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

Ontario and Prairie Region | Canadian Science Advisory Secretariat
Science Response 2020/055

SUPPLEMENT TO THE BIOPHYSICAL AND ECOLOGICAL OVERVIEW FOR SOUTHAMPTON ISLAND (SI) EBSA TO INCLUDE ADDITIONAL AREAS WITHIN THE SOUTHAMPTON ISLAND AREA OF INTEREST (AOI)

Context

An Area of Interest (AOI) for the waters surrounding Southampton Island (SI) and Chesterfield Inlet is being considered for designation as a Marine Protected Area (MPA) under the *Oceans Act*. In support of MPA development, a Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) regional advisory meeting was conducted for the SI Ecologically and Biologically Significant Area (EBSA) on December 5–6, 2018 (DFO 2020a). The purpose of that meeting was to identify ecological significance of the SI EBSA (i.e., unique characteristics of a region, such as physical oceanographic drivers, key species, and habitats), knowledge gaps and vulnerabilities, and provide advice on conservation priorities (ecological components targeted for protection) and potential conservation objectives (quantitatively/qualitatively measurable statements to achieve goals), based upon a Biophysical and Ecological Overview Report as background information (Loewen et al. 2020a). At the time of the 2018 regional peer-review meeting, an AOI boundary was not yet decided on, and therefore the SI EBSA was considered the scope of the review. Since then, the boundaries for the SI AOI were announced (August 2019), which included two additional areas beyond the boundaries of the SI EBSA: 1) the marine waters adjacent to the community of Chesterfield Inlet (northern portion of the Western Hudson Bay Coastline (WHBC) EBSA), and 2) the north side of SI (portion of the Repulse Bay/Frozen Strait (RB/FS) EBSA; Figure 1). The Kivalliq Regional Inuit Association has supported further discussions on marine protection options for the remainder of the area adjacent to Wager Bay and Repulse Bay, currently these areas are not part of the SI AOI.

Due to the expansion of areas within the SI AOI which were not originally part of the SI EBSA review, DFO Marine Planning and Conservation (MPC; formerly Oceans Management) requires supplementary science advice for the additional areas of the AOI. This request includes describing key ecological and biological features for the additional areas within the AOI, identifying knowledge gaps and vulnerabilities, and refining the potential conservation objectives (COs) provided in the first assessment (DFO 2020a). Although not described here, future work will be based upon the results of various assessments of the area (i.e., the Biophysical and Ecological Overview for SI EBSA and this supplement to it, Inuit Qaujimajatuqangit, socio-economic, petroleum potential) and consultations with partners. These assessments will also help to finalize the COs, provide the foundation for an ecological risk assessment of activities within the area, and determine final boundaries of a potential MPA and how the MPA should be designed (e.g., measures to be put in place). This Science Response Report (SRR) for the additional areas within the SI AOI was reviewed by experts within a Science Response Process held August 26–27, 2020, and September 17, 2020. The information presented here should be considered in combination with previous science advice provided for the SI EBSA (i.e., DFO 2020a).

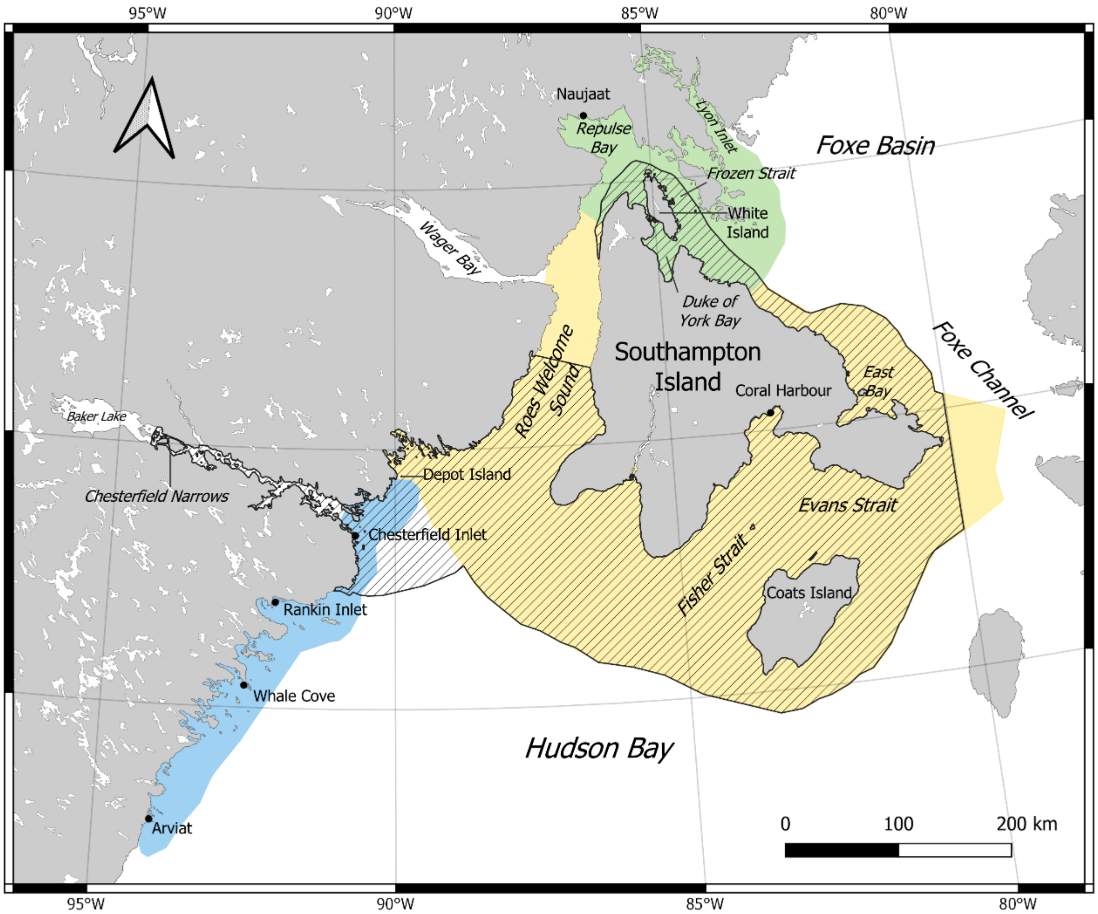

Figure 1. Southampton Island (SI) Area of Interest (black line and diagonal shading), overlaid with the WHBC (blue), SI (yellow), and RB/FS (green) EBSAs (DFO 2011) in the Kivalliq Region of Nunavut.

This Science Response Report results from the Science Response Process of August 26–27, 2020 and September 17, 2020 on the Supplement to the Biophysical and Ecological Overview for Southampton Island Ecologically and Biologically Significant Area (EBSA) to include additional areas.

Background

To support Canada's domestic and international commitments regarding sustainable development of marine environments, DFO undertook exercises to identify EBSAs in the Pacific, Atlantic, and Arctic Ocean regions (e.g., DFO 2011). Evaluation criteria for DFO EBSAs follows the Convention on Biological Diversity and DFO Departmental advice (DFO 2004). Presently, the identification of EBSAs in the Canadian Arctic serves as a key knowledge base for the development of ecosystem-based management in the marine environment, including the development of the Arctic component of Canada's network of Marine Protected Areas (MPAs), called for in the *Oceans Act*. Furthermore, EBSAs are typically used as a starting point in the identification of potential AOIs.

Three previously identified EBSAs overlap the SI AOI: the RB/FS, WHBC, and SI EBSAs (DFO 2011). However, early in the process for AOI identification, MPC requested that DFO Science provide advice on key biophysical and ecological features within just the SI EBSA. Information and data considered in the SI EBSA assessment in 2018 included both scientific and Indigenous published knowledge, as well as expert opinion, and a review of this information can be found in Loewen et al. (2020a). Three priority areas were also identified (East Bay extending into Foxe Channel, Evans and Fisher straits, and Roes Welcome Sound polynya; Figure 1), and six COs were proposed (DFO 2020a):

1. to maintain the ecosystem structure (e.g., biodiversity) and function of the SI EBSA; in particular, these key priority areas: East Bay, Evans and Fisher straits (between Southampton and Coats islands), and Roes Welcome Sound; and the nearshore coastal marine environment;
2. to mitigate the adverse effects of anthropogenic activities (e.g., vessel traffic and tourism) within the SI EBSA generally, and particularly in the three key priority areas;
3. to ensure the sustainability and health of key species (e.g., Atlantic Walrus, Arctic Char, seabirds, Polar Bear, Beluga, Ringed and Bearded Seals) within the SI EBSA;
4. to maintain the presence (quantity, quality and productivity) of key prey species and other ecologically significant species (e.g., benthic invertebrates, small pelagic fishes, kelp, Ringed Seal) within the SI EBSA, and to allow for higher trophic level feeding;
5. to understand the connectivity between the oceanographic drivers, open-water features (i.e., polynya), and sea ice environments (e.g., landfast ice), and how these influence change in regional productivity; and,
6. to maintain current structure and function of the nearshore coastal marine environment (e.g., sediment loading, species distribution changes).

During the peer-review meeting, a number of key features were identified beyond the SI EBSA boundaries but were excluded from the advice, as the scope and focus of the review was only on the SI EBSA. Additionally, gaps in relevant knowledge and data compilations were identified to exist for the SI EBSA across a variety of research fields (DFO 2020a), some of which were broader than the EBSA and could be expanded to adjacent areas. The habitats, ecological processes, and species within the SI EBSA are vulnerable to regional and global stressors, which can be categorized as either pervasive (e.g., climate change, transboundary movement of contaminants, ocean acidification), or area-specific (e.g., shipping, local source pollution, invasive species, predation). Several examples were listed in the SI EBSA Science Advisory Report, however, many were considered to be regional (i.e., Hudson Bay Bioregion) in scope (DFO 2020a).

Analysis and Response

The AOI boundaries now expanded to include portions of the WHBC and RB/FS EBSAs (Figure 1). In order to provide the most useful and up-to-date advice for the additional areas within the AOI boundaries, a re-review of recent published literature and information to supplement Cobb et al. (2011) and Loewen et al. (2020a) was developed. This SRR uses the key ecological and biological features already described for the WHBC and RB/FS EBSAs (Cobb et al. 2011, DFO 2011), but also draws on additional new information, data, and expert opinion.

Western Hudson Bay Coastline EBSA

The WHBC EBSA is an important Arctic Char (*Salvelinus alpinus*) migration corridor and marine feeding region, a Beluga Whale (*Delphinapterus leucas*) aggregation area, and an important fall migration route for Polar Bears (*Ursus maritimus*). The area is known for a consistent frontal zone, with winter shore leads and dense coastal kelp beds and macroalgae. These key features will be discussed in relation to the portion of the WHBC EBSA that falls within the SI AOI boundary (Figure 2). Chesterfield Inlet provides the only major riverine freshwater source to the SI AOI; whereas other freshwater sources around SI are generally from ice melt. The watershed area is 287,100 km^2 and the long (200 km) narrow inlet connects Baker Lake to western Hudson Bay.

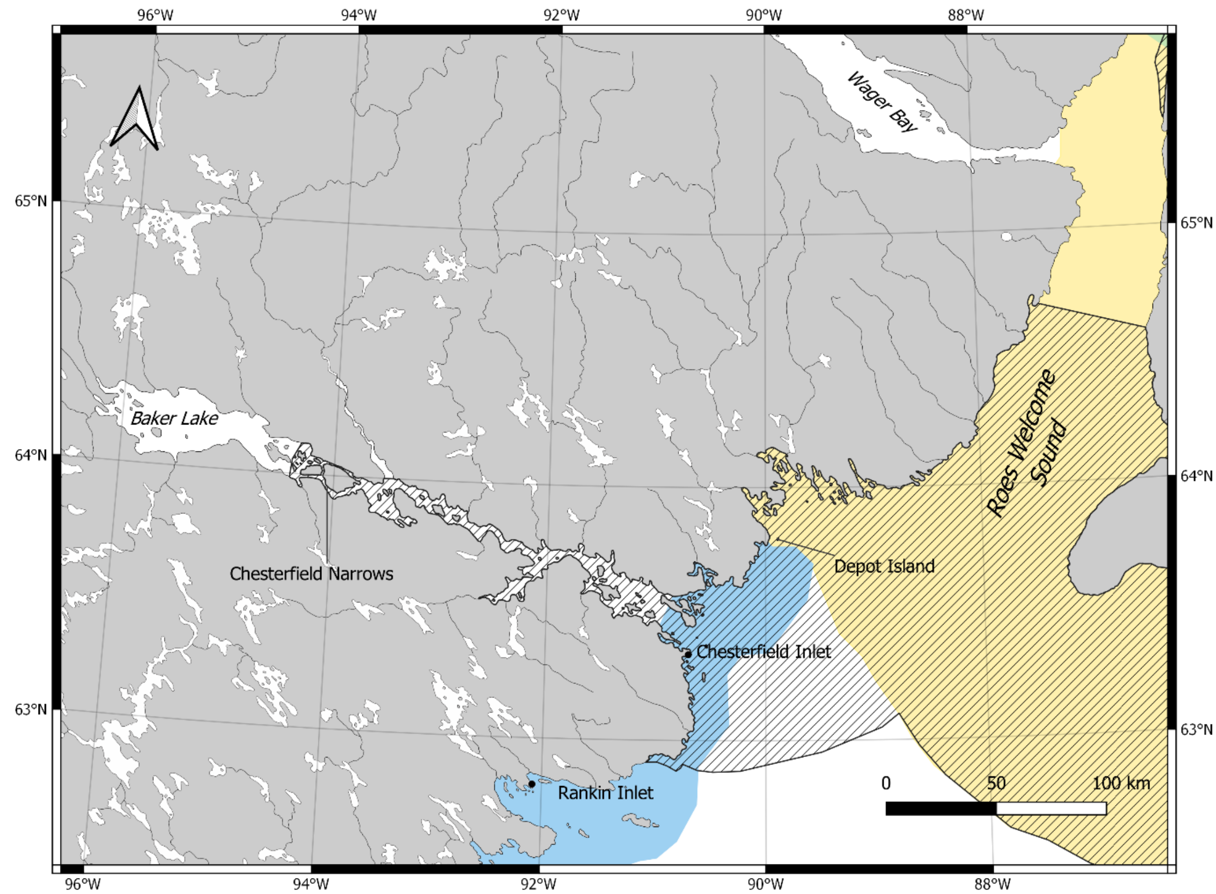

Figure 2. The northern portion of the WHBC EBSA (in close proximity to Chesterfield Inlet) that is part of the SI AOI. The WHBC (blue) and SI (yellow) EBSAs and the SI AOI boundary (black line and diagonal shading) are provided.

Frontal zone and winter shore leads: Coastal Polynya

The physical drivers that control and influence the formation of polynyas and flaw lead systems, also create conditions that support increased primary and zooplankton production (Arrigo and van Dijken 2004). As a result, a cascade effect in the food web occurs, supporting greater populations of upper trophic level species (e.g., marine mammals). Additionally, the presence of a polynya can alter both productivity and food web structure (Arrigo and van Dijken 2004). Landfast ice, and the associated frontal zones and winter shore leads, are known to extend from Churchill (Manitoba) to Roes Welcome Sound along the western side of Hudson Bay. Danielson (1971), Smith and Rigby (1981), Stirling et al. (1981), Markham (1986), and Stewart and Lockhart (2004) provide long-term evidence of an extensive landfast lead system off the west coast of Hudson Bay. A regional sea ice-ocean model developed by Saucier et al. (2004) showed a significant anomaly in salinity flux, ice production, and low mean sea ice concentration during winter months. It was hypothesized, and supported in principle, that the anomaly was dynamically forced by surface winds (Prinsenberg 1988, Gough and Allakverdova 1998, Gough et al. 2004, and Gunn 2014). Recently, Kirillov et al. (2020) showed that the cyclonic circulation and wind driven events impacted the west-east asymmetric sea ice thickness in Hudson Bay. The system is re-characterized as a coastal polynya based on the recurrence of lower sea ice thickness, concentration and extent, and surface wind forcing events.

From 2002–2011, the open water extent of the WHBC polynya has been 1,672 km^2 (mean) and 820.31 km^2 (median; Gunn 2014). Polynya formation events ranged in size from a minimum of 39.06 km^2 to a maximum extent of 13,867 km^2 on March 17, 2010 (Gunn 2014). Annual sea ice extent event maxima ranged from 4,726 km^2 (2008/2009) to 13,867 km^2 (2009/2010), indicating a significant amount of inter-annual variability (Figure 3 and Figure 4; Gunn 2014). The WHB coastal polynya is smaller in size than the three largest polynyas in the Arctic: Northeast Water, North Water, and Cape Bathurst (Arrigo and van Dijken 2004). At a local level, it is also smaller than the Roes Welcome Sound polynya (52 km^2; Loewen et al. 2020a) in the years that the WHBC polynya is at minimum extent. The Chesterfield Inlet region of the AOI sits within the northern portion of this coastal polynya (Figure 5).

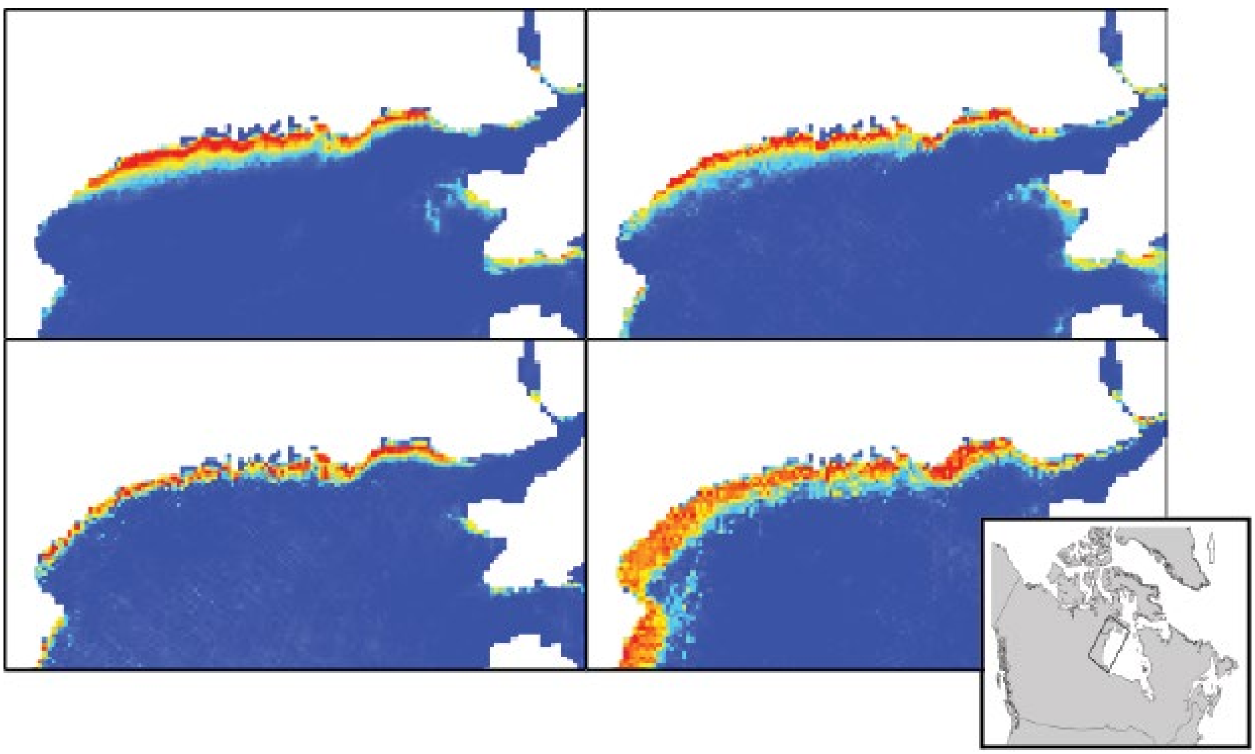

Figure 3. Sea ice concentration for January 26, 2004, January 16, 2005, February 11, 2006, and January 1, 2007, demonstrating examples of polynya maxima for the northwestern coast of Hudson Bay (Source: Gunn 2014). Deep blue represents 100%, aqua represents above 50%, yellow to orange represents below 50% and red colouration represents 0% sea ice concentration.

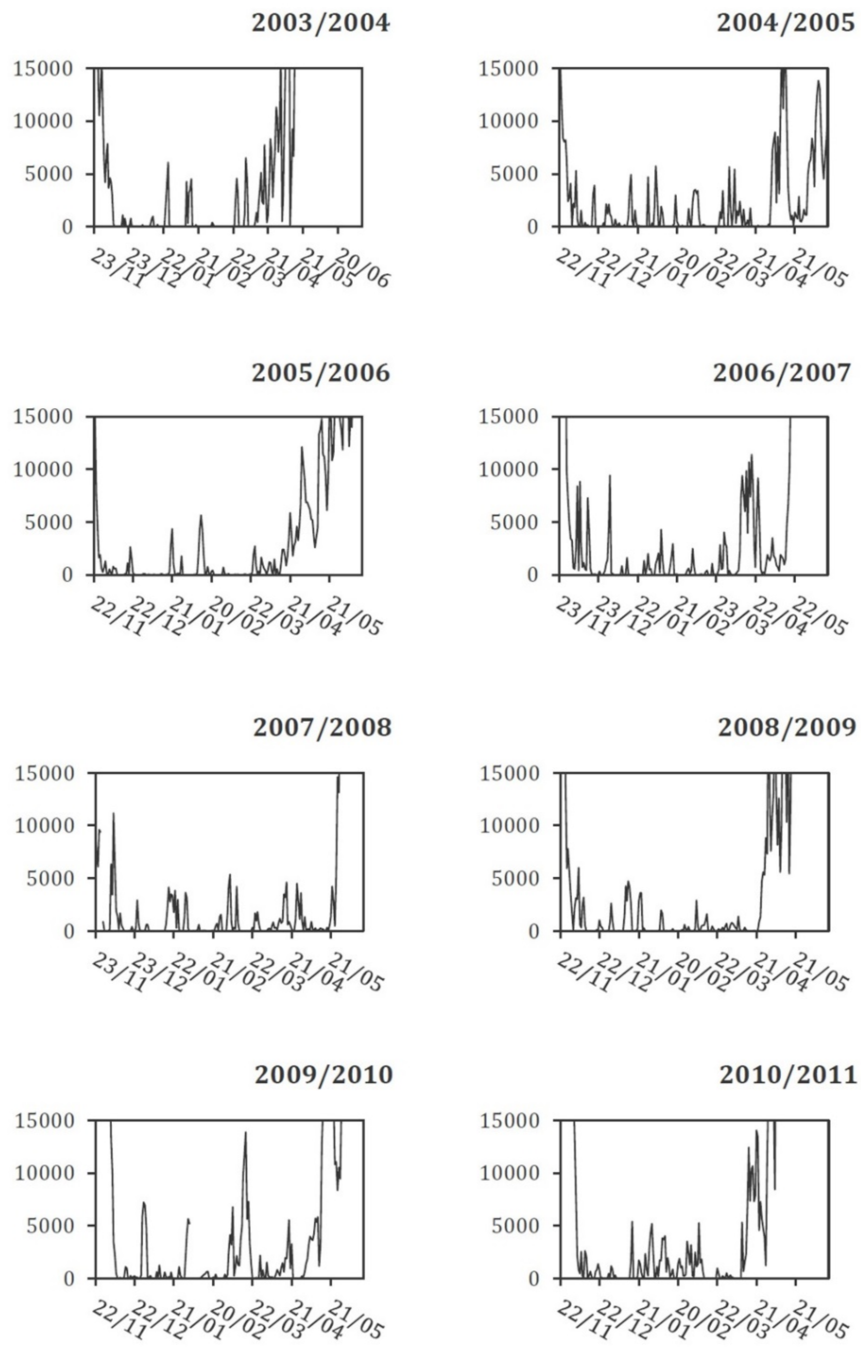

Figure 4. Sea ice extent for the northwestern Hudson Bay coastline extending from Churchill, MB, to the southern portion of Roes Welcome Sound, with date on the x-axis and area (km^2) on the y-axis (Source: Gunn 2014). Low sea ice extent in the winter months supports the presence of a coastal polynya.

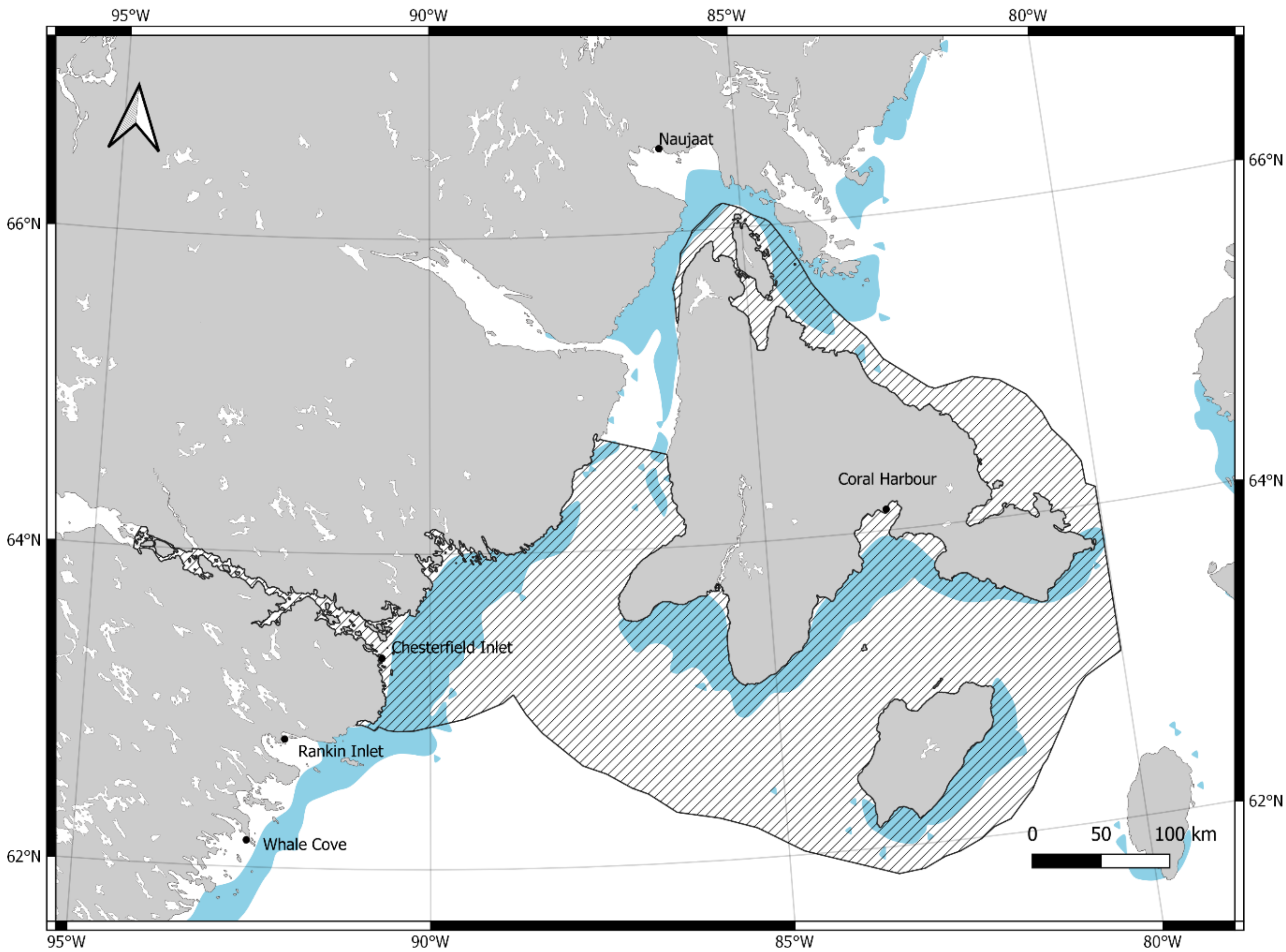

Figure 5. Polynya and flaw lead systems (blue) in the SI region (Data source: Roff et al. 2020), including the SI AOI boundary (black line and diagonal shading).

Macroalgae and Coastal Kelp Beds

Macroalgae and coastal kelp beds provide the basis of structural complexity in habitat formation for epibenthic species (Ordines et al. 2011). Fish are interlinked to this structural complexity and these benthic habitats to complete life processes (i.e., recruitment, feeding, growth, and reproduction; Ordines and Massutí 2009). A detailed summary of macroalgae and coastal kelp beds for the SI AOI region is provided in Loewen et al. (2020a,b). The Government of Nunavut (GN) (2008; Figure 6) identified macroalgae and coastal kelp areas near the mouth of Chesterfield Inlet and along the coast northward to Roes Welcome Sound. The SI Marine Ecosystem Project (SIMEP; Filbee-Dexter et al. 2019; Figure 7) provided preliminary analysis of macroalgae around SI (Figure 8). Macroalgae species identified were predominantly *Saccharina latissima, Saccharina longicruris, Agarum clathratum*, *Laminaria solidungula*, *Alaria esculenta*, and *Sacchorhiza dermatoda* (Figure 8). Depth played a significant role in kelp densities (i.e., kelp densities were highest between 15m and 20–30m depth) (SIMEP; Filbee-Dexter et al. 2019) and kelp forests were very dense in Roes Welcome Sound (15 m depth). Misuik and Aitken (2020) identified Hollow Stem Kelp (*Laminaria* sp.), Sea Colander (*A. clathratum*), and Coralline algae (*Clathomorphum* sp. and *Lithothamnion* sp.) in the Chesterfield Inlet portion of the SI AOI. A predictive model to determine suitable habitats/environments to support the presence of five macroalgae species: *A. clathratum*, *S. latissima*, *L. solidungula*, *A. esculenta*, and *L. digitata* was developed by J. Goldsmit (DFO Winnipeg, pers. comm.) (Figure 9; methods for developing the model are similar to Goldsmit et al. 2018). All five species of macroalgae are predicted to be present in the Chesterfield Inlet portion of the SI AOI. In addition, Idlout (2020) identified kelp beds along the coastline from Chesterfield Inlet past Depot Island to the mouth of Roes Welcome Sound. During the GenICE cruise (Figure 7) aboard the R/V William Kennedy (2019), researchers surveyed fauna with a benthic beam trawl. Preliminary analysis suggested that macroalgae were highly abundant and diverse (18.8 water salinity; 28–40 m depth) within Chesterfield Inlet proper to Baker Lake (C. Lavoie, Laval University, pers. comm.). Preliminary sample identification onboard the ship confirmed the presence of a number of macroalgae species (Figure 10) including: *S. latissima*, *A. esculenta*, *Fucus* sp., *Palmaria palmata*, *L. solidungula*, *S. dermatodea*, *A. clathratum*, and *Desmarestia aculeate*.

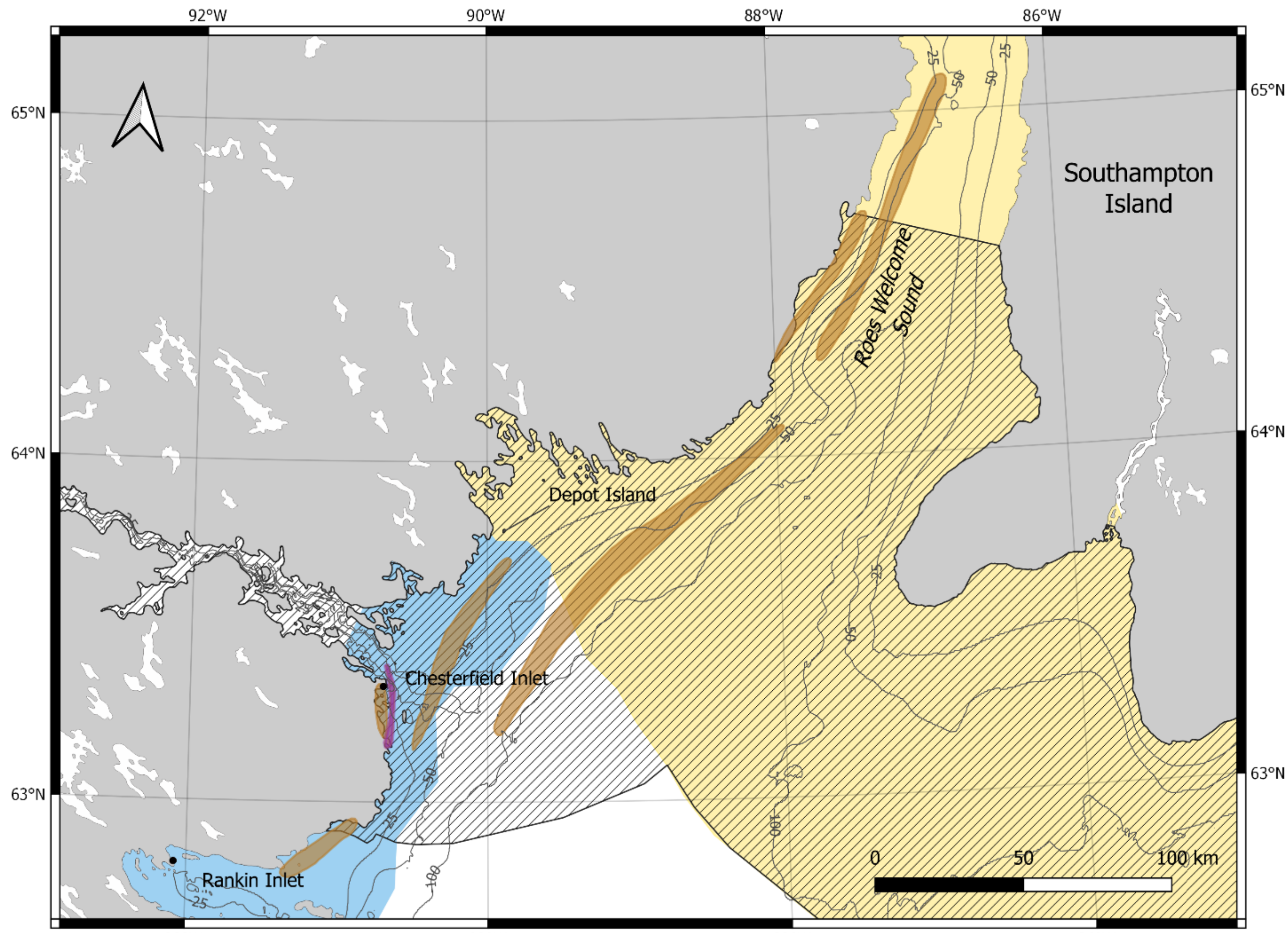

Figure 6. Macroalgae and coastal kelp beds identified for the Chesterfield Inlet region from the Nunavut Coastal Resource Inventory (Data source: GN 2008). The brown polygons represent Edible Kelp and Hollow Stemmed Kelp, the purple polygon represents Sea Colander, Bladder Wrack, and Rockweed. The WHBC (blue) and SI (yellow) EBSAs and the SI AOI boundary (black line and diagonal shading) are provided. Bathymetric contours were derived from the GEBCO Compilation Group (2019).

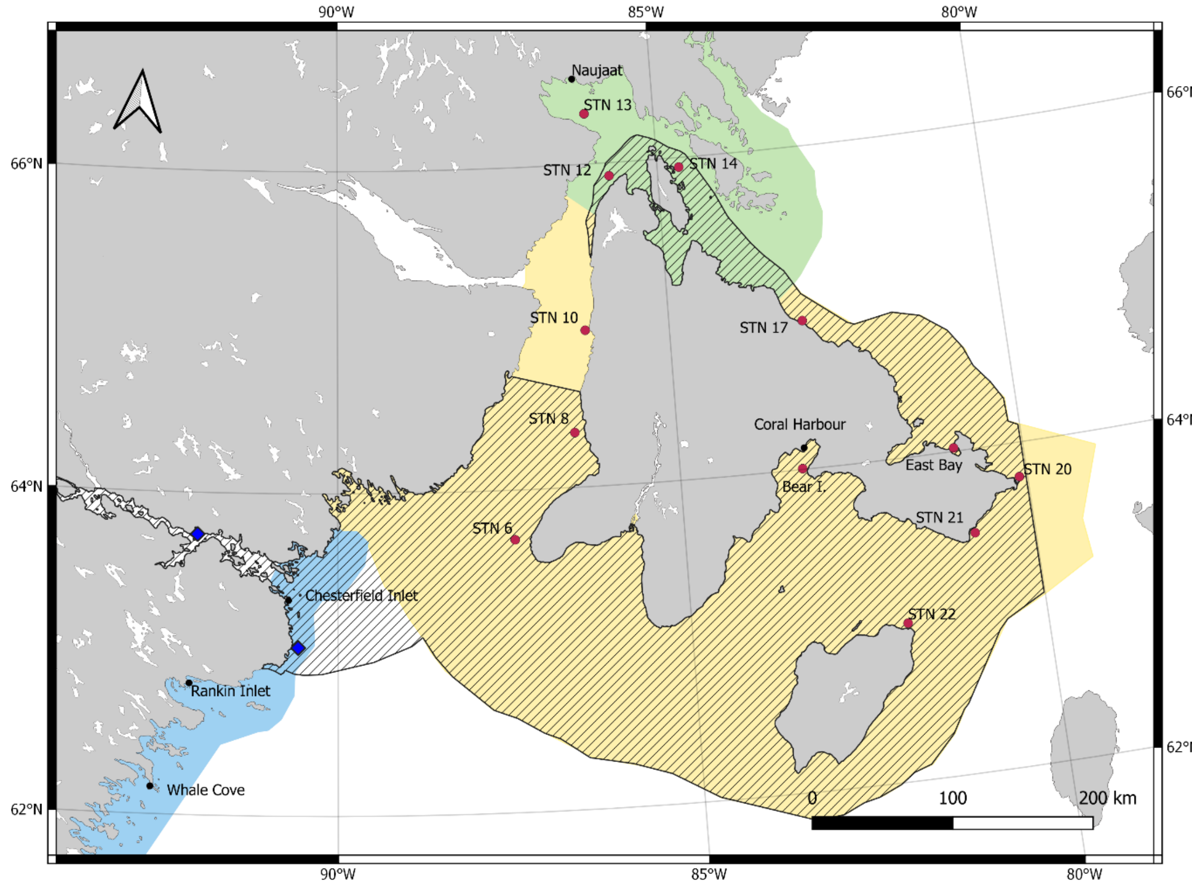

Figure 7. 2019 SIMEP (red circles) and GenICE (blue diamonds) macroalgae sampling stations for the SI region. The WHBC (blue), SI (yellow), RB/FS (green) EBSAs and the SI AOI boundary (black line and diagonal shading) are provided.

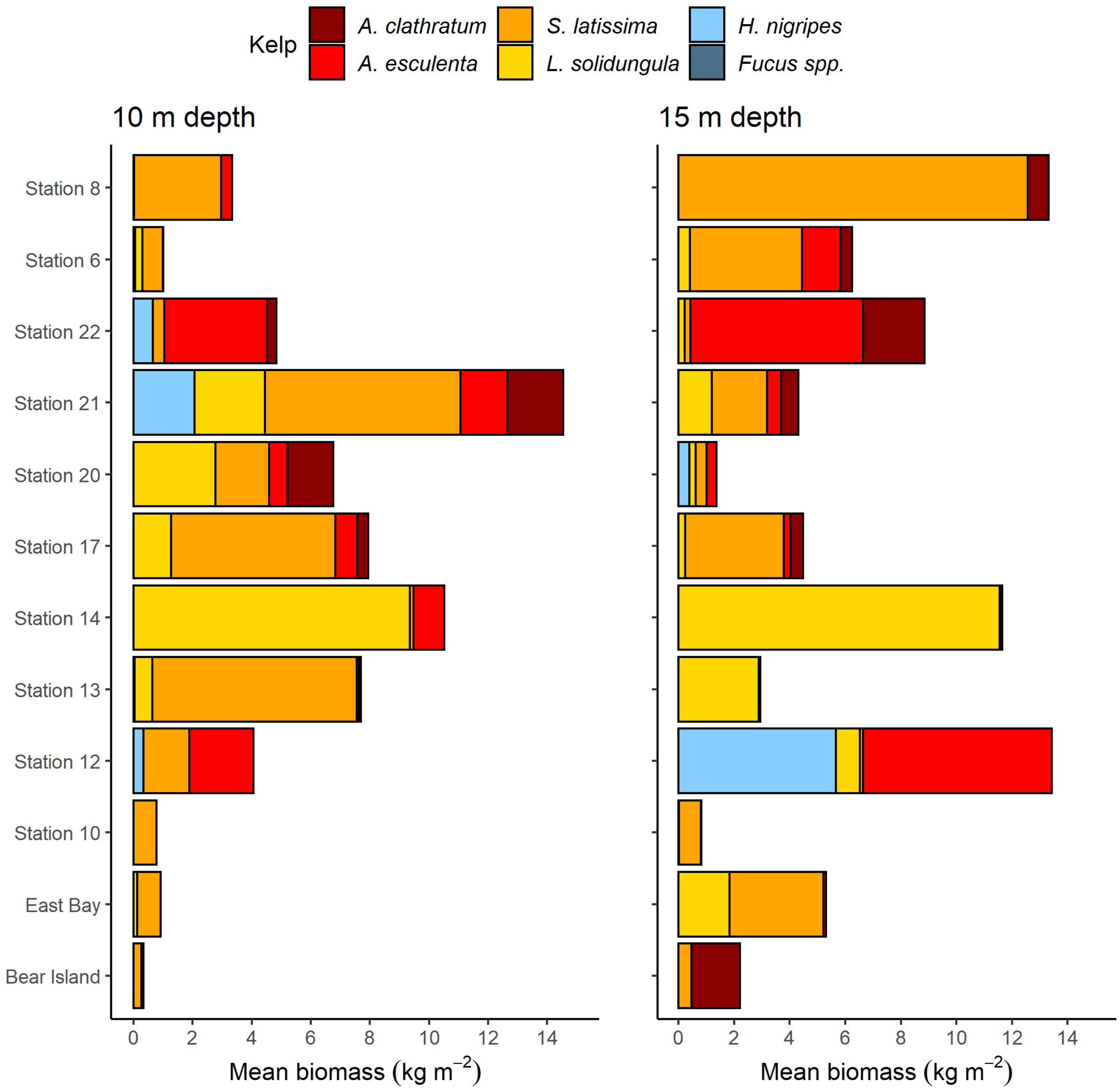

Figure 8. Mean biomass of kelp species in different sites around SI. Total bar length is total kelp cover or biomass (see Appendix 1 for details on methodology) (Figure credit: K. Filbee-Dexter, University of Western Australia).

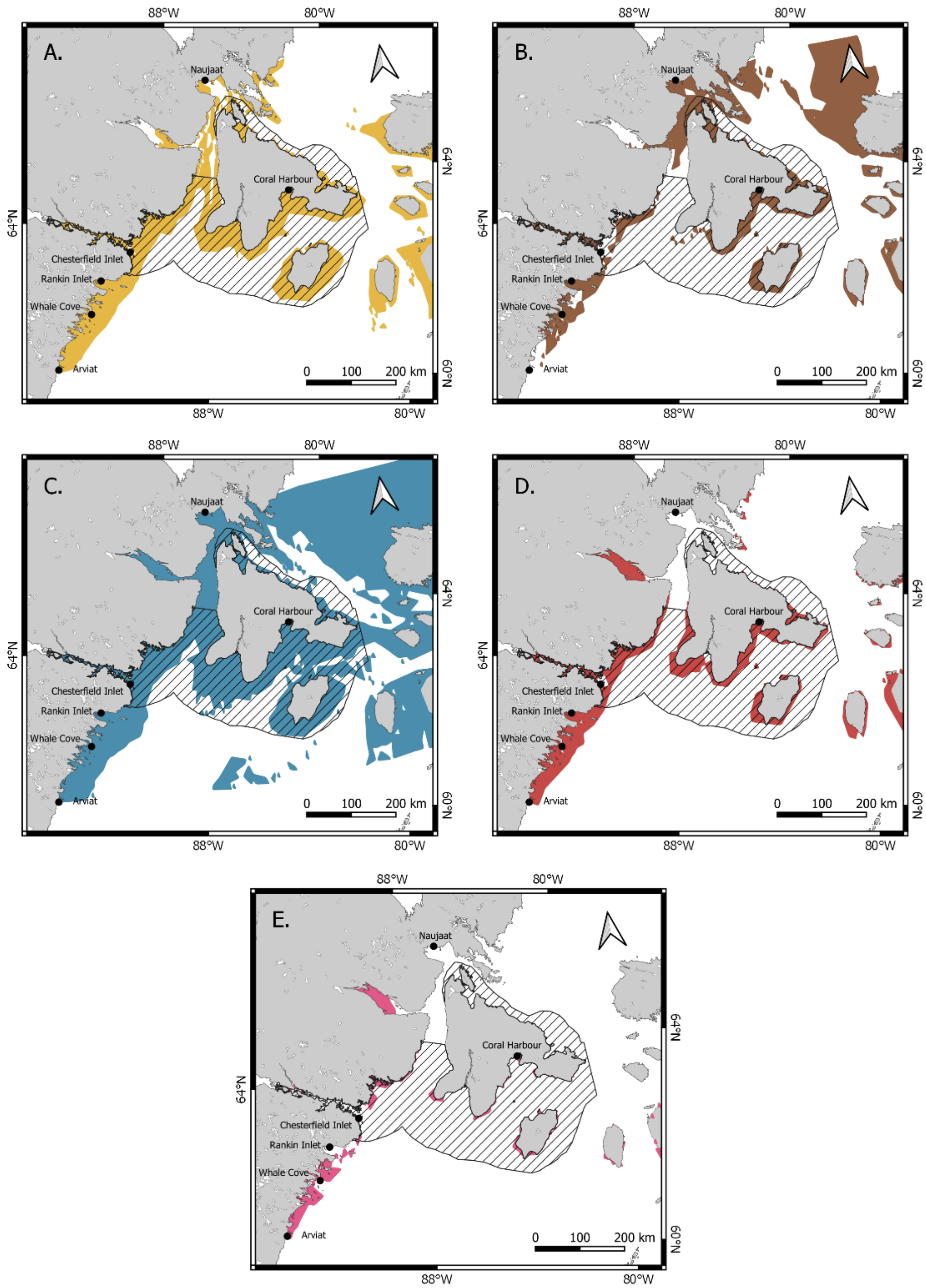

Figure 9. Predicted distribution of macroalgae species showing habitat suitability within the SI AOI and surrounding area where panel A. represents A. clathratum, B. represents S. latissimi, C. represents L. solidungula, D. represents A. esculenta, and E. represents L. digitata. The model was developed using Maximum Entropy to model species distribution. A threshold of maximum sensitivity and specificity was used to convert model results into binary predictions (suitable/not suitable). The complete methodology was based on the one shown in Goldsmit et al. (2018). Model development: J. Goldsmit, DFO Winnipeg.

Figure 10. A photo of macroalgae collected on the (2019) GenICE Cruise. Species present in the photograph are as follows: Fucus sp., L. solidungula, S. latissima, A. esculenta, P. palmate, and S. dermatodea (Photo Credit: C. Lavoie, Laval University).

Arctic Char Migration Corridor and Marine Feeding Region

Anadromous Arctic Char are distributed throughout the SI AOI during the summer months for marine feeding and migrations between important foraging areas. Despite past and present fishing activity in the region, there are no updated scientific data available for char along the WHB coastline (including Chesterfield Inlet); however, models developed by Roff et al. (2020) predict extensive use of coastlines within the SI AOI. This is consistent with research on Arctic Char in other regions of Nunavut that highlights the importance of coastal areas for marine foraging and travel between feeding areas (Moore et al. 2016). It is almost certain that Arctic Char in the region use estuaries extensively for foraging, and as transition zones for acclimation between fresh- and saltwater environments (Spares et al. 2015, Moore et al. 2016, Harris et al. 2020a). Within these areas, Arctic Char are likely to predominantly use the top 3–5 m of the water column, while undertaking sporadic foraging dives to deeper water habitats (Harris et al. 2020a). Loewen et al. (2020a) summarized distribution, historical tagging, and scientific publications for char within the region. Numerous rivers within Chesterfield Inlet proper appear to support movements of anadromous char from freshwater to marine feeding areas based on subsistence and commercial harvesting activities in the region (Figure 11; GN 2008, Coad and Reist 2018; DFO unpublished data). These freshwater systems are likely used for overwintering, rearing of young and reproduction within the region and drain directly into the SI AOI. Past fisheries (late 1980’s and 1990’s) in Uvajuq, Akuq, Qimatujuarvik, Qasigiarsiurvik and Sungaarnarsivik rivers had large catches (25,000 lbs of fish all locations combined), however, these large numbers are no longer observed in the present day (Idlout 2020). No research has been done to assess the reason for the decline in fish catch (i.e., overharvest and/or other anthropogenic impacts and/or climate change).

Chesterfield Inlet's commercial fishery (Schedule 5 of the Northwest Territories Fishery Regulations: varied quota 4,500 kg) takes place in Fish Bay, with gillnets being set along the east and west sides of the inlet. Arctic Char biomass and population numbers have not been assessed, and little is known about char in this region (both abundance and life history). Fish abundance estimates are available from two nearby rivers south of the AOI near Rankin Inlet, NU. Weir estimates for the Diana River and Meliadine River recorded 69,405 and 1,210 fish from August-September 1986 and August-September 1990 respectively (McGowan 1987, 1992). Community members have reported a decline in the ability to capture char from Fish Bay (Idlout 2020). In 2018, Kivalliq Arctic Foods processed 9,000 lbs. of char from the WHBC EBSA harvested by community members (A. Finley, DFO Winnipeg, pers. comm.). In 2019, 7000 lbs. of Arctic Char were commercially harvested from the communities of Whale Cove, Rankin Inlet, and Chesterfield Inlet (L.N. Harris, DFO Winnipeg, pers. comm.). The majority of the char sold to Kivalliq Arctic Foods over the past couple of years have had a whiter coloured flesh, which makes the fish less marketable (A. Finley, DFO Winnipeg, pers. comm.). The Nunavut Wildlife Harvest Study (Priest and Usher 2004) reports a five year (1997–2001) average of 2,481 Arctic Char taken for subsistence purposes annually for the community of Chesterfield Inlet. Winter fishing in Chesterfield Inlet occurs at Josephine Lake during November and December, and summer fishing starts mid-July and continues until early September (A. Finley, DFO Winnipeg, pers. comm.). The majority of subsistence fishing occurs during the fall upstream run near Josephine River (A. Finley, DFO Winnipeg, pers. comm.).

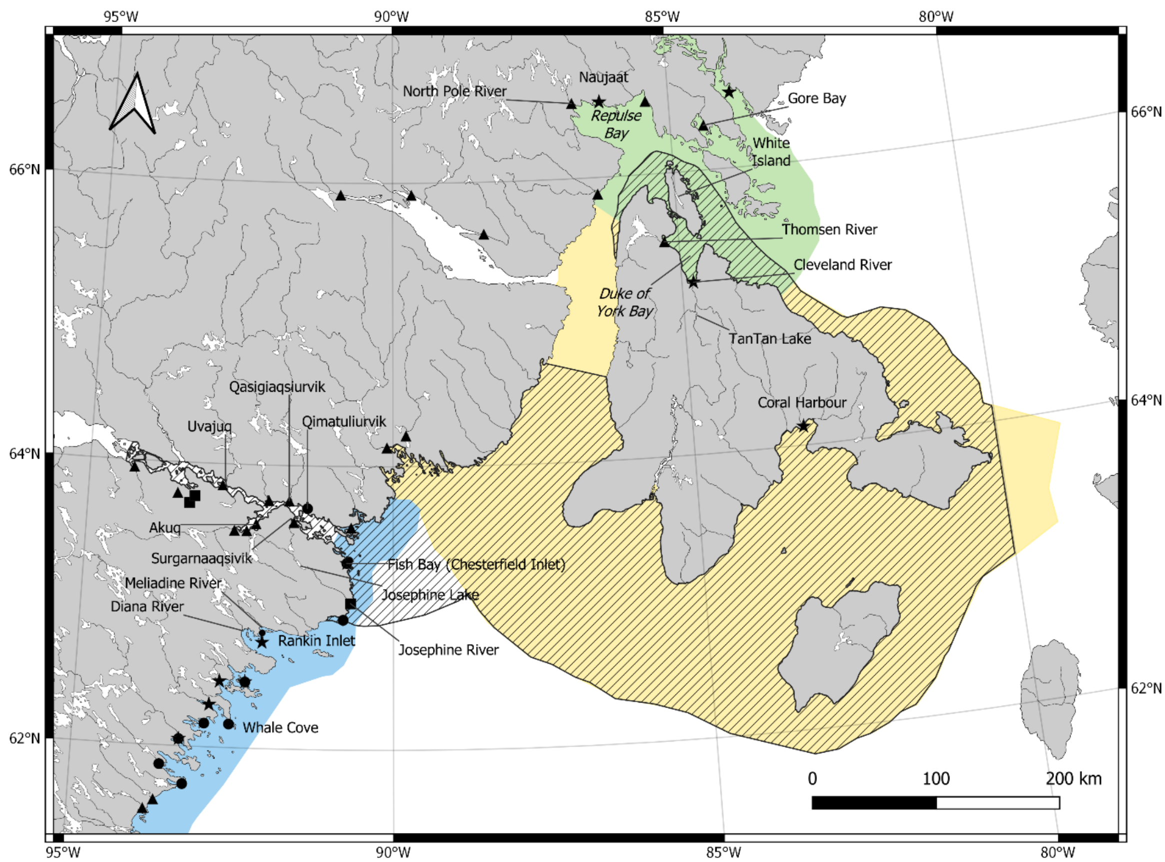

Figure 11. Arctic Char commercial and test fishing locations in the vicinity of the WHBC EBSA, the RB/FS EBSA, and the SI EBSA (squares represent the timeframe of the 1980's, triangles represent the timeframe of the 1990's, circles represent the timeframe of the 2000's, and stars represent the timeframe of the 2010's) from the DFO Fisheries Management and Harvest Information System (FMHIS) database.

Beluga Aggregation Area

Beluga found within the SI AOI belong to the Western Hudson Bay (WHB) population. A detailed summary of population numbers, seasonal habitat use, and migratory pathways for the SI AOI is provided in Loewen et al. 2020a. Beluga in the Chesterfield Inlet portion of the AOI (within and outside the mouth of Chesterfield Inlet) are present from April to November during the floe edge and open water season (Idlout 2020). They are thought to enter Chesterfield Inlet and feed all the way from the estuarine portion of the inlet towards Baker Lake during the summer months (Idlout 2020). During this time, Beluga are thought to feed on squid and cod (Idlout 2020). More common southern fish species, such as Capelin, have started shifting their distribution northward with increasing temperatures (Rose 2005). As a result, a diet shift from Arctic Cod to Capelin (*Mallotus villosus*) occurred for the WHB Belugas in the 1980's (Kelley et al. 2010). A nursery calving area is thought to occur within Roes Welcome Sound along the southwestern shore of SI (Idlout 2020). No new scientific information for the WHB Belugas has been made available since Loewen et al. (2020a).

Polar Bear Migration

Polar Bears found within the SI AOI predominantly belong to the Foxe Basin population. The Chesterfield Inlet portion of the AOI sits in a zone where Foxe Basin, Hudson Strait, and Western Hudson Bay Polar Bear populations may converge and inter-mix during the winter/spring months while bears are on the sea ice. During the ice-free season, the bears stay within territories on land (Peacock 2010). A detailed summary of the Foxe Basin Polar Bear population numbers, seasonal habitat use, and migratory pathways for the SI AOI is provided in Loewen et al. (2020a). Denning locations in the Chesterfield Inlet portion of the AOI have been documented and compiled from past studies along the northwestern coastal area towards Wager Bay (Florko et al. 2020; Figure 12). The mouth of the inlet, extending north along the coast has been identified as an important summering area for Polar Bears (GN 2008), as well as a spring and winter season hotspot (Yurkowski et al. 2019).

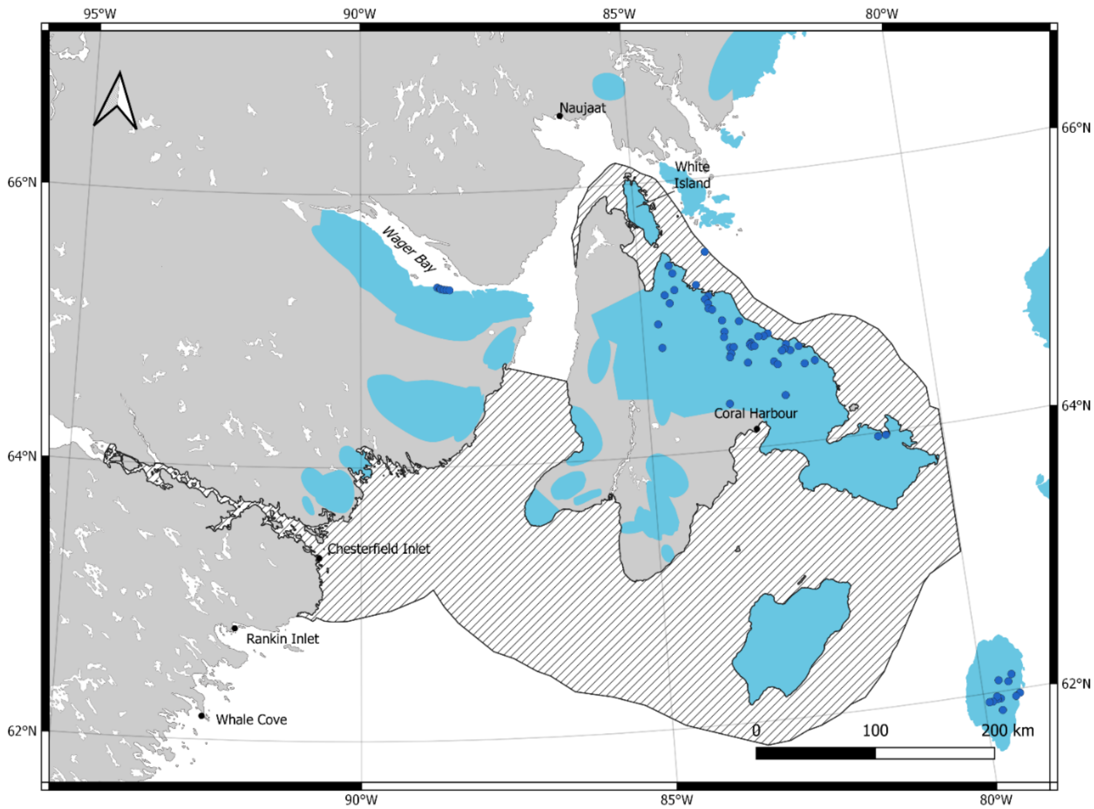

Figure 12. Polar Bear denning locations for the SI AOI (black line and diagonal shading) identified by dark blue circles and light blue shaded areas. (Data source: Florko et al. 2020 and Roff et al. 2020).

New Information and Data to support the WHBC EBSA

Oceanography and River Inputs for the Chesterfield Inlet

New and unpublished oceanographic and river input data are available from the 2019 GenICE Cruise and the 2016 Nuliajuk Cruise for the Chesterfield Inlet region of the SI AOI. While sea ice meltwater is believed to be the primary contributor of freshwater around SI, Chesterfield Inlet delivers a major source of riverine freshwater to the coastal domain waters circulating counterclockwise around Hudson Bay. With a watershed area of 287,100 km^2, this long (200 km) narrow inlet connects Baker Lake to western Hudson Bay and has numerous rivers delivering freshwater to the inlet along its length (Figure 2). In general, the water structure of the Inlet is estuarine with a fresher surface layer flowing seaward (eastward) and saline bottom water flowing landward (westward) during summer months (Figure 13). In summer months (July–September), the water column is vertically stratified, particularly near the mouth of the Inlet, where a halocline at approximate 10–20 m separates the outward-flowing fresh surface water from the deep, saline (32.5 psu) bottom waters entering Chesterfield Inlet from Hudson Bay. Near the head of the Inlet, surface water salinity is freshest at approximately 14 psu during summer, while near the mouth of the Inlet surface salinities are greater at 22.5 psu during summer, reflecting entrainment and mixing of bottom saline water to the surface (Figure 13). During spring (April–June), limited Conductivity-Temperature-Depth (CTD) profiles show surface waters near the mouth of Chesterfield Inlet are more saline (31 psu) than during summer, while the halocline is less pronounced but still present at about 30 m water depth (Figure 14). Bottom water salinity during winter (January–March) is similar to summer at approximately 32.2 psu.

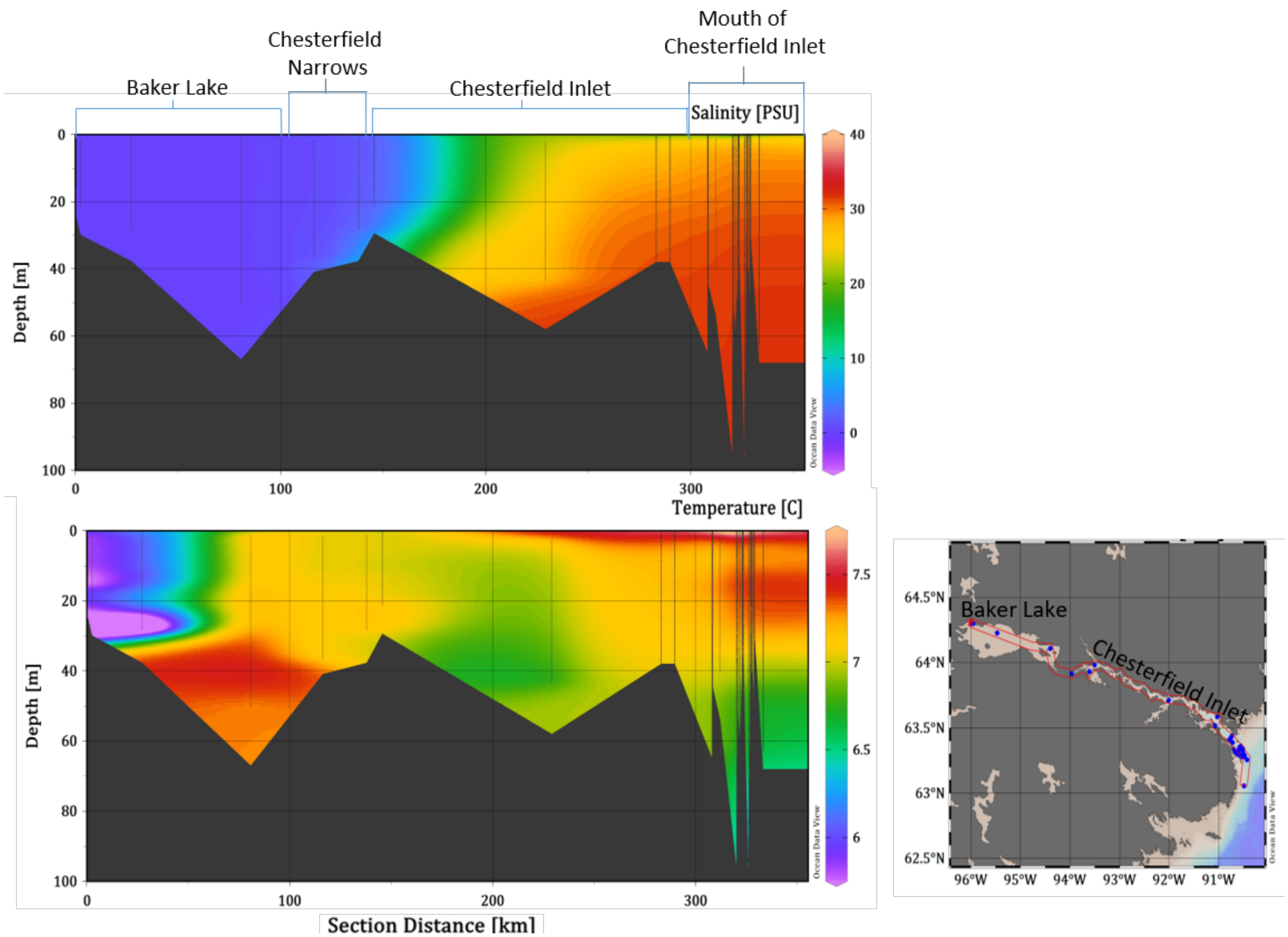

Figure 13. Salinity and temperature profiles along the length of Baker Lake and Chesterfield Inlet collected from the GenICE cruise in September 2019 and the Nuliajuk cruise in August 2016 (near the mouth of the Inlet only). (Figure credit: P. Calabria Carvalho and M. Kamula, University of Manitoba).

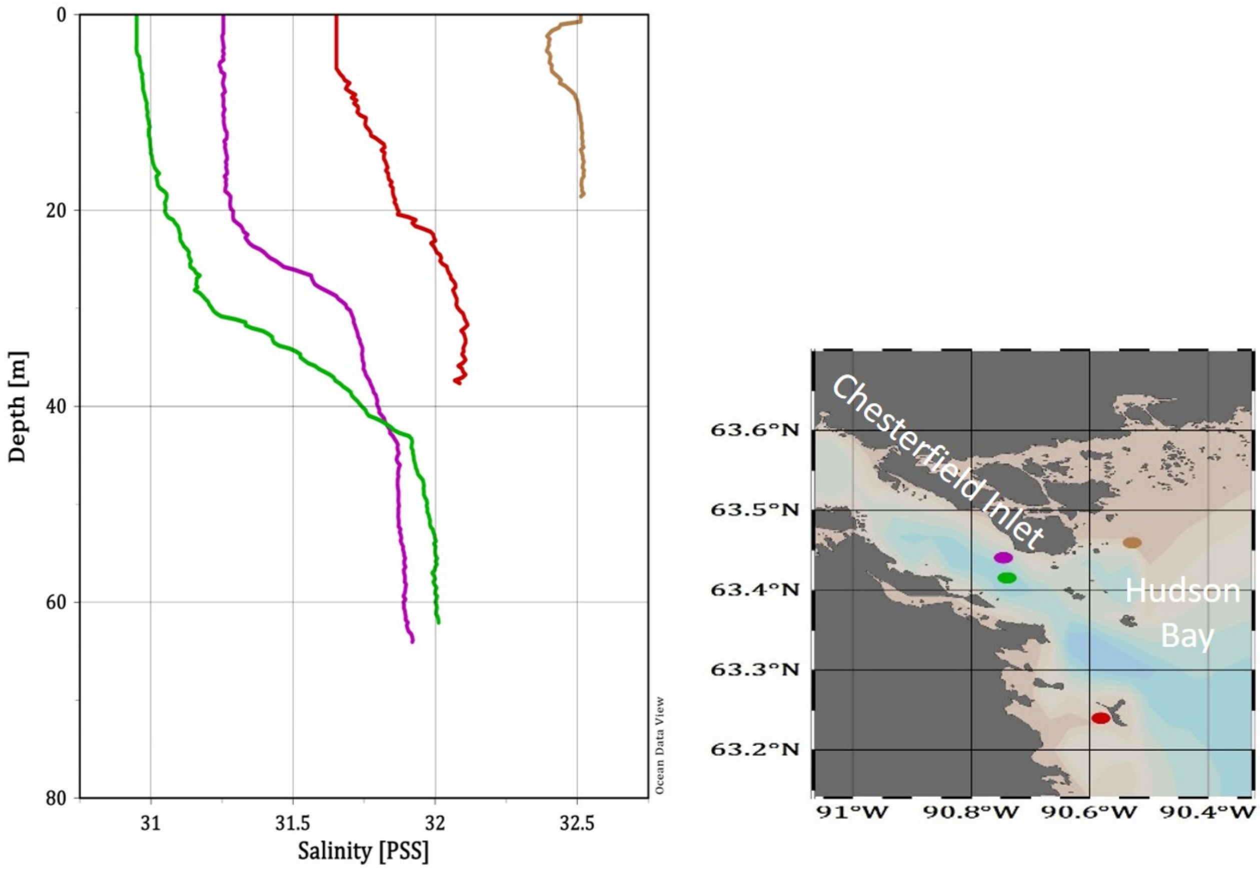

Figure 14. Salinity profiles from CTD measurements near the mouth of Chesterfield Inlet in May 2018 (Figure credit: P. Calabria Carvalho and M. Kamula, University of Manitoba).

Water mass properties around of the SI AOI

The relationship between salinity and the oxygen isotope ratio ($\delta^{18}O$) of seawater has been used in high latitude seas for decades to trace the distribution of sea ice brine and meltwater as well as meteoric water (i.e., precipitation and runoff) (cf., Tan and Strain, 1996 and references within). To better understand sources and distribution of sea ice melt water, river runoff, and brine within the context of ongoing climate change, University of Manitoba researchers have been collecting coastal water samples, and measuring $\delta^{18}O$ and salinity throughout the SI AOI, including Chesterfield Inlet and adjacent waters (e.g., Wager Bay – Ukkusiksalik National Park), since 2016. Similar to CTD profiles, $\delta^{18}O$ signatures in relation to salinity show discrete water mass properties in northwestern Hudson Bay and Foxe Basin (M. Kamula, University of Manitoba, pers. comm.). In general, surface summer waters along the northwestern side of SI in Foxe Basin are freshened (~ 28 psu), while still maintaining an enriched $\delta^{18}O$ signature, pointing to the presence of sea ice meltwater (M. Kamula, University of Manitoba, pers. comm.). As this water flows through Frozen Strait, vertical mixing dilutes the sea ice meltwater signal, making the summer subsurface waters in Repulse Bay dense and cold. During winter months, $\delta^{18}O$ and salinity within Repulse Bay in 2018 and 2019 were greater than anywhere in the region, suggesting that brine production and/or convection of waters from Foxe Basin during winter months may be an important process for bottom water formation within the SI AOI. Wager Bay, which is another large deep bay (> 250 m) similar to Repulse Bay, may be another important area for bottom water formation as indicated by similarly high salinity and $\delta^{18}O$ signatures within its bottom waters (M. Kamula, University of Manitoba, pers. comm.). The waters from Wager Bay become highly mixed as they travel through Wager Bay Narrows and Roes Welcome Sound. Unlike waters from further north in Repulse Bay and Wager Bay, the $\delta^{18}O$ signature and salinity at the mouth of Chesterfield Inlet are more negative and less saline, respectively, suggesting a greater input of riverine freshwater (M. Kamula, University of Manitoba, pers. comm.).

The main conduits for waters from the Canadian Arctic Archipelago to the Hudson Bay system are Fury and Hecla Strait (located north of Foxe Strait), directly upstream of SI. The prevailing circulation in Hudson Bay is counter-clockwise, thus these waters are of higher salinity relative to southerly coastal waters which mix with river water along the west and southern coast of the bay. The biogeochemistry of waters around SI are not well represented in published studies to date. However, studies by Azetsu-Scott et al. (2014) and Burt et al. (2016), using data from 2005 and 2010 respectively, show that with a few notable exceptions, the distribution of pH and other carbonate parameters in surface waters generally mimic the distribution of freshwater, with maximum in the high-salinity waters of Hudson and Foxe straits. This includes calcium carbonate saturation states (W) that were also found to be well correlated with salinity (Azetsu-Scott 2014), and well above 1 (supersaturated) in the high-salinity waters of northwestern Hudson Bay. The saturation state for aragonite (W_{Ar}), while high (well in excess of 1) in the northwest, decreased along the southern coast due to the dilution of both TA and DIC by freshwater input. In subsurface waters, W_{Ar} horizon shoals to within 60–70 m in the northwest coast, and these waters, although with values of $W_{Ar} < 1$, were observed to be only slightly undersaturated. Without direct measurements from the region directly surrounding SI we can only speculate the carbonate system in those waters was similar to waters sampled in northwest Hudson Bay, directly to the south of the area of interest. Analysis of data from the BaySys (Hudson Bay System Study) and SIMEP cruises (both in 2018; the latter directly in waters surrounding SI), will confirm the contemporary state of ocean acidification in the SI region. Note, the surface distributions of carbonate parameters throughout the Hudson Bay system were similar between 2005 and 2010, with some minor differences that were attributed to the seasonality (Burt et al. 2016), however, as noted by the authors, with only two such datasets taken at slightly different times of the year, more information is required to make conclusive statements regarding acidification rates in this region. Continued monitoring is important as cold Arctic waters are particularly susceptible to the ocean acidification owing largely to the prevalence of freshwater that is typically poorer at buffering a change in pH in response to increased levels of dissolved CO2 relative to seawater.

Roes Welcome Sound Ice Bridge

Roes Welcome Sound is a narrow channel in northwestern Hudson Bay that separates SI from mainland Kivalliq, and connects Foxe Basin to Hudson Bay (Figure 15). The area is seasonally covered by sea ice from October through June or July. Typically, there is a thin band of landfast sea ice along both sides of the Sound and a mobile ice cover that drifts through the middle of the Sound. The mobile pack ice is forced by wind and currents, and is periodically flushed out of the Sound into Hudson Bay, creating a polynya. Community members from Coral Harbour, Naujaat, and Chesterfield Inlet have shared their knowledge of an ice arch that forms approximately every four years across the Sound during winter (David Babb, University of Manitoba, pers. comm.). The arch connects SI to the mainland just south of the outlet to the Wager Bay narrows (Figure 15). Ice arches are unique features that form in narrow channels when a mobile ice cover converges. Typically ice arches are studied for their role in the creation of polynyas downstream (e.g., the ice arch in Nares Strait that forms the North Water Polynya), and while the Roes Welcome Sound ice arch does contribute to the formation of a polynya to its south, it provides a stable connection for human travel and hunting (e.g., caribou on the mainland; DFO 2020b). Researchers from the University of Manitoba have used archived satellite images to determine that the ice arch has formed during 12 winters since 1971, or approximately 24% of the time. They are also currently studying the conditions that foster the formation of this unique feature of the Hudson Bay icescape and what continued warming and further reductions in the regional ice cover may mean for the arch and polynya formation.

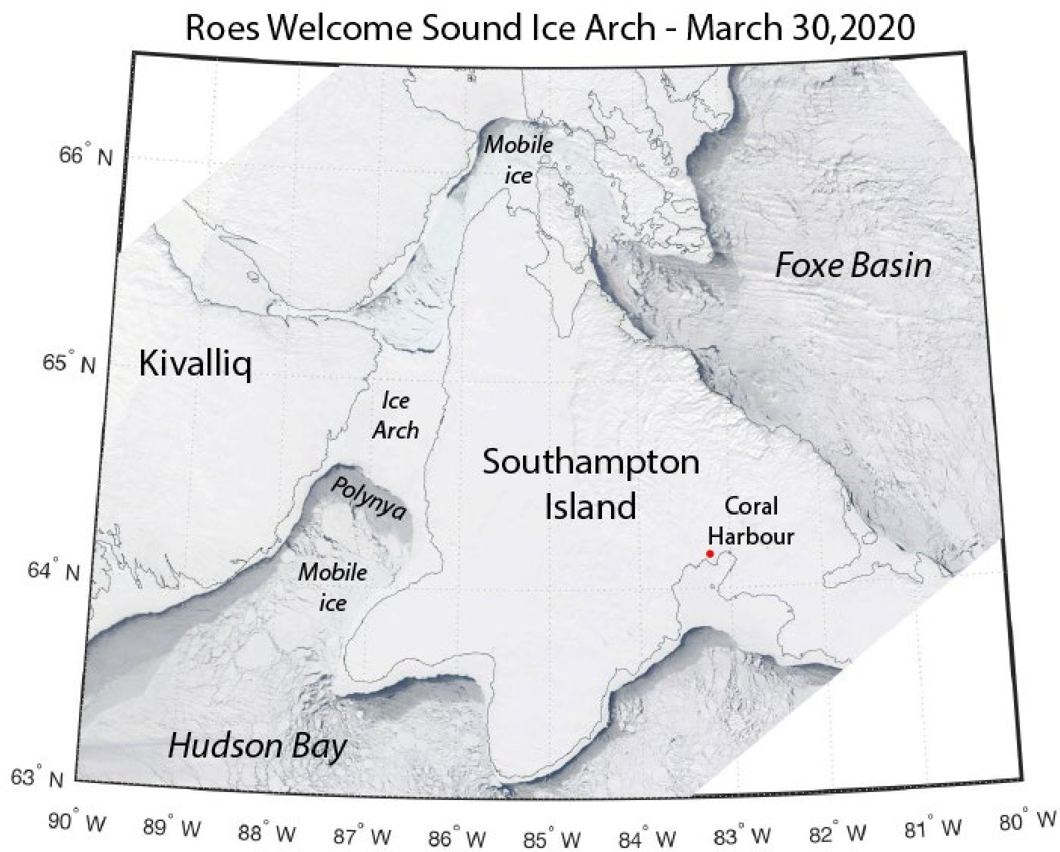

Figure 15. MODIS image of the area surrounding Roes Welcome Sound on March 30, 2020, showing the ice arch between SI and mainland Kivalliq (Figure credit: David Babb, University of Manitoba).

Bathymetry and Benthic Substrates

Bathymetry and benthic habitat mapping was completed for regions near Chesterfield Inlet in 2016 (Figure 16; Misiuk and Aitken, 2020). A deeper trough is present running northwest into the Inlet and southeast away from the Inlet (Figure 16). Sediment with rock was the most common substrate and occurred in shallow areas and close to shore. Fine and mixed sediment occurred in deep waters to the east of Chesterfield Inlet and continued northwest into the inlet. Ungraded shell hash and shell hash (indicative of live mollusk populations) with rock occurred sporadically in deeper waters. Coarse sediment was infrequently observed.

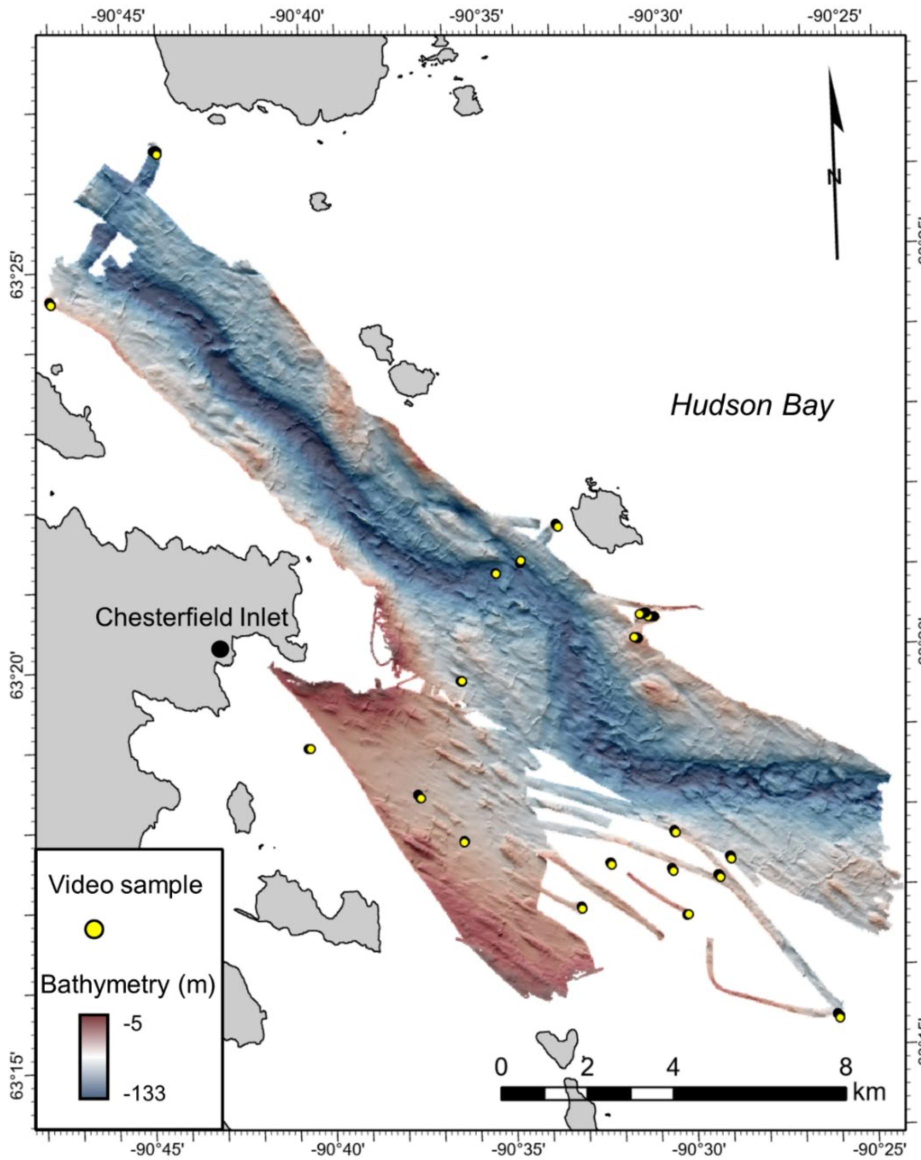

Figure 16. Bathymetric map in and around Chesterfield Inlet (Source: Misiuk and Aitken 2020).

Benthic Communities

A detailed summary of macro and epibenthic communities was reported for the general SI AOI region and can be found in Loewen et al. (2020a,b). Misuik and Aitken (2020) identified sea anemones, soft corals (*Gersemia rubiformis*), barnacles (*Balanus* sp.), Toad Crab (*Hyas coarctatus*), sponges, Basket Stars (*Gorgonocephalus* sp), Brittle Stars, Polar Sea Star (*Leptasterias polaris*), Sea Urchin (*Strongylocentrotus droebachiensis*), Arctic Saxicave (*Hiatella arctica*), Cockle (*Ciliatocardium ciliatum*), Scallops (*Chlamys islandica*), and Truncate Soft-Shelled Clam (*Mya truncata*) in video-analysis of sampling stations. Additionally the SIMEP program (Filbee-Dexter et al. 2019) noted the presence of seastars, brittle stars, gastropods, isopods, small crustaceans, anemones, large concentrations of mysid shrimps (an important food source for pelagic predators), and very low abundance of sea urchins in association to kelp forests. Epiphyte cover on kelp was also low and consisted of bryozoans, gastropod eggs, and small mussels (< 1cm).

Six fine scale habitats (or benthoscapes) were characterized near Chesterfield Inlet based on high resolution environmental data (Figure 17; Misiuk and Aitken 2020): 1) Muddy sand (mS) commonly contained brittle stars, but otherwise exhibited low epifaunal diversity, 2) Muddy sand with rock and shell hash (mS-R-Sh) occurred proximal to mS, and also exhibited relatively low biodiversity, but with a more mixed substrate, 3) Coralline-encrusted rocks with gravel, shell hash, and the brown algae *Agarum clathratum* (corR-G-Sh-ag) was characterized by algae-encrusted rocks surrounded by a coarser gravel matrix and large shells, with a more diverse assemblage of epifauna, including sea anemones, 4) Coralline-encrusted rocks with sand and large brittle stars (corR-S-bs) was fairly similar to corR-G-Sh-ag, but with a finer sediment matrix surrounding algae-encrusted rocks and large brittle stars (c.f., *Ophiopholis aculeata*) with outstretched arms that were exclusive to, and characteristic of, these sites, 5) Shell hash with mud (Sh-M) was observed at only one location, but was distinct from the other habitats, with a low diversity of visible epifauna, and; 6) Shell hash matrix (rock, gravel, and scallops; Sh-R-G-sc) was the most commonly observed, and was easily identifiable in deep water by dense scallop beds in a predominately shell hash matrix. Further, Misiuk and Edinger (2017) developed a model that predicted scallop (*Chlamys islandica*) presence. They were most likely to occur (> 90%) in patches in the deep trough oriented northwest-southeast to the east of Chesterfield Inlet at depths > 40 m.

Five stations in the Chesterfield Inlet region of the AOI were sampled to characterize epifaunal and infaunal communities (two near the mouth of Chesterfield Inlet, one south of the inlet away from the coast and two north of the inlet near the mouth of Roes Welcome Sound; Figure 18; Pierrejean et al. 2020). The station closest to the mouth had low epifaunal biomass (0.02–1 g m^{-2}), epifaunal density (1–5 ind. m^{-2}) and epifaunal taxonomic richness (5–10 taxa). It was mainly composed of amphipods (e.g., *Gammarellus homari*) and gastropods (e.g., *Margarites helicinius*). A second sampling station near the mouth of Chesterfield Inlet had high epifaunal biomass (10–45.2 g m^{-2}) and low epifaunal density (1–5 ind. m^{-2}), and intermediate taxonomic richness (20–40). In contrast, this station presented high infaunal biomass (200–1025 g m^{-2}), density (200–6240 ind. m^{-2}) and taxonomic richness (35–74 taxa). This station showed high proportion of brittle stars (*Ophiopholis aculeata*), soft corals (*Duva florida*), polychaetes (e.g., *Micronephthys minuta*) and bivalves (*Mya truncata* and *Macoma calcarea*), and intermediate proportion of sea urchins (*Strongylocentrotus* sp.), crinoids (*Heliometra glacialis*) and basket star (*Gorgonocephalus arcticus*).The most offshore station, north of Chesterfield Inlet, had low epifaunal biomass (10–45.2 g m^{-2}) and density (1–5 ind. m^{-2}) and intermediate epifaunal taxonomic richness (20–40 taxa). Infaunal community showed intermediate biomass (60–200 g m^{-2}), density (1,000–2,000 ind. m^{-2}) and taxonomic richness (25–35 taxa). This station was mainly composed of brittle stars (*Ophiura sarsii, Amphipholis squamata and Ophiopholis aculeata)* and Scarlet Sea Cucumber (*Psolus fabricii*). The sampling station south of the mouth of Chesterfield Inlet (sitting outside the SI AOI) had high epifaunal biomass (10–45.2 g m^{-2}), epifaunal density (10–29.5 ind. m^{-2}), and epifaunal taxonomic richness (40–71). In contrast, infaunal community showed intermediate biomass (60–200 g m^{-2}), low density (200–1000 ind. m^{-2}) and taxa richness (15–25 taxa). This station was mainly composed of brittle stars (*Ophiura sarsii*), molluscs (*Yoldia amygdalea, Hiatella arctica* and *Musculus niger*) and arthropods (*Paratryphosites abyssi*).

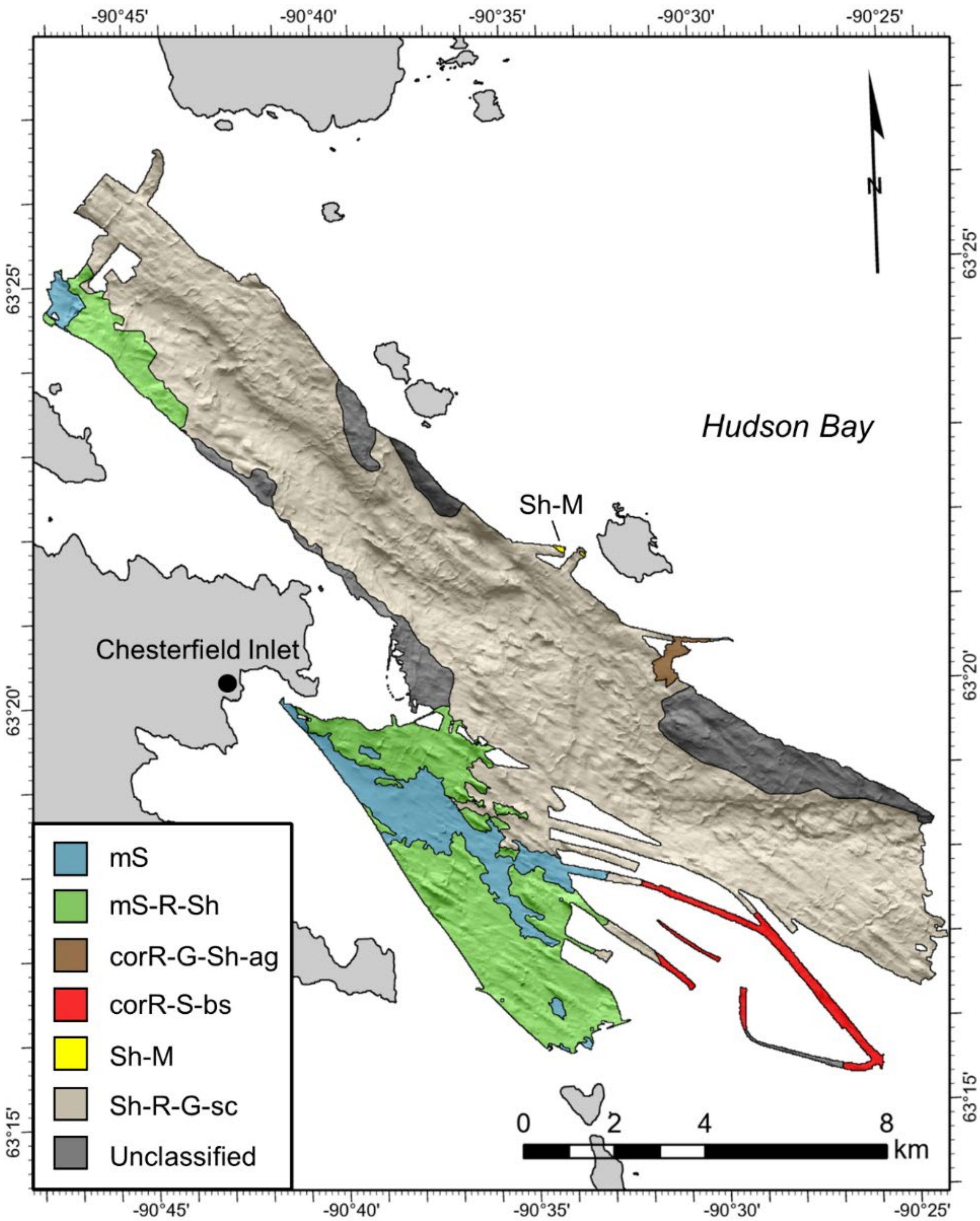

Figure 17. Benthoscapes classified from video samples and delimited by the segmented backscatter layer (Source: Misuik and Aitken 2020). mS = Muddy sand; mS-R-Sh = Muddy sand with rock and shell hash; corR-G-Sh-ag = Coralline-encrusted rocks with gravel, shell hash, and the brown algae; corR-S-bs = Coralline-encrusted rocks with sand and large brittle stars; Sh-M = Shell hash with mud; and Sh-R-G-sc = Shell hash with rock, gravel, and scallops.

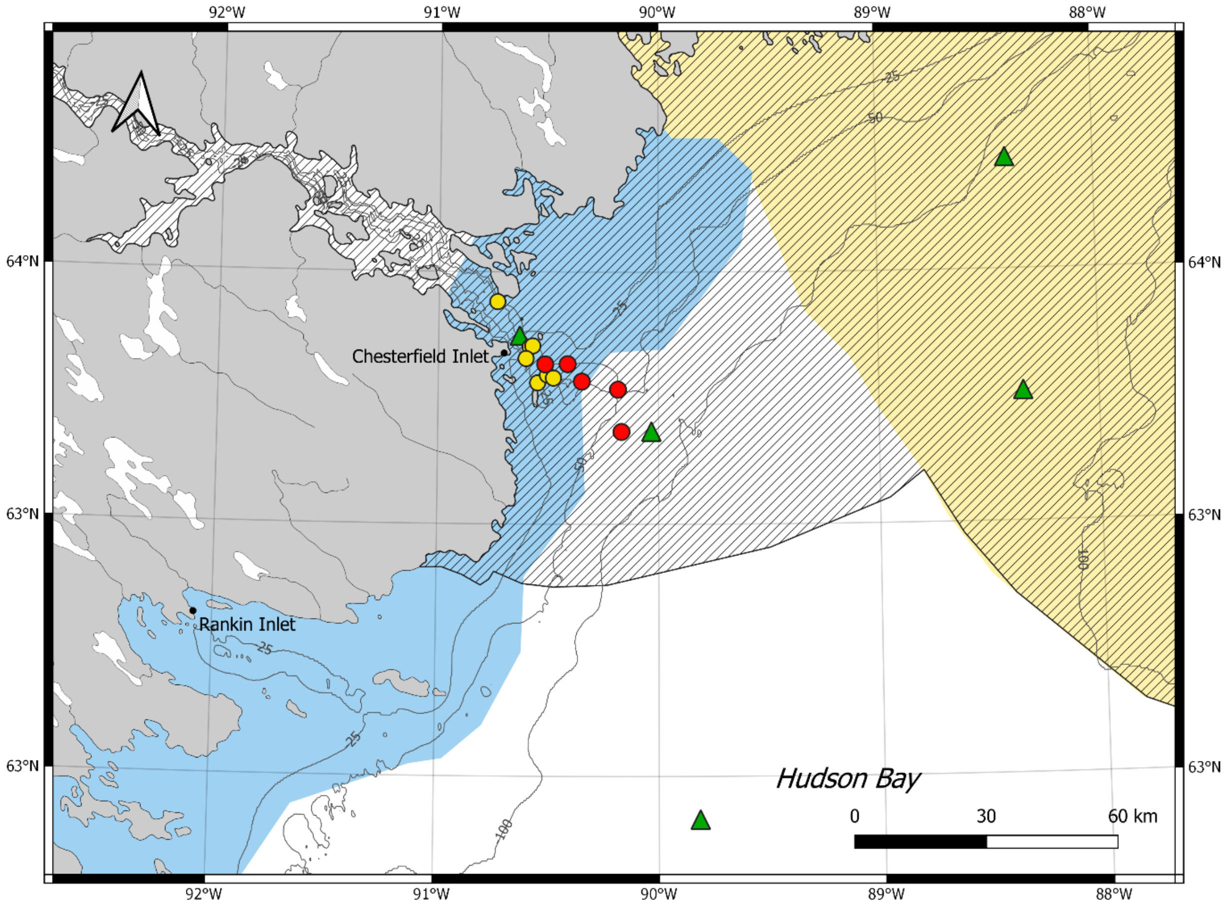

Figure 18. Sites with dense scallop beds in 2016 (yellow circles), general locations of bathymetric mapping and video sampling (yellow circles), historical scallop samples (red circles; from Atkinson and Wacasey 1989) and epifaunal and infaunal sampling from SIMEP and/or GenICE programs (green triangles). (Data source: Misuik and Aitken 2020 and M. Pierrejean, University of Laval).

Marine and Anadromous Fishes

Chesterfield Inlet proper to Baker Lake has numerous freshwater systems that drain into the inlet itself, and are used as migratory corridors between freshwater and estuarine/marine habitats. This region provides the largest source of riverine freshwater to the SI AOI (based on the oceanographic sections above) and thus, supports the passage for movement of anadromous fishes between critical freshwater (i.e., used for spawning, rearing and overwintering) and estuarine/marine habits (i.e., those primarily used for foraging). Based on the oceanography of the area, the entirety of the inlet also appears to be an ideal estuarine habitat for summer feeding, and a migration corridor for anadromous fishes to other coastal regions and marine waters. A full list of anadromous fishes, distribution maps, and data summary can be found in Loewen et al (2020a,b). Notably, in addition to Arctic Char, several *Coregonus* species and Lake Char (*S. namaychush*) are present in the region (Loewen et al. 2020a,b). Some Lake Char in the greater WHBC EBSA (Diana River, NU) use estuarine coastal habitats to feed in summer months (H. Swanson, University of Waterloo, pers. comm.). This is consistent with Lake Char estuarine/marine feeding that has been observed in other areas of Nunavut (Swanson et al. 2010, Harris et al. 2020b). The GN (2008) also reports the presence of Broad Whitefish (C*. nausus*) in the region, however, to date DFO surveys have not captured Broad

Whitefish in the region. This species is generally thought to be in high abundance in the Western Arctic (i.e., Mackenzie River system). Future documentation of Broad Whitefish occurrence is required for determining its overall importance and distribution in the area. Roff et al. (2020) developed a model which highlights the importance of coastal regions as key marine fish habitats for *Coregonus* spp. General lack of scientific studies on all anadromous fish species in the region are noted, including population assessments, current species identifications, trophic and food web studies, and life history characteristics.

A full list of marine fishes, distribution maps, and summary data can be found in Loewen et al. (2020a,b). Generally, there is alack of directed scientific study and data collection for marine fishes in the Chesterfield Inlet portion of the AOI. The GenIce Cruise captured five species within Chesterfield Inlet proper as bycatch species in benthic trawling activities: Stout Eelblenny (*Anisarchus medius*), Daubed Shanny (*Leptoclinus maculatus*), Longhorn Sculpin (*Myoxocephalus octodecemspinosus*), Arctic Staghorn Sculpin (*Gymnocanthus tricuspis*) and Arctic Alligatorfish (*Ulcina olrikii*). Further, the GenICE Cruise captured eight marine fish species at stations between Coral Harbour and Chesterfield Inlet: Atlantic Alligatorfish (*Aspidophoroides monopterygius*), Arctic Cod (*Boreogadus saida*), Fourline Snakeblenny (*Eumesogrammus praecisus*), Twohorn Sculpin (*Icelus bicornis*), Kelp Snailfish (*Liparis gibbus*), Daubed Shanny, Lowfin Snailfish (*Paraliparis calidus*) and Arctic Alligatorfish. Cottidae, Agonidae, Liparidae and Stichaeidae were the most common families. Arctic Cod and Capelin are known to occur in the region and are distributed along the coastal environment into Hudson Bay proper. Preliminary marine fish reports (benthic and pelagic trawls) from the SIMEP Cruise (2018, 2019) (K. Hedges, DFO Winnipeg, pers. Comm.) generally suggest that cod species (Gadidae spp.), eelpout species (Zoarcidae spp.), sculpin species (Cottidae spp.), snailfish species (Liparidae spp.), larval fishes, eel blenny species (Pseudochromidae spp.), and Atlantic Poacher (*Leptagonus decagonus*) are found in and around SI. The GN (2008) notes the presence of several other marine fishes at the mouth of Chesterfield Inlet, including Greenland Halibut (*Reinhardtius hippoglossoides*), eelpout species, sculpin species, Capelin, flounder species (Pleuronectidae spp.) and wolffish species (Anarhichadidae spp.). Roff et al. (2020) provides a marine fish habitat model suggesting that there is important habitat for Lumpfish (*Cyclopterus lumpus*) and Fourhorn Sculpin (*Myoxocephalus quadricornis*) in the SI AOI. Based on the large amount of macroalgae in the region, it is likely that kelp associated fish species, such as the Fish Doctor (*Gymnelus viridis*) and Arctic Shanny (*Stichaeus punctatus*) are present. They are known to have a strong association with kelp habitats in marine environments (e.g., Elliot et al. 2008, Coad and Reist 2018).

Marine Mammals (Seals, Narwhal, and Walrus)

Several marine mammal species use the Chesterfield Inlet portion of the SI AOI seasonally. A detailed summary of biological demographics and seasonal migratory pathways for seal species, Narwhal (*Monodon monoceros*), and Atlantic Walrus (*Odobenus rosmarus*) for the SI AOI is provided in Loewen et al. (2020a). Harbor Seals (*Phoca vitulina*) are not abundant in this area, but are most commonly found within Chesterfield Inlet and moving upwards in rivers to follow fish (GN 2008, Idlout 2020). The GN (2008) reports that Bearded Seals (*Erigna barbatus*) and Harp Seals (*Pagophilus groenlandica*) are less abundant in the region. However, local communities documented Bearded Seals to be most abundant in the region in the fall (October) (Idlout 2020). In addition, Roff et al. (2020) document small habitat distributions for both Harp (Figure 19) and Bearded (Figure 20) seals for the region that generally occur around the mouth of Chesterfield Inlet. Ringed Seals (*Pusa hispida*) are thought to occur in very low abundances in the Chesterfield Inlet portion of the AOI.

The Northern Hudson Bay (NHB) Narwhal population primarily summers around the northern SI AOI. The most recent population estimate is provided in the RB/FS section of the SRR. Roff et al. (2020) provides a map of seasonal (summer) habitat use for Narwhal, demonstrating the use of the Chesterfield Inlet portion of the SI AOI (Figure 21). Walrus are also known to use the Chesterfield Inlet portion of the SI AOI as feeding and haul-out habitat near Depot Island (during the winter), and migrate (fall and spring) to additional feeding and haul-out areas in Roes Welcome Sound (e.g., Idlout 2020, Loewen et al. 2020a).

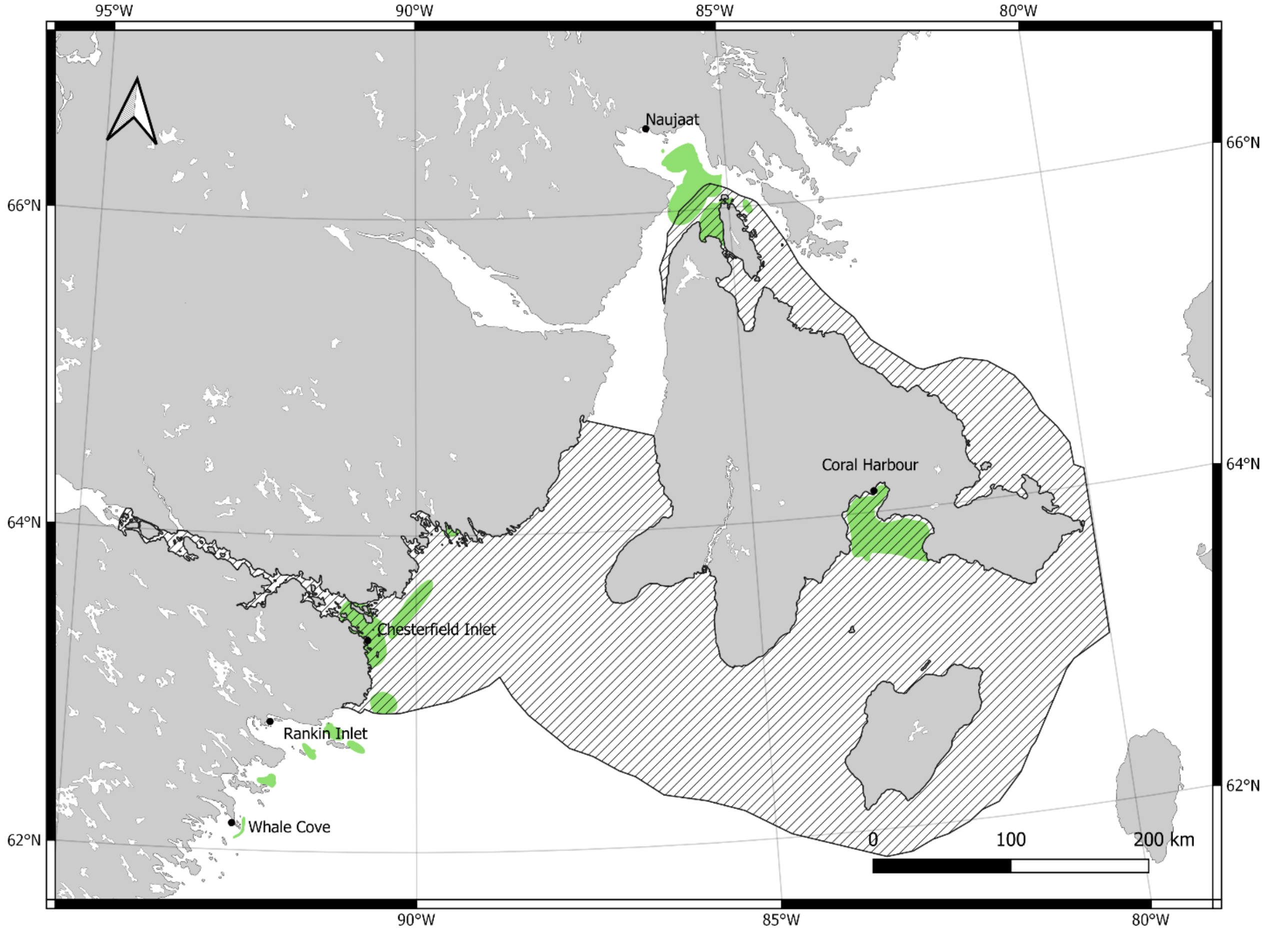

Figure 19. Key Harp Seal habitat use (green) for the SI AOI (black line and diagonal shading) (Data source: Roff et al.2020).

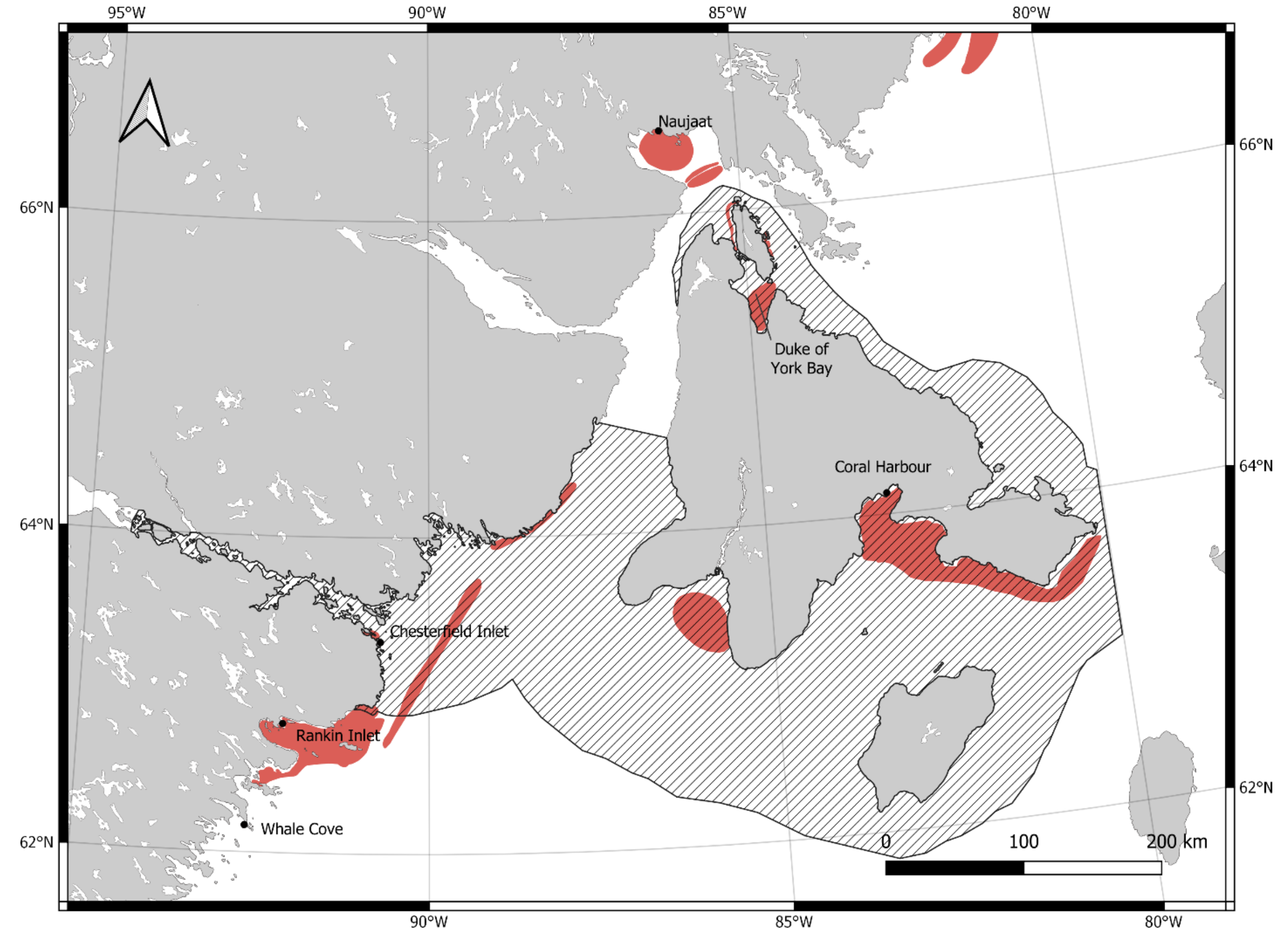

Figure 20. Key Bearded Seal habitat use (red) for the SI AOI (black line and diagonal shading) (Data source: Roff et al.2020).

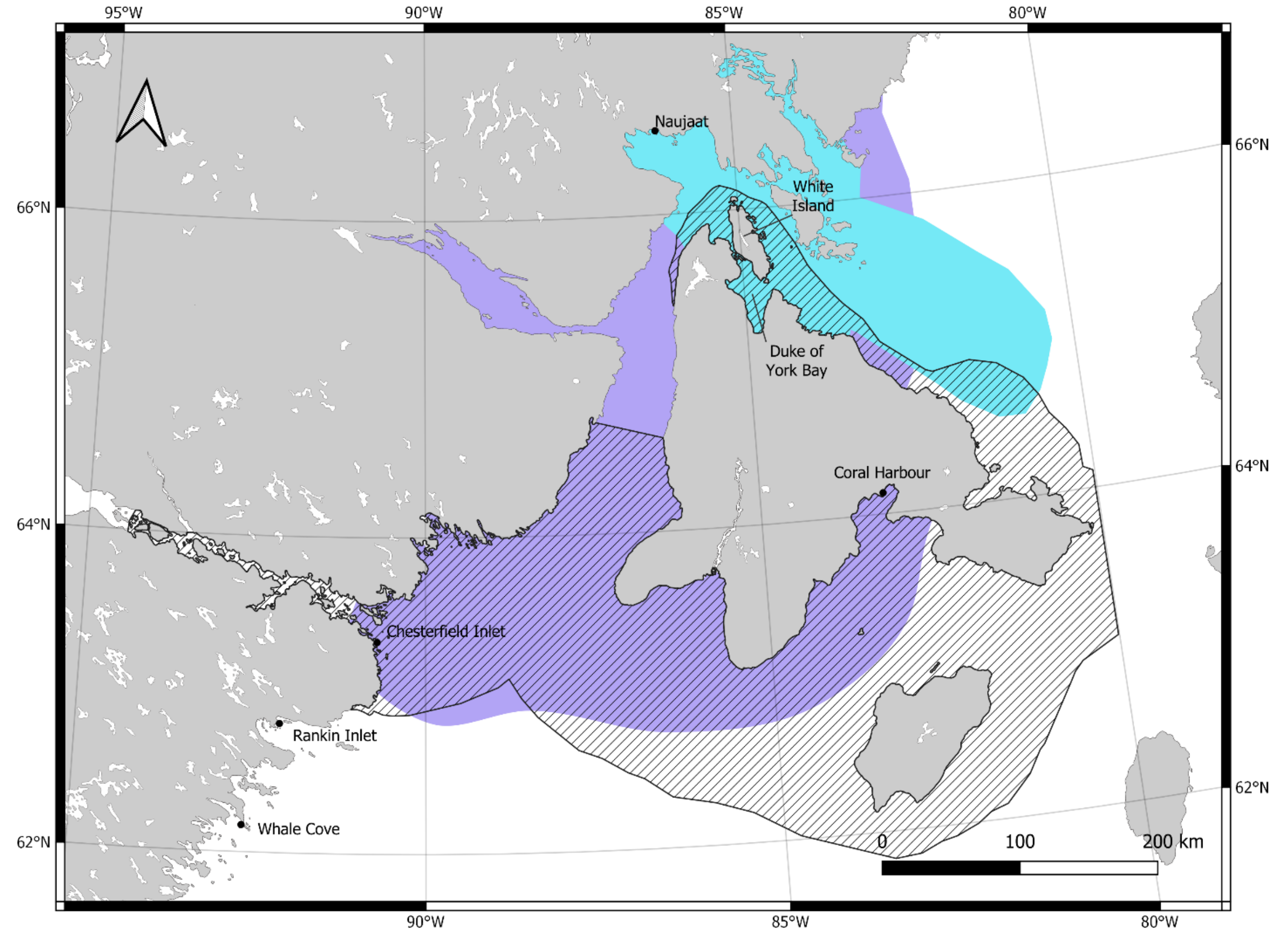

Figure 21. Northern Hudson Bay (NHB) Narwhal summer range (purple) and foraging/calving areas (blue) for the SI AOI (black line and diagonal shading) (Data source: Roff et al. 2020).

Repulse Bay/Frozen Strait EBSA

The main features of the RB/FS EBSA include complex oceanography (i.e., strong currents, bathymetry and the presence of two recurrent polynyas), summer feeding areas for marine mammals (e.g., Narwhal, Beluga, Bowhead, and Atlantic Walrus), Arctic Char and seabirds, and high numbers (i.e., a significant portion of the Canadian breeding population) of the Iceland Gull subspecies, Thayer's Gull. These features will be discussed in relation to the portion of the EBSA that falls within the SI AOI boundary (Figure 22). The RB/FS region of the AOI sits along the northern coast of SI, including Duke of York Bay, areas around White Island, and extends along the coast to the northern portion of Roes Welcome Sound.

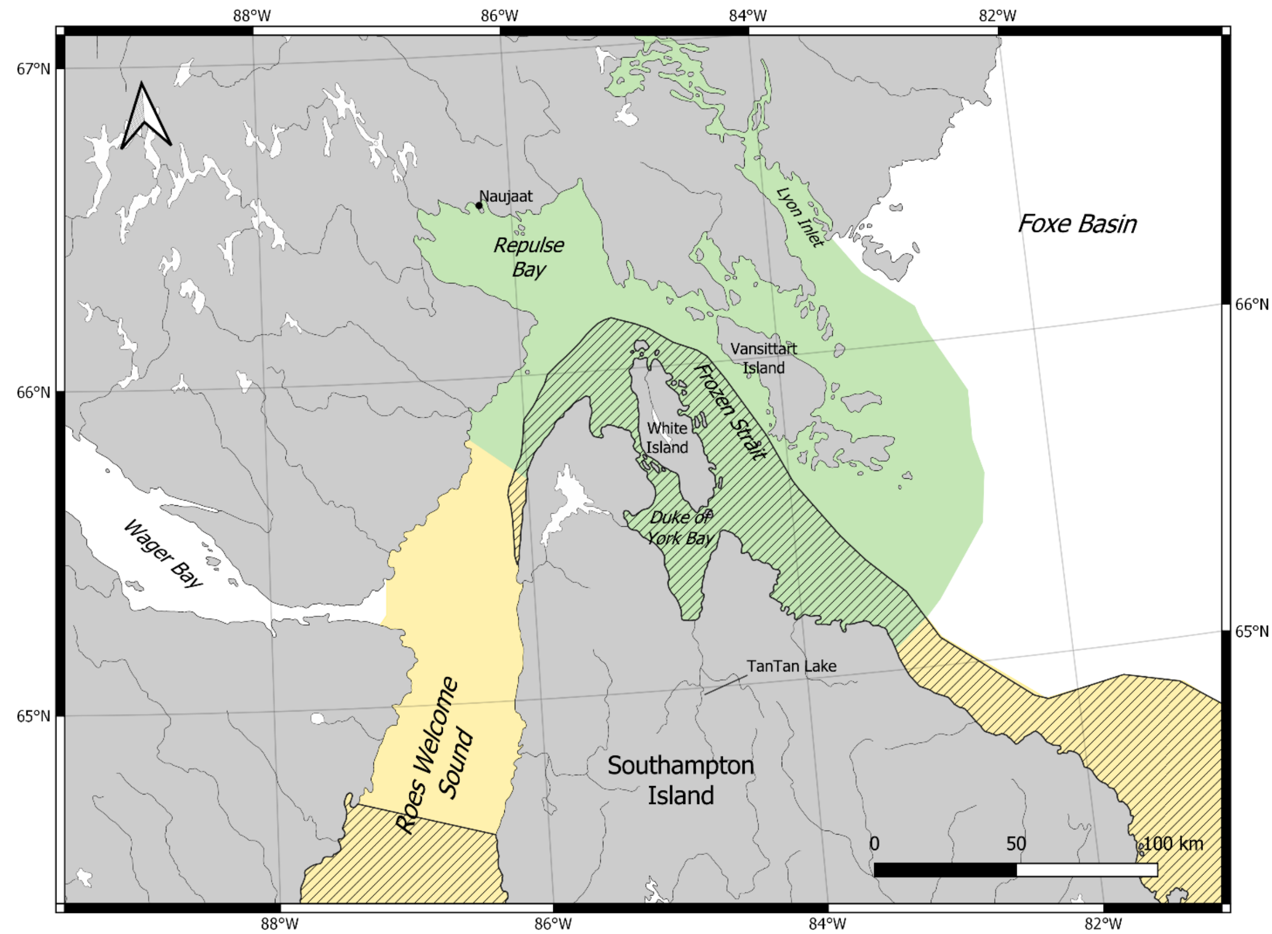

Figure 22. Map of the RB/FS (green) portion of the SI AOI (black line and diagonal shading).

Complex Oceanography

The RB/FS EBSA has complex oceanography with variations in bathymetry, currents, and multiple polynyas. Loewen et al. (2020a) provides a summary of known oceanographic information for the region. Lack of scientific data collection is generally noted for this northern portion of the SI AOI. CTD profiles were collected in the SI region (SIMEP Cruise, Figure 23, University of Manitoba) during the summer of 2019, and Repulse Bay (Figure 24; University of Manitoba) during winter of 2018–2019, to better understand water mass properties. These data suggest there are four distinct oceanographic regions within the SI AOI region: 1. Repulse Bay, 2. Foxe Basin, 3. Roes Welcome Sound, and 4. Fisher and Evans Strait along the south shore of SI (Figure 23 and Figure 24). Low temperature and salinity to the north of SI and in Foxe Basin, are indicative of active ice melt well into the summer months (August 2019), while, in contrast, salinity and temperature along the south side of SI were higher (Figure 23). Vertical stratification was not present in summer of 2019 at the northern end of Roes Welcome Sound, but was observed in Foxe Basin and along the southern regions of SI (Figure 23). The lack of vertical stratification in northern Roes Welcome Sound is likely due to strong tidal currents vertically mixing water down to > 100 m depth. In Repulse Bay colder and saltier, yet weakly-stratified, surface waters were observed in August 2019. Similarly, during winter (February) and spring (May/June) months, Repulse Bay is weakly stratified (Figure 24). These early results, despite few oceanographic observations, support hypotheses that the northern region of SI is distinct, and can be characterized by intense tidal mixing; the main mechanism by which the Roes Welcome Sound polynya is formed. Additionally, chlorophyll *a* is highest much closer to the surface and present to a greater magnitude within Repulse Bay than observed elsewhere in the region (Figure 23). These early results further support hypotheses of tidally driven mixing at the northern ends of Frozen Strait and Roes Welcome Sound, which supplies new nutrients to surface waters in adjacent regions and thereby supports a richer, pelagic-based ecosystem on the north side of the island, versus a more benthic ecosystem on the south side. Similar to the WHBC EBSA, the biogeochemistry of waters in the RB/FS EBSA are not well represented in the published studies to date. Analysis of data from the BaySys and SIMEP cruises (both in 2018; the latter directly in waters surrounding SI), will confirm the contemporary state of ocean acidification in the SI region.

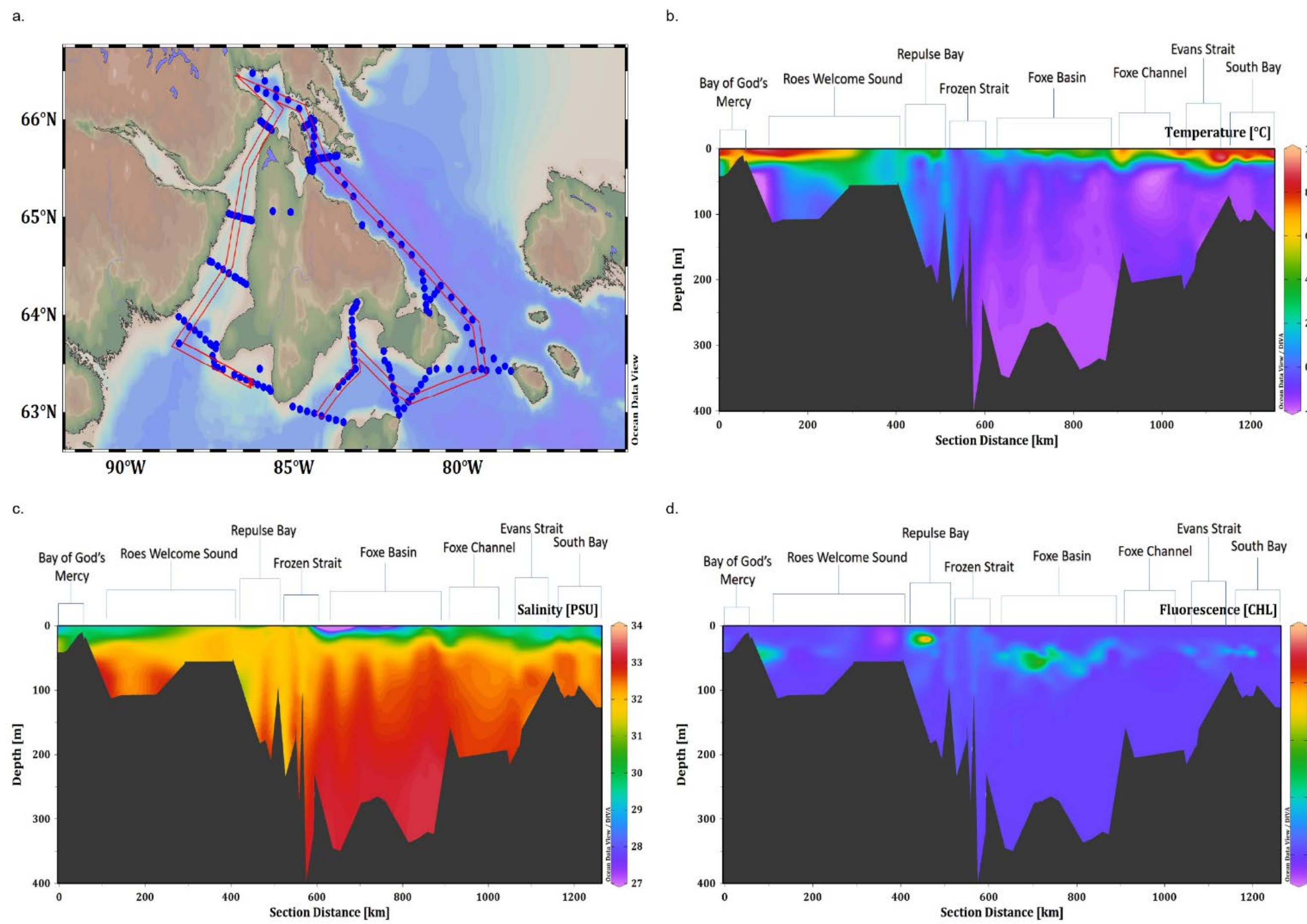

Figure 23. CTD casts collected around SI as part of the SIMEP 2019 cruise (a) provide detailed summer temperature (b), salinity (c) and in vivo fluorescence around the island. (Figure credit: C.J. Mundy and E. Kitching, University of Manitoba).

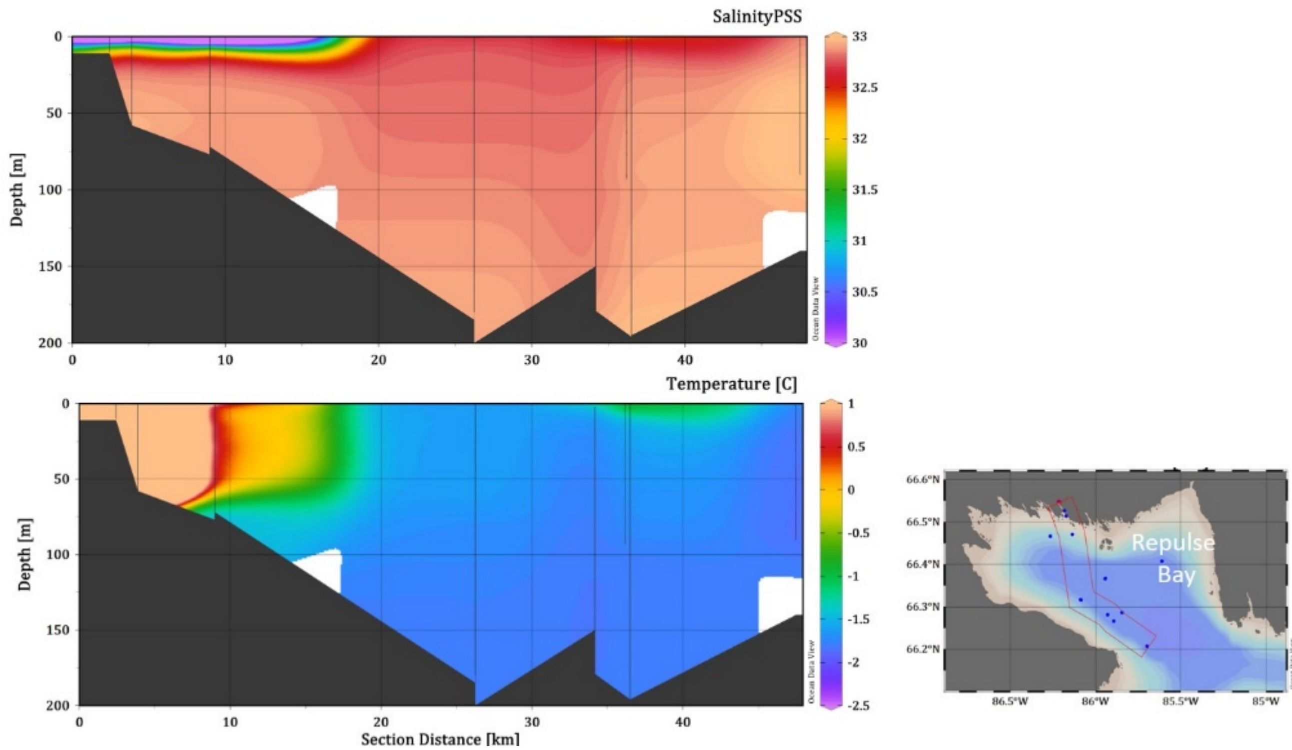

Figure 24. Salinity and temperature profiles across Repulse Bay during winter and spring of 2018 and 2019 (Figure credit: M. Kamula, University of Manitoba).

Summer Feeding Areas – Arctic Char

Anadromous Arctic Char are distributed throughout the SI AOI during the summer months, feeding in the marine region and migrating between important foraging areas. Loewen et al. (2020a) summarized historical tagging and science publications for char and Loewen et al. (2020b) reports the distribution of char within the region. There is little updated scientific data available for char along the northern portion of SI despite past and present fishing activity in the region. The community of Naujaat is the closest settlement to the northern portion of the AOI. Marine and coastal fishing activity for char occurs at various locations around the mainland of Repulse Bay and northward along the coast, as well as at White Island. The Nunavut Wildlife Harvest Study (Priest and Usher 2004) reports a five-year (1997–2001) average of 4,283 Arctic Char taken for subsistence purposes annually for the community of Naujaat. During that time, most fish were sold locally to the Arviq Hunters and Trappers Organization and Naujaat Co-op Store (Preist and Usher 2004). In addition, the residents of Coral Harbour fish in the northern portion of the AOI, specifically at locations in Duke of York Bay. The Nunavut Wildlife Harvest Study (Priest and Usher 2004) reports a five-year (1997–2001) average of 6,668 Arctic Char taken for subsistence purposes annually for the community of Coral Harbour. Two commercial fisheries (Schedule 5) are known for Duke of York Bay at the Cleveland and Thomsen rivers with quota of 9,100 kg and varied quota of 2,300 respectively (Figure 11; DFO FMHIS database).

Inuit community members have identified locations of occurrence for chars in the Repulse Bay region (GN 2011), and the northern portion of SI (GN 2012). Idlout (2020) identified rivers leading from TanTan Lake (to Duke of York Bay) as an important area for Arctic Char (Figure 22). It was suggested that there were five rivers draining into the Duke of York Bay that supported Arctic Char migration and thus this area is considered to have high abundance of char (Idlout 2020). In addition, char coastal feeding habitat was identified in the Duke of York Bay and along the northern coastline of SI (Idlout 2020). Roff et al. (2020) also identified coastal areas in this region (including Duke of York Bay and areas around White Island) of the AOI as important marine feeding habitat for char. Subsistence harvesting for Arctic Char in the winter season occurs outside the northern portion of the AOI on the Heritage River, North Pole River, and Gore Bay (A. Finley, DFO Winnipeg, pers. comm.). Summer fishing occurs in multiple locations as fish are widely distributed in both freshwater and marine habitats (A. Finley, DFO Winnipeg, pers. comm.). Fish flesh from this region is bright orange/red in colour and high quality (A. Finley, DFO Winnipeg, pers. comm.). The community of Naujaat presently does not commercially sell fish to Kivalliq Arctic Foods (Rankin Inlet) due to high shipping costs. In 2019, a community sampling program for char was initiated to understand diet and marine food web ecology (L. Harris, DFO Winnipeg, pers. comm.). Preliminary analysis suggests char from the Naujaat region feed on a variety of fish and invertebrates, with species composition varying spatially (L. Harris, DFO Winnipeg, pers. comm.). Char in the region are highly opportunistic foragers and nearly 60 distinct prey items were identified in preliminary analyses of stomach contents (L. Harris, DFO Winnipeg, pers. comm). Some of the more common fish and invertebrates identified from stomach contents include: Arctic Cod, Capelin, Sandlance (Ammodytes sp.), Sculpins (Cottidae sp.), Fourhorn Sculpin, Cyclopoida, Hyperiidae sp., *Themisto libellula*, *Onisimus litoralis, Gammarus wilkitzkii*, *Ischyrocerus* sp., *Mysis* sp., *Harpacticoida* sp., *Calanus hyperboreus*, mayflies (Baetidae sp.), and *Nereis* sp. A community sampling program for char was conducted again in the summer of 2020 to evaluate how Arctic char diet in the region may vary between years.

Summer Feeding Areas – Beluga

The northeastern portion of SI, including Duke of York Bay and areas around White Island (within RB/FS EBSA), has been identified as an important region for summer feeding for the WHB Beluga. WHB Beluga are thought to gather at river mouths in the northwestern areas of SI in the springtime to feed on Arctic Char (GN 2011). A detailed summary of WHB Beluga biological demographics, diet, and seasonal migratory pathways for the SI AOI can be found in Loewen et al. (2020a). In addition, Roff et al. (2020) suggests that the East Bay region of SI is a calving area for WHB Beluga. Similarly, Idlout (2020) notes that the East Bay and the Duke of York Bay region of the SI AOI are calving areas for WHB Beluga. Beluga are present around the northwest tip around to the southwestern tip of SI during the summer months (Idlout 2020).

Summer Feeding Areas – Narwhal

The northeastern portion of SI, including Duke of York Bay and areas around White Island (within RB/FS EBSA), has been identified as an important region for summer feeding for NHB Narwhal (Figure 21). A detailed summary of Narwhal biological demographics, diet, and seasonal migratory pathways for the SI AOI is provided in Loewen et al. (2020a). The most recent population estimate was updated to 19,200 (95% CI = 11,300–32,900) Narwhal (Watt et al. 2020), a slight increase of the 2011 adjusted estimate of 12,500 (95% CI = 7,500–20,700) individuals. The GN (2011) reports high numbers of Narwhal around Naujaat and at the floe edge during the spring. They are absent when Killer Whales (*Orcinus orca*) are present in the area, and likely use the coast and bays to escape predation. Watt et al. (2020; Figure 25) reports the 2018 visual aerial survey findings showing Narwhal sightings in and round the SI AOI region.

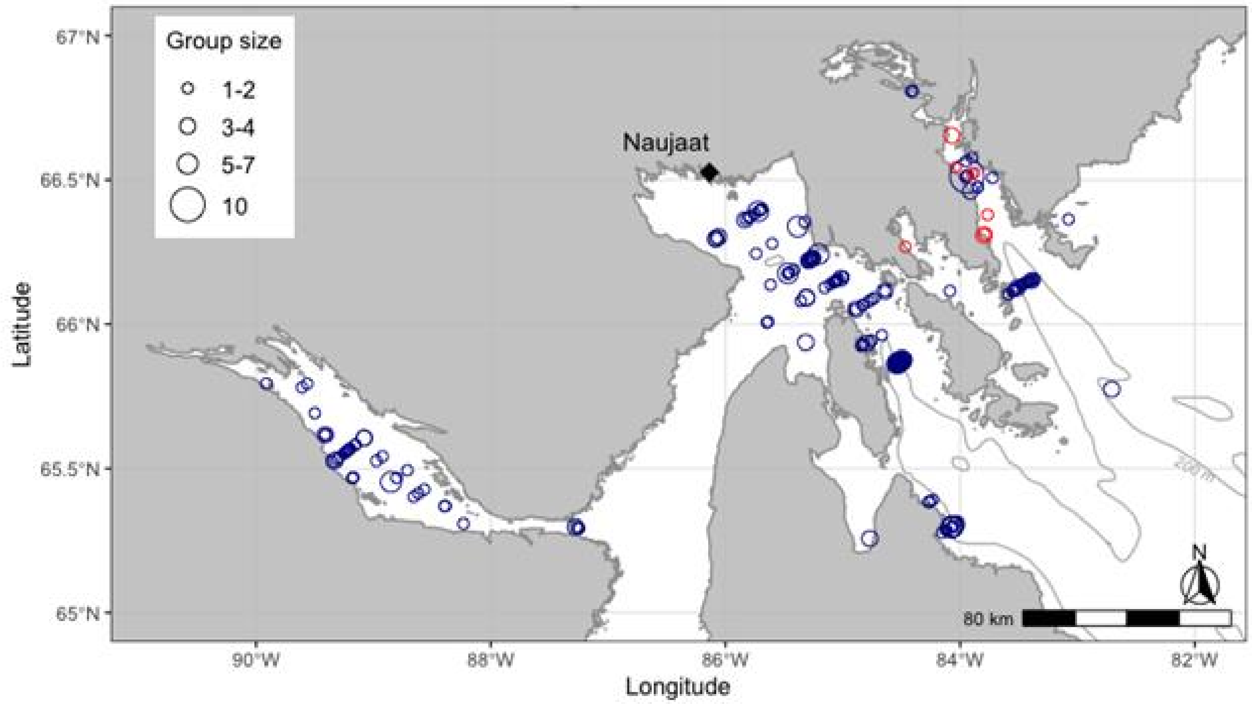

Figure 25. Map of all Narwhal sightings in the first replicate survey (blue) and sightings during the repeat survey of the North Bays stratum (red) during the 2018 visual aerial survey in Northern Hudson Bay (Source: Watt et al. 2020).

Summer Feeding Areas – Bowhead (*Balaena mysticetus*)

The Eastern Canada-West Greenland (EC-WG) Bowhead population is thought to have key habitat throughout the SI AOI (Figure 26). The northwestern portion of SI, including Duke of York Bay and areas around White Island (within RB/FS EBSA), has been identified as an important region for calving and nursery areas for Bowhead in addition to regions around Evans Strait in the southeastern area of the island (Figure 26). A detailed summary of Bowhead biological demographics, diet, and seasonal migratory pathways for the SI AOI is provided in Loewen et al. (2020a).

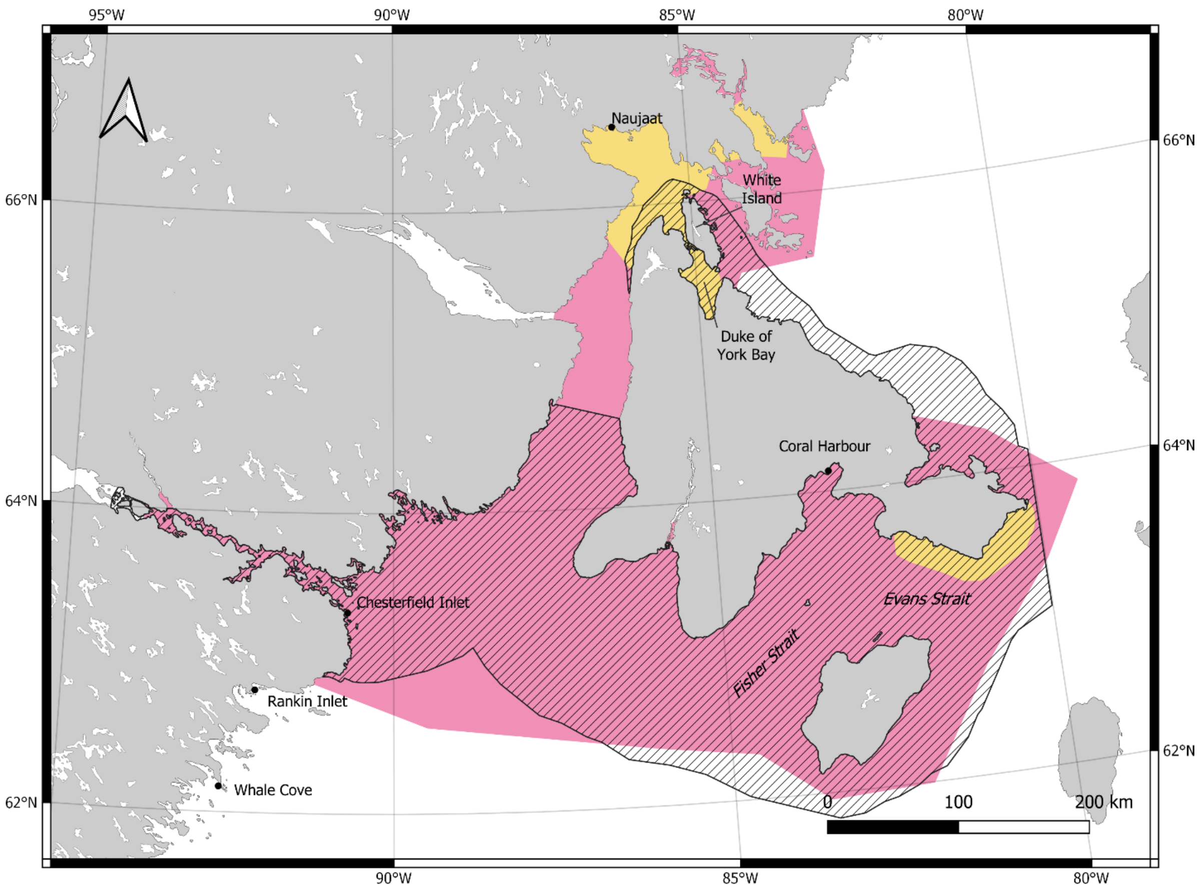

Figure 26. Bowhead key summer habitats (pink) and calving and nursery regions (yellow) in the SI AOI (black line and diagonal shading) (Data source: Roff et al. 2020)

Summer Feeding Areas – Atlantic Walrus

The Hudson Bay-Davis Strait (HB-DS) Atlantic Walrus stock is thought to have key habitat throughout the majority of the SI AOI. The northwestern portion of SI, including Duke of York Bay, areas around White Island and along the coastline (within RB/FS EBSA), has been identified as areas for haul-outs and feeding (Loewen et al. 2020a). A more detailed summary of Walrus biological demographics, diet, and seasonal migratory pathways for the SI AOI can be found in Loewen et al. (2020a).

Summer Feeding Areas – Seabirds

Many coastal areas of northwestern SI and White Island appear to be suitable habitat for seabird breeding (Gaston et al. 2012; Figure 27). Cliffs and rocky coasts generally support breeding habitats for murres, gulls, Northern Fulmars, Black Guillemots (*Cepphus grylle*) and Atlantic Puffin (*Fratercula arctica*), whereas low lying beaches and tundra support Arctic Terns (*Sterna paradisaea*), Sabine's Gull (*Xema sabini*), and American Herring Gulls (*Larus smithsonianus*). No murre, fulmar or kittiwake colonies occur within this region of the SI AOI. Extensive surveys on gull colonies for the Eastern Canadian Arctic occurred in 1971–1973 and 1984–1985. Gaston et al (1986) estimated ~ 6,600 Sabine's Gulls and ~ 4,600 Arctic Terns during surveys of Foxe Basin and northern Hudson Bay. When potential habitat was accounted for, the estimates increased to ~ 26,000 and ~ 14,000 respectively. Black Guillemot populations are estimated at 23,100 for Hudson Strait, 8,800 for the east coast of Hudson Bay, 6,600 for the west coast of Hudson Bay, and 5,000 for Frozen Strait (Gaston et al. 2012). Estimates for Thayer's Gull (*Larus glaucoides thayeri*) are provided in the section below. Gaston et al (1986) identified Tundra Swans (*Cygnus columbianus*), Atlantic Brant (*Branta bernicla*), Canada Geese (*Branta canadensis*), Snow Geese (*Anser caerulesens*), Common Eider (Somateria mollissima), Northern Pintail (*Anas acuta*), King Eider (*Somateria spectabilis*), Long-tailed Duck (*Clangula hyemalis*), Jaegers (S*tercoraius spp.*), Herring Gull (*Larus argentatus*), Thayer's Gull, Sabine's Gull (*Xema sabini*), Arctic Tern, and Black Guillemot in the northern portion of the SI AOI.

A general lack of present-day knowledge is noted for seabirds in this region (K. Elliot, McGill University, pers. comm.). Yurkowski et al. (2019) noted an absence of seabird hotspots in this region of the SI AOI, however, this is likely due to the lack of available telemetry data for the analysis. However, this region of the Arctic does appear to be a staging area, breeding area, and migratory corridor for numerous sea duck species (Prach et al. 1981, Gaston et al. 1986, Mallory et al. 2018). Species such as the Common Eider are known to breed in colonies associated with reoccurring polynyas and marine habitats (Prach et al. 1981). In other regions of their range, such as Greenland and Alaska, they feed on molluscs, gastropods, and crustaceans (Cramp 1980), found along inshore coastal waters of < 10m. Other sea ducks, such as King Eider and Long-tailed Ducks, can feed at depths up to 60m in coastal waters. Small Common Eider breeding colonies are thought to occur in the northern region of the SI AOI (Prach et al. 1981).

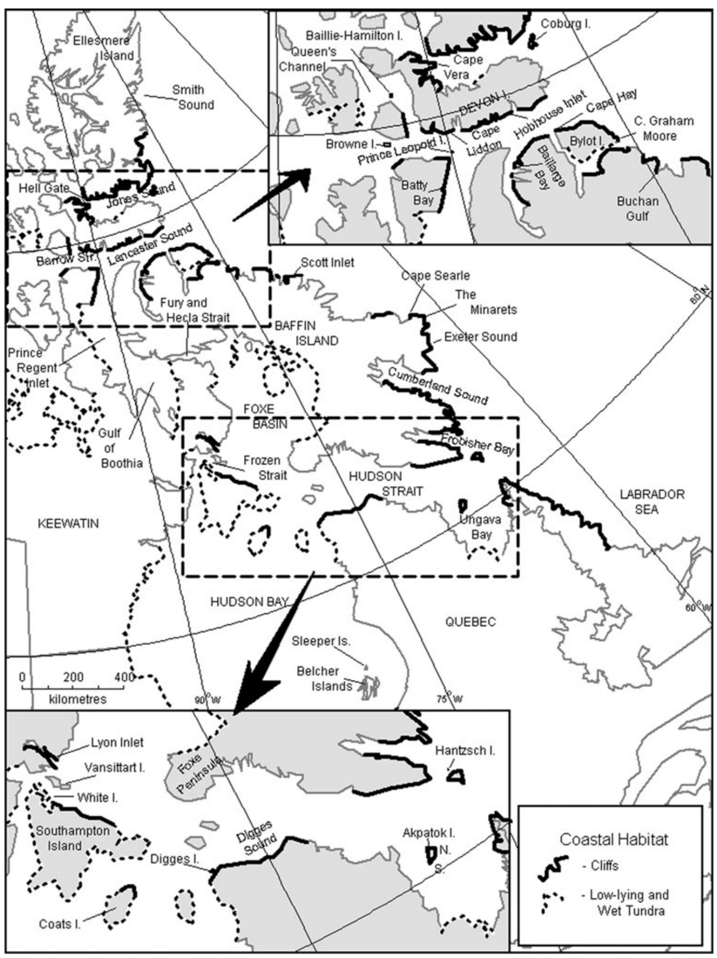

Figure 27. Eastern Arctic Canada cliff and low-lying tundra breeding habitats for seabirds (Source: Gaston et al. 2012).

Iceland Gulls (subspecies Thayer's Gull)

Iceland Gulls (*Larus glaucoides*) are both partial migrants and full-time occupants of Arctic environments. Some individuals migrate south to winter in Iceland, the United Kingdom, and the northeastern and west coasts of the United States and Canada (The Cornell Lab of Ornithology 2019). The species as a whole is restricted to Greenland and the Eastern Canadian Arctic for breeding habitat (The Cornell Lab of Ornithology 2019). The Iceland Gull has a complex taxonomy and is presently divided into three sub-species: Kumlien (*Larus glaucoides kumlieni*), Thayer's, and Iceland gulls (Richards and Gaston 2018). The gulls breed in large colonies (50–100 nests) on coastal cliffs with narrow ledges in Arctic environments (Richards and Gaston 2018). The gulls forage over open water among pack ice, pulling prey from the ocean surface without landing. They forage close to shore and on beaches, feeding mainly on fish, but also mussels, snails, large zooplankton, carrion, offal in harbours, fishing remains and occasionally garbage, the eggs and young of other seabird species, terrestrial plants, algae, and berries. They are known to winter at the edges of polynyas and along coasts. The Thayer's subspecies winters on the West Coast of North America (The Cornell Lab of Ornithology 2019) and are known to breed along the rocky coasts of the northeastern portion of SI, Lyon Inlet, and White Island (Gaston et al. 1986). Thayer's Gull colonies were surveyed in 1983, 1994, 2006, and 2009 at White Island, Vansittart Island, and Lyon Inlet with population estimates ranging from 1,623 birds in 2006 to 2,407 birds in 2009 (Gaston et al. 2012). The north coast of SI was surveyed in 1983, 2006, and 2009 with population estimates ranging from 895–1,400 (Gaston et al. 2012). In general, cliff nesting gulls were highest in number on the northeast coast of SI (900–1,000 pairs), White Island (600–700 pairs) and Lyon Inlet (650–750 pairs, Figure 28).

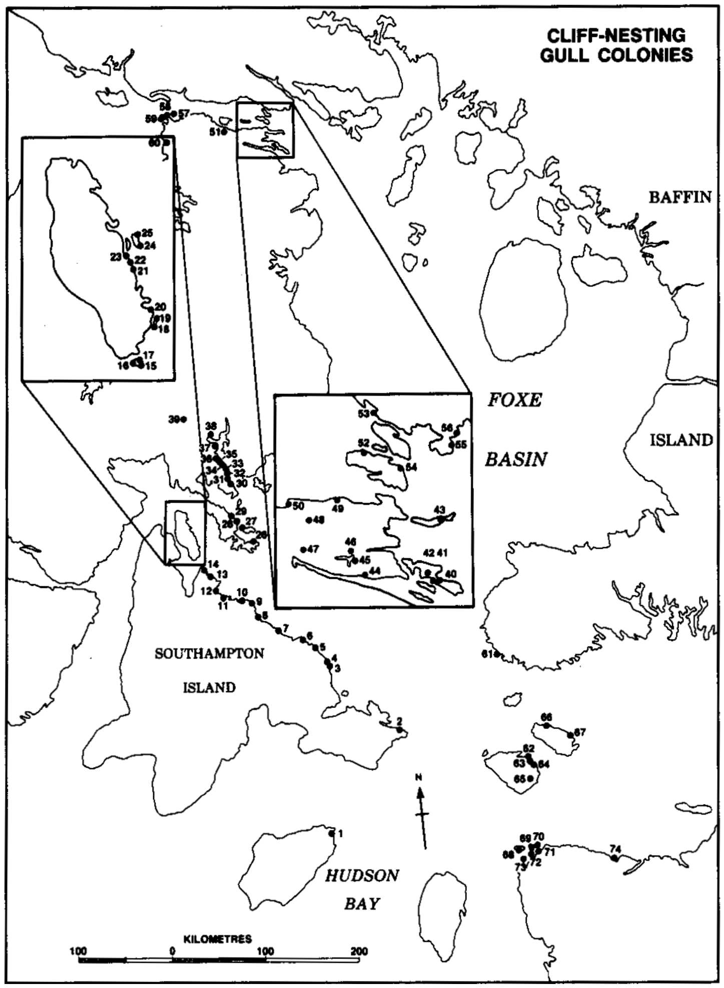

Figure 28. Distribution of breeding colonies for gull species (Larus glaucoides thayeri, L. glaucoides, L. hyperboreus) that nest on cliffs (Source: Gaston et al. 1986).

New Information and Data to support the Repulse Bay/Frozen Strait EBSA

Macroalgae

The GN (2011) documents the presence of kelp near White Island and the northwestern coastal area of SI respectively. On the northern side of SI, where bathymetry was sloped, kelp were generally smaller in size and patchy in distribution (Figures 7 and 8; Filbee-Dexter et al. 2019). At shallow sampling stations with high currents, lush kelp forests, dominated by *Alaria esculenta* were observed (Figures 7 and 8; Filbee-Dexter et al. 2019). Predictive models show that there are suitable habitats/environmental conditions to support the presence of three macroalgale species (*A. clathratum*, *S. latissimi*, *and L. solidungula*; Figure 9) in the northern portion of the SI AOI (J. Goldsmit, DFO Winnipeg, pers. comm.). Macroalgae provide unique habitats for fishes and other species that may be present in the region, such as small fishes, invertebrates (molluscs), rock cods, crabs, and seals (Idlout 2020). Many shore birds, seabirds and young migratory birds use kelp habitats to access food sources living within or in association (Idlout 2020). Additionally, Idlout (2020) documented kelp beds on the northeast and southeast coastal regions of White Island.

Marine and Anadromous Fishes

Duke of York Bay drains numerous freshwater systems, providing seasonal fish passage to estuarine waters. As previously discussed, Arctic Char is present in these freshwater systems. Other char species, such as Lake Char and Bull Char (*S. confluentus*) are known to occur in rivers draining into Repulse Bay from the mainland of Nunavut (GN 2011), an area that sits adjacent to the SI AOI. Bull Char have not been captured during scientific sampling in the region. Ninespine Stickleback (*Pungitius pungitius*) and Threespine Stickleback (*Gasterosteus aculeatus*) are also found in some freshwater/coastal areas. Some Lake Char may use estuarine/coastal habitats in the greater WHBC EBSA to feed in summer months (H. Swanson, University of Waterloo, pers. comm.), as has been found in other regions of Nunavut (Swanson et al. 2010, Harris et al. 2020b). A full list of anadromous fish, distribution maps, and data summary are provided in Loewen et al (2020a,b). General lack of scientific studies on all anadromous fish species in the region are noted, including population assessments, current species identifications, trophic and food web studies, and life history characteristics.

A full list of marine fish distribution maps and data summary can be found in Loewen et al. (2020a,b). There is a lack of scientific data for marine fishes in the northern portion of the SI AOI. The recent SIMEP cruise (2019) did not cover the Duke of York Bay, though it did collect benthic and pelagic trawl data from stations near White Island (Hedges et al. 2019). Arctic Cod and Capelin are known to occur in the region and are distributed along the coastal environment into Hudson Bay proper. Idlout (2020) suggests a high abundance of Capelin (Duke of York Bay) and lower abundance of Arctic Cod in the region. Preliminary marine fish reports (benthic and pelagic trawls) from the SIMEP Cruise (2018, 2019) generally suggest that cods, eelpouts, sculpins, snail fish, larval fish, eel blenny, and Atlantic Poacher (*Leptagonus decagonus*) are found in and around SI. The GN (2011 and 2012) noted the presence of several marine fishes in Repulse Bay extending towards White Island, northern SI and Duke of York Bay including Atlantic Cod (*Gadus morhua*), Capelin, Rainbow Smelt (*Osmerus mordax*), Arctic Staghorn Sculpin (*Gymnocanthus tricuspis*), Shorthorn Sculpin (*Myoxocephalus scorpius*), Twohorn Sculpin (*Icelus bicornis*), Leatherfin Lumpsucker (*Eumicrotremus derjugini*), Lumpsucker sp. (Cyclopteridae sp.), McAllister's Eelpout (Zoarridae *sp*.), Northern Hagfish (*Myxine glutinosa*), Polar Eelpout (*Lycodes polaris)*, and Threespot Eelpout (*Lycodes rossi*). Roff et al. (2020) provides a marine fish habitat model suggesting that there is significant Lumpfish and Fourhorn Sculpin habitat in the SI AOI.

Additional Marine Mammal Information

Several marine mammal species use the RB/FS portion of the SI AOI seasonally. A detailed summary of biological demographics and seasonal migratory pathways for seal species, Polar Bear, and Killer Whale for the SI AOI is provided in Loewen et al. (2020a). The GN (2011) reports the presence of Ringed Seals (*Pusa hispida*; Figure 29) and Bearded Seals (*Erigna barbatus*; Figure 20) in the Duke of York Bay region of the AOI. Both Bearded Seals and Ringed Seals are thought to have a high abundance in the region (GN 2011). Hooded Seals (*Cystophora cristata*; Figure 30) and Harp Seals (*Pagophilus groenlandica*; Figure 19) are also known to be present at the northern tip of the SI AOI. Extensive Polar Bear denning habitat has been identified on White Island and along the whole northeastern coastline of SI (Loewen et al. 2020a and Figure 12). Killer Whale occurrence has been documented in Repulse Bay (GN 2011) and within Duke of York Bay (Idlout 2020).

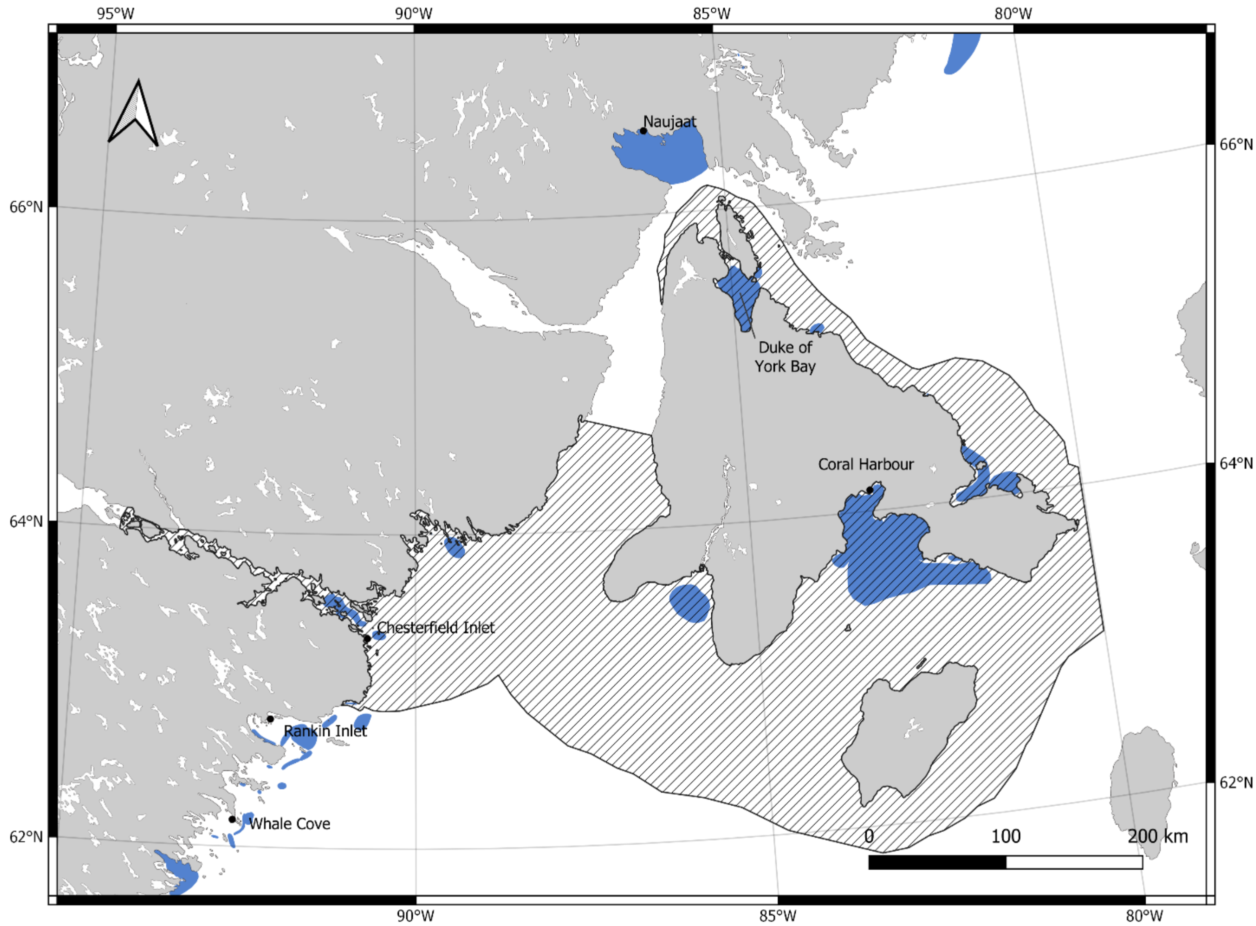

Figure 29. Ringed Seal locally identified habitat (blue) for the SI AOI (black line and diagonal shading) (Data source: Roff et al. 2020; summarized from the GN 2008–2017).

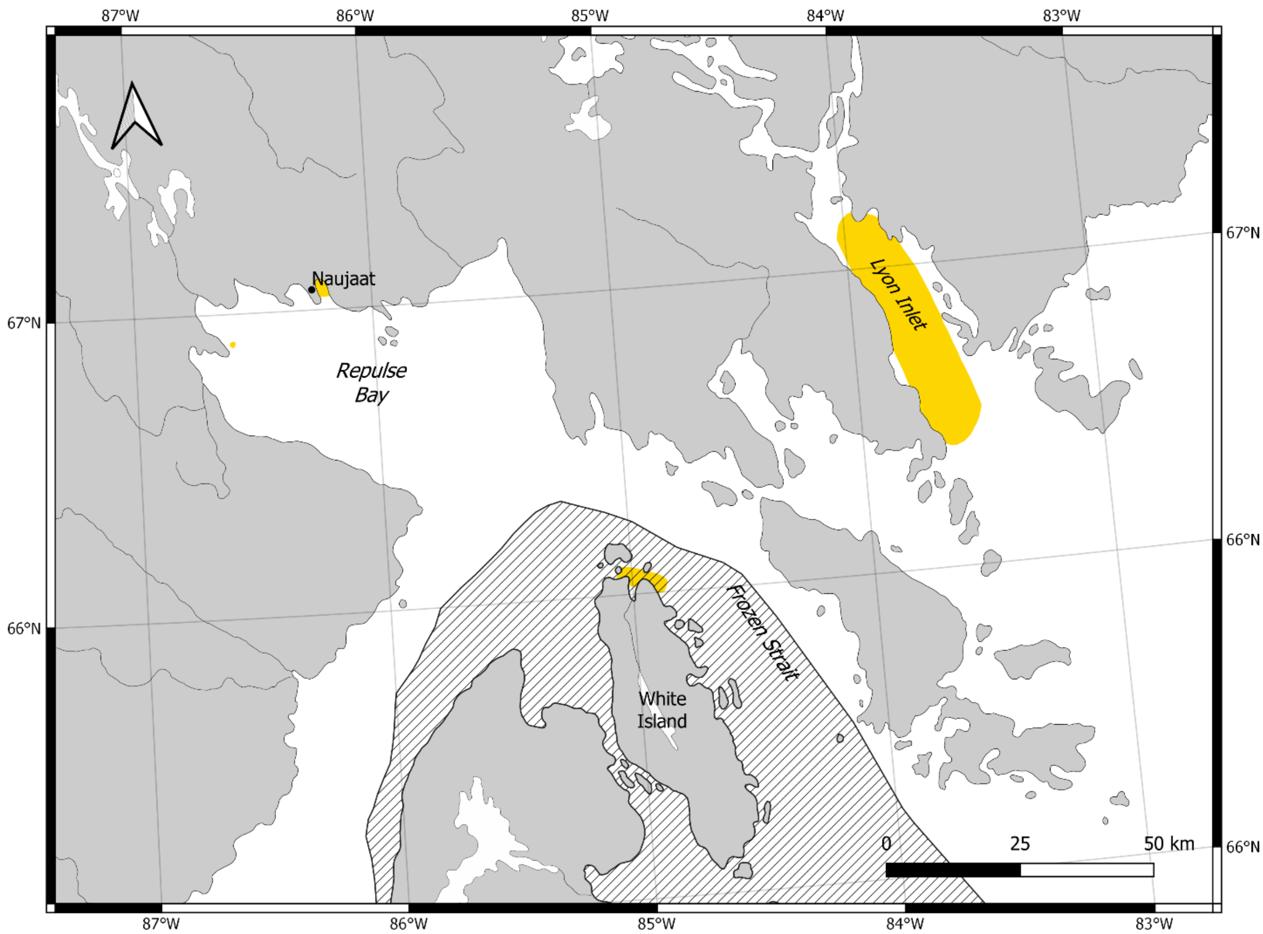

Figure 30. Areas of occurrence for Hooded Seal (yellow) in and around the community of Naujaat; the northern portion of the SI AOI (black line and diagonal shading) is provided (Data source: GN 2011).

MPA Network Planning and Connectivity

World Wildlife Fund (WWF) Canada identified a potential network of marine conservation areas across the Canadian Arctic (Roff et al. 2020). Areas within the SI AOI and the additional areas near Chesterfield Inlet and the northern part of SI, Roes Welcome Sound, and FS were identified as components in a potential network spanning four of five Canadian Arctic marine bioregions. Scenarios presented for a potential network consistently identify an area around the entrance to Chesterfield Inlet, as well as a larger area extending across the northern tip of SI from southern Baffin Island into Repulse Bay, as significant. This is driven by the presence of the features that have led to the consideration of the region as an MPA, but also shows that the areas under consideration are ecologically relevant across the Hudson Bay Complex marine bioregion. In the future, the SI AOI region would help to form part of a robust, functional MPA network. The WWF report also looked at some measures of connectivity among different sites in the SI AOI (and elsewhere), including an analysis using a model of larval drift over time, at select depths. The analysis showed a degree of connectivity among the components of the potential network around SI.

Evaluation and Revision of Conservation Objectives for the SI AOI

Ecological Significance/Conservation Priorities

The additional areas of the SI AOI (Figure 1) were evaluated and summarized based on unique characteristics identified during the 2011 EBSA selection process and new information in the previous sections of the document. This information builds upon the CSAS meeting held in December 2018, entitled “Ecological and Biophysical Overview of the Southampton Island Ecologically and Biologically Significant Area in support of the identification of an Area of Interest”, and all associated output documents (Loewen et al. 2020a,b, DFO 2020a,c). The information provided in this Science Response Report functions as the basis for assessing ecological significance, knowledge gaps, and vulnerability in the additional areas of the AOI outside the SI EBSA. This updated information will further inform potential conservation objectives as part of the MPA process (see DFO 2020a). Ecologically significant components were identified and discussed for each additional area (Figure 1), and their associated knowledge gaps and vulnerabilities are discussed in the following section.

Chesterfield Inlet (northern portion of the WHBC EBSA)

1. Coastal polynya – The mouth of Chesterfield Inlet is part of a reoccurring coastal polynya that forms along the west side of Hudson Bay. The coastal polynya provides important open-water habitats that support various marine mammal, sea duck, and seabird species for migration, feeding, molting, and reproduction.
2. Anadromous fishes migration corridor and marine feeding region – Anadromous fishes (i.e., *Salvelinus* spp. and *Coregonus* spp.) use the freshwater systems that drain into Chesterfield Inlet proper to complete overwintering, rearing, and reproduction as part of their life cycle. They use estuarine and marine habitats in the region extensively for foraging, and therefore unhindered access to rivers draining into Chesterfield Inlet will be significant for stock health of any anadromous fishes in the region.
3. Beluga aggregation area – WHB Beluga are found within Chesterfield Inlet and at the mouth of the inlet during the summer season (April to November), and use these regions for feeding and a migration route to calving/nursery areas within Roes Welcome Sound.
4. Fall migration area for Polar Bears – The Foxe Basin Polar Bears are thought to have denning areas on the north side of the mouth of Chesterfield Inlet. The mouth of Chesterfield Inlet is also used as an important migration corridor for Polar Bears.
5. Macroalgae and dense kelp beds – Macroalgae communities are present in Chesterfield Inlet proper (up to Baker Lake) and at the mouth of Chesterfield Inlet. The macroalgal communities within, versus those outside the inlet, appear to use different habitat characteristics, and display different species composition.
6. Physical characteristics – Rivers draining into Chesterfield Inlet are a major freshwater source flowing into the SI AOI and have different water mass characteristics in comparison to other areas of the AOI. The formation of an ice bridge typically occurs one in four years (since 1971) south of Wager Bay and north of Chesterfield Inlet in Roes Welcome Sound. This bridge supports Inuit transportation for hunting caribou on the mainland and holds Inuit cultural significance. In addition, the bathymetry of Chesterfield Inlet is characterized by a deeper trough that is associated with high densities of clams and scallops.
7. Benthic biodiversity – Physical oceanographic drivers support a rich benthic ecosystem in the SI AOI region. There is evidence of high regional benthic biodiversity, and a high density

of some benthic species (i.e., clams and scallop beds) in the marine areas near the mouth of the Chesterfield Inlet.

8. Habitat for fishes and marine mammals –The Chesterfield Inlet region of the AOI has key macroalgal habitats and benthic species (i.e., clams and scallops) that support marine fishes and mammals in the region. Marine fishes, such as the Fish Doctor and Arctic Shanny, have strong connectivity and association to the abundance of kelp. Seals, Narwhal, and Walrus also use this portion of the SI AOI seasonally for feeding. Walrus specifically feed upon the clams and scallop beds, and have important haul-out sites near Depot Island.

North side of SI (portion of the RB/FS EBSA)

1. *Complex oceanography* – The northern area of SI is thought to have a distinct water mass, characterized by intense tidal mixing that helps to form the Roes Welcome Sound polynya; mixing also supports a richer pelagic-based ecosystem.
2. *Seasonal habitat use* – The region is a productive summer area (i.e., feeding, birthing, and rearing of young) and is important habitat for a number of species including, but not limited to, Narwhal, WHB Beluga, EC-WG Bowhead, HB-DS Atlantic Walrus, and anadromous Arctic Char. The Duke of York Bay is consistently identified as an area of high seasonal use by many different wildlife.
3. *Productivity and biodiversity* – The northern portion of the SI AOI sits in close proximity to polynya systems that can support diverse and productive ecosystems. Macroalgae communities have been identified along the north side of SI and on the southwest side of White Island, and suggest high abundance (i.e., density and depth) not observed elsewhere in the Canadian Arctic. The Duke of York Bay is observed to have high levels of biodiversity with the presence of numerous marine mammals and fishes (i.e., Killer Whale, Polar Bear, Ringed Seal, Hooded Seal, Bearded Seal, Beluga, Narwhal, Capelin, etc.).
4. *Seabirds* – This region of the AOI is not known to be a hotspot for seabirds, however, sea duck colonies, such as the Common Eider, are associated with reoccurring polynyas and marine habitats. This northern region of the AOI is likely a staging area, breeding area, and migratory corridor for numerous sea duck species. Sea duck feeding occurs in inshore coastal waters. A subspecies of Iceland Gulls, the Thayer’s Gull, is known to have breeding colonies along the northeast portion of SI, Lyon Inlet, and White Island.
5. *Polar Bear denning habitat* – Extensive Polar Bear denning has been identified on White Island and along the northeastern coastline of SI.

Priority Areas

The mouth of Chesterfield Inlet extending inland (Figure 31; light blue shaded region clipped to the 100m bathymetric contour) has been highlighted as a priority area within – and extending a little outside – the SI AOI. Oceanographic evidence suggests a rich benthic driven ecosystem within the region. High benthic richness and diversity was also identified in the marine areas near the mouth of the inlet. Dense scallop and clam beds have been identified running into the mouth of the inlet inland, following a deep underwater trough feature. Their presence supports high-level trophic feeders, such as Walrus and seal species. In addition, the macroalgal forests provide spatially complex benthic habitat to support high levels of diversity. These macroalgal forests create habitats needed for feeding and completing the life cycle (i.e., reproduction and rearing of young) of marine fishes. Macroalgal presence dampens wave action on shore and provides shade for other species, as well as promoting carbon sequestration on a regional level. The inlet itself provides riverine waters to the SI AOI, supporting passage of anadromous fishes between freshwater systems and summer feeding habitats. Polar Bear denning habitat has been identified on the mainland near the mouth of Chesterfield Inlet.

The Roes Welcome Sound area (Figure 31; yellow shaded area) has been highlighted as a priority area within and outside the SI AOI (DFO 2020a) and was extended further northward to the tip of SI by the request of expert participants during the CSAS Science Response (August 26–27, 2020) meeting. Key physical oceanographic drivers occur in this northern section of Roes Welcome Sound, and support the presence and reoccurrence of the polynya. These drivers (i.e., intense intertidal mixing) create conditions of increased productivity within the region, further supporting the presence of high-level trophic feeders. Oceanographic evidence suggests that the northern region of the SI AOI is a rich pelagic ecosystem.

The Duke of York Bay extending around White Island priority area (Figure 31; purple shaded area) has also been highlighted as a priority area within the SI AOI. This region is significant for summer feeding and is a nursery area for diverse high-level trophic feeders (i.e., Narwhal and Bowhead). Five rivers drain into the Duke of York Bay, with both presence of marine fishes and a high abundance of anadromous fish, specifically Arctic Char. The region has macroalgal forests that provide spatially complex benthic habitat to support high levels of diversity. In addition, this region has significant Polar Bear denning habitat. The region has seabird breeding habitat along the northeastern shore of SI, and serves as a migration corridor, staging area, and breeding habitat for sea ducks.

The RB/FS extending to Lyon Inlet priority area (Figure 31; green shaded area) has been highlighted as a priority area within, and extending outside, the SI AOI. This region is a significant summer feeding area for high-level trophic feeders, such as Narwhal and Bowhead Whales. The Lyon Inlet area also supports breeding and nesting colonies for seabirds, specifically Thayer's Gulls.

Although each priority area was selected based upon unique features and processes, it was recognized by the Science Response meeting participants that the Duke of York Bay and RB/FS extending to Lyon Inlet priority areas overlap along the northeast-southeast side of White Island. This overlap is specifically based on high use areas and movements of Narwhal in the coastal areas near White Island. It is further recognized that marine mammal migration corridors occur in this overlapping region of the two priority areas.

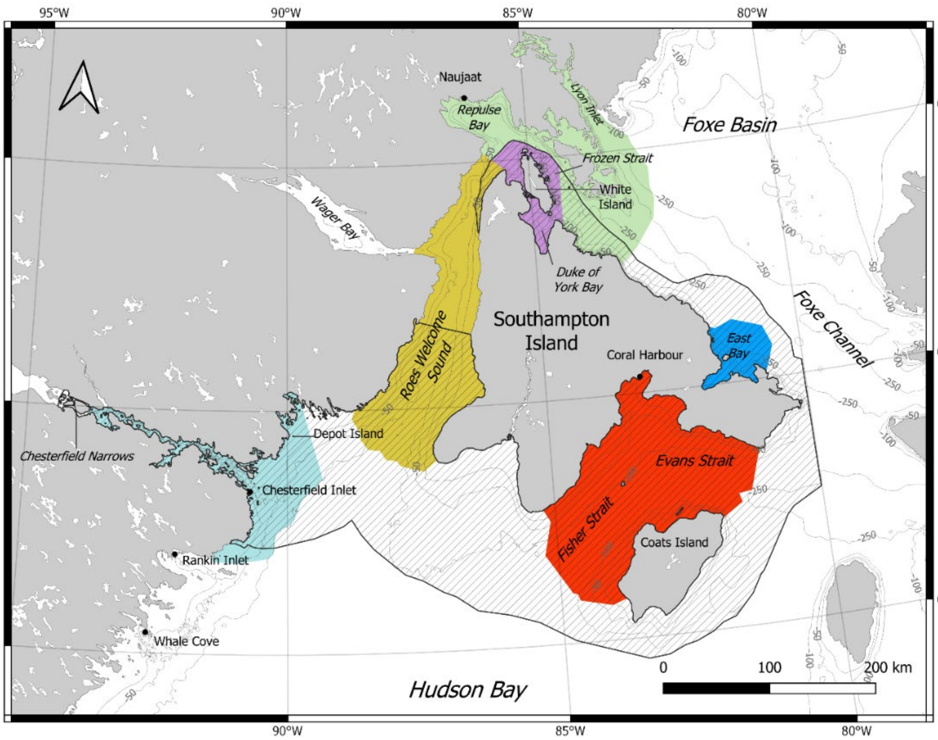

Figure 31. Priority areas for the SI AOI (extending outside the AOI boundary): Chesterfield Inlet (aqua blue), Roes Welcome Sound (yellow), Duke of York Bay extending around White Island (purple), RB/FS extending to Lyon Inlet (green), Fisher and Evans straits (red) and East Bay (blue). Duke of York Bay extending around White Island and RB/FS extending to Lyon Inlet priority areas overlap along the northeast-southeast side of White Island.

Discussion and Revision of Potential Conservation Objectives

The original suggested COs for the SI EBSA are found in DFO (2020a) and are considered for the following revision (underlined sections are the revision of the original CO):

1. to maintain the ecosystem structure (e.g., biodiversity) and function (e.g., productivity) of the SI **AOI**; in particular, these key priority areas: East Bay, Evans and Fisher straits (between Southampton and Coats islands), Roes Welcome Sound, **south of Wager Bay narrows** and **extending north to the tip of SI**, **the mouth of Chesterfield Inlet extending inland to the southeast side of the Chesterfield Narrows, Duke of York Bay extending around White Island**, **RB/FS extending to Lyon Inlet**, and the nearshore coastal marine environment;
2. to mitigate the adverse effects of anthropogenic activities (e.g., vessel traffic and tourism) within the SI **AOI** generally, and particularly in the **six** key priority areas listed in the first CO above;
3. to ensure the sustainability and **population** health of key taxa (e.g., Atlantic Walrus, Arctic Char and other anadromous fishes, seabirds, Polar Bear, Beluga, **Narwhal, Bowhead, Kelp**, Ringed and Bearded Seals) within the SI **AOI**; and,
4. to maintain the presence (quantity, quality, and productivity) of key prey species (e.g., benthic invertebrates, small pelagic fishes, **kelp associated fish communities**, Ringed Seal, **Bearded Seal, Harp Seal**) within the SI **AOI**, and to allow for higher trophic level feeding.

Two of the original suggested COs were eliminated from the list due to the ambiguity of intent and redundancy with aforementioned COs. Information from these two COs were shifted to the knowledge gaps and data deficiency section of the report.

Stressors and Vulnerabilities

Previously reviewed stressors and vulnerabilities from the 2018 process are listed in Loewen et al. 2020a and DFO 2020a. Here we discuss additional stressors and vulnerabilities applicable to this review of new areas, and to the region as a whole:

1. climate change (reduced extent and duration of sea ice, northward range expansion of southern species)
   - Increased presence of Killer Whales in RB/FS that prey upon other marine mammals in the region (Higdon and Ferguson 2009).
   - A shift from Arctic Cod- to Capelin-based food web and resulting implications for higher trophic levels (Kelley et al. 2010).
   - Coastal erosion and sediment loading of nearshore coastal environments.
   - Changing sea ice conditions are thought to disrupt Beluga Whale migration, food web dynamics, and feeding areas.
   - Changing sea ice conditions have resulted in more time on land for Polar Bears, resulting in the potential for increased human-bear interactions.
   - Ocean acidification and its impact on the marine environment and biota.
2. human activities (mining, shipping, tourism, fishing and hunting)
   - Mining (i.e., gold, diamond, and uranium) and associated shipping activities (i.e., presence of large vessels anchoring near Chesterfield Inlet for long periods of time, ballast water discharge, noise pollution, contaminants, spill potential, and ice breaking activities within Chesterfield Inlet to Baker Lake).
   - Installation of submarine fibre-optic cable, either laying on the ocean bed surface or buried (i.e., dredging the ocean floor and disturbing benthic species and habitats), including maintenance of cables.

Knowledge Gaps and Data Deficiencies

Previously reviewed knowledge gaps and data deficiencies from 2018 process on the SI EBSA are listed in Loewen et al. 2020a and DFO 2020a, and are similar to those described for the additional areas assessed in this Science Response Report. The known knowledge gaps and data deficiencies for this region are:

1. Anadromous fish (both Chesterfield Inlet and north side of SI) population estimates, population dynamics, diversity, life histories, freshwater and marine habitat use, and food web ecology are not well known. A stronger understanding of species presence in the region, alongside sample collection for full taxonomic identification, is needed.
2. Marine fish (both Chesterfield Inlet and north side of SI) diversity, life histories, food web ecology are not well known.
3. Limited number of oceanographic studies have been completed for both Chesterfield Inlet and north side of SI. Continued baseline monitoring is needed to better understand water mass sources, exchange and transport, deep-water formation, nutrient and carbon

dynamics, ocean acidification, and sea-ice dynamics. Information on primary productivity and associated oceanographic measurements are also limited presently.

4. Regular marine mammal population estimates for stocks present in summer in the Hudson Bay Complex Marine Bioregion are needed to understand population distribution and abundances in the region.
5. Benthic community diversity and abundance have limited studies for Chesterfield Inlet and are not known for the northern areas of SI AOI. There are limited data on macroalgal ecology and its influence on surface carbon sequestration into deep sediments (i.e., blue carbon production) in the SI AOI. No scientific data on benthic community have been collected to date in Duke of York Bay.
6. There is limited and outdated information on seabirds in the northern areas of SI AOI. There is also confusion whether Thayer's Gulls are different from Iceland Gulls; the breeding habitat on the northeastern side of SI may be highly significant.
7. There is limited and outdated information on sea ducks, and fall migratory pathways of seabirds along the WHB coastline.
8. Zooplankton abundance and species diversity has not been reported for the Chesterfield Inlet and north side of SI portions of the SI AOI.

Conclusions

An assessment of additional areas for the SI AOI has followed on the previous CSAS process entitled: "Ecological and Biophysical Overview of the SI Ecologically and Biologically Significant Area in support of the identification of an Area of Interest" (Loewen et al. 2020a). Proposed potential COs (DFO 2020a) from this process were modified to account for new scientific data assessed for the additional areas. Updated stressors, vulnerabilities, knowledge gaps, and data deficiencies were also identified for both additional areas. Three new priority regions were identified in this Science Response Report, using all information available, including Inuit/local knowledge, peer-reviewed publications, and new unpublished scientific data analysis (i.e., GenICE and SIMEP cruises): 1) the mouth of Chesterfield Inlet extending inland, 2) Duke of York Bay extending around White Island, and 3) the RB/FS Inlet extending to Lyon Inlet. The Chesterfield Inlet priority area was selected based upon high benthic richness and diversity, presence of high-level trophic feeders, spatially complex benthic habitats that supports a high diversity of invertebrates/marine fish life cycles, connectivity to riverine waters to support anadromous fish passage from freshwater systems to marine environments, summer marine feeding habitat for anadromous fish, and Polar Bear denning habitats. The Duke of York Bay area was selected based upon the presence of diverse high-level trophic feeders, summer feeding and calving/nursery areas for marine mammals, the presence of anadromous and marine fishes specifically a high abundance of Arctic Char, the seabird breeding habitat along the northeastern shore of SI, a migration corridor, staging area and breeding habitat for sea ducks, the presence of macroalgal forests, and the presence of Polar Bear denning habitat. The RB/FS extending to Lyon Inlet priority area was selected based upon the summer feeding area for high-level trophic feeders and presence of seabird breeding and nesting colonies (i.e., Thayer's Gulls). The Roes Welcome Sound priority area (DFO, 2020a) was extended northward to encompass the intense intertidal mixing that supports the recurrence of polynyas and a rich pelagic ecosystem. As new information is gathered within the AOI new ecologically significant areas may be identified in the future.

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Appendix 1. Macroalgal identification and collection methods (SIMEP)

At 13 sites in Southampton Island, divers laid 30 m transects along 5, 10 and 15 m depth contours. Along these transects, eight 1 x 1 m quadrats were haphazardly placed and photographed. Photographs were exported into ImageJ and analyzed for percent cover of all kelp species and other macroalgae. Video transects were analyzed by taking frame grabs (10–12 per transect) at regularly spaced intervals along the video (~ 20–30 s depending on total video time). Only high-quality images with a clear view of the canopy or substrate were used. In ImageJ, we overlaid 49 points over each image and identified the seaweeds (or substrate) under each point and calculated a percent cover. Seaweeds were separated into kelps (*Agarum clathratum, Alaria esculenta, Hedophyllum nigripes, Laminaria digitata, Laminaria solidungula, Saccharina latissima, Sacchorhiza dermatodea*), fucoids and fleshy brown macroalgae, *Desmarestia* spp., filamentous red and/or brown macroalgae, and coralline algae. Substrata were classified into bedrock, boulders, cobbles, pebbles, shells, and sand, using a simplified version of the Wentworth scale. For sites sampled with photograph quadrats, substrata type was recorded *in situ* by divers who estimated the percent of total substrate that was bedrock, boulders, cobbles, pebbles, shell, and sand. For sites with only video measures, substrata composition was estimated using the amount of visible seafloor in each frame. For frames with 100% canopy cover and no visible sea floor, substratum was estimated from nearest sections of video. Note, this method could underestimate rock cover at these sites, because it would be more likely to be covered by seaweed than sand. Yet, we found higher canopy cover on sand and pebble substrates. These estimates were verified using dive logs describing substratum from each transect.

Macroalgal biomass collections (SIMEP)

At each site we collected all macroalgae in four 0.25 m^2 quadrats, placed them in mesh bags and brought them back to the ship or onshore to be processed. Macroalgae were only collected if the holdfast fell within the quadrat. All collected seaweeds were identified to species or coarse macroalgal group (red fleshy, brown fleshy, filamentous) and weighed. Each kelp individual was weighed to the nearest g, and total weight of each group of macroalgae recorded. To obtain the proper proportion of kelp biomass per meter square at each site and region, we calculated the kelp mean biomass at each sampling level starting with quadrats within each depth, and then depths within each site, and finally sites within each region.

We identified floating *Saccharina* morphologies, which are sometimes referred to as *S. longicruris* as *Saccharina latissima* based on recent genetic analysis (McDevit and Saunders 2010). However, we saw distinct floating and prostrate morphologies in different regions. We also had issues differentiating *Laminaria digitata* and *Hedophyllum nigripes,* because we were not confident in specific identifications in the field, but *H. nigripes* likely had the more Arctic distribution around Southampton Island.

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