudes to those in Fisher and Evans straits.

Table 1. Estimated mean tidal elevations (cm) for semidiurnal and diurnal constitents in the Southampton Island Ecologically and Biologically Significant Area (SI EBSA) from the Bedford Institute's WebTide Tidal Prediction Model (accessed on August 8th, 2019).*

Location	Tidal Amplitude (cm)				
	Semidiurnal			Diurnal	
	M_2	N_2	S_2	K_1	O_1
North Roes Welcome	285.8	49.7	112.3	4.8	1.6
Mid Roes Welcome	272.1	47.4	109	5.8	2.1
South Roes Welcome	242.3	42.3	97.3	6.2	2.4
Bay of Gods Mercy	144.8	26.1	55.9	6.3	2.4
Cape Low	111.8	20.4	42.1	5.6	2.3
Coral Harbour	108.3	20.8	39.7	5.8	2.7
Evans Strait	87.3	17.3	32.5	4.9	2.3
Fisher Strait	82.8	15.7	28.8	4.4	1.9
Coats Island East	73.3	14.2	26.6	3.7	1.7
Coats Island West	75.4	13.6	27.3	3.7	1.4
Cape Donovan	117.4	21.7	41.8	3.9	0.8
East Bay	96.8	18.5	34.9	4.7	1.7
Junction Bay	92.6	18.5	36.9	5.6	2.6

*Semidiurnal constituents: M_2 is the Principal Lunar, N_2 is the Larger Lunar Elliptic, and S_2 is the Principal Solar (the subscript 2 referes to the two complete tidal cycles for each astronomic cycle). Diurnal constituents: K_1 is the Luni-solar Declinational and O_1 is the Principal Lunar Declinational[1].

[1] Understanding Tides

RIVER DISCHARGE AND PLUME

River discharge in the SI EBSA is minimal year round. Most rivers on Southampton Island are small and all except the largest flow only four months of the year (Bird 1953). Few streams are found along the steep-sided cliffs of northern Southampton Island (Stewart and Lockhart 2005) and freshwater discharge to that coast is minimal. In addition to these numerous small brooks, a few notable watercourses traverse Southampton Island. The longest and widest of these, the Boas River (Figure 2), begins in the highland at the centre of the island and flows south through the low-lying region to its mouth in the Bay of Gods Mercy (Zhang 2011). The river becomes increasingly braided as it approaches the coastline and its delta is included in the Harry Gibbons Bird Sanctuary. It is low-relief with an average fall of 0.6–1.1 m/km (Bird 1953). The Cleveland River also begins near the centre of the island, but flows north to Duke of York Bay (Zhang 2011). The Ford River flows west from the highland in the eastern part of the island toward its mouth in Coral Harbour (South Bay). The Boas and Ford rivers empty into Hudson Bay, whereas the Cleveland River empties into Frozen Strait (Zhang 2011). These rivers generally connect several small, shallow inland lakes and, after spring runoff, much of the drainage consists of underground seepage (Stewart and Bernier 1984).

Although several rivers on Southampton Island empty into the EBSA, historical discharge data are available for only the Kirchoffer River, which flows into South Bay near the community of Coral Harbour (Déry et al. 2005, ECCC 2017). The Kirchoffer River has a drainage area of 3,160 km^2 and a mean annual discharge of approximately 26.0 m^3/s, with a peak flow exceeding 490 m^3/s, typically reached by late June or early July. There was little to no discharge from the river between October and May. The Kirchoffer River has an average fall of 3.8 m/km (Bird 1953).

River runoff in the Hudson Bay Complex strongly influences its calcium carbonate saturation state, which, with low pH can affect ocean acidification (Azetsu-Scott et al. 2014). This influence is greater in western and eastern Hudson Bay, which receives flow from a number of major rivers. Runoff in the SI EBSA is also relatively low and calcium carbonate saturation is higher. During summer, there is transport and deposition by rivers of till waste material, old river terraces and solifluction slopes in Southampton Island (Bird 1953). However, with the exception of areas with unconsolidated material, riverine erosion in Southampton Island since the last glaciation has been negligible and deposition into the EBSA marine environment relatively minimal.

The freshwater input into the marine environment has a much greater impact on surface layer stratification in coastal areas beneath the landfast ice where other environmental factors (attenuated tides, wave energy, wind) are reduced or absent (Ingram and Larouche 1987a,b, Ingram and Prinsenberg 1998). Increased tidal kinetic energy was inversely related to the volume of La Grande River plumes under the ice in Hudson Bay (Freeman et al. 1982). Even with effects from mixing, under-ice river plumes in Hudson Bay were 10–40 times larger in area and two to three times thicker (within a given isohaline) than at similar summer discharges as a result of the insulating factor of ice (Ingram and Larouche 1987a,b). Turbulence, entrainment and mixing rates are much lower than during open-water periods, such that winter plume influence is much more far-reaching than during summer despite the very low runoffs. These under-ice plumes can affect biota. For example, thicker plumes from the Great Whale River in eastern Hudson Bay negatively affected prey density and irradiance, halting the feeding of Arctic Cod (*Boreogadus saida*) and Sand Lance (*Ammodytes* sp.) larvae in the area (Fortier et al. 1996). Larger winter plumes from the same river also increased concentrations of phytoplankton relative to ice algae (Legendre et al. 1996).

DISTRIBUTION AND SEASONAL ICE PATTERNS

In general, SI ESBA waters are ice-covered during winter (historically by mid-November) and ice-free during summer, by late July to eary August (Figure 12, Stewart and Barber 2010, CIS 2010, 2017). Most ice in the Hudson Bay Complex is annual, although a small amount of multi-year ice (MYI) can enter into northern Foxe Basin via Fury and Hecla Strait (Markham 1986). Maximum sea ice thickness in the Hudson Bay Complex ranges from 175–215 cm in northern Foxe Basin to 100–125 cm in James Bay (Markham 1981, Prinsenberg 1986a, Gagnon and Gough 2006). Sea ice in the nearshore areas of the SI EBSA is often described as grey-white in color and thick first year, while the offshore is mostly first-year ice of medium thickness (CIS 2016). Sea ice along the western and northeastern shores of Southampton Island, including southern Foxe Basin, Frozen Strait, and Roes Welcome Sound, generally reach greater maximum thickness (175–200 cm) than do Foxe Channel, Evans and Fisher straits, and Bay of God's Mercy areas (150–175 cm) to the south (Markham 1981).

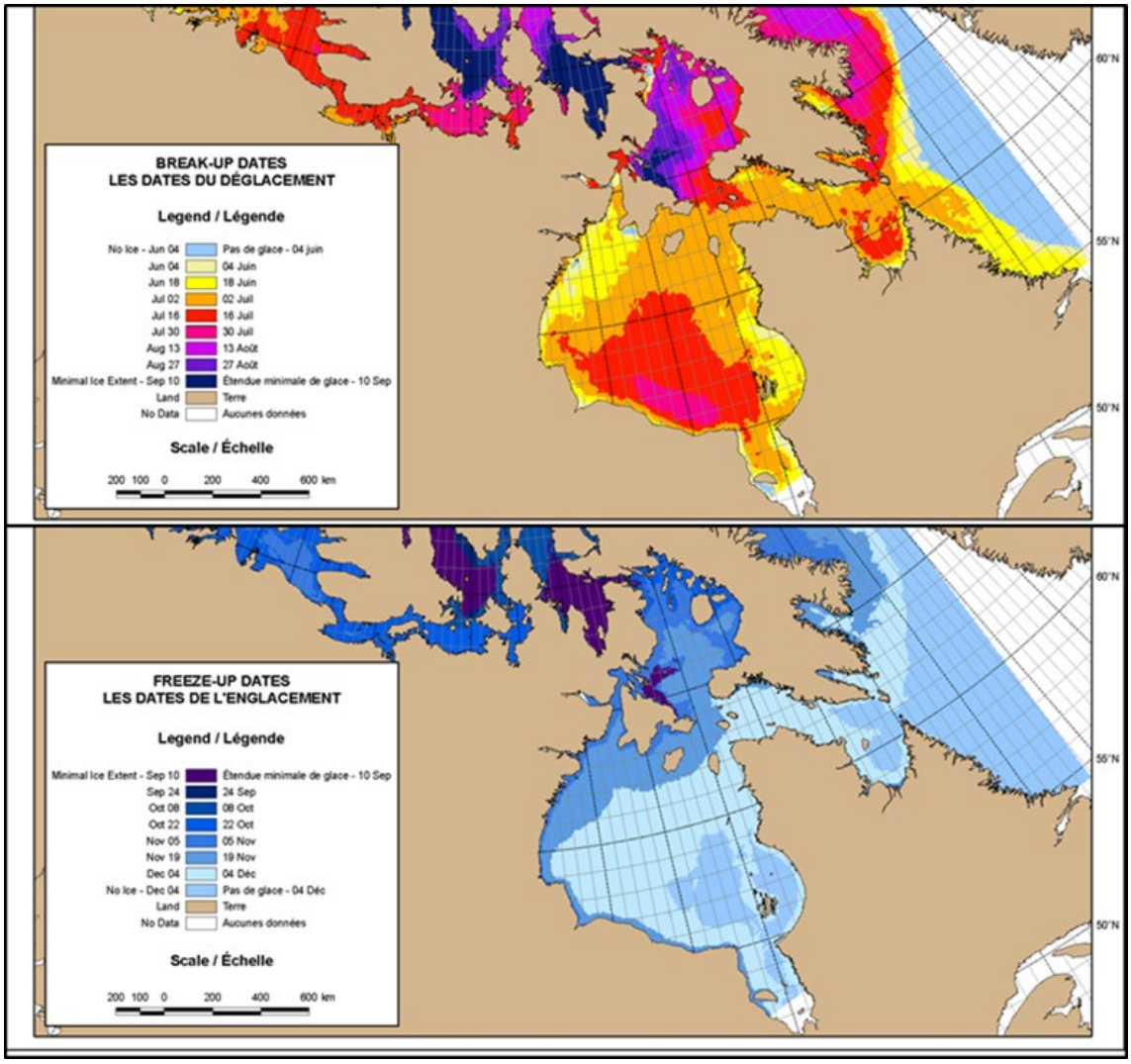

Figure 12. Ice formation and breakup in the Hudson Bay complex from 1981 to 2010 (Source: CIS 2017).

Using modeling, Saucier et al. (2004) detailed seasonal landfast ice thickness throughout the Hudson Bay Complex, including the SI EBSA, from fall 1996 to summer 1997. During fall, thickness around the island was consistently about 25 cm. During winter, ice was thinnest

(62.5–125 cm) in Bay of God's Mercy, South Bay, and along the northeastern coast and thickest in Frozen Strait, Roes Welcome Sound, Coats Island, and the East Bay area, reaching a maximum of approximately 200–250 cm at the north end of Roes Welcome Sound and the southeast tip of the island. By spring, thick ice (> 200 cm) remained in Repulse Bay, Roes Welcome Sound and the southeastern end of the island, while remaining ice in the EBSA was largely 62.5–125 cm thick (Saucier et al. 2004). In the 1960s and 70s, sea ice was observed to thin quickly near Coral Harbour from late June to mid-July (Bilello 1980). By late summer, ice was thin or absent from much of the EBSA, with a small patch of thicker ice (approximately 100 cm) in northern Roes Welcome Sound (Saucier et al. 2004). Ice thickness can be locally amplified in areas with ice ridges and rubble fields (Markham 1986, Prinsenberg 1988). In northern Hudson Bay, Markham (1986) noted an average of six ridges per km with most 1.0–1.5 m in height and maximums in the 3.0–3.5 m range. However, due to ridges floating isostatically higher than surrounding ice, the actual additional ice contribution was calculated at 0.15 m/2.0 m of ridge/km for Hudson Bay (Prinsenberg 1988).

Within the Hudson Bay Complex, ice formation typically begins in November along the west coast of northern Foxe Basin and Hudson Bay. Areas to the north of Southampton Island such as Repulse Bay, Lyon Inlet and Frozen Strait are among the first waterbodies near the SI EBSA where ice-cover forms (Figure 12, CIS 2010, 2013a, 2013b, 2017). By December, the waters around Southampton Island, including all of Foxe Basin, the western half of Hudson Bay and the western portion of Hudson Strait experience 9/10 or greater ice coverage. Sea ice near Coral Harbour typically reached maximum thickness by late May (Bilello 1980). Moving pack ice dominates in the Hudson Bay Complex, where it frequently comprises 90% or more of the total ice cover (CIS 2010, 2017). Landfast ice occurs along shorelines and islands where ocean currents and wind-driven ice movement are reduced. In the SI EBSA, landfast ice occurs in all major bays along the shores of Southampton Island, particularly along the northeastern shore and in the South Bay area (CIS 2010). Repulse Bay, Lyon Inlet and islands to the south of Lyon Inlet (all located north of Southampton Island) are also bound by landfast ice (CIS 2017). In other areas to the north of Southampton Island, such as Frozen Strait and Roes Welcome Sound, vigorous ocean currents prevent the formation of landfast ice (Prinsenberg 1986a). However, satellite images show that every two to four years or so an ice bridge forms across Roes Welcome Sound, connecting Southampton Island to the mainland (M. Kamula, University of Manitoba, pers. comm.). The conditions and processes that attribute to the ice bridge forming is not well understood.

During spring break up, changes in the extent and thickness of ice cover around Southampton Island are minimal until early June when ice sheets begin to deteriorate and some ablation occurs (Bilello 1980). Landfast ice begins to disappear along shorelines and from areas where tidal and ocean currents are large (CIS 2010). Near the SI EBSA, Frozen Strait, Roes Welcome Sound and the southern shore of Southampton Island are among the first places where ice reduction occurs, breaking up earlier than much of the northern coastline (CIS 2017). Melting proceeds rapidly by late June/early July (Bilello 1980). Northwesterly winds cause further expansion of open water areas north of Southampton Island throughout July. Ice concentrations decrease rapidly in August, as Hudson Bay, Hudson Strait, and southern Southampton Island become ice-free (Figure 12; Bilello 1980, CIS 2017). As Foxe Basin clears of ice, remnant ice floes driven by wind and current move into the area north of Southampton Island, which is generally ice-free earlier in the season. Melting and transport of ice out of the basin continue throughout September. Complete clearing normally occurs before the end of September, although in some years loose pack ice may persist for the duration of the open-water period. First-year ice and MYI start to enter Foxe Basin from Fury and Hecla Strait in August and this continues throughout the summer, though MYI is not a component of the ice cover around Southampton Island.

CLIMATIC CHANGES AND PROJECTIONS

In recent decades, surface air temperatures (Etkin 1991, Skinner et al. 1998, Comiso 2003, Hochhiem et al. 2010) and the duration of the ice-free period have increased significantly (Gagnon and Gough 2005a) in Hudson Bay. Corresponding decreases in sea ice extent (Parkinson and Cavalieri 2008, Hochhiem et al. 2010, Tivy et al. 2011) and snow depth (Ferguson et al. 2005) have also occurred. For example, Falkingham et al. (2002) identified a decrease of 40% in sea ice coverage in the Hudson Bay region from 1969–2001. Furthermore, Smith and Barber (2007) indicated that the import of MYI into northern Foxe Basin via Fury and Hecla Strait is becoming a rarer event given the recent reduction in sea ice in the CAA.

Sea ice break-up in recent years occurred approximately two to three weeks earlier than in the 1970s (Gagnon and Gough 2005a, Stirling and Parkinson 2006, Scott and Marshall 2010) while autumn freeze-up occurred six days later each decade between 1982 and 2005 (Stirling and Parkinson 2006, Laidler et al. 2009). Scott and Marshall (2010) suggested that increased southwesterly winds in June and corresponding surface temperature increase are at least partially responsible for the earlier break-up. Hochhiem et al. (2010) examined trends in air temperature and ice characteristics in Hudson Bay from 1980 to 2005. Their results were consistent with previous investigations and showed a consistent air temperature warming of 0.23°C per decade that has resulted in significant decreases in sea ice extent and concentration, and earlier break-up and later freeze-up dates (a shift of 0.8–1.6 weeks each). Using 1980–2014 data, Andrews et al. (2017) identified an increase in the open-water season of 1.14 days/y, which has the potential to further increase shipping traffic through Hudson Strait and Hudson Bay to and from the Port of Churchill and mining operations near Baker Lake and Rankin Inlet. Iverson et al. (2014) identified even greater rates of change (2.4d/yr) in the Northern Hudson Bay Narrows from 1988–2012. This shipping route passes near the southeast tip of Southampton Island and south of Coats Island and could affect migratory cetaceans using the SI EBSA.

Modeling of future climate conditions projected that the trends in sea ice characteristics observed in recent years will continue (Gagnon and Gough 2005b, Joly et al. 2011). Using data on historical sea ice trends from Hochheim and Barber (2014) and assuming those trends continue, Andrews et al. (2016) extrapolated increases in the open-water season length of 2.1, 2.3 and 3.3 weeks by 2030, and 4.1, 4.7 and 6.5 weeks by 2050 in Hudson Bay, Foxe Basin, and Hudson Strait, respectively. Using the Canadian Regional Climate Model 4, Joly et al. (2011) projected a delay in freeze-up of 25 days in Hudson Bay and 31 days in Foxe Basin for the period of 2041–2070 when compared to 1961–1990. Similarly, break-up is projected to occur 24 days earlier in Hudson Bay and 22 days earlier in Foxe Basin. Hudson Strait is projected to be essentially ice-free during December and June. Furthermore, significantly lower sea ice volume is expected throughout the shorter ice season and sea ice thickness is predicted to decline by 20–60%. The greatest changes to sea ice concentration and thickness are expected to occur in Hudson Strait and southern Hudson Bay; however, large decreases in ice extent are also projected for southern and western Southampton Island (Joly et al. 2011). Preliminary results from the Nucleus for European Modeling of the Ocean (NEMO) model at the University of Manitoba's Centre for Earth Observation Science (CEOS) on sea ice changes in the Hudson Bay Complex are in general agreement with Joly et al.'s (2011) projections (Andrews et al. 2016).

LOWER TROPHIC LEVELS

There are few studies characterizing the lower trophic levels that form the base of the marine food webs in the Hudson Bay Complex, and there is little information for the SI EBSA. Lower trophic levels comprise autotrophic and heterotrophic prokaryotes and eukaryotes which make

up the bulk of the production in marine systems, supporting all trophic pathways and ecosystem architecture. The description below focuses on autotrophic eukaryotes (i.e., phytoplankton and ice algae) while recognizing the overarching importance of prokaryotes in the cycling of carbon and other elements. While not included in the discussion, microbes are an important component of Arctic marine food webs and in nitrogen cycling, contributing to over 95% of primary production in oceans (Matrai et al. 2013). Limited data are available with respect to species assemblages, distributions and responses to changing climatic conditions throughout the Arctic (Pedro-Alios et al. 2015); however, DNA sequencing indicated that the Hudson Bay microbial eukaryotic community is distinct from those in the CAA and Baffin Bay (Lovejoy 2014).

PHYTOPLANKTON PRODUCTION AND EXPORT

Phytoplankton and ice-associated algae directly or indirectly provide the energy and biomass inputs to higher trophic levels. Studies by Lapoussière et al. (2009) and Ferland et al. (2011) demonstrated the large sinking export of intact protist cells in Hudson Strait, indicating a strong pelagic-benthic coupling in this region. Further Lapoussière et al. (2013) showed spatial variability in primary production determined by hydrographic conditions and nutrients.

Total marine phytoplankton diversity in the Canadian Arctic is higher than in the Pacific or Atlantic regions, with more than 1,229 estimated taxa (Archambault et al. 2010, Poulin et al. 2011, Darnis et al. 2012). Available data indicate that the biodiversity of lower trophic levels in Hudson Bay includes 586 taxa, and is dominated by diatoms (261 taxa) and dinoflagellates (150 taxa) (Archambault et al. 2010). The diversity of Bacillariophycae and Bacillariophyta, which include many ice-associated species, appears to be somewhat lower in Hudson Bay relative to the rest of the Arctic (Archambault et al. 2010). For a list of all 484 phytoplankton, ice algae, and macrophyte taxa collected within the region by Bursa (1961a, b), Legendre and Simard (1979), Lee (1980), Anderson et al. (1981), Roff and Legendre (1986), and Harvey et al. (1997), see Loewen et al. (2020), which represents a minimum level of diversity for the SI EBSA.

Relatively few studies have examined the SI EBSA phytoplankton community. Consequently, much of the information herein is derived from studies conducted in nearby northern Foxe Basin, Hudson Bay, and Hudson Strait (Bursa 1961a, b, Harvey et al. 1997, Ferland et al. 2011). Large-scale modeling of primary production and ice algal biomass in ten Arctic regions suggests a total mean annual algal production for all areas of 15.1 Tg C/y with about 2.7 Tg C/y of that production in the CAA/Baffin Bay region that includes Foxe Basin (Deal et al. 2011) and it is one of the more productive of all pan-Arctic shelves (Carmack and Wassman 2006, Deal et al. 2011). Sea ice extent, thickness, and seasonality contribute to productivity in this region. Due to the wide range of temporal and spatial variations associated with ice algal production, and variations in the tidal mixing and upwelling, current models of primary productivity likely underestimate actual production and overall contributions to the Arctic region (Michel et al. 2015).

Temporal and spatial variation in phytoplankton light absorption has been measured for four Arctic regions, including Hudson Bay and Hudson Strait during fall (Brunelle et al. 2012). The study included two sites, one on the eastern tip of Southampton Island and the other east of Coats Island, within the SI EBSA. In general, coloured dissolved organic matter contributed up to 80% of all light absorption in Hudson Bay, more than in any other region, as a result of the large freshwater inflows in southern and eastern Hudson Bay. Phytoplankton contributed the majority (65%) of absorption in Hudson Strait. The two sites within SI EBSA waters shared similar absorption ratios to southern and eastern Hudson Bay, but had a higher proportion (67%) of the picophytoplankton found in southwestern Hudson Bay and the CAA, which may be related to lower nutrient availability. Light limitation, nutrient availability, community composition

and cell sizes driven by physical processes were the most important sources of the observed variability in light absorption spectra (aφ*; 443 nm) among regions (Brunelle et al. 2012).

Productivity is often associated with hydrographic conditions and hydrodynamics. Measurements of chlorophyll a concentrations in the region show higher phytoplankton biomass in Hudson Strait (Irwin et al. 1983, Subba Rao and Platt 1984, Smith et al. 1985) compared to Foxe Basin (Irwin et al. 1983) and Hudson Bay (Ferland et al. 2011). Phytoplankton production in Foxe Basin typically reaches a maximum in mid- to late August (Bursa 1961 a, b). Although diatoms, dinoflagellates, and ciliates are the most abundant taxa in Foxe Basin, overall diversity in that area is lower than in central and eastern Hudson Strait (Bursa 1961a. b, Harvey et al. 1997). Overall biodiversity of phytoplankton in Hudson Bay is high (Harvey et al. 1997).

Ice algal growth in the Arctic is limited by different environmental factors over the course of the year. Initially growth is limited by light availability, followed by a combination of light and nutrient availability, and type/amount of precipitation over the winter. Nitrate or silicic acid typically limits ice algal growth at the sea ice water interface Lavoie et al. 2005). Light transmission through sea ice is dependent on snow cover conditions (Perovich 2007, Light et al. 2008, Mundy et al. 2005, Campbell et al. 2015). Ice microalgae community composition in the SI EBSA has not been investigated. Sibert et al. (2010) estimated rates of ice algal production, calculated through a regional 3-D ice-ocean model, of over 300 mg C m-2 day-1 in Foxe Basin, western Hudson Bay and southern Hudson Strait, (including Ungava Bay) in May. Overall, Sibert et al. (2010) demonstrated high spatio-temporal variability in ice algal dynamics.

Recent increases in primary productivity have been measured throughout the Arctic (Arrigo et al. 2008, Frey et al. 2011, Bélanger et al. 2013, Ardyna et al. 2014) and may continue with the declining sea ice cover (Arrigo et al. 2012, Tremblay et al. 2012). Declining sea ice may cause increased upwelling events; however, other factors such as deep convection influence primary production. In the past ice edge blooms were documented and there is uncertainity if they are presently or will be more widespread in the future. The potential increase in under-ice blooms in the context of a thinner ice cover is expected to shift centres of primary and secondary production away from the ice edge where seabirds and marine mammals feed (Barber et al. 2015), with potential consequences for local food webs throughout the Hudson Bay and adjoining regions.

MARINE MACROPHYTES

The most direct observations of macrophytes in the SI EBSA (see Loewen et al. 2020 for full list of species) were made by resource users in Naujaat (northwest coast of Southampton Island; GN 2011) and Coral Harbour (southern coast and offshore islands; GN 2012). Intertidal benthic algae and macrophytes have also been directly surveyed in the Foxe Basin region in a limited nearshore section of Steensby Inlet by North/South Consultants Inc. et al. (2010). Some marine macrophytes have also been identified in northwestern Foxe Basin by local resources users from Igloolik (GN 2008). Additionally, predictions can be made from intertidal surveys conducted at other locations in the Canadian Arctic (Lee 1973, Wilce 1994).

The majority of marine flora in Nunavut consists of species common to the North Atlantic (Lee 1973, Wilce 1994). These species are well-adapted to low light conditions, a short growing season, and constant low water temperatures, with several perennials that may live for decades (Wilce 1994). Macrophyte abundance is typically lowest at water depths shallower than 3 m (due to ice scour) and greatest between 3 and 15 m (Cross et al. 1984, Wilce 1994). More recent surveys indicate that the kelps, reds, and encrusting coralline algae may be found to depths of at least 30 m but have oberserved to be found in deeper depths (B. Konar, University of Alaska Fairbanks, pers. comm.).

Marine macrophytes in northern Foxe Basin identified by local resource users from Igloolik include Hollow-stemmed Kelp (*Laminaria longicrurus*), Edible Kelp (*Alaria esculenta*), and Bladder Wrack (*Fucus* sp.) (GN 2008). Hollow-stemmed Kelp are widespread in areas with high current in Roes Welcome Sound, dulse (*Palmaria* spp.) on the shorelines of Frozen Strait, and sea colander (*Agarum* sp.) in shallow, nearshore habitat on northwest Southampton Island (GN 2011). Other taxa along the northwestern coast of Southampton Island include *Alaria esculenta*, *Fucus* sp., and Spiny Sour Weed (*Desmarestia aculeata*). *Fucus* sp. are widespread along the southern shore of Southampton Island, *Agarum* sp. are common near the community and *Laminaria longicrurus* are found near Walrus and Bencas islands (GN 2012). Green Sea Fingers (*Codium fragile*) and Lungwort (*Mertensia* sp.) are found in isolated shoreline areas of South Bay and small, offshore islands.

ZOOPLANKTON

Zooplankton and sympagic fauna are critical links between primary productivity and higher trophic levels (e.g., benthic and pelagic macroinvertebrates, fish, birds, marine mammals). Despite their importance, investigations related to zooplankton and sympagic communities in the SI EBSA and other areas of the Arctic are limited. Zooplankton surveys were conducted in Hudson Bay (Estrada et al. 2012), Hudson Strait (Estrada et al. 2012), Foxe Basin (Grainger 1959, 1962, 1965, Harvey et al. 2001, Estrada et al. 2012), the CAA (Buchanan et al. 1977, Darnis et al. 2012, Harwood et al. 2017), and Frobisher Bay (Grainger and Hsiao 1990). Arctic zooplankton diversity was estimated at (minimum) 131 families and 372 species, which is similar to that of the Atlantic Ocean and lower than that of the Pacific (Archambault et al. 2010, Darnis et al. 2012). Survey results indicated that the Hudson Bay system (including the SI EBSA) supports less than half the number of species (166) identified in northern Arctic waters; however, total diversity in the Hudson Bay region was likely underestimated based on undersampling of Annelida (Archambault et al. 2010).

Arthropoda (especially Maxillopoda) and Cnidaria were the most diverse and abundant groups in the Hudson Bay system, in contrast to the calanoid- and harpacticoid-dominant Arctic region. Diversity of the less common zooplankton phyla (Mollusca, Ctenophora, Chaetognatha, and Chordata) was similar other Arctic regions. Overall abundance was also much lower in the Foxe Basin region than in more temperate waters or Arctic waters further east (e.g., Hudson Strait) where higher salinities and reduced current mixing and stratification are prevalent (Grainger 1959, Harvey et al. 2001). Estrada et al. (2012) found that the total zooplankton biomass on the northern side of SI EBSA was as much as 4 times higher than in Hudson Bay proper. This study identifies water column structure as a key driver of zooplankton biomass/diversity and thus for differentiation of communities in and around the SI EBSA proper. The species of amphipods from the SI EBSA differentiated the area from Hudson Strait and Hudson Bay sampling stations (Estrada et al. 2012). Loewen et al. (2020) provides a list of taxa identified in or near the SI EBSA (Grainger 1959, 1962, Thomas 1999, Harvey et al. 2001). Copepoda and Amphipoda, particularly sympagic species, were the most diverse taxa.

Ice floe edge zooplankton and sympagic amphipods in the SI EBSA have not received direct attention, but community composition is expected to be similar to areas with seasonal ice cover. Calanoid, harpacticoid and cyclopoid copepods, Hyperiid amphipods and the sympagic species *Onisimus glacialis*, *Apherusa glacialis*, and *Gammarus wilkitzkii* are common at floe edges in nearby regions (Grainger 1959, 1962, Atkinson and Wacasey 1989a, Pomerleau et al. 2011a). During a study of Bowhead Whale aggregations within Foxe Basin during 1996 and 1997, Thomas (1999) found that zooplankton density (dominated by copepods) decreased with increasing distance from the floe edge. In addition, zooplankton density increased as the summer season progressed, presumably in response to increased algal growth (Thomas 1999).

Similarly, Grainger (1959) found that zooplankton volume near Igloolik in 1955 and 1956 was lowest in mid-April (late winter) and highest in late September prior to ice formation. These trends were primarily a consequence of shifts in herbivorous zooplankton abundance in response to algal growth. Of the 28 species of zooplankton recorded by Grainger (1959) near Igloolik, the most abundant were copepods, although chaetognaths (arrow worms; *Parasagitta elegans*), cirriped larvae, hydrozoan cnidarians (*Halitholus cirratus*), and pelagic tunicates (Fritillaria borealis) were also common. Annual variation in zooplankton development was attributed, in part, to variations in duration of ice cover (Grainger 1962).

Arctic waters entering Foxe Basin through Fury and Hecla Strait influence zooplankton populations throughout most of northern and central Foxe Basin (Grainger 1962, 1965). In contrast, southern Foxe Basin, Foxe Channel and waters in the vicinity of Southampton, Nottingham and Charles islands and, to a lesser extent, northeastern Foxe Basin, are influenced primarily by subarctic waters. Zooplankton species typical in Arctic communities such as *Calanus glacialis*, *C. hyperboreus*, and *Pseudocalanus minutus* are most abundant in the north and central regions of Foxe Basin and much less common in the south near Southampton Island (Grainger 1962, NSC et al. 2010). Where present in the south, these species are typically found at greater depths than in the north, as they follow sinking cold water masses (Grainger 1962). Species indicative of a subarctic influence (e.g., *Calanus finmarchicus*) are more common in southern Foxe Basin than in the north, but are still much less abundant than in Hudson Strait (Harvey et al. 2001).

BENTHIC COMMUNITY

The distribution and abundance of benthic organisms are influenced by a number of factors, including substrate type, water depth, sea ice (e.g., scouring), physical and chemical properties of the water column, and food availability. Approximately 1,000–1,300 benthic taxa are estimated for Canadian Arctic waters, which is more diverse than the Pacific Ocean and at least as diverse as the Atlantic coasts of Canada (Archambault et al. 2010, Snelgrove et al. 2012, Darnis et al. 2012). Although the current number of observed species is considered an underestimate (Piepenburg et al. 2011), diversity in the Hudson Bay ecoregion was the lowest among the Arctic regions studied by Cusson et al. (2007), and may be explained by low primary production (Archambault et al. 2010). However, there are limitations to the Cusson et al. (2007) study that need to be considered. Cusson et al. (2007) used Atkinson and Wacasey's (1989a, b) data to perform their analysis. These data sets were limited to near-shore and shelf habitats and ignored benthic habitat greater than 200 m.

New unpublished research is suggesting that this region may be more productive than previously assumed (M. Pierrejean, Université Laval, pers. comm.). Specificially, the SI EBSA has the highest productivity in the Hudson Bay complex including Hudson Strait. To determine how environmental parameters structure communities, Pierrejean et al. (2018) used a Hierarchical Modelling Species Communities (Ovaskainen et al. 2017). The model is based on occurrence species from 31 stations issued of historical data (e.g., Atkinson and Wacasey 1989a, Cusson et al. 2007, Piepenburg et al. 2011) and recent data. With these data, they developed a preliminary map of epibenthic species for the species richness predicted. Water depth, sea ice, surface chlorophyll, dissolved oxygen concentration, depth temperature and salinity were used in developing the model. The model highlighted 5 areas with a high taxa richness predicted: James Bay with more than 60 taxa richness predicted, the East of the Bay with more than 40 taxa richness predicted, the center of the Bay with almost 30 taxa richness predicted, the East of SI EBSA with 20 taxa richness predicted and the Roes Welcome Sound polynya with 10 taxa richness predicted (Figure 13). The center of the Bay and the east of SI are characterized by deep current convergence (Saucier et al. 2004) and this may provide a

supply of nutrient resulting in a high benthic productivity. Barber and Massom (2007) defined two polynyas in Hudson Bay: the Roes Welcome Sound polynya and the area near Belcher Islands (East of the Bay) corresponding to a high taxa richness predicted in the model.

Benthic taxa identified in or near marine waters of the SI EBSA can be found in Loewen et al. (2020). A minimum of 430 taxa were identified in the area with amphipods, polychaetes, gastropods, hydrozoans, and bryozoans among the more diverse of the major taxa.

Kostylev et al. (2015) developed a preliminary map of benthic scope for growth for Canada's offshore waters, including Hudson Bay and Foxe Basin. The authors defined "scope for growth" as the amount of energy available to animals for growth and reproduction. Seabed bathymetry, near bottom and surface temperature, salinity and water density, oxygen saturation, surface chlorophyll and near bottom nutrient data were used in developing the model. Despite the fact that the scope for growth calculation was based on Canadian offshore waters as a whole (i.e., not as separate regions), the model supported the current understanding of benthic productivity in the region, following longitudinal and onshore-offshore gradients (Kostylev et al. 2015). The model characterized Hudson Bay with an average to low scope for growth, with values higher along the coastline. In contrast, Foxe Basin showed a high scope for growth, which was attributed to high oxygen saturation (Kostylev et al. 2015).

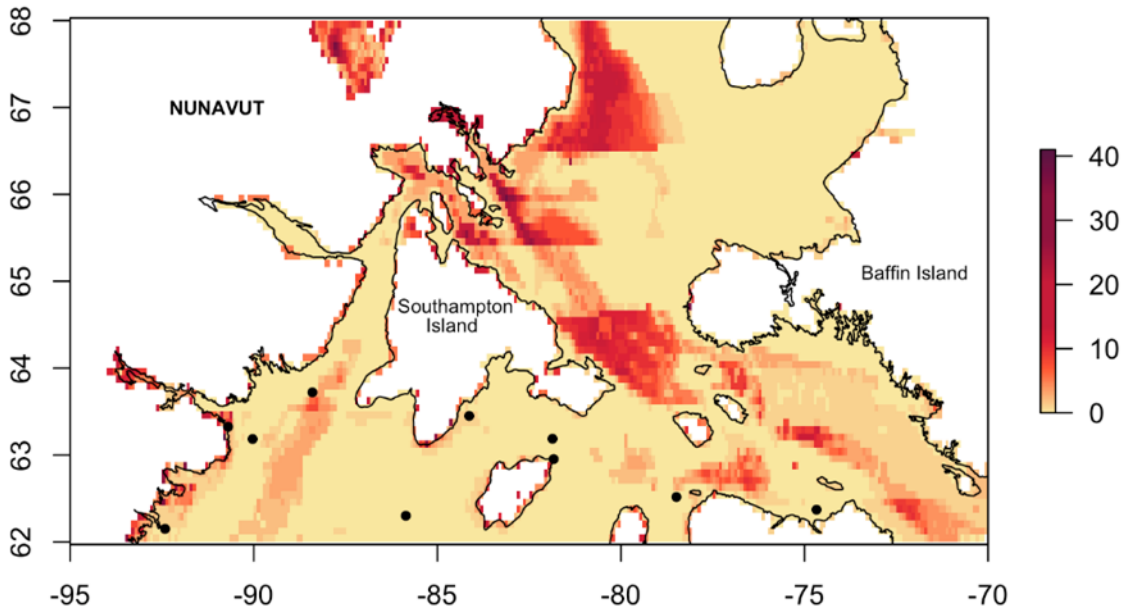

Figure 13: Predicted areas of modelled benthic species richness in and around the Southampton Island (Source: M. Pierrejean). The circles represent actual sampling stations for 2018. Red to deep red on the scale represents high level of taxa richness.

A total of 479 benthic invertebrate species were collected from 177 stations in Hudson Bay between 1953 and 1965, and several of those were collected in the SI EBSA (Atkinson and Wacasey 1989a). East Bay was in recent years sampled by divers for benthos however the data remains unpublished at the time of this report (P. A. Smith, ECCC, pers. comm.). Annelida tended to be the dominant phylum throughout the Hudson Bay system (Atkinson and Wacasey 1989a, Cusson et al. 2007). Within the four sites located in the EBSA, 171 species from 24 higher taxa (classes, orders, or phyla) were identified, of which 58 were not found at nearby sites in Foxe Basin. These EBSA sites were deeper (range of 29–110 m), on average, than other sites sampled in northern Foxe Basin. A mixture of survey depths and sampling techniques used over multiple years during the Atkinson and Wacasey (1989a) survey can

account for at least some of the community composition differences among EBSA sites. Sites located within the EBSA had particularly diverse assemblages of polychaetes, amphipods, cnidarians, echinoderms, gastropods, and bivalves (Atkinson and Wacasey 1989a). Species that are ubiquitous and abundant throughout the Foxe Basin/Hudson Bay area included the bivalve (*Hiatella arctica*), Discordant Mussel (*Musculus discors*), the amphipod (*Anonyx nugax*), decapods (*Lebbeus polaris* and *Arcturus baffini*), Green Sea Urchin (*Strongylocentrotus droebachiensis*), and the Ophiuroid (*Ophiacantha bidentate*) (Calder 1970, Atkinson and Wacasey 1989a, b). Shrimp became more common with distance east into Hudson Strait from northern Hudson Bay (Hudon 1990).

Benthic community composition appears to vary by region. For example, Atkinson and Wacasey (1989a, b) found that approximately 29% of the taxa identified from northwestern Foxe Basin and the southern Foxe Channel/Coats Island regions were unique to each of those locations. In contrast, samples from the Frozen Strait and Roes Welcome Sound area had the greatest number of taxa (375), but the fewest (approximately 11%) that are unique to the region (Calder 1970, Atkinson and Wacasey 1989a, b). Overall, Foxe Basin and Southampton Island have a distinct (in terms of diversity) benthic community when compared to nearby Hudson Strait or Hudson Bay (Cusson et al. 2007). Kenchington et al. (2011) identified the Roes Welcome Sound polynya (often referred to as the Southampton Island polynya) as a separate EBSA due to potentially high benthic productivity and richness (Kenchington et al. 2011).

More than half of the taxa collected from northern Southampton Island are amphipods and ectoproctans, several of which are relatively common (Loewen et al. 2020). In the southern Foxe Channel/Coats Island area, which is influenced by currents from both Hudson Bay and Hudson Strait, polychaetes are the most diverse, comprising almost 40% of the 89 unique taxa. Three of the most common individual taxa in this region are the Iceland Scallop (*Chlamys islandica*), Blue Mussel (*Mytilus edulis*), and Arctic Lyre Crab (*Hyas coarctatus*), all of which originate and are more abundant further to the east.

Most of benthic invertebrate surveys in Foxe Basin have been conducted in subtidal and shelf habitats with the majority of sampling stations ranging from 0–192 meters in depth with < 5 stations > 200m (Calder 1970, Atkinson and Wacasey 1989a, b). Substrate type, light, suspended sediment, current, salinity, temperature and dissolved oxygen are all important determinants of benthic community structure in subtidal areas (Dale et al. 1989), while bottom salinity, temperature, and primary production are key variables in shelf habitat (Cusson et al. 2007).

Some local knowledge of macroinvertebrate distribution exists for Southampton Island (GN 2011, 2012). Clams (*Bivalvia*), sea stars (*Echinodermata*), sea butterflies (*Gastropoda*), Iceland Scallop (Chlamus islandica), urchins, amphipods, ctenophores, Arctic Moonsnail (*Cryptonatica affinis*), jellyfish, shrimp, and Armhook Squid (*Gonatidae*) were reported in coastal areas throughout northwestern Southampton Island (GN 2011). Along the southern coast of the island, particularly in South Bay, Truncate Softshell Clams (*Mya truncata*) are commonly preyed upon by Walrus (*Odobenus rosmarus*) (GN 2012). The edible Blue Mussel (*Mytilus edulis*) are also common in the area. Cockles, Iceland Scallop, whelk, urchins, sea star, crabs, sea cucumber, shrimp, amphipods, mysids, squid, barnacles (*Cirripedia*), Arctic Moonsnail, Naked Sea Butterfly (*Clione limacina*), ctenophores, jellyfish, and limpets were also reported from South Bay and surrounding waters.

MARINE AND ANADROMOUS FISHES

Southampton Island is part of both the Hudson Bay and Hudson Strait ecozones (Coad and Reist 2004). Descriptions of fish species presence and distribution are largely lacking for the Hudson Bay Complex, possibly due to the lack of commercially exploitable fisheries resources

(Stewart and Lockhart 2005). Ponton and Fortier (1992) and Ponton et al. (1993) reported a number of fish larvae within the Grande rivière de la Baleine plume (southeastern Hudson Bay) in spring and summer. Arctic Cod and Sand Lance larvae were most abundant; however, those of Slender Eelblenny (*Lumpenus fabricii*), Gelatinous Seasnail (*Liparis fabricii*), Arctic Shanny (*Stichaeus punctatus*), sculpins (*Cottidae*), Capelin (*Mallotus villosus*), Burbot (*Lota lota*), and coregonines, were also present in some portions of the study area depending on salinity (Ponton et al. 1993). It is unknown whether similar nursery areas occur within river plumes of the SI EBSA.

Approximately 42–44 species of marine fish have been documented to occur in Hudson Bay, while 88 species occur in Hudson Strait, and 18 have been recorded from Foxe Basin (Coad and Reist 2018). Although fish community investigations in the SI EBSA are limited, many of the species observed in these regions could be present in the EBSA. Stewart and Lockhart (2005) suggested that at least 61 species of fish were present in the Hudson Bay/James Bay marine ecosystem, and that the number of Arctic marine fish species increases with latitude. Of the Hudson/James Bay species, 25 are wholly marine, ten are found in both marine and estuarine environments, nine are anadromous, 16 are semi-anadromous, one (Fourhorn Sculpin; *Myoxocephalus quadricornis*) is wholly estuarine, and one (Atlantic Salmon; *Salmo salar*) is diadromous (Stewart and Lockhart 2005). Anadromous and semi-anadromous species (with the exception of Arctic Char, *Salvelinus alpinus*) are less common in northern Hudson Bay (including Southampton Island) than in James Bay as coastal waters are more saline towards Southampton Island. Species such as coregonines, Burbot, and Lake Trout (*Salvelinus namaycush*) are less common to the north. The number of species is low compared to Hudson Strait, which may reflect sampling effort and/or differences in bathymetry and other habitat parameters (Stewart and Lockhart 2005). Loewen et al. (2019) provides a full list of fish species that do, or may, occur in the SI EBSA based on IQ (GN 2011, 2012) and available science information (e.g., Coad and Reist 2018, Stewart and Bernier 1984). This report also provides fish species distributions for each family group for the SI EBSA and surrounding regions (Coad and Reist 2018, Loewen et al. 2020).

At least three snailfish (*Liparis* sp.) species are found along the shorelines of Southampton and Coats islands (Able and McAllister 1980). Repulse Bay IQ identified schools of Capelin (*Mallotus villosus*) throughout the bay and several species of sculpins (*Cottidae*), lumpsuckers (*Cyclopteridae*), and eelpouts (*Zoarcidae*) near the community (GN 2011). In addition to the abundant and ubiquitous Arctic Char and Arctic Cod (*Boreogadus saida*) (described below), residents of Coral Harbour also identified Greenland Cod (*Gadus ogac*), lumpsuckers, Capelin (*South Bay*) and multiple sculpin species year-round along the northern and southern coasts (GN 2012 on Coats Island shores. Arctic Skates (*Amblyraja hyperborea*) were noted in offshore waters at the mouth of South Bay.

Beamish (2002) suggested that climate change could have a greater impact on global fisheries than overfishing. This effect may be more dramatic in the Arctic where temperature increases are expected to be greatest. Wisz et al. (2015) projected that by 2100, 41 Atlantic species may reach Pacific waters and 44 Pacific species may extend to the Atlantic. Due to changes in environmental parameters such as habitat suitability, larval transport in currents, migration patterns, and population growth, marine animals were projected to shift their distribution towards the poles at a rate of 40 km annually (Cheung et al. 2008, 2009). Present day surveys are being conducted in the SI EBSA.

Seabird foraging studies conducted in the SI EBSA documented changes in diet over time, suggesting that the relative abundance of some marine fish species may be changing. Gaston et al. (2003) reported a substantial decrease in the occurrence of Arctic Cod, sculpins and eelpouts in Thick-billed Murre (*Uria lomvia*) chick diets at the Coats Island breeding colony

between 1980 and 2002. An increase in the occurrence of Capelin and Sand Lance in the murre chick diet was noted for the same time period. July ice cover in Evans Strait during the 1981–1999 period was half that in previous years, suggesting that the observed diet shift in murre chicks reflected changes in the abundance of forage fish populations as a result of the general warming of Hudson Bay. Continued shifts in murre chick diets despite more stable ice conditions since the late 1990's suggested that a progressive and cumulative environmental change was occurring in the marine community near Southampton Island (Gaston and Elliott 2014).

Most inshore and inland commercial fishing in Nunavut focuses on Arctic Char, although some communities have developed fisheries based on whitefish (*Coregonus* sp. and/or *Prosopium* sp.) and Greenland Halibut (*Reinhardtius hipploglossoides*) (GN 2016a). The community of Coral Harbour recently showed interest in developing a char fishery , and while commercial harvests have not yet begun, three waterbodies on or adjacent to northern Southampton Island and the Repulse Bay/Frozen Strait EBSA currently have assigned quotas (GN 2016a). Residents of Coral Harbour harvest Arctic Char and other species (e.g., Lake Trout, Least Cisco [*Coregonus sardinella*], cod (*Gadidae*) and sculpins throughout Southampton Island and adjacent coastal areas year-round (Riewe 1992).

ARCTIC CHAR (*SALVELINUS ALPINUS*)

Despite the presence of both anadromous and non-anadromous Arctic Char in the SI EBSA (GN 2012), population and life history investigations have not been conducted directly in the SI EBSA. Anadromous Arctic Char use nearshore waters in the SI EBSA wherever there are suitable and accessible rivers or lakes for spawning (GN 2011, 2012). Telemetry studies in other regions of the Canadian Arctic further demonstrate that Arctic Char generally prefer to use coastal habitats in marine environments (Moore et al. 2016, Spares et al. 2012). Char have not been observed along the west coast of Southampton Island and have a patchy distribution along the coast (Nuvuarjualuk Bay, south of the Ascension Islands, Cape Fisher, the Porsid Mountains, Canyon River, Cape Bylot, Duke of York Bay, south of Cape Munn) (GN 2012). Char are present in several rivers along the coast of Southampton Island, including the Canyon River, tributaries draining from the Porsild Mountains, Maumi Lake at Mount Minto, Iglurjuakuiluit Inlet, Post River, Ford River, Thomsen River, tributaries at Cape Munn, and the Cleveland River in Duke of York Bay (GN 2012). Downstream migrations out of freshwater lakes typically begin in June. Char remain in marine waters feeding throughout the open-water period, returning to river systems in August to spawn and overwinter (GN 2012). Arctic Char are an important subsistence resource for residents of Coral Harbour. The community harvests char in both coastal and freshwater systems in and around Southampton Island (Riewe 1992). Anadromous forms are primarily caught in the Cleveland and Sutton rivers (Riewe 1992).

During the summer period, Arctic Char are known to migrate into marine coastal waters and intermix between different stocks of freshwater origins. Chars in the SI EBSA may originate from Southampton Island rivers or may likely be from char populations along the Western Hudson Bay coastline and potentially elsewhere. It is also known from other locations such as Cumberland Sound (Harris et al. 2014, Moore et al. 2014) and Cambridge Bay regions (Harris et al. 2016) that non-reproductive chars may use any freshwater system to over-winter and only return to their freshwater river of birth for reproduction. Tagging and weir studies by McGowan (1986, 1996, and 1997) demonstrated a fluctuation of char population numbers based upon seasonal (fall) river water levels for migration into fresh water along the Western Hudson Bay coastline (D. McGowan, retired Fisheries and Oceans Canada, pers. comm.). Non-reproductive migratory char were thought to intermix for freshwater overwintering.

ARCTIC COD (*BOREOGADUS SAIDA*)

Arctic Cod are circumpolar (Welch et al. 1993, Benoit et al. 2008, Mecklenburg et al. 2011) and are an important component in marine food webs throughout the Canadian Arctic (Bain and Sekerak 1978, Bradstreet 1980, Cobb et al. 2008, Loseto et al. 2008, 2009, Majewski and Reist 2015, DFO 2018). Upwellings, recurrent polynyas, nearshore areas, flaw lead features and ice-edges have all been identified as potentially important areas for Arctic Cod. Their diet consists of sympagic copepods and amphipods along the floe edge in spring (Bain et al. 1977, Bain and Sekerak 1978) and in broken ice and open water during summer (Hop et al. 1997). Consequently, predicted decreases in sea ice extent and thickness of ice cover will likely influence Arctic Cod distribution and affect food web structure and function throughout the Arctic (Hop et al. 1997, CAFF 2017).

Arctic Cod are abundant in nearshore areas off Southampton and Coats islands (GN 2011, 2012), particularly coastal areas of southern Southampton Island and small islands in Fisher and Evans straits where they are important prey for the large, local seabird colonies (e.g., Harter et al. 2013, Gaston and Elliott 2014). In a study of the Coats Island Thick-Billed Murre colony, Harter et al. (2013) noted the importance of Arctic Cod to murre diets, particularly larger cod. As older, larger cod are more frequently associated with ice than smaller, juvenile cod (Lowry and Frost 1981, Bradstreet et al. 1986, Jarvela and Thorsteinson 1999), a potential reduction or loss in sea ice with climate change could affect cod distribution and population structure, as well as fish community assemblage and food web dynamics in the region (Harter et al. 2013). During a long-term study (1981-2013) of Coats Island murres, Gaston and Elliot (2014) identified a substantial shift in murre diets from Arctic Cod-dominant to Capelin-dominant, which was strongly affected by ice conditions and resulted in lower growth rates for chicks.

MARINE MAMMALS

The waters surrounding the SI EBSA provide seasonal or year-round habitat for numerous marine mammal species, including at least four whale species, five species of phocid seals, Walrus (*Odobenus rosmarus*), and Polar Bears (*Ursus maritimus*). Whale species and Harp Seals (*Pagophilus groenlandicus*) make annual movements into the EBSA and surrounding areas during periods of open water. In contrast, Ringed Seals (*Pusa hispida*), Bearded Seals (*Erignathus barbatus*), Walruses and Polar Bears, are year-round residents to the SI EBSA region. The distribution, abundance and ecology of the principal marine mammal species occurring in the SI EBSA are discussed in the following sections. Individuals of each of these species make seasonal movements both within the EBSA and between the EBSA and other areas. Some of these movements cover large distances (e.g., fall Narwhal migrations to eastern Hudson Strait), while others may be localized, such as Ringed Seals moving to offshore areas to feed during summer.

Several whale species occur infrequently and in small numbers within the SI EBSA, including Long-finned Pilot Whale (*Globicephala melas*), Minke Whale (*Balaenoptera acutorostrata*) and North Atlantic Right Whale (*Eubalaena glacialis*) (GN 2011, 2012). The North Atlantic Right Whale is designated as endangered under the Canadian Species at Risk Act (SARA), as well as by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The occurrence of Hooded Seals within the SI EBSA appears to be less common, and the number of animals observed yearly is unknown (GN 2011). Since the distributional ranges of the above species do not generally extend into the SI EBSA, these species were not considered further.

BELUGA (*DELPHINAPTERUS LEUCAS*)

Belugas occurring in the SI EBSA are part of the western Hudson Bay (WHB) population (Figure 14; COSEWIC 2016). The current population is considered stable and estimated at 57,300 animals (95% Confidence Interval [CI] = 37,700–87,100; Richard 2005, Richard 2010a) based on summer aerial surveys conducted in 2004 (Richard 2005). At the time of last assessment in 2004, COSEWIC designated the WHB Beluga population as being of Special Concern, largely due to lack of contemporary data describing population trends at that time, and concern regarding commercial shipping and potential hydroelectric development along rivers whose estuaries supported large numbers of summering Belugas (COSEWIC 2004a).

WHB Belugas have a large annual range (Figure 14). While a small proportion of the population can remain in Hudson Strait during the summer months (June–August), most animals migrate from this overwintering area to summer feeding areas in the coastal waters of western Hudson Bay (Richard 2010a). Those moving into western Hudson Bay primarily concentrate in the Seal, Churchill, and Nelson river estuaries during summer, with smaller numbers found in coastal waters between the Winisk River in Ontario to Lyon Inlet immediately north of the SI EBSA (Sergeant 1973, Richard 1990, 1993, 2005, Richard et al. 2010). The movements of Belugas tagged with satellite-linked transmitters in the 1990s (Martin et al. 2001) and early 2000s (Smith et al. 2007), suggested that the northern limit of the WHB Beluga range is Lyon Inlet. However, IQ collected in Igloolik also suggested that WHB Belugas may migrate north along the east coast of Melville Peninsula in the spring into northern Foxe Basin (GN 2008). Both satellite telemetry data and IQ indicated that both Hudson Strait and Ungava Bay are used by WHB Belugas as overwintering habitat (McDonald et al. 1997, Smith et al. 2007). In addition, Sergeant (1973) and Sergeant and Brodie (1975), suggested that Beluga overwintered in Roes Welcome Sound, however winter aerial surveys (1981/1982) observed few to no whales within the Roes Welcome Sound polynya (Finley et al. 1982, Richard et al. 1990). These observations suggested that the polynya is not used as extensively for overwintering as previously thought. Instead, the majority of overwintering whales in the Southampton Island region were observed north of Mansel Island (Finley et al. 1982).

Spring migrations to summering areas are less understood than fall migrations, but generally occur between late April and May (Sergeant 1973). Most Belugas are believed to follow the eastern coast of Hudson Bay south to the Belcher Islands, and then across Hudson Bay through the pack ice, arriving along the Manitoba coast in late May and early June (Reeves and Mitchell 1989a, COSEWIC 2004a). However, a small number of whales move westward from Hudson Strait towards Southampton Island. Although the SI EBSA is largely used as a corridor by Belugas moving into summering areas along the western Hudson Bay coast (Higdon 2017), a small number of whales remain in the area throughout the summer (GN 2012). Belugas begin to arrive in the SI EBSA in May and June, moving westward along the southern coast of Southampton Island (Finley et al. 1982). Coral Harbour Inuit reported WHB Belugas in Duke of York Bay (north coast of the island), off the East Bay Bird Sanctuary (east coast), in Gorden Bay (west coast), and from Junction Bay to Allinataaq Lake and in South Bay along southern Southampton Island (GN 2012). IQ indicated that Belugas frequent the mouths of rivers during spring migration, particularly in Duke of York Bay where Arctic Char are most abundant (GN 2012). Fresh water is also known to promote molting (St. Aubin et al. 1990). East Bay was also identified by several Coral Harbour hunters as a calving area (GN 2012). It has been observed that large numbers (10s to low hundreds) of Belugas congregate in the shallow waters at the head of East Bay (P. A. Smith, ECCC, pers. comm..). Belugas are also commonly seen from seabird observation blinds at Coats Island and may provide a 30 year record on presence and timing of movements for this area.

Fall migrations from summering areas toward Hudson Strait begin during early to late September (Figure 14) (McDonald et al. 1997, Martin et al. 2001, Smith et al. 2007). Migration routes from the main summering areas vary, with some whales moving north along the western Hudson Bay coastline (Smith et al. 2007), others traveling across the deep waters of Hudson Bay (Martin et al. 2001, Smith et al. 2007), or moving east toward the Belcher Islands and then north to Hudson Strait (Smith et al. 2007). Many Belugas summering in the Nelson, Churchill, or Seal river estuaries, pass through the SI EBSA during fall migration. Unpublished satellite telemetry data recorded six Belugas tagged in the Seal River estuary in 2012 moving north through Roes Welcome Sound to Lyon Inlet and Frozen Strait (COSEWIC 2016). Several whales tagged in the Nelson River estuary in 2002–2005 moved east along the southern coast of Southampton Island and northeast through SI EBSA waters (Smith et al. 2007). The portion of the fall migration through the SI EBSA typically occurs from October through December (Smith et al. 2007).

Information describing Beluga diets within the SI EBSA is limited; however, local IQ suggested that WHB Belugas remain near river mouths in spring to feed on Arctic Char (GN 2011, 2012). Nunavik hunters reported sculpin, cod (various species), Atlantic salmon, Capelin, Sand Lance, herring, and decapod crustaceans in the stomachs of harvested Belugas, with some regional differences (Breton-Honeyman et al. 2016). Kelley et al. (2010) compared the relative occurrence of Arctic Cod and Capelin from WHB Belugas sampled at Arviat, with those of the Cumberland Sound and High Arctic Beluga populations. Fatty acid analyses illustrated that cod were a large component of the diet for the two northern populations, whereas Capelin were much more important to WHB Belugas. The difference in diets was attributed to the extended occurrence of open water in Hudson Bay, which favours the occurrence of Capelin. In more northern areas where ice is more prevalent, Arctic Cod are more abundant than Capelin (Kelley et al. 2010). A recent shift in the diets of Coats Island seabirds toward Capelin and Sand Lance, and fewer Arctic Cod was reported in response to sea ice loss in the region (Gaston et al. 2003, Provencher et al. 2012, Gaston and Elliott 2014). Although data for this area are limited, a similar shift in Beluga diets may be occurring in the SI EBSA and surrounding areas (Yurkowski et al. 2017).

Historically, WHB Belugas were commercially exploited from the 1600s to 1960 (Reeves and Mitchell 1989b). Exploitation was highest in western Hudson Bay, where the annual commercial harvest was approximately 500 whales per decade for most of the 1820–1940 period (Baker et al. 1992). It is unclear how past commercial exploitation may have affected the size of the WHB population. Many Inuit communities harvest WHB Belugas at different times of the year throughout the Hudson Bay Complex (Turgeon et al. 2012, COSEWIC 2016). During 1977–2015, an average of 408 (SE=16, N=39) WHB whales were reported harvested annually by the Nunavut and Nunavik communities in Hudson Bay, Hudson Strait, south Baffin Island and Ungava Bay (DFO 2018). Coral Harbour harvests Belugas more commonly from South Bay and less commonly from areas such as Ujagasukjualuk Bay, Lyon Inlet and Duke of York Bay during summer (GN 2012). Although recent harvest numbers for the community are not available, Priest and Usher (2004) estimated Coral Harbour landings at 85 ± 14 per year from May 1996 to June 2001. More recently, Hoover et al. (2013) reported a harvest of seven Belugas in Coral Harbour in 2007. Annual harvests of WHB Belugas from other communities in 2007 were: Arviat (n = 50), Chesterfield Inlet (n = 12), Rankin Inlet (n = 38), Naujaat (n = 21), Sanikiluaq (n = 52) and Whale Cove (n = 10).

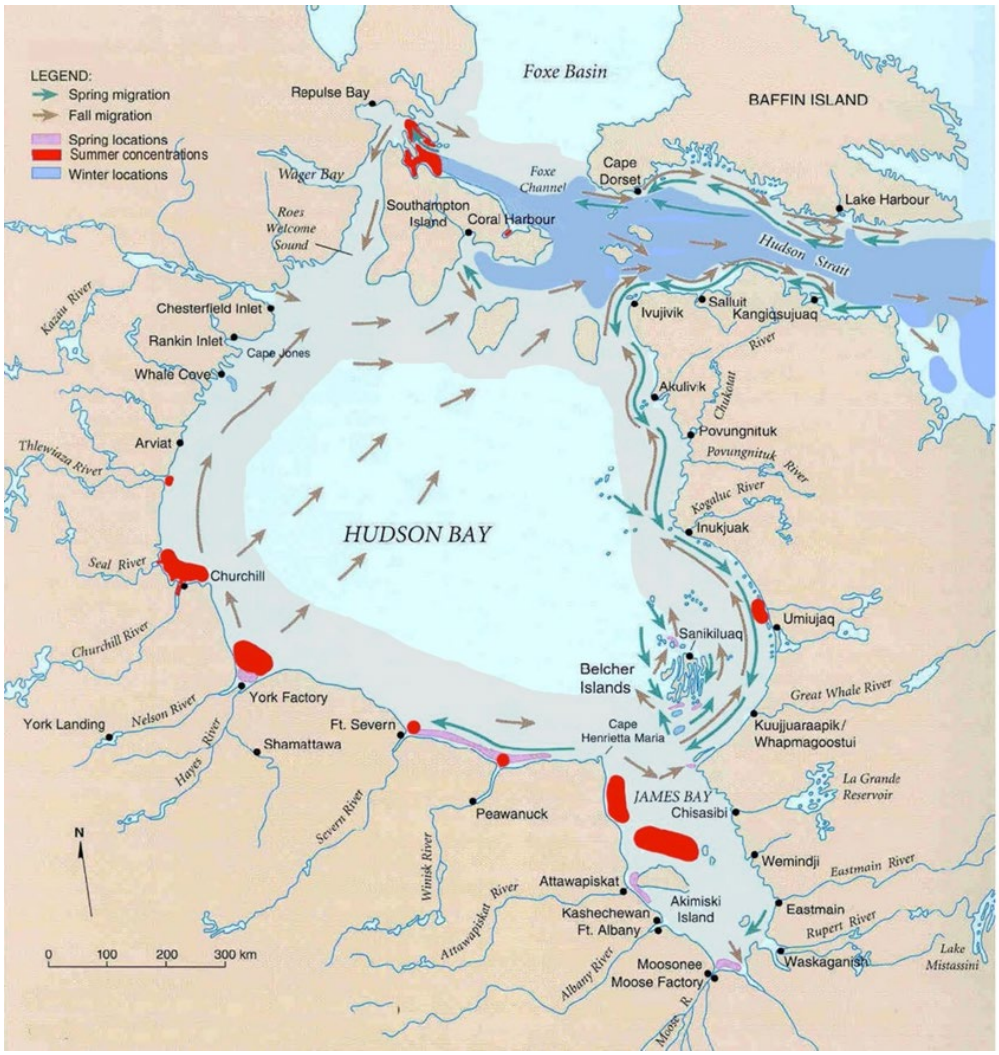

Figure 14. Hudson Bay Beluga Whale core habitat (grey), including the spring and fall movements, and areas where they migrate in spring, concentrate in summer, and migrate to spend the winter. Compiled from traditional and scientific sources. (Source: COSEWIC 2016, Stewart & Lockhart 2005).

BOWHEAD (*BALAENA MYSTICETUS*)

Bowhead Whales have a nearly circumpolar distribution in the northern hemisphere (Figure 15). Those occurring in the SI EBSA are part of the Eastern Canada-West Greenland (EC-WG) population (Heide-Jørgensen et al. 2003a, 2006, Dueck et al. 2006, Postma et al. 2006, 2014, IWC 2007, COSEWIC 2009), one of two recognized in Canadian waters. The EC-WG population is designated as Special Concern by COSEWIC (COSEWIC 2009) and is not listed under the Species at Risk Act (SARA). Although Bowheads in Hudson Bay/Foxe Basin and Davis Strait/Baffin Bay were previously thought to constitute separate stocks, updated genetic (Postma et al. 2006, IWC 2007) and satellite tracking (Heide-Jørgensen et al. 2003a, 2006, Dueck et al. 2006) data indicated that these groups belong to a single population (COSEWIC 2009). Members of the EC-WG population range from the west coast of Greenland in Baffin Bay, through Lancaster Sound and the CAA, into Hudson Strait, Hudson Bay, and Foxe Basin (Heide-Jørgensen et al. 2006, Dueck et al. 2006). A portion of coastal habitat used by the EC-WG Bowhead population is federally protected in the Niginganiq National Wildlife Area,

located on northeastern Baffin Island at Isabella Bay. Additional protections will be considered with the establishment of the Tallurutiup Imanga MPA in Lancaster Sound .

Historically, the EC-WG population was severely depleted as a result of commercial whaling between the 1500s to early 1900s (COSEWIC 2009) but is now believed to be increasing (NWMB 2000, COSEWIC 2009, Witting 2014). Growth rate for the population is likely similar to that of Bowheads in the western Arctic at 3.4% (Bering-Chukchi-Beaufort population) (DFO 2011b). A recent population estimate for the EC-WG Bowhead population, based on 2013 aerial survey data, was 6,446 whales (95%; CI = 3,722–11,200; Coefficient of Variation [CV] = 26%; DFO 2015, Doniol-Valcroze et al. 2015). However, this estimate was likely a conservative one due to gaps in survey coverage (Foxe Basin, Lancaster Sound, and northern Hudson Bay were not surveyed) and clustering of whales in some areas (e.g., Isabella Bay, Cumberland Sound) (DFO 2015, Doniol-Valcroze et al. 2015). In 2015, a second estimate of 7,660 whales (95% High Density Interval [HDI] 4,500–11,100) was calculated using genetic capture-mark-recapture analysis (DFO 2015, Frasier et al. 2015). From this analysis, a location-specific population estimate of 38 whales (95% HDI 20–124) was obtained for Repulse Bay (Frasier et al. 2015). An August 1995 aerial survey of northwestern Hudson Bay, including the western Hudson Bay coast from Whale Cove to Roes Welcome Sound, Repulse Bay, Frozen Strait and the northeast coast of Southampton Island was estimated at 75 ± 27.5 (95% CI = 17–133) whales in that region (Cosens and Innes 2000).

The EC-WG population wintering locations include areas of unconsolidated pack ice in Hudson Strait and, to a lesser extent, southeastern Baffin Island and Davis Strait (COSEWIC 2009). Summer feeding and nursery areas are located in Baffin Bay and the Canadian High Arctic, northern and southern Foxe Basin, and Hudson Bay (Thomas 1999, Heide-Jørgensen et al. 2003a, Dueck and Ferguson 2008, COSEWIC 2009, Nielsen et al. 2015). The population is segregated by age and sex for much of the year, with juveniles and female/calf pairs preferring nursery areas in northern Hudson Bay, Foxe Basin and Prince Regent Inlet/Gulf of Boothia during summer (Cosens and Blouw 2003, DFO 2015, Ferguson et al. 2010, Stephenson and Hartwig 2010, Postma et al. 2014). A multi-year (2002–2006) satellite tracking study conducted by DFO found that EC-WG Bowheads preferred areas of relatively low ice coverage, thin ice, and small floe areas close to the maximum ice extent in winter and areas of high ice coverage, thick ice, and large floe size areas in summer (Ferguson et al. 2010). While ice conditions selected in winter are believed to minimize risk of ice entrapment, summer selection is thought to reduce the risk of Killer Whale predation while providing access to ice-associated prey (Ferguson et al. 2010, Thomas 1999).

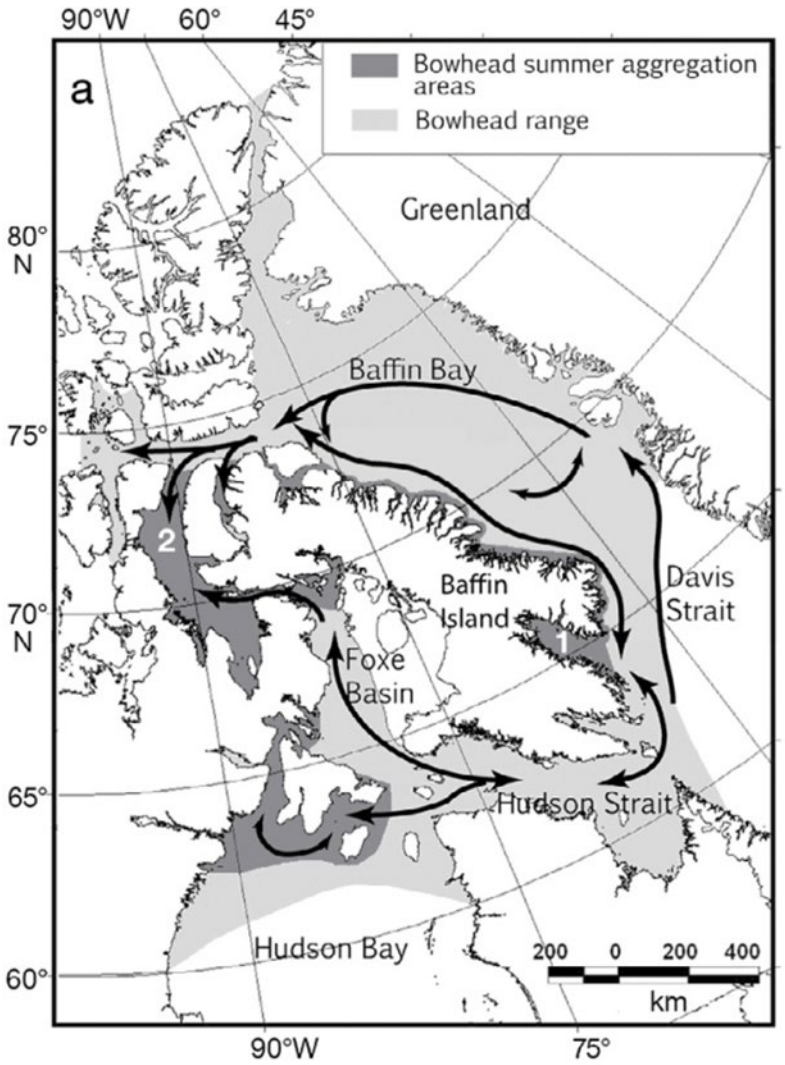

Figure 15. Generalized movements of the Eastern Canada-West Greenland (EC-WG) Bowhead population (Source: Ferguson et al. 2010).

The SI EBSA is used largely as a migratory corridor for Bowheads moving to summer feeding areas in Repulse Bay, Lyon Inlet, and Frozen Strait (DFO 2011b, Higdon 2017). Westward migrations from overwintering areas in Hudson Strait to northwestern Hudson Bay (including the SI EBSA) or northern Foxe Basin occur in April and May (Reeves and Mitchell 1990, Koski et al. 2006). Bowheads arrive at the floe edge off southwestern Southampton Island in May and June then move north, as ice breakup allows, through Roes Welcome Sound to Repulse Bay and Frozen Strait (Figure 15; Reeves et al. 1983, Reeves and Mitchell 1990). Other members of the population move into Foxe Basin along its west coast, passing by the southeastern coast of Southampton Island and moving towards summer feeding and nursery areas near Fury and Hecla Strait (DFO 2010, 2011b, Cobb 2011). Fall migration begins in September and continues into November (Finley et al. 1982, Dueck et al. 2006); however, some animals in northern Foxe Basin move south towards Southampton Island as early as August (Dueck et al. 2006).

A small proportion of the EC-WG population remains in the SI EBSA during summer to feed (Cosens and Innes 2000, GN 2012). Crothers (2017) identified the EBSA as potentially important Bowhead foraging habitat based on satellite remote sensing data for sea ice and

chlorophyll a concentrations. Nielsen et al. (2015) also identified the Repulse Bay area as an important feeding area for Bowheads. Higdon (2017) identified waters off the southeastern coast of Southampton Island as a potentially important calving and rearing area for Bowheads based on observations of calves in the area. Coral Harbour residents observed Bowheads along the northeast coast of Coats Island, in Duke of York Bay near the Thomsen River, at Junction Bay south to Leyson Point, and within the South and Ujagasukjualuk bay area between Imiqutailat Spit and Maurice Point during summer and early fall (GN 2012). IQ from Repulse Bay noted an abundance of whales in Repulse Bay and across the north end of Roes Welcome Sound near White Island.

Although no dietary information is available for Bowheads in the SI EBSA, Pomerleau et al. (2011b) reported a variety of epibenthic, benthic and pelagic fauna in the stomachs of three domestically harvested EC-WG Bowheads in the eastern Arctic between 1994 and 2009. Although sample size was low, preliminary results indicated that Bowheads may exhibit some degree of flexibility with regard to prey selection. Additional studies suggested that the EC-WG Bowhead diet consisted primarily of calanoid copepods, mysids and euphausids (Finley 2001, Lowry et al. 2004, Lee et al. 2005, Laidre et al. 2007, Pomerleau et al. 2011a, 2012). Using fatty acid composition analysis, Pomerleau et al. (2014) found that calanoid copepods formed an important component of Bowhead diets in Foxe Basin. Results also indicated a lack of sexual or age segregation when feeding. However, differences in fatty acids were observed among groups of whales from discrete foraging areas, indicating either summer mixing of whales from different wintering areas and prey assemblages or selective feeding (Pomerleau et al. 2014). Bowheads have been observed along ice edge habitat near Igloolik in July where high concentrations of zooplankton were present (Thomas 1999).

A small number of EC-WG Bowheads are harvested in Greenland and Canada. In Canada, EC-WG Bowhead subsistence fisheries are co-managed by the Nunavut Wildlife Management Board (NWMB), the Nunavik Marine Region Wildlife Board and DFO (DFO 2015). The Total Allowable Harvest is five whales per year in the Nunavut Settlement Area and two per year in the Nunavik Marine Region. In both Settlement Areas, a DFO Licence is issued for approved subsistence Bowhead harvest that prohibits hunting of calves (i.e., a Bowhead Whale that is mottled in appearance and < 7.5 m in length) or whales accompanied by calves. Hunts are authorized pursuant to Subsection 4 (1) of the Marine Mammal Regulations . The International Whaling Commission permits two harvest attempts per year for West Greenland, with an annual review requirement by the Scientific Committee of the International Whaling Commission (DFO 2015). Based on 2013 aerial survey data and a recovery estimate of 0.5, DFO concluded that the EC-WG population could sustain a maximum human-induced mortality of 52 whales annually resulting from all sources of anthropogenic mortality (e.g., harvest, struck and lost, net entanglements, ship collisions) (DFO 2015, Doniol-Valcroze et al. 2015).

NARWHAL (*MONODON MONOCEROS*)

Currently, two spatially and genetically segregated Narwhal populations are recognized in Canadian waters: Northern Hudson Bay (NHB) and Baffin Bay (BB) (DFO 1998a,b, de March et al. 2003, Petersen et al. 2011). An additional population (the East Greenland [EG]), inhabits the eastern shores of Greenland and the Greenland Sea (Petersen et al. 2011). Narwhals occurring in the SI EBSA belong to the Foxe Channel summering aggregation of the NHB population (DFO 2005). Stock differentiation based on spatial distribution is supported by genetic (e.g., Petersen et al. 2011), contaminant (de March and Stern 2003), and satellite telemetry (e.g., Heide-Jørgensen et al. 2003b, Dietz et al. 2008, Richard 2010b) data.

The current corrected NHB population estimate based on August 2011 aerial survey data for the Repulse Bay/Frozen Strait/Roes Welcome Sound/northwest SI EBSA area is 12,485

(CV = 0.26) whales (Asselin et al. 2012). The current estimate is substantially higher than previous population estimates based on visual and photographic surveys conducted in the early 1980s (1,355 animals in 1984, 95% CI: 910–2,100; Richard 1991) and in 2000 (1,778 95% CI: 1,688–2,015; Bourassa 2003), largely due to earlier estimates being uncorrected and having variable survey coverage (COSEWIC 2004b). In an attempt to standardize population estimates between years, Asselin and Ferguson (2013) re-calculated the 2011 population estimate using methods from 1982 and 2000. Their results using older methods with new data more closely resembled the earlier estimates (1,737 [95%; CI = 1,002–3,011] and 1,945 [95%; CI = 1,089–3,471], for 1982 and 2000, respectively), emphasizing how survey and estimation methods can affect abundance estimates.

NHB Narwhals migrate seasonally through Hudson Strait between wintering grounds in eastern Hudson Strait and the Labrador Sea and summer feeding and calving areas in Repulse Bay and nearby waters (Figure 16; Richard 1991, Gonzales 2001, GN 2008, 2011, 2012). Sexual segregation typically occurs in summering habitat where there may be separate groups of mature females with calves, immature and maturing males, and large mature males (Hay 1984). Westdal et al. (2010) examined the timing of migration and seasonal areas of occupation by monitoring the movements of nine Narwhals tagged with satellite linked radio transmitters in Repulse Bay during August 2006 and 2007 (Westdal et al. 2010). Local IQ was collected concurrently to support the telemetry study. Results from this study suggested that the Repulse Bay, Lyon Inlet and Frozen Strait areas, including the northern coast of Southampton Island, were primary summering areas for NHB Narwhals. At the end of summer, tagged whales left the SI EBSA but remained off the northeast coast of Southampton Island until early November (Westdal et al. 2010). All animals followed a similar migration route through central Hudson Strait and arrived at their wintering grounds off Resolution Island in the Labrador Sea in late December, much farther south than other Narwhal populations (Westdal et al. 2010).

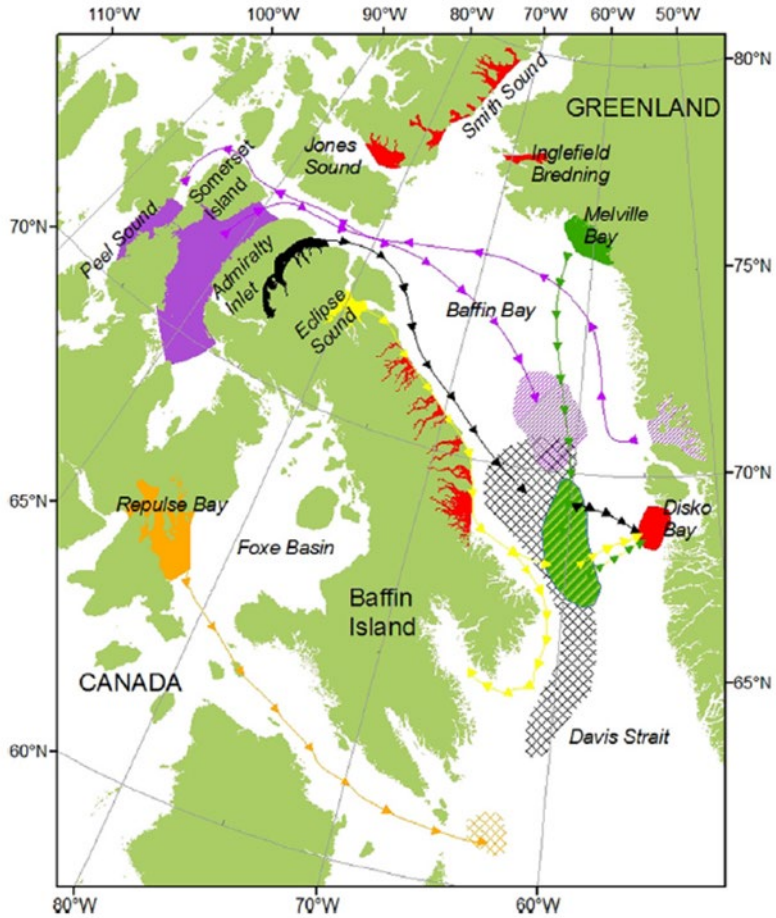

Figure 16. Core summering aggregations (i.e., stocks) of Narwhals in Canada and Greenland, including movement (arrows) to wintering areas: Eclipse Sound (yellow), Admiralty Inlet (black), Somerset Island (purple), Repulse Bay (Hudson Bay, orange), Melville Bay (Green), East Baffin Bay (red), Jones and Smith Sound (red), Disko Bay (red), Inglefield Bredning (red) (Source: Heide-Jørgensen et al. 2013).

Until recently, information pertaining to Narwhal diets was limited to domestically harvested whales sampled in Baffin Bay. BB Narwhal fed largely on fish, including Arctic Cod, Polar Cod, Greenland Halibut, and squid (Finley and Gibb 1982, Remnant and Thomas 1992, Laidre and Heide-Jørgensen 2005). Other occasional prey items from this area were snailfishes, redfishes, sculpins, eelpouts, skate (*Rajidae*) egg sacs, several species of shrimp, Capelin, and wolffish (Hay and Mansfield 1989, Laidre and Heide-Jørgensen 2005).

Watt et al. (2013) compared diet strategies among all globally occurring Narwhal populations using stable isotope analysis, reporting that benthic prey such as shrimp were more important in NHB Narwhal diets than those of the BB or EG populations. No evidence of gender-based differences in prey consumption was found in the NHB population (70% of males and 60% of females consumed benthic prey; Watt et al. 2013), though males did feed more intensively on the benthos, likely because of their larger size and enhanced diving ability. Observed differences in feeding strategies among the populations suggested that Narwhals may adapt their feeding behaviour to compensate for potential changes to their environment. Subsequent analysis of dive behaviour recorded by the nine Narwhal tagged in Repulse Bay supported stable isotope results by showing the NHB whales made more dives in the deep zone than in the mid-water region, which was reflective of benthic foraging behaviour (Watt et al. 2015). Watt

et al. (2017) used the same data set to identify seasonally important foraging areas for NHB Narwhals. Under the assumption that deep dives to (approximately) the seafloor were indicative of feeding, the analysis confirmed that Repulse Bay, Lyon Inlet and Frozen Strait along the northeastern coast of Southampton Island were important feeding areas during summer. Additional important feeding areas were identified in Hudson Strait during the fall migration and east of the entrance to Hudson Strait in winter (Watt et al. 2017). Higdon (2017) identified Frozen Strait as the main migratory channel NHB Narwhals use moving into and out of important foraging habitat in the Repulse Bay area. Important calving and nursing habitat was identified throughout the entire summer core area in the vicinity of Southampton Island.

In Nunavut, Narwhals are managed jointly by DFO and the NWMB, community Hunters and Trappers Organizations and Regional Wildlife Organizations (COSEWIC 2004b). Using the Potential Biological Removal (PBR) method, an updated Total Allowable Landed Catch (TALC) of 157 was developed for the entire NHB stock based on the 2011 population estimate (Asselin et al. 2012). The updated TALC was much higher than earlier years (DFO 2008). However, Asselin et al. (2012) noted several sources of uncertainty with the new calculations, including: small survey coverage, the correction factor for availability bias was based on the diving behavior of a small number of whales and small associated variance; and use of a fixed loss rate (1.28) when calculating the TALC.

The NHB Narwhal population is a distinct management unit and is harvested at certain times of the year by the communities of Naujaat, Coral Harbour, Chesterfield Inlet, Rankin Inlet, Cape Dorset, Whale Cove, Kimmirut, Arviat, Baker Lake and Hall Beach (NWMB 2013). Coral Harbour harvest rates are relatively low, with an average of three whales taken annually from 1998-2011 under a quota of ten (NWMB 2013). IQ indicated that residents occasionally harvest this species in South and Ujagasukjualuk bays and north in the Lyon Inlet and Duke of York Bay areas during summer (GN 2012). From 1996 to 2016, Naujaat harvested an annual average of 65 Narwhals, which was less than the established quota for the community of 72 (DFO unpublished, NWMB 2013).

KILLER WHALE (*ORCINUS ORCA*)

Killer Whales are present in all oceans of the world (Ford 2002). Those occurring in eastern Canada are not listed under the SARA but are designated by COSEWIC as Special Concern (COSEWIC 2008a). The minimum global population of Killer Whales was estimated at 50,000 (Forney and Wade 2006).

Currently, insufficient data exist with which to differentiate among stocks of Killer Whales in the northwest Atlantic Ocean or Canadian Arctic. Using a database of over 450 Killer Whale sightings over the past 250 years, Higdon (2007) found that only eight occurred in Foxe Basin. Historically, Killer Whales were rarely seen west of Baffin Bay as Hudson Strait remained covered in ice year-round. Since the 1930s, central Hudson Strait experienced a significant reduction in sea ice concentration between late June and mid-August, which Higdon and Ferguson (2009) suggested allowed Killer Whales to access the Hudson Bay area. The authors proposed that as climate change progresses, similar declines in sea ice coverage will provide Killer Whales with increasing access to Canadian Arctic waters.

Available evidence suggests that Killer Whale occurrences in the eastern Canadian Arctic are becoming more frequent (Higdon et al. 2012, GN 2008). Recent interviews with residents of Igloolik and Hall Beach indicated that more Killer Whales have been moving through Fury and Hecla Strait in recent years (Higdon and Ferguson 2009, GN 2008, Westdal et al. 2013). In the SI EBSA area, Killer Whales were observed along the northeast coast of Coats Island, at Junction Bay, Imiqutailat Spit, throughout South Bay, and at Walrus Island (GN 2012). IQ

collected from Coral Harbour did not suggest there is an increased frequency of Killer Whale observations in those areas (GN 2012).

Killer Whale movement patterns within the Hudson Bay Complex and the SI EBSA are not well documented. However, IQ suggested that after migrating through Hudson Strait, Killer Whales enter Repulse Bay through Frozen Strait and will also move into Lyon Inlet (Higdon et al. 2013). A single instance of Killer Whales moving through Roes Welcome Sound was noted. Several interviewees indicated that the whales move north and south along the western Hudson Bay and Foxe Basin coastlines. Four interviewees suggested that Killer Whales do not migrate through Fury and Hecla Strait, but three others indicated that they do, following Bowheads into the Gulf of Boothia in summer and Narwhal in the opposite direction in autumn.

Killer Whales in the eastern Arctic are known to consume a wide variety of marine mammal prey, including Belugas, Narwhals, Bowheads and several species of phocid seals (Reeves and Mitchell 1988, Higdon 2007, Higdon et al. 2012, Ferguson et al. 2012). Ferguson et al. (2010) suggested that Killer Whales may target different prey seasonally; Narwhals and Belugas were targeted early and late in the ice-free season and Bowheads were targeted during the peak of the open-water period. Using IQ estimates of prey mortality and modeling techniques, the authors further estimated that 57 Bowheads (range 28–90), 112 Narwhal (range 10–234), 174 Beluga (range 12–326), and 117 seals (range 12–322) were potentially consumed annually from the Hudson Bay region by Killer Whales (Ferguson et al. 2010). Fish appeared to be consumed only infrequently (Ferguson et al. 2012, Higdon et al. 2012).

Killer Whales are not actively targeted as part of the domestic harvest but are occasionally hunted or killed opportunistically in parts of the Arctic (Higdon 2007). Historically, commercial whalers killed them as pests or competitors. Higdon (2007) estimated that less than 40 Killer Whales were killed in the eastern Canadian Arctic between the 1950s and 2008.

BEARDED SEAL (*ERIGNATHUS BARBATUS*)

Bearded Seals are year-round residents of, and are distributed widely throughout, the Canadian Arctic south of 85ºN (McLaren 1958, Mansfield 1963, 1967a, Smith 1981, Cleator 1996). They have a patchy distribution (Smith 1981) and generally occur at considerably lower densities throughout their range than do Ringed Seals (Stirling et al. 1982, Bengtson et al. 2005, Stephenson and Hartwig 2010). However, they are believed to be more abundant in Foxe Basin than in other areas of the Arctic due to the greater availability of shallow water habitat and presence of the Roes Welcome Sound polynya (Smith 1981, Beckett et al. 2008). Although discrete populations of Bearded Seals have not been delineated in Canadian waters, Rice (1998) recognized Atlantic (*Erignathus barbatus barbatus*) and Pacific (*Erignathus barbatus nauticus*) subspecies, which were supported by genetic data (Davis et al. 2008). Bearded Seals in the SI EBSA belong to the Atlantic subspecies.

Detailed investigations of Bearded Seal abundance in the Arctic have not been conducted to date. Cleator (1996) suggested an estimate of greater than 190,000 animals based on survey data collected over a 35-year period; however, the estimate was considered to be speculative. Studies documenting the abundance of Bearded Seals in the SI EBSA and the Hudson Bay Complex as a whole are likewise limited. Aerial surveys conducted along the WHB coastline from the Nelson River estuary north to Rankin Inlet produced densities of 0.122 and 0.024 seals/km^2 of ice in 1994 and 1995, respectively (Lunn et al. 1997). From these data, it was estimated that 12,290 (Standard Error [SE] = 2,520) Bearded Seals occurred within the study area in 1994 and 1,980 (SE = 560) in 1995. Differences in survey timing between years may explain the observed decrease (Lunn et al. 1997).

Bearded Seals prefer a combination of moving ice and open water over areas typically no more than 100 m deep (Mansfield 1963, Lowry et al. 1980). The shallow waters allow easier access to prey along the sea floor, whereas moving ice provides hauling out areas to rest, moult and birth young (Kovacs et al. 1996). Bearded Seals will often follow seasonally advancing and retreating ice to maintain this association (Mansfield 1963, Burns 1981, Cleator 1996, Cameron et al. 2010). However, some Bearded Seals are relatively sedentary and undertake only local movements (Mansfield 1963, Burns 1981, Cleator 1996). Bearded Seals prefer areas with persistent polynya habitat as these areas provide open water throughout the winter (Burns 1981, Stirling et al. 1981). In summer, seals will haul-out on land or sand bars within rivers when ice is not available (Mansfield 1963, Burns 1981, Bernhardt 2014). For example, in a survey of the Nelson River estuary on the west coast of Hudson Bay, Bearded Seals arrived shortly after ice break-up, and in 2006 and 2007 increased in number after (approximately) mid-August (Bernhardt 2014). This timing generally coincided with the animals' annual moult and break-up of remaining sea ice remnants in southern Hudson Bay (Bernhardt 2014).

Within the SI EBSA, Bearded Seals occur at the northern tip of Southampton Island at Cape Munn and in Duke of York Bay, along southern Southampton Island and throughout Evans Strait (GN 2012). One Coral Harbour resident indicated that Bearded Seals may overwinter in South Bay near the community (GN 2012) and, while not indicated in local interviews from Coral Harbour, it is likely that they also overwinter in the Roes Welcome Sound polynya. Although movement patterns of Bearded Seals in the Hudson Bay Complex have not been scientifically studied, IQ indicated that movements along the coast of Southampton Island occur year-round (GN 2012).

Bearded Seals are generalist feeders, consuming a variety of benthic and epibenthic organisms (Dehn et al. 2007). Diet information for Bearded Seals in the SI EBSA is unavailable; however, Bearded Seals in the Belcher Islands fed on decapods, molluscs and Arctic Cod (Smith 1981) and age classes of bearded seals along the western coast of Hudson Bay differed with biomarkers suggesting juveniles eat more fish and shrimp whereas adults eat more clams (Young et al. 2010).

Bearded Seals are harvested in low numbers in the SI EBSA by residents of Coral Harbour and possibly residents of Naujaat. Priest and Usher (2004) reported that Coral Harbour residents harvested, on average, 76 Bearded Seals annually between June 1996 and May 2001. During the same period, Repulse Bay residents harvested an average of 14 Bearded Seals annually.

HARBOUR SEAL (*PHOCA VITULINA*)

Harbour Seals are broadly distributed (7,145,752 km^2 area of occupancy) throughout coastal waters of the northern hemisphere and are common in temperate areas where ice does not form (COSEWIC 2007, Stephenson and Hartwig 2010, Lowry 2016a). Those in Canadian waters belong to the western Atlantic subspecies (*Phoca vitulina concolor*) (Lowry 2016a) and in the eastern Arctic are found throughout the Hudson Bay Complex, along the east coast of Baffin Island and at numerous locations along the Atlantic coast (COSEWIC 2007). Harbour Seals primarily occur in nearshore and shallow-water habitats and are often observed in association with fresh water such as estuaries and rivers (Wheeler 1953, Mansfield 1967b, Beck et al. 1970, Paulbitski 1974, Lowry 2016a). In the Hudson Bay Complex, this species is known from major rivers entering into western Hudson Bay, Foxe Basin (Mansfield 1967b, Bernhardt 2006, COSEWIC 2008b, Bajzak et al. 2013), and the Belcher Islands (Bigg 1969 Smith et al. 1996).

The estimated global population of Harbour Seals is approximately 610,000–640,000 animals, of which 60,000 belong to the western Atlantic subspecies (Bjorge et al. 2010, Lowry 2016a). The current population trend is unknown for this subspecies (Lowry 2016a). Similarly, little is

known regarding Harbour Seal abundance and movement patterns in the eastern Arctic. Within the Hudson Bay Complex, small groups of Harbour Seals are known to aggregate at the mouths of large rivers, including the Maguse, McConnell, Thlewiaza, Caribou, Seal, Churchill, Owl, and Nelson rivers (Mansfield 1967b, Bernhardt 2006, COSEWIC 2008b, Bajzak et al. 2013) and Kasegalik River in the Belcher Islands (Freeman 1964, Bigg 1969, Smith et al. 1996). Information relevant to Harbour Seal use of the SI EBSA is limited. Stephenson and Hartwig (2010) used habitat preferences displayed by Churchill River Harbour Seals to predict their distribution throughout the eastern Canadian Arctic in areas where they are known to occur. All coastal waters within the SI EBSA were identified as being suitable habitat for the species, although they were considered to be uncommon in the area (Stephenson and Hartwig 2010). Local IQ identified Harbour Seals in Duke of York Bay at the north end of Southampton Island, throughout South Bay to Maurice Point, and from Allinataaq Lake to Cape Kendall along the southwestern shoreline of the island (GN 2012). They have also been observed on Coats Island (GN 2012) and in northern Roes Welcome Sound (GN 2011). In the SI EBSA, Harbour Seals are most commonly observed in the vicinity of river mouths (GN 2011, 2012).

Harbour Seal investigations in western Hudson Bay generally focus on the Churchill River mouth. Seals in that area use haul-out sites upstream of the tidal influence during open-water periods, making foraging forays into the estuary and coastal Hudson Bay (Bernhardt 2006, Bajzak et al. 2013). During periods when ice cover prevented access to the Churchill River haul-out location, seals remained in leads and cracks along the Hudson Bay coastline, returning to the river when ice conditions permitted (Bernhardt 2006, Bajzak et al. 2013). Seals equipped with satellite-linked radio tags did not venture into waters deeper than 50 m, regardless of season (Bajzak et al. 2013). Seal abundance at the Churchill River haul-out site was monitored between 1996 and 2005 (Bernhardt 2006) and again from 2014 to 2016 (S.D. Petersen, Assiniboine Park Zoo, pers. comm..). Monitoring results suggested a large increase in the number of seals using the area over the last 20 years. Reasons for this are not yet clear and it is unknown if there is a similar trend throughout the species` range in the Hudson Bay Complex and, more specifically, within the SI EBSA.

Fatty acid analyses showed that Harbour Seals accounted for 15–20% of Foxe Basin and western Hudson Bay Polar Bear diets, and were similar in proportion to Bearded Seals (Thiemann et al. 2008b). Harbour Seals are generalists, feeding on a variety of prey including fish, cephalopods and crustaceans from the surface to approximately 100 m depth (Pitcher 1980, Olesiuk et al. 1990, Pierce et al. 1991, Tollit et al. 1998). They are adaptable to seasonal changes in prey availability (Tollit et al. 1997, Thompson et al. 1996). Diet specific to SI EBSA Harbour Seals is unknown.

This species is harvested in the SI EBSA by hunters from Coral Harbour and Naujaat (GN 2011, 2012). Harvest rates are not known.

HARP SEAL (*PAGOPHILUS GROENLANDICA*)

Harp Seals occur in the northern Atlantic and Arctic oceans below 84ºN (Riedman 1990). They are migratory and generally found in the Hudson Bay Complex and other Arctic regions only during the open-water period (Collins 1983, Stewart and Barber 2010). Of the three geographically distinct populations occurring in the North Atlantic Basin (McLaren and Davis 1982), individuals from only the Northwest Atlantic (NA) population are found in the SI EBSA. Most Harp Seals in the Arctic are found in Davis Strait and Baffin Bay, but small numbers can be found along the south coast of Southampton Island as far west as southern Roes Welcome Sound during summer (Sergeant 1965, 1976, Collins 1983, Stewart and Lockhart 2005). Large herds have occasionally been reported in South Bay and may reach the floe edge at Repulse Bay (Milton Freeman Research Ltd. 1976). IQ from Coral Harbour identified the South Bay area

to Maurice Point-Imiqutailat Spit as an area of Harp Seal occurrence (GN 2012). Naujaat (formerly Repulse Bay) residents reported Harp Seals (mainly offshore) from Kanguqarvik to an area approximately 40 km south of Repulse Bay in July and August (GN 2011). Additional IQ for Foxe Basin indicated that Harp Seals are abundant north of the SI EBSA near Igloolik and in Fury and Hecla Strait during summer and early autumn (GN 2008).

The Canadian Harp Seal population has recently increased in size from an estimated 2 million animals in the 1970s to at least 6 million (to 2010; Stephenson and Hartwig 2010). Long-term (1952–2014) modeling results for the NA population as a whole estimated pup production at 853,000 (SE = 202,000) for 2014 and a total population size of 7,411,000 (SE = 656,000) (DFO 2014, Hammill et al. 2014). Hammill et al. (2014) also suggested that a decrease in Harp Seal productivity had occurred since the early 1990s, but small sample sizes in recent years contributed uncertainty. Despite this, the NA population is generally considered to be stable or possibly increasing (Kovacs et al. 2011, 2012, Hammill et al. 2014). An increased population and recent decreases in ice cover have resulted in further expansion of this species into the central Arctic and Hudson Bay Complex than observed in previous years (Stephenson and Hartwig 2010).

In Canada, the NA Harp Seal population overwinters in the Gulf of St. Lawrence and northern Newfoundland where they give birth on the pack ice during late February or March (DFO 2014). In spring, these seals move into summering areas in the Canadian Arctic as the ice retreats (Mansfield 1963, Sergeant 1965). While most continue north to Lancaster Sound, Eclipse Sound and Admiralty Inlet, a small proportion moves into Hudson Strait, Foxe Basin and Hudson Bay (Mansfield 1967b). Harp Seals entering Hudson Bay remain there from ice break-up (early June) to early October prior to freeze-up (Mansfield 1968, Gamble 1988). The number of Harp Seals using Foxe Basin and Hudson and James bays is currently unknown.

The diet of NA Harp Seals is highly variable and includes more than 100 species of invertebrates and fish (Reijnders et al. 1993). Among the more important prey species are cod (*A. glacialis* and *B. saida),* Capelin, herring (*Clupea harengus*), amphipods, and euphausids (Mansfield 1963, Reijnders et al. 1993). Harp Seals are preyed upon by Polar Bears and Killer Whales (Thiemann et al. 2008b, McKinney et al. 2009, Ferguson et al. 2012). Although Harp Seals comprised at least a small proportion of the diets of all Hudson Bay Complex Polar Bear subpopulations, they were the second most important pinniped for Foxe Basin bears (Thiemann et al. 2008b), which inhabit the SI EBSA. It is expected that Harp Seals will become an increasingly important prey source for Hudson Bay and Foxe Basin Polar Bears as climate changes and open-water pinnipeds (Harp and Harbour seals) increase in abundance relative to pack-ice seals (Bearded and Ringed) (McKinney et al. 2009, Peacock et al. 2010). IQ identified Harp Seals as Killer Whale prey, particularly in the Foxe Basin and southern Baffin Island regions (Ferguson et al. 2012).

Northwest Atlantic Harp Seals are hunted throughout their range and are harvested both for subsistence and commercially, though commercial harvests have decreased in recent years (Kovacs et al. 2011, 2012, Kovacs 2015). Inuit harvest Harp Seals in Labrador, Arctic Canada and Greenland, whereas commercial harvests are conducted in the Gulf of St. Lawrence and northern Newfoundland (DFO 2014). Commercial harvests in Canada have declined from 355,000 seals in 2006 to 91,000 seals in 2013 due, in part, to difficult ice conditions and weaker markets (DFO 2014). Greenland catches have varied from 66,100 to 92,200 seals annually since 2003 (DFO 2014). Over 95% of the commercial harvest consists of young-of-the-year (YOY) and an estimated 12,000 seals are removed incidentally during commercial fishing activities (e.g., by-catch, struck and loss). Within the Kivalliq Region, annual five-year mean harvests were reported for Arviat (n = 1), Chesterfield Inlet (n = 5), Coral Harbour (n = 18), Repulse Bay (n = 1) and Whale Cove (n = 6) (Priest and Usher 2004). Cape Dorset, within the

Baffin Region, reported a five-year mean Harp Seal harvest of 15 animals per year (Priest and Usher 2004). Subsistence harvests are currently not regulated, while the commercial harvest is regulated by a five-year (2014 to 2018) management plan (DFO 2014). Canadian Harp Seal populations are not listed under the SARA or assessed by COSEWIC. The species is listed as Least Concern on the IUCN Red List of Threatened Species (Kovacs 2015).

RINGED SEAL (*PUSA HISPIDA*)

Ringed Seals are an important element of the Arctic marine ecosystem, both as the primary prey of Polar Bears and as a major consumer of marine fish and invertebrates (Lowry et al. 1980, Smith 1987). This species has a broad circumpolar distribution, and is closely linked to sea ice (Frost and Lowry 1981, Lowry 2016b, Reeves 1998). Minimal genetic variation across the entire species range suggests that all Ringed Seals occurring in Canada belong to a single population or stock (Davis et al. 2008, Palo et al. 2001, Martinez-Bakker et al. 2013). Estimating global or regional Ringed Seal population sizes is complicated due to their large and variable distribution and difficulty determining observed versus unobserved (i.e., diving) individuals during surveys (Frost and Lowry 1981). With these caveats in mind, the number of Ringed Seals occurring in the Canadian Arctic was estimated to be at least a few million (Reeves 1998, Lowry 2016b) to as many as six or seven million (Stirling and Calvert 1979). Kingsley (1987) developed an estimate of 1.2 million for the Baffin Bay area based on a combination of aerial surveys and Polar Bear population size and energetic requirements.

Ringed Seals occur throughout the Hudson Bay Complex and are common year-round residents of the SI EBSA. Abundance in the SI EBSA has not been examined; however, Smith (1975) estimated approximately 519,000 Ringed Seals in Hudson and James bays. Aerial surveys conducted along the western coast of Hudson Bay between Churchill (MB) and Arviat (NU) from 1994 to 2008 documented Ringed Seal densities between 0.4 and 1.6 seals/km^2 (Lunn et al. 1997, DFO 2009, Chambellant 2010, Young et al. 2015). Habitat-specific densities were highest (3.4 seals/km^2 on landfast ice during spring (Chambellant 2010). Maximum sustainable yield for the species was estimated at 7% (Reeves 1998). Ringed Seals in the SI EBSA are harvested by both Coral Harbour and Repulse Bay (GN 2011, 2012). Priest and Usher (2004) reported that Coral Harbour residents harvested an average of 712 Ringed Seals per year between June 1996 and May 2001. During the same period, Repulse Bay residents harvested an average of 415 Ringed Seals annually. Ringed Seals from Hudson Bay were on average 25% smaller but more reproductive than High Arctic seals (Ferguson et al. 2018).

Ringed Seals were initially thought to remain in the same general region throughout the year, perhaps making smaller-scale movements in response to ice formation and break-up (McLaren 1958). Subsequent studies showed that age segregation occurred during different seasons, and that some individuals (usually juveniles) can make extensive seasonal movements (e.g., Heide-Jørgensen et al. 1992, Smith 1987, Teilmann et al. 1999). Satellite-linked radio telemetry studies indicated that some movement occurred between the Thule area of west Greenland and Lancaster Sound (Born et al. 2002) and, more recently, there was evidence of large-scale (> 1000 km) movements of adults during open-water periods (Martinez-Bakker 2013, Yurkowski et al. 2016). Telemetry tagged Ringed Seals in Hudson Bay showed marked seasonal shifts in movement and dive behaviour related to seasonal sea ice and reproductive behaviour (Luque et al. 2014).

The importance of sea ice areas with good snow cover in Ringed Seal life histories has been well documented. This species uses sea ice exclusively for breeding, moulting, and resting (Smith and Stirling 1975, Frost and Lowry 1981, Reeves 1998), particularly landfast ice (Tynan and DeMaster 1997) and first-year pressure ridges (Barber and Iacozza 2004). In the SI EBSA, Ringed Seal distribution largely reflects the distribution of landfast ice in the area (GN 2012). IQ

indicated that Ringed Seals occur in most large bays and shorelines of Southampton Island where landfast ice occurs, including the Roes Welcome Sound/Repulse Bay area (GN 2011), Duke of York Bay (north coast), the eastern and southern coasts of Southampton Island, and along floe edges wherever they persist (GN 2012). They were identified as abundant in the area, particularly along the northern coast of Southampton Island (GN 2011, 2012). In addition the availability of sufficient snow cover for protection and survival of seal pups while being nursed has been shown to be critical for survival (Ferguson et al. 2005, Iacozza and Ferguson 2014).

Ringed Seals are highly adaptable in terms of foraging behaviour and as a result, their diets are variable (McLaren 1958). Typically, Ringed Seal diets include small fish and, during periods of open water, large crustaceans (Mansfield 1963, Lowry et al. 1980, Holst et al. 2001, Labansen et al. 2007) with Hudson Bay studies showing that young seals ate more zooplankton compared to adults that preferred forage fish (Young et al. 2010). While Ringed Seal diets in the SI EBSA have not been investigated, those of seals in western Hudson Bay are largely comprised of Sand Lance, and to a lesser extent, Arctic Cod and invertebrates (Stirling 2005, Chambellant 2010). In Foxe Basin from 1947-1950, Arctic Cod were a more important component of Ringed Seal diet (McLaren 1958), but this may represent more of a temporal than spatial difference in feeding habits. Ringed Seal diet varied considerably year-to-year and geographically between western and eastern Hudson Bay (Young et al. 2014). Proportions of Arctic Cod in Coats Island seabird diets and other low Arctic regions decreased (to nearly zero in some colonies) between the early 1980s and 2008/2009, while proportions of Sand Lance and Capelin have increased (Gaston et al. 2003, Provencher et al. 2012, Gaston and Elliott 2014). It is thought these changing dietary proportions reflect a shift in prey type availability as decreases in sea ice affect the distribution of ice-associated Arctic Cod. Given these recent changes in seabird diets within the SI EBSA, it is possible that similar shifts have occurred in the local seal population. Ringed Seals are susceptible to extreme changes to sea ice as shown by their response to an 2010 climatic event that resulted in the longest open water period recorded for Hudson Bay with demographic and reproductive consequences to seals in the following year (Ferguson et al. 2017)

Declining trends of Ringed Seal reproduction and pup survival observed in western Hudson Bay (Ferguson et al. 2005, Stirling 2005) and low body condition indexes and ovulation rates (Harwood et al. 2000) have been attributed to earlier break-up of sea ice and overall low ice years. It is not known whether changing ice conditions observed near the SI EBSA have had similar effects on local Ringed Seal reproductive success.

WALRUS (*ODOBENUS ROSMARUS*)

Walruses have a discontinuous circumpolar distribution (Stewart et al. 2014). Populations from eastern Canada and Greenland belong to the Atlantic subspecies (*Odobenus rosmarus rosmarus*). The Atlantic Walrus in Canada was originally treated by COSEWIC as two separate populations: Eastern Arctic population (Not at Risk in April 1987 and May 2000) and Nova Scotia - Newfoundland - Gulf of St Lawrence population (extirpated in April 1987 and May 2000). In 2017, Atlantic Walruses were split into three major populations: the High Arctic (special concern), Central/Low Arctic (special concern), and Nova Scotia-Newfoundland-Gulf of St. Lawrence (extinct) (COSEWIC 2017). The Canadian Arctic populations are comprised of seven discrete stocks, based largely on summering areas (Figure 17; Stewart 2008, DFO 2013, Shafer et al. 2014). The high Arctic population includes the Baffin Bay (BB), West Jones Sound (WJS), and Penny Strait-Lancaster Sound (PS-LS) stocks, and the Central/Low Arctic population includes the North and Central Foxe Basin (N-FB, C-FB), Hudson Bay-Davis Strait (HB-DS) and Southern and Eastern Hudson Bay (SE-HB) stocks.

The two Foxe Basin and HB-DS stocks can be distinguished with lead isotope and trace element profiles (Outridge and Stewart 1999, Outridge et al. 2003) as well as microsatellite genetic studies (Shafer et al. 2014); however, Shafer et al. (2014) found some evidence to suggest that the two Foxe Basin stocks may instead represent a single stock. The three high Arctic stocks formed a large genetic cluster, with some support for maintaining WJS separate (Shafer et al. 2014). Another microsatellite study found that Walrus from southeast Baffin Island did not differ from those in western Greenland, but were distinct from Hudson Strait and northwest Greenland Walruses (Andersen et al. 2014). Walruses occurring in the SI EBSA are part of the HB-DS stock (DFO 2013).

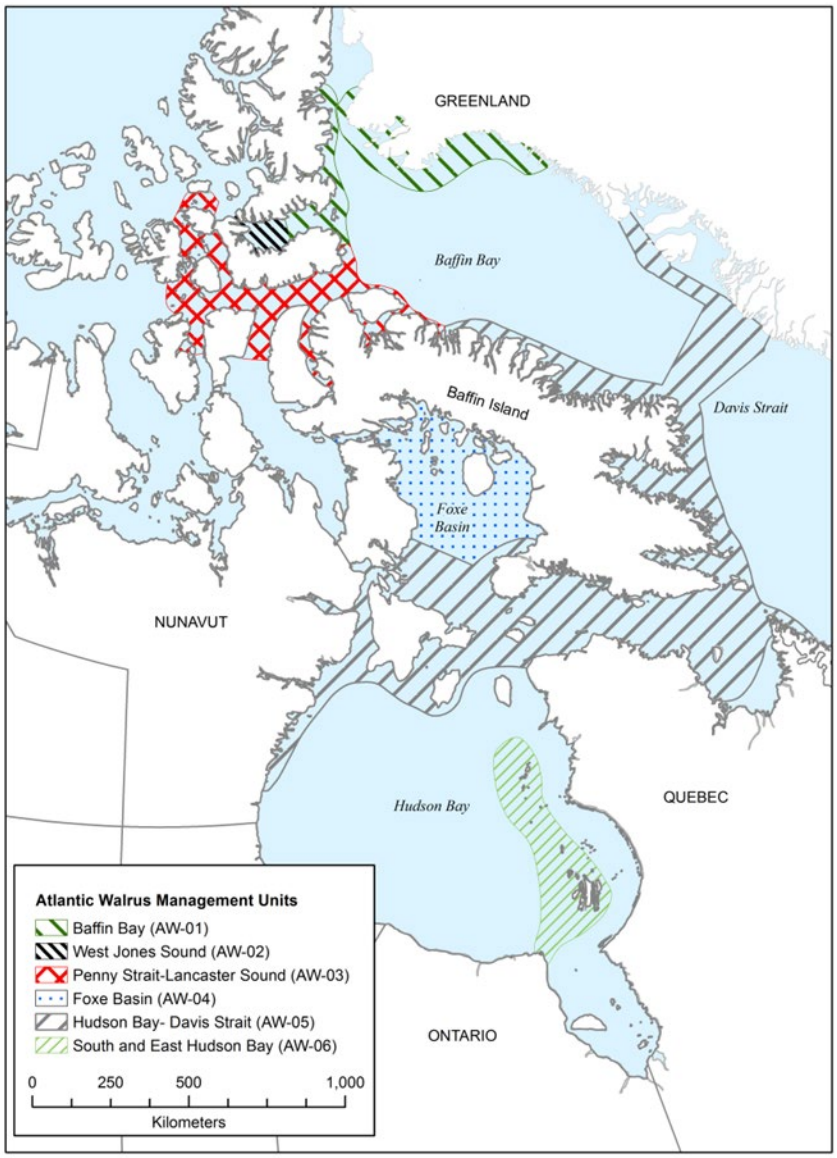

Figure 17. Atlantic Walrus management units in the Canadian Arctic. The High-Arctic population includes the Baffin Bay (AW-01), West Jones Sound (AW-02), and Penny Strait-Lancaster Sound (AW-03) units. The Central Arctic population includes the Foxe Basin (AW-04), Hudson Bay-Davis Strait (AW-05), and South and East Hudson Bay (AW-06) units (Source: DFO 2019).

The most recent population estimate for the HB-DS stock was approximately 7,000 individuals and was based on 2,144 hauled out animals observed during fall 2014 aerial surveys and

modeling results (Hammill et al. 2016a,b). Although the survey did include the SI EBSA region, it could not cover the total area representative of the HB-DS stock .This estimate was slightly larger than two previous estimates of 4,675 (95%; CL = 1,845–11,842) and 6,020 (95%; CL = 2,485–14,585) obtained from systematic line-transect surveys of Hudson Strait in spring 2012 (Elliot et al. 2013). Differing estimates among surveys are unsurprising given the challenges enumerating Walrus stocks, including aggregated distributions and correlated haul-out behaviour (DFO 2016). For example, during the 2014 surveys, counts of Walruses on Walrus Island on 11 and 16 September were 248 and 2,579, respectively. Hammill et al. (2016a) compared count observations from multiple surveys at Southampton, Walrus, and Coats islands. The number of animals observed during the 2014 surveys was similar to those observed during 1954, 1961, 1977, and 1988-1990 surveys (Hammill et al. 2016a). Numbers were also relatively similar over time in the Fraser/Nottingham/Salisbury islands area. However, when data were run through a model intended to separate observation error of each survey from natural variability in population dynamics, it was estimated that the HB-DS stock decreased from approximately 10,400 animals in 1954 to a minimum of 3,900 in 1986 with a subsequent increase to the current estimate of 7,000 (Hammill et al. 2016b).

Seasonal movements of the HB-DS population are poorly understood. At some locations where conditions permit, such as the Roes Welcome Sound polynya, Walruses remain year-round, making only localized movements in response to changing ice conditions (Orr and Rebizant 1987, Fleming and Newton 2003, Ghazal 2014). In contrast, extended seasonal movements may occur in other areas, such as fall movements north out of Hudson Bay and into Hudson Strait (Reeves 1995). Tagging studies conducted in the mid-1950s at Bencas, Coats, and Southampton islands revealed only localized movements (Mansfield 1959, Loughrey 1959) and current IQ suggests that Walruses in the vicinity of Southampton Island are year-round residents (Riewe 1992, GN 2011, 2012). During open-water periods, Walruses tend to remain near terrestrial haul-outs if ice is not available. Within the SI EBSA, important haul-out sites are found on Bencas, Coats and Walrus islands (AMAP et al. 2013, DFO 2019), and additional sites occur along the southern and northwestern coasts of Southampton Island (GN 2011, 2012, Ghazal 2014, DFO 2019). During winter, Walruses occur in the Chesterfield Inlet-Roes Welcome Sound area, off the floe edge along the south and east coasts of Southampton Island, and along the west and southwest coasts of Foxe Peninsula. In late spring and summer, Walruses favour the floating pack ice of Evans Strait and Hudson Strait, and then move ashore to terrestrial haul-out sites as pack ice dissipates. In the fall, Walruses are concentrated at or near terrestrial haul-outs on Bencas, Walrus, Coats, Mills, Nottingham, and Salisbury islands and on western Foxe Peninsula (Orr and Rebizant 1987, Fleming and Newton 2003, GN 2012, DFO 2019).There is a similar shoreward movement of Walruses in the Repulse Bay area in the fall (Fleming and Newton 2003).

Walruses are primarily bottom feeders, foraging in sediments on the ocean floor for molluscs and other invertebrates (Outridge et al. 2003, Dietz et al. 2013). In some instances, larger prey such as seals may be consumed. For example, Muir et al. (1995) suggested that the elevated organochlorine levels of Walruses in eastern Hudson Bay reflected foraging at a higher trophic level (e.g., Ringed Seals). Mallory et al. (2004) observed Walruses foraging on adult Thick-billed Murres at Coats Island. As many as 67 murres may have been killed by a single Walrus in one day.

Although hunting is the greatest known cause of mortality, recent assessments indicate that total annual harvests from these communities are sustainable (Stewart et al. 2013, Hammill et al. 2016, DFO 2019). Walruses from the HB-DS stock are currently harvested by more than 20 communities (COSEWIC 2006, Hammill et al. 2016a). Residents of Coral Harbour harvested 16 Walruses annually, on average, between 2009 and 2014 (Hammill et al. 2016a). Using mean

reported harvests between 2009 and 2014 for all communities combined (85 Walruses/y) and population estimates derived from surveys in 2014, Hammill et al. (2016a) determined that PBR (Potential Biological Removal) estimates range from 90 to 180, which only represented animals for the northern Hudson Bay-Hudson Strait component of the HB-DS stock. Reported harvests of the HB-DS stock between 2009 and 2014 from all communities averaged a sustainable 85 animals per year, with some evidence of a declining trend in number of harvested animals, though harvest reports were sporadic prior to 1980. Coral Harbour and Naujaat (formerly Repulse Bay) harvested an annual average of 14 and four Walruses, respectively, from 2005–2014, which is a decrease from the average 115 and 17 animals harvested per year from 1960–1975 (Hammill et al. 2016a). In 2018–19, eight Walruses were harvested by the community of Coral Harbour. Similar declines in number of harvested animals have been noted throughout the Canadian Arctic following periods of sometimes intense commercial harvesting in the 19th and early 20th centuries (Stewart et al. 2014). In addition to its subsistence hunt, Coral Harbour is the only community that currently conducts regular sport hunts of Walruses in northwestern Hudson Bay (Stewart et al. 2014). Prior to the suspension of the Igloolik sport hunt (2008), annual landed sport hunting catch was typically less than five Walruses. Since then, catches from Coral Harbour have increased slightly with seven individuals reported in the 2018-19 sport hunt.

A predicted reduction in the extent and duration of sea ice with climate change is expected to negatively affect Walrus populations (Kovacs et al. 2011, 2012, 2015, DFO 2019), particularly those in Foxe Basin, Hudson Bay and Davis Strait (Hovelsrud et al. 2008). Hovelsrud et al. (2008) suggested that these southern populations will move north into Gulf of Boothia as the sea ice retreats. Forecasted growth in shipping, aircraft traffic, tourism, and port development with declining sea ice have the potential to negatively impact walrus throughout Hudson Bay and the SI EBSA (DFO 2019). Walrus are particularly sensitive to mechanical noise caused by vessel and aircraft-based traffic (DFO 2019), which can cause stampedes that have been associated with mortality due to trampling, abortion of fetuses, and separation of cow-calf pairs (COSEWIC 2017). Studies in Hudson Bay show walruses can abandon haul-out sites for up to three or four days after being disturbed by boats and aircraft (Mansfield and St. Aubin 1991), while prolonged or repeated disturbances can cause long-term abandonment of haul-out sites and preferred feeding areas (Johnson et al. 1989, Born et al. 1995).

POLAR BEAR (*URSUS MARITIMUS*)

Polar Bears have a circumpolar distribution throughout the northern hemisphere and occur in relatively low densities throughout most ice-covered areas as far north as 88°N (DeMaster and Stirling 1981, Durner and Amstrup 1995). The global polar bear population was most recently estimated at 26,000; however, this estimate excludes the Arctic Basin subpopulation for which there are no abundance data (Wiig et al. 2015). Approximately 15,500 bears occur in Canada or in subpopulations shared with Canada (COSEWIC 2008c). There are 13 Polar Bear subpopulations, which are also management units (MU), occurring (either partially or entirely) in the Canadian Arctic and sub-Arctic (Figure 18). Southampton Island has been identified as an important summer habitat for this Foxe Basin (FB) MU (Peacock et al. 2008). The range for this subpopulation covers some 1.1 million km^2 in Foxe Basin, northern Hudson Bay and western Hudson Strait (Taylor and Lee 1995, COSEWIC 2002, 2008c). IQ gives extent of occurrence and area of occupancy sizes of 815,790 km^2 and 2,135 km^2, respectively (Kowalchuk and Kuhn 2012).

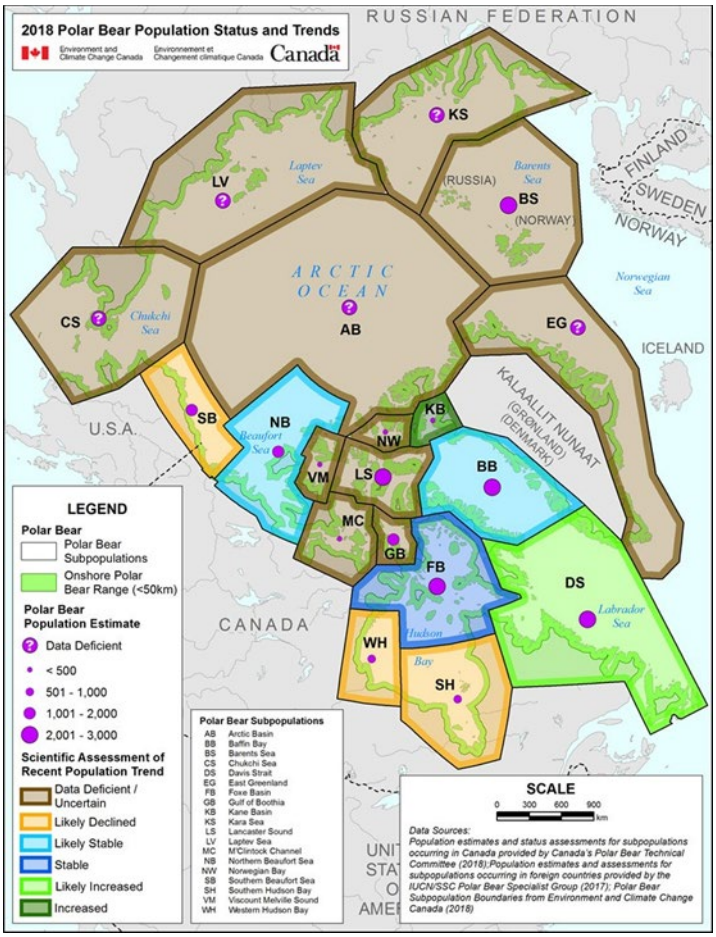

Figure 18. Circumpolar Polar Bear subpopulations (ECCC 2018). Polar Bears inhabiting the Southampton Island region belong to the Foxe Basin subpopulation. (Source: ECCC/International Union for the Conservation of Nature's Polar Bear Specialist Group).

Recognized boundaries of the FB subpopulation are based on mark–recapture studies (Taylor and Lee 1995), aerial studies (Stapleton et al. 2016), telemetry studies (Taylor et al. 2001, Sahanatien et al. 2015), IQ (COSEWIC 2002, 2008c), and population genetics (Paetkau et al. 1999, Thiemann et al. 2008b, Malenfant et al. 2016, Viengkone et al. 2016). Some of the earliest estimates (1989–1994) of the FB subpopulation size, based on mark-recapture data were approximately 2,100–2,200 animals (Taylor et al. 2006). Following a reduction of harvest levels in 1996, Inuit TK and scientific opinion suggested an increase in population size to about 2,300 bears (McDonald et al. 1997, COSEWIC 2008c, Obbard et al. 2010). Aerial surveys were conducted during the 2009 and 2010 ice-free seasons, when bears were confined to land (Stapleton et al. 2012, 2016), and these surveys resulted in an average abundance estimate of 2,585 (95% CI: 2,096–3,189) bears for the region.

FB Polar Bears form a genetic cluster with the WHB and DS subpopulations (Paetkau et al. 1999, Thiemann et al. 2008b, Malenfant et al. 2016). In contrast, despite their proximity, there appears to be little genetic exchange between FB and Gulf of Boothia subpopulations (Paetkau et al. 1999). Past studies showed genetic differences between the three subpopulations in the Hudson Bay region are very small and do not indicate evolutionarily significant units, particularly between the WHB and FB bears, though they can still indicate important differences in adaptive traits (Paetkau et al. 1999). However, recent population structure and space use (Sahanatien et al. 2015), and fine-scale genetic analyses (Crompton et al. 2008, 2014, Peacock et al. 2015,

Malenfant et al. 2016, Viengkone et al. 2016, 2018) of Hudson Bay area bears, supported the designation of different subpopulation boundaries for the region. Sahanatien et al. (2015) compared seasonal and annual movement metrics (i.e., home range, movement rates, time on ice) to home-range fidelity (static and dynamic overlap), and ice dynamics, and found that the genetic clusters generally coincided with the three major waterbodies (Foxe Basin, Hudson Bay, and Hudson Strait) in the region. Bears had strong annual and seasonal home range fidelity, and no other area showed as much mixing as Southampton Island. Bears captured on the island showed convergence of the three clusters with Hudson Bay bears largely on the western and southwestern shores, Hudson Strait bears on the southeastern, and Foxe Basin bears on the eastern (Sahanatien et al. 2015, Viengkone et al. 2016, 2018). Most of the remaining Southampton Island bears were part of the northern FB cluster, though some were also from the eastern Hudson Strait/Davis Strait cluster.

Throughout their range, Polar Bears feed primarily on Ringed Seals but also feed on Bearded Seals (e.g., Thiemann et al. 2008a, Galicia et al. 2016), Walruses (Calvert and Stirling 1990, Thiemann et al. 2008a, Galicia et al. 2016), other marine mammals (Stirling and Archibald 1977, Smith 1980, Lowry et al. 1987, Thiemann et al. 2008a), Arctic Cod, geese and their eggs, terrestrial mammals, and a variety of seabirds (Smith and Hill 1996, Derocher et al. 2000, Iverson et al. 2014). Because of their strong dependence on Ringed Seals, the distribution and population size of Polar Bears are thought to be regulated primarily by the demographics of that particular species (Stirling and Øritsland 1995).

Fatty acid analysis has been used to examine Polar Bear feeding habits and trends in marine food webs in the Canadian Arctic, including the FB subpopulation (Thiemann et al. 2008a, Galicia et al. 2016). An initial survey that sampled 109 FB bears from 1972-2004, found that Polar Bear diets were comprised of seven different marine mammal species, with approximately 55% of the diet being comprised of Ringed Seals, which is a lower proportion than other subpopulations (Thiemann et al. 2008a). FB bears fed on the largest proportion (7% of their diet) of Walrus of any subpopulation and, overall had the second most diverse diet after the Lancaster Sound bears. There were seasonal (spring-summer and fall-winter), as well as age and sex, differences in fatty acid profiles of FB bears. For example, Bearded Seals and Walruses were consumed more often by older bears, particularly males, and least by independent female cubs while Harbour Seals were consumed most often by females and young males, especially during fall-winter. As Harp Seals migrate into Foxe Basin during spring, their prevalence in Polar Bear diets increased. An additional 103 harvested bears were analysed for diet from 2010–2012 by Galicia et al. (2016). Diet varied spatially within the subpopulation with Ringed Seal dominant in northern and southern Foxe Basin, and equal proportions of Ringed and Harp seals consumed by western Hudson Strait bears. Walrus were consumed most in northern Foxe Basin by large males, while Bowhead Whales were consumed equally in all areas, by all age and size classes. Galicia et al. (2016) suggested that a potential increase in Bowhead carcasses from Killer Whale predation and subsistence harvests may represent an important supplemental food source for FB Polar Bears, particularly as sea ice declines limit on-ice feeding on Ringed Seals.

The SI EBSA provides valuable denning and foraging habitat and is considered a summer refugium for Foxe Basin Polar Bears (DFO 2011c). In August 2008, Peacock et al. (2008) estimated 240 bears were on Southampton Island during the ice-free season. Cub production for the FB bears has been identified as robust, contributing to a stable, healthy population (Stapleton et al. 2012, 2016). Survival rates for FB bears have not been directly measured, but are assumed to be similar to Baffin Bay, which are moderate for cubs (0.57) and higher than most other populations for adult males and females (Taylor et al. 2005, Aars et al. 2006). Encounter rates during an aerial survey were highest near the coast, although bears were

observed > 40 km inland (Stapleton et al. 2012, 2016). Polar Bears have been observed crossing Coats Island, and they frequently cross Southampton Island between Native Bay and East Bay (P. A. Smith, ECCC, pers. comm.). It is thought that they remain on the shorefast ice in the southern Southampton Island region hunting seals and cross to East Bay when the southern shorefast ice breaks up (P. A. Smith, ECCC, pers. comm.).

Repulse Bay IQ identified an increase in bear numbers around northern Southampton Island and other coastal areas near the community from May to August (GN 2011). During spring, bears are found along the floe edge, especially in Frozen Strait where they hunt sub-adult seals, before moving to coastal areas in summer (GN 2011, 2012). Vansittart Island to the north of Southampton Island was identified as important denning and feeding area, with an abundance of Ringed Seals due to the complexity of the coastline, which delays sea ice break-up (GN 2011, 2012). Coral Harbour IQ identified bear habitat all along the eastern coast of Southampton Island, small bays and inlets near the community, offshore in Evans Strait, and on Cape Kendall to the west (GN 2012). Denning habitat was noted to the southeast near East Bay and towards the northern end of the island. Spring feeding habitat was identified near South Bay, with migration routes (northwards in fall and southwards in spring) all along the island's circumference (Figure 19; GN 2012). Other important feeding habitat was identified in Foxe Channel where the greatest concentration of sub-adult Ringed Seals can be found.

Figure 19. Migration routes of Polar Bears on Southampton Island, derived from from local interviews in Coral Harbour (Source: GN 2012).

Sea ice provides critical habitat for Polar Bears, functioning as a platform that allows them access to seals and other prey. During winter and spring, Polar Bears are typically observed along the floe edge, in areas of moving ice, along the edge of polynyas, and along cracks in land-fast ice (Smith 1980, Stirling et al. 1984). Polar Bear habitat use in FB has not been studied in detail, however bears have been seen near Igloolik during the early winter months and within the area where the Fury and Helca Strait polynya forms (GN 2008).Bear populations

in similar marine areas are likely to be found on moving ice (Stirling et al. 1993, Ferguson et al. 2000, Ferguson et al. 2001), with the exception of pregnant females in dens (Ramsay and Stirling 1990, Richardson et al. 2005). During the ice-free period, Polar Bears move inland where they fast until the ice returns (Ferguson et al. 1997, Lunn and Stirling 1985).

Large-scale changes in ice regime attributable to climatic warming or other causes could reduce a bear's opportunity to access food, and has been shown to have negative effects on individuals and populations (Stirling and Derocher 1993, Stirling et al. 1999). Foxe Basin is one of the subpopulation ranges predicted to show the greatest rates of change in extent of sea ice (ACIA 2005) and it will likely experience climate change impacts sooner than more northern populations (Peacock et al. 2011). It is due to their strong dependence on sea ice that Polar Bears were identified as one of the more sensitive species to climate change by Laidre et al. (2008). For example, Southern Beaufort Sea bears increased their use of terrestrial habitat and become more dependent on scavenging since the late 1990s as ice has retreated (Atwood et al. 2016a). Furthermore, females from the Baffin Bay and Kane Basin populations delayed den entry and selected dens at higher elevations with steeper slopes in the 2000s when compared with the 1990s (Escajeda 2016). Survival rates of the Baffin Bay population showed a decline from 2003-2009, that was attributed to decreased spring ice cover during the same period (Peacock et al. 2012). Spring sea ice retreated has declined by approximately 5.3 days/decade in Foxe Basin, which is similar to that of the Western Hudson Bay (Stern and Laidre 2016), who's subpopulation is currently in decline (Lunn et al. 2016).

Some of the greatest threats facing Polar Bear populations throughout the Arctic are attributed to sea ice condition and quality, caused by rising temperatures, and to a lesser extent, prey availability, which is also linked to ice extent (Atwood et al. 2016b). It is thought that home-range fidelity may decline as the spatial and temporal predictability of sea ice changes (Sahanatien et al. 2015). The ecoregion that included FB Polar Bears was one of three that showed a nearly 50% chance of population decrease by 2050 (Atwood et al. 2016b). Amstrup et al. (2007) predicted the loss of 2/3 of the global population and the complete extirpation or severe depletion of 6 subpopulations, including Foxe Basin, within 45 years. Some studies suggest that FB and Hudson Bay Polar Bears will move northwards into the Gulf of Boothia as sea ice retreats (Hovelsrud et al. 2008).

Hunters from several communities in the region harvest FB Polar Bears. Overall, there is a permitted harvest of 106 (+ Quebec) bears from the FB subpopulation (COSEWIC 2008c, York et al. 2016). Five-year average annual harvests from the early 2000s were 98.6 (COSEWIC 2008c, Kowalchuk and Kuhn 2012) and 108.8 from the 2010s (York et al. 2016); both rates are considered sustainable. In the vicinity of Southampton Island, most bears are harvested by hunters in Repulse Bay and Coral Harbour, which have annual quotas of 20 (GN 2011) and 65 (GN 2012) bears, respectively. Duke of York, South and East bays, and all of the Bell Peninsula, are noted as important harvesting areas (GN 2012). Early harvest rates were considered unsustainable and the population decreased from approximately 3,000 bears in the 1970s to 2,100 by 1996, when quotas were reduced in Nunavut (Schliebe et al. 2006).

Polar Bear status assessments have been conducted by a variety of organizations at multiple population levels (global, national, and regional). Globally, the species is not necessarily threatened with imminent extinction, but may need some protection and is, therefore, listed under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2013, 2017). The Convention on the Conservation of Migratory Species of Wild Animals (CMS 2014, 2017) has similarly listed it under their Appendix II in 2014.

In Canada, Polar Bears have been assessed as a Species of Special Concern (COSEWIC 2008c). Recognized threats, primarily from climate change, include direct and indirect effects to

habitat quality (sea ice), prey, changes in human activity levels, and increased contaminant levels. The FB subpopulation is managed by Nunavut and guided by the Nunavut Wildlife Act (2003) and Nunavut Polar Bear Co-Management Plan (GN 2016b). Currently the FB subpopulation range includes protected habitat in Ukkusiksalik National Park (Wager Bay area), Dewey Soper Migratory Bird Sanctuary (southwest Baffin Island), and several smaller areas, including two bird sanctuaries (East Bay and Harry Gibbons) on Southampton Island that total 58,340.96 km^2 or 5.7% of the subpopulation`s range (DSF 2007).

Persistence chemicals such as PCBs (Polychlorinated biphenyls) and PBDEs (Polybrominated diphenyl ethers) found in FB Polar Bears are among the lowest concentrations compared to all Canadian subpopulations (Braune et al. 2005, Verreault et al. 2005, Jordan 2013) and are below levels known to negatively impact bear health (Nuitjen et al. 2016). DDT (Dichlorodiphenyltrichloroethane) concentrations in FB bears, however, have been measured above levels known to cause liver lesions and decreased skull bone mineral density (Nuitjen et al. 2016). Although these legacy contaminants have declined in Polar Bears since their use was banned in many parts of the world, the decline has not been as rapid as in other species such as Ringed Seals and seabirds (Braune et al. 2005). Chlordane concentrations in FB are lower than in most eastern and western Canadian Arctic subpopulations, but higher than in the CAA (Jordan 2013). Another legacy POP, dieldrin, is relatively high in FB bears, exceeding the concentrations known to cause renal hyperplasia and increased risk of osteoporosis (Nuitjen et al. 2016).

BIRDS

Bird surveys began on Southampton Island and surrounding areas in the 1930s. Bray (1943) reported several species in waters surrounding Southampton Island, including Loons (Pacific, Gavia pacifica, and Red-throated G. stellata; numerous along the entire coastline during the summer), Semipalmated Sandpipers (*Calidris pusilla*), Red Phalaropes (*Phalaropus fulicarius*), Red-necked Phalaropes (*Phalaropus lobatus*), Parasitic Jaegers (*Stercorarius parasiticus*), Long-tailed Jaegers (*Stercorarius longicaudus*), and a Holboell's (*Red-necked*) Grebe (*Podiceps grisegena*).

Colonies of Glaucous Gulls (*Larus hyperboreus*) are known to nest throughout coasts and lowland interior parts of Southampton Island in spring and summer (Richardson and Gaston 1998), feeding primarily on fish, and chicks and adults of other seabirds (Gerson and Gerson 1986). Several other seabirds nest along the coasts of Southampton Island, including the Thayer's subspecies of Iceland Gull (*Larus glaucoides thayeri*; north coast), Herring Gulls (*Larus argentatus*; all coasts), Sabine's Gull (*Xema sabini*; South Bay region, closely associated with terns) and Arctic Terns (Sterna paradisaea; all low coasts) (Bray 1943, Gerson and Gerson 1986). Bray (1943) identified Mandt's (Black) Guillemots (*Cepphus grylle*) as abundant in the coastal waters surrounding Southampton Island.

In 1959, two migratory bird sanctuaries (MBSs) were created on Southampton Island; East Bay and Harry Gibbons MBSs. Both sanctuaries are currently regulated under the Migratory Birds Convention Act (1994) and administered by the Canadian Wildlife Service. East Bay, is a site identified as of marine importance to seabirds and sea ducks in Mallory et al. (2018). East Bay (Mitvik Island area and southern coast; Figure 20) supports Arctic Canada's largest single colony of Common Eiders (formerly up to 8000 pairs; now ~3,500 pairs), including the North Atlantic (*Somateria mollissima borealis*) and Hudson Bay (*S. mollissima sedentaria*) subspecies (Latour et al. 2008). Avian cholera has caused mass mortalities in eiders and has the potential to cause a strong depletion in the East Bay population (Descamps et al. 2012).

The area also supports a colony of approximately 200 pairs of Black Guillemots (Latour et al. 2008). Other waterfowl species that are common and nest in the East Bay area include King

Eiders (*Somateria spectabilis*), Long-tailed Ducks (*Clangula hyemalis*) and Tundra Swans. Northern Pintail (*Anas acuta*) are seen regularly and are thought to breed in the area. Other aquatic species known to breed within the sanctuary include: Sabine's Gull (Mallory and Fontaine 2004) and Herring Gulls, Red-throated and Pacific Loons, Arctic Terns, and both Parasitic and Long-tailed Jaegers. Whimbrels (*Numenius phaeopus*) pass through the area in large numbers during fall migration (ECCC 2017). Arctic Terns and Sabine's Gull nest together on the shores of East Bay along narrow bands of brackish water just above the summer high tide line (Abraham and Ankney 1986). Both species arrive when the tundra is still mostly snow-covered and the bay is frozen. As the season progresses and more foraging habitats become available, the two species begin to show different patterns of habitat and food use. Throughout the egg, chick, and post-fledging stages, dipterans were typically used by Sabine's Gulls in the freshwater microhabitat, and amphipods were used by Arctic Terns in the salt water zone. Brant (*Branta bernicla*), 2% of the Canadian population of Lesser Snow Goose (*Chen caerulescens*) also use East Bay Site.

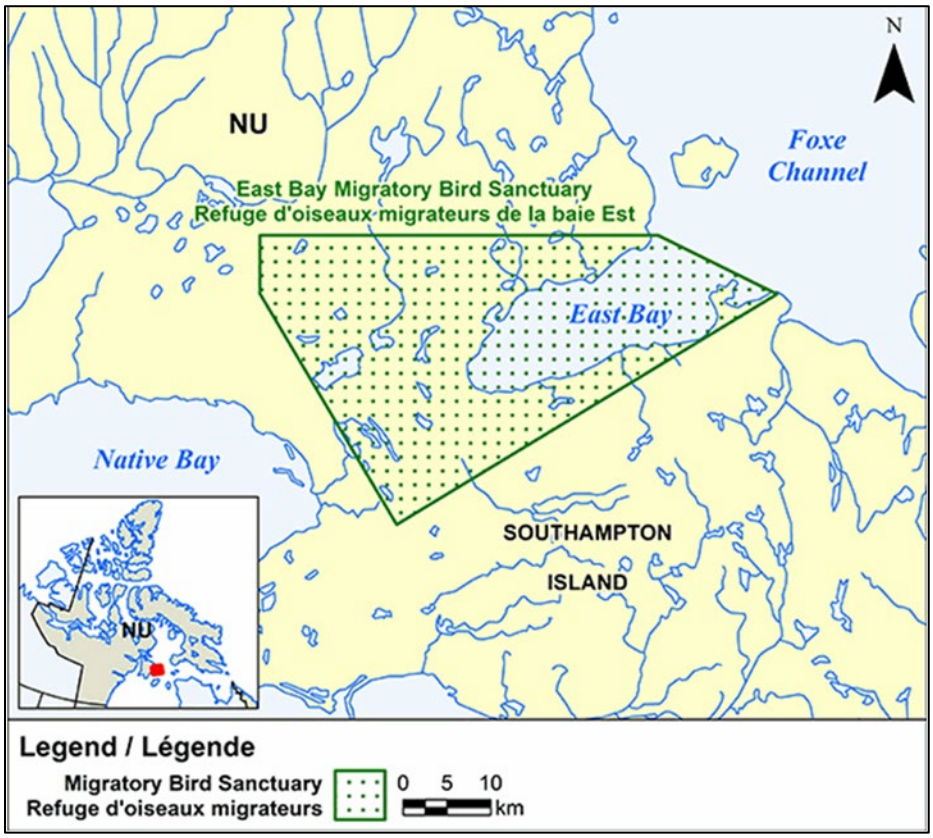

Figure 20. East Bay Migratory Bird Sanctuary along northeast Southampton Island (Source: ECCC 2017).

A 6,120 km^2 area surrounding the Boas River delta and overlapping with the Harry Gibbons Sanctuary (Figure 21) was identified as a key migratory bird terrestrial habitat site by Latour et al. (2008). Atlantic Brant, Cackling Goose, Ross's Goose (*Chen rossii*), Common Eider, King Eider, Long-tailed Duck and Tundra Swan also nest in the Harry Gibbons MBS, along with Pacific and Red-throated Loons, Sabine's and Herring gulls, Ruddy Turnstone, Red Phalarope and Parasitic Jaeger.

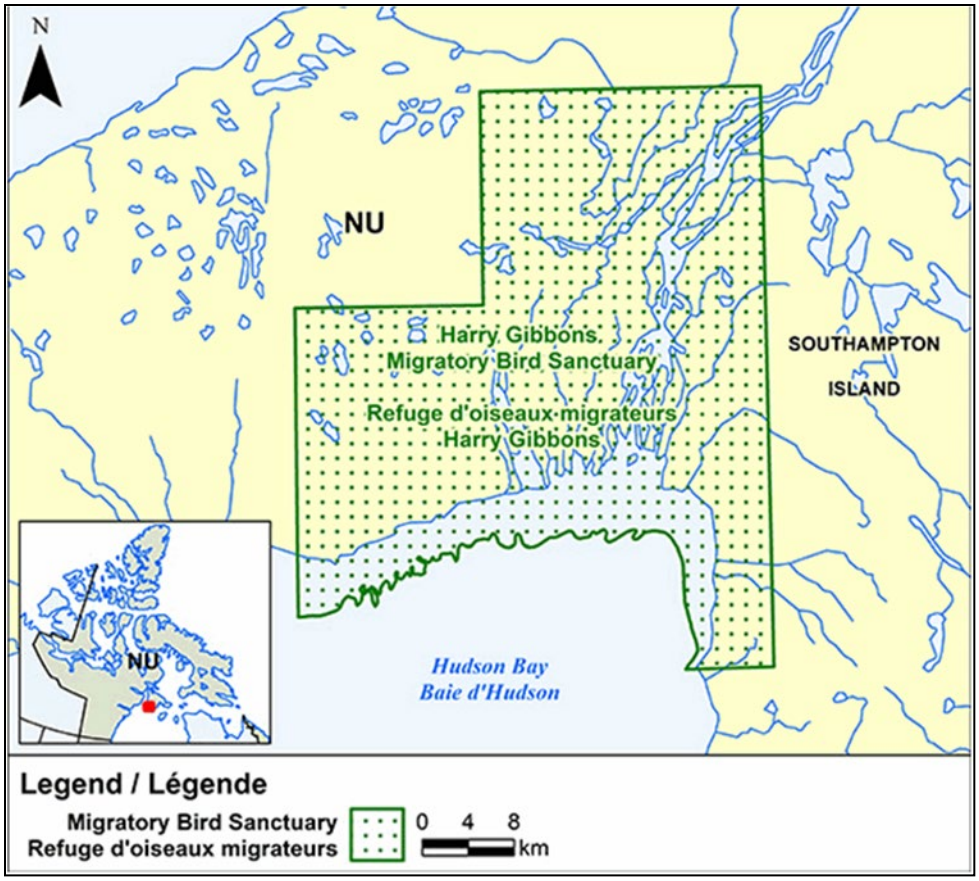

Figure 21. Harry Gibbons Migratory Bird Sanctuary along southwest Southampton Island (Source: ECCC 2017).

Approximately 84 species of birds were observed on Coats Island since 1975, including many species outside their normal ranges (Gaston and Ouellet 1997). The island has a similar avifauna to Southampton Island except for an absence of lemming predators (Long-tailed Jaeger, Snowy Owl *Nyctea scandiaca*) and only small numbers of Snow Geese, although good numbers of Cackling Geese and some Brant breed there (Gaston and Ouellet 1997). Additional species nesting on Coats Island include Iceland Gull (*Larus glaucoides*), 50 pairs; (Mallory et al. 2018), Herring Gulls (inland), and Black Guillemots (Gerson and Gerson 1986). In addition to murres, approximately 30 pairs of Glaucous Gulls occur at Cape Pembroke (Gaston and Elliott 2013). The latter species typically arrives in the eastern Arctic in late May and lays eggs in mid-June that hatch in the first half of July. Black Guillemot typically migrate south in October; however, some stay in the Arctic all winter. Small numbers of Razorbills (*Alca torda*) have been reported on Coats Island since the 1990s, especially in years when sandlance (*Ammodytes* spp.) are abundant locally (Gaston and Woo 2008).

The sedge lowlands on the northern and western parts of Coats Island support several tundra-nesting species, including King Eiders, Sabine's Gull, Cackling Geese (*Branta hutchinsii*), Semipalmated (*Calidris pusilla*), White-rumped (*C. fuscicollis*), Purple (*C. maritima*) and Pectoral Sandpipers (*C. melanotos*). Although no density or population estimates are available, observations suggest that the area contains significant populations of these species. Great Black-backed Gulls (*Larus marinus*) were not recorded on the Island in the 1980s, but were regular in small numbers by 1995 (Gaston and Ouellet 1997). A list of bird species recorded in and around the SI EBSA has been summarized in Loewen et al. (2019).

Coats Island is identified as a key marine site for migratory birds in the Canadian Arctic and lies within the SI EBSA (Mallory et al. 2018). A key migratory bird habitat was identified approximately 3 km west of Cape Pembroke along the northern tip of Coats Island (Latour et al. 2008). The site is an International Biological Programme Site (Nettleship 1980 in Mallory and Fontaine 2004), an Important Bird Area in Canada (NU005; IBA Canada 2004), and a Key Marine Habitat Site in Nunavut (Mallory and Fontaine 2004).

THICK-BILLED MURRES (*URIA LOMVIA*)

Thick-billed murres are the most abundant marine bird species in the Canadian Arctic (Gaston et al. 2012). There are two sub-colonies of murres at Coats Island located in two adjacent bays (population size 60,000) and one colony at Digges Island (800,000) that forage in the SI EBSA (Mallory et al. 2018). During the pre-breeding season in April and May, murres migrate back to Hudson Bay (Figures 22–23), arriving at the Coats Island colony in mid-May (Gaston et al. 2011). The distribution of murres during this season is likely strongly linked to the presence of openings in the sea ice. Gaston and Hipfner (1998) reported that ice cover is generally complete when the murres arrive and has usually disappeared before most of the chicks hatch in late-July.

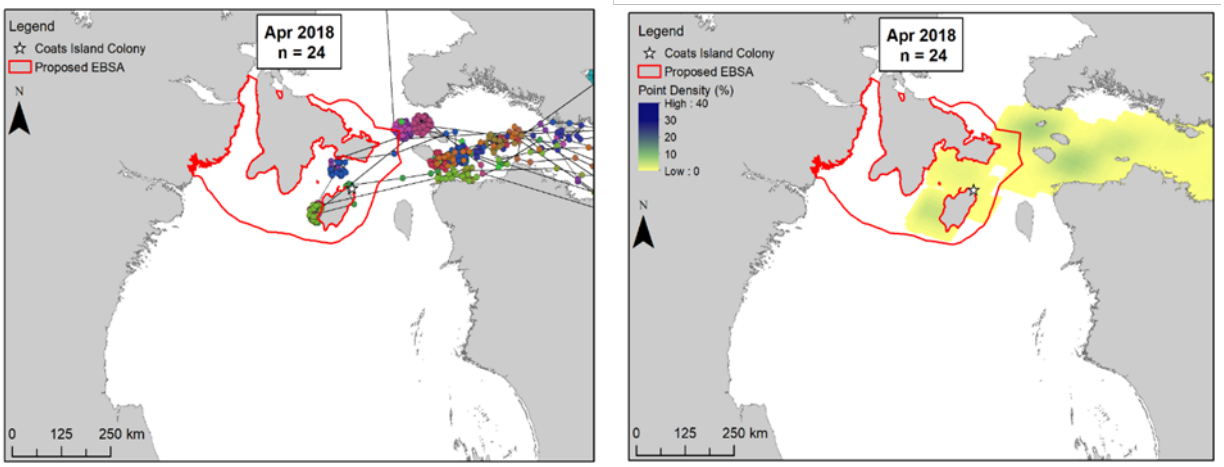

Figure 22. The non-breeding distribution of thick-billed murres (n=24) from the Coats Island colony in April 2018. Left: Each point colour represents a different individual and lines represent the whole geolocator track.Right: Shaded areas represent the point density distributions of all locations for that month.

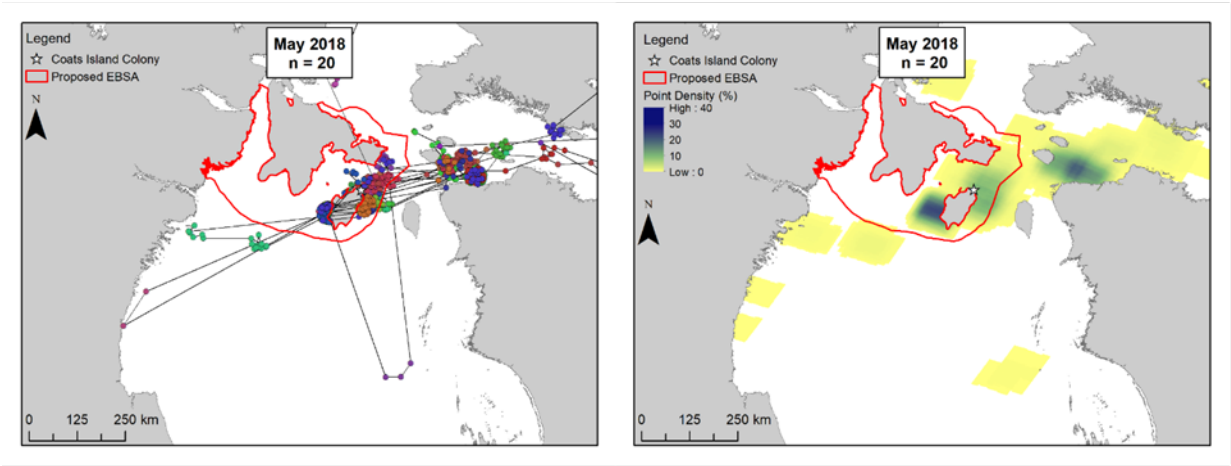

Figure 23. The non-breeding distribution of thick-billed murres (n=20) from the Coats Island colony in May 2018.Left: Each point colour represents a different individual and lines represent the whole geolocator track. Right: Shaded areas represent the point density distributions of all locations for that month.

The breeding season of thick-billed murres from the Coats Island colony takes place from June to August. From 2016 to 2018, 225 GPS deployments have been made on breeding murres at Coats Island (Table 2). Early in the breeding season during incubation, breeding murres take longer foraging trips and travel farther from the colony (Figures 24–26; Table 3). Once chicks hatch, murres make shorter foraging trips and stay closer to the colony (Figures 24–26; Table 3). However, non-breeding murres may continue to forage further away. The majority (> 90%) of GPS tracking has been conducted on the western sub-colony where birds primarily forage north and west of the colony. Limited GPS tracking of murres from the east sub-colony indicates that these birds may forage more to the east of the colony, especially during the chick-rearing stage. Because most tracking has focused on the western sub-colony, GPS data (Figures 24–28) probably underestimates the extent to which birds from the eastern sub-colony use the east coast of Coats Island for foraging.

During the post-breeding season in August and September, adult murres undergo a flightless moult and males are accompanied by flightless chicks (Figures 27-28). As the genus *Uria* is sensitive to oil pollution, thick-billed murres may be adversely affected by increases in shipping along with oil and gas development (Gaston et al. 2013). Murres would be especially vulnerable to oil spills during the flightless moult stage.

Table 2. Number of GPS deployments on murres at Coats Island by breeding stage and year.

Year	Incubation (Jun-Jul)	Chick-rearing (Jul-Aug)
2016	79	59
2017	15	53
2018	18	2

Table 3. Summary statistics for foraging trips by murres breeding at Coats Island, by week of the year. Medians and 90th percentiles shown for trip duration (hr), maximum distance travelled from the colony (km), and minimum dive depth (m).

Week	Trips	Murres with chicks (%)	Trip Duration (hr)		Maximum Distance (km)		Depth (m)	
			Median	90%	Median	90%	Median	90%
26	24	0	9.7	17.8	13.3	82.8	57.4	75.6
27	98	1.0	9.2	16.5	28.8	68.0	21.0	80.2
28	179	24.0	7.8	13.0	32.1	66.7	55.4	81.3
29	207	77.3	3.5	9.1	20.8	47.0	64.4	98.6
30	401	99.8	2.2	7.5	16.6	39.6	78.1	108.5

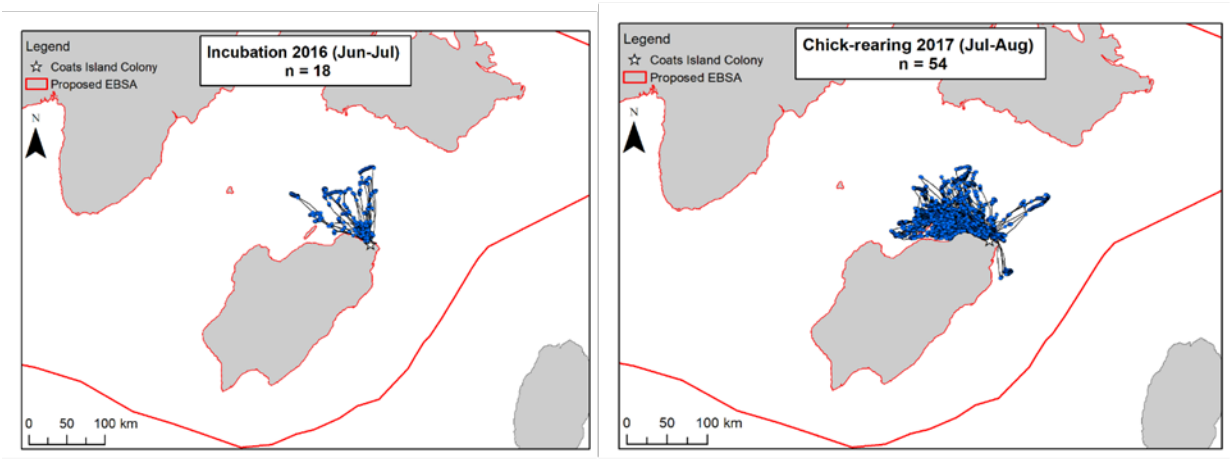

Figure 24. Left: The breeding distribution of thick-billed murres (n=18) from the Coats Island colony during the incubation stage in June–July 2016. Right: The breeding distribution of thick-billed murres (n=54) from the Coats Island colony during the chick-rearing stage in July–August 2017. Blue points show locations where murres were diving or swimming on the water's surface and lines represent the whole GPS track.

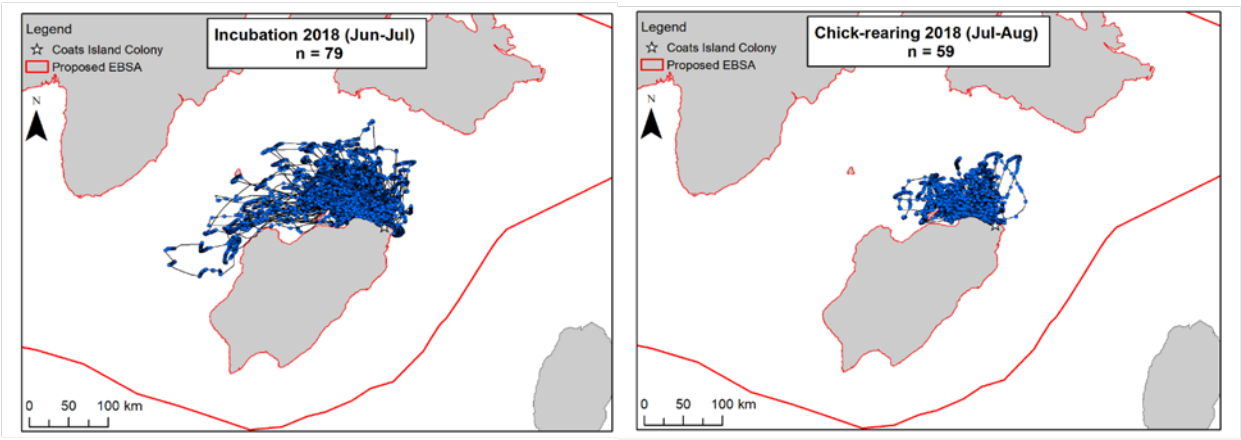

Figure 25. The breeding distribution of thick-billed murres from the Coats Island colony during the incubation stage in June–July 2018 (left) and chick-rearing stage in July–August 2018 (right). Blue points show locations where murres were diving or swimming on the water's surface and lines represent the whole GPS track.

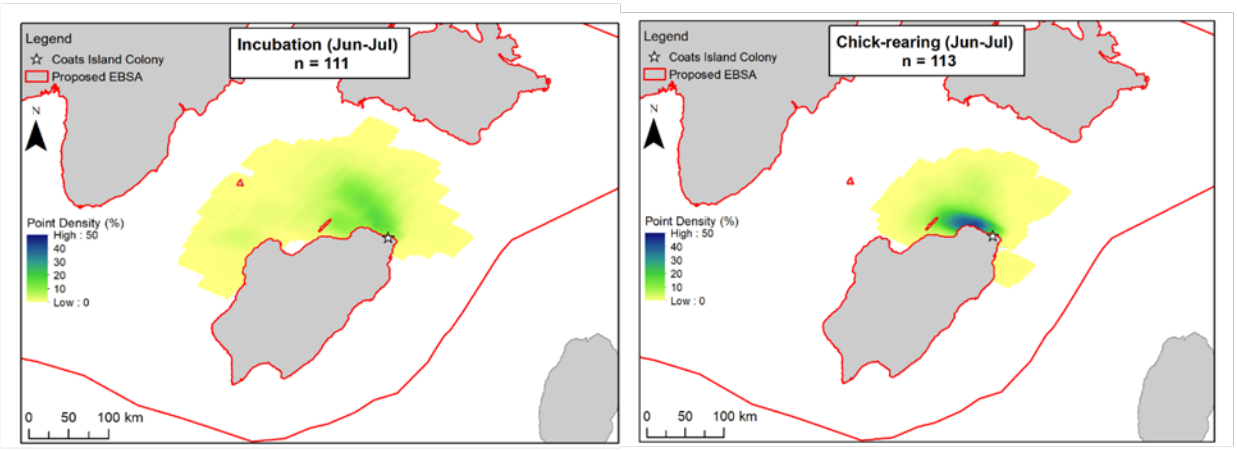

Figure 26. The breeding distribution of thick-billed murres from the Coats Island colony during the incubation stage from June–July 2016 to 2018 (left) and chick-rearing stage from June–July 2016 to 2018. Shaded areas represent the point density distributions of foraging locations.

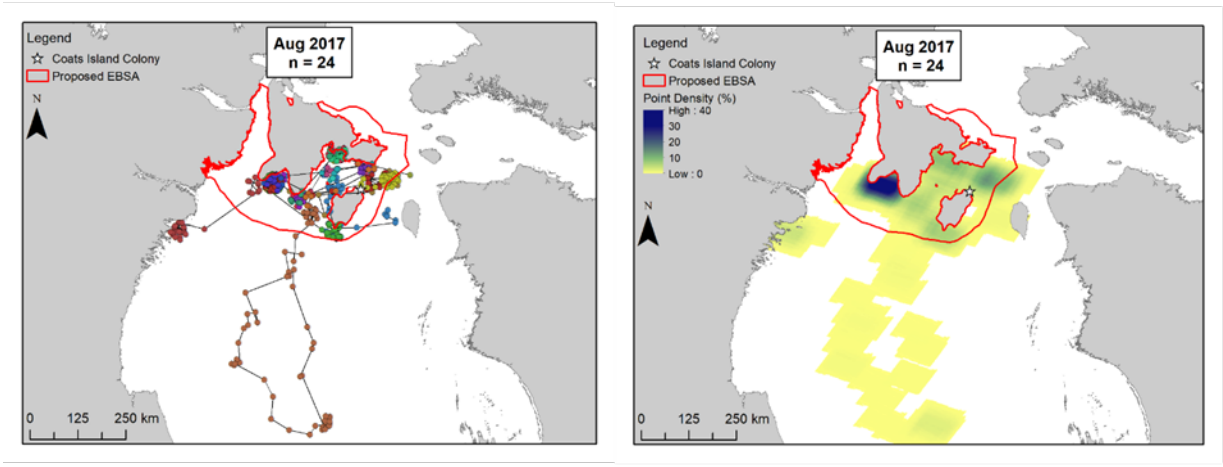

Figure 27. The post-breeding distribution of thick-billed murres (n=24) from the Coats Island colony in August 2017. Left: Each point colour represents a different individual and lines represent the whole geolocator track.Right: Shaded areas represent the point density distributions of all locations for that month.

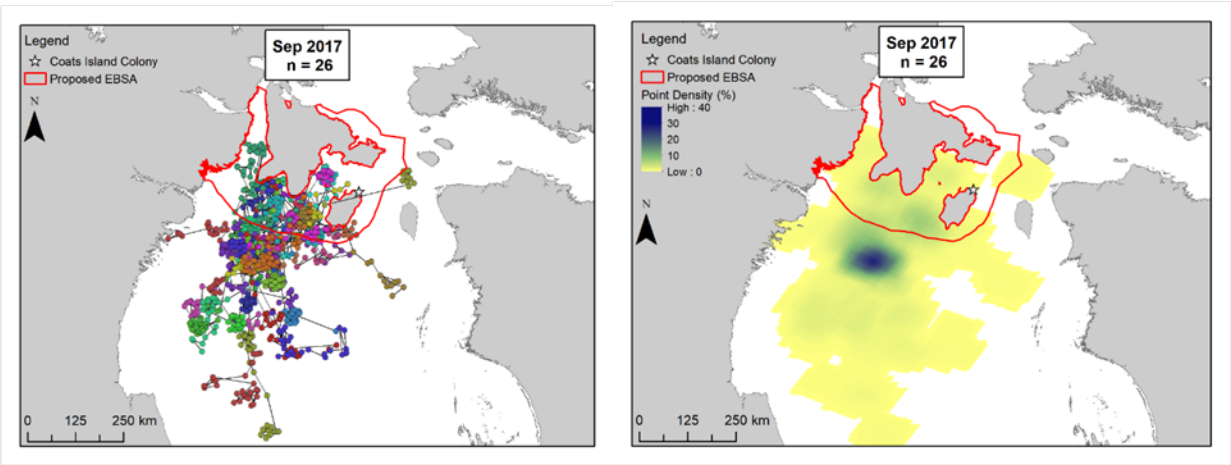

Figure 28. The non-breeding distribution of thick-billed murres (n=26) from the Coats Island colony in September 2017. Left: Each point colour represents a different individual and lines represent the whole geolocator track. Right: Shaded areas represent the point density distributions of all locations for that month.

During a long-term study (1981-2013) of Coats Island murres, Gaston and Elliot (2014) identified a substantial shift in murre diets from Arctic Cod to Capelin, which was strongly affected by ice conditions and resulted in lower growth rates for chicks. Harter et al. (2013) showed that large Arctic Cod were more energy-rich per unit mass than smaller individuals. As older, larger cod are more frequently associated with ice than smaller, juvenile cod (Lowry and Frost 1981, Bradstreet et al. 1986, Jarvela and Thorsteinson 1999), a potential reduction or loss in sea ice could affect cod distribution and population structure, as well as fish community assemblage, which would strongly influence the foraging efficiency of these nesting birds' food web dynamics in the region (Harter et al. 2013). Elliott et al. (2009) found that thick-billed murres flew farther for a given prey item later in the breeding season and "fished down the food web", starting with large fish, then progressing to smaller fish, and finishing with invertebrates. As the foraging season progresses, a halo of depleted prey items occurs up to approximately 20 km

from the colony (Elliott et al. 2009). Other risks to the Coats Island murre colony are predators; gulls and Arctic foxes (*Vulpes lagopus*) are the typical predators of murre eggs (Gaston and Elliott 2014). Early arrival of Polar Bears (*Ursus maritimus*) in 2011, likely due to early ice break-up, caused overlap between terrestrial foraging by bears and the breeding season of murres (Gaston and Elliott 2013). Despite observations since 1981, bears have been observed on the murre colony in 1998, 2003, 2011, 2016 and 2018, implying an increasing rate of overlap with seabird breeding. Combined with increased mosquito parasitism, which has been increasing since the 1990s, the 2011 polar bear resulted in adult mortality and reproductive failure of the murres and reduced the population by 20%. Mallory et al. (2004) also observed Walrus (*Odobenus rosmarus*) foraging on adult thick-billed murres at Coats Island.

Additional species nesting on Coats Island include Iceland Gull (*Larus glaucoides*; 50 pairs; (Mallory et al. 2018) Herring Gulls (inland) and Black Guillemots (Gerson and Gerson 1986). In addition to murres, ~30 pairs of Glaucous Gulls occur at Cape Pembroke (Gaston and Elliott 2013). The latter species typically arrives in the eastern Arctic in late May and lays eggs in late-June that hatch in late-July. They generally feed close to shore and focus on Arctic or Polar Cod early in the breeding season. Black Guillemot typically migrate south in October; however, approximately 10% stay in the Arctic all winter. Small numbers of Razorbills (*Alca torda*) were recently reported on Coats Island (Latour et al. 2008). The sedge lowlands on the northern and western parts of Coats Island support several tundra-nesting species, including King Eiders, Sabine's Gull, Cackling Geese (*Branta hutchinsii*), Purple Sandpipers (*Calidris maritima*) and Pectoral Sandpipers (*Calidris melanotos*). Although no density or population estimates are available, observations suggest that the area contains significant populations of these species. Gaston and Ouellet (1997) noted that Long-tailed Jaeger, which is common on nearby Southampton Island, is rare or absent from Coats Island, except in passage. There are also no snow goose colonies on the Island, although good numbers of Cackling Geese and some brant breed there. Great Black-backed Gulls (*Larus marinus*) were not recorded on the Island in the 1980s, but were common by 1995 (Gaston and Ouellet 1997).

A list of bird species recorded in and around the SI EBSA can be found in Loewen et al. (2019).

ECOLOGICAL SIGNIFICANCE

The synthesis on the state of knowledge provided in previous sections of this document gives the basis for identifying ecological significance, knowledge gaps, and vulnerability in the SI EBSA. It is the ecological significance, knowledge gaps, and vulnerability that will inform the development of conservation objectives as part of the MPA process. Six ecologically significant components were identified in the SI EBSA, and their associated knowledge gaps and vulnerabilities are discussed in the following section:

1. Migration Corridor for Beluga, Bowhead, and Narwhal

The SI EBSA is known to be a seasonal (fall and spring) migration corridor and hotspot for Beluga, Bowhead, and Narwhal moving to and from Hudson Bay, Davis Strait, and Foxe Basin areas (Figure 29). WHB Beluga generally overwinter in Hudson Strait and Ungava Bay, and summer concentrations are primarily located in the coastal waters of Western Hudson Bay and Repulse Bay/Lyon Inlet (Figure 14). Belugas migrate through the SI EBSA during spring and fall, primarily using Roes Welcome Sound in the fall, and waters north of the EBSA around Repulse Bay and south of SI during the spring and fall. For EC-WG Bowhead Whales, the SI EBSA is used largely as a migratory corridor for whales moving to summer feeding areas in Repulse Bay, Lyon Inlet, and Frozen Strait (Figure 15). NHB Narwhals migrate seasonally through Hudson Strait between wintering grounds in eastern Hudson Strait and the Labrador Sea, and summer feeding and calving areas in Repulse Bay and nearby waters (Figure 16).

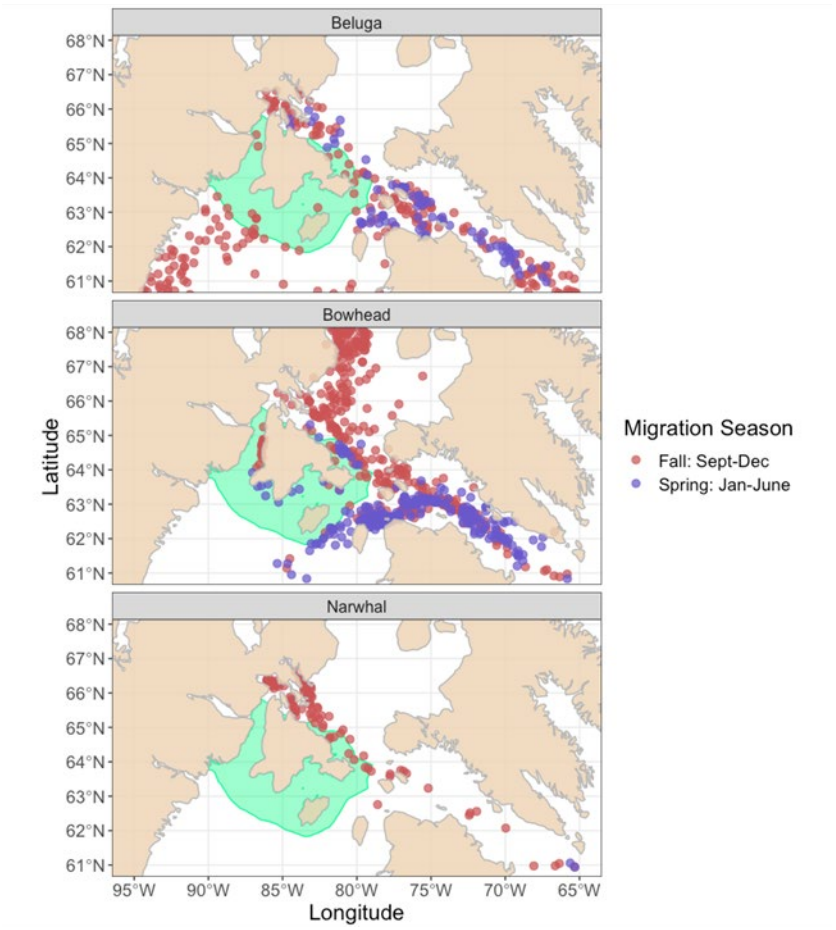

Figure 29. Spatial distributions of Beluga, Bowhead and Narwhal, and seasonal movement (fall, September-December, and spring, January–June) between the SI EBSA (green), and Hudson Bay, Hudson Strait, and Southern Foxe Basin. Data is from tagged satellite-linked radio transmitters and provided by Yurkowski et al. 2019. Note: some transmitters did not last a full migration season.

2. Marine Mammal (Beluga, Narwhal, Bowhead and Polar Bear) Seasonal Residence (feeding) and Calving/Denning Areas

Some Beluga, Narwhal, and Bowhead whales remain in the Southampton Island area throughout the summer (Figure 30). Local IQ and scientific observations suggest Beluga, Narwhal, and Bowhead may calve and rear young in the SI EBSA. Specifically, IQ indicated that East Bay is an important Beluga calving area. A small proportion of the EC-WG Bowhead population remains in the SI EBSA during the summer months (Figure 30). Waters off the southeastern coast of Southampton Island are delineated as a potentially important calving and rearing area for Bowheads based on observations of calves in the area. For Narwhal, important calving and nursing habitat has been identified throughout the entire summer core area north (and outside) of the EBSA within Repulse Bay.

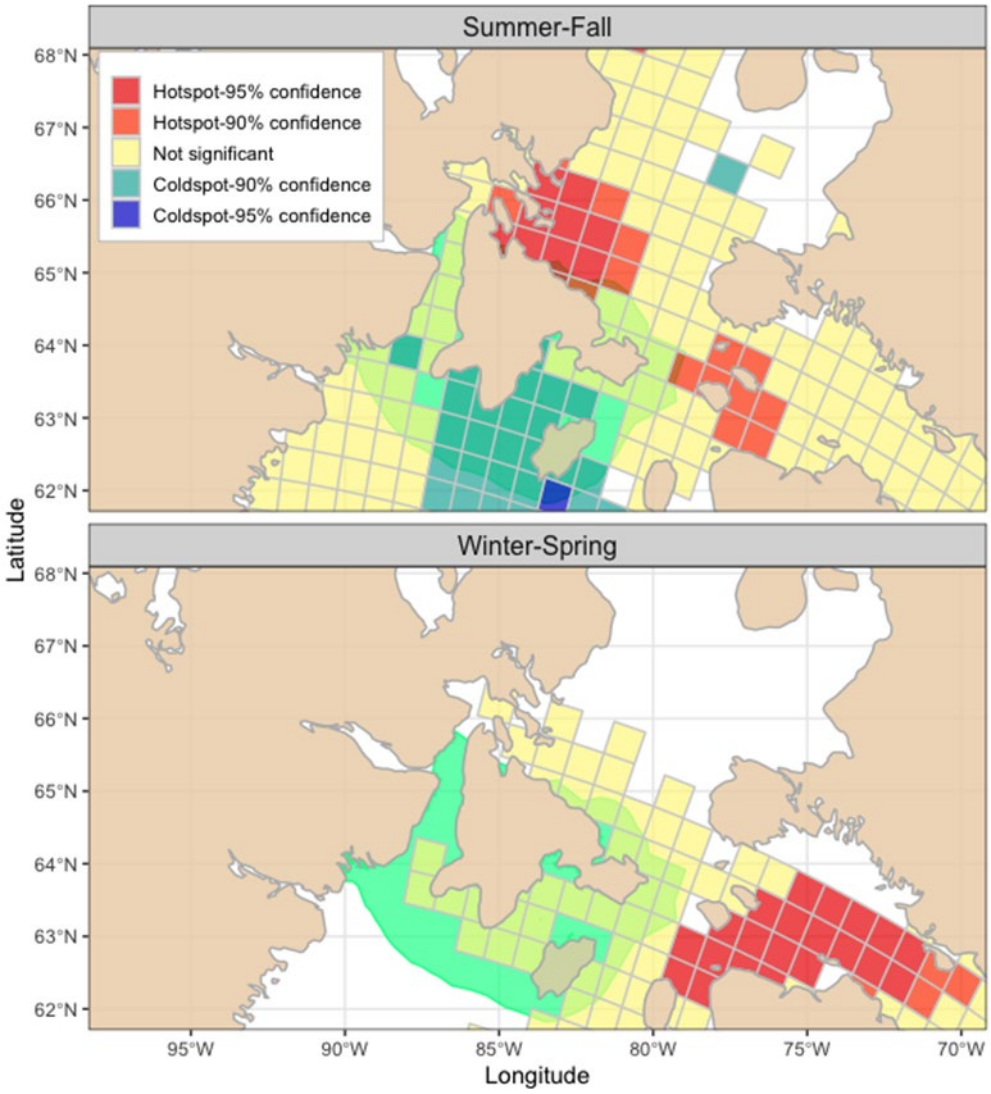

Figure 30. Maps of marine mammal hotspots for summer–fall (June–December) and winter-spring (January–May) within the SI EBSA. Hotspots, high (red-orange) and low (coldspot: blue), derived from number of unique individuals of cetaceans and pinnipeds tagged with satellite-linked radio transmitters (Note: walrus tagging data is absent in the creation of these figures and within this study) (Data from Yurkowski et al. 2019).

The SI EBSA provides valuable denning habitat for the Foxe Basin Polar Bears (Figure 31). Vansittart Island to the north of Southampton Island is recognized as important denning and is known as an area increasingly used by adult female bears. Denning habitat has been identified around the southeast of Southampton, near East Bay and towards the northern end of the island (Figure 31).

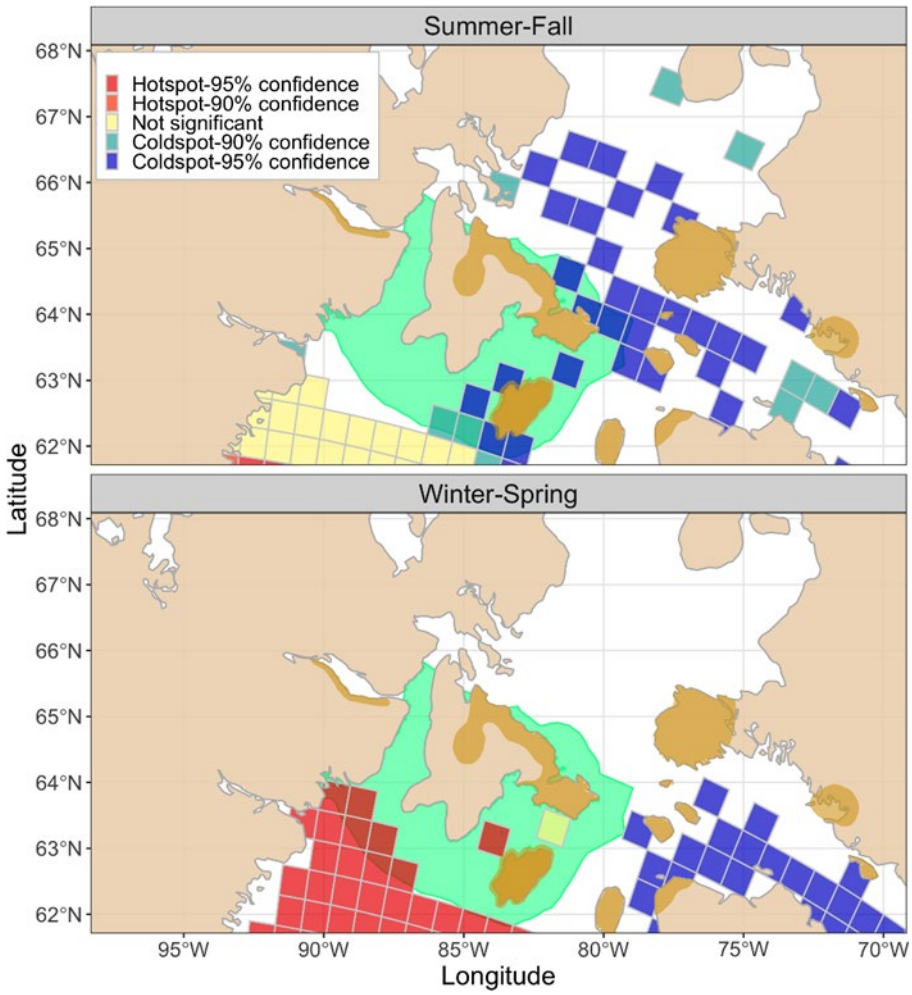

Figure 31. Maps of Polar Bear hotspots, high (red-orange) and low (coldspot: blue), derived from number of unique individuals tagged with satellite-linked radio transmitters by summer-fall and winter-spring across the study area (Data from Yurkowski et al. 2019). Denning areas (yellow) on Southampton Island and adjacent areas geo-referenced from Peacock et al. 2010.

3. Seabirds and their prey species

Significant colonies of seabirds are found within the SI EBSA and several species use this region along their migratory routes on a seasonal basis (Figure 32). Of significance are the two Thick-Billed Murre breeding colonies found on Coats Island, that support approximately 2% of the Canadian population, and Arctic Canada's largest single colony of Common Eiders at East Bay. Thick-Billed Murres prey species are Arctic Cod, Capelin, other small fish species, and secondarily invertebrate species. There is a preference to consume Arctic Cod due to higher energy content desired for survival and chick rearing.

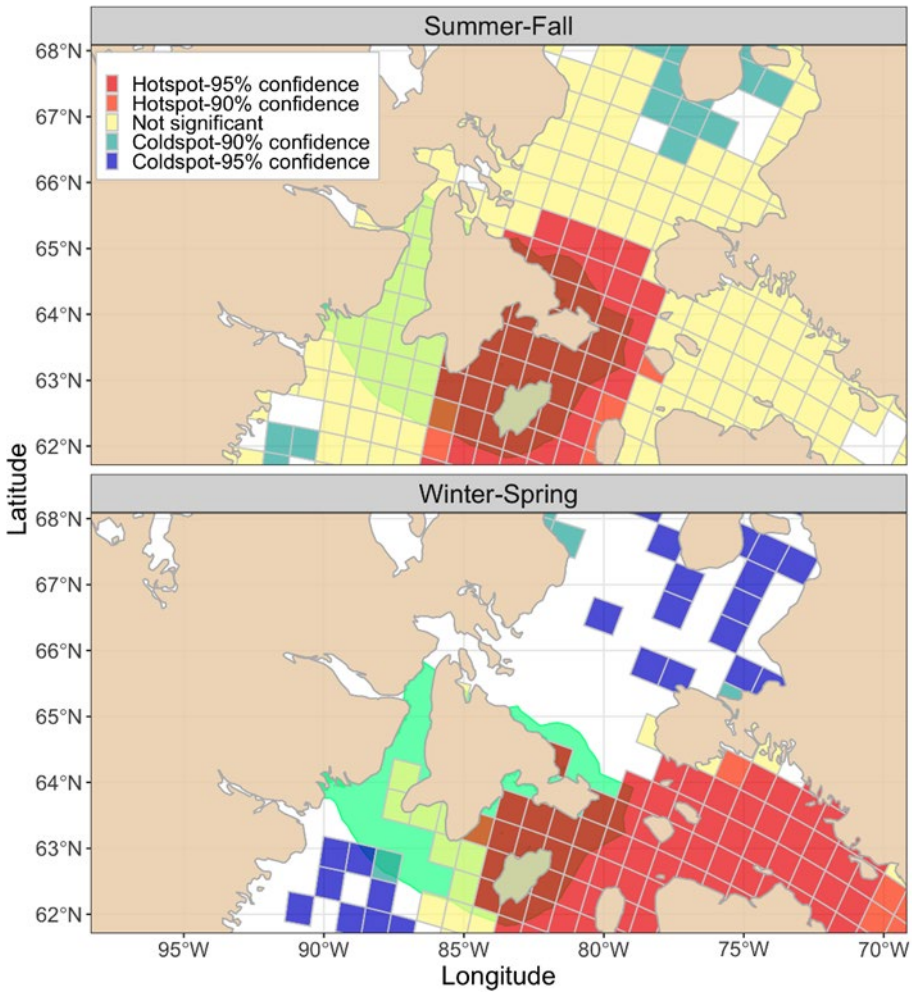

Figure 32. Maps of seabird hotspots, high (red-orange) and low (coldspot: blue), by summer-fall and winter-spring across the SI EBSA (green) and surrounding area (Data from Yurkowski et al. 2019).

4. Resident Marine Mammals (Walrus and Polar Bear) and their Prey Species

Walrus and Polar Bear living in the vicinity of the SI EBSA are thought to be year-round residents moving locally during the seasons (Figure 31). Additionally, based on this residency time within the EBSA, prey species for their survival are of ecological significance. Walruses can occur year-round in Roes Welcome Sound and Frozen Strait. Important haul-out sites are found on Bencas, Coats, and Walrus islands, and additional sites occur along the southern and northwestern coasts of Southampton Island (Figure 33). Walrus primarily feed on macro benthos such as molluscs and other invertebrates. They have also been known on occasion to consume larger prey, such as Ringed Seals and adult Thick-billed Murres.

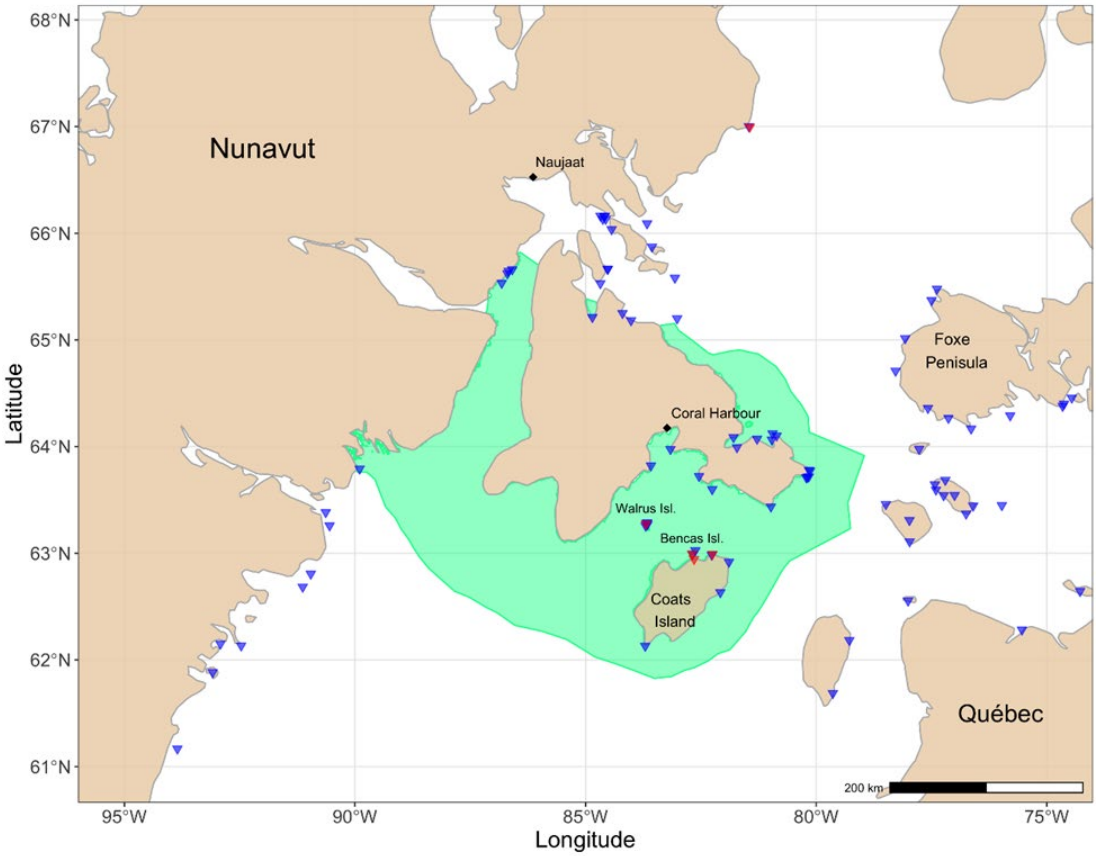

Figure 33. Known terrestrial haul-out sites for Atlantic Walrus in the SI EBSA (green) and surrounding area, compiled from the Fisheries and Oceans Canada Central and Arctic Region survey database (red) and other sources (blue) identified in Higdon (2016) (Source: DFO 2019).

Walrus and Polar Bear (Figure 31) living in the vicinity of the SI EBSA are thought to be year-round residents moving locally during the seasons. Additionally, based on this residency time within the EBSA, prey species for their survival are of ecological significance. Walruses can occur year-round in Roes Welcome Sound and Frozen Strait. Important haul-out sites are found on Bencas, Coats, and Walrus islands, and additional sites occur along the southern and northwestern coasts of Southampton Island (Figure 33). Walrus primarily feed on macro benthos such as molluscs and other invertebrates. They have also been known on occasion to consume larger prey, such as Ringed Seals and adult Thick-billed Murres.

5. Migratory Arctic Char and Other Subsistence Food

The communities of Coral Harbour, Naujaat, Chesterfield Inlet and Rankin Inlet all conduct subsistence harvest of Arctic Char within the SI EBSA. Migratory Arctic Char are the most abundant salmonid available for subsistence harvesting and local food security for the community of Coral Harbour (Figure 34). In addition, migratory Arctic Char are thought to be a food source for Beluga residing in the SI EBSA during the summer months. Other species harvested are Beluga, Narwhal, Walrus, Bowhead, Ringed Seal, and Bearded Seal.

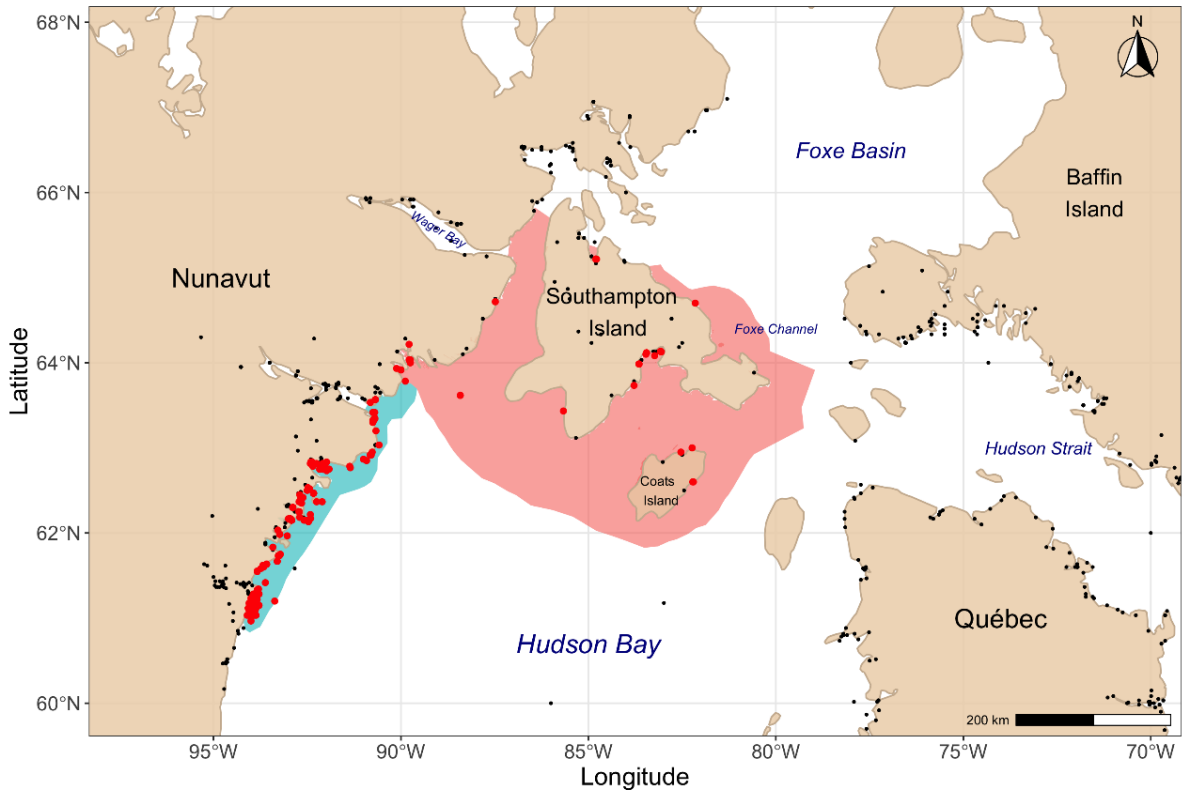

Figure 34. Arctic Char occurances for the regions in and around Foxe Basin, Hudson Strait, Ungava Bay, Hudson Bay (black circles) and specifically in the SI EBSA region and the Western Hudson Bay EBSA (red circles) demonstrating an abundance of stocks available for subsistence harvesting (Coad and Reist 2018).

6. Roes Welcome Sound Polynya

The Roes Welcome Sound Polynya is a unique oceanographic feature of the SI EBSA (Figure 2). This polynya provides open-waters during the winter months to seals, Walruses, and other marine mammals (i.e., Beluga Whales and Narwhal). It is the preferred winter habitat for Bearded Seals and is used by Walrus year-round. Further, this polynya is considered to be critical habitat for a multitude of migrating birds.

VULNERABILITIES

1. Climate change (reduced extent and duration of sea ice, northward range expansion of southern species)
    - Shifts in species diets (e.g., seabirds, belugas) from Arctic Cod to Capelin.
    - Predicted reduction in the extent and duration of sea ice is expected to negatively affect Walrus populations particularly those in Foxe Basin, Hudson Bay and Davis Strait.
    - Climate mediated reductions in sea ice are likely to influence polar bear demography through changes in prey availability resulting in population declines similar to those observe in southern Hudson Bay. Reductions in sea ice are likely to increase the use of terrestrial habitats potentially resulting in increased human bear conflicts and greater foraging by bears at seabird colonies.

- Arctic pack ice retreat could have a particularly strong influence on the foraging efficiency of nesting birds.

2. Human activities (mining, shipping, tourism, hydroelectric development, hunting)
   - Bowhead numbers were historically impacted by commercial whaling industry and present day subsistence harvests are managed through a Total Allowable Harvest.
   - Environmental effects of ballast water release, vessel bi-fouling, and aquatic invasive species from large transport vessels.
   - Disturbance of Walrus haul out sites and marine mammals due to adventurers and tourism activities, and mechanical noise caused by vessel and aircraft-based traffic.
   - Presence of contaminants and their impacts to marine mammal physiology.
   - Increased shipping from mining development and development/activities at the Port of Churchill (secondary effects: potential for ship strandings, noise pollution, marine mammal strikes, and spills of contaminants).
   - Potential increased opportunity for the defence of life and property kills as a result of declines in Polar Bear body condition and increased terrestrial habitat use.
3. Predation and Parasitism
   - Gulls and Arctic foxes (*Vulpes lagopus*) are the typical predators of murre eggs.
   - Increased Polar Bear predation and mosquito parasitism resulted in adult mortality and reproductive failure of the murres and reduced the population by 20%.
   - Increased predation by Polar Bears of Common Eiders at East Bay Island is leading to low reproductive success and/or complete cohort failures for breeding birds representing a long term threat to the persistence of this colony.
   - Walrus foraging on adult Thick-billed Murres at Coats Island.

KNOWLEDGE GAPS AND DATA DEFICIENCIES:

- Lack of contemporary data describing population trends for beluga;
- Insufficient data to differentiate among stocks of Killer Whales in the northwest Atlantic Ocean and the Canadian Arctic;
- Lack of life history knowledge and population assessments for migratory Arctic Chars in the SI EBSA;
- Insufficient data on marine fish life histories around the SI EBSA;
- Insufficient data on Walrus movements in the SI EBSA;
- Lack of electronic files for Arctic Char (Fisheries Management Sector) exploratory and commercial licences for approximately the last 10 years of records.

DISCUSSION

The key objective of this Ecosystem Overview Report was to conduct a peer-review of the Southampton Island EBSA based on information and scientific research (past and current) for the EBSA and surrounding area. The results of this process have allowed DFO to identify and map key biophysical and ecological components within the EBSA and recommend conservation objectives for each, these details can now be found in the associated Science Advisory Report (SAR). These objectives are developed to consider the desired and measureable state of the

conservation priorities. This assessment also captures known and potential/likely activities and stressors to the study area, and how these have the ability to affect the key biophysical and ecological components.

In August 2019, the Government of Canada announced a marine area around Southampton Island in Hudson Bay as an Area of Interest (AOI) for potential Marine Protected Area (MPA) designation under Canada's Oceans Act. Most of the Southampton Island EBSA is captured in the AOI. Lesser portions of the Repulse Bay/Frozen Strait and Western Hudson Bay Coastline EBSAs are also captured in the AOI. Fisheries and Oceans Canada will work with local communities, Inuit organizations and the Government of Nunavut, with the participation of other government agencies, industry and conservation organizations, during the MPA establishment process. This biophysical and ecological overview will assist in delineating a future MPA boundary (along with key priority areas), and will feed into an ecological risk analysis to inform the development of the regulatory approach for the proposed MPA. The information contained within the SAR will support advice on monitoring protocols and strategies, identification of information gaps requiring further research, and the development of a management plan for the area.

To support this document, a Canadian Data Report of Fisheries and Aquatic Sciences (Loewen et al. 2020) has been published and contains listings of taxa of phytoplankton, ice algae and macroalgae, zooplankton and ice fauna, and benthic and epibenthic macroinvertebrates found with the Southampton Island EBSA. It also contains fish species found within EBSA, as well as some that may occur within this area, maps of fish distributions by family and bird species reported in a near the SI EBSA.

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