APPENDIX 9C

COASTAL ENVIRONMENT SENSITIVITY MAPPING

CORI: 10-29 (v.16) 10 December 2010

Spill Sensitivity of Proposed Port and Shipping Routes
Mary River Iron Mine Project

prepared for

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Scope of Project
This project considers the potential for open-water diesel spills associated with fuel shipment to Nunavut as part of the Mary River Iron Mine Project; open-water spills could originate from proposed annual shipments of diesel in support of mine operations. The assessment examines potential environmental sensitivity associated with two proposed shipping routes: a northern route to Milne Inlet via Eclipse Sound and a southern route to Steensby Inlet via Foxe Basin and Hudson Strait. The northern shipping routes is 570 km in length and the southern route is 1,610 km.

A worst-case spill of 5 ML is assumed for evaluating impact scenarios. Spill trajectory analyses suggests that a 15km swath to each side of the proposed shipping route is likely to contain a significant proportion of the spill trajectories so a 30-km wide corridor aligned with the proposed shipping routes is used to assess resources at risk within this *area of concern*.

Northern Shipping Route
The northern shipping route enters eastern Eclipse Sound from Baffin Bay and turns southwards into Milne Inlet, at the western end of Eclipse Sound. The proposed unloading port is at the southern terminus of Milne Inlet. The shipping route passes within the 15 km of Pond Inlet village. Approximately 600 km of Milne Inlet-Eclipse Sound-Pond Inlet shoreline lie within the *area of concern* (i.e., the 15 km swath each side of the proposed shipping route). There is an existing sensitivity atlas for this shipping route (AESAS; Environment Canada 2000).

Significant concentrations of narwhal occur in Milne Inlet during the summer open-water season (estimates of up to one third of the total narwhal population; Richards *et al* 2010). Although the sensitivity of narwhal to spills is unknown, the large aggregation of animals in a small area could result in a significant exposure to a worst-case, open-water diesel spill.

There are large aggregations of marine birds along the proposed shipping route, particularly near the eastern mouth of Pond Inlet. Some estimates suggest that as much as 1% of some bird populations could be represented within a single aggregation (Mallory and Fontaine 2004). These aggregations represent a significant concern for a worst-case, open-water spill.

Southern Shipping Route
The southern shipping route enters eastern Hudson Strait, passes close to the community of Cape Dorset and turns northward in Foxe Basin, passing ~15 km offshore from Prince Charles Island and into Steensby Inlet, where the fuel terminal would be located. There are approximately 900 km of shoreline within the *area of concern*, of which 500 km (56%) is located in the Steensby Inlet area. Much of the proposed southern route passes well offshore from Foxe Basin shorelines. There is no pre-existing sensitivity atlas for this route and this study represents a first-order sensitivity assessment based on coastal habitat mapping and published environmental literature.

Significant bird colonies and bird usage occurs along the shorelines of Foxe Basin and Hudson Strait, and the area includes 13 designated Important Bird Areas. Although these areas are generally more than 15 km from the proposed shipping route, birds do forage offshore to considerable distances and may be vulnerable to open-water spills. Hundreds thousands of thick-billed murre fledglings migrate from colonies (Hantzsch Is and Digges Sound) to Newfoundland by swimming.

Estuarine habitats include salt marsh that is an important feeding habitat of geese and also co-occurs with many anadromous arctic char streams. Estuaries in Steensby Inlet and northern Foxe Basin are within 15 km of the shipping route, so have the potential to be contacted in a worst-case, open-water spill.

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1.1 Scope of Sensitivity Assessment

This report provides an overview of potential sensitivity of resources to a open-water diesel spill near the proposed ports and along the proposed shipping routes (Figure 1) through Milne Inlet and Eclipse Sound (Northern Shipping Route; 570 km long) and through Foxe Basin – Hudson Strait (Southern Shipping Route; 1,610 km long). The proposed Mary River Iron Mine project calls for diesel fuel to be shipped to both of the proposed ports during open-water season; fuel will be stored on shore to support year-round operations of the mine. While the potential for large marine diesel spill is considered unlikely, a spill is possible and worst-case spill scenarios are developed for both the port areas and for the shipping routes.

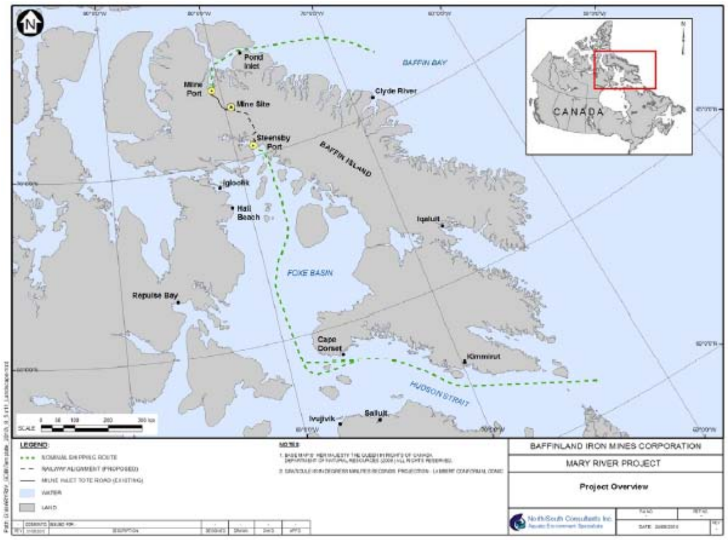

Figure 1 Proposed Northern and Southern Shipping routes for the Mary River Iron Mine project.

The risk assessment that identified a 5 ML spill as a "credible, worst-case spill scenario" are identified in a separate document (AMEC 2010a, b). The spill scenarios are used as first approximation to evaluate potential contact with pelagic and coastal resources. While some of the aspects of a spill are known (product type, season of spill), the location of a potential spill could include any place along the proposed shipping routes. As such, resources within a probable spill envelope are considered in this assessment.

There is shoreline sensitivity mapping information for the northern shipping route (Arctic Environmental Sensitivity Atlas System, AESAS; Environment Canada 2000) but there is no existing sensitivity mapping for shorelines along the southern shipping route. Reconnaissance-level shoreline habitat mapping was developed for the Foxe Basin-Hudson Strait shipping route (methodology described in Appendix A) as part of this assessment. Information on other resources that could potentially be affected by a diesel spill were compiled from existing data sources.

The overall approach of this assessment is to identify the resources that may be present near the shipping route at the times when a spill could occur (i.e., open-water season). This involves mapping the resources and knowing some thing about the resources life cycle and seasonal use of habitats. Previous experiences of similar diesel spills provide some additional information on the potential extent and longevity of a spill before it dissipates. In the assessment of potential spill effects on resources, the concepts of ***sensitivity*** of a resource to a spill and the ***risk*** of contact with a spill are considered.

Sensitivity

For this assessment, we considered sensitivity as the ability of a resource to recover in the event of contact with a diesel spill. The ability to recover is a factor of: (a) the sensitivity of an individual to toxicity posed by a spill, (b) the percentage of a population that could potentially be affected by a spill and (c) the general health of the population (e.g., cumulative effect). For example, most species of seabirds are considered sensitive to a spill (contact with a spill is usually be lethal) but if their population is widely distributed then even though a number of individuals may be killed, the recovery potential is good and the resource is considered to have a low sensitivity to the spill scenarios. However, a seabird group that tends to aggregate, where a large part of population could be exposed to the spill, would be considered highly sensitive. There are some resources where the sensitivity to the spill toxicity is not known (e.g., narwhal). Because narwhal aggregate with a significant portion of their population in a small area, they would be considered *potentially* highly sensitive.

Risk

The use of the term “risk” in this assessment is to identify the likelihood of overlap between a resource and the spill. For the assessment, we assume that a spill has occurred (admittedly, a very low probability) and examine the likelihood of a resource to be contacted. In some cases, the resource is not present (e.g., juvenile arctic char out-migrate through estuaries during freshet when there is little chance of a spill) or is in very low densities (e.g., ringed seals) so the risk of contact is low.

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2.1 Diesel Weathering

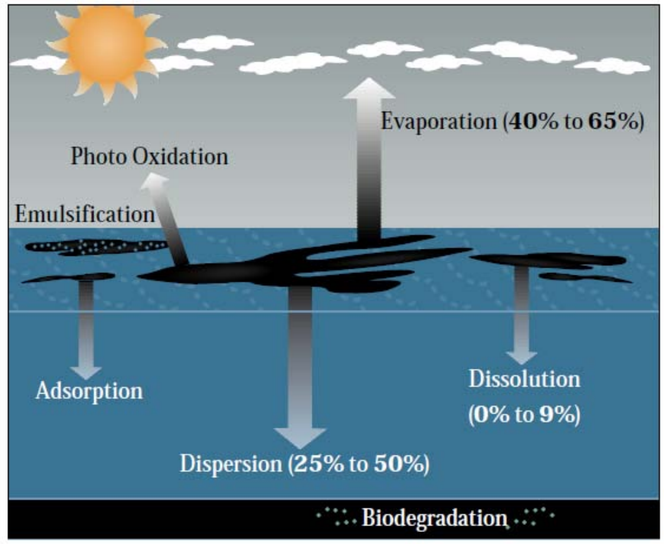

Figure 2. Weathering processes that affect diesel spills (from NOAA 2010a).

Diesel is a relatively volatile fuel and will weather rapidly when spilled on water. Diesel is classified as a low-viscosity, Group 2 fuel (Roberston *et al* 1997) and when spilled on water, rapidly spreads and thins (Fig. 2; NOAA 2010a). A spill weathering model that predicts the fate of spills based on fuel properties as well as environmental conditions such as water temperature, winds speed, etc. (NOAA 2010b) shows the weathering of diesel under conditions that are likely to similar to the proposed shipping routes (Fig. 3). The model shows that approximately 90% of the spilled fuel ("diesel, "Canadian") is likely to be weathered within 96 hr of the spill initiation, where weathering includes evaporation into the atmosphere (~60% by volume) and dispersal into the water column (~ 30% by volume; Fig. 2, Fig. 3). The type of diesel used in the models is important as different diesels have different weathering properties, where "heavier" diesels show much lower evaporation rates and higher in-water dispersion rates (Fig. 4).

In most cases, the modeling indicates that the worst case diesel spill of 5 ML is likely to have a relatively short duration, in the order of days to weeks. Lighter diesel fuels, high winds and warmer water temperatures are all factors that would lead to shorter duration of the diesel slicks on the water surface. Depending on weather conditions at the time of the spill, the spill may contact shorelines, where continued weathering will take place.

As the fuel weathers, it becomes more dense and more viscous. The most toxic components of a diesel fuel tend to evaporate rapidly during the early part of a spill (benzenes evaporate completely within 8-12 hr after the spill).

2.2 Port Spills

Proposed port locations in Milne Inlet in Eclipse Sound, and Steensby Inlet in Foxes Basin were assessed for spill potential in separate modeling efforts (AMEC 2010a, AMEC 2010b). A probability map for open-water spill potential in Milne Inlet is included in Figure 5. This map provides a summary of 900 model runs of the spill scenario using a variety of historical wind data to realistically emulate open-water wind conditions within Milne Inlet (AMEC 2010a). The modeling indicates 98 % of the slicks are occur within a 2 km radius of the spill site. The modeling further indicates that most of the spills contact the shoreline and a substantial amount of the total spill is likely captured on nearby beaches, assuming no mitigation takes place. Of the 900 model runs, only two resulted in shoreline contact within Koluktoo Bay (AMEC 2010a). The

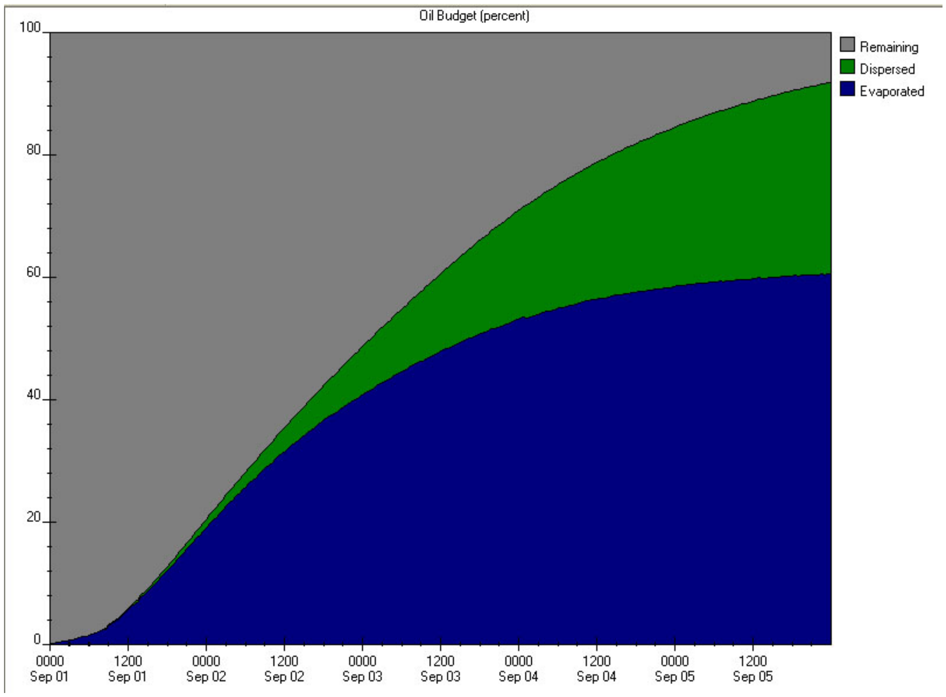

Figure 3. Weathering characteristics of a 5 ML (43,000 bbl) diesel spill in 2° C waters under moderate wind and wave conditions. “Canadian diesel” (see ADIOS2 model) is used as the spilled fuel.

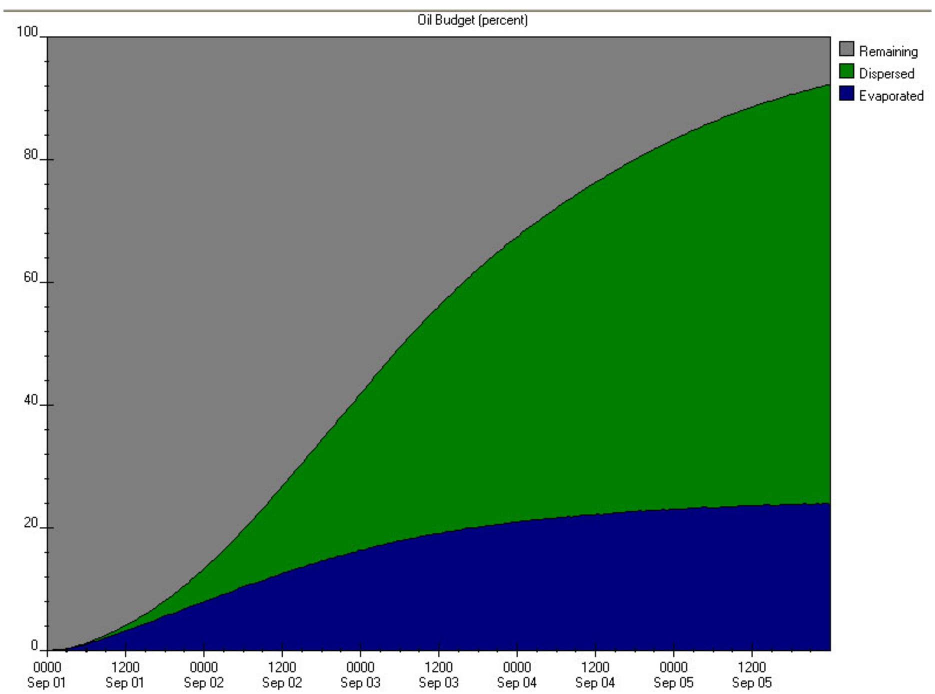

Figure 4. Weathering characteristics of a 5 ML (43,000 bbl) diesel spill in 2° C waters under moderate wind and wave conditions. “USA Southern” diesel (see ADIOS2 model) is used as the spilled fuel. Note the significantly lower evaporation rates and higher dispersion rate of this diesel type.

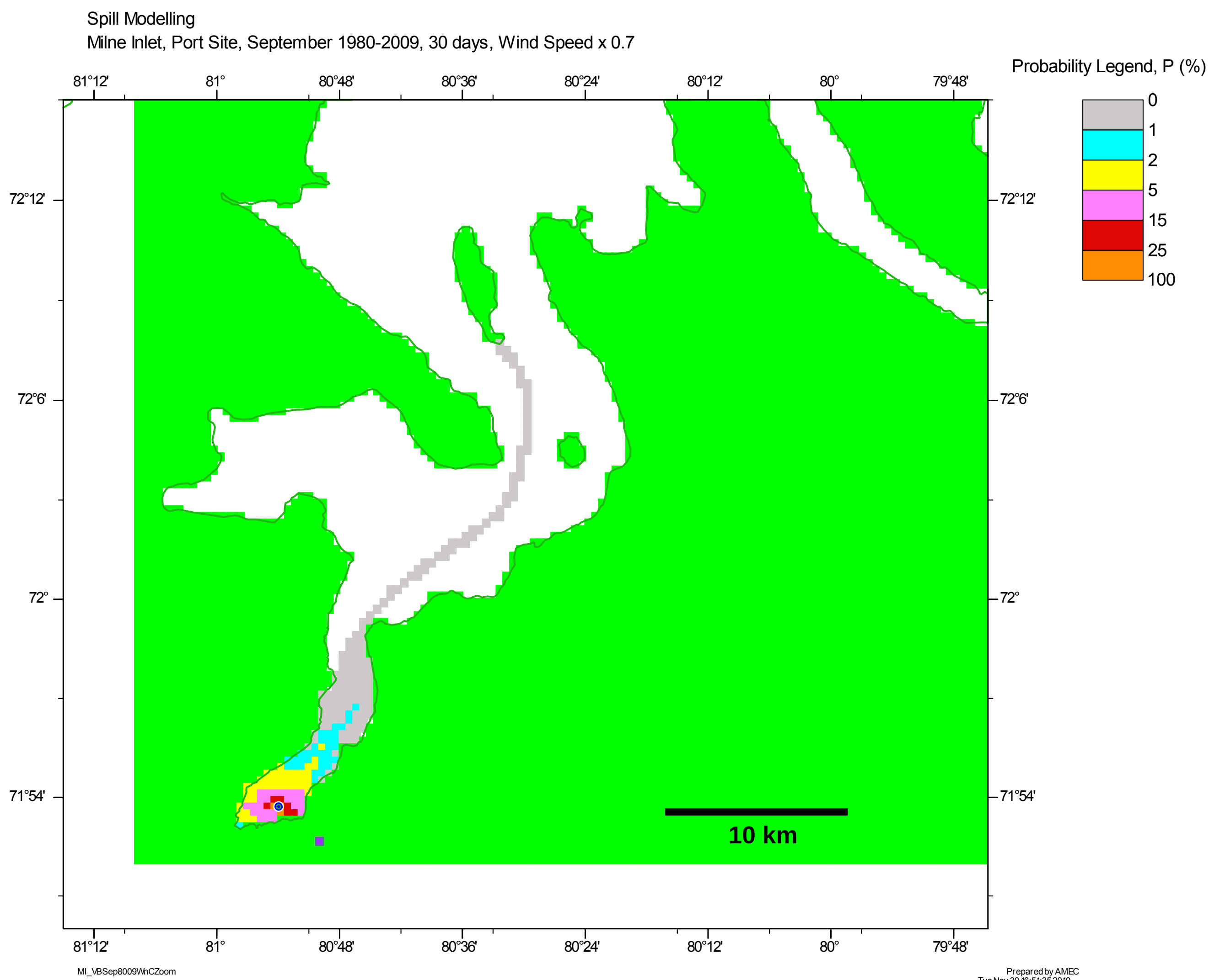

Figure 5. Probability envelopes from 30 years of wind data (900 individual trajectories using long term wind data for the Milne Inlet area). The yellow coloring indicates the 98% probability envelope (that is, 98% of the modeled spills are within this envelope – a maximum of <2 km from the spill site (from AMEC 2010a).

modeling indicates a total of <15km of shoreline are contained within the 98% probability envelope.

A probability map of open-water spill potential for Steensby Inlet is shown in Figure 6. Again the 98% probability envelope shows the limit of the vast majority of the modeled, open-water spills from a proposed port within Steensby Inlet. This 98% probability envelope is a maximum of 15 km from the proposed port and spill site. In the case of the Steensby Inlet modeling, the length of shoreline within the envelope is <15km and the radius of the 98% envelope is approximately 13 km.

There is good potential for mitigation in the port areas as there will be a support vessels and likely would be staging areas for response equipment in both port areas.

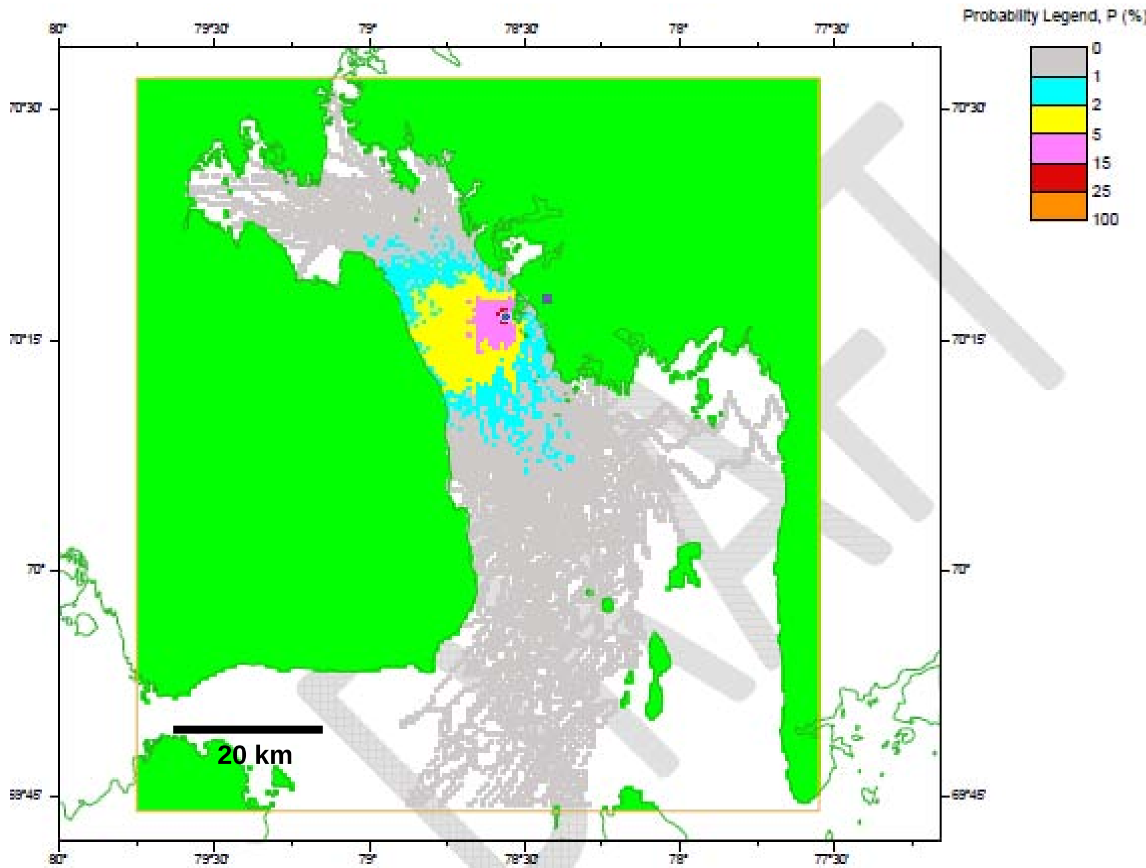

Figure 6. Probability envelopes from 900 individual trajectories using long term wind data for the Steensby Inlet area. The yellow coloring indicates the 98% probability envelope (that is, 98% of the modeled spills are within this envelope – a maximum of 13 km from the spill site (from AMEC 2010b).

2.3 Shipping Route Spills

The proposed northern shipping route is an estimated 570 km to Baffin Bay and the proposed southern shipping route is 1,610 km to Davis Strait. No site specific spill scenarios along the shipping routes have been run. There are a very large number of potential spill scenarios that could be run along the two proposed shipping routes to accommodate differing coastlines, tidal current regimes and localized wind climates. In particular, the spill location is unknown and tidal currents outside of the port areas are poorly understood so forecasting becomes very hypothetical. Using the results from the more detailed modeling for the Steensby Inlet spill modeling, a ‘generic spill’ with a 15 km spill radius is assumed for the shipping routes. That is, a swath of 15 km each side of the proposed shipping route (Fig. 7, 8) is assumed to contain 98% of the possible trajectories for an open-water diesel spill. The assumed swath width is based on review of the Steensby Inlet probability plots and provides a first order approximation of possible worst-case spill extents, recognizing that tidal currents and wind regimes may differ in other regions. This swath is used to identify potential resources at risk from an accidental, worst-case spill.

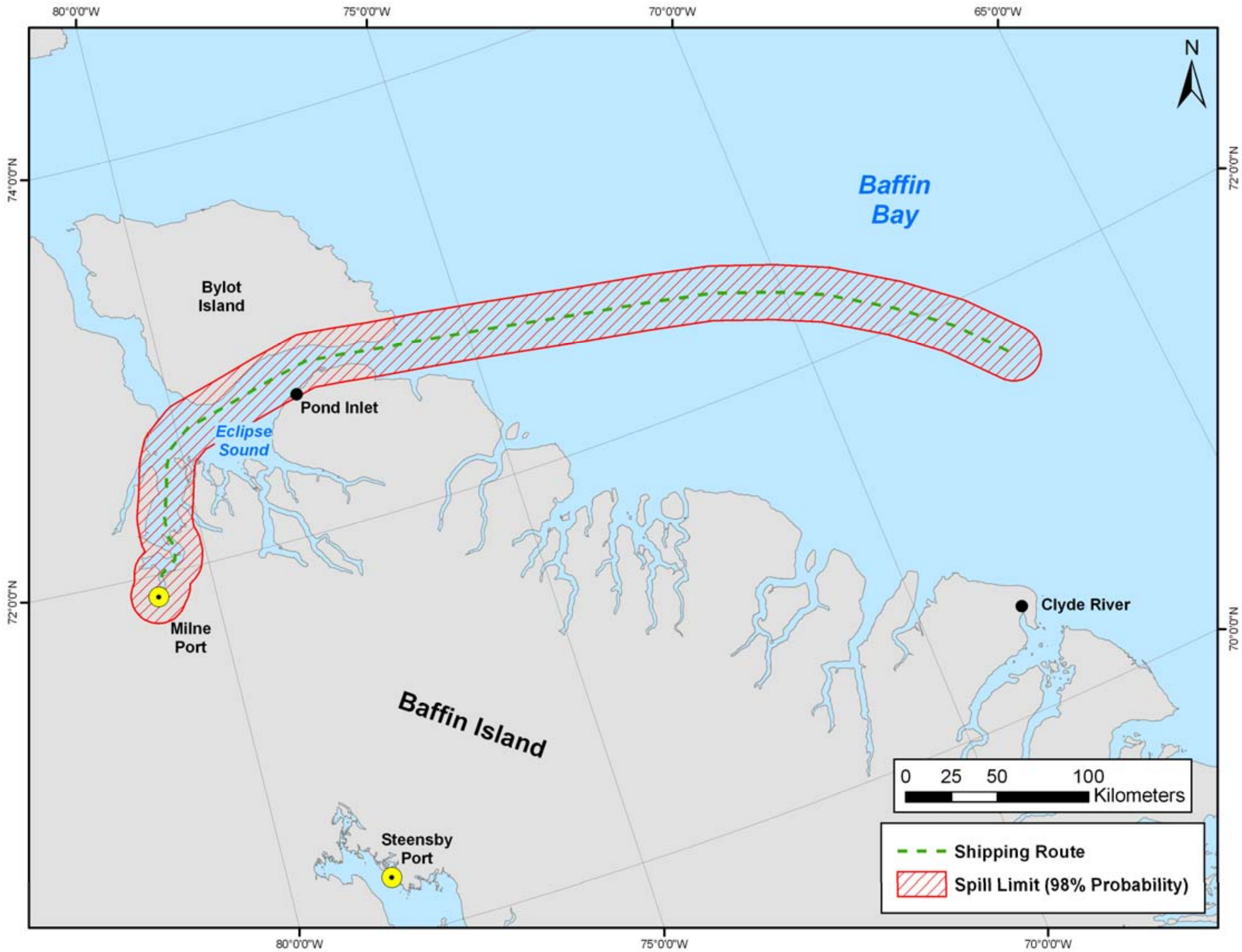

Figure 7. Approximate proposed northern shipping route with a 30km swath (15 km to each side of the proposed route), which nominally encompasses the 98% probability envelope for spills. Note that specific spill trajectory models have not been run along the proposed route.

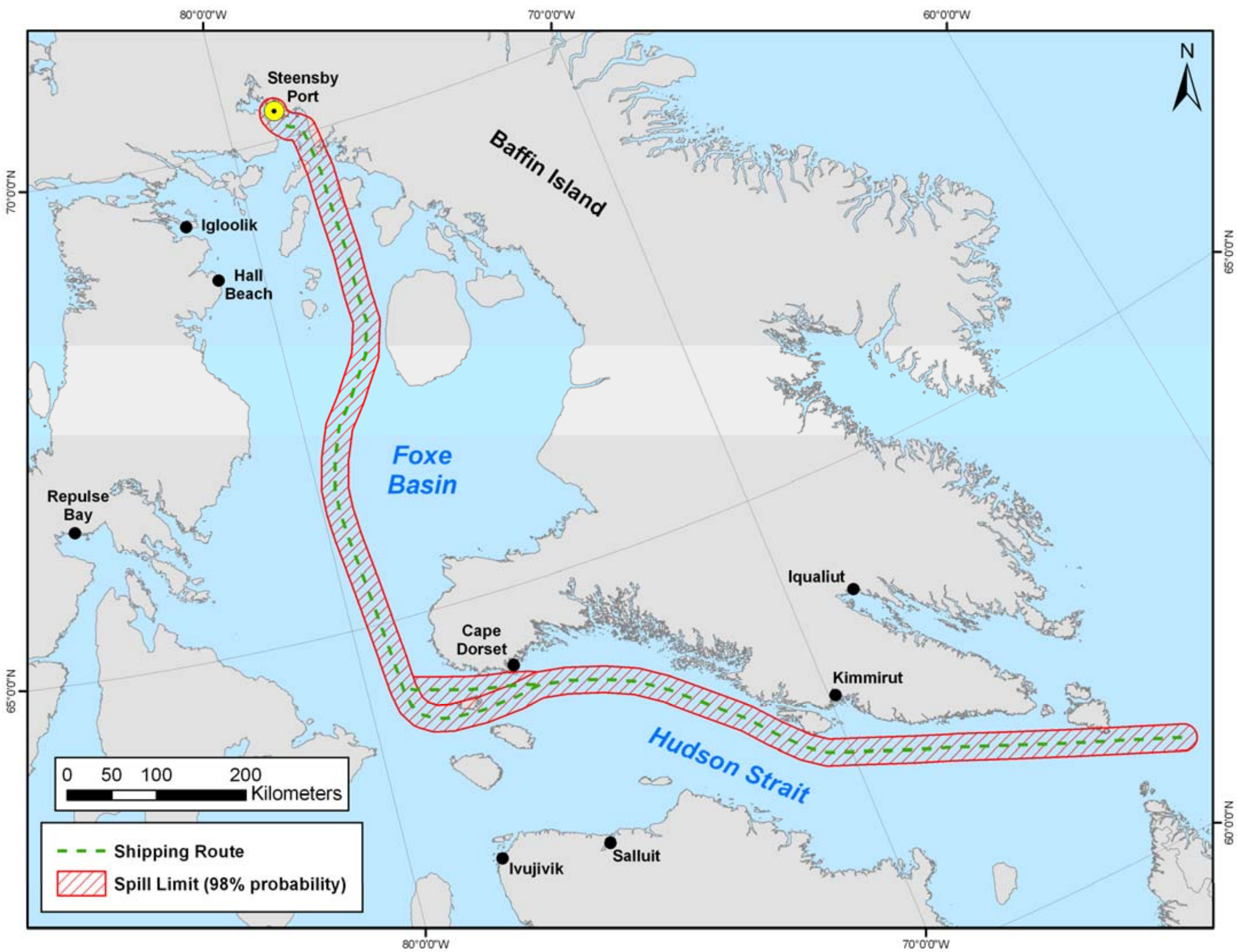

Figure 8. Approximate proposed southern shipping route with a 30 km swath (15 km to each side of the proposed route), which nominally encompasses the 98% probability envelope for spills. Note that specific spill trajectory models have not been run along the proposed route.

Typical slick sizes (>1 micron thickness) for such a spill are 18 km^2 after one day, 35 km^2 after two days, 50 km^2 after three days and 70 km^2 after four days (John McClintock, AMEC Earth and Environmental, pers. com. 2010). If slicks encounter a shoreline, some fuel will adhere to intertidal sediments, particularly in the upper intertidal zone, where longer substrate drying times occur. Because diesel is non-viscous, there is potential for penetration into intertidal sediments. On the other hand, diesel spills are typically very thin, so the overall volumetric loading to a shoreline is low, limiting the amount of penetration that could occur. In the port spill modeling (AMEC 2010a, AMEC 2010b), the total shoreline contacted by sheens is less than 15 km. For the shipping route spill assessment it is assumed that *a few tens of kilometers of shoreline oiling could occur in worst-case scenarios where shorelines are within 15 km of the shipping route.*

In summary, the key elements of our spill sensitivity assessment assume the following spill features:

- a worst case spill of 5 ML of diesel (assume ADIOS2 “diesel [Canada]” fuel type NOAA 2010b).
- the spill occurs near the centre of the proposed shipping lane.
- it is highly probable that the spill will be largely confined to a 15 km swath on each side of the shipping lane.
- slick areas are in the order of 18 km^2 after one day and 70 km^2 after seven days.
- shorelines within 15 km of the shipping lane may be contacted by the spill; if they are contacted, it is likely that worst-case contact would be a few tens of kilometers (not 100s of kilometers).
- in general, diesel slicks are thin (~1-10 microns) so that should shoreline contact occur, loading levels are low.
- shorelines outside of 15 km from the shipping lanes are unlikely to be contacted.
- a spill would be most toxic, shortly after the spill, before significant weathering has taken place; locations more distant from the centre of the shipping lane would experience lower toxicity levels.
- spill scenarios assume no mitigation; in some locations, particularly near the port sites, there is good potential for mitigation.
- diesel persistence is relatively short – generally a matter of days and at worst case one to two weeks.

One of the assumptions fo this assessment is that spills are likely to originate along the proposed shipping routes. However, one of the principal causes of spills is navigational error where the vessel deviates from it planned track. This assessment does not considered the potential deviation of ships from the planned route and such deviations will increase the areas of concern.

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3.1 Overview of Resources at Risk

There are approximately 2,200 km of proposed shipping routes for the Mary River project and assuming a 30 km swath for the spill probability envelope, there are approximately 70,000 km^2 of areas at risk (18,000 km^2 on the northern route and 52,000 km^2 on the southern route). Some shoreline falls within the 30 km swath – 600 km of shoreline on the northern route and 900 km of shoreline on the southern route.

Resources at risk include: coastal habitat, marine mammals, coastal and marine birds, marine fish and lower trophic resources (e.g., plankton, invertebrates). In addition, there are some human-use activities that could be impacted by an open water spill. An environmental atlas for use in spill planning and response has been assembled for the northern route (Environment Canada 2000) but there is no on-the-shelf atlas available for the southern route. Appendices A and B describe reconnaissance coastal habitat mapping compiled for the southern route and existing data sources are used to define some resources at risk along the proposed Foxe Basin shipping route.

3.2 Coastal Habitat at Risk

Coastal Vegetation

There are two special biotic habitats that could be impacted by a spill: *salt marsh* (Fig. 9, 10) and the attached macro algae *Fucus* (Fig. 11). Salt marshes occur in the upper intertidal zone and *Fucus* seaweed is more common in the lower intertidal zone.

Figure 9. Salt marsh in the upper intertidal zone of Steensby Inlet. Salt marsh was mapped along 13% of the shoreline in Steensby Inlet (CORI 2008a).

Figure 10. Detail of upper intertidal salt marsh showing extensive grazing of plants, high water table and iron oxidation.

Figure 11. The macroalagae *Fucus* in the lower intertidal zone of a Steensby Inlet beach. *Fucus* seaweed was mapped along 45% of the Steensby Inlet shoreline (CORI 2008a).

Salt Marsh

Johnston and Pepper (2009) used Morrison's (1997) habitat classification to stratify sampling in their investigation of breeding birds and habitat associations on Prince Charles and Air Force Islands. The salt marsh habitat category is described as having > 50% vegetation cover, with dominant species as salt-tolerant grass, (*Puccinellia*), bear sedge (*Carex ursina*), and salt marsh starwort (*Stellaria humifusa*). Substrate moisture was described as 'saturated' (Fig. 10).

The zonation of salt marsh plant community on Bray Island, in northeast Foxe Basin, is described by Dansereau (1953), as having 'large expanses' of the salt grass *Puccinellia phryganodes*, dominating the upper intertidal marsh, in particular in sheltered bays and coves. At the upper edge of the salt marsh, colonies of *Cochlearia groenlandica* and *Stellaria humifusa* occur. Dansereau (1953) also describes the only rooted vascular plants found on sandy beach habitats, as occasional occurrence of oysterleaf (*Mertensia maritima*) in shallow depressions in the sand.

Sub-arctic salt marshes in southern Hudson Bay are heavily used as breeding and feeding grounds by lesser snow gees and Canada geese (Cargill and Jeffries 1984). The researchers describe the salt marsh assemblages as 'dominated by *Puccinellia phryganodes* and *Carex subspathacea'*. Although somewhat south of the Foxe Basin and Hudson Strait shorelines, the description of the dominance of the salt marsh by these same species as are characterize the salt marsh assemblages further north shows that it's likely that coastal salt marshes throughout the whole region are dominated by the same species of *Puccinellia* and *Carex*.

The species richness of Arctic and sub-Arctic salt marshes is described as 'low' compared to temperate marshes (Perillo *et al* 2009) and the common species that have circumpolar distribution is the grass, *Puccinellia phryganodes.* Individuals are extremely resilient to harsh environments and can withstand months of frozen ice conditions. The sedge *Carex subspathacea* is also widespread circumpolar species which tends to occur in more brackish water areas than does the *Puccinellia.* Several other salt marsh species are listed by Perillo *et al* (2009) from south Hudson Bay surveys.

Salt marshes are generally regarded as sensitive to spills because of their oleophillic nature (oil tend to stick to organic substrates) and because they almost always occur in low-energy environments where natural recovery rates are low (Hayes *et al* 1992/2001; Hoff 1995; Owens and Sergy 2004; Peterson *et al* 2002). Plants may suffer direct mortality from oiling or lower growth rates from oil retained in associated peat substrates.

Mitigation is problematic as salt marshes are very sensitive to trampling (Hoff 1995). Natural recovery is usually the preferred response option supplemented by spot sorbent and flushing treatments where appropriate (EPPR 1998).

Macroalagae

Fucus seaweed is common along the coast of Eclipse Sound and Foxe Basin. CORI (2008a) mapped *Fucus* seaweed along 57% of the Milne Inlet shoreline and along 45% of the Steensby Inlet shoreline. *Fucus* is likely to have similar occurrences throughout Eclipse Sound and Foxe Basin. Fucus occurs both within the intertidal zone (Fig. 11) and in the subtidal (CORI 2008b; 2008c, Wilce 1997). The ecological significance of *Fucus* for these regions is uncertain, although it does represent primary productivity and it is widely distributed.

Intertidal zone fucus would be vulnerable to fuel contact during low tides. *Fucus* experienced mortality and damage during the *Exxon Valdez* spill (Driskell *et al* 2001), although it was difficult to separate the effect of oil impacts from that of the cleanup. It is likely that *Fucus* would experience both mortality and damage as a result of contact with a diesel spill. However, given that *Fucus* is widely distributed both alongshore and within the subtidal and that potential spill impacts are for limited extents of shorelines (tens or kilometers or less), it is likely that recovery would be substantial within one generation.

Northern Route

There are approximately 600 km of shoreline within the proposed northern shipping route *area of concern.* Shore types and sensitivity were extracted from the Arctic Environmental Sensitivity Atlas System (AESAS; Environment Canada 2000). Those shore types that overlap with the northern shipping route *area of concern* are summarized in Table 1. The synthesized sensitivity values are listed in Table 2 (note that

Table 1. Summary of Northern Route Shore Types

Shore Type	km
Beaches	152
Barrier Beaches, Spits w Lagoons	8
Large Delta Complexes	12
Bedrock Cliffs/Talus	420
Total:	***592.***

the AESAS sensitivity assessments were based on the assumption of a heavier fuel spills, e.g., crude oil or bunker oil, and are not directly relevant to the open-water diesel spill consider in this assessment).

Table 2. Sensitivity Classes in Area of Concern

Sensitivity	km
Extreme (red)	0
High (orange	396
Moderate (yellow)	186
Low (green)	9
Total km	***592***

The AESAS data do not include intertidal biota, but mapping of the Milne Inlet portion of the northern shipping route (CORI 2008a) indicates that salt marsh is rare (est. 4 % of shoreline) and *Fucus* seaweed is common (est. 57% of shoreline). It is likely that these estimates are relevant to remainder of the proposed route.

Worst case spill scenarios suggest that up to “a few tens of kilometers” of shoreline could be impacted in a worst case spill (AMEC 2010a). While persistence of diesel on the water surface is likely to be days to a week, some diesel is likely to contact the shore, especially within the narrow Milne Inlet. Surficial sediments are coarse (CORI 2008a), generally a pebble-cobble-bounder veneer over sand but the immediate subsurface of sediments in low-energy areas may be silt and sand, which significantly reduces penetration and retention potential. Diesel spills are typically thin, except near the immediate source of the spill, so the overall loading of fuel to shoreline substrate is low and persistence is likely to be *days* to *weeks*, except very close to the spill site, where greater penetration and retention could occur (McLaren 1985). Greatest persistence is likely to be in upper intertidal zones (Owens and Sergy 2004).

Retention in salt marshes, which are known to occur along at least 5% of the coast, may be *weeks* to *months*. It is likely that diesel contact would cause mortality and damage to salt marsh plants.

A worst case diesel spill is likely come into contact with *Fucus*, a seaweed commonly visible in the lower intertidal zone that occurs along more than 50% of the shoreline within Milne Inlet. Since *Fucus* is in the lower intertidal it would come into direct contact with surface slicks only at low tide and this could cause mortality and damage, but only to shorelines contacted by fuel (e.g., less than a few tens of kilometers). Since *Fucus* is widely distributed along the shore (CORI 2008a) and within the subtidal (CORI 2008b) recovery potential is considered good. Dispersed fuel within the water column may cause damage but since the effect is likely to be short, recovery potential is considered good.

Southern Route

Coastal habitats have not been systematically described in a format similar to that of the Arctic Environmental Sensitivity Atlas System (AESAS; Environment Canada 2000). A reconnaissance level characterization was conducted to address this deficiency. The methodology used to complete this mapping is described within Appendix A, and the coastal habitat types mapped are described in detail within Appendix B. An estimated 36,221 km of coastline were mapped.

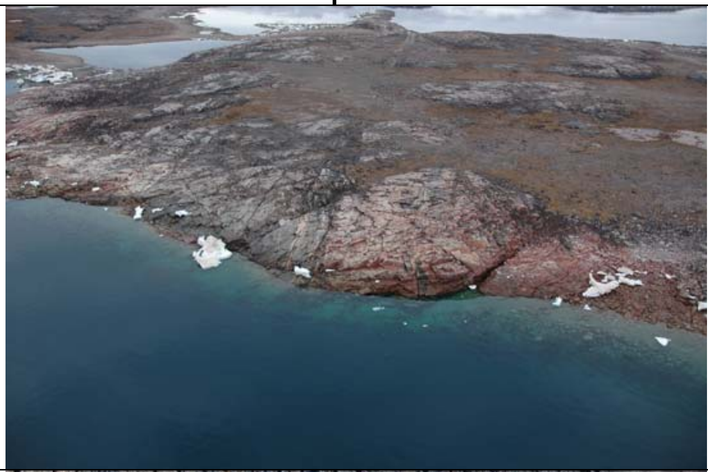
Table 3 shows the relation of Foxe Basin Shore Types mapped as part of this study and the standard Environment Canada (Owens and Sergy 2000, 2004) shore types.

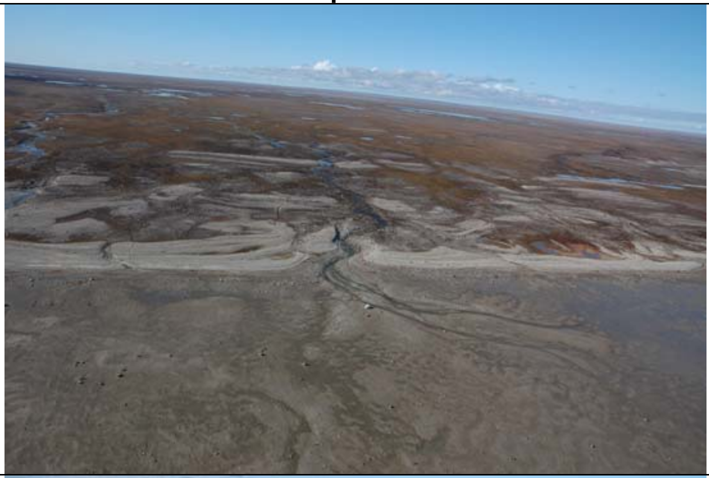
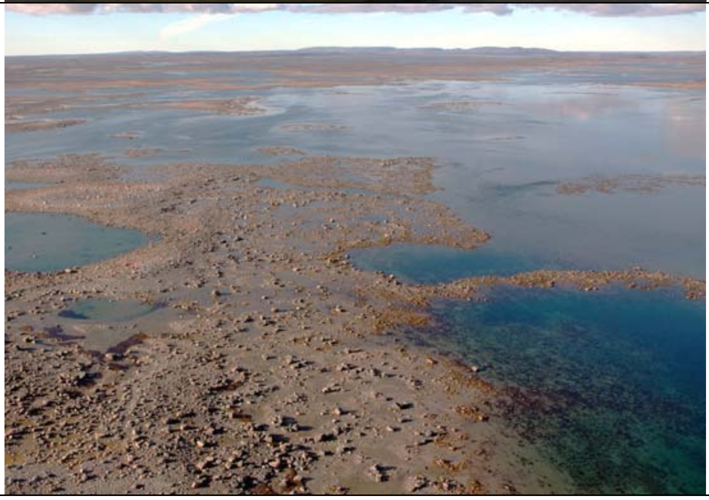
Table 3. Comparison of Foxe Basin and SCAT Shore Types

Foxe Basin Mapping Shore Types	**Environment Canada SCAT Shore Types** (after Owens and Sergy 2000, 2004)
Bedrock	Bedrock
Beach	Sand & Gravel Beaches, Sand Beaches, Pebble-Cobble Beaches, boulder Beaches
Tidal flats	Mud Flat, Sand Flats
Tidal Flats w Ridge & Swale	Mud Flats, Sand Flats, Salt Marsh
Delta Complexes	Sand Flats, Salt Marsh
Lagoon Complexes	Sand Beaches, Sand & Gravel Beaches, Salt Marsh, Inundated Tundra

Table 4 summarizes key features of the Foxe Basin Shore types that were mapped as part of this assessment (see Appendix B for more detail).

Table 4. Summary Description of Foxe Basin Shore Types

Foxe Basin Mapping Shore Types	Example Photo
Bedrock bedrock control, usually narrow and steep. May include some coarse sediment pocket beaches.	
Beach mostly coarse sediment, boulder-cobble over sand matrix but lower energy beaches may include silt. Usually <50 m wide. May include salt marsh in low energy areas.	
Tidal Flats wide intertidal flats – often >1 km in width. Discontinuous coarse sediment (boulder-cobble) over sand. Upper intertidal coarse sediment beach	

Foxe Basin Mapping Shore Types	Example Photo
Tidal Flats w Ridge & Swale wide intertidal flats, often >1 km in width. Discontinuous coarse sediment (boulder-cobble) over sand. Upper intertidal includes berms. Ridge and swale lagoons in backshore with salt marshes in swales.,	
Delta Complexes River-mouth areas with delta flats and distributary channels, frequently with large salt marsh areas. Estuaries are major conduit for anadromous fish.	
Lagoon Complexes lagoon complex areas with high crenulated, complex shorelines. Salt marshes are common. Very low wave energy levels.	

Note: see Appendix B for detailed description of Foxes Basin Shore Types

Figure 12 schematically shows the occurrence of coastal habitats within the Foxe Basin – Hudson Strait region. Of the 36,000 km of shore habitat mapped, an estimated 891 km of shoreline fall within the area of concern (see Fig. 8), much of which is within Steensby Inlet and the northern-most portion of Foxe Basin (497 km or 56%).

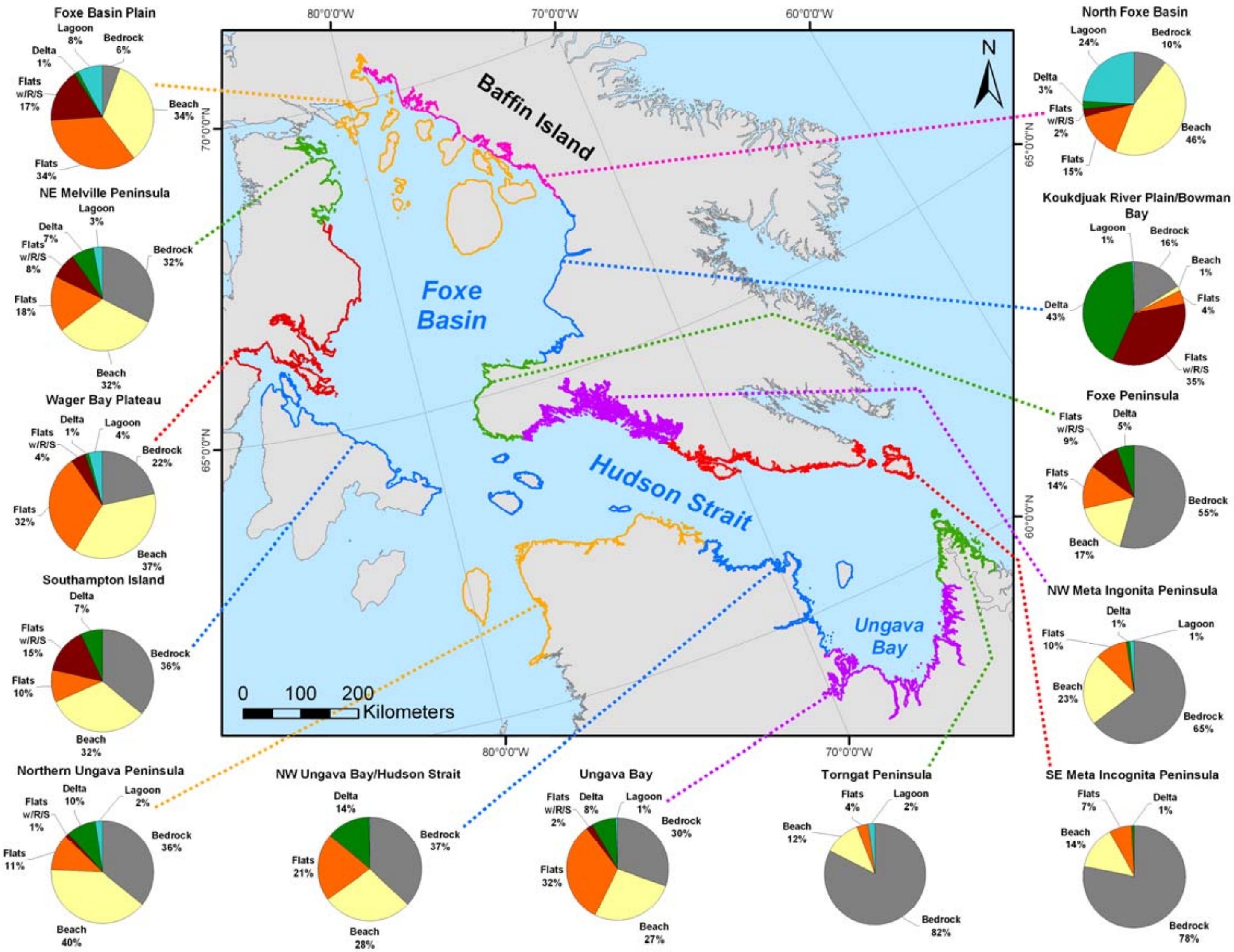


Figure 12 Summary of coastal habitat occurrence in Foxe Basin. The summaries are based on 36,000 km of imagery classification (see Appendix A and Appendix B) of 13 Coastal Regions using Goggle Earth imagery.

3.3 Marine Mammals at Risk

Northern Route

Table 5 summarizes marine mammal occurrence from the Arctic Environmental Sensitivity Atlas System (AESAS; Environment Canada 2000) relative to spill scenarios for the proposed northern shipping route .

The AESAS (Environment Canada 2000) data indicate there is potential overlap of the spill scenarios and known occurrences of marine mammals along the proposed northern shipping route. Of particular concern would be the presence of large portions of the total narwhal population in western Eclipse Sound and Milne Inlet (Richard *et al* 2010). While the potential effects of a diesel spill on narwhal are unknown. The effects of oil spills on marine mammals are difficult to predict (Salazar 2003) and defining petroleum toxicity in marine mammals as a result of oil spills has not been conclusive (Engelhardt 1983; Short 2000). For example, it has been suggested that there is no conclusive evidence that there are acute or chronic effects on cetaceans from hydrocarbon contamination associated with oil spills (Short 2000). Engelhardt (1983) identified that the susceptibility of marine mammals to petroleum toxicity is not general, and that species-specific responses occur although correlation and inferences often are required to predict effects. Furthermore, numerous causal relationships between oil spills and marine mammal mortalities have been suggested by post-spill investigations and studies, but these claims have often been debated and/or considered unsubstantiated (Short 2000; Engelhardt 1983) (e.g., AB killer whale pod mortalities and *Exxon Valdez* spill).

Milne Inlet Port Area

Milne Inlet is an important summering location of narwhal and is also used by beluga and bowheads. The frequency of use in the proposed port area is unknown. the risk of contact by a spill in Milne is considered *high*.

In the event of a diesel spill in the port area of Milne Inlet, there is some potential for mitigation as there are support vessels that could assist in the deployment of hazing devices. Narwhal or bowhead could be temporarily displaced from a spill area by using acoustical devices, although a hazing plan, appropriate equipment and regulatory approval would be required prior to such a program.

Southern Route

A number of marine mammals use Foxe Basin and Hudson Strait seasonally and are potentially vulnerable to a worst-case diesel spill. Key marine mammal species include: bowhead whales, beluga whales, narwhals, walrus, and seals.

Bowheads

The Fury and Hecla Strait area is the primary summering are for bowheads within Foxe Basin (Fig. 13). Polynia in the Hudson Strait area provide an important wintering area for bowhead whales (Fig. 13). The overall proposed open-water, southern shipping route does not overlap with bowhead habitat and bowheads are considered at *low* risk of contact from an open-water diesel spill.

Belugas

The use of Foxe Basin and Hudson Strait by beluga is shown in Figure 14. While there is some open-water use of Foxe Basin and Hudson Strait, the core areas of beluga use are in Hudson Bay, Frobisher Bay and Lancaster Sound. In general, the proposed open-water, southern shipping route does not overlap with beluga core-use areas. Belugas are considered at low risk from an open-water diesel spill.

Table 5. Summary of Marine Mammal Concerns from AESAS (Environment . Canada 2000)

Location	Marine Mammal Concerns	Months	Reference
Milne Inlet	Milne Inlet, Tremblay Sound, and Koluktoo Bay are a major summering ground for narwhals	Jul, Aug, Sep	AESAS Na88, Na89 Finley and Gibb 1982 Koski and Davis 1979 Mansfield *et al* 1975 Silverman 1979
	Bowhead whales frequent Eclipse Sound and Milne Inlet	Jul, Aug, Sep	AESAS Bh89 Davis and Koski 1980
SW Bylot Is (Eclipse Snd)	Eclipse Sound is a major summering area of narwhal	Jul, Aug, Sep	AESAS Na87 Finley and Gibb 1982 Koski and Davis 1979 Mansfield *et al* 1975 Silverman 1979
	A significant number of bowhead whales occupy Eclipse Sound in the summer	Jul, Aug, Sep	AESAS Bh89 Davis and Koski 1980
SE Bylot Is (NE Pond In.)	During early summer, large numbers of narwhals move through shore leads in Pond Inlet toward their traditional summering grounds in Eclipse Sound. Narwhals return eastward through Pond Inlet in late September and early October	Jul, Sep, Oct	AESAS Na97 Finley and Gibb 1982 Koski and Davis 1979 Mansfield *et al* 1975 Silverman 1979
	A major migration route for harp seals	Jul, Sep	AESAS: Hs103, Hs104 Greendale and Brousseau-Greendale 1976 Johnson *et al* 1976 Koski and Davis 1979
Pond Inlet (S. Pond In.)	During early summer, large numbers of narwhals move through shore leads in Pond Inlet toward their traditional summering grounds in Eclipse Sound. Narwhals return eastward through Pond Inlet in late September and early October	Jul, Sep, Oct	AESAS Na94 Finley and Gibb 1982 Koski and Davis 1979 Mansfield *et al* 1975 Silverman 1979
SE Pond Inlet (C. Liverpool, C. Fanshawe)	A major migration route for narwhals during their spring (May-July) and fall (September) migrations (31, 35, 41).	May, June, Jul, Sep	AESAS Na103-Na 105 Greendale and Brousseau-Greendale 1976 James Dobbin 1982 Koski and Davis 1979
	A major migration route for bowheads during their spring and fall migrations	May, June, Jul, Sep	AESAS Na103-Na 105 Greendale and Brousseau-Greendale 1976 James Dobbin 1982 Koski and Davis 1979
	A major migration route for harp seals	Jul, Sep	AESAS: Hs103, Hs104 Greendale and Brousseau-Greendale 1976 Johnson *et al* 1976 Koski and Davis 1979

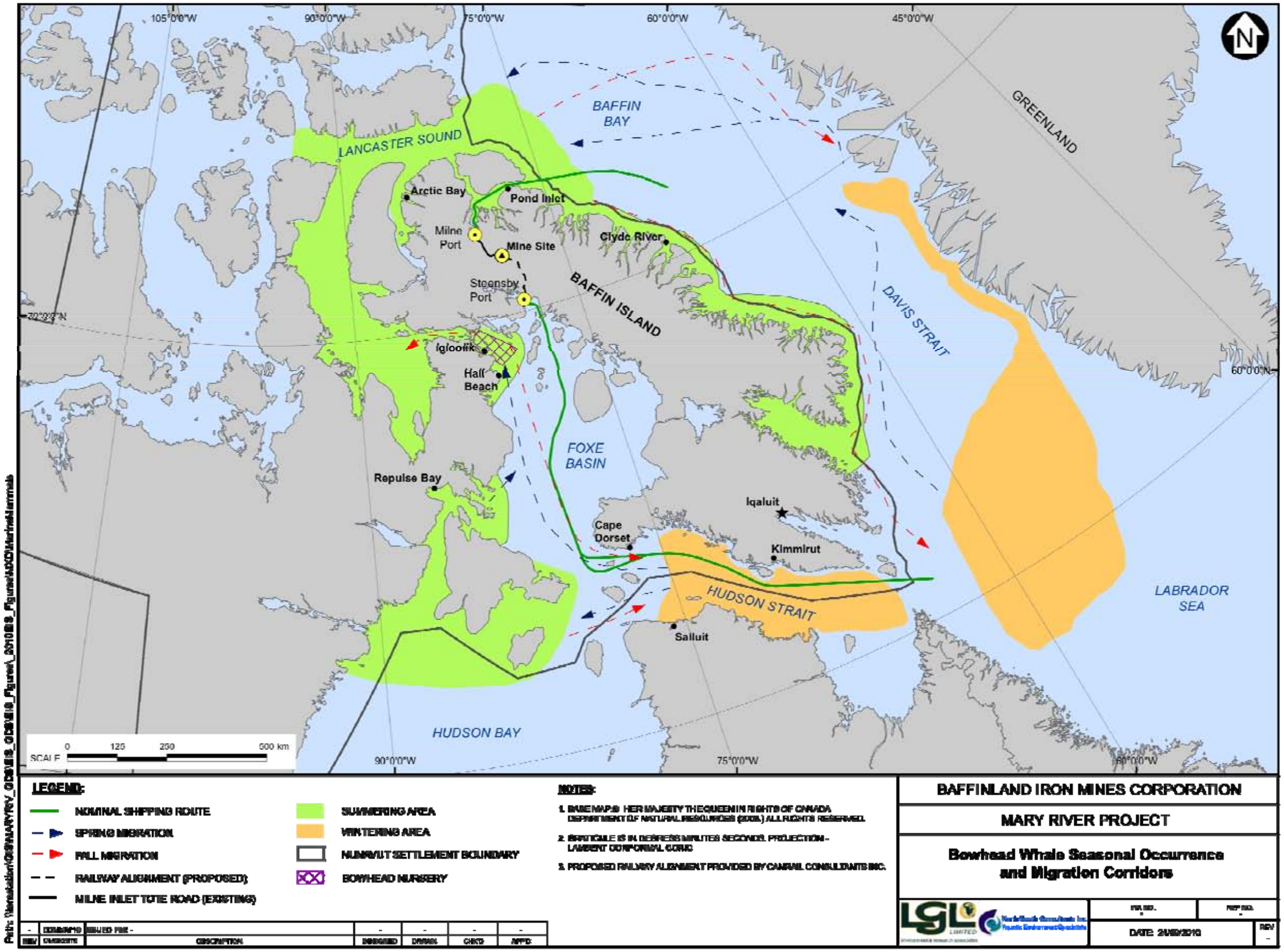


Figure 13. Distribution of bowhead whales.

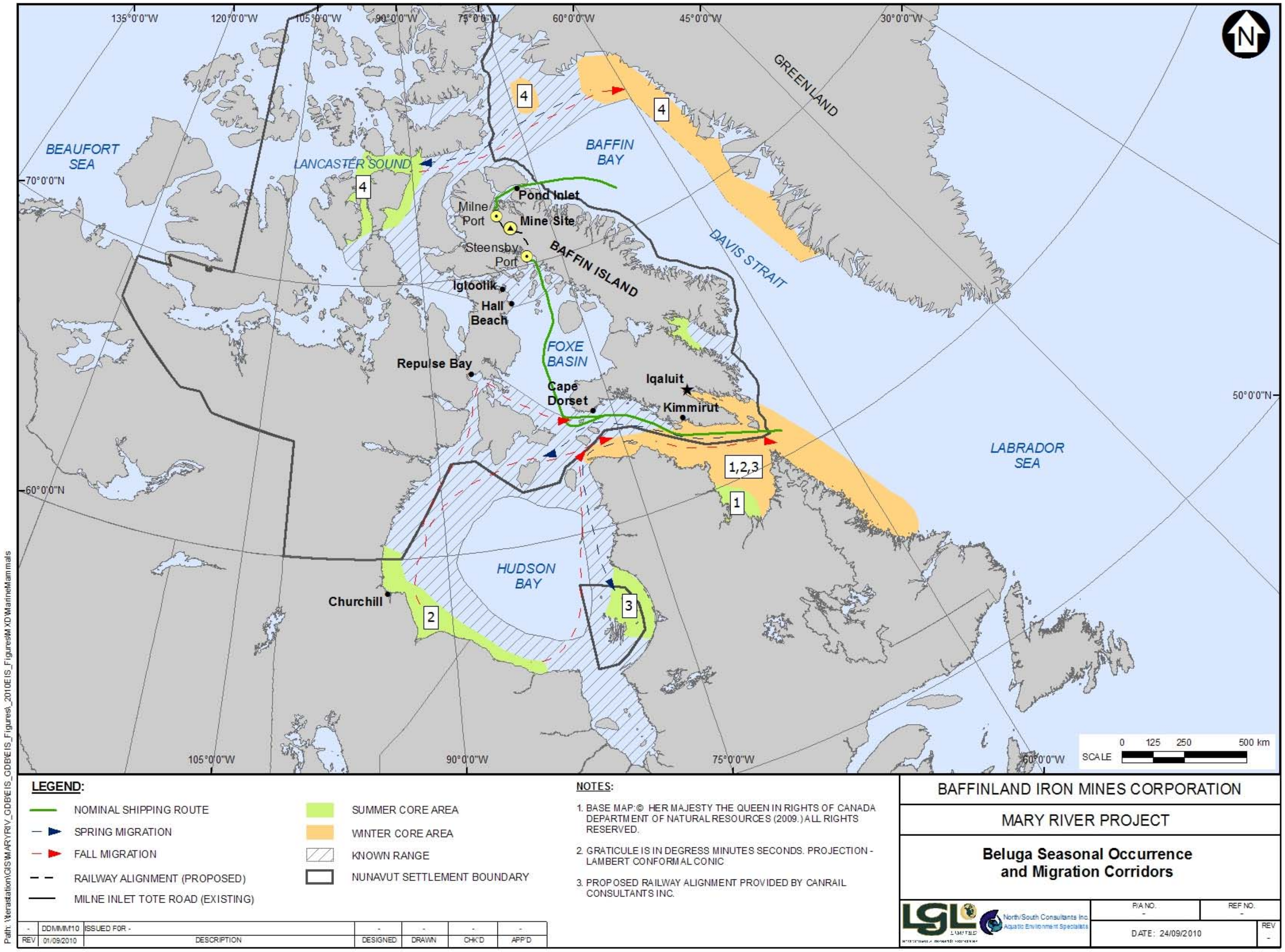


Figure 14. Distribution of belugas.

Narwhal

Narwhal are an important subsistence species in the region and their use of Foxe Basin and Hudson Strait is shown in Figure 15. There are some core-use areas in southwestern Foxe Basin but these are well outside of the proposed open-water southern shipping route where spills might originate. Narwhal appear to be at *low* risk from potential contact with a worst-case, open-water diesel spill within Foxe Basin and Hudson Strait.

Walrus

Walrus occur throughout Foxe Basin and Hudson Strait (Fig. 16), and the northern portion of Foxe Basin is shown to be a year-round concentration area. As such, there is considerable overlap between areas commonly occupied by walrus and the potential area of concern associated with a worst-case, open-water spill related to the shipping channel, particularly in northern Foxe Basin and Steensby Inlet. the overlap of the *area of concern* and walrus distrubtion suggests a *moderate* risk of contact with an open-water spill.

Seals

Four species of seal are known to occur within Foxe Basin and Hudson Strait. Ringed seal use ice habitat for wintering and pupping in northern Foxe basin and the shallow areas of eastern Foxe Basin (Fig. 17; Stephenson and Hartwig 2010); they also are found throughout Foxe Basin during the summer open-water season. Harbour seal are summer visitors to the coastal areas of Hudson Strait and southwestern Foxe Basin (Fig. 18; Stephenson and Hartwig 2010). Bearded seals are noted as common throughout Foxe Basin and along coastal areas of Hudson Strait (Fig. 19; Stephenson and Hartwig 2010). Harp seals are listed as common and occurring throughout Foxe Basin and Hudson Strait (Fig. 20; ; Stephenson and Hartwig 2010).

Seals are regarded as at *low* risk to worst-case, open water spill as they are widely distributed so a limited number of animals would potentially be contacted by the short duration and limited extent open-water diesel spill.

<u>Steensby Inlet Port Area</u>

Steensby Inlet is a known summering area of walrus and is occasionally used by narwhal, ringed seals, bearded seals and harp seals. Should a spill occur near the port facility, it may be feasible to displace marine mammals from the spill site using acoustical hazing techniques.; such a plan would require development and regulatory approval in advance.

3.4 Marine Birds at Risk

<u>Northern Route</u>

The Arctic Environmental Sensitivity Atlas System (AESAS; Environment Canada 2000). shows a number concerns for bird sensitivities within the northern shipping route areas of concern (Table 6). Pond Inlet and Eclipse Sound shorelines are important summering and important feeding areas. Mallory and Fontaine (2004) note that "*effectively, more than 1% of the Canadian population could be almost anywhere in these regions on any given day depending on ice conditions and the distribution of prey species"* (this statement applies to loons, swans, geese, sea ducks, gulls, alcids, terns).

In the event of a spill during open-water season, there is the potential for both shoreline and on-the-water contact with marine birds. Should a worst-case, open water diesel spill occur, marine birds are considered at *high* risk of contact, especially in eastern areas of Pond Inlet (Table 6).

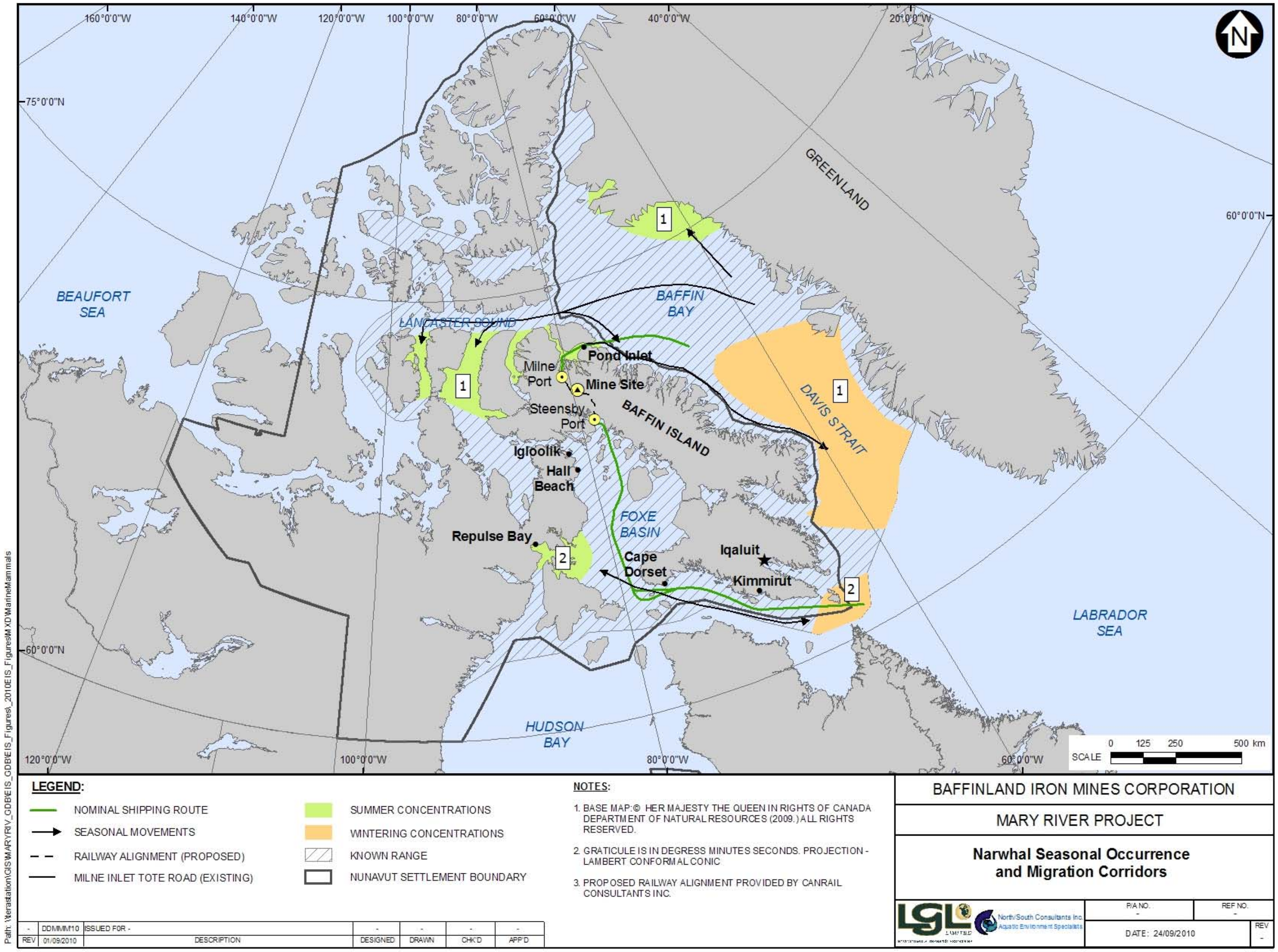


Figure 15. Distribution of narwhal.

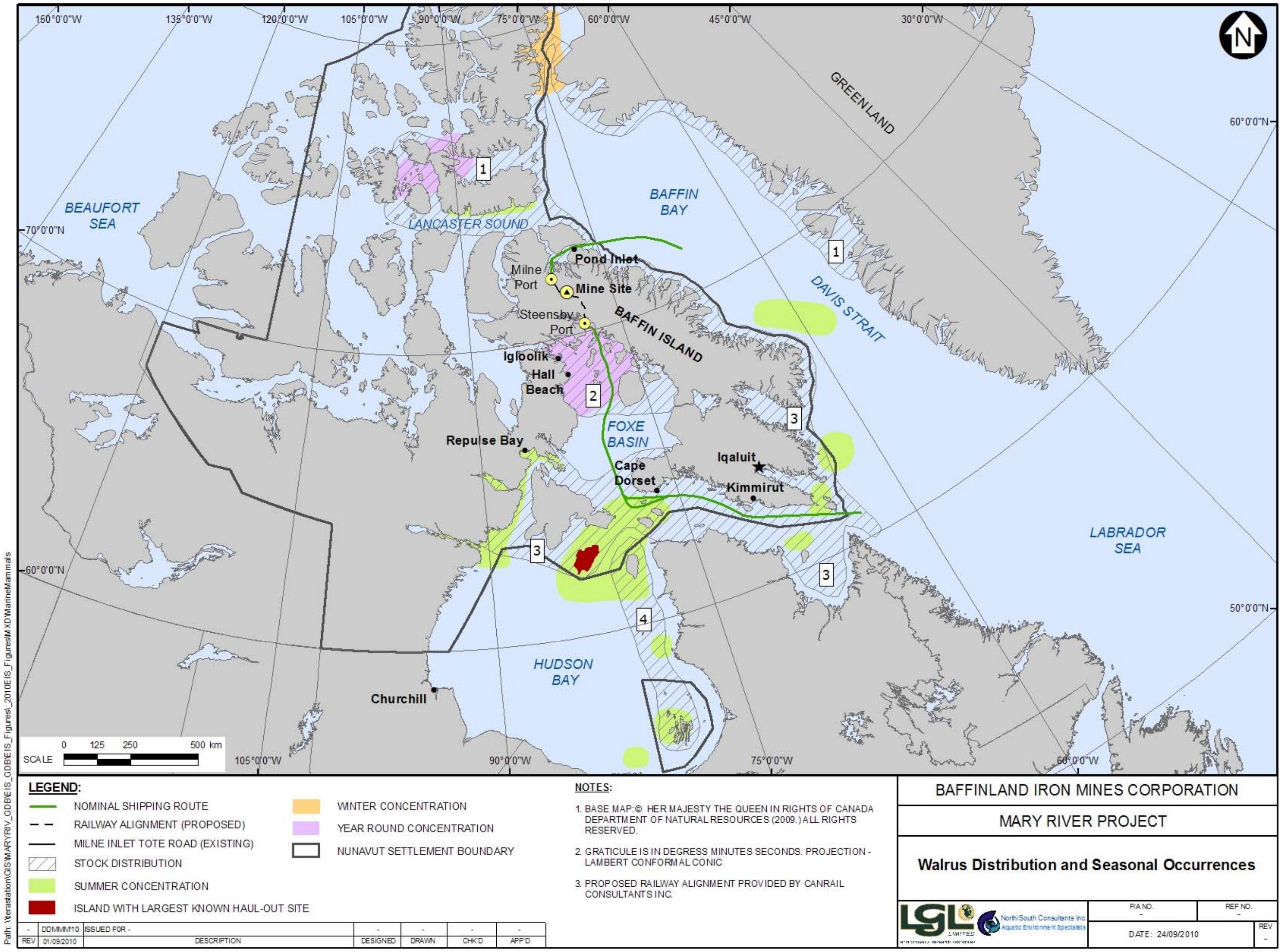


Figure 16. Distribution of walrus.

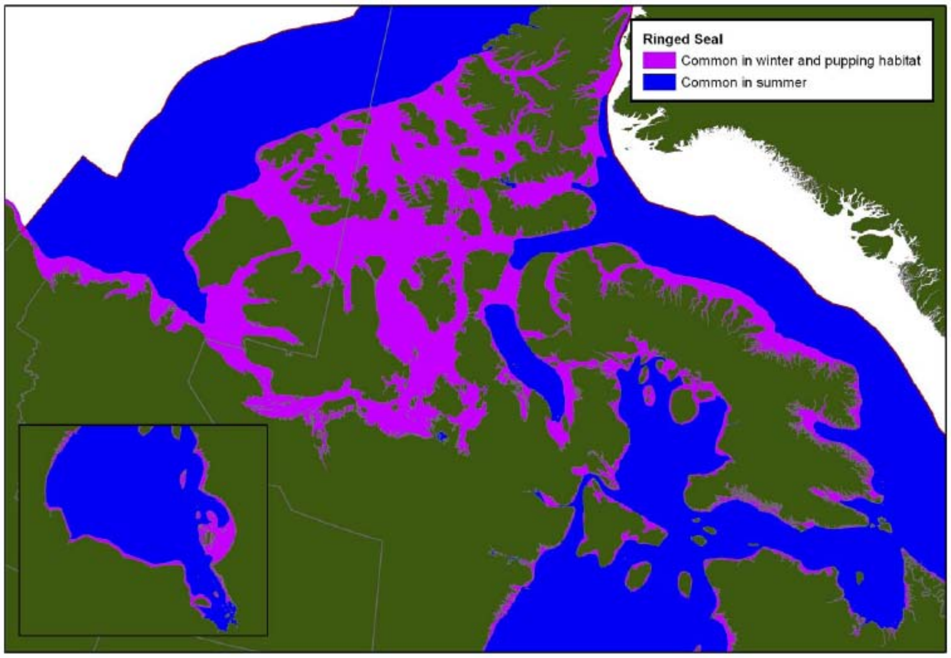


Figure 17. Occurrence of ringed seals in Foxe Basin and Hudson Strait (from Stephenson and Hartwig 2010).

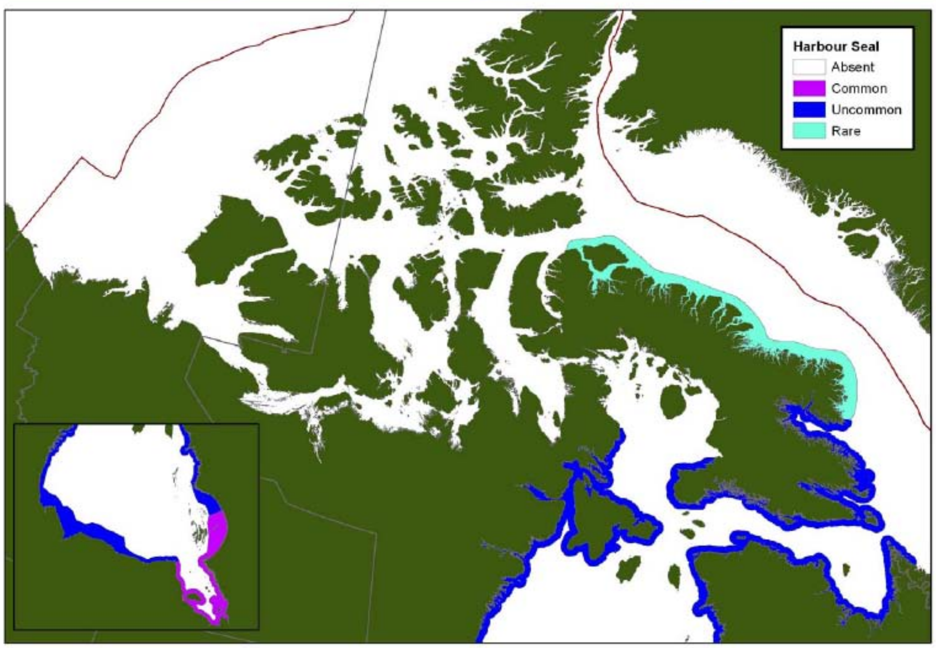


Figure 18. Occurrence of harbour seals in Foxe Basin and Hudson Strait (from Stephenson and Hartwig 2010).

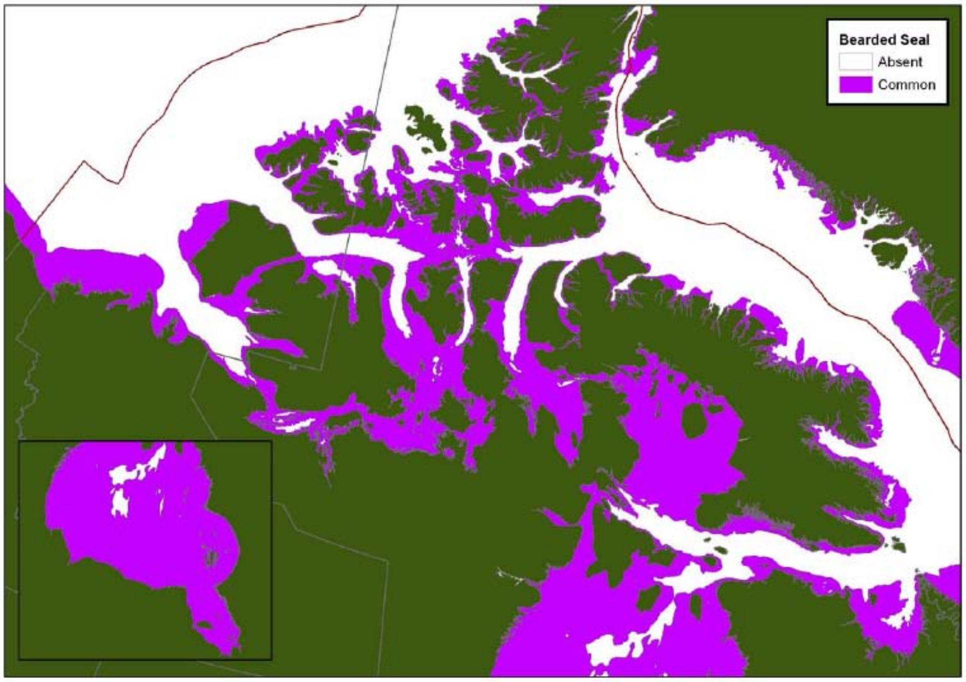


Figure 19 Occurrence of bearded seals in Foxe Basin and Hudson Strait (from Stephenson and Hartwig 2010).

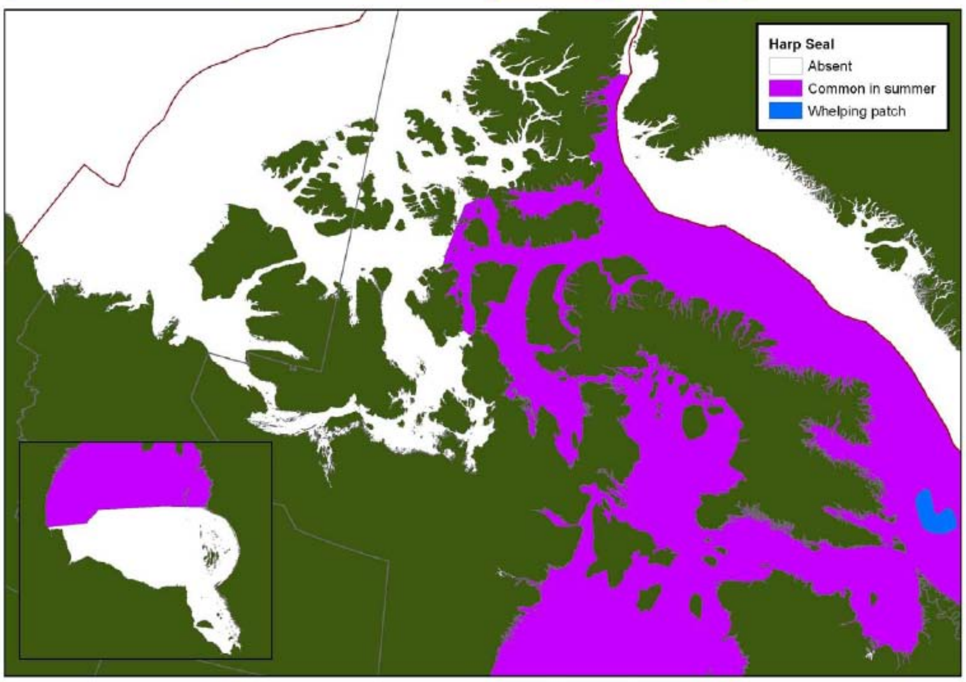


Figure 20 Occurrence of harp seals in Foxe Basin and Hudson Strait (from Stephenson and Hartwig 2010).

Table 6 Summary of Marine Bird Concerns from AESAS (Env. Can 2000)

Location	Marine Bird Concerns	Months	Reference
SW Bylot Is	thousands of long-tailed ducks	Aug, Sep	AESAS: SD98,99 Mclaren and Renaud 1979
	hundreds of greater snow geese	July, Aug	AESAS: Ge99 Mclaren and Renaud 1979
	large numbers of glacous gulls and smaller numbers of arctic terns	Aug, Sep	AESAS: Gu98, Gu99 Mclaren and Renaud 1979
SE Bylot Is	Bylot Island Migratory Bird Sanctuary;		AESAS: R96
	About 50,000 thick-billed murres and 6,000 black-legged kittiwakes nest in a colony at Cape Graham Moore (IBP site; IBA)	May to Aug	AESAS: A1Gu107 Mclaren and Renaud 1979 McLaren 1980
	Thousands of eiders, some long-tailed ducks	May to Aug	AESAS: SD107 McLaren 1980
Pond Inlet	hundreds of fulmars use the coast east of Pond Inlet Village and feed in offshore tide rips	Aug to Sep	AESAS Fu93, Fu94 McLaren and Renaud 1979
	Ivory gulls, glacous gulls and kittiwakes use the coast east of the Pond Inlet Village	Sep to Oct	AESAS: Gu93,94 McLaren and Renaud 1979 Renaud and McLaren 1980
	During September, thousands of oldsquaws and some eiders occur in Guys Bight, east of Pond Inlet Village	Sep	AESAS: SD95 Johnson *et al* 1976 McLaren and Renaud 1979
SE Pond Inlet	thousands of fulmars occur along the fast ice edge	Jun to Jul	AESAS: Fu 103, Fu104 McLaren and Renaud 1979 McLaren 1980
	thousands (~50/km^2) of kittiwakes concentrated along the fast ice	Jun to Sep	AESAS: Gu103, Gu104 McLaren and Renaud 1979
	flocks of 100+ terns occur along the coast of Bathurst Bay, the site of a nesting colony	Aug	AESAS: Gu104 McLaren and Renaud 1979
	thousands of murres utilize the coast from Cape Hay to Cape Byam Martin	May to Jul	AESAS Al103,Al104, Al105 McLaren and Renaud 1979
	thousands eiders and some flocks of oldsquaws occur along the Cape Fanshawe shoreline	May to Aug	AESAS: SD 103, SD104, SD105 McLaren and Renaud 1979 McLaren 1980

Milne Inlet Port Area

The Milne Port area is not identified as a significant bird area in comparison to other areas of the proposed northern shipping route.

The port area is likely to have resources for spill response that may not be feasible for use along other areas of the shipping route. These resources are likely to include support vessels, booms and bird hazing equipment. Small vessels could be used to deploy protection booms at estuaries to minimize potential contamination of salt marshes, which are a habitat that is heavily used by snow geese during their migrations. The addition use of bird hazing equipment, such as propane cannons can be used to reduce the potential of bird-spill interaction, especially in estuary areas. Given the potentially short duration of s spill, bird hazing equipment would need to be stationed with the port response equipment to permit rapid deployment.

Southern Route

Large numbers of marine birds use Foxe Basin and Hudson Strait region annually for breeding, feeding, migration, molting, or wintering. In addition to breeding birds, thousands of non-breeding birds also inhabit these waters.

A dozen sites in Foxe Basin and Hudson Strait have been identified as *Important Bird Areas* (IBA) by the international conservation initiative coordinated by BirdLife International. (online mapping tool at: www.ibacanada.com) (Fig. 21 and Table 7). These sites are designated as 'globally' or 'continentally' significant.

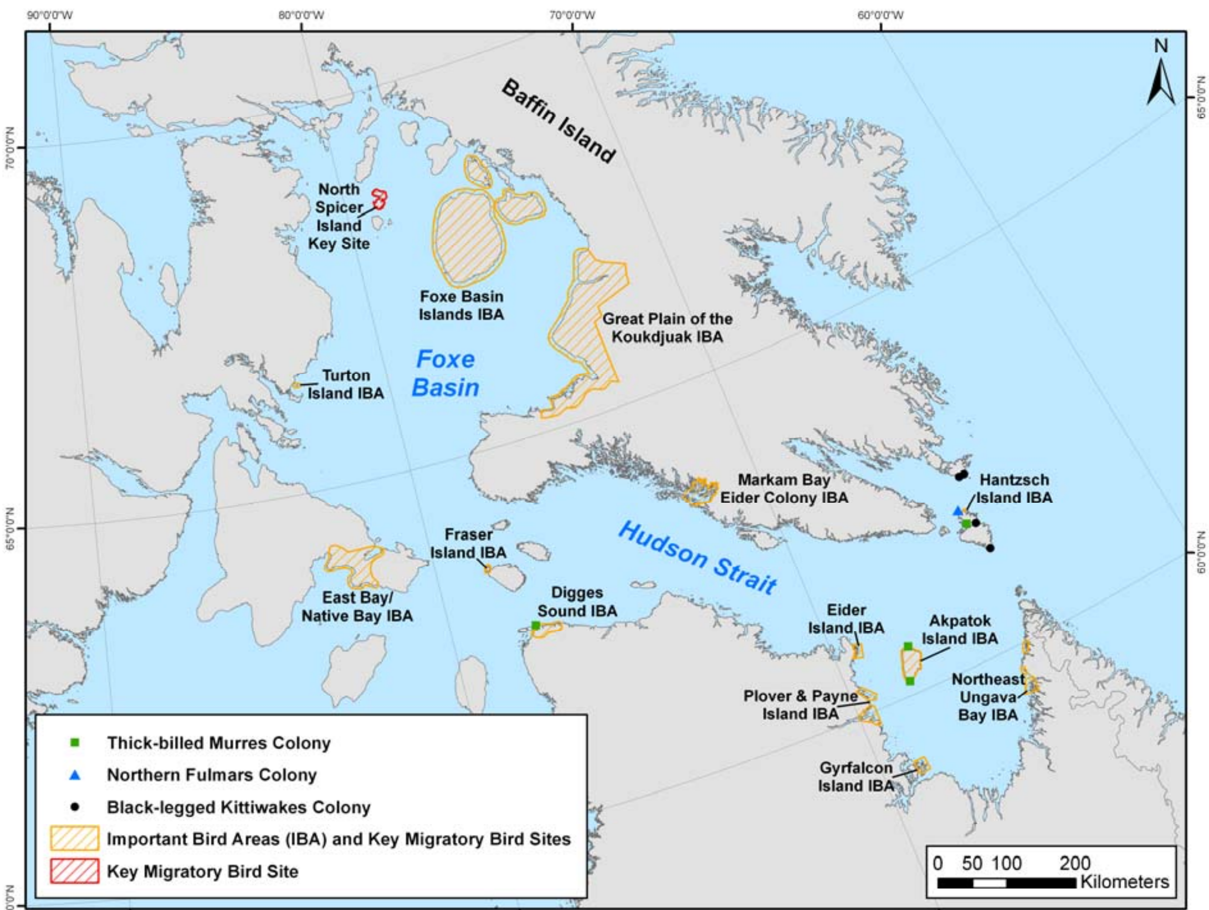


Figure 21. Summary of key bird features of Foxe Basin.

Key marine habitat sites for birds are defined by Mallory and Fontaine (2004) as areas that support at least 1% of the Canadian population of at least one migratory bird species (Table 7). Marine habitat sites include coastline, open sea, and polynya–shore lead habitats. A number of sites in the vicinity Foxe Basin region also include marine components have other types of protected designations as well, including national wildlife areas and migratory bird sanctuaries (Mallory and Fontaine 2004).

Table 7. List of key Marine Bird Sites and Important Bird Areas in Foxe Basin and Hudson Strait.

Location	Marine Bird Concerns	References
Foxe Basin Islands **Important Bird Area**: Prince Charles Island, Air Force Island, and Foley Island (NU011)	These islands have **globally** and **continentally significant** populations of waterfowl, sea birds and shorebirds. Globally significant populations include: Snow Goose, Brant; Sabines Gull (numbers estimated > 35,000 is the largest known concentration in the world); and shorebirds: Semipalmated Sandpiper, Black-bellied Plover; American Golden-Plover; Ruddy Turnstone; Red Phalarope and White-rumped Sandpiper (the estimate of > 100,000 pairs is the largest known breeding concentration in the world, and is perhaps half of the global population of this species). Nesting King Eiders, Common Eiders, Oldsquaws and Herring Gulls are also common along the coast and on inland pools.	Important Bird Areas web atlas www.ibacanada.com
Other areas of Foxe Basin	Other areas of Foxe Basin are also important bird areas. These include gull colonies, principally Thayer's or Kumlien's gulls, with a few Glaucous Gulls found along the western coast of Foxe Basin in colonies ranging from a few birds to 2000 pairs. Colonies of Arctic Terns are distributed around Foxe Basin, with some colonies of more than 500 birds located near Fury and Hecla Strait. Black Guillemots occur north of Southampton Island and near Fury and Hecla Strait, and some overwinter in Foxe Basin polynyas. Colonies of Common Eiders occur near Turton Island, White Island, and Jens Munk Island. Gaston *et al* (1986) also observed thousands of King Eiders, mostly males, in northern Foxe Basin, and they surmised that this area must be an important molting location for this species.	Mallory and Fontaine 2004
Great Plains of the Koukdjuak, east coast Baffin Island	This site is the largest goose colony in the world with over 2 million geese, mainly Lesser Snow Geese nesting here. Significant numbers of Cackling geese, Atlantic Brant, and Sabine's Gulls as well as Long-tailed Ducks and King and Common eiders are found there as well. Canadian Important Bird Area (NU078), includes marine coastline through Dewey Soper Migratory Bird Sanctuary, and Bowman Bay Wildlife Sanctuary; Ramsar Wetland of International Importance, and an International Biological Program Site.	Latour *et al* 2008
North Spicer Island	Atlantic Brant nesting site, representing 1% of the Canadian population Sabine's Gulls, Arctic Terns, Long-tailed Ducks, Pacific Loons, and Red-throated Loons were also observed on the island	Latour *et al* 2008
Turton Island, W Foxe Basin	Turton Island is one of the largest colonies of nesting Common Eiders in the Canadian Arctic, with 3,800 to 5,900 pairs Other bird species nesting on Turton Island include Tundra Swans, Canada Geese, Atlantic Brant, Black Guillemots, Herring Gulls, and Arctic Terns Important Bird Area (NU021)	Latour *et al* 2008

Location	Marine Bird Concerns	References
Boas River delta, SW Southampton Island	Slightly over 10% of the nesting Lesser Snow Geese in Canada occurred here. There was a fourfold increase in numbers of geese nesting in the area between 1973 and 1997. Snow Geese arrive in late May or early June. Non-breeding Snow Geese leave the area in mid-August, followed by the breeding birds in early September. The Boas River area also supports nesting populations of Atlantic Brant, Cackling Geese, and Tundra Swans. The site includes Harry Gibbons Migratory Bird Sanctuary and is also an Important Bird Area (NU022) and an International Biological Program Site.	Latour *et al* 2008
East Bay, SE Southampton Island	Supports Canada's largest single colony of Common Eiders 3,500 to 4,500 pairs as well as large numbers of Lesser Snow Geese. Black Guillemots, Atlantic Brant, Sabines Gull and numerous shorebirds also occur here. This site lies within the East Bay Migratory Bird Sanctuary. It is an Important Bird Area in Canada (NU023) and it is also within a Key Marine Habitat Site in Nunavut	Mallory and Fiontaine 2004 Latour *et al* 2008
Coats Island, southeast of Southampton Island, at Cape Pembroke	Two Thick-billed Murre colonies, with 33 000 pairs, or about 2% of the Canadian population. Coats Island is also one of the key seabird research sites in eastern Canada. Black Guillemots, Glaucous Gulls, and Peregrine Falcons, Iceland Gull and Herring Gulls are also common. This marine region is used by seabirds from late April through September. Coats Island is an International Biological Program site and an Important Bird Area (NU005) and a Key Marine Habitat Site in Nunavut	Mallory and Fontaine 2004
Fraser Island, off the northwestern tip of Nottingham Island (at the western mouth of the Hudson Strait)	Fraser Island supports 1,000 to 3,000 pairs of nesting Common Eiders (Gaston *et al* 1986), which represents from 1 to 3% of the Canadian population. The eiders migrate into the area in late May Recent studies tracking the fall migration of eiders from Foxe Basin into Hudson Strait indicated that Fraser Island and Nottingham Island are important areas for molting eiders in late August and September This key site is an Important Bird Area in Canada (NU024)	Important Bird Areas web atlas www.ibacanada.com Latour *et al* 2008

Location	Marine Bird Concerns	References
Digges Sound	Two colonies of Thick-billed Murres at Digges Sound have approximately 300,000 pairs of nesting birds, or 20% of the Canadian population. Black Guillemots , Glaucous Gulls , Iceland Gulls, Herring Gulls, Arctic Terns, Atlantic Puffins also occur. Significant concentrations of marine birds may be distributed through out this region, depending on the annual patterns of ice breakup and the distribution of prey This marine region is occupied by seabirds from late April through September. A key period occurs in August, when birds are departing the colony with their young on a swimming migration through Hudson Strait to the offshore areas of Newfoundland and Labrador (Gaston and Elliot 1991). In early September 1980, chicks were concentrated in an area about 140 km north and west of Digges Sound. At least 40,000 chicks were present, and at least 140,000 adults were scattered east of 72°W (Gaston 1982). Important Bird Area (NU001) and Key Marine Habitat Site in Nunavut.	Latour *et al* 2008
Markham Bay, south coast of Baffin Island	**Continentally Significant** Common Eider colony, designated as Important Bird Area (NU101), with 8,000 to 10,000 pairs Eiders occur in this area from April through October Iceland Gulls colonies, as well as Black Guillemots are also common in this area.	Important Bird Areas web atlas www.ibacanada.com Mallory and Fontaine 2004 Latour *et al* 2008
Hantzsch Island, Resolution Island Group, southeast tip of Baffin Island	Hantzsch Island has **Globally** and **Continentally Significant** seabird concentrations, and is designated as a Canadian Important Bird Area (NU025). At least 50,000 pairs of Thick-billed Murres have been reported nesting here, which accounts for about 3% of their national population. Over 2% of the national Black-legged Kittiwake population has also been observed at this site (5,000 pairs). Other species that nest here include small numbers of Glaucous Gulls and possibly Northern Fulmars. Birds are present in highest concentrations from early May to October. Thick-billed Murres are particularly at risk from spill accidents, due to their extensive flightless migration to the wintering territory, at the end of the breeding season.	Important Bird Areas web atlas www.ibacanada.com Latour *et al* 2008
Akpatok Island, northwest Ungava Bay	Two large colonies of Thick-billed Murres occur on Akpatok Island. These colonies are estimated at approximately 520,000 pairs which makes the island Thick-billed Murre colony in Canada, at more than 20% of the Canadian population. Murres arrive at waters around the island in early May and depart on a swimming migration with their young at the end of August Black Guillemots, Peregrines and Gyrfalcons, as well as Glaucous Gulls also breed here. Akpatok Island is an International Biological Program Site, an Important Bird Area in Canada (NU007) and a Key Marine Habitat Site in Nunavut	Latour *et al* 2008

Location	Marine Bird Concerns	References
Ungava Bay Islands	A number of archipelagoes in Ungava Bay provide nesting habitat for over 19% of the Canadian population of Common Eiders. The most important of these archipelagoes are the Eider Islands, the Plover and Payne islands, the Gyrfalcon Islands, and islands of northeastern Ungava Bay. Eiders are found throughout migration, breeding and molt in coastal areas around Ungava Bay from April to October	Latour *et al* 2008

Different types of marine birds have different vulnerability and sensitivity to spills, because they may use habitats differently than each other for foraging and migration. For example, eiders ducks forage primarily nearshore and usually are within a few kilometres of their nesting areas. However, males leave colony during molt, and may aggregate in large numbers away from the colony. Females and young leave colony in late August (Latour *et al* 2008).

Thick billed murres nest in colonies in very large numbers and as offshore feeders, they may travel 200 km on foraging trips. Murres have a synchronous life cycle, with young of the year leaving the colonies in large numbers during a short period of time. Young birds, accompanied by adult males, then embark on long distance swimming migration to wintering grounds to the south. Offshore spills could potentially affect large numbers of swimming migrant young or adults foraging trips which are some distance from the colonies (Latour *et al* 2008).

Shipping routes pass in close proximity to both the North Spicer Is key bird area and the Foxe Basin Islands IBA (Fig. 21); should a worst-case spill occur along this portion of the route, birds from these colonies are considered at *high* risk of coming into contact with the spill. The large thick-billed murre colony at Hantzch Island and Digges Sound are also considered *high* risk as bird complete a flightless, marine migration to their wintering grounds so these birds occur well offshore (Latour *et al* 2008). Marine birds from other Important Bird Areas are considered at *low* risk because of the distance of the proposed shipping route from the shore colonies.

Birds are very sensitive to contact with fuel, which is trapped on feathers and significantly reduces insulation such that birds die of hypothermia (O'Hara and Morandin 2010). All seabirds are considered *highly sensitive* to oiling.

3.5 Marine Fish at Risk

<u>Northern Route</u>

Char are ubiquitous in larger streams within the region. Especially important areas are identified by AESAS (Env. Can. 2000) and are summarized in Table 8.

The greatest concern should a spill occur is potential stranding of oil within estuaries where the elevated fuel concentrations in the water column could cause injury or damage to migrating fish, especially juvenile fish. However, the outmigration of juveniles and over-wintering adult fish typically occurs during freshet (May, June; Evans *et al* 2002), a season when fuel delivery or spills will not occur. In-migration of adult fish occurs in mid-August to mid-September, with peak runs occurring near the last week of August in the Steensby Inlet area (Evans *et al* 2000). While adult fish are typically less sensitive to hydrocarbon effects, aggregations of char in estuarine areas near the river mouth would be a concern.

Table 8 Summary of Key Marine Fish Concerns from AESAS

Location	Marine Fish Concerns	Months	Reference
Milne Inlet	The Robertson and Tugaat Rivers are important to anadromous char; char are likely to occur in other smaller rivers	Jul to Sep	AESAS: CH89 LGL 1983 Stewart and MacDonald 1981
Navy Board Inlet, Eclipse Sound	Anadromous Arctic char are known to feed and migrate through the Mala River and Alpha River areas	Jul to Sep	AESAS CH87, Ch88 LGL 1983 Stewart and MacDonald 1981
Tay Sound, southern Pond Inlet	Anadromous Arctic char are known to feed within and migrate through Tay Sound and Paquet Bay during the open water season. They are also known to occur in the vicinity of Salmon River and Erik Harbour	Jul to Sep	AESAS: CH93, CH94 LGL 1983

Because of the volatile nature of the diesel fuel and weathering rapid, it is unlikely that effects would extend to more than one season within the estuary channels.

Milne Inlet Port Area

There are several estuaries with arctic char runs in the Milne port area that could be exposed to a fuel spill. It is important that these be identified in the spill contingency plan for protection priority as salt marsh occurs more commonly in these systems. There are likely to be more response capabilities near the ports site, including support vessels and booms, so that countermeasures near the port could be quite effective in the event of an open-water diesel spill.

Southern Route

The primary marine fish species of concern near the proposed southern shipping route is the anadromous arctic char. The potential for at sea impacts to arctic char from a shipping route diesel spill appears low because (a) the duration of the spill is short (days to a week), (b) the spill extent limited (<10 x 10 km) and (c) the fish are assumed to be widely dispersed at sea.

Anadromous char are likely to be found at higher densities near estuaries and stream mouths and as such, are more vulnerable to spill impacts (Evans *et al* 2002). In general, the proposed shipping routes are more than 15 km from the shore so the probability of fuel reaching the shorelines is small, except near the northern portion of Foxe Basin and within Steensby Inlet. Figure 22 shows a map of anadromous fish streams in this area, and estuaries associated with the streams would be of concern in the event of spill. Out-migration of juvenile and adult arctic char are considered at low risk from possible spill affects because this migration occurs at freshet (Evans *et al* 2002) when shipping or spills are unlikely to occur. In-migration, which occurs in the late summer and peaks in late August is at higher risk if a spill strands within an estuary because the fish often aggregate near the estuary before entering the river system (Evans *et al* 2002). It is probable that most fuel shipments would occur after the peak in-migration (e.g., mid September), mitigating the risk somewhat.

It is likely that anadromous fish streams occur throughout Foxe Basin and Hudson Strait and Figure 12 provides a general summary of habitats throughout the Basin and Hudson Strait. In most areas, deltaic complexes comprise about 1-10% of the shoreline. The exception is the Koukdjuak River/Bowman Bay Coastal Regional where 45% of the shoreline is mapped as a deltaic complex (Fig. 12). All of these areas in the main portion of Foxe Basin and Hudson Strait are considered *low* risk areas due to distance from the proposed shipping route. The potential

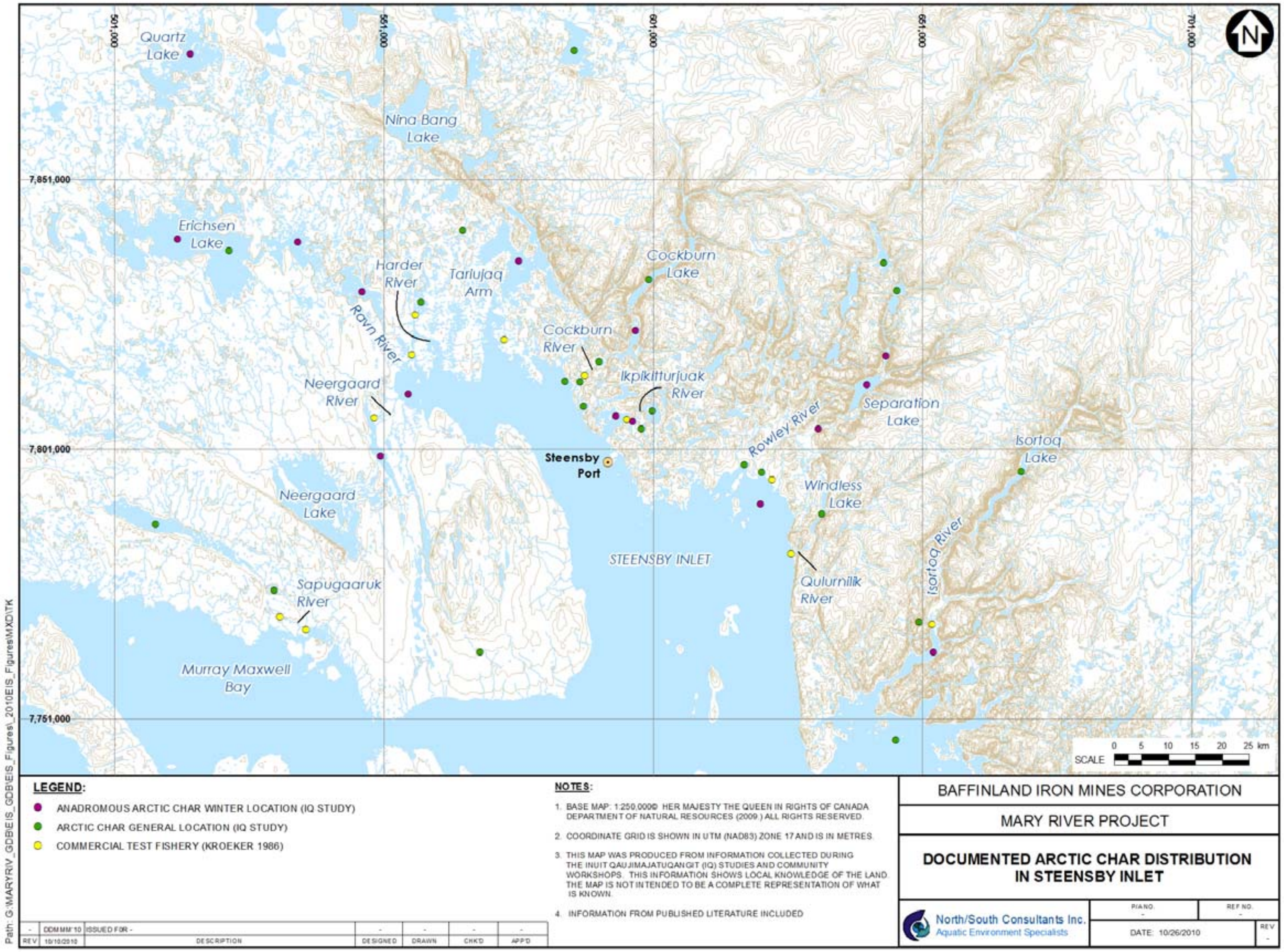


Figure 22 Locations of anadromous arctic char streams in Northern Foxe Basin and Steensby Inlet.

for mitigation is also considered low because of the remoteness from any logistical infrastructure.

The risk for potential contact in northern Foxe Basin is considered low to moderate as it is likely a worst-case, open-water spill within Steensby Inlet would reach some estuaries.

Steensby Inlet Port Area

There is the potential for a timely response in the port areas should a spill occur due to the presence of support vessels and the availability of spill response equipment. Estuarine areas are typically the type of habitat designated for immediate protection because of the associated anadromous fish runs that pass through and because estuaries often include extensive salt marshes, which tend to retain fuel when stranded. Open-water mitigation potential is considered good for those estuaries in close proximity to the port.

3.6 Human Use Activities at Risk

Northern Route

There are 27 archaeological sites identified in AESAS within the areas of concerns along the proposed shipping route, although it is probable that there are actually hundred of unidentified sites in this area. It is unlikely that a spill would directly impact the archaeological sites, which are above the high-water line. The greatest risk to archaeological sites is associated with cleanup operations when large numbers of people could be involved with a response and cleanup operations. Standard Shoreline Cleanup Advisory Team (SCAT) protocols typically require archaeological surveys *prior* to any cleanup operations (Sergy and Owens 2004) and should sites be identified, qualified site monitors are required as part of the response plan.

Resource harvesting sites are common throughout the region during the open water season (Env. Can. 2000); 44 seasonal hunting camps are identified in AESAS but there are likely dozens of other unidentified sites that are routinely used in the region. An open-water spill could disrupt resource harvesting activities (e.g., gill netting; narwhal hunting). The combination of spills and associated cleanup activities, would extend for weeks so there is the potential for a substantial portion of the open-water hunting season to be locally disrupted.

Milne Inlet Port Area

Narwhal are known to aggregate in Milne Inlet and there are many permanent camps and seasonal camps along the Inlet. A spill and the associated response would likely disrupt hunting patterns and these effects could extend over a period of weeks such that a substantial portion of the hunting season could be lost in the event of a worst-case, open-water spill of diesel.

Southern Route

We have no specific mapping of hunting locals along the proposed southern shipping route. We assume, however, that hunting activities would be carried out in similar fashion to those that occur on the northern route. Hunters were commonly observed in Steensby Inlet during the open-water season, several hundred kilometers from the Village of Igoolik. As with the northern route, the combination of spills and associated cleanup activities, would extend for weeks so there is the potential for a substantial portion of the open-water hunting season to be locally disrupted.

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4.1 Scope of Sensitivity Assessment

The overall scope of this assessment is large in that the overall length of shipping routes considered are more than 2,000 km and the total area of concern in excess of the 65,000 km^2 (Table 9). The proposed southern shipping route has had no previous sensitivity mapping so information on resources potentially at risk from open-water diesel spills was compiled from a wide variety of published and grey literature. A regional habitat inventory of 36,000 km of shoreline was compiled (see Appendices A, B, C) to support the assessment. The southern shipping route is considered a first-order approximation of sensitivities to potential spills.

Table 9 Shipping Route Attributes

Attribute	Northern Route	Southern Route
Route Length	570 km	1,610 km
Area of Concern (w 15 km buffer)	17,100 km^2	48,300 km^2
Shoreline within Area of Concern	601 km	891 km

4.2 Overview of Sensitivity and Risk

We summarize the sensitivity and risk for the resources and activities that occur along each shipping route. This comparative approach provides an overview of key spill issues for the project. For the purpose of this discussion, *sensitivity* is the ability to recover from spill effects and *risk* is defined as the probability of contact. (right inset). Resources of special concern are those for which large aggregations of a significant proportion of the total population occur within a relatively small area – that is, a large proportion of the population could potentially come into contact with a spill. In some cases, these resources are also sensitive to spill affects (e.g., diving ducks).

Sensitivity – the ability of a habitat, resource or activity to recover from the effects of a diesel spill on water. Resources that are likely to require more than one generation or in some cases more than one year to recover are considered *highly* sensitive. Resources that are likely to experience short-term, non lethal effects are considered to have a *low* sensitivity.

Risk – risk considers the probability of resource interaction with the spill. Risk considers the proximity of resources or activities to the potential spill source, in this case the shipping route. Risk also considers timing of shipping and timing of resource events (e.g., migration corridors).

The compilation is included in Tables 10 and 11.There are some resources that are considered high sensitivity and high risk. These resources of special concern include:

narwhal, whose sensitivity to diesel spills is unknown but where large portions of the population aggregate in a relatively small area in Milne Inlet and eastern Eclipse Sound.

marine birds near the eastern entrance to Pond Inlet. Birds are known to be sensitive to spills and considered at high risk in the event of a spill due to large aggregations near the shipping route.

marine birds in Foxe Basin and Hudson Strait, particularly those associated with globally significant Important Bird Areas of the Foxe Basin Islands IBA (e.g., Prince Charles Is), the Digges Sound IBA and the Hantzsch Island IBA, where hundreds of thousands of thick-billed murres undertake flightless, marine migrations to their wintering grounds.

hunting activities that take place throughout the region of the shipping routes and where response operations could disrupt hunting activities such that a some portion of the open-water hunting season could be lost.

Table 10 Summary of Sensitivity and Risk[1] Associated with the Northern Shipping Route

Resource	Sensitivity	Risk
Coastal Habitat	In general, shores contact by diesel will recover within days to weeks so a *low* sensitivity. The exception is salt marsh, where fuel may persist for weeks to months (*moderate* sensitivity)	Within Milne Inlet, the risk from a worst-case spill is *high* as it is highly probable that fuel will reach shorelines. Risk is considered *moderate* for Eclipse Sound and Pond Inlet as some shore within 15 km buffer zone.
Marine Mammals	Sensitivity of narwhal to a diesel spills is uncertain. However, because a large part of population could be contacted any effect could be long term so considered *high* sensitivity	Risk of contact between a worst-case spill and narwhal is considered *high* as a large portion of total population summers in Milne Inlet
	Sensitivity of bowheads to a diesel spill is uncertain. However, because bowheads are widely distributed impacts at a population level considered *low.*	Risk from a worst case spill is considered *low* as only a limited number of bowheads likely exposed to a spill (10x10km max)
Marine Birds	Most marine birds will be killed by contact with diesel spills and are considered *highly* sensitive to spills.	Risk of spill contact will vary by species, season and location. Eastern Pond Inlet is considered an area of special concerns as large aggregations occur. The risk of contact along much of the northern route is *high*.
Marine Fish	The estuarine portion of fish habitat is most sensitive but considered *low* for out-migration (during freshet) and *moderate* for in-migration when adult fish aggregate near estuary.	risk considered *low* because out-migration (May, June) and in-migration (mid-Aug to mid Sep) are offset from possible fuel spill periods (mid Sep)
Hunting Activities	Spill duration is short but response operations could occur over longer period of time – an entire hunting season could be effected so sensitivity considered *high*.	Within Milne Inlet, risk is considered *high* that a worst-case spill would disrupt hunting activities. In Eclipse Sound and Pond Inlet a spill is likely to disrupt some hunting activities so a *moderate* risk.

Notes: [1] *Risk* in this table refers to the probability of contact *assuming* a worst-case spill has occurred. Worst-case spills are considered very low probability of events.

Table 11 Summary of Sensitivity and Risk[1] Associated with the Southern Shipping Route

Resource	Sensitivity	Risk
Coastal Habitat	In general, shores contact by diesel will recover within days to weeks so a *low* sensitivity. The exception is salt marsh, where fuel may persist for weeks to months (*moderate* sensitivity)	Within Steensby Inlet, the risk from a worst-case spill is *high* as it is highly probable that fuel will reach shorelines. Risk is considered *low* for Foxe Basin-Hudson Bay route because it is generally well beyond the 15 km buffer.
Marine Mammals	Sensitivity of most marine mammals to diesel is *uncertain*.	Risk of contact between a worst-case spill and most Foxe Basin marine mammals is considered *low*. The risk associated with walrus in northern Foxe Basin is assessed as *moderate* because there likely would be some contact in the event of a worst-case spill.
Marine Birds	Most marine birds will be killed by contact with diesel spills and are considered *highly* sensitive to spills.	The risk of potential contact of a worst-case spill is likely to range from low (central areas of Foxe Basin where the shipping route is well offshore to *high* (e.g., Charles Island, Hantzsch Island) where the shipping route is close to shore or where marine birds may be found well offshore.
Marine Fish	The estuarine portion of fish habitat is most sensitive but considered *low* for out-migration (during freshet) and *moderate* for in-migration when adult fish aggregate near estuary.	risk considered *low* because out-migration (May, June) and in-migration (mid-Aug to mid Sep) are offset from possible fuel spill periods (mid Sep)
Hunting Activities	Spill duration is short but response operations could occur over longer period of time – an entire hunting season could be effected so sensitivity considered *high*.	Within Steensby Inlet, risk is considered *moderate* that a worst-case spill would disrupt some hunting activities. In most area of Foxe Basin the risk is considered low, except closer to the communities of Igloolik, Hall Beach, Cape Dorset and Kimmirut.

Notes: [1] *Risk* in this table refers to the probability of contact *assuming* a worst-case spill has occurred. Worst-case spills are considered very low probability of events.

4.3 Limitations of Assessment

This assessment is made based on a number of assumptions (see list on page 15) about potential spills and is restricted to an assessment of diesel spills only.

There are over 36,000 km of shoreline within Foxe Basin and Hudson Strait and although this is an existing shipping route to Hudson Bay and villages within Foxe Basin and Hudson Strait, there is no existing sensitivity atlas for use in the assessment (e.g., like the Arctic Environmental Sensitivity Atlas System; Environment Canada 2000). A first-order habitat mapping was conducted to address this deficiency (see Fig. 12 on page 23 and Appendix B and C). This mapping provides a significant advancement in terms of the understanding of regional habitat variability. Other environmental information was compiled from published resources. While site specific resource information is not identified in this assessment, the assessment does highlight the key resources and issues associated with potential spills along the shipping route.

Some mitigation techniques are mentioned in the text. However, these strategies are outlined only in concept and require further consideration within the project spill contingency plan. We do not provide an specific recommendation about mitigation. Some of the conceptual techniques that are identified (e.g., wildlife hazing) will require discussion and approval from regulatory agencies.

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APPENDIX A

Mapping Methodology

Overview of Mapping Approach

Environment Canada has produced an Arctic Environmental Sensitivity Atlas System (Environment Canada 2000) for the region covering the proposed northern shipping route (Fig. 1) but no such atlas exists for the proposed southern shipping route. To address this deficiency a reconnaissance level compilation of coastal habitats was completed for the 36,000 km shoreline bordering the proposed southern shipping route. Key points of the habitat mapping are summarized below:

1. Google Earth imagery provided the region-wide data source for all the shorelines in Foxe Basin. Habitat types had to be distinguishable on Google Earth to be included in the assessment (Table 4; Appendix B).

2. high resolution imagery (video and georeferenced photos) of Steensby Inlet collected in 2007 as part of the Baffinlands project (CORI 2008a) was used to “calibrate” habitat types identified on Google Earth (see Appendix B for examples).

3. additional coastal imagery opportunistically acquired during 2010 polar bear overflights was used to assist mappers with the Google Earth classification; this dataset consisted of 12,500 georeferenced coastal photos.

4. ground surveys conducted in Steensby Inlet during 2008 provided on-the-ground information about shoreline substrate types and biota (see CORI 2008c).

5. in as much as possible, the habitat types mapped within Foxe Basin are matched with Environment Canada standardized spill sensitivity mapping (Owens and Sergy, 2000, 2004), although Google Earth does not provide the same resolution to map all of the Environment Canada shore types (Table 3).

The primary challenges in mapping these shore types from Google Earth imagery are: (a) it is not possible to directly distinguish bedrock shore types from beach shore type (the intertidal shore type was often inferred from the backshore morphology), (b) salt marshes, a sensitive and common feature of the Foxe Basin shorelines, are not visible on Google Earth images and must be inferred and (c) we lacked high resolution shoreline photos for south-eastern Foxe Basin and Southampton Island so confidence in mapping these areas is lower.

APPENDIX B

Foxe Basin Shore Type Descriptions

Bedrock Shore Type

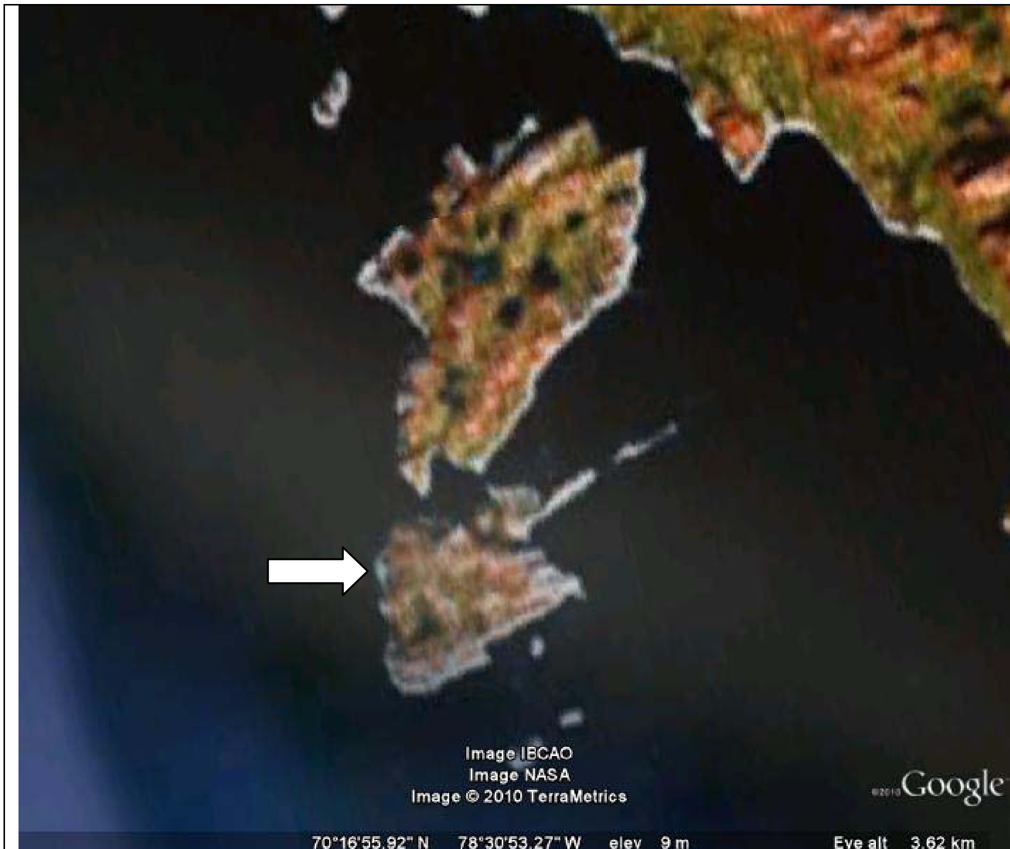


Figure B-1. Google Earth image of a bedrock shoreline, upper Steensby Inlet

Figure B-2. Oblique aerial photo of the *Bedrock* shore type at the same location as above image in upper Steensby Inlet

Bedrock Shore Type

Figure B-3. *Bedrock* shore ground photo from upper Steensby Inlet

Description:
Bedrock shore types are controlled by bedrock and are primarily bedrock within the intertidal zone, although small pocket beaches of boulder-cobble sediment may occur locally. Bedrock shores are usually steep (>20° slopes) and comparatively narrow in intertidal width (generally <25 m). *Bedrock* shores are more common along the intrusive or metamorphic bedrock types of Foxe Basin. *Bedrock* shores are more likely to have steeper nearshore gradients than other shore types.

Shore Type Ecological Significance
Bedrock shore are generally barren of intertidal biota, although *Fucus* seaweed does grow within small crevices. Sessile invertebrates are rare (a few barnacles). Bedrock may support kelp communities in the subtidal although kelp coverage is sparse in depths less than 10m due to ice scour.

Spill Response Issues
Bedrock shores have low permeability, which will limit penetration into the substrate. Retention oil from spills is typically low. Access by boat is likely easier than most shore types due to steeper offshore gradients.

Environment Canada Shore Type Equivalent (Owens and Sergy 2004, p. 84)
Bedrock

Beach Shore Type

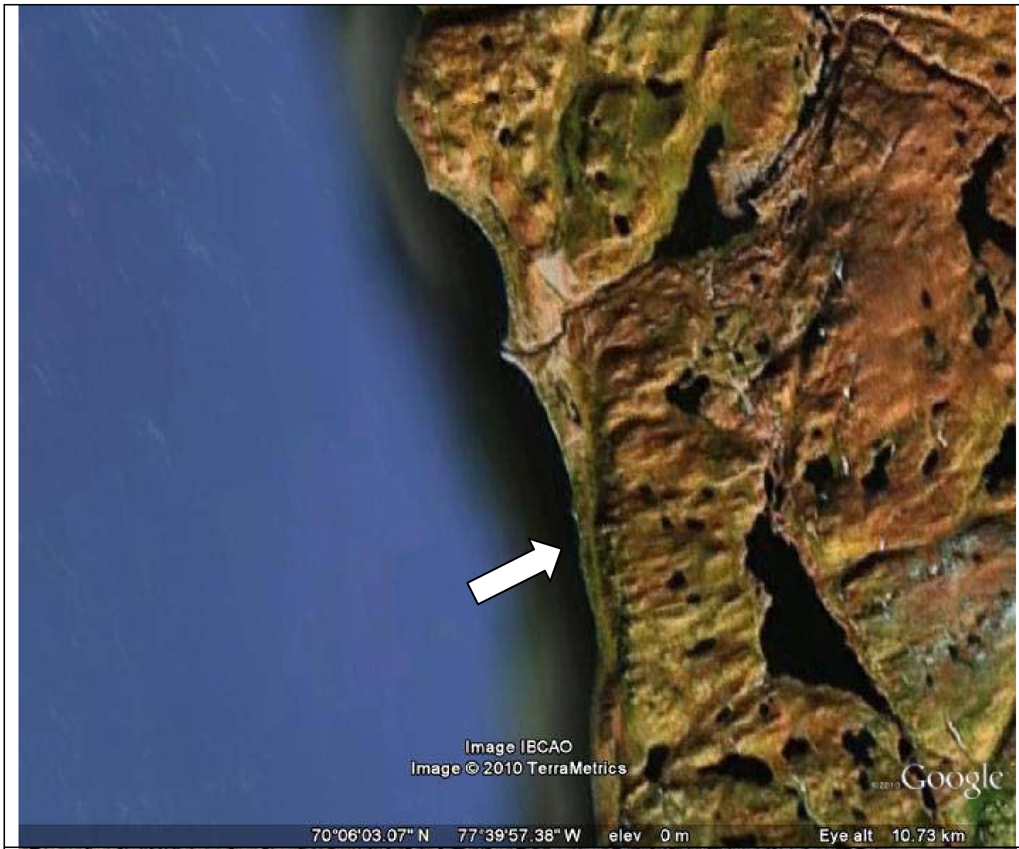


Figure B-4. Google Earth image of a *Beach* shore type, upper Steensby Inlet

Figure B-5. Oblique aerial photo of the *Beach* shore type shown in the Google Earth image, Steensby Inlet. Estimated beach width is 40 m.

Beach Shore Type

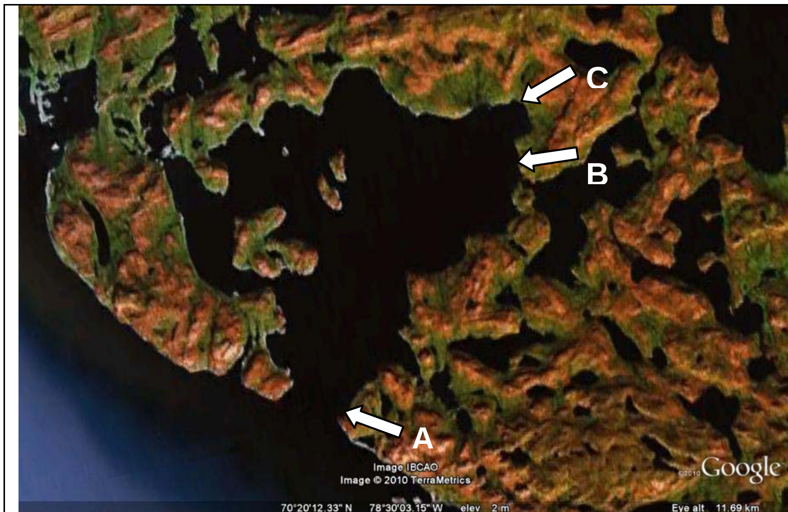


Figure B-6. Google Earth image of a large embayment to the north of the proposed Steensby port site.

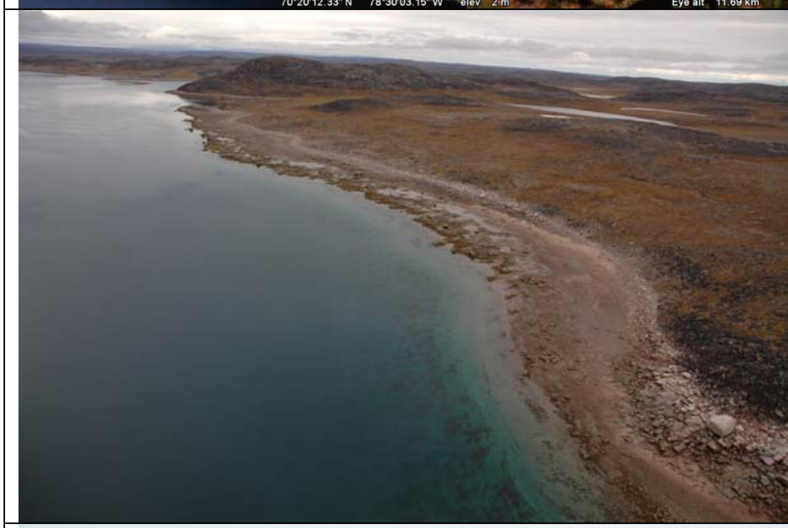


Figure B-7 Example of *Beach* shore type near the proposed Steensby (Location A) looking east. Estimated beach width is 35 m. *Fucus* seaweed is visible as the golden brown colour on boulders near the low-water line. Some subtidal kelp is visible as dark patches in the subtidal.

Figure B-8 Ground photo of the *Beach* shore type, Location A. Beach width is approximately 35 m.

Beach Shore Type

Figure B-9. *Beach* shore type in a more protected location of the bay (Location B). Darker coloration is *Fucus* seaweed on boulders near the water line. The primary matrix of this beach appears to be sand with some silt covered with a discontinuous veneer of boulder/cobble.

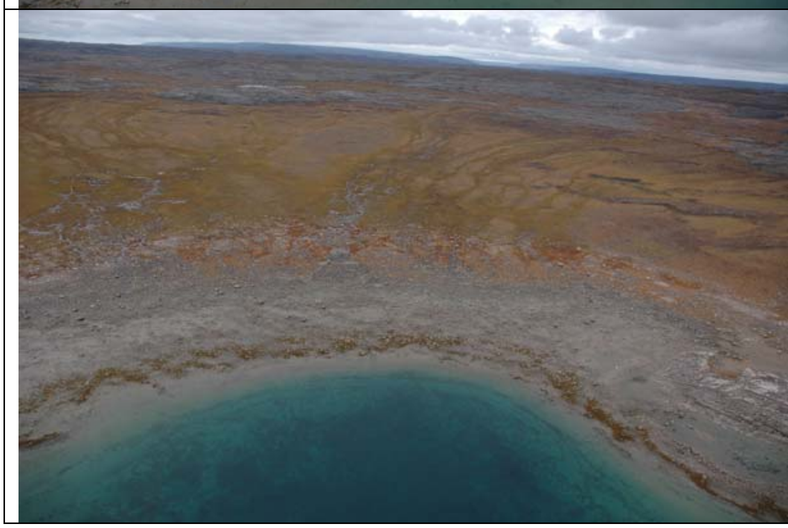


Figure B-10. An example of a *Beach* shore type in a very protected portion of the (Location C). Some *Fucus* seaweed is visible in the lower intertidal zone along the boulder ridge. The light brown coloration in the upper intertidal zone is salt marsh vegetation. Beach width is estimated at 60 m.

Description:
Beach shore types are likely the most common shoreline of Foxe Basin. *Beach* shore types are comprised of a combination of sand with veneers of boulder-cobble. Lower exposure areas are likely to include more sand and even silt. Higher exposure areas are likely to have more continuous cobble/boulder veneer with sand below the cobble/boulder armor. Shore-parallel, boulder-cobble ridges are common and related to ice-push and ice-sorting. Intertidal widths are usually less than 50m.

Shore Type Ecological Significance
On low energy *Beach* shore types there may be salt marsh vegetation in the upper intertidal zone, especially in low energy areas. Salt marsh vegetation is significantly grazed by geese. In Steensby Inlet where high resolution imagery has been collected, salt marsh vegetation occurs along 13% of the shoreline.

Fucus type seaweed is common (~45% of shoreline) along *Beach* shore types where is it attached to cobble and boulders along the low-water line. Filamentous algae is also present (est. ~10% of shoreline). Benthic kelps are frequently observed in the shallow subtidal zone.

Spill Response Issues
The permeability of *Beach* shore types varies, depending on the matrix of the beach sediments. In low wave exposure areas, the beach matrix is likely silt and sand, and the beach sediments are relatively impermeable, although surface veneers of boulder-cobble will be permeable. Retention is likely to be low to moderate on these low energy shores. On higher exposure shorelines, there likely be less silt and sand in the beach matrix so *Beach* shore types in moderate exposures are likely to have moderate permeability. Surface armor of cobble-boulder is likely to be permeable to most spilled fuels except for weathered Bunker C oils.

Salt marshes are likely to occur in the upper intertidal zones of some *Beach* shore types and more frequently in low-exposure areas than high exposure areas.

Environment Canada Shore Type Equivalent (Owens & Sergy 2004, p. 84)
Sand Beaches, Mixed Sediment (sand & gravel) Beaches, Pebble-Cobble Beaches, Boulder Beaches

Tidal Flat Shore Type

	Figure B-11. Google Earth image of a *Tidal Flat* shore type near the Rowley River, Steensby Inlet.
	Figure B-12. Oblique aerial photo of the *Tidal Flat* shore type near the Rowley River. Some *Fucus* seaweed is visible on boulders.

Tidal Flats Shore Type

Description:
The *Tidal Flat* shore type is characterized by intertidal flats that are commonly more than 1 km in width. The flats typically extend from the mid-intertidal zone to the low-water line and into the subtidal. The mid- to lower-intertidal flats are typically comprised of sand with silt contents controlled by water exposure; boulders are common but cobbles and pebbles are comparatively rare. The upper intertidal zone of the *Tidal Flat* shore type is usually a coarse beach-face and berm. Upper intertidal sediments may range from sand to boulder, depending on local sediment supply. Distinct berms or storm ridges sometimes occur in the upper intertidal; they are often comprised of well-sorted pebble or cobble and represent single storm events.

Shore Type Ecological Significance
Salt marsh may occur in the upper intertidal zone of low-energy flats. The wide intertidal flats may have discontinuous cover of *Fucus* seaweed on boulders near the low-water line. Accumulations of organics (e.g., seaweed detritus) occurs in tide-pools on the flats and brilliant white *Beggiatoa* bacteria is sometimes observed on these organic mats. Subtidal kelp attached to boulders may occur offshore.

Spill Response Issues
Stranded oil is not likely to adhere to the tidal flats due to their fine nature, high water content and low permeability. Oil is likely to lift off flats and accumulate in the coarser upper intertidal zone.

The permeability of upper intertidal beach sediments will vary, depending on the matrix of the sediments. In low wave exposure areas, the upper intertidal beach matrix is likely silt and sand, and the sediments relatively impermeable, although surface veneers of boulder-cobble will be permeable. Retention is likely to be low to moderate on these low energy shores. On higher exposure shorelines, there likely be less silt and sand in the beach matrix so *Tidal Flat* shore types in moderate exposures are likely to have moderate permeability. Surface armor of cobble-boulder is likely to be permeable to most spilled fuels except for weathered Bunker C oils.

Access to *Tidal Flat* shorelines will be a challenge. Access to the upper intertidal zone by boat will be highly tide-dependent.

Environment Canada Shore Type Equivalent (Owens & Sergy 2004, p. 84)
Mud Tidal Flats, Sand Tidal Flats

Flats with Ridge and Swale Shore Type

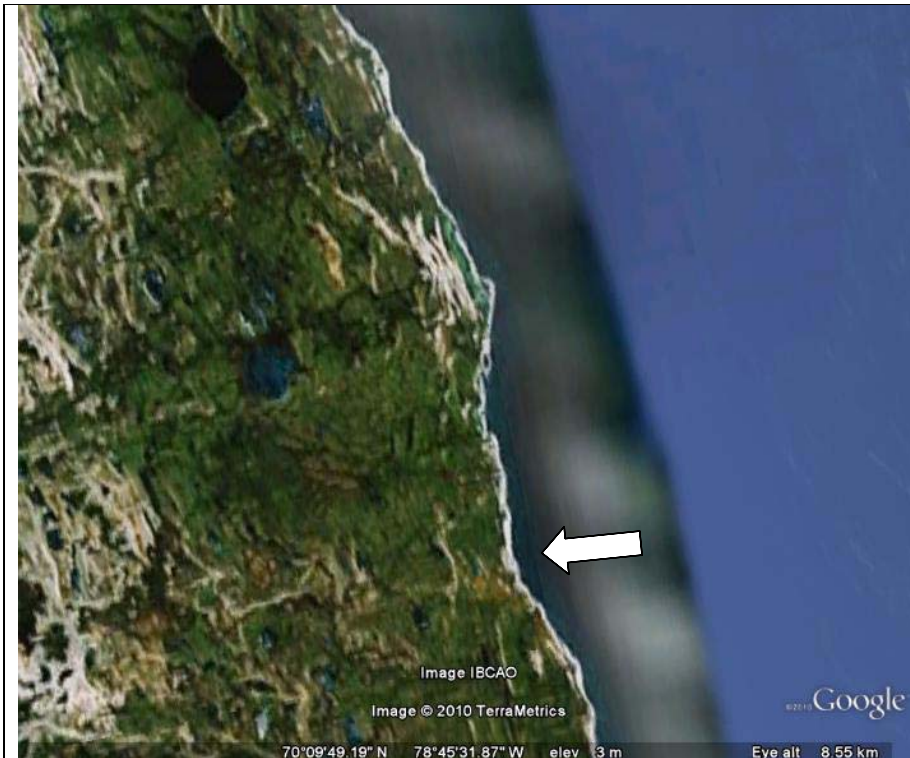


Figure B-13 Google Earth image of a , lower Steensby Inlet showing a location of *Tidal Flat with Ridge and Swale* shoreline.

Figure B-14. Oblique aerial photo of the *Tidal Flat with Ridge & Swale* shore type at the same location as above image in upper Steensby Inlet

Flats with Ridge & Swale Shore Type

Description:
The upper intertidal zone of the *Tidal Flat with Ridge & Swale* shore type is usually a narrow beach face and berm with numerous other beach ridges in the backshore creating a ridge and swale topography. The swales may be inundated during normal tides or storm surges, and salt marsh typically grows in the swales.

The mid-and lower-intertidal zones of the *Tidal Flat with Ridge & Swale* shore type is similar to the *Tidal Flat* shore type and characterized by intertidal flats that are commonly more than 1 km in width. The flats typically extend from the mid-intertidal zone to the low-water line and into the subtidal. The mid- to lower-intertidal flats are typically comprised of sand with silt contents controlled by water exposure; boulders are common but cobbles and pebbles are comparatively rare.

Shore Type Ecological Significance
Salt marshes are common with swales in supratidal and upper intertidal zones, where they are heavily grazed by geese.

The wide intertidal flats may have discontinuous cover of *Fucus* seaweed on boulders near the low-water line. Accumulations of organics (e.g., seaweed detritus) occurs in tide-pools on the flats, and brilliant white *Beggiatoa* bacteria is sometimes observed on these organic mats. Subtidal kelp attached to boulders may occur offshore.

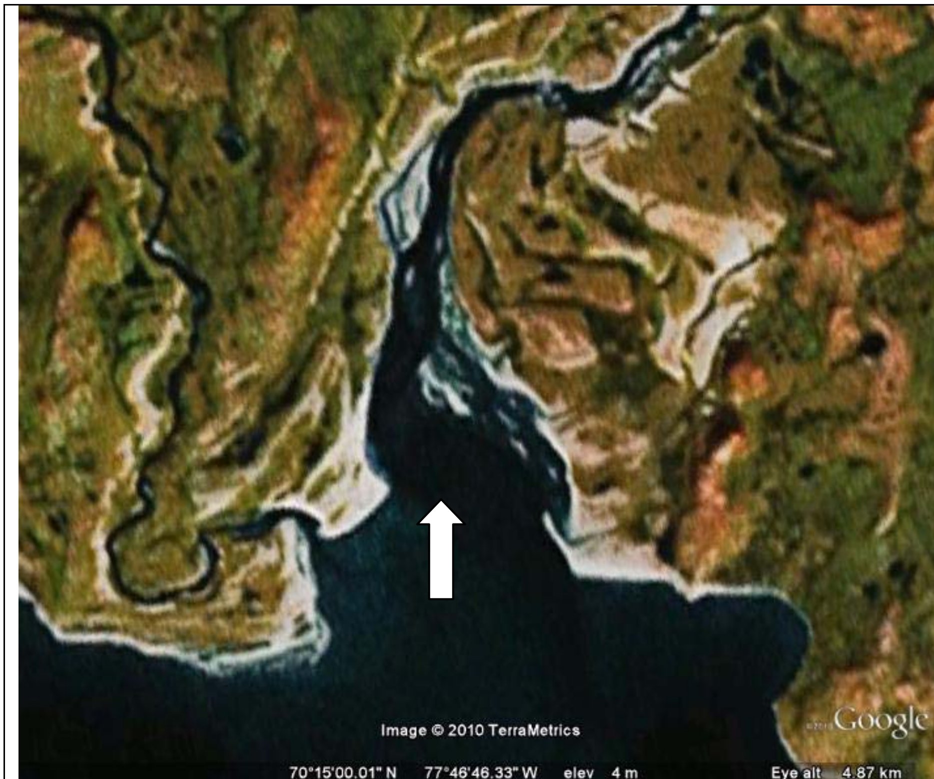
Spill Response Issues
The *Tidal Flat with Ridge and Swale* shore type is probably the most sensitive shore type to spills. If spilled oil is swept into the salt marsh swales, it will likely severely impact the marshes and will persist for long periods of time. The low exposure of the swale environments results in very slow rates of natural recovery and cleanup is not likely to be very effective (cleanup is difficult due to marsh sensitivity to trampling).

Stranded oil is not likely to adhere to the tidal flats due to their fine nature, high water content and low permeability. Oil is likely to lift off flats and accumulate in the coarser upper intertidal zone.

Access to *Tidal Flat* shorelines will be a challenge. Access to the upper intertidal zone by boat will be highly tide-dependent.

Environment Canada Shore Type Equivalent (Owens & Sergy 2004, p. 84)
Mud Tidal Flats, Sand Tidal Flats

Fluvial/Deltaic Shore Type

	Figure B-15. Google Earth image of the mouth of the Rowley River, Steensby Inlet.
	Figure B-16. Oblique aerial photo of the *Delta Complex* shore type at the mouth of the Rowley River, Steensby Inlet. Salt marshes are visible in the inter-swale areas (arrow)

Deltaic Complex Type

Description:
The *Delta Complex* shore type is the complex of tidal flats, channels, salt marshes and beach ridge complexes that occur in association with rivers of the Foxe Basin. The complexes are most often sandy but may include coarser sediments such as pebbles, cobble and boulders. There is very commonly a salt marsh habitat incorporated into the channel complexes. *Delta Complexes* are estuarine and dominated by a combination of river currents, tidal currents and wave action.

Shore Type Ecological Significance
Delta Complexes are often associated with anadromous fish streams so represent an important gateway between terrestrial and marine environments. There are often extensive salt marshes within the complexes.

Spill Response Issues
Salt marshes are commonly associated with these *Complexes* and known to be sensitive to spill impacts and difficult to clean. Oil reaching these marshes is likely to be persistent.

The channels and associated flats will present access challenges for small boats.

Environment Canada Shore Type Equivalent (Owens & Sergy 2004, p. 84)
Sand flats, Salt Marshes

Lagoon Complex Shore Type

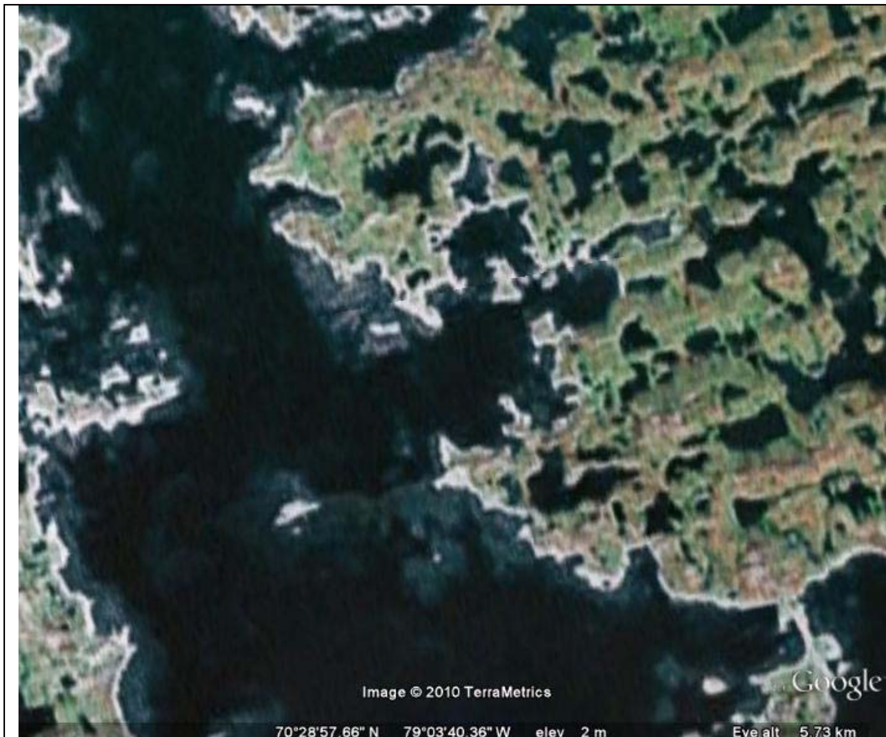


Figure B-17. Google Earth image of a bedrock shoreline, upper Steensby Inlet showing an area considered a *Lagoon Complex.*

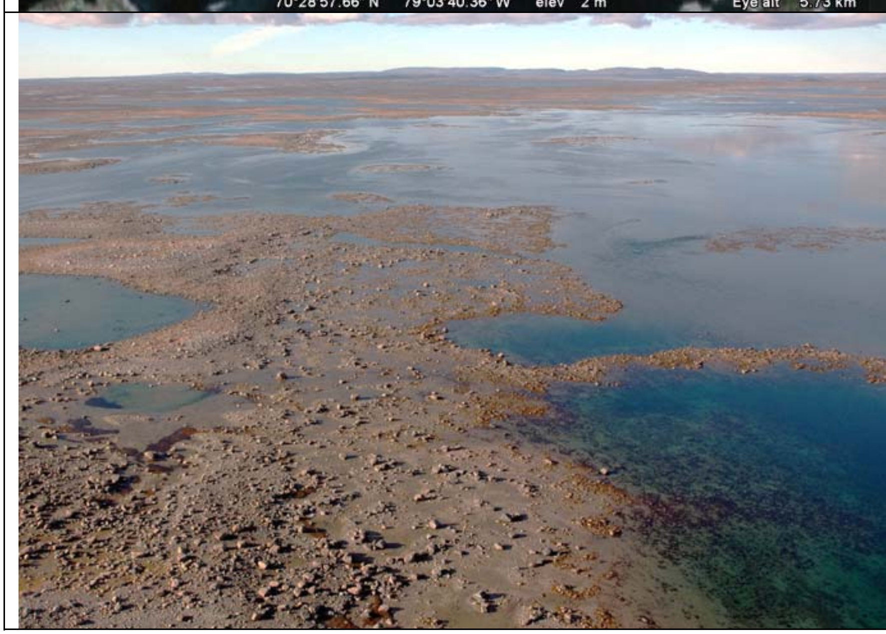


Figure B-18. Oblique aerial photo of the *Lagoon Complex* shore type in upper Steensby Inlet. These areas are inundated at each high tide. The dark patches in the subtidal are macro algae.

Lagoon Complex Shore Type

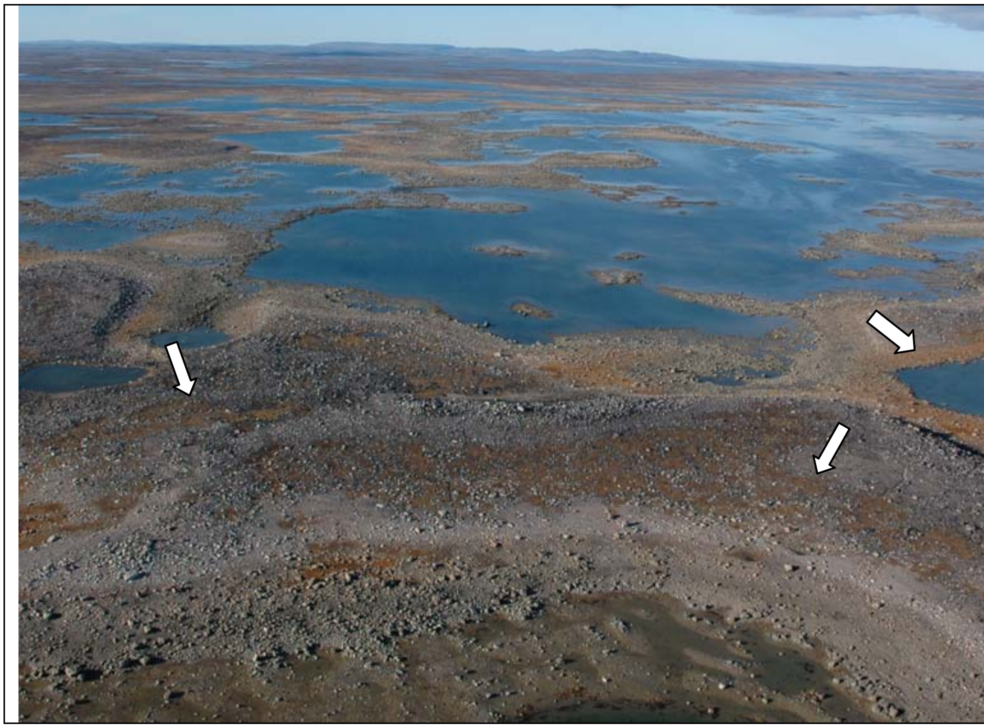


Figure B-19. *Lagoon Complex* shore type in upper Steensby Inlet. Intertidal salt marsh is common and visible as the "rust" color in the upper intertidal of the lagoons (arrows).

Description:
Lagoon Complexes are relatively common on low-gradient shorelines in Foxe Basin. They form a highly crenulated shoreline with very low wave exposures. Sediment within the complexes ranges from sand-silt matrices to boulders. Intertidal zones are typically very poorly organized without any prominent beach face or berm due to lack of wave exposure. Salt marshes are common in the upper intertidal zones. Subtidal basins within the complexes commonly include kelp. Brine pools, organic detritus and *Beggiatoa* bacterial mats also occur within these basins.

Shore Type Ecological Significance
Salt marshes are common within these complexes and probably occur along 25-50% of the intertidal zone. Subtidal kelp occurs in the more open channels.

Some subtidal pools are accumulate detritus (decomposing seaweed), as evidenced by the common occurrence of *Beggitatoa*¸ an anoxic bacterial mat.

Spill Response Issues
Oil reaching entering these *Lagoon Complexes* would likely degrade very slowly and have lengthy persistence.

Access for booming or cleaning operations would be challenging.

Environment Canada Shore Type Equivalent (Owens & Sergy 2004, p. 84)
Sand Flats, Salt Marshes, Inundated Tundra.

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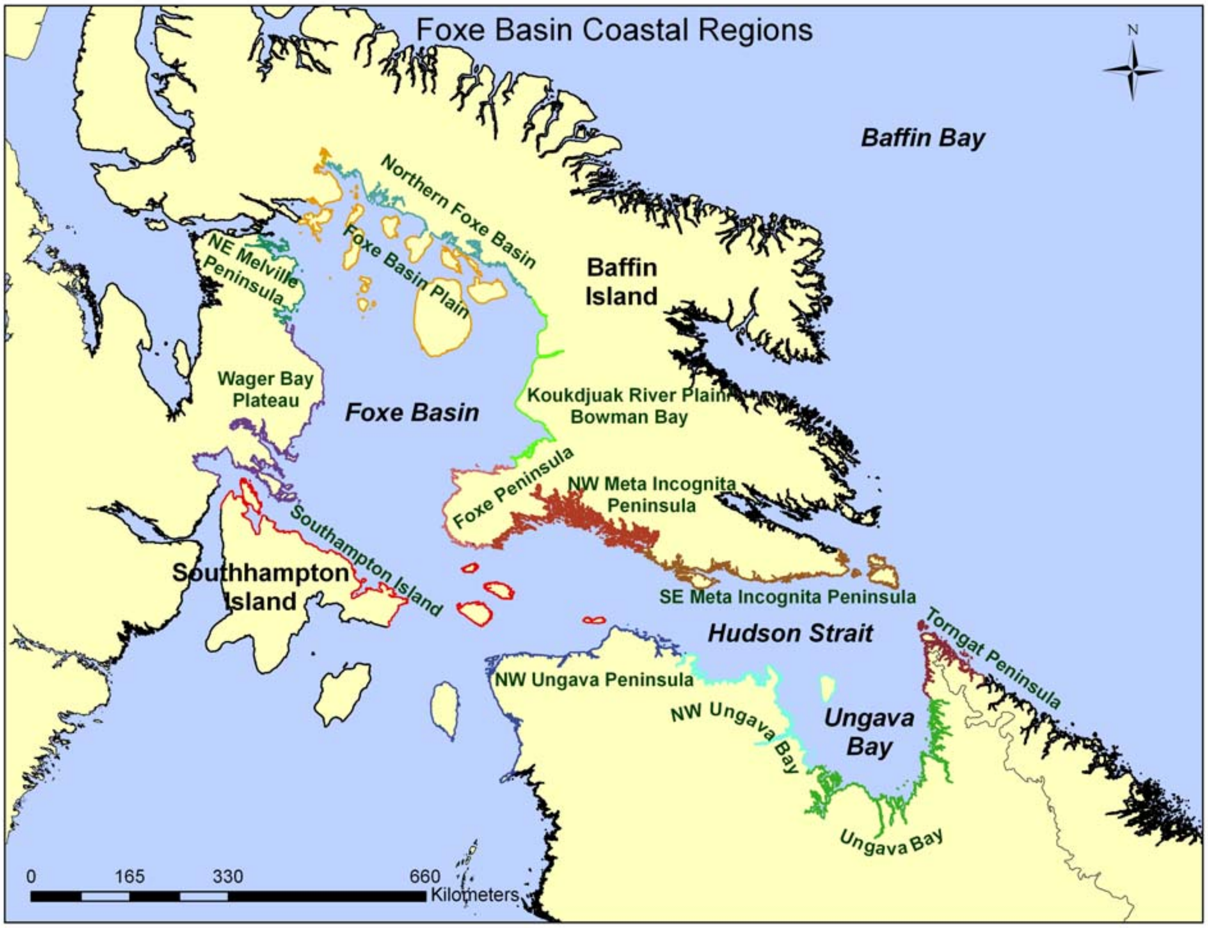
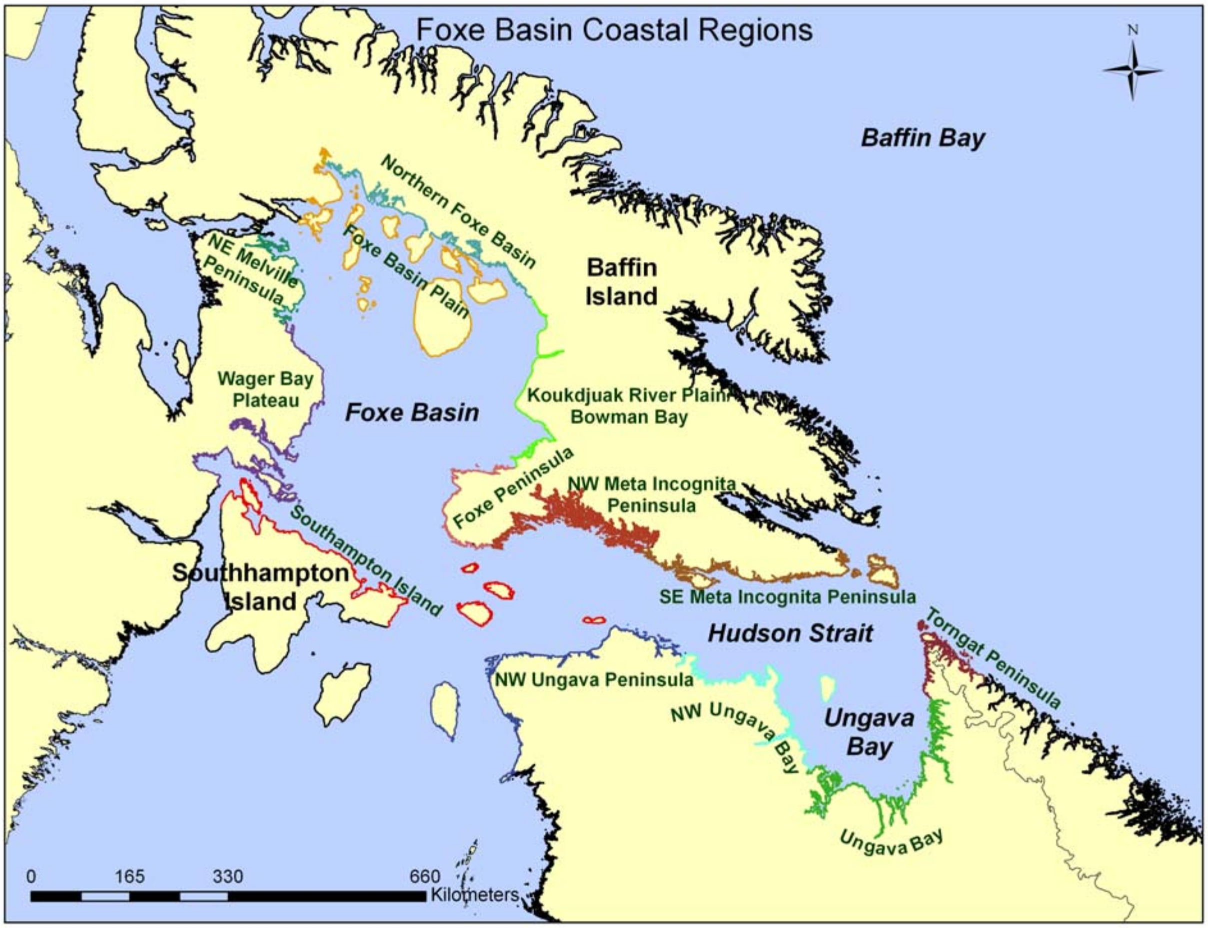
APPENDIX C
Foxe Basin Coastal Region Descriptions



Location Map of Regions

Summary, Torngat Peninsula Coastal Region

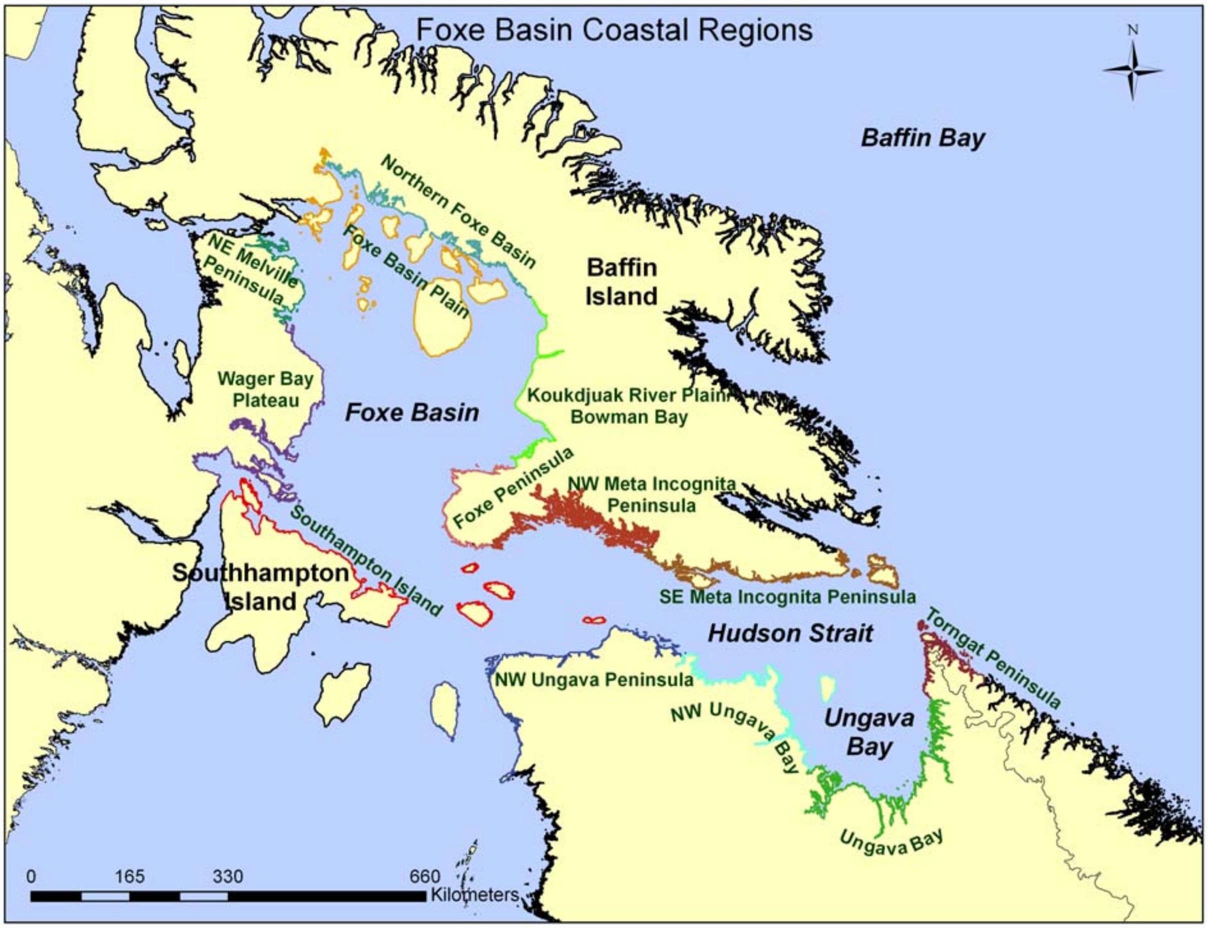
Overview of Region	The Torngat Peninsula lies in the Low Arctic oceanographic zone, at the eastern entrance to Hudson Strait. This region also includes the Button Islands. Strong currents are prominent in this region, especially the east side, where the Hudson Strait flows into the Davis Strait. The Torngat mountains contain the highest peaks of eastern, continental North America, with deep fjords bounded by steep rock walls. There are no settlements in the area.
Shoreline Length	1 963km
Ice Regime	Ice freeze-up usually occurs by mid-October, although the ice remains unconsolidated. Ice break-up begins in April.
Wave Climate	Exposed (max fetch >500 km) Shoreline 68% Semi-Exposed (max fetch 50-500 km) Shoreline 1% Protected (max fetch <10 km) Shoreline 31%
Large Rivers	None
Shore Types	Bedrock 82% Beaches 12% Flats 4% Flats w Ridge and Swale 0% Delta/Fluvial Complexes 0% Lagoon Complexes 2%
Key Ecological Features	
Coastal vegetation (CORI 2008)	unknown
Anadromous Fish Streams	unknown
Marine Mammal Use	beluga, narwhal, bowheads, walrus, seals (ringed, harp, harbour) and polar bears inhabit this region.
Bird Colonies	Thick-billed Murres, Common Eiders, Ivory Gulls, Northern Fulmars, Black-legged Kittiwakes. IBA: Galvano Island (LB024).



Location Map of Regions

Summary, Ungava Bay Coastal Region

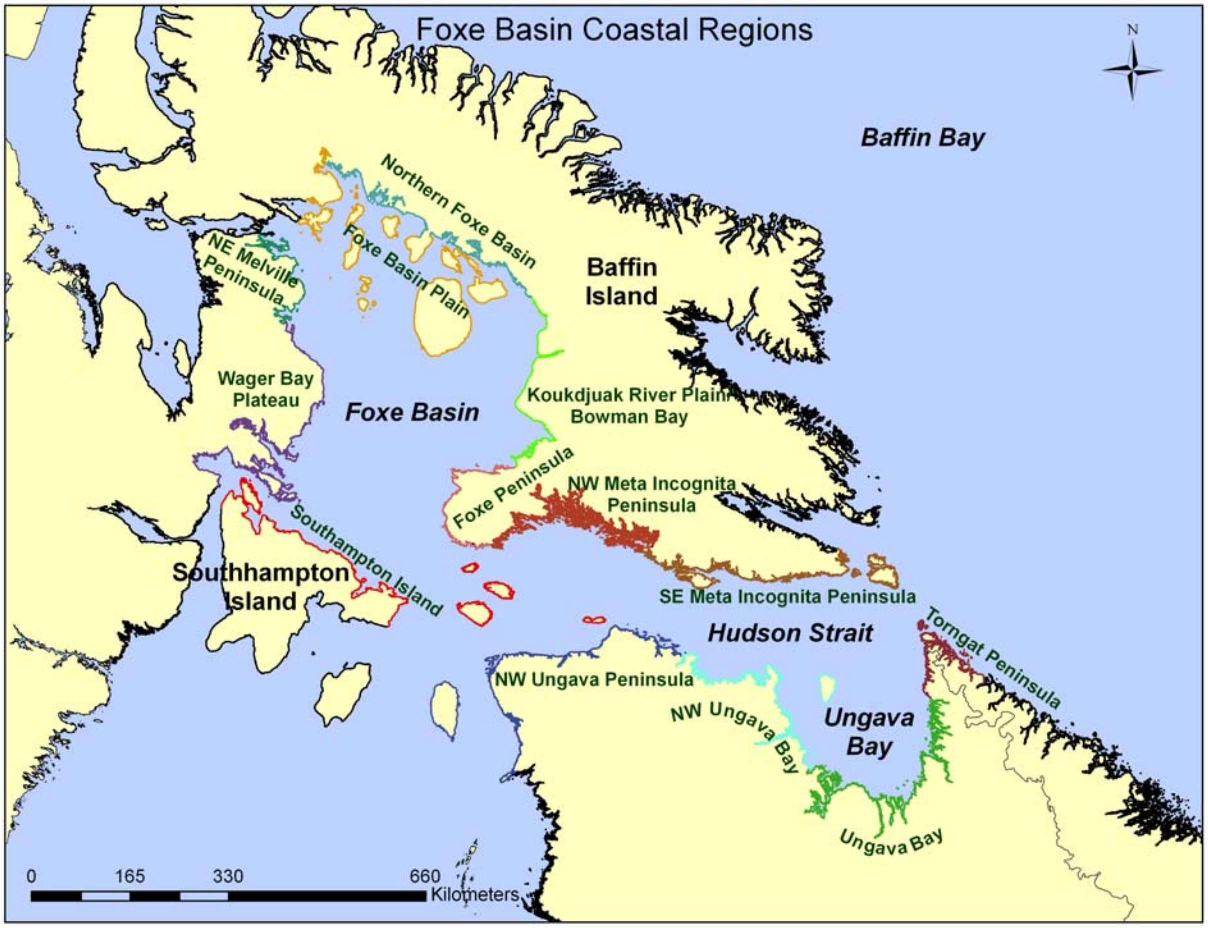
Overview of Region	Ungava Bay lies in the Low Arctic oceanographic zone. Ungava Bay is a large bay south of Baffin Island and opens into Hudson Strait. Ungava Bay is surrounded by numerous Inuit villages, the largest of which is Kuujjuaq, Quebec, at the mouth of the Koksoak River
Shoreline Length	4 033km
Ice Regime	Ice freeze-up usually starts by mid-October, although the ice remains unconsolidated. From January to April, mobile pack ice dominates Hudson Strait. Ice is confined to Ungava bay until late July.
Wave Climate	Exposed (max fetch >500 km) Shoreline 60% Protected (max fetch <10 km) Shoreline 40%
Large Rivers	Koksoak River, Leaf River, George River, Whale River, Korac River, Tunulic River
Shore Types	Bedrock 30% Beaches 27% Flats 32% Flats w Ridge and Swale 2% Delta Complexes 8% Lagoon Complexes 1%
Key Ecological Features	
Coastal vegetation (CORI 2008)	unknown
Anadromous Fish Streams	unknown
Marine Mammal Use	beluga, narwhal, bowheads, walrus, seals (ringed, harp, harbour, bearded) and polar bears inhabit this region.
Bird Colonies	Common Eiders (19% of Canadian population) IBA's: Northeast Ungava Bay (NU029), Gryfalcon Island (NU028).



Location Map of Regions

Summary, NW Ungava Bay & Hudson Strait Coastal Region

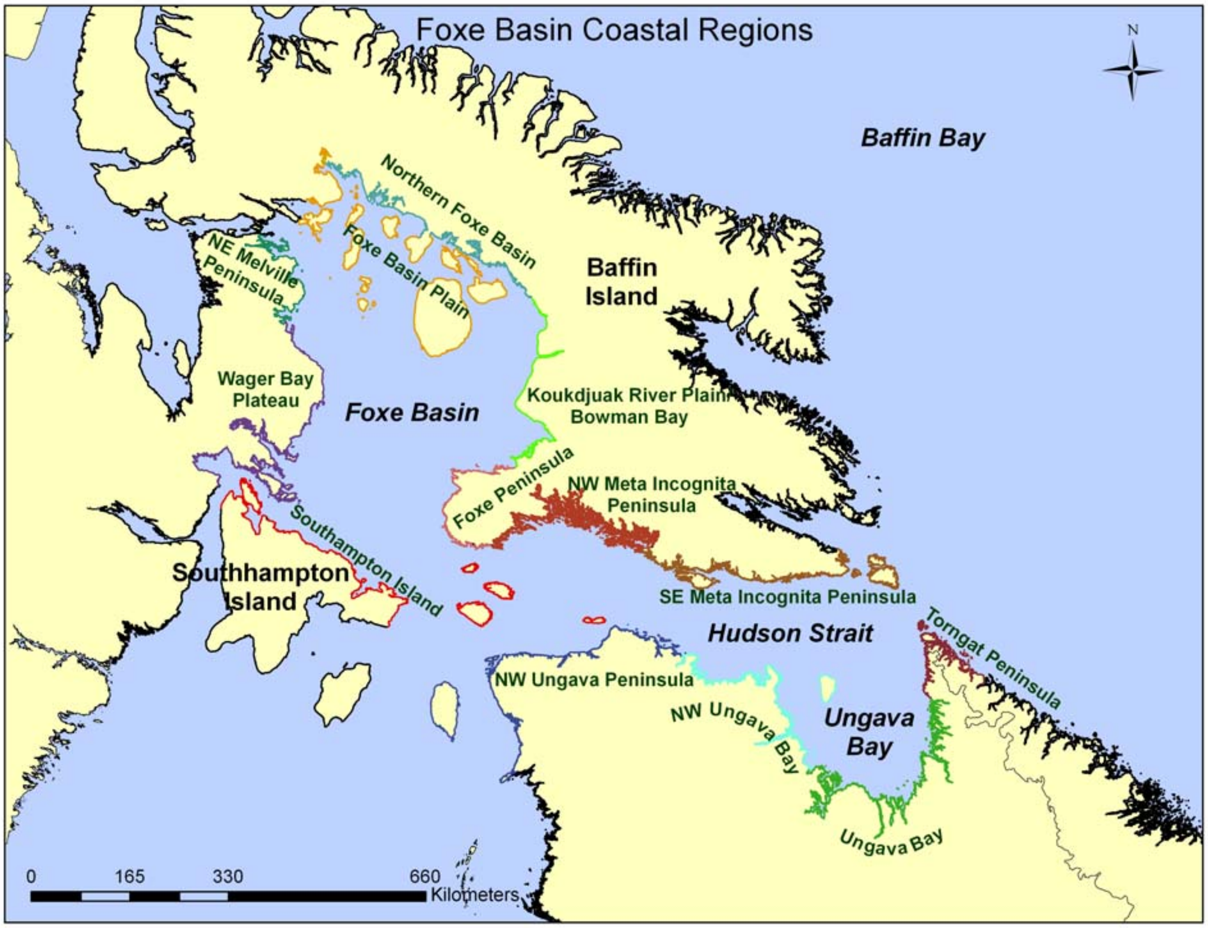
Overview of Region	Ungava Bay and Hudson Strait lie in the Low Arctic oceanographic zone Hudson Strait links the Atlantic Ocean to Hudson Bay. It lies between Baffin Island and the northern coast of Quebec. NW Ungava Bay is surrounded by numerous Inuit villages, the largest of which is Kangirsuk, Quebec.
Shoreline Length	2 161km
Ice Regime	Ice freeze-up usually starts by mid-October, although the ice remains unconsolidated. From January to April, mobile pack ice dominates Hudson Strait. Ice is confined to Ungava bay until late July.
Wave Climate	Exposed (max fetch >500 km) Shoreline 25% Semi-Exposed (max fetch 50-500 km) Shoreline 65% Protected (max fetch <10 km) Shoreline 10%
Large Rivers	Arnaud River
Shore Types	Bedrock 37% Beaches 28% Flats 21% Flats w Ridge and Swale 0% Delta/Fluvial Complexes 14% Lagoon Complexes 0%
Key Ecological Features	
Coastal vegetation (CORI 2008)	unknown
Anadromous Fish Streams	unknown
Marine Mammal Use	beluga, narwhal, bowheads, walrus, seals (ringed, harp, harbour, bearded) and polar bears inhabit this region.
Bird Colonies	Thick-billed Murres (Akpatok Is. supports largest (520,000 pairs or 20%) number of breeding Thick-billed Murres in Canada. Black Guillemots, Peregrines and Gyrfalcons, Glaucous Gulls breed here. IBA's: Akpatok Island (NU007), Eider Islands (NU026), Plover and Payne Islands (NU027).



Location Map of Regions

Summary, Northwestern Ungava Peninsula Coastal Region

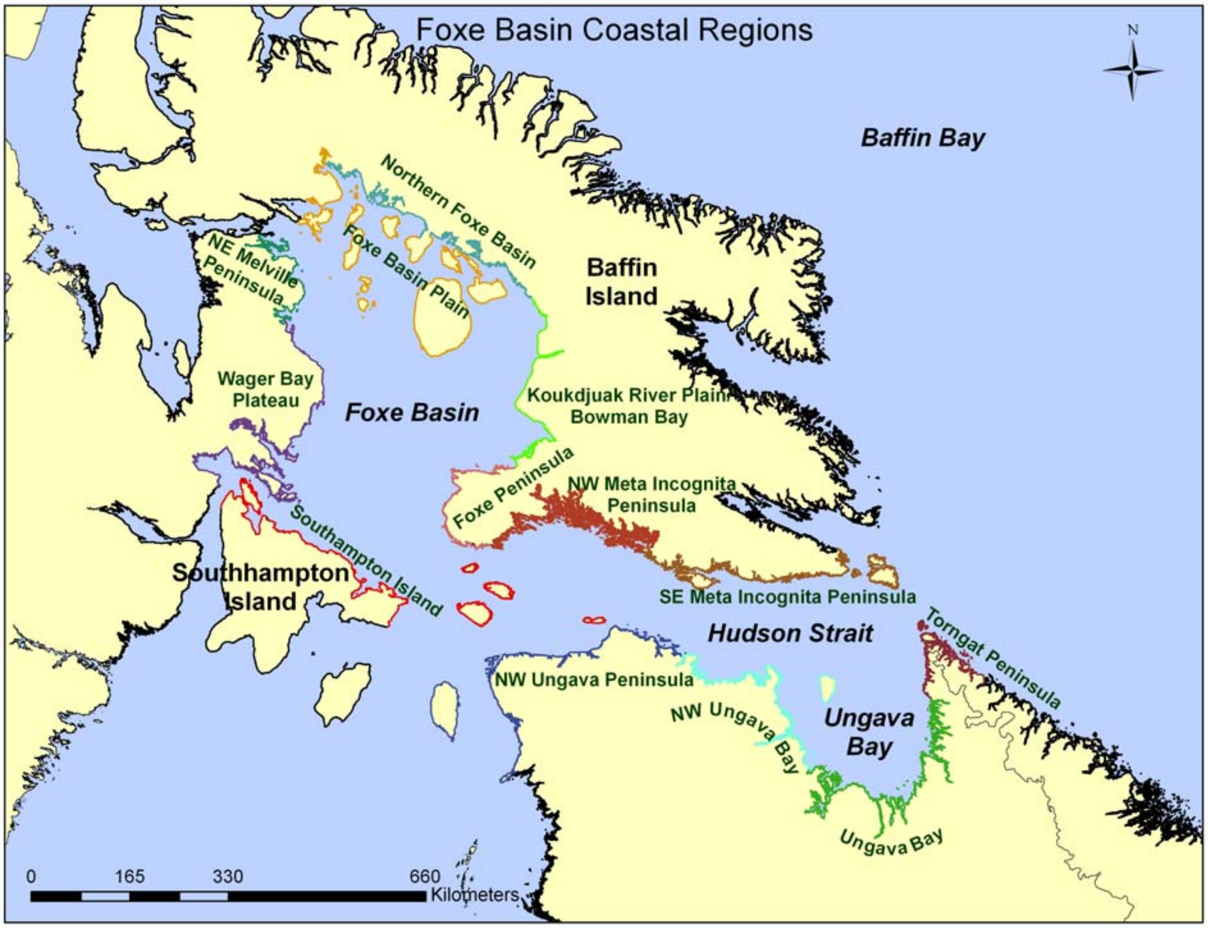
Overview of Region	The Northwestern Ungava Peninsula region is located at the southwestern extent of Hudson Strait to Ungava Bay, and including some of Northern Hudson Bay in northern Quebec. There are three permanent settlements in this region. Akulivik in north Hudson Bay, Inujivik at the mouth of Hudson Bay, and Salluit in Hudson Strait.
Shoreline Length	2,258 km
Ice Regime	Ice freeze-up usually occurs by mid-to-late October. Mobile pack ice predominates Hudson Strait January to April with landfast ice formed around coastlines. Ice break-up begins in April and little ice remains by late July.
Wave Climate	Exposed (max fetch >500 km) Shoreline 43% Semi-Exposed (max fetch 50-500 km) Shoreline 49% Protected (max fetch <10 km) Shoreline 9%
Large Rivers	Korak River
Shore Types	Bedrock 36% Beaches 40% Flats 11% Flats w Ridge and Swale 1% Delta Complexes 10% Lagoon Complexes 2%
Key Ecological Features	
Coastal vegetation (CORI 2008)	unknown
Anadromous Fish Streams	unknown
Marine Mammal Use	beluga, narwhal, bowheads, walrus, seals (ringed, harp, harbour, bearded) and polar bears inhabit this region.
Bird Colonies	An estimated 287,000 breeding pairs of Thick-billed Murre nest in Digges Sound. This is also home to pairs of Black Guillemots and Iceland Gulls as well as some Atlantic Puffins. Tundra Swans, Oldsquaw, Herring Gulls, Common Elder, and colonial water birds and seabirds have been observed. IBA: Awry Island (NU018), Diggs Sound (NU001).



Location Map of Regions

Summary, SE Meta Incognita Peninsula Coastal Region

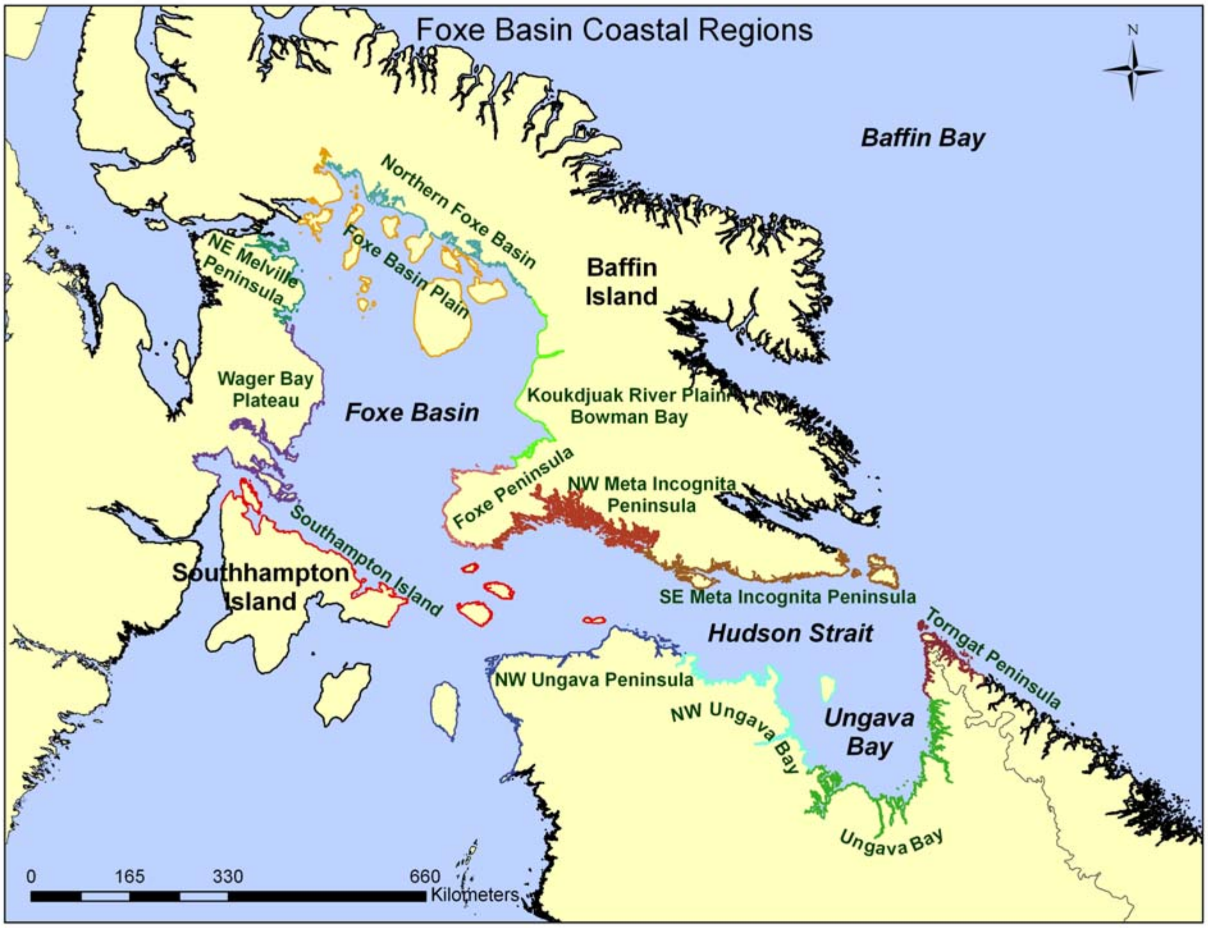
Overview of Region	The Baffin Island Meta Incognita Peninsula is located at the eastern extent of Hudson Strait, to the southern entrance to Frobisher Bay. The region is remote and relatively pristine. Kimmirut (Lake Harbour) is the only permanent settlement.
Shoreline Length	4 624 km
Ice Regime	Ice freeze-up usually begins in Late October or early November, but can vary greatly among years. Ice break-up typically begins in April near open water, but may persist into late July.
Wave Climate	Exposed (max fetch >500 km) Shoreline 55% Semi-Exposed (max fetch 50-500 km) Shoreline 17% Protected (max fetch <10 km) Shoreline 28%
Large Rivers	The Ramsay River, the Soper River, and rivers flowing into Barrier and Wight Inlets
Shore Types	Bedrock 78% Beaches 14% Flats 7% Flats w Ridge and Swale 0% Delta Complexes 1% Lagoon Complexes 0%
Key Ecological Features	
Coastal vegetation (CORI 2008)	unknown
Anadromous Fish Streams	unknown
Marine Mammal Use	beluga, narwhal, bowheads, walrus, seals (ringed, harp, harbour, bearded) and polar bears inhabit this region.
Bird Colonies	Thick-billed Murres (~50,000pairs or ~3% of Canadian population), Black-legged Kittiwakes (~5,000 pairs or ~2% of Canadian population) and Northern Fulmars (<49) at Hantzsch/Edgell Islands (Globally Significant). Black-legged Kittiwakes at Resolution Island. Common Eiders, Glaucous and Iceland Gulls also common to the area. At-risk species of Ivory Gulls and Harlequin Ducks have also been observed. IBA: Hantzsch Island (NU025).



Location Map of Regions

Summary, NW Meta Incognita Peninsula Coastal Region

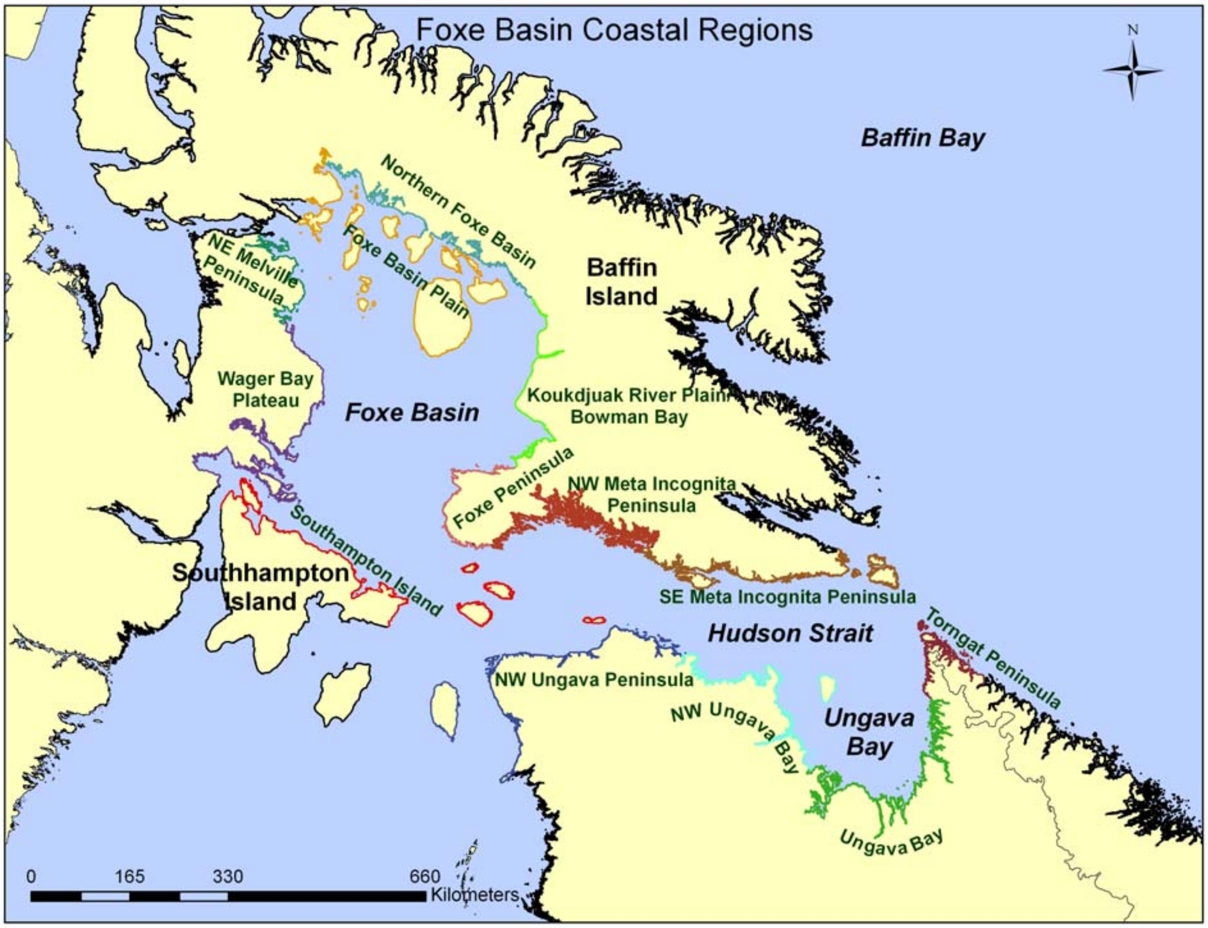
Overview of Region	The Baffin Island Cape Dorset Hudson Strait is located at the western extent of Hudson Strait, from the southernmost extent of Foxe Basin at Cape Dorset to mid-Hudson Strait. Dense archipelago of thousands of islets and sherries; numerous embayments and inlets. The region is remote and relatively pristine. Cape Dorset is the only permanent settlement. Amajuba is no longer inhabited.
Shoreline Length	7 703 km
Ice Regime	Ice freeze-up usually occurs by mid-October. Mobile pack ice predominates Hudson strait January to April, with landfast ice formed around coastlines. Ice break-up begins in April, with a recurrent shore lead along south shore of Baffin Island. Little ice remains by late July.
Wave Climate	Exposed (max fetch >500 km) Shoreline 14% Semi-Exposed (max fetch 50-500 km) Shoreline 15% Protected (max fetch <10 km) Shoreline 71%
Large Rivers	No major named rivers; rivers flowing into Charka, Kook, Ava Inlets and Amajuba, Bland ford and White Bear Bays.
Shore Types	Bedrock 65% Beaches 23% Flats 10% Flats w Ridge and Swale 0% Delta Complexes 1% Lagoon Complexes 1%
Key Ecological Features	
Coastal vegetation (CORI 2008)	unknown
Anadromous Fish Streams	unknown
Marine Mammal Use	beluga, narwhal, bowheads, walrus, seals (ringed, harp, harbour, bearded) and polar bears inhabit this region.
Bird Colonies	Continentally Significant Common Eider colony at Markham Bay supports up to 7% of the Canadian population (8,000 – 10,000 breeding pairs). Substantial numbers of Iceland Gulls and Black Guillemots also observed. IBA: Markham Bay (NU101).



Location Map of Regions

Summary, Foxe Peninsula Coastal Region

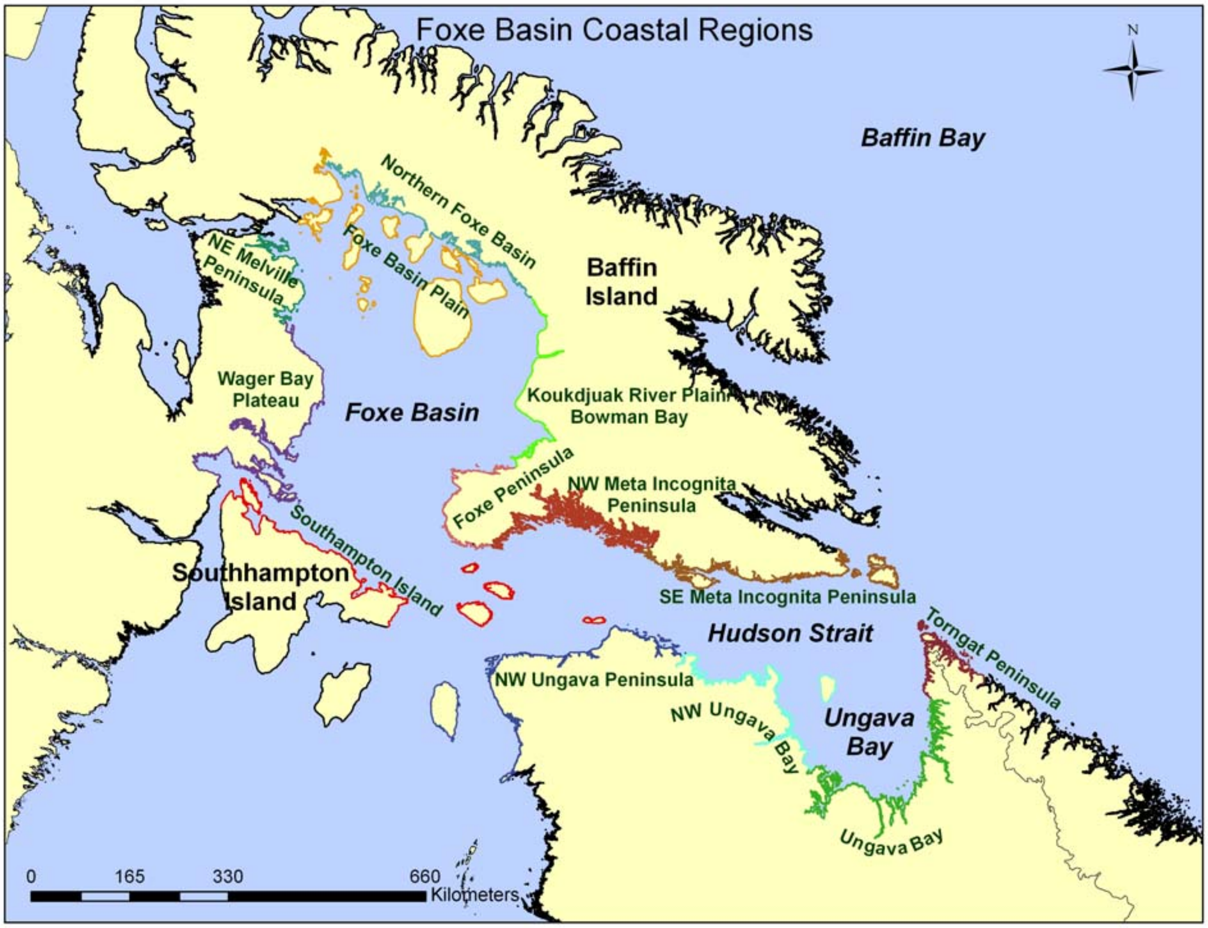
Overview of Region	The Foxe Peninsula lies south of the Great Koukdjuak Plains on the east side of Foxe Basin on Baffin Island. The south side of the Peninsula opens up into Hudson Strait. It is a remote area with no permanent settlements.
Shoreline Length	1 043 km
Ice Regime	Ice freeze-up usually starts by mid-October and ice break-up usually starts in mid-July. Mobile pack ice continues through summer in Foxe Basin. Mobile pack ice predominates Hudson Strait Jan to Apr with landfast ice formed around coastlines.
Wave Climate	Exposed (max fetch >500 km) Shoreline 8% Semi-Exposed (max fetch 50-500 km) Shoreline 82% Protected (max fetch <10 km) Shoreline 10%
Large Rivers	Romanic River, Dunne River
Shore Types	Bedrock 55% Beaches 17% Flats 14% Flats w Ridge and Swale 9% Delta Complexes 5% Lagoon Complexes 0%
Key Ecological Features	
Coastal vegetation (CORI 2008)	unknown
Anadromous Fish Streams	unknown
Marine Mammal Use	beluga, narwhal, bowheads, walrus, seals (ringed, harp, harbour, bearded) and polar bears inhabit this region.
Bird Colonies	Tundra swan, Canada Geese, Oldsquaw, Herring Gulls sightings. Lesser snow geese, Brant in Koukdjuak Plains.



Location Map of Regions

Summary, Koukdjuak River Plain & Bowman Bay Coastal Region

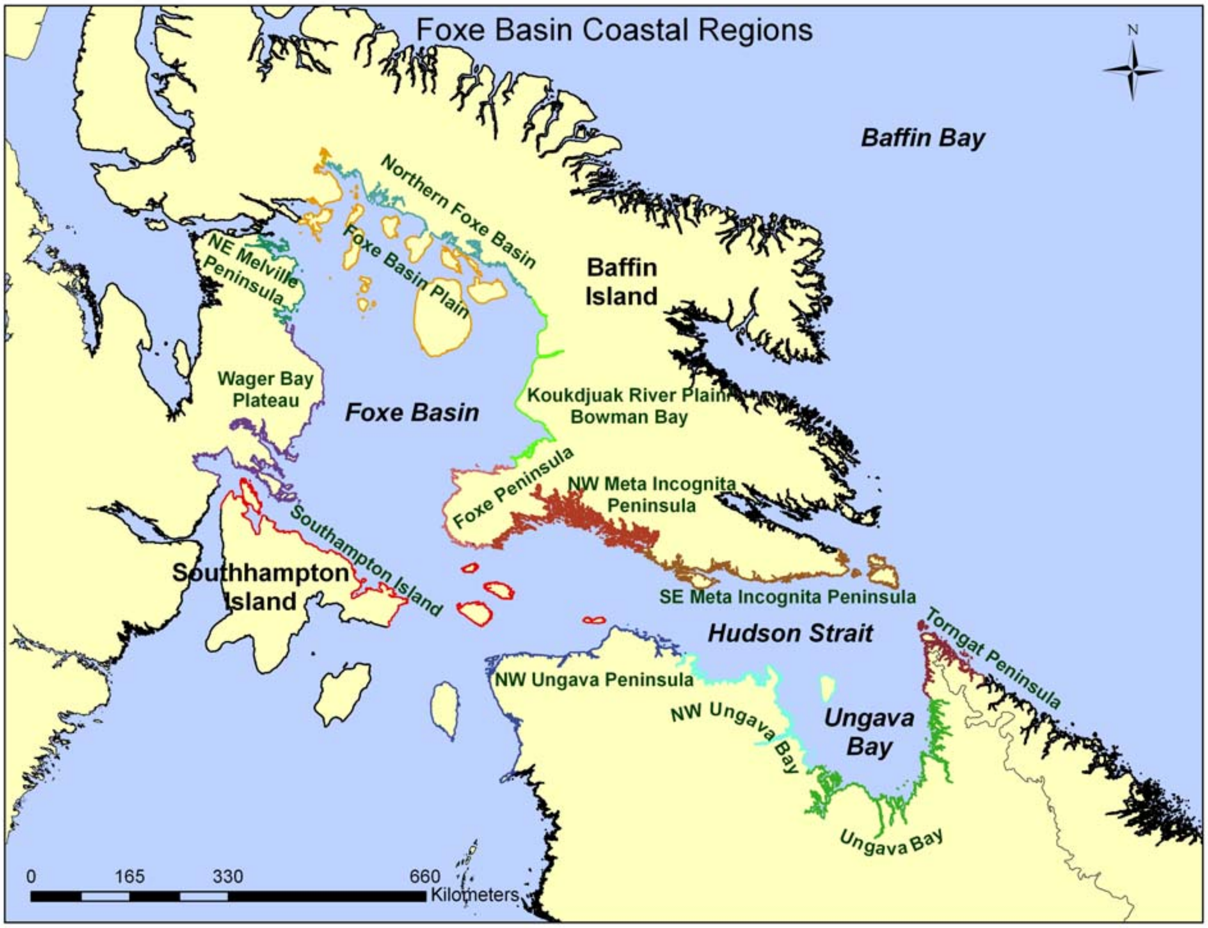
Overview of Region	The great plains of the Koukdjuak are on the easternmost section of Foxe Basin. It is home to the Dewey Soper Migratory Bird Sanctuary (8,159 sq km) and the Bowman Bay Wildlife Sanctuary (1,079 sq km). There are no permanent settlements.
Shoreline Length	915 km
Ice Regime	Ice freeze-up usually occurs by mid-October. Ice break-up usually occurs mid July. Mobile pack ice continues through summer in Foxe Basin.
Wave Climate	Semi-Exposed (max fetch 50-500 km) Shoreline 74% Semi-Protected (Max fetch 10-50 km) Shoreline 13% Protected (max fetch <10 km) Shoreline 13%
Large Rivers	Koukdjuak River, Bluegoose River.
Shore Types	Bedrock 16% Beaches 1% Flats 4% Flats w Ridge and Swale 35% Delta Complexes 43% Lagoon Complexes 1%
Key Ecological Features	
Coastal vegetation (CORI 2008)	
Anadromous Fish Streams	
Marine Mammal Use	beluga, narwhal, bowheads, walrus, seals (ringed, harp, bearded) and polar bears inhabit this region.
Bird Colonies	The Great Plain of the Koukdjuak on Baffin Island is the world's largest goose nesting colony, with upwards of 2 million birds, 75 percent of which are Lesser Snow Geese and the remainder Canada Geese and Brant. Jaegers, Herring Gulls, Arctic Terns have been observed on the Great Plain. IBA: Great Plain of the Koukdjuak (NU078).



Location Map of Regions

Summary, Foxe Basin Plain Coastal Region

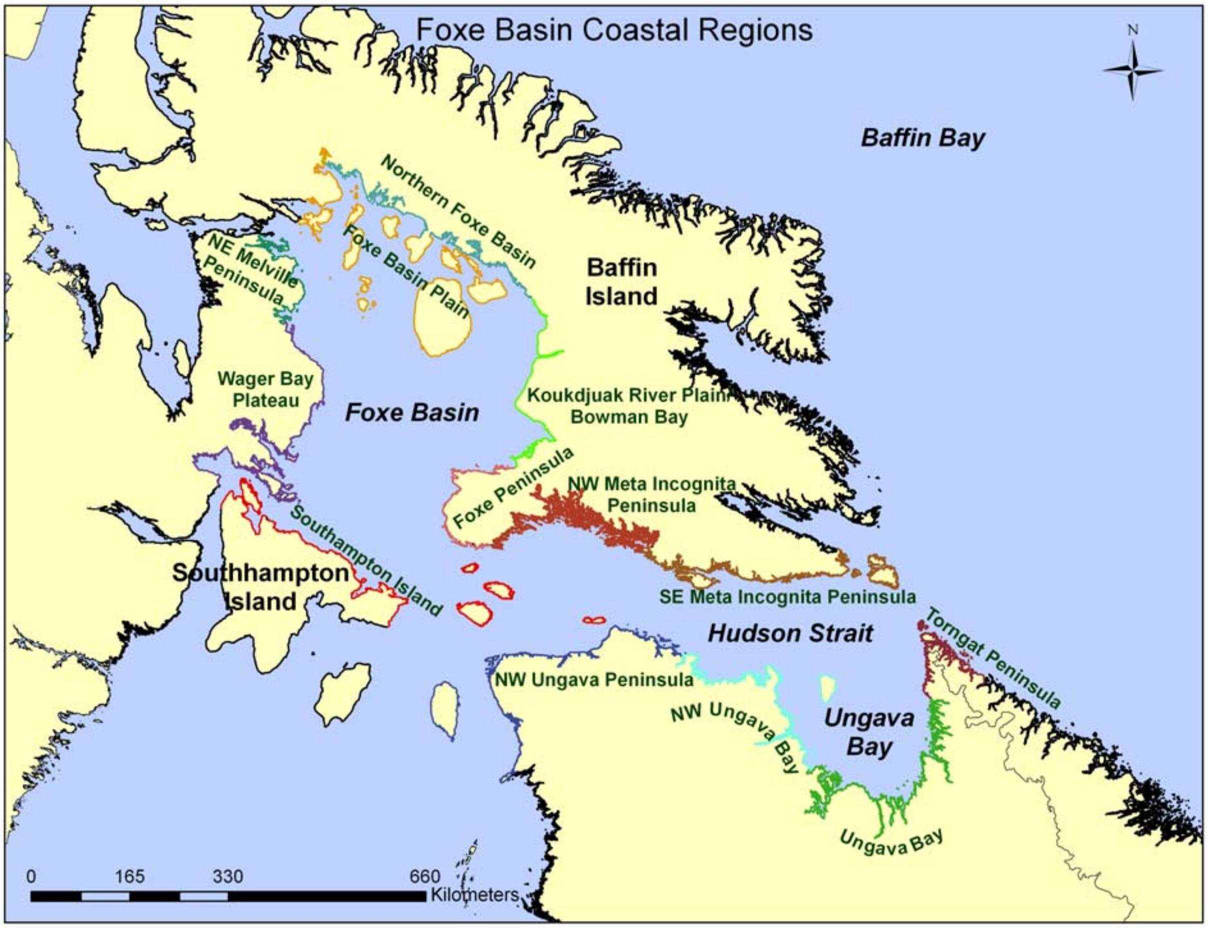
Overview of Region	The North Foxe Basin Islands range from south of Steensby Inlet to the West reaches of Foxe Basin along the south coast of Baffin Island and including some stretches of Baffin Island. The region is remote and has no permanent settlements.
Shoreline Length	2 848 km
Ice Regime	Ice freeze-up usually occurs by mid-October. Ice break-up usually occurs mid July and the area is ice free early August. Landfast ice dominates in the north for much of the year. Pack ice is present for much of the summer.
Wave Climate	Exposed (max fetch >500 km) Shoreline 5% Semi-Exposed (max fetch 50-500 km) Shoreline 54% Semi-Protected (Max fetch 10-50 km) Shoreline 32% Protected (max fetch <10 km) Shoreline 9%
Large Rivers	No major named rivers; Rivers flowing from Prince Charles Island into Foxe Basin and from NW Baffin Island into Murray Maxwell Bay.
Shore Types	Bedrock 6% Beaches 34% Flats 34% Flats w Ridge and Swale 17% Delta Complexes 1% Lagoon Complexes 8%
Key Ecological Features	
Coastal vegetation (CORI 2008)	
Anadromous Fish Streams	Raven River, Harder River, Neergaard River
Marine Mammal Use	beluga, narwhal, bowheads, walrus, seals (ringed, harp, bearded) and polar bears inhabit this region.
Bird Colonies	Globally and continentally Signicant North American stronghold for the Sabine's Gull, with some (>35,000 pairs nesting here is the largest known concentration in the world). Brant, Black Guillemots, Ivory Gulls, Jaegers, and Snowy Owls observed on Prince Charles and Air Force Islands. Arctic Tern sightings in Foxe Basin Islands Region. White-rumped Sandpiper (>10,000 pairs is half the global population). The Spicer Islands includes 1% of the Canadian population of Atlantic Brant. IBA: Foxe Basin Islands (NU011); IBA Spicer Islands



Location Map of Regions

Summary, North Foxe Basin Coastal Region

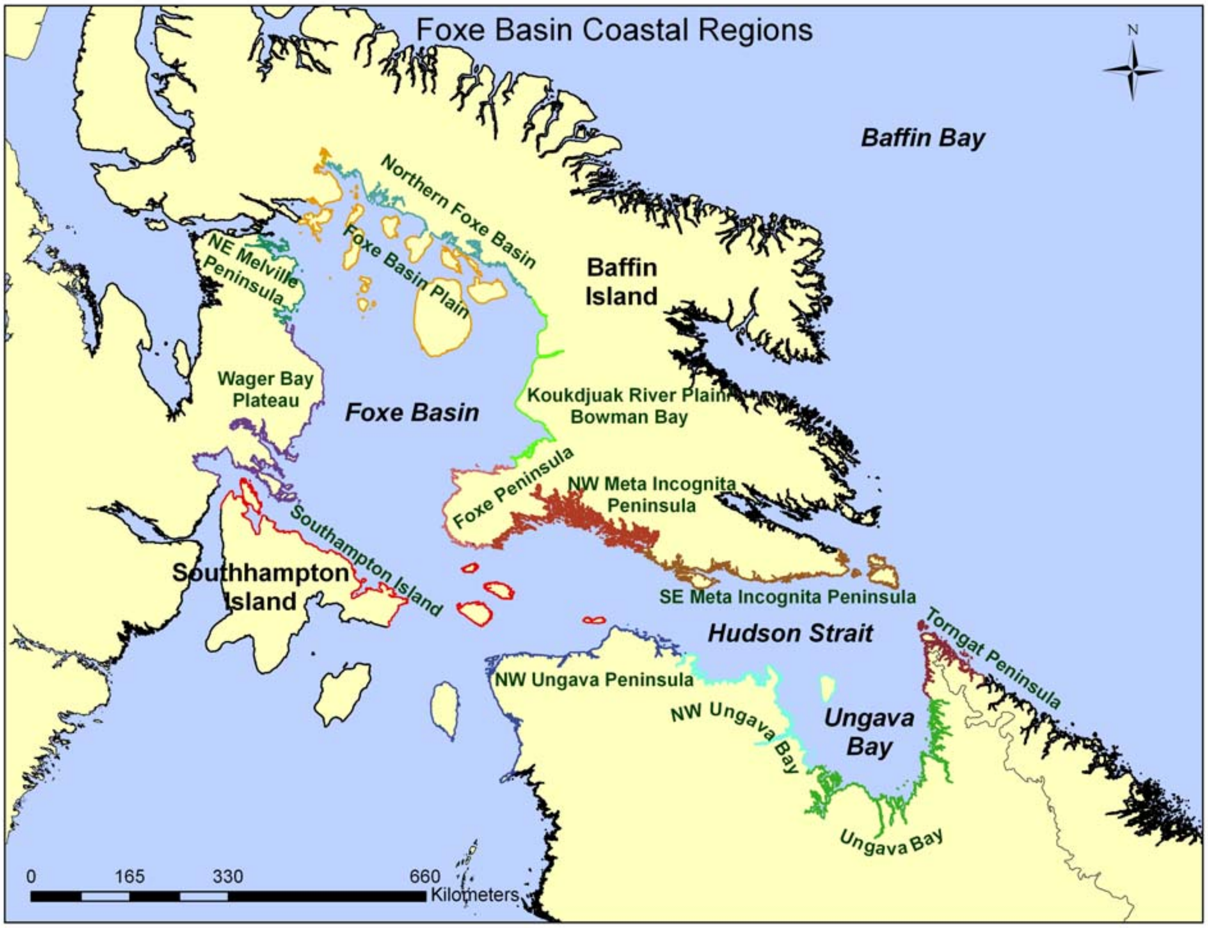
Overview of Region	This region is composed of large lagoon shorelines. It is remote and is relatively pristine. The proposed Steensby Inlet port site (Baffinlands) is located in the north portion of this region. In detailed aerial surveys around Steensby Inlet, only a few permanent, seasonal hunting camps were noted.
Shoreline Length	1 956 km
Ice Regime	Ice freeze-up usually starts in late October. Ice break-up usually starts in Northern Foxe Basin in early July.
Wave Climate	Semi-Exposed (max fetch 50-500 km) Shoreline 37% Semi-Protected (Max fetch 10-50 km) Shoreline 22% Protected (max fetch <10 km) Shoreline 41%
Large Rivers	Rowley River, Yupik River
Shore Types	Bedrock 10% Beaches 46% Flats 15% Flats w Ridge and Swale 2% Delta Complexes 3% Lagoon Complexes 24%
Key Ecological Features	
Coastal vegetation (CORI 2008)	13% of shoreline has salt marsh (CORI 2008a) 45% of shoreline has *Fucus* (CORI 2008a)
Anadromous Fish Streams	Rowley River, Cockburn River, Soto River, Ikpikitturjuak River
Marine Mammal Use	beluga, narwhal, bowheads, walrus, seals (ringed, harp, bearded) and polar bears inhabit this region.
Bird Colonies	Snow Geese, Oldsquaw< King Eiders and Herring Gull.



Location Map of Regions

Summary, NE Melville Peninsula Coastal Region

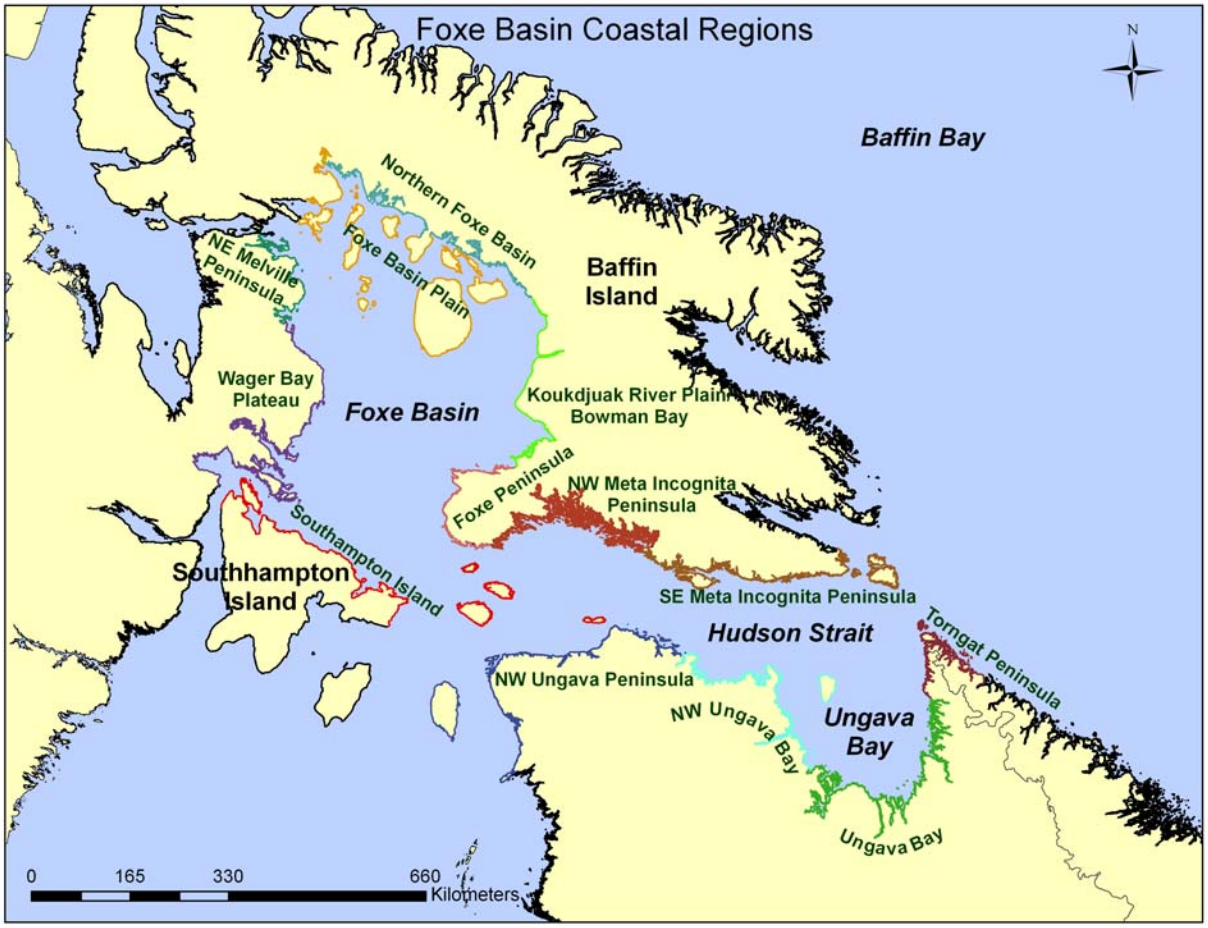
Overview of Region	The Northeast Melville Peninsula region is located on the Westernmost stretch of Foxe Basin. Raised beach features are common due to isostatic uplift. Igloolik and Hall Beach are the two permanent settlements in this region.
Shoreline Length	1 060 km
Ice Regime	Ice freeze-up usually occurs by mid-October. Ice break-up usually occurs mid July. Mobile pack ice continues through summer in Foxe Basin.
Wave Climate	Semi-Exposed (max fetch 50-500 km) Shoreline 75% Protected (max fetch <10 km) Shoreline 25%
Large Rivers	Crozier River, Ikerasak River
Shore Types	Bedrock 32% Beaches 32% Flats 18% Flats w Ridge and Swale 8% Delta Complexes 7% Lagoon Complexes 3%
Key Ecological Features	
Coastal vegetation (CORI 2008)	
Anadromous Fish Streams	
Marine Mammal Use	beluga, narwhal, bowheads, walrus, seals (ringed, harp, bearded) and polar bears inhabit this region.
Bird Colonies	Cliff-nesting gull colonies in the north reaches of Melville Peninsula. Sabine's Gull, Arctic Tern sightings. Some snowy owl sightings between Igloolik and Hall Beach.



Location Map of Regions

Summary, Wager Bay Plateau Coastal Region

Overview of Region	The Wager Bay Plateau is located on the southeastern corner of the Melville Peninsula and tucked into the southwest corner of Foxe Basin, it includes Repulse Bay, Lyon Inlet and Vansittart Island. The settlement of Repulse Bay with a population of approximately 750 people is located in this region.
Shoreline Length	3 160 km
Ice Regime	Ice freeze-up usually occurs in around mid-November in this southern area of Foxe Basin. Ice usually clears Foxe Basin by late August to early September.
Wave Climate	Semi-Exposed (max fetch 50-500 km) Shoreline 60% Semi-Protected (Max fetch 10-50 km) Shoreline 14% Protected (max fetch <10 km) Shoreline 26%
Large Rivers	Aua River and Barrow river both empty into western Foxe Basin. The North Pole River empties into Repulse Bay.
Shore Types	Bedrock 22% Beaches 37% Flats 32% Flats w Ridge and Swale 4% Delta Complexes 1% Lagoon Complexes 4%
Key Ecological Features	
Coastal vegetation (CORI 2008)	unknown
Anadromous Fish Streams	unknown
Marine Mammal Use	beluga, narwhal, bowheads, walrus, seals (ringed, harp, bearded) and polar bears inhabit this region.
Bird Colonies	Turton Island on the western shore of Foxe Basin is an important bird area with the Common Eider (3,800 to 5,900 breeding paris) being noteworthy. Other species nesting on Turton Island include Tundra Swans, Canada Geese, Black Guillemots, Herring Gulls and Arctic Terns. IBA: Turton Island (NU021).



Location Map of Regions

Summary, Southampton Island Coastal Region

Overview of Region	Southampton Island is a large island at the entrance to Hudson Bay at Foxe Basin. One of the larger members of the Canadian Arctic Archipelago, Southampton Island is part of the Kivalliq Region in Nunavut. Also found in this region are Nottingham Island, Mill Island, Charles Island, Salisbury Island, Fraser Island and White Island. The only settlement on Southampton island is Coral Harbour with a population of 712.
Shoreline Length	2,504km
Ice Regime	Ice freeze-up usually starts by November. From January to April, mobile pack ice dominates Hudson Strait. Ice break-up begins in June.
Wave Climate	Exposed (max fetch >500 km) Shoreline 41% Semi-Exposed (max fetch 50-500 km) Shoreline 50% Semi-Protected (Max fetch 10-50 km) Shoreline 7% Protected (max fetch <10 km) Shoreline 2%
Large Rivers	Kokumiak River, Canyon River, Cleveland River, Thomsen River.
Shore Types	Bedrock 36% Beaches 32% Flats 10% Flats w Ridge and Swale 15% Delta Complexes 7% Lagoon Complexes 0%
Key Ecological Features	
Coastal vegetation (CORI 2008)	unknown
Anadromous Fish Streams	unknown
Marine Mammal Use	beluga, narwhal, bowheads, walrus, seals (ringed, harp, harbour, bearded) and polar bears inhabit this region.
Bird Colonies	Over 10% of nesting Lesser Snow Geese in Canada breed here. Brants, Tundra Swans, Cackling Geese, Canada Geese, Snow Geese, Common Eiders (1,000 to 3,000 pairs or ~ 35 of Canadian population), Oldsquaw, Jaegers, Herring Gull, Cliff Nesting Gull, Arctic Terns, Black Guillemot. IBA's: Fraser Island (NU024), East Bay – Native Bay (NU023), Harry Gibbsons Migratory Bird Sanctuary (NU022) and East Bay Migratory Bird Sanctuary.

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APPENDIX D

Foxe Basin – Hudson Strait Wave Exposure Classification

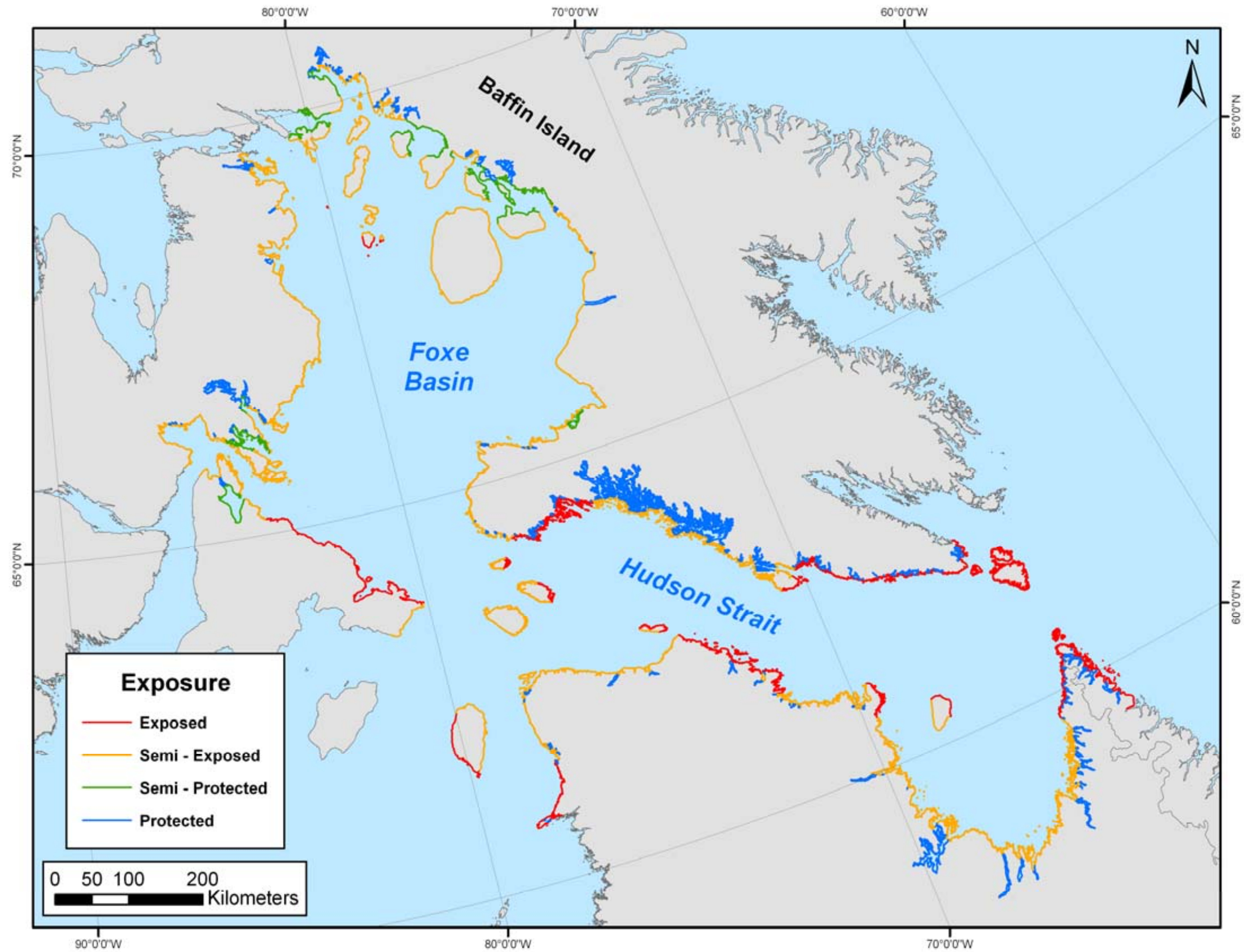

Figure D-1 Wave exposure classes, based on maximum open-water fetch distances where **exposed** = max fetch >500 km; **semi-exposed** = max fetch = 50-500 km; **semi-protected** = max fetch 10-50 km and **protected** = max fetch < 10 km.