THE PETROLEUM AND ENVIRONMENTAL MANAGEMENT TOOL

Application of Risk Assessment Tool and Cumulative Effects Model for the Eastern Arctic and High Arctic Study Areas

FINAL REPORT



Photo courtesy Narwhal-Whales

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EXECUTIVE SUMMARY

To help guide development in the Canadian Arctic, Aboriginal Affairs and Northern Development Canada (AANDC) developed the Petroleum and Environmental Management Tool (PEMT). The online tool[1] maps the sensitivities of a variety of arctic features, ranging from whales to traditional harvesting, across the Canadian Arctic. The tool is intended to aid government, oil and gas companies, Aboriginal groups, resource managers and public stakeholders in better understanding the geographic distribution of areas which are sensitive for environmental and socio-economic reasons.

This document is an extension and application to the previous report 'The Petroleum and Environmental Management Tool: Risk-based analysis and cumulative effects scenarios for the Eastern Arctic' (Nunami Stantec Ltd. 2011b). The original report explored two approaches to estimate the relative risk associated with the environmental effects of development activities; a risk based analysis of project effects, and cumulative effects scenarios. The preliminary risk based analysis and cumulative effects scenario model was developed using four Valued Components (VCs): bowhead whale, toothed whale, thick-billed murre, and commercial fisheries. This report presents results from an updated and more realistic cumulative effects scenario with updated distribution data for the original four Eastern Arctic VCs and applying the model to the remaining four VC's in the Eastern Arctic study area. Distribution data and associated sensitivity layers for all Eastern Arctic VC's was updated prior to running the model. The original four VCs included bowhead whale, toothed whale, thick-billed murre, and commercial turbot fisheries. The additional VCs considered for the Eastern Arctic study area include polar bear, Arctic char, walrus, and traditional harvest. Development scenarios were created for the High Arctic study area and the model was applied to five VCs: polar bear, narwhal, migratory birds, Peary caribou, and traditional harvest. The analysis provides an indication of relative risk of cumulative effects based on ecological, physical, political, or social thresholds for each VC.

The results described in this document support earlier conclusions that the cumulative effects of development on VCs vary considerably.

[1] The PEMT is available at http://www.ainc-AANDC.gc.ca/nth/og/pemt/index-eng.asp

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LIST OF ACRONYMS

AANDC .... Aboriginal Affairs and Northern Development Canada

CWS .... Canadian Wildlife Service

DFO .... Fisheries and Oceans Canada

DST .... Decision Support Tool

EEM .... Environmental Effects Monitoring

EISC .... Environmental Impact Steering Committee

IBA .... Important Bird Area

km .... kilometers

m .... meters

MMO .... Marine Mammal Observer

MODU .... Mobile Offshore Drilling Unit

NBRLUP .... North Baffin Regional Land Use Plan

OCCP .... Olokhaktomiut Community Conservation Plan

PEMT .... Petroleum Environmental Management Tool

PTS .... Permanent Threshold Shift

RMF .... Risk Management Framework

SARA .... *Species at Risk Act*

TTS .... Temporary Threshold Shift

VC .... Valued Component

ZOI .... Zone of Influence

1 INTRODUCTION

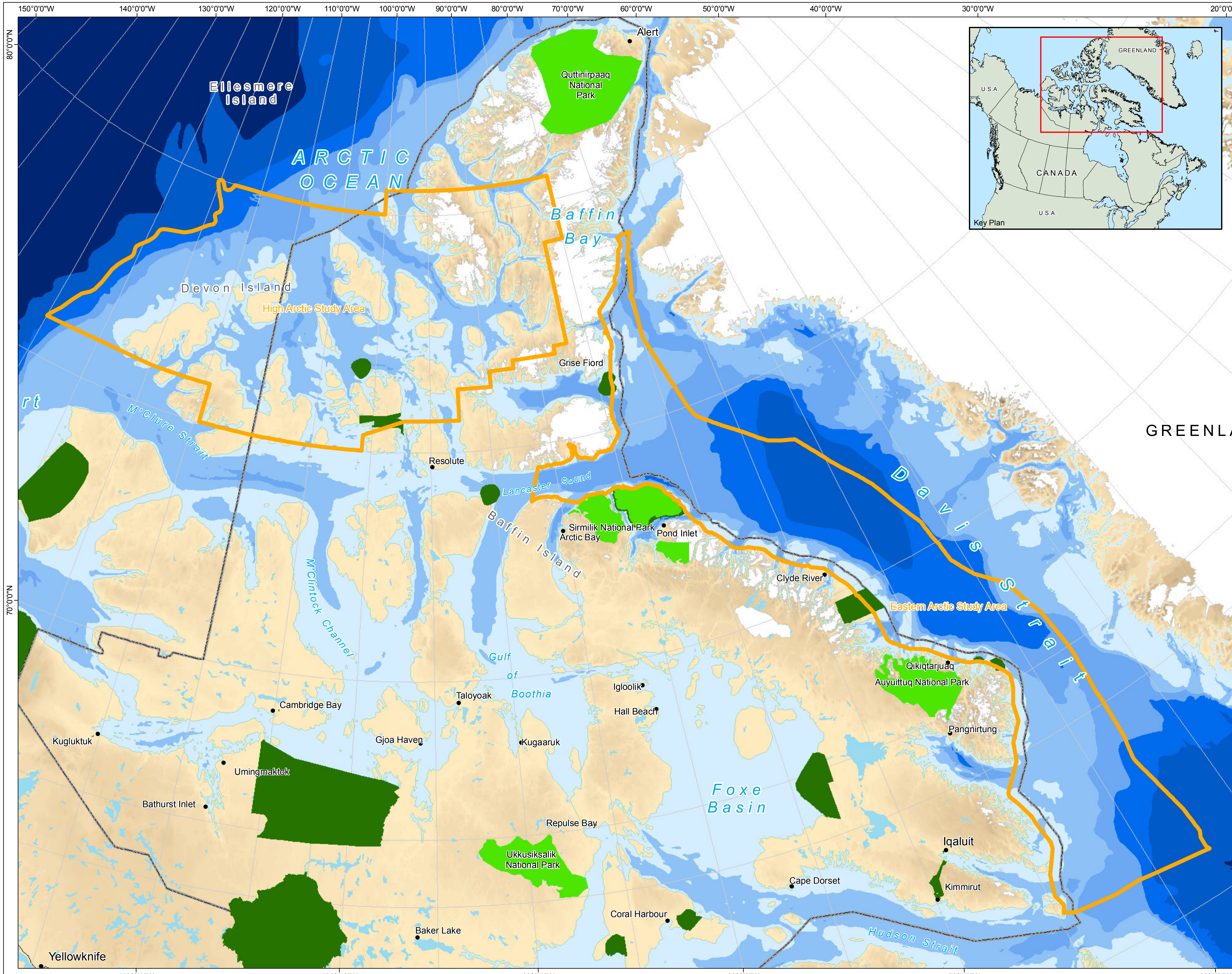
To help guide development in the Canadian Arctic, Aboriginal Affairs and Northern Development Canada (AANDC) developed the Petroleum and Environmental Management Tool (PEMT). The online tool[2] maps the sensitivities of a variety of arctic features, ranging from whales to traditional harvesting. The tool is intended to aid government, oil and gas companies, Aboriginal groups, resource managers and public stakeholders in better understanding the geographic distribution of areas which are sensitive for environmental and socio-economic reasons.

This document discusses the application of two approaches for building upon the PEMT. The risk based analysis describes a simple method for characterizing the relative risk of project activities. The resulting values associated with each VC for each potential activity would be incorporated into the PEMT to provide simple measure of risk for a particular area. The cumulative effects scenarios provide a simple model for identifying and estimating cumulative effects resulting from oil and gas development in the Eastern Arctic and High Arctic study areas (Figure 1-1). Based on hypothetical development scenarios, the model is applied to Valued Components (VCs) which were identified in the development of the PEMT tool for these two study areas. It then provides an output of the relative cumulative effects associated with potential future development and baseline activities.

[2] The PEMT is available at http://www.ainc-AANDC.gc.ca/nth/og/pemt/index-eng.asp

Eastern Arctic and High Arctic, Nunavut, Canada Study Areas

Fig 1-1



Base Features

- Community
- Grid Line
- Ice Cap
- Study Area Boundary
- Conservation Area
- National Park
- Lakes / River

Depth (m)

- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:9,000,000

100 50 0 100 200 300 400

Kilometres

Prepared By:
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Aboriginal Affairs and Northern Development Canada | Affaires autochtones et Développement du Nord Canada

Projection: Canada Lambert Conformal Conic, NAD83
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Even in well studied areas, understanding the interactions that lead to cumulative environmental effects can be complex. This is more challenging for areas that are relatively less studied or for future scenarios. Both are true when considering development in the Arctic.

Arctic research, even when it is done on indirectly related components, can illuminate the environmental or socio-economic effects of oil and gas development. For example, recent research on bowhead whales is contributing to our understanding of how they respond to underwater noise generated by vessel traffic and seismic arrays. However, we are only beginning to understand how these effects may act cumulatively.

This exercise was initiated in the Eastern Arctic study area with the risk analysis and cumulative effects model applied to four VCs (bowhead whale, toothed whales, migratory birds, and commercial fisheries) (Nunami Stantec Ltd. 2011b). This document provides further analyses on the remaining Eastern Arctic VCs (polar bear, arctic char, walrus, and traditional harvest) with updated distribution data and a modified development scenario. We further explore the analysis of the High Arctic study area VCs (polar bear, migratory birds, Peary's caribou, and traditional harvest) with a development scenario created for this area.

2 METHODS

The risk assessment tool provides a simple method for characterizing the relative risk of project activities. It is based on the sensitivity of a given area and the relative strength of the interaction between a development activity and a given component of the arctic environment.

The cumulative effects model uses VC specific sensitivity ratings developed for the High Arctic and Eastern Arctic Study Areas (Nunami Stantec Ltd. 2010, 2011a) and estimates the spatial extent and relative severity of potential cumulative effects resulting from a hypothetical oil and gas development scenario. The interaction of cumulative effects is complex and there is considerable uncertainty associated with a model based approach to predicting potential effects on the environment. When interpreting model outputs, it is important to consider that any scenario generated is based on simplistic assumptions and incomplete or dated information. With these caveats in mind, results may or may not represent an accurate representation of cumulative effects for an actual project or suite of projects in the two study areas. Results from the model may help to facilitate discussion, visualize alternatives, and identify useful follow up activities, but should not be interpreted as fact.

2.1 Risk Assessment Tool

The PEMT currently identifies sensitive areas based on their importance to a VC, but not all development activities affect all VCs equally. Expanding the PEMT to account for this variability can increase the accuracy of characterizing the potential risk of effects.

A simple approach was developed to characterize the risk of an environmental effect (Nunami Stantec Ltd. 1011b). The approach developed for the PEMT was founded on the risk management framework (RMF) developed by Fisheries and Oceans Canada (DFO). The core principals of this approach are as follows. Sensitivity is based on location; some areas are more sensitive than others and by incorporating this aspect into the analysis, a more accurate measure of environmental risk can be produced. Integrating the probability and consequence of an effect into the analysis increases the accuracy further. The overall risk on an environmental effect depends on the:

1. Nature of the activity
2. Potential environmental effects associated with the activity
3. Interaction between the effects and the VC
4. Sensitivity of the area where the activity occurs.

The PEMT includes the sensitivity information for a variety of VCs (eight in Eastern Arctic and five in High Arctic). The approach developed incorporates information which characterizes the degree (or scale) of a potential effect and a means to estimate the risk. Information related to the nature of the activity and potential environmental effects (1 and 2 above), is discussed for each VC in Section 2.4 below.

2.1.1 Scale of Potential Effect

Two approaches to characterizing the scale of adverse effects were developed and compared in the previous report (Nunami Stantec Ltd 2011b). These approaches are summarized below. The scale of the potential effect depends on the activity type, not where it occurs. One activity (e.g., vessel traffic) will have the same “scale of effect”; the location of the activity is important when the scale and sensitivity are combined to assess the resulting risk. Two scales were developed and described below; the three level scale and the ten level scale.

2.1.1.1 Interactions Measured on the Three Level Scale

The three level scale is simple (three categories), easy to apply (no estimates of probability or multiplication), relatively easy to understand and has less risk of “false precision” (assigning values that are beyond our ability to estimate with reasonable accuracy). In the three level scale, each interaction between an activity, effect, and a VC is given a score of 0, 1, or 2 and is described in Table 2-1.

Table 2-1: Scale of Environmental Effects

Attributes	Scale Score
Negligible interaction between an activity and a VC. An activity is not likely to cause an environmental effect for a given VC that would result in an important change to the viability or sustainability of that VC. For example, a high altitude overflight passing over swimming bowhead whales is unlikely to cause an interaction, and if an interaction were to occur, would be negligible and this interaction would be scored as a zero.	**0**
An interaction occurs but the effect is unlikely to be high consequence. Based on past experience and professional judgment, the interaction would (a) not result in a high consequence environmental effect, even without mitigation, or (b) the interaction would not be high consequence when codified practices or proven mitigation are used to avoid, reduce, and/or mitigate effects are applied.	**1**

Attributes	Scale Score
An interaction is important and, under some circumstances, may result in a high consequence environmental effect. The word "may" is key as without additional study it is not possible to say whether a given activity will or will not have a high consequence effect. Rather, there is a potentially strong interaction that merits additional attention, often in the context of an environmental assessment. For example, the underwater noise generated by seismic exploration has the potential to substantially affect marine mammals, although whether this actually occurs depends on a number of factors and requires additional study.	**2**

2.1.1.2 Interactions Measured on the Ten Level Scale

The ten level scale is used as an alternative to measure risk on a finer scale. This scale is based on the interaction of two factors:

Scale of an environmental effect = probability of an effect x consequence

The probability of an effect is a conservative estimate based on professional judgment, of the likelihood of an effect occurring if the activity overlaps with the VC. How far an effect propagates (i.e., the zone of influence) depends on the intensity of the impact and the VC in question. For example, for a whale-vessel strike to cause mortality, they must be in immediate proximity of each other, whereas the effect of underwater noise can extend many kilometers.

The scale is not linear; it jumps from 0, 1, 5, and 10. The consequences of the effects become much more important moving down the scale, and therefore, are given higher numerical values. A regional change in a population has a greater consequence to a species than a local change in a population, which is more important than temporary change in behavior of a few individuals. The consequence of an effect is characterized in Table 2-2.

Table 2-2: Consequence of an Effect

Scale	Descriptor
0	Negligible
1	Temporary change in behavior
5	Local change in population or use of important habitat, within area of direct of activity
10	Detectable regional (study area) change in population, or use of critical habitat

2.1.2 Summary of Key Steps

Appendix A provides a summary of all the factors related to risk ratings for each of the VC's in the High Arctic and Eastern Arctic study areas. Since each activity, effect, and VC may interact differently, each requires a separate score on a scale of 0 to 2 or on a scale from 1 to 10.

- The first column (anthropogenic activities) lists the variety of activities expected to occur in the Eastern Arctic and High Arctic study areas. The next three columns list when these activities will occur (e.g., during routine vessel traffic, seismic operations, and exploration drilling).
- The effects of these activities on the VCs are illustrated next. In each case the types of effects are broken down into categories (such as habitat quality, water quality, and health).
- The risk of an environmental effect is characterized on scales of 0 – 2 and 0 – 10.

A score of zero in the table represent no meaningful interaction between the activity, effect, and VC in question.

On the 10 point scale, the maximum potential score is ten, which would result from an activity that is certain to cause a given effect (probability = 1) and that effect is likely to result in a regional change (scale = 10), given that 1 x 10 = 10. None of the interactions studied were judged to reach this theoretical maximum.

The following is a summary of the key steps involved in this process.

1. A PEMT user would identify:
   a) A type of activity (from a list provided)
   b) The VC of interest (from a list provided)
   c) Where the activity would occur (from a graphical interface). The user would have to identify a specific location as a single spot on a map, a line (for linear activities, such as ship travel), or a two dimensional area (assuming the activity would occur throughout that area).
2. PEMT[3] would then characterize the:
   a) **Sensitivity of the area identified by the user.** This would be done based on the VC and location identified by the user, and the sensitivity scores already in the PEMT. Sensitivity would be characterized along a gradient of least sensitive (1) to most sensitive (10).
   d) **Scale of potential effect.** This would be done based on the activity identified and one of the two methods described in Section 2.1. The scale of potential effects would be characterized along a gradient of no effect (0) to greatest potential effect (either 2 or 10, depending on which of the two methods described above was used).
   e) **Risk of environmental effects.** This risk score would be generated by multiplying the scores for sensitivity and scale and then characterize the product as high, moderate, low, or negligible. This information could be communicated to a PEMT user either in text or graphically by displaying the scores on a map (with risk scores generated for each cell in the PEMT map).

[3] The pathways linking activities, environmental effects, and their interaction with VCs would already be built into the PEMT, allowing the following steps.

This approach would only assess areas where an activity will occur (as defined by the user). It does not attempt to calculate how far out from that spot, in space or in time, effects may persist. It is also important to keep in mind that the focus of this approach is routine project-specific effects. Assessing the risk of accidents and malfunctions or cumulative effects requires different tools. Cumulative effects are discussed in Section 2.2.

2.1.3 Categorizing Risk

Sensitivity information can be drawn directly from the PEMT, and scale of an effect can be characterized using one of the two methods described above. It is now possible to assess the risk of an environmental effect.

The proposed approach adapts DFO's Risk Assessment Matrix (Figure 2-1) for application in the PEMT. This matrix characterizes risk of an environmental effect based on the sensitivity of an area and the scale of a negative effect. In the DFO Matrix, risk falls into one of five categories:

- **No Risk** (the blue area). There is no risk of an effect because either the scale of the negative effect is negligible; an area has no value/zero sensitivity for a VC, or both.
- **Low Risk** (the green area). An activity is not likely to result in an important residual effect if appropriate mitigation measures[4] are applied.
- **Medium Risk** (the yellow area). An activity may result in a small or temporary negative effect, even if appropriate mitigation measures are applied. Furthermore, the relationship between cause and effect is well understood, mitigation measures are known to be effective (i.e., uncertainty is low), and the residual effect is not expected to pose an important risk to the VC in question.
- **High Risk** (the orange area). An activity will result in a residual environmental effect that may affect the viability of the VC. This may be because the effect may persist over time, influence a broad area, or alter key or vulnerable resources, even with mitigation. These interactions would typically form the focus of environmental assessments.
- **Very High Risk** (the red area). These activities have residual effects which are unacceptably large or important and would be the focus of environmental assessments.

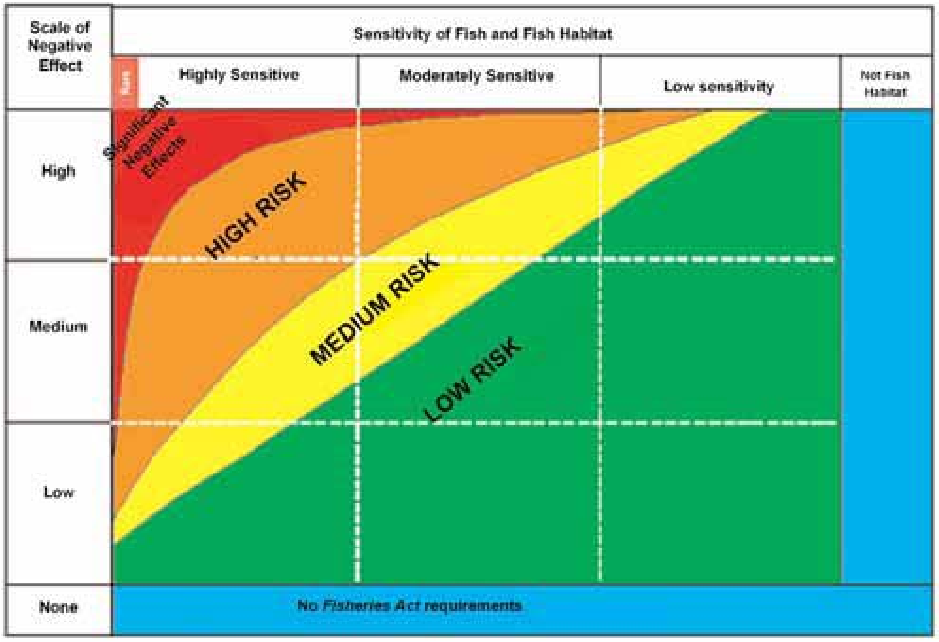
A Risk Assessment Matrix for the PEMT should be simpler than DFO's for several reasons. First, the PEMT can support decisions, but a more detailed environmental assessment would be needed to determine if a given effect is significant. The PEMT should not be expected to make this determination.

Second, given the complexity of interrelationships between a variety of stressors and VCs, the precise information needed to finely parse risk is likely not available. An example may make this clearer. Consider an activity which has a high scale of negative effects but occurs in an area of low sensitivity. This interaction would fall into the top right corner of the DFO matrix. The activity could be characterized as low, medium, or high risk depending on precisely where it fell within the high

[4] Appropriate mitigation measures may include standard industry practices, government guidelines, and identified best management practices.

scale/low sensitivity cell in the DFO matrix. In the Arctic, information needed to make such fine scale distinctions is not generally available without some amount of field surveys.

Figure 2-1: DFO's Risk Management Matrix



Source: DFO 2006

To increase its practicality, it is recommended that the PEMT apply similar principles as DFO's risk management matrix, as they are useful and transferable. But the Risk Assessment Matrix itself should be simplified. One example of how this might be done is illustrated in Table 2-4. This is essentially a simplified version of the DFO Matrix. It is a lookup table whereby the PEMT could determine the risk of an environmental effect for any spot on a map. This risk score would be generated by multiplying the scores for sensitivity and scale and then characterized as high, moderate, low, or negligible. This information could be communicated to a PEMT user in text or graphically by displaying the scores on a map (with risk scores generated for each cell in the PEMT map).

Table 2-4: Lookup Table for Characterizing the Risk[1] of an Environmental Effect

Scale of Negative Effect[3]	Sensitivity of an Area[2]				
	5 (High)	**4 (Moderately High)**	**3 (Moderate)**	**2 (Moderately Low)**	**1 (Low)**
2 (High)	10	8	6	4	1
1 (Low)	5	4	3	2	1
0 (Negligible)	0	0	0	0	0

NOTES:
[1] Risk is characterized based on the produce of the sensitivity of an area x the scale of a negative effect:
High—scores of 8 to 10 (red)
Moderate—scores of 4 to 6 (orange)
Low—scores of 1 – 3 (green)
Negligible—score of zero (blue)
[2] Sensitivity information for a given VC is drawn directly from the existing PEMT
[3] In this example the Scale of Negative Effect is based on the simpler method described in Section 4.1.1. Using the more complex scale of 0 to 5 described in Section 4.2.2 would follow the same process but would require an expanded table.
The sensitivity numbers provided above are illustrative. Were the user to proceed with this approach, they would need to be tested using activities and areas to ensure and adjusted as needed.

2.2 Cumulative Effects Model

Valued components respond differently to the effects of oil and gas development activities. They may be vulnerable to a range of potential cumulative effects both in terms of the nature of the response and the distance over which it occurs. For example, whales are sensitive to underwater noise, which can affect communication and behavior over a scale of tens of kilometers. Migratory birds, on the other hand, would not be as sensitive to underwater noise, given that their utilization of the underwater habitat does not expose them to underwater noise as frequently and different physiology results in birds receiving sound differently from mammals. By attempting to capture these varied responses, the analysis presented here attempts to illustrate the variety of potential cumulative effects, both in terms of their nature and spatial extent.

Since each of the VCs is expected to respond differently to oil and gas development activities, each is analyzed separately in the model and separate cumulative effects predictions are developed for each of the VCs.

Several inputs are used in the cumulative effects model.

- The development scenario: this is a spatial model of a hypothetical development scenario that considers what could be a reasonably foreseeable snapshot of what oil and gas development activities may occur at a given time in the future (see Section 2.3 for a full description). This is the only input which is the same for each VC.
- The potential environmental effects of anthropogenic activities are described in Section 2.4.
    - The zone of influence for the effect of an activity on a VC. This is the distance from the source that a given impact (e.g., underwater noise generated by seismic airguns) may affect a given VC (e.g., bowhead whales).
    - The scope or intensity of this effect [within the zone of influence (ZOI)]. This is a measure of the strength of the interaction between the impact (e.g., airgun noise) and the effect for a given VC (e.g., How strongly will bowhead whales be affected?).
- The VC specific sensitivity of the area in which an effect occurs. This information is drawn directly from the sensitivity layers currently in the PEMT. See Section 2.5 for a full discussion on Eastern Arctic and High Arctic study areas.

The model uses geographic representation of various activities associated with the development scenarios (Table 2-3). The activities are described in Section 2.3.

Table 2-3: General Summary of Activities Associated with Development Scenarios

Activity/Disturbance	Geographic Representation in the Model
2D Seismic Exploration	**Line.** These lines represent a typical seismic vessel's tracks within an area sampled during a single summer season (90 day period).
3D Seismic Exploration	**Polygon.** Represented by a 25 km x 25 km square, this area represents a 3D seismic lease area. We assume that seismic vessel's tracks are almost completely covering this area within a 90 day period.
Vessel Traffic (regular marine traffic moving along prescribed routes)	**Line.** Regular marine traffic moving along known routes (lines) to and from ports on Baffin Island.
Support Vessel Traffic (traffic related to oil and gas exploration activities)	**Polygon.** Assumed that the support vessels stay close to the seismic vessels during a typical seismic operation. This is represented by a polygon buffering the seismic area.
Supply Vessel	**Line.** Supply vessels move to and from ports on land to seismic ships or drill ships within the scenario polygons.
Helicopter Traffic	**Line.** Helicopter traffic is represented by a straight line connecting ports on land and seismic areas or drill ships.
Exploration Drilling Vessels	**Point.** Drilling vessels are represented as a point given that they are stationary during operations.

Each activity is given one or more VC-specific zone(s) of influence and effect scale(s) (intensity). For example, vessel traffic has two buffers; one for vessel strikes and one for communication masking, each having a particular intensity associated with the type of activity. The GIS model automates this process allowing the user to enter a buffer distance and intensity for each type of activity.

Where buffers overlap, the model adds their intensities, thus resulting in a higher cumulative disturbance for that area. But as described above, disturbance is only half the equation, as the sensitivity of an area for a given VC is also important. Thus, the disturbed areas (buffers) are overlaid with the previously developed VC sensitivity layers. When overlaying the anthropogenic disturbance buffers with the VC sensitivity layers, the GIS model multiplies the activity's intensity rating with the VC's sensitivity rating to give the final output rating. This approach addresses additive effects but, given the need for simplicity, does not address synergistic effects.

The model makes it possible to automate the process of buffering, manipulating and combining spatial data into one resultant layer. Furthermore, it facilitates the analysis of different scenarios or disturbance ratings.

A more complete description of the technical details associated with the model can be found in Appendix B (the architecture of the model) and C (the values used for the zones of influence and scales of negative effects).

2.3 Development Scenarios

Development scenarios for each study area were created using information from a number of sources, including oil and gas development currently occurring elsewhere in Eastern Canada and the circumpolar region, past oil and gas development activities in the Canadian Arctic, and current activities associated with oil and gas lease areas in the Canadian Arctic. All scenarios are built for a 90 day summer (open water) season. All vessels transiting in the Arctic will abide by the *Arctic Water Pollution Prevention Act* (Transport Canada, 2012a). Under this act, vessel movement may be restricted if there is ice present. This act restricts vessel type and time of year depending on the location.

It is important to note that these are hypothetical development scenarios, not predictions of what development is likely to occur in the Arctic. While the intent is to make them realistic, they are illustrative and do not represent plans associated with oil and gas development in Canada. They are merely chosen to illustrate certain situations and serve as a basis for evaluating associated potential effects. A central premise of this approach is that the development scenarios should be adjusted as new information becomes available.

The GIS-based cumulative effects model is built in a way to facilitate this, making it easy to explore the potential implications of changing the location or nature of development activities. There can be variation in the way development is carried out. For example, in terms of oil and gas exploration, drilling programs can vary depending on type of equipment, nature of survey, depth of drilling target, etc. The development scenarios are chosen to be broadly representative of what might occur. But as is true with all elements of the cumulative effects model, their predictive value will be improved when they are recalibrated based on new information and actual experience.

This section describes the process for exploring potential future cumulative effects in the Eastern Arctic and High Arctic study areas. This analysis focuses on the routine key anthropogenic activities. Accidents and malfunctions, such as oil spills, are not part of this analysis.

A general summary of oil and gas development activities with specific information regarding activity parameters is provided in Appendix C, Table C1. A general description of these activities and how they are applied to the development scenarios is provided below.

2.3.1 Oil and Gas Exploration

The oil and gas exploratory phase typically involves one or more kinds of seismic surveys to provide data about the subsurface geology, followed by exploration drilling to confirm the presence or absence of hydrocarbons.

Seismic Activities

Seismic energy waves propagate through ‘overburden’ rock to hydrocarbon reservoirs and are then reflected back to receivers where they register as a pressure pulse, providing an acoustic image of the subsurface. Seismic surveys can either be two dimensional (2D) or three dimensional (3D), the latter of which is more expensive but produces more extensive data.

Offshore seismic activities are conducted from a seismic survey vessel towing a submerged acoustic energy source array. The vessel will traverse along predetermined lines in the area while the arrays discharge at regular intervals. Offshore seismic is conducted during the open water season, which varies by location but may span from July through October (the cumulative effects model assumes a 90 day period). The *Statement of Canadian practice with respect to the mitigation of seismic sound in the marine environment (DFO 2010)* recommends minimum mitigation standards for seismic operations in Canadian waters including establishing safety zones of at least 500 m around the air source array, ramp-up procedures for starting up the airguns, shut-downs of the array if marine mammals are within the safety radius during operation, and use of a mitigation gun during periods of line change in low visibility.

The seismic vessel may come to shore for resupply. Depending on the duration of the particular survey, the seismic vessel may be supported by other vessels or aircraft to provide supplies, crew changes and ice management support. Of note, while new methods for on-ice and below ice seismic surveys are being tested, they are not included in the current PEMT.

Exploration Drilling

Drilling is required to confirm the presence or absence of hydrocarbons once seismic surveys have identified targets of interest. Exploration drilling involves mobilizing the drilling rig to the site, positioning on site, drilling and testing the well(s), abandoning the wells, and demobilizing the drilling rig. A variety of structures might be used for drilling, including pier platforms, artificial islands, Mobile Offshore Drilling Units (MODUs), jack-up rigs, semi-submersible (i.e., anchored platforms), and drillships.

The model developed here assumes ship-based exploratory drilling. This requires support/supply vessels to transport equipment, supplies and personnel to the rig. Helicopter support is also often needed. In addition to offshore facilities, operations may require a base or support facilities onshore for equipment storage. Waste generated includes drill cuttings, drilling fluids and chemicals, cement, sewage, drainage, rig wash, assorted solid wastes and atmospheric emissions.

Offshore exploratory wells are drilled in a number of sections of decreasing diameter. Steel casing is then run down the well and cemented in place. Drill cutting and fluids are returned to the surface in the space between the drill string and steel casing, except for the initial spudding of the top section of the well when drill cuttings and aqueous muds are released directly to the surrounding seabed. Drilling fluid is recycled and used more than once prior to disposal.

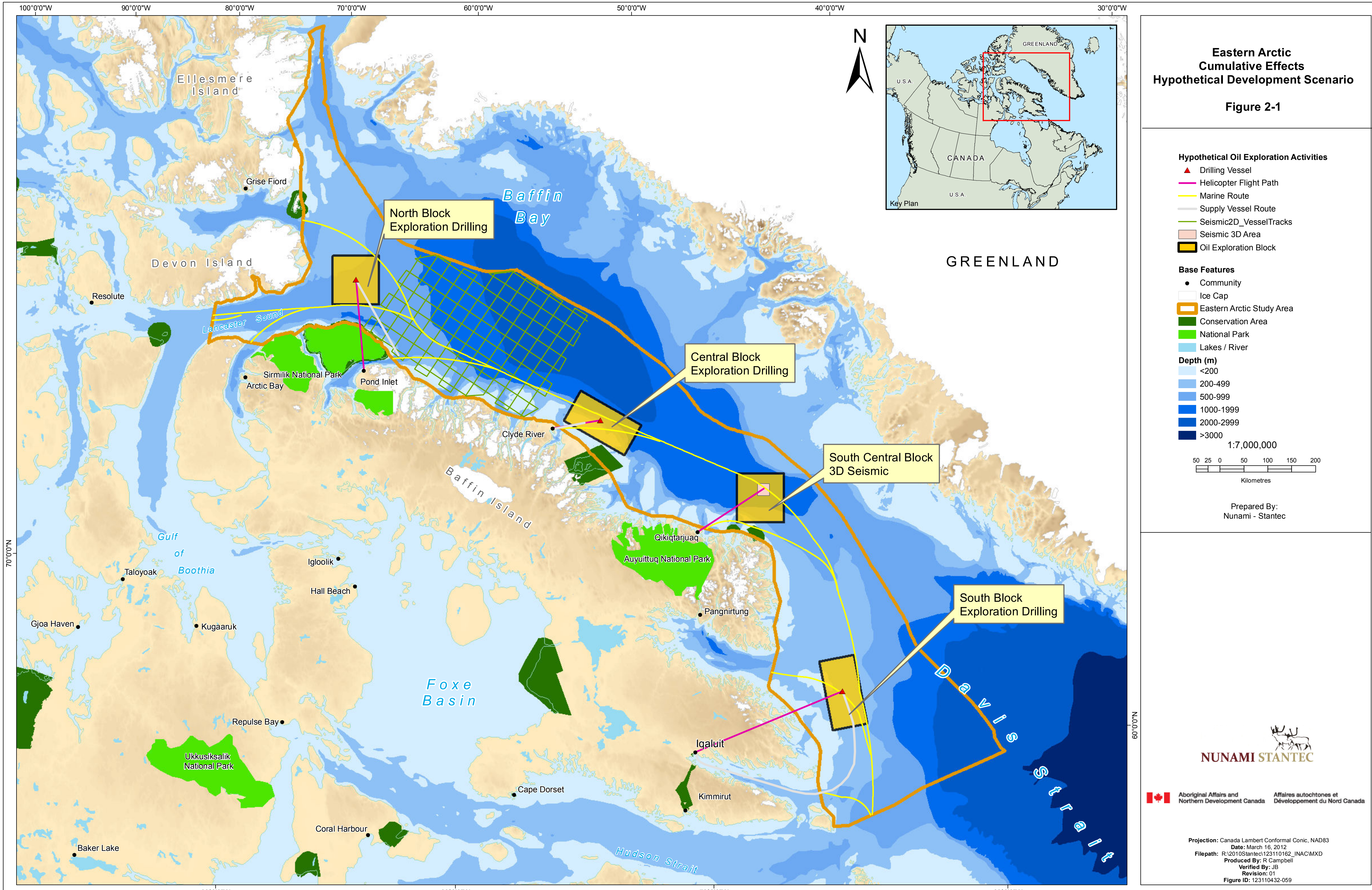
If hydrocarbons are encountered, the potential production of the well is tested. In a well test hydrocarbons are allowed to flow up the well bore to the rig under controlled conditions so that samples can be taken for analyses and to determine the capability of the reservoir to deliver oil and/or gas. Well testing also usually involves flaring/burning of the reservoir oil and/or gas. Once testing is complete, mechanical packers and cement plugs are used to seal the well and the casing is cut below the seabed and removed.

2.3.2 Other Anthropogenic Activities

Other human use activities that currently occur or are expected to occur in the future include commercial fishing, other shipping activities (including cruise ships), tourism, and the transport of mining products. Effects associated with these activities are similar to those associated with oil and gas development and primarily relate to marine transportation.

2.3.3 Eastern Arctic Development Scenario

The hypothetical development scenario for the Eastern Arctic study area includes activities associated with oil and gas exploration and other anthropogenic activities that would be reasonably expected to occur in this region (Figure 2-1). As the Eastern Arctic study area contains only marine areas, land-based development activities are not included in the development scenario. It includes four delineated blocks intended to represent lease areas where oil and gas operators are actively exploring (using 3D seismic or drilling), and a larger area where coarser exploration would be occurring using a 2D seismic vessel. The four blocks are distributed throughout the region so that they encompass areas where past exploration has occurred and/or areas where the known geology of the region suggests petroleum potential (Nunami Stantec Ltd. 2011b). The blocks are situated in water depths ranging from approximately 200 to 2,000 m. Each drilling or 3D seismic activity is associated with a flight path (for helicopter support) and a vessel route (for supply and or support vessels) that is linked to the nearest or most realistic port on Baffin Island.



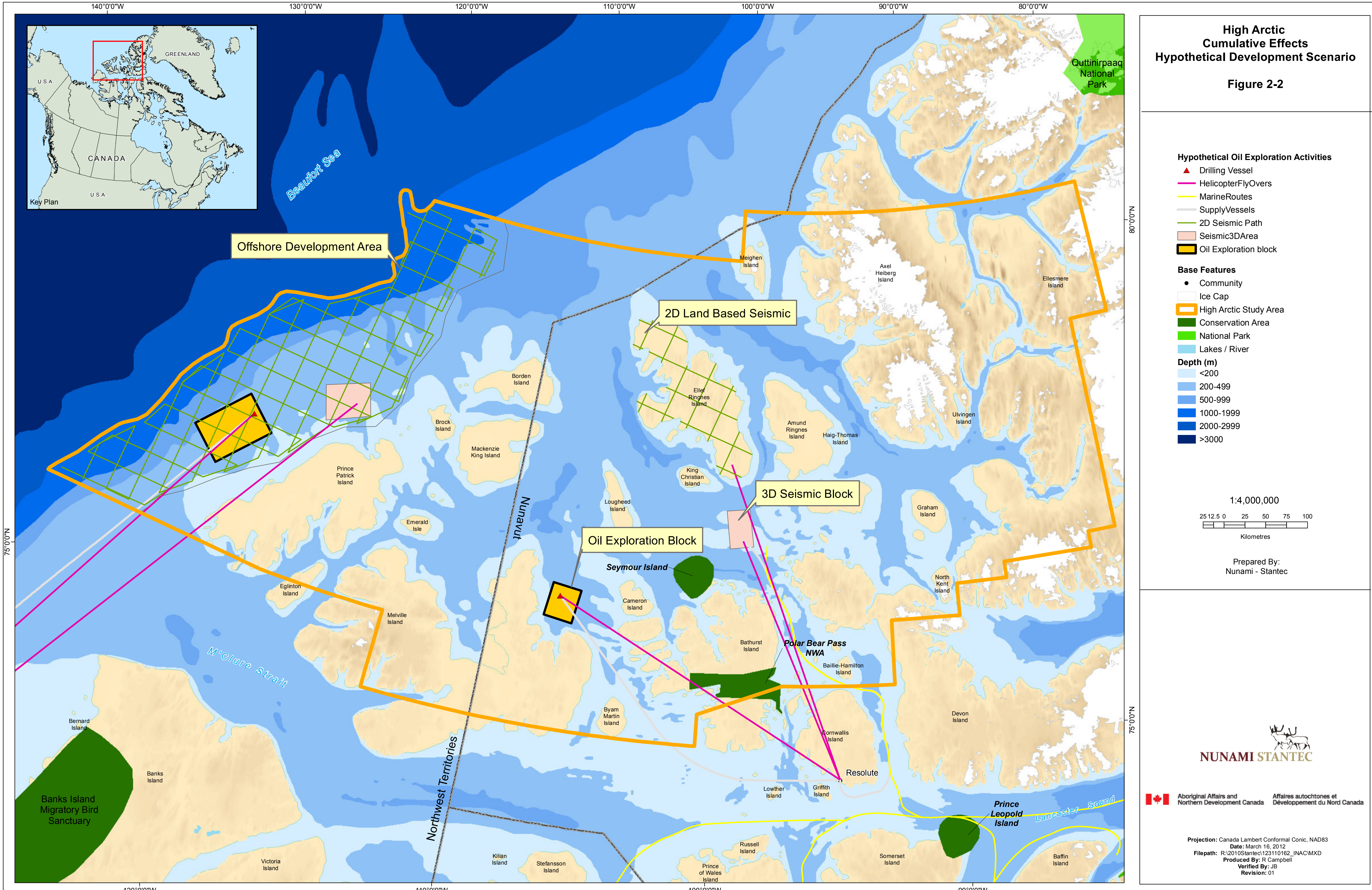
Eastern Arctic
Cumulative Effects
Hypothetical Development Scenario
Figure 2-1
Hypothetical Oil Exploration Activities
Drilling Vessel
Helicopter Flight Path
Marine Route
Supply Vessel Route
Seismic2D_VesselTracks
Seismic 3D Area
Oil Exploration Block
Base Features
Community
Ice Cap
Eastern Arctic Study Area
Conservation Area
National Park
Lakes / River
Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000
1:7,000,000
Kilometres
Prepared By:
Nunami - Stantec
NUNAMI STANTEC
Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada
Projection: Canada Lambert Conformal Conic, NAD83
Date: March 16, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-059
North Block
Exploration Drilling
Central Block
Exploration Drilling
South Central Block
3D Seismic
South Block
Exploration Drilling
GREENLAND
Baffin Bay
Ellesmere Island
Devon Island
Lancaster Sound
Baffin Island
Gulf of Boothia
Foxe Basin
Davis Strait
Hudson Strait
Grise Fiord
Resolute
Sirmilik National Park
Arctic Bay
Pond Inlet
Clyde River
Qikiqtarjuaq
Auyuittuq National Park
Pangnirtung
Iqaluit
Kimmirut
Cape Dorset
Igloolik
Hall Beach
Taloyoak
Kugaaruk
Gjoa Haven
Repulse Bay
Ukkusiksalik National Park
Coral Harbour
Baker Lake
Key Plan
CANADA
U.S.A.
GREENLAND

A few changes were made to this iteration of the development scenarios. The flight path and support vessel route from the South Block (exploration drilling) was changed from using Pangnirtung as the base station to Iqaluit. Although it is situated slightly further from the block, it was considered to be more reasonable in terms of cost effectiveness (crew transfer, supply costs) and time (crew would fly into Iqualuit, then straight out to the location). The other modification is the size of the 2D seismic swath and the space between the 2D seismic tracks. Since 2D seismic dataset is coarse and broad, the size of the program area was increased to reflect a more realistic 2D program.

2.3.4 High Arctic Development Scenario

The hypothetical development scenario for the High Arctic study area includes activities associated with oil and gas exploration and other anthropogenic activities that would be reasonably expected to occur in this region (Figure 2-2). The High Arctic study area includes both terrestrial and marine habitat which has been subject to oil and gas exploration in the past. The scenario includes four delineated blocks in marine areas, intended to represent lease areas where oil and gas operators are actively exploring (using 3D seismic or drilling), and two larger areas (one on land and one in the Beaufort Sea) where coarser exploration would be occurring using a 2D seismic vessel or heli-portable operations (on Ellef Ringnes Island). The four blocks are distributed throughout the region so that they encompass areas where past exploration has occurred and/or areas where the known geology of the region suggests petroleum potential (Nunami Stantec Ltd. 2011a). Offshore exploration blocks are situated in water depths ranging from 200 to 1,000 m. Each drilling or 3D seismic activity is associated with a flight path (for helicopter support) and a vessel route (for supply and or support vessels) that is linked to the nearest or most realistic port (assumed to be Tuktoyuktuk for Beaufort operations or Resolute for operations in the Central Arctic).

The High Arctic study area is characterized by a shorter open water season than the Beaufort or Eastern Arctic regions and includes areas with permanent sea or land-fast ice that make exploration of the area more challenging. For this reason, the development scenario for the High Arctic includes icebreaking as a development activity. The underlying assumption is that due to the potential presence of ice, that ice capable ships may be more commonly required for supply and support to oil and gas development as well as for other anthropogenic activities in the region including tourism (cruise ships).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130°0'0"W
120°0'0"W
110°0'0"W
100°0'0"W
90°0'0"W
80°0'0"W
80°0'0"N
75°0'0"N
GREENLAND
U.S.A.
CANADA
U.S.A.
Key Plan
Beaufort Sea
Offshore Development Area
2D Land Based Seismic
3D Seismic Block
Oil Exploration Block
Quttinirpaaq National Park
Meighen Island
Axel Heiberg Island
Ellesmere Island
Borden Island
Brock Island
Mackenzie King Island
Ellef Ringnes Island
Amund Ringnes Island
Haig-Thomas Island
Ulvingen Island
King Christian Island
Prince Patrick Island
Lougheed Island
Emerald Isle
Graham Island
Nunavut
Seymour Island
North Kent Island
Eglinton Island
Cameron Island
Melville Island
Bathurst Island
Polar Bear Pass NWA
Baillie-Hamilton Island
M'Clure Strait
Devon Island
Bernard Island
Byam Martin Island
Cornwallis Island
Banks Island
Banks Island Migratory Bird Sanctuary
Northwest Territories
Resolute
Lowther Island
Griffith Island
Prince Leopold Island
Lancaster Sound
Russell Island
Kilian Island
Stefansson Island
Victoria Island
Prince of Wales Island
Somerset Island
Baffin Island
High Arctic
Cumulative Effects
Hypothetical Development Scenario
Figure 2-2
Hypothetical Oil Exploration Activities
Drilling Vessel
HelicopterFlyOvers
MarineRoutes
SupplyVessels
2D Seismic Path
Seismic3DArea
Oil Exploration block
Base Features
Community
Ice Cap
High Arctic Study Area
Conservation Area
National Park
Lakes / River
Depth (m)
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1000-1999
2000-2999
>3000
1:4,000,000
25 12.5 0 25 50 75 100
Kilometres
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2.4 Environmental Effects of Activities

This section describes the environmental effects of development activities on the VCs analyzed for the Eastern Arctic and High Arctic study areas. VCs previously analyzed for the Eastern Arctic include the bowhead whale, toothed whale, thick-billed murre, and commercial fisheries (Nunami Stantec Ltd. 2011b). Where available, the data for these VCs was updated and the updated scenarios were analyzed. The environmental effects of activities on these VCs were extracted from previous reports (Nunami Stantec Ltd. 2010, 2011a) and included here to provide a complete understanding of effects. Additional VC's for the Eastern Arctic and High Arctic Study Areas were also analyzed:

Updated Eastern Arctic VCs:

- Bowhead whale
- Toothed whales
- Thick-billed murre
- Commercial turbot fishery.

New Eastern Arctic VCs:

- Polar bear
- Arctic char
- Species of conservation concern: walrus
- Traditional harvest.

High Arctic VCs:

- Polar bear
- Narwhal
- Migratory birds
- Species of conservation concern: Peary caribou
- Traditional harvest.

Appendix D lists all the values to characterize the effect of development activities on VCs. The interaction between each of the VCs and each of the activities is characterized by:

- The zone of influence over which the effect occurs. Since the exact distance is unknown, a minimum and maximum potential value is included for each interaction.
- The scope of the effect, which is calculated as the product of the duration of the effect (the proportion of the summer season when it will occur), the probability of an effect, and the consequence of an effect.

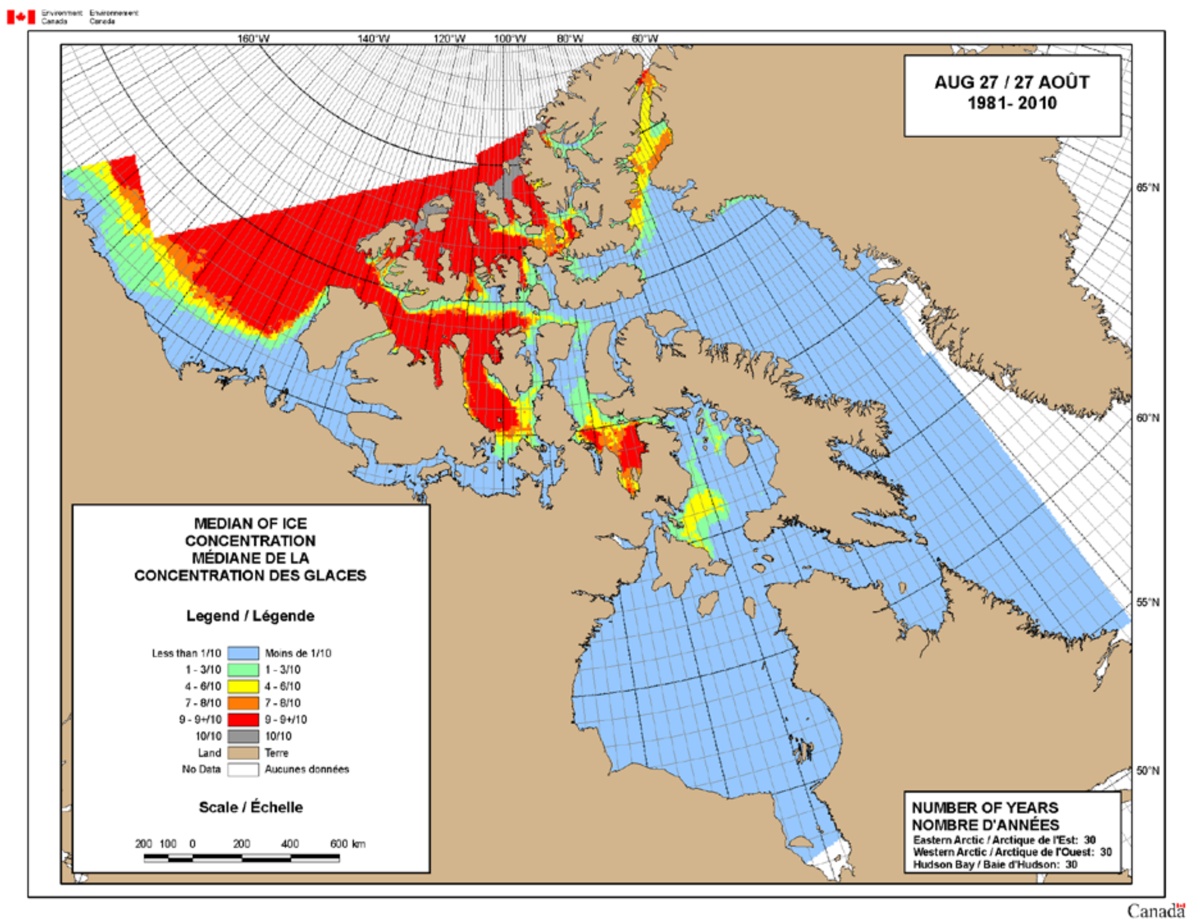
Effects on VC's are summarized into four categories:

1. **Change in habitat**—includes effects caused by sensory disturbance (e.g., due to communication masking, artificial lighting, visual disturbance), displacement from habitat due to physical loss (e.g., due to changes in food supply distribution and abundance, nesting or mating habitat) or alteration (e.g., icebreaking, acoustic disturbance).
2. **Change in behaviour**—includes effects caused by sensory disturbance (e.g., altered movement or migration patterns, avoidance).
3. **Change in health**—includes chronic or acute health effects resulting from contaminated habitat or food sources, damage to sensory organs (i.e., temporary or permanent threshold shift; TTS and PTS), altered energy expenditure, vessel strikes, and abandonment of young or a haulout[5] due to disturbance (e.g., birds abandoning nests).
4. **Change in access to resources**—includes reduced commercial catches and displacement of commercial fishing vessels due to limitations on access to fishing areas, reduced traditional harvest opportunities due to restrictions in hunting or fishing areas, and loss of access to resources due to tainting or contamination concern.

Some VCs display prominent seasonal use of particular habitat and potential effects from development may also be limited temporally by season, therefore seasonality was considered when developing development scenarios. As sea ice coverage is the major limiting factor to shipping and marine based oil and gas activities in the study area, the summer season was considered in the development activity scenarios. The analysis provided is based on a 90 day summer (open-water) season which is generally expected to occur between early July and late October in the Eastern Arctic (Nunami Stantec Ltd. 2010) and mid-June to mid-September in the High Arctic (Nunami Stantec Ltd. 2011a). The 30 year median of ice concentration for the Canadian Arctic indicates a completely open water area for the Eastern Arctic and variable ice conditions for the High Arctic (Figure 2-3). The 30 year median was taken for the week of August 27 to give a visual perspective on the lowest ice presence in both study areas.

[5] A haulout is defined as the terrestrial or ice habitat of a species of pinniped. It is typically used for resting, socializing and breeding.

Figure 2-3: 30 Year Median Summer Arctic Ice Concentration



SOURCE:
Environment Canada (2012)

2.4.1 Bowhead Whales—Eastern Arctic

Activities associated with shipping and oil and gas development in the Eastern Arctic could result in changes in feeding, migration and the rearing of calves (i.e., nursing) under some circumstances. Potential changes in bowhead health may include increased risk of mortality or injury (e.g., due to vessel strikes), permanent and temporary hearing loss, non-auditory physiological effects (e.g., stress), reductions in communication (e.g., masking) and reduced prey availability.

The operation of seismic arrays and the associated generation of underwater sound could potentially result in changes in habitat use by bowhead whales and possibly affect bowhead whale health. Vessel operation and exploratory drilling will also generate underwater noise, which can influence the spatial distribution of bowhead whales.

Vessel Traffic

Vessel traffic associated with the development scenario includes the seismic vessel, supply vessels, support vessels, and refueling vessels. Increased vessel activity may potentially lead to vessel-whale strikes (change in health) and acoustic-related effects (change in behaviour, displacement from habitat, and communication masking) on bowhead whales.

Vessel strikes of slow moving whales, including bowheads, are more likely to occur when ships 80 m and longer are travelling at 14 knots or faster (Laist *et al*. 2001). Vessels travelling at lower speeds (< 14 knots) are less likely to cause direct mortality in large cetaceans and also tend to cause less behavioural disturbance (Laist *et al*. 2001). It is assumed that vessels associated with development scenarios in the Eastern Arctic will not exceed a maximum cruising speed of 14 knots when mobilizing to, and demobilizing from, the Program area. This minimizes the potential for direct mortality of bowhead whales as a result of vessel strikes. Seismic vessels operate at very low speeds (~ 4.5 knots), when acquiring seismic information, hence whale-vessel strikes are unlikely during this activity. It is also assumed that given the low intensity of vessel traffic and the area that could be transited by these vessels, that the potential for whale strikes is low and that risk to the population is therefore minimal.

Supply and support vessels will generally accompany a seismic vessel during seismic acquisition and provide support to drilling platforms during the exploratory drilling phase of development and will, therefore, be traveling at low speeds during seismic and drilling operations. They are also used for refueling or resupplying the seismic vessel or drill ships and will be travelling along defined shipping routes to the nearest supply port. During transit and operation within the development area, all vessels are expected to comply with a speed restriction of less than 14 knots to reduce the likelihood of direct mortality of a bowhead whale. Mitigation typically includes Marine Mammal Observers (MMOs) on the seismic vessel and support vessel to ensure potential interactions with bowhead whales are further minimized.

Underwater acoustic emissions from traveling vessels may result in changes in bowhead whale behaviour such as changes in surfacing rate, breathing rate and diving cycles (Richardson *et al*. 1995). Studies have shown that bowhead whales will temporarily avoid transiting vessels up to 4 km away (Richardson and Fraker 1985). Conservative estimates of maximum and minimum zones of influence for the effects of underwater vessel noise were used in the model to demonstrate the variation and relative uncertainty associated with the effects of underwater noise on cetacean species. Vessel traffic associated with development activities is expected to occur for the duration of the operating season (open-water); therefore, the duration of effects was given a value of 1.00.

All vessels used for the development scenario Programs will comply with the *Arctic Waters Pollution Prevention Act*, conform to Regulation 4 of the Annex IV of MARPOL convention and ensure regular testing of effluent takes place to conform to regulatory requirements. No bilge water will be discharged and solid wastes will be either incinerated or disposed of on land after the Program. Therefore, no environmental effects associated with waste management from seismic ships, drill ships and support vessels are expected on bowhead whales; this is reflected in the very low probability of effects on bowhead whales due to pollution.

Seismic Acquisition

Several recent reviews are available on reactions to seismic sound by marine mammals (Gordon *et al*. 2004; Miller *et al*. 2005; Moulton and Miller 2005; Stone and Tasker 2006; Gailey 2007; Abgrall *et al*. 2008). Generally, baleen whales (the group to which bowhead whales belong) tend to avoid active airgun arrays, but the distance at which they react can be variable. They often show no overt reactions at distances greater than a few kilometres; however, when exposed to strong noise pulses at closer distances, they often react by deviating from their migratory course or interrupting their feeding and moving away. From a review of 201 seismic surveys conducted in United Kingdom waters between 1997 and 2000, baleen whales showed a statistically significant displacement of ~ 600 m when comparing closest distance of approach of the whales with and without seismic array activity (Stone and Tasker 2006).

While seismic operations within the defined area will occur over the course of the open-water period (depending on ice and weather conditions), when bowhead whales are most likely to be present, effects to feeding whales from the passing array will be short-term in duration and localized in nature. Creation of underwater noise by the arrays will be continuous; however, given the transitory nature of the seismic activity relative to any specific geographic location within the survey area, effects relating to feeding bowhead whale are likely to be infrequent.

Drilling

Underwater noise from drilling rigs is attributed to two sources; the drilling process and the propellers keeping the drill ship/rig in position. For the purpose of the PEMT, it is assumed that exploration drilling will occur from a dynamically-positioned drill ship. It is recognized that other drilling platforms could be used (e.g., bottom-founded structures; floating, anchored structures) that do not require propeller positioning. Noise produced by the propellers will result in the same effects for bowhead whales as regular vessel traffic (see above), but the spatial extent of the acoustic disturbance will be limited to the area immediately surrounding the drilling activity. Bowhead whales have been observed to avoid drilling operations within a radius of up to 10 km in Alaska (Richardson *et al*. 1990). This value was used as the maximum zone of influence for the effects of drilling noise on bowhead whales in Appendix C; however, it is important to note that this reaction may not be exclusively attributed to drilling noise given the volume of vessel traffic associated with an active drilling rig. The greatest risk to bowhead whales from underwater noise produced by drilling rigs is displacement from critical habitat (e.g., feeding areas or migration routes) and communication masking. Since the drill rig is operating in a fixed geographical position for the duration of the open water season, the duration of effect and probability of these effects potentially occurring are rated relatively high[6]. Due to the nature of the noise generated from drilling activities, the risk of physical injury is low.

[6] Note that the sensitivity of the area is not considered here, but is taken directly from the PEMT.

Support Aircraft Operations

All support Aircraft Operations are expected to follow EISC Overflight Guidelines when possible (Environmental Impact Steering Committee 2011). Low flying aircraft (≤ 300 m altitudes) may initiate short-term changes in bowhead whale behaviour including: rapid dives, avoidance of aircraft, and dispersal (Richardson and Malme 1993; Patenaude *et al*. 2002). To effectively mitigate potential effects of aircraft use on bowhead whales and other marine mammals, flying altitude restrictions will be implemented at > 300 m except for takeoff and landing (Environmental Impact Steering Committee 2011). Therefore, aircraft effects on bowhead whales are unlikely to occur. Given the confidence of effective mitigation, the zone of influence for sensory disturbance to bowhead whales due to aircraft operations was conservatively estimated to be 0 km (min) to 0.5 km (max). Given the intermittent nature of support aircraft operations, the duration of effect and probability of effect were similarly low (Appendix D).

2.4.2 Toothed Whales—Eastern Arctic and High Arctic

As with bowhead whales, toothed whales could potentially be affected by shipping or oil and gas development activities that result in changes in feeding, migration and the rearing of calves (e.g., nursing). Toothed whales (including beluga, narwhal, and killer whales for the Eastern Arctic study area and narwhal for the High Arctic study area) are susceptible to less risk of mortality and physical injury due to ship strikes because they are generally faster and more agile than the larger baleen whales. Possible primary effects of concern for toothed whales include permanent and temporary hearing loss, non-auditory physiological effects (e.g., stress), reductions in communication (e.g., masking) and reduced prey availability.

With the exception of some species specific differences in physiology, general effects from development activities are expected to be similar for all cetaceans. Values incorporated in the model are identical for bowhead whale and toothed whale (Appendix D). Variation in the outcome of the model results from differences in VC specific habitat sensitivity and is more thoroughly discussed in Section 3.

The following information applies specifically to toothed whales.

Vessel Traffic

The likelihood of a highly mobile (e.g., fast swimming) animal, such as a beluga whale or narwhal, being struck by a vessel associated with oil and gas development activities is minimal. Studies on whale-vessel strikes suggest the larger baleen whales are more susceptible to strikes than their smaller, toothed counterparts (Laist *et al*. 2001). Some behavioural studies of narwhal reaction to approaching vessels suggest narwhals “freeze” (seek shallow water and remain immobile) (COSEWIC 2004a). As described above for bowhead whales, mitigation is expected to reduce the risk of vessel strikes.

Ice breaking is considered in the High Arctic development scenario and increases the potential effects on toothed whales due to vessel traffic. Beluga whales may avoid the noise from icebreakers at long distances from the source (e.g., 35 – 50 km) and are documented to remain away from the area for up to two days (Finley *et al*. 1990). Narwhals have a varied reaction to icebreaking and vessel noise, either moving long distances away or tending to "freeze" and be silent. The path of an icebreaker opens up new channels in ice. If the whales follow the path of the icebreaker there is potential for them to be trapped in the refreezing ice.

Seismic Acquisition

The dominant frequencies of beluga echolocation range between 20 – 60 and 100 – 130 kHz, while their hearing is most sensitive in the mid-frequency range, between 32 – 108 kHz (Richardson *et al*. 1995; Klishin *et al*. 2000). Most energy produced by airgun arrays is below 0.1 kHz, well below the frequencies of the calls and optimum hearing of belugas. As a result, while seismic noise is potentially audible, belugas may be rather insensitive to seismic sound pulses (Richardson *et al*. 1995). However, recent studies measured substantial high frequency energy output from airguns, at levels clearly audible to most—if not all—cetacean species (Goold and Coates 2006).

It is important to note that both the likelihood and severity of biological effects on toothed whales that may result from seismic surveys are likely to vary with local environmental conditions (e.g., ice coverage, bottom topography, sea state), as well as the condition of the organisms themselves (e.g., breeding state, nutritional state). Additionally, the paucity of scientific information, particularly with respect to field experiments, makes it extremely difficult to evaluate effects of seismic sounds on these particular species.

Drilling

Effects from drilling are expected to be similar to those described for bowhead whale (see above).

2.4.2.1 Support Aircraft Operations

Aircraft flying at low altitude are known to disturb beluga whales and narwhal (Richardson *et al*. 1995). Patenaude, *et al.* (2002) documented short-term behavioural responses of belugas to a helicopter and twin otter fixed-wing aircraft, including short surfacing, long dives, sudden dives, diving under ice pans, abrupt changes in direction and temporary displacement. Some individuals react to aircraft flying at altitudes as high as 500 m, but reactions are more common at altitudes 150 – 200 m (Patenaude *et al*. 2002). Narwhals were observed to dive quickly from an approaching helicopter below 244 m (Kingsley *et al*. 1994). To mitigate these effects, flying restrictions are expected to require all Project-related aircraft to maintain a minimum altitude of 300 m (Environmental Impact Steering Committee 2011).

2.4.3 Migratory Birds—Eastern Arctic and High Arctic

Eastern Arctic

Davis Strait and associated coastal areas of Baffin Island, Devon Island, and Ellesmere Island provide important habitat for a number of seabirds, including thick-billed murre, black guillemot, northern fulmar, and ivory gull. While all of these species are potentially relevant for modeling, thick-billed murre may be the most appropriate species on which to focus, given that it has large coastal colonies, forages extensively offshore, and appears to be relatively sensitive to disturbance. Guillemot colonies are smaller, nests are better protected, and they forage closer to shore. Ivory gulls generally nest far inland, and are unlikely to be exposed to underwater disturbances. Fulmars also have large coastal colonies, but in some parts of their range have habituated well to disturbances.

High Arctic

The High Arctic study area contains a number of important areas for a variety of marine birds, including three species of conservation concern (ivory gull, Ross's gull, and the red knot). While the Eastern Arctic model focused on the thick-billed murre as a representative species, the High Arctic model focuses on legislated Migratory Bird Sanctuaries, the key marine and terrestrial habitat areas as identified by the Canadian Wildlife Service (CWS), Important Bird Areas (IBAs) as identified by BirdLife International, and biological hotspots (Parks Canada). Areas of sensitivity have been defined for these areas (Nunami Stantec Ltd. 2011a), and by considering important areas, multiple species associated with these areas are included in the analysis.

The discussion of anthropogenic effects on arctic seabirds focuses most frequently on oil spills, which are beyond the scope of the cumulative effects scenarios analyzed here. There is relatively little literature concerning routine effects of disturbance, and many reports focus on anecdotal observations, rather than systematic studies. However, by reviewing literature on the aforementioned species, as well as other common arctic seabirds such as thick-billed murre, it is possible to characterize the issues that are likely to be of greatest concern. A generic guideline suggested by Chardine and Mendenhall (1998) is that disturbance at a nesting colony should be suspected and monitored if human activity is audible, is visible within 1 km, or if birds are observed to maintain a heightened level of alertness or other evidence of response to human activities. However, it should be noted that disturbance thresholds have generally not been experimentally tested, and therefore predictions are largely based on the relative intensity of stimuli within the context of behavioural responses that have been documented.

2.4.3.1 Vessel Traffic

Disturbance to seabirds can be caused by vessels near shore. In particular, thick-billed murres have been reported to abandon colonies in response to increased boat traffic (Barrett and Vader 1984). There is potential for vessels to temporarily displace feeding seabirds from preferred foraging areas, resulting in additional energy expenditure and possibly reduced foraging efficiency (Bryant *et al*. 1999). Since many seabirds have high metabolic requirements, they can be sensitive to increased energetic demands or reduced rate of food availability and intake. Thick-billed murre is considered sensitive to changes in prey distribution and abundance (Gaston and Hipfner 2000). Black guillemots forage closer to shore, and could be negatively affected by disturbance of prey communities in the nearshore zone (Butler and Buckley 2002). Considering the relative size of foraging areas in comparison to the locations that might be disturbed by vessel traffic, and the temporary nature of such disturbance, this effect is likely to be of low consequence, and the probability of occurrence is estimated at 0.2.

2.4.3.2 Seismic Acquisition

Underwater noise created by seismic acquisition is unlikely to be an important concern for seabirds. At close range, it may prompt a change in behaviour in the form of birds relocating to forage at a greater distance from the source of noise; however, this effect would already be captured in the disturbance effects noted above.

2.4.3.3 Drilling

Noise-related effects are as noted above for seismic acquisition. Operation of drilling rigs within sight of breeding colonies may cause disturbance for some species, but there is likelihood of habituation to a relatively distant and constant stimulus. As with vessel traffic, stationary structures such as drilling rigs have the potential to displace seabirds from preferred foraging areas. Considering the small footprint of such structures and the potential for habituation, the probability of an effect is considered low and estimated at 0.2.

2.4.3.4 Support Aircraft Operations

Overflights by helicopters and fixed-wing aircraft are consistently identified as the greatest stressor on seabirds at breeding colonies. Such disturbance can stimulate panic flights, leaving eggs or chicks vulnerable to predators or in the case of murres to the direct loss of eggs, since they incubate them on their feet (Chardine and Mendenhall 1998). The disturbance threshold for thick-billed murres has been reported as up to 1 km for helicopters (Gaston and Hipfner 2000). Thick-billed murres are also known to temporarily abandon their nests in response to overflights, as well as other sensory disturbance such as gunshots, but threshold distances have not been estimated (Curry and Murphy 1995; Chardine and Mendenhall 1998). Northern fulmars appear to be somewhat more tolerant, showing little reaction to aircraft as close as 100 m at some colonies, although tending to be more sensitive at remote locations (Hatch and Nettleship 1998). While ivory gulls have bred along an active airstrip in Greenland and on military bases in Russia, the abandonment of a nesting colony on Seymour Island and a decline in the Brodeur Peninsula population are attributed to a heavy volume of traffic from helicopters and other low-flying aircraft (Mallory *et al*. 2008). The Northern Land Use Plan for the Northwest Territories seismic operations recommend a general minimum flight altitude of 650 m, and flights be minimized over important bird habitat and where it is not possible to avoid this habitat, a minimum altitude of 1,100 m where birds are known to concentrate (e.g., IBAs and MBS) (Government of Canada 2011). In order to make a conservative analysis based on these recommended minimum flight altitudes, 650 m was used as the minimum and 1,100 m used as the maximum model of effects. Since the majority of research suggests that murres and other seabirds respond negatively to aircraft, even though there are occasional exceptions, the probability of disturbance caused by aircraft is estimated to be low (.05).

2.4.3.5 Human Activity

Disturbance can also be caused by human activity in the vicinity of breeding colonies. Human presence in nesting colonies can cause temporary desertion and failure, largely by facilitating attacks from opportunistic predators on abandoned nests (Birkhead and Nettleship 1980; Gaston and

Donaldson 1994; Butler and Buckley 2002). However, there is also some evidence that colonial seabirds may become habituated to human activity over time (Fjeld *et al*. 1988; Chardine and Mendenhall 1998). Northern fulmars appear to habituate to various forms of disturbance (Hatch and Nettleship 1998). Ivory gulls also seem relatively tolerant of human presence, even visiting active camps (COSEWIC 2006b; Mallory *et al*. 2008). Given that terrestrial activities will not occur within colonies, the probability of any such disturbance affecting seabirds is low, and is estimated at 0.01.

2.4.4 Polar Bears—Eastern Arctic and High Arctic

Vessel Traffic

Vessel traffic associated with the development scenario includes the seismic vessel, supply vessels, support vessels, and refueling vessels. Increased vessel activity may potentially lead to vessel – bear interactions in the case of ice-breaking (change in behaviour, displacement from habitat). While polar bears are capable of swimming large distances in the open water, there are no recorded instances of a vessel-bear strike in the Canadian Arctic and is considered unlikely. Polar bears do not seem to be deterred from noise associated with offshore oil activities (even when swimming in the water), construction, ice-breakers or vessel traffic (Richardson *et al*. 1995).

Mitigation measures to reduce the risk of vessel strikes with other marine mammals (as described above under bowhead whales) will also mitigate risk to swimming polar bears.

Seismic Acquisition

Marine based seismic operations can only occur over the course of the open-water period (depending on ice and weather conditions). Polar bears are unlikely to be affected by seismic sound while travelling on the ice, but may be subject to effects if direct interaction occurs while they are swimming. Although it is not uncommon to see polar bears swimming in open water, adverse interactions with polar bears would be unlikely and effects would be limited.

Drilling

The presence of ice-based stationary drill-ships and drill-sites has been shown to attract polar bears, possibly from seal utilization of rig-induced cracks (Stirling 1998). This may increase access to prey (Richardson *et al*. 1995) but may also increase the threat of killing these bears in areas of higher human activities. For the purposes of the PEMT, drill-ships will be present in open water or low ice cover and therefore the interaction with polar bears is expected to be minimal.

Support Aircraft Operations

All support Aircraft Operations are expected to follow EISC Overflight Guidelines (Environmental Impact Steering Committee 2011) when possible. Low flying aircraft (≤ 200 m altitudes) may initiate short-term changes in polar bear behaviour including startle response, running, and avoidance (Richardson *et al*. 1995). To effectively mitigate potential effects of aircraft use on polar bears and other marine mammals, flying altitude restrictions will be implemented at > 300 m except for takeoff and landing (Environmental Impact Steering Committee 2011). This is consistent with the NWT Land

Use Guidelines for seismic operations which recommend a minimum flight altitude of 300 m above denning areas (Government of Canada 2011). Given the flying restrictions, aircraft effects on polar bears are unlikely to occur. Given the confidence of effective mitigation, the zone of influence for sensory disturbance to polar bears due to aircraft operations was conservatively estimated to be 0 km (min) to 0.65 km (max). The maximum zone of 0.65 km is based on the minimum recommended flight altitude for general wildlife for NWT (Government of Canada 2011). Given the intermittent nature of support aircraft operations, the duration of effect and probability of effect were similarly low (Appendix D).

2.4.5 Arctic Char—Eastern Arctic

Vessel Traffic

Shipping itself is expected to have minimal effects on Arctic char. Coastal infrastructure related to shipping such as docks or causeways may have potential short or long-term effects on Arctic char. The construction of docks would likely only have short-term effects during the period of construction when Arctic char migration may be disrupted. The construction of causeways which extend out from shore may also cause short-term disruptions in feeding migrations. The potential for longer-term effects are unknown but the migrations of adults of similar species such as Dolly Varden char and Arctic cisco do not appear to be affected by causeways constructed in the Alaskan Beaufort Sea (Fechhelm *et al*. 1999).

Seismic Acquisition

Few studies have been conducted on the effects of seismic operations on salmonids and most of these studies involved the effects of the use of explosives to conduct seismic activities. No studies on the effects of seismic arrays have been conducted specifically with Arctic char. The use of air guns has greatly reduced mortalities in fish during seismic surveys. Mortality is generally restricted to the immediate few meters under the air gun, affecting mainly fish eggs and larval fish. Mortality of fish eggs and larval fish by air guns is far less than natural mortality (Saetre and Ona 1996). Pacific herring have exhibited a number of behavioural responses such as startle response, alarm and avoidance (Schwarz and Greer 1984) during seismic activities; however, these responses stop shortly after cessation of seismic operations.

There is the potential that Arctic char feeding migrations may be disrupted during seismic operations in coastal waters. The disruption of feeding migrations may reduce the amount of energy the Arctic char can obtain during the short feeding season. If the fish do not obtain the necessary energy reserves, it may have consequences for survival and/or reproduction.

Drilling

Exploration drilling activities would likely only have potential effects on Arctic char if these activities occurred in nearshore areas or mouths of rivers containing anadromous char. No data is available on the effects of drilling activities on Arctic char; however, underwater noise created by drilling or production activities may cause disruptions in char migration or lead to reduced catches by local fishermen. Drilling in the offshore is unlikely to have effects on Arctic char populations.

2.4.6 Species of Conservation Concern

Species of conservation concern often have additional ecological, cultural and/or economic importance. There are six species of conservation concern with ranges that overlap with the Eastern Arctic study area. Polar bear and bowhead whale are already considered as individual VCs. Toothed whales (including narwhal and beluga) are assessed individually. Migratory birds (including ivory gull) are considered as representative VCs. Therefore, walrus was chosen as a representative marine species of conservation concern. Low to moderate sensitivity rating was given to areas where walrus concentrate in the summer.

2.4.6.1 Walrus—Eastern Arctic

Vessel Traffic

Disturbances (i.e., noise, vessel or human activity) may induce haul-out clearing and stampedes. This effect may cause mortality, increased expended energy (especially in pups), communication masking, change in thermoregulation and increased stress (COSEWIC 2006a). Prolonged or repeated disturbances may cause walruses to abandon their haul-outs (Mansfield and St. Aubin 1991; Richardson *et al*. 1995). At present levels of industrial activity, potential threats to walruses are low. Ship noise and oil and gas exploration could displace walruses from their haul-outs and interfere with their communication (Stewart 2002).

Seismic Acquisition

Pinnipeds spend time on land and under water, and typically do not rely on communicating over great distances like cetaceans and as such their hearing has not evolved in the same way. There is a lack of species-specific hearing thresholds for marine mammals, but based on limited studies available, walrus are appear to have similar hearing to other pinnipeds (Richardson *et al*. 1995; Kastelein *et al*. 1996). Seismic noise is not considered to have adverse effects on pinniped species.

Drilling

Walrus may show some kind of reaction to the presence of a ship or drill rig, but it is unknown to what extent they react to the presence of the vessel as opposed to the sound being generated. Pinnipeds, including walrus, are generally less susceptible to disturbance when they are in the water compared with when they are hauled out. Icebreaking elicits the greatest response, whereas a vessel underway without ice breaking support or anchored elicited lower responses from walrus; response threshold was generally less than 1 km (Richardson *et al*. 1995).

Support Aircraft Operations

Walrus response to aircraft are similar to other pinniped species which varies with a variety of factors (e.g., range and type of aircraft, size of haulout, age, sex, and group size) (Richardson *et al*. 1995).

In general, females, juveniles, and pups tend to react more quickly than adult males. Many pinniped species, including walrus, are known to stampede into the water for a vessel or aircraft approaching too closely (e.g., 150 m) or too quickly. Stampeding behaviour puts young pups at risk of being trampled to death. Walrus reactions are variable, with some reports of disturbance from aircraft flying up to 1800 m away (Fay 1984 [publ. 1986]).

2.4.6.2 Peary Caribou—High Arctic

Peary caribou were chosen as a representative VC for terrestrial species of conservation concern in the High Arctic. The other species of concern are given consideration under the other VCs modeled (ivory gull, Ross's gull, and red knot under migratory birds; polar bear; narwhal under toothed whale). The High Arctic study area development scenario includes land-based activities, which have the potential to affect terrestrial animals. Peary caribou are listed as Endangered under the *Species at Risk Act*. The range of Peary caribou is considered to be moderate/high sensitivity (Nunami Stantec Ltd. 2011a).

Vessel Traffic

Peary caribou move between arctic islands and therefore vessel traffic could interfere with their movement (Miller and Gunn 1978, 1980). Concerns about the increase in shipping on caribou inter-island movements have been raised (COSEWIC 2004b).

Land-based Seismic Acquisition and Drilling

All caribou species are susceptible to disturbances caused by development. Caribou are known to avoid seismic vehicles and camps by a distance of at least 0.8 km (COSEWIC 2004b). Caribou have been observed to avoid cut-overs (Vors *et al*. 2007) and infrastructure (Vistnes and Nellemann 2008). The biggest concern related to land structures is the potential for restriction to foraging areas (COSEWIC 2004b), rather than the sound or vibrations from acquisition.

Support Aircraft Operations

Peary caribou may be susceptible to disturbance from low flying aircraft and ground vehicles and construction of ground installations which may hamper movement to better feeding grounds or migrations.

2.4.7 Traditional Harvest—Eastern Arctic and High Arctic

The analysis of susceptibility of traditional harvesting to oil and gas activity is restricted to consideration of routine exploration and development activities. As such, the potential effects of a catastrophic event such as an oil spill are not considered. Most oil and gas activities in the study area will occur in the marine environment; however, shore bases to support activity may be required. The development scenario in the High Arctic study area includes land based activities.

Harvested species and the sensitivity of habitats to oil and gas activity will affect the presence and abundance of the species and, therefore, availability for harvest. Sensitivity of each wildlife species is discussed elsewhere in this report. Traditional harvesting activity and oil and gas activity may interact directly when both activities occur in the same area at the same time. Industry activity may be both mobile (seismic) or stationary (drilling, shore support base) providing opportunities for a number of direct interactions with traditional harvesting (e.g., ice breaking, noise propagation, visual disruption), which can potentially negatively affect harvesting.

Vessel Traffic

Shipping to support oil and gas activity may disrupt migrations of marine wildlife and consequently their availability for harvest. The presence of marine vessels in a traditional harvesting area may prevent or discourage boat based harvesters from utilizing the areas. Intensive shipping such as regular transits between a shore base and an offshore location may result in traditional harvesters moving to another area or being unable to harvest all together.

Seismic Acquisition

Seismic activity in the study areas is expected to be conducted by marine vessels during the open water season and on land (High Arctic) during the summer season. Direct interaction of offshore activities with traditional harvesting is expected to be limited; however, vessel traffic may interfere with migration of marine wildlife and potentially affect the availability of species for harvesting. Activities on land have a greater potential for interacting spatially and temporally with traditional harvesters.

Ice-based Activities

It is likely that drilling in the study area would be undertaken by drill ships or other mobile structures. Therefore oil and gas activities affecting ice in the study area would be expected to be related to ice management and transfer of people and materials to offshore drilling locations. Noise associated with ice breaking may indirectly affect harvesting as species may avoid areas of activity. Depending on the drilling season, location and resupply locations, ice breaking could interact with traditional harvesting. Ice breaking and resulting ship tracks can present a safety hazard as a result of open water and rough ice when the tracks freeze.

2.4.8 Commercial Turbot Fishery—Eastern Arctic

There are three main commercial fisheries in Nunavut. These are the turbot (Greenland halibut), shrimp and Arctic char fisheries. The turbot fishery consists of an offshore fishery in Davis Strait and a winter fishery in Cumberland Sound. Since the analysis presented here focuses on the summer season, activities would not affect the winter turbot fishery. The shrimp fishery is also conducted offshore in Davis Strait. The Arctic char fishery occurs in rivers and coastal areas along the east coast off Baffin Island. The coastal fishery is the portion of this fishery that could potentially experience cumulative effects based on the scenarios provided for this exercise. The offshore turbot fishery has been chosen for this exercise as it has the greatest potential for effects occurring and is also the largest fishery in Nunavut. Offshore turbot fisheries occur in deep water often at depths of 1,000 m or greater.

Industries which could potentially conflict with fishing activities and result in cumulative effects on the turbot fishery are shipping and oil and gas exploration activities. It is probable that shipping and fisheries will continue to increase over the next 10 years. Nunavut is also exploring opportunities to establish new fisheries which may also play a role in contributing to cumulative effects in the future.

It is important to note and caution that no studies have been conducted on the effects of oil and gas activities (e.g., offshore Atlantic Canada) on turbot or turbot fisheries. It is also difficult to compare studies on other fisheries with that of the turbot fishery. Effects can vary by species, temperature, depth and potentially other factors. For example, most studies on the effects of seismic on fish or fisheries have been on fish which contain an air bladder which turbot do not. Seismic sound may affect fish with air bladders differently than those without.

Potential cumulative effects on the offshore turbot fishery may occur due to increased vessel traffic, seismic acquisition and drilling. Support aircraft operations would not contribute to any cumulative effects to the fishery.

Vessel Traffic

Underwater noise from shipping is unlikely to contribute to effects on turbot or the fishery and, therefore, no zone of influence has been provided for ship noise or the behavior of turbot.

Seismic Acquisition

Boudreau, *et al.* (1999) identified a number of potential effects on fisheries from seismic activity such as:

- Decreased catch rates due to scaring (displacement) of fish
- Interference with fish spawning
- Space conflicts with existing fishing activities (and potential for damage to equipment such as nets)
- Mortalities in a number of species and a number of life stages.

Seismic operations can also cause declines in catches of fish. Reductions of over 50% in catches of cod (Løkkeborg 1991; Engas *et al*. 1996), haddock (Engas *et al*. 1996), and rockfish (Skalski *et al*. 1992) have been reported.

Displacement and other Behavioural Changes

Seismic activities can displace some fish species from an area where a fishery is occurring. Reductions in fish density have been recorded as high as 50% (NERI 2009). Displacement of fish for some fisheries can range up to 10 km or more (NERI 2009) and displacement is likely to be higher closer to the sound source. A zone of influence was selected between 1 to 10 km for displacement. The upper limit of 10 km is likely a conservative estimate as studies reporting displacement were conducted on species containing an air bladder and not on deep water flat fish such as turbot which have no air bladder. The absence of an air bladder in fish such as turbot as previously discussed can reduce the effects from sound as compared to species which have air bladders. While displacement of fish may also occur between 0 to 1 km, zero was not used as a fisheries vessel would be at least 1 km or more from a seismic vessel for safety purposes.

Fish may also react behaviourally to seismic sound beyond the 10 km range to distances greater than 30 km (NERI 2009). These reactions are generally less intense in nature as compared to being displaced from a wide area. These behavioural changes can include startle responses or changes in movement such as avoidance behavior by swimming short distances away from the sound, often doing so by swimming downwards. As previously discussed the deep water habitat of turbot and their lack of an air bladder, reduces the potential for effects as result 30 km is considered a conservative estimate. However, although there is a low probability that effects to the fishery would occur, they cannot be fully discounted, as no studies have been conducted on turbot and their response to seismic sound.

The potential for ecological effects on fish of a fishery are considered low; however, the ability to catch fish is dependent on the target species (DFO 2004) as species may respond to seismic sound differently. It is unlikely the effects of seismic would lead to long-term changes in average catch rates or to the size of fish stocks in general (Gausland 2003).

Interference with Fish Spawning

There would be no interference with turbot spawning and seismic activity. Seismic activity would occur during the summer months while turbot spawn in winter. As a result, no effect on the turbot fishery is expected through this temporal mechanism.

Space Conflicts

Space conflict refers to the situation where a fisheries vessel changes its area for trawling due to the presence of a seismic vessel. Interaction between fishing vessels and seismic and other activities is inevitable in areas where activities are highly concentrated (Canada - Nova Scotia Offshore Petroleum Board 2003). However, in the Eastern Arctic, it is unlikely that areas of high concentrations of industrial activities will overlap areas of high fishing activity as is seen in the offshore areas of eastern Canada. Although the probability is low for spatial conflicts to occur, the effect if a conflict occurred could result in reduced catches of turbot.

There is no data on the distances that fishing vessels use to avoid seismic vessels. The distance is determined by the ships captains; knowing the location of each other’s vessel, the depth of water where an activity is occurring, weather, ice, and whether seismic or fishing gear is in the water. For the purpose of this assessment, it was assumed that active seismic and fishing vessels would maintain a minimum distance of 1 to 5 km from the seismic vessel.

Mortalities

Low densities of turbot eggs and larvae can be found in the upper 10 m of the water column and are widely dispersed. Due to the presence of some eggs and larvae in the upper water column, there is the potential for small numbers of turbot eggs and larvae to incur mortality by seismic sound. As turbot grow from larvae to juvenile to adult they move downwards into deeper water. The older larger turbot, which are the target for commercial fisheries, are generally found at depths of 1,000 m or greater. At these depths, seismic sound would not cause mortality. Mortality of larvae and eggs would be localized and limited to a small number of individuals. Effects on turbot populations would be negligible. No zone of influence is required related to turbot mortalities.

Drilling

Underwater Noise—Displacement

Displacement is most likely to occur with fish which are territorial. Turbot are not territorial and are migratory in nature. There is still potential that displacement may occur locally. Any displacement effect would likely also be temporary in nature as fish generally react less to continual sounds as would occur from drilling activities. The probability of an affect would be low, within a short range (1 – 2 km) of the drill itself and the duration temporary. The consequence of the effect would also be expected to be low to nil. As the potential effect on turbot would not affect the fishery, no zone of influence is identified.

Drilling Mud Disposal—Chronic Health Affects

Dispersed muds, cuttings and associated hydrocarbons can cause localized sublethal effects for some bottom dwelling organisms (e.g., benthos) (Boudreau *et al*. 1999), but generally would not affect pelagic fish. The zone of influence from drilling mud disposal is generally limited to less than a kilometer from the disposal site. Environmental Effects Monitoring (EEM) studies sometimes extend to 5 km from a drill to ensure that monitoring extends beyond the zone of influence; however, drilling mud is generally not detected after several hundreds of meters. As a precautionary approach, a conservative zone of influence used from 0 to 0.5 km. Effects also would likely decrease rapidly once drilling operations ceased (Boudreau *et al*. 1999). Due to the migratory behaviour of turbot, as well as their large spatial variability, it is unlikely any potential effects would be identified at a population level. Therefore, the probability of chronic health effects from drilling mud disposal is low and the duration period would be short. No effects to the commercial fishery would be expected.

Drilling Mud Disposal—Tainting

There is little evidence to suggest concern over possible tainting of finfish resources due to drilling discharges (Boudreau *et al*. 1999). The potential impacts of tainting can be expected to be less with isolated exploratory wells than with a production field and should not be an issue where water-based muds are used (Boudreau *et al*. 1999).

Space Conflicts

For safety purposes, fishing vessels would require to stay a certain distance from a drilling rig or drill ship. Boudreau, *et al.* (1999) assumes a safety radius of 1 to 1.5 km around a drill ship. This safety radius may be larger under arctic conditions due to the potential of ice. The locations where drilling is occurring will have a direct effect on the probability of a conflict with fishing vessels. Due to the limited number of drill ships expected at any exploration area and number and depth where fishing vessels would be operating, the probability of an effect is low, while duration would depend on the location of the drill ships.

2.5 Sensitivity of an Area

To maintain a level of consistency in the application of the PEMT, the development of the sensitivity layers for each selected Valued Component (VC) in this study area was based on the methodology undertaken for the Canadian Beaufort Sea Decision Support Tool (DST) (Gartner Lee Limited 2008). As such, the decisions were made with a combination of various sources of relevant ecosystem (habitat use and availability) and socio-economic information. Each rating and its spatial distribution across the study area was dependent on data availability. While the general information on the selected VC is comprehensive, much of the habitat usage by VC is closely correlated with the seasonal patterns of sea ice. As a result, the spatial distribution of habitat usage may vary substantially on an annual basis and can be highly dependent upon environmental conditions. Taking this variability into consideration, sensitivity ratings were applied based on conservative interpretations of potential effects from projects among seasons.

2.5.1 Updated VC Distribution Data

The biological data for the Eastern Arctic VCs was updated based on the recently issued Arctic Marine Workshop report (Stephenson and Hartwig 2010). Some changes in distribution or new data on habitat use caused some minor changes to be issued in the sensitivity maps. The updated distribution maps are described below and are provided in Appendix E (Figures 1 – 4).

2.5.1.1 Bowhead Whale

The known distribution of the bowhead whale has expanded, most notably, the summer range into Lancaster Sound and the winter range in western Hudson Strait and a swath across Davis Strait to the coast of Greenland (Figure 1). This data was based on scientific survey data, Traditional Knowledge and reports from communities. The summer range expanded the moderate/high layer to include all of Lancaster Sound, and the moderate/high sensitivity layer in winter increased due to the important transition zone between Baffin Island and Greenland.

2.5.1.2 Toothed Whales

The toothed whale VC includes data on beluga whale, narwhal, and killer whale. Small updates were made to the general distribution, most notably the addition of killer whale range data (as part of ‘Toothed Whale Distribution’), which filled in some range gaps in the Foxe Basin and Gulf of Boothia (Figure 2). The data on killer whales has increased, and likely due to the decreased amount of ice in the Hudson Strait and Hudson Bay.

The summer core area for beluga whale changed negligibly, and outside of the study area. The narwhal summer range increased south along the eastern coast of Baffin Island; however, since this area was already given a rating of moderate/high sensitivity; there was no change to the summer sensitivity map. The border of the North Water Polynya was scored as high sensitivity in the winter due to its importance as a feeding and congregation area for beluga whale.

2.5.1.3 Polar Bear

Polar bear denning areas were updated to include recently identified areas. Polar bear range was updated to display seasonal range (i.e., summer and winter) (Figure 3). The offshore winter range which is considered to be of moderate sensitivity was expanded. Therefore, the range of the moderate sensitivity layer expanded correspondingly. The Qaqulluit and Akpait National Wildlife Areas were considered high sensitivity during both summer and winter because they are legally protected as conservation areas.

2.5.1.4 Species of Conservation Concern

The species of conservation concern VC included the polar bear, bowhead whale, beluga, narwhal, walrus, and ivory gull. Updates were made based on changes to individual VCs (i.e., polar bear, bowhead whale, beluga, and narwhal) (Figure 4). Information regarding amigration corridor for walrus between Greenland and Baffin Island was included. This new data is based on tagged animals. These additions increase the winter sensitivity layer from low to low/moderate in the area of the walrus migration zone and bowhead winter range. The summer sensitivity layer increased from low to moderate/low in the range of the walrus migration zone.

2.5.1.5 Arctic Char, Migratory Birds, Traditional Harvest, and Commercial Fishing

No further updates were given regarding the remaining VCs: Arctic char, migratory birds, traditional harvest or commercial fishing. No changes were made to the distribution maps or sensitivity layers.

2.5.2 Sensitivity Rankings

A summary of key information is provided below so that readers can understand the basis of the relevant sensitivity layers. A full description of the development of the sensitivity layers can be found in Nunami Stantec (2010). The sensitivity figures for the Eastern Arctic and High Arctic study areas can be found in Appendix F (Figures 1 – 13).

2.5.2.1 Eastern Arctic

Bowhead Whale

Sensitivity rankings for Eastern Arctic bowhead whales were developed using two primary types of information: 1) known range/distribution of this species, summer aggregation areas, and wintering areas (as determined from available literature sources [e.g., COSEWIC status reports and the Parks Canada Arctic Marine Workshop] and professional experience in this region); and, 2) ecological sensitivity described recently by Laidre, *et al.* (2008). Hence, application of the ecological sensitivity components included by Laidre, *et al.* (2008) may not always be consistent with known locations of bowhead habitat. It is important to note that the definition of winter (November – June) and summer (including July – October) heavily influences the sensitivity layers given the very large influence of ice in this region. To address and incorporate the extreme variability imposed by the dynamic ice regime, 30 year median ice charts, produced by the Canadian Ice Service (Figure 3-1), were used in applying the ecological sensitivities (as described by Laidre, *et al.* 2008, and others) and known ice distribution.

Lastly, a maximum sensitivity approach was used in differentiating between sensitive bowhead whale habitat types. In other words, if an area could be considered as having two different sensitivity rankings (for one or more months), only the highest sensitivity ranking was mapped. Sensitivity ratings for the summer open water season are presented in Figure 1.

Determination of sensitivity for bowhead whale is based on the following.

High Sensitivity (5)

Isabella Bay (Niginganiq) National Wildlife Area, is a well-known critical bowhead whale feeding habitat and hence designated as highly sensitive.

Highly sensitive habitat for bowhead whales also includes important summer feeding areas as designated by DFO. There are currently no such designated areas in the Eastern Arctic study area.

Moderate-High Sensitivity (4)

A moderate to high sensitivity rating was given to areas that provide valued seasonal habitat for bowhead whales. This includes shallow water (approximately 10 m to 100 m depth) and the continental shelf (approximately 100 m to 300 m depth) which provides habitat year round.

Much of the summer continental shelf and shallow-water habitat within the Eastern Arctic study area is classified as moderate to high bowhead whale habitat sensitivity. The Lancaster Sound region was designated as moderate to highly sensitive summer bowhead whale habitat for the increased number of animals in this region during July. Two types of moderate to highly sensitive bowhead habitat were identified within the Eastern Arctic study area during the open water season:

1. Those regions approximating the main shear-zone/lead off the coast of Baffin Island
2. Lancaster Sound and northern Baffin Bay. Large numbers of bowhead whales are known to use Lancaster Sound in June and evidence exists to suggest open-water regions next to pack-ice in northern Baffin Bay are used by numerous whales in late winter (June).

Moderate Sensitivity (3)

Moderately sensitive bowhead whale habitat includes areas of dense annual pack-ice and summer habitat where shear zones, leads, open water and open water adjacent to pack-ice are present.

In the summer (July primarily), the offshore region within the study area joining Baffin Bay and Davis Strait contains dense annual pack-ice, and hence this is the basis for the ranking of moderate sensitivity in this region.

Low-Moderate Sensitivity (2)

Areas that overlap with known bowhead whale habitat, or adjacent to known bowhead whale habitat were rated as low to moderately sensitive. This rating was also given to areas with loose annual pack-ice and shelf break habitat in the summer.

In the summer, bowhead whale habitat ranked with low to moderate sensitivity (4) was defined to represent the loose off-shore annual pack-ice in southern Baffin Bay and northern Davis Strait. This would be primarily for July and August given that ice is largely absent in this region (30 year median) in September and October.

Low Sensitivity (1)

Low sensitivity was given to areas where the bowhead whale is not known to be present, but potential habitat exists. This includes areas in the summer months such as shore-fast ice, deep ocean basins, estuaries, and lagoons.

In the summer, low sensitivity habitat in northern Baffin Bay was defined primarily on the basis of the deeper water and distance from pack-ice. Presence of offshore open-water in July in north-western Baffin Bay therefore was designated low sensitivity.

Toothed Whales

Sensitivity rankings for Eastern Arctic toothed whales were developed using two primary types of information: 1) known range/distribution of beluga, narwhal, and killer whale (as determined from available literature sources [e.g., COSEWIC status reports and the Parks Canada Arctic Marine Workshop] and professional experience in this region); and, 2) ecological sensitivity described recently by Laidre, *et al.* (2008). Hence, application of the ecological sensitivity components included by Laidre, *et al.* (2008) may not always be consistent with known locations of toothed whale habitat. It is important to note that the definition of winter (November – June) and summer (July – October) heavily influences the sensitivity layers given the very large influence of ice in this region. To address and incorporate the extreme variability imposed by the dynamic ice regime, 30 year median ice charts, produced by the Canadian Ice Service, were used in applying the ecological sensitivities (as described by Laidre, *et al.* 2008, and others) and known ice distribution.

Lastly, a maximum sensitivity approach was used in differentiating between sensitive toothed whale habitat types. In other words, if an area could be considered as having two different sensitivity rankings (for one or more months), only the highest sensitivity ranking was mapped. Summer sensitivity ranking for toothed whale habitat in the Eastern Arctic study area is summarized in Figure 2.

High Sensitivity (5)

Areas identified as highly sensitive for toothed whales includes areas designated as critical for any of the toothed whale species and a spatially limited area (< 100 km) during the summer months that provides specific ecological functions essential to toothed whales.

With the exception of the protected areas in the region that overlap with the analysis, highly sensitive summer toothed whale habitat was not identified in the Eastern Arctic study area.

Moderate-High Sensitivity (4)

Areas with moderate to high sensitivity in the summer includes habitat with loose (beluga) or dense annual pack ice (narwhal), shallow continental shelf, estuaries, lagoons and fjords for belugas and shear-zone/leads, fjords, shelf-break, deep ocean basins for narwhals.

Summer toothed whale habitat of moderate to high sensitivity was determined primarily to reflect known ranges of beluga and narwhals (north eastern coast of Baffin Island, Lancaster Sound and Devon Island region), their preference for fjords (both beluga and narwhal), shallow continental shelf regions (belugas within their range) and areas of 'shelf break' (for narwhals).

Moderate Sensitivity (3)

Moderate sensitivity during the summer months was given to areas of open water, shelf-break, and the ice-edge (pack ice next to open water). This rating would also apply to areas that contain moderate to large numbers of toothed whales and shear zones and leads that are utilized by belugas.

Moderately sensitive toothed whale summer habitat was described primarily to capture the ice edge (pack ice next to open water) region of north western Baffin Bay. Moderate to large numbers of toothed whales may potentially occur in the Lancaster Sound region in July and hence this area has been also designated as moderately sensitive summer habitat.

Low-Moderate Sensitivity (2)

Loose annual ice or multiyear pack ice in summer and open-water habitat (> 20 km from pack ice or land-fast ice or ice edge) in winter is considered low to moderately sensitive habitat for toothed whales.

Coastal summer toothed whale habitat in the south-western corner of the Eastern Arctic study area was identified as low to moderately sensitive habitat primarily on the reasonable likelihood of beluga whale presence in this region.

Low Sensitivity (1)

Low sensitivity habitat includes areas where no beluga or narwhal summer habitat is identified, summer offshore (> 100 km), deep water (non-shelf break), and open-water habitat.

According to Laidre, *et al.* (2008) narwhal summer habitat is primarily coastal in nature. Similarly, beluga whales prefer coastal environs in the summer. Consequently, low sensitivity summer toothed whale habitat was identified for the majority of the offshore portion of the Eastern Arctic study area. A narrow band of low sensitivity coastal toothed whale habitat, extending south of Clyde River to Cumberland Peninsula, was identified given that narwhal and belugas are not known to be common in this region.

Migratory Birds

Since limited information was available for thick-billed murre, the ratings used for the environmental sensitivity are based more generally on information available for migratory birds (Figure 3).

High Sensitivity (5)

Habitat given a rating of high sensitivity includes areas globally important to migratory birds because they meet any of the following criteria:

a) Supports 1% of the North American population (following the IBA guidelines)
b) Supports a very significant (i.e., 10%) portion of the Canadian population of a migratory bird species at any time during the year and/or an endangered species (e.g., breeding areas for the endangered ivory gull)
c) Identified as being either globally or continentally significant Important Bird Area
d) Legally protected (e.g., national or territorial park, marine protected area, migratory bird sanctuary, critical habitat for VC under the *Species at Risk Act*).

In the study area these areas include:

- North Water Polynya
- Eastern Jones Sound
- Eastern Lancaster Sound
- Cape Hay
- Cape Graham Moore
- Cape Searle (Qaqulluit) and Reid Bay (Minarets; Akpait)
- Cumberland Sound
- Frobisher Bay.

Moderate-High Sensitivity (4)

Moderate to high sensitivity was given to areas nationally important to migratory birds including:

- Areas that either support a significant (i.e., 1%) proportion of the national population at any time during the year or have been identified as nationally significant Important Bird Areas.
- Areas identified as key to the national persistence of a migratory bird species. Following Mallory and Fontaine (2004), areas that support at least 1% of the national population are considered key habitat by the Canadian Wildlife Service and include marine areas within a 30 km radius of the major nesting colonies.
- Biological hotspots identified by Parks Canada, which includes areas of high productivity and numbers of seabirds.

In the study area, these areas include biological hotpots identified by CWS (outside of those areas listed as a 5 above).

Moderate Sensitivity (3)

Moderate sensitivity was given to areas that are regionally important to migratory birds because they support a high proportion of the regional population or have been identified as key to regional persistence.

In the study area, these areas include areas of moderate to high densities but less than 1% of the Canadian population, including:

- Coastal areas
- Offshore areas to the limit of summer pack ice
- Floodplains
- Upland areas
- Areas within the known range migratory birds whose populations are heavily dependent on the Canadian Arctic (the PEMT uses the summer range of Baird's Sandpiper).

Low-Moderate Sensitivity (2)

Low to moderate sensitivity was given to areas considered locally important to migratory birds. In the study area, these areas include areas with low to moderate densities. This includes areas which, while not permanently covered in ice, are outside the usual ranges of most migratory birds.

Low Sensitivity (1)

Low sensitivity was given to areas that have very limited or no use by migratory birds. In the study area, these areas include areas of permanent ice (the summer extent of pack ice).

Commercial Turbot Fishery

In developing a sensitivity layer for commercial turbot fishing, the sensitivity rating was dependent on the presence of commercial abundance of turbot and the frequency and amount of documented commercial fishing activity. Currently the commercial fishing season primarily coincides with the open water season which is likely when oil and gas activities would be expected to occur in the study area. Sensitivity ranking for commercial fishing in the Eastern Arctic study area is summarized in Figure 4.

Determination of sensitivity for Commercial Fishing is based on the following ratings.

High Sensitivity (5)

High sensitivity areas include those where commercially fished species are present in area, there is a commercial quota established, and there is active commercial fishing.

Moderate-High Sensitivity (4)

Moderate to high sensitivity applies to areas where commercially fished species are present and a commercial quota is established, but there is no current commercial fishing activity during open water season.

Moderate Sensitivity (3)

Moderate sensitivity was given to areas where commercially fished species are present in area and traditional subsistence fisheries are known to occur.

Low-Moderate Sensitivity (2)

Areas where limited information is available but suggests that commercial fish species and habitat may be present were given a low to moderate sensitivity rating.

Low Sensitivity (1)

Low sensitivity applies to areas where there is no documented information on presence of commercial fish species and no documented information about habitat for commercial fish species.

Polar Bear

Polar bear sensitivity in the Eastern Arctic study area in summer is summarized in Figure 5.

High Sensitivity (5)

Habitat defined as highly sensitive for polar bears includes critical habitat as identified under SARA to protect areas that are essential to the survival of species that are listed as threatened or endangered under federal legislations. Critical habitat for polar bears in the Eastern Arctic study area has not yet been identified or protected. Habitat that is legally protected as a park or conservation area is also considered highly sensitive.

Moderate/High Sensitivity (4)

Areas with seasonally dynamic ice, landfast ice, polynyas, and leads provide important feeding areas for polar bears during critical times of the year. These areas are rated as moderate to high sensitivity given that a proportion of the population may be concentrated in the areas at certain times of the year. As sea ice conditions are highly variable from year to year, these areas are rated as moderate/high sensitivity in the summer and winter seasons to indicate that this habitat is important to the polar bear population for periods throughout the year.

Polar bears show high fidelity to denning sites and these areas are essential to the survival of the species. Denning sites are used by polar bears during the open water season for conserving energy while seal hunting is not practical or in the winter for maternity dens.

Areas identified as important polar bear habitat under the Government of Nunavut's Wildlife Areas of Special Interest, or under the international Biological Program are also given a rating of moderate/high sensitivity for the summer and winter seasons.

Moderate Sensitivity (3)

Habitat rated as moderate sensitivity includes areas of dense annual pack ice which provides foraging habitat during non-critical times of the year. This includes the offshore regions of the polar bear core range that are covered in sea ice for most of the winter season.

Low/Moderate Sensitivity (2)

Multiyear pack ice provides limited denning or foraging use for polar bears in the Davis Strait/Baffin Bay region but may be utilized by bears for foraging in early summer before the sea ice recedes completely.

Low Sensitivity (1)

Low sensitivity areas include offshore regions of open water during the summer and areas outside of the known polar bear range.

Arctic Char

Sensitivity ranking is based on the use of marine waters by anadromous adult Arctic char, the size of the aggregations utilizing specific coastal areas, and the season. The use of coastal areas by Arctic char for feeding is important for overwintering and reproductive success. Summer sensitivity ranking for Arctic char habitat in the Eastern Arctic study area is summarized in Figure 6.

High Sensitivity (5)

There are no high sensitivity areas for Arctic char in marine waters. Spawning, rearing and overwintering all occur in freshwater.

Moderate/High Sensitivity (4)

Moderate to high sensitivity is applied to river mouths and estuaries during the open water season (summer).

The mouths and estuaries of rivers used by Arctic char are important aggregation areas for feeding and as a gateway for char moving upriver to overwinter and spawn, and downriver to the sea for feeding. Activities in and around the mouth or estuary of an Arctic char river have the potential to affect a large proportion of the adult population, thereby potentially affecting overwintering or reproductive success of one or more year classes.

Moderate Sensitivity (3)

Moderate sensitivity is applied to habitat between the shore and 0.5 km during the open water season (summer).

Aggregations of adult Arctic char utilize the nearshore coastal areas during the open water season for feeding. A majority of an adult char's energy budget is obtained during this open water period. Activities which may affect their feeding could reduce their energy input resulting in reduced overwintering or reproductive success. Arctic char tend to remain close to shore but it is not known how far offshore they move, therefore a precautionary approach was taken in selecting a distance of 0.5 km out from shore to delineate this sensitivity area.

Low/Moderate Sensitivity (2)

This area of sensitivity ranges from 0.5 km to 10 km offshore during the open water season. This range is arbitrary due to the lack of available information on the use of this area by Arctic char however it does attempt to take a precautionary approach in determining the potential use of this area by Arctic char. Although it is suspected that most Arctic char stay relatively close to shore, some Arctic char may venture further offshore. The extent offshore and numbers of char which might utilize these waters, if any, is unknown. Due to the uncertainty of the use of this area by Arctic char the sensitivity ranges from low to moderate.

Low Sensitivity (1)

Arctic char do not utilize coastal or offshore marine waters during the ice covered season. As there is no to minimal risk to species sustainability in these areas during this time period the sensitivity ranking for Arctic char is low.

Although some individuals of Arctic char may venture into offshore waters (> 10 km from shore), Arctic char appear to mainly stay in coastal nearshore areas during the open water season. Arctic char which may use the offshore environment would likely be small in number and widely dispersed. It is unlikely that activities occurring in offshore waters would have any effect on the sustainability of Arctic char populations. The ranking for the offshore during the open water season is low for the VEC Arctic char.

Species of Conservation Concern—Walrus

Sensitivity ranking for species of conservation concern is based on the presence or absence of populations, colonies or important seasonal habitat of any species identified as sensitive by COSEWIC, SARA, or IUCN. Walrus was chosen to represent the Eastern Arctic species of conservation concern. Summer sensitivity ratings for walrus are presented Figure 7.

Low/Moderate Sensitivity (2)[7]

A rating of low/moderate sensitivity represents areas that overlap with the range of any species Identified as ‘Special Concern’ under SARA or COSEWIC or ‘Near Threatened’ under IUCN. Walrus is listed by COSEWIC as a species of Special Concern; therefore the walrus summer range and transition corridors were given a sensitivity rating of low/moderate.

Traditional Harvest

In developing the sensitivity layer for traditional harvesting, consideration was given to the Areas of Importance identified in Appendix G of the North Baffin Regional Land Use Plan (NBRLUP) and the frequency and amount of documented harvesting activity. Four levels of importance are defined for areas in the NBRLUP, based on a combination of importance to community harvesting and wildlife productivity. The Areas of Importance presented in the NBRLUP cover most of the Eastern Arctic study area.

For that portion of the study area not covered by the NBRLUP, the presence of species of harvest interest and the intensity of harvesting activity as presented in the Nunavut Atlas was evaluated to determine sensitivity rankings. Summer and winter sensitivity ranking is combined for traditional harvest in the Eastern Arctic study area and is summarized in Figure 8.

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[7] Walrus was used as a representative species for the Species of Conservation Concern VC in the Eastern Arctic. Sensitivity ratings for this VC in the Eastern Arctic are based on conservation status; therefore since walrus is designated as Special Concern, all areas identified where walrus occur are considered low/moderate sensitivity.

Sensitivity levels for traditional harvesting are defined as follows.

High Sensitivity (5)

Highly sensitive ratings are given to those areas deemed essential harvesting locations (community cannot survive without the area), an area that provides essential habitat with no alternative available, or an area that supports rare, threatened or endangered species or is protected or proposed for legislative protection (NBRLUP). This rating is also given to areas documented as important/intense harvesting area in references, areas where key wildlife habitat documented to be present and areas that are proximate to communities.

Moderate/High Sensitivity (4)

Areas of great importance to the community and where much of the community's harvest comes from are rated moderate/high sensitivity. This rating also applies to areas that provide important wildlife habitat (however, alternate habitat is available) (NBRLUP), areas documented as important harvesting area in references, or travel routes to harvesting and/or camping locations.

Moderate Sensitivity (3)

Moderate sensitivity was applied to areas of general harvesting use by the community or where a smaller proportion of harvest comes from these areas than more important areas. Generally there are fewer species present, key habitat for harvested species is not present, and alternate habitat is available (NBRLUP) however, some harvesting has been documented to occur.

Low/Moderate Sensitivity (2)

This rating applies to areas where species of harvest interest may be present, but there is limited documented harvesting.

Low Sensitivity (1)

These areas are not used much by the community and little information exists to assess its importance to wildlife (NBRLUP). There is little to no documented harvesting and no important habitat for species of traditional harvest interest is known to be present.

2.5.2.2 High Arctic

Polar Bear

The sensitivity ratings for polar bear in the High Arctic study area follow the same rationale as in the Eastern Arctic (see Section 2.5.2.1 above), with some differences as highlighted below. Sensitivity ranking for polar bear in the High Arctic study area is summarized in Figure 9.

High Sensitivity (5)

As in the Eastern Arctic, habitat defined as highly sensitive for polar bears includes critical habitat as identified under SARA to protect areas that are essential to the survival of species that are listed as threatened or endangered under federal legislations. Critical habitat for polar bears in the High Arctic study area has not yet been identified or protected. Habitat that is legally protected as a park or conservation area is also considered highly sensitive.

Moderate/High Sensitivity (4)

See polar bear sensitivity criteria in Section 2.5.2.1 above.

Areas identified as important polar bear habitat under the Government of Nunavut's Wildlife Areas of Special Interest, or under the International Biological Program (IBP) are also given a rating of moderate-high sensitivity for the summer and winter seasons. There is only one IBP site that falls within the High Arctic Study area (i.e., on southern Axel Heiberg Island).

Moderate Sensitivity (3)

Habitat rated as moderate sensitivity includes areas of dense annual pack ice which provides foraging habitat during non-critical times of the year. This includes the offshore regions of the polar bear core range that are covered in sea ice for most of the winter season.

Moderate/Low Sensitivity (2)

Marine and sea ice habitat outside of the core polar bear range may provide limited denning or foraging use for a lower density of the polar bear population.

Low Sensitivity (1)

Low sensitivity areas include terrestrial habitat and areas outside of the polar bear range.

Narwhal

Sensitivity rankings for narwhal habitat in the High Arctic study area were developed using two primary types of information: 1) known and likely range/distribution of this species (as determined from available literature sources [e.g., COSEWIC status reports]; and, 2) ecological sensitivity described recently by Laidre, *et al.* (2008). Hence, application of the ecological sensitivity components included by Laidre, *et al.* (2008) may not always be consistent with known locations of narwhal habitat. For example, COSEWIC (2004) states that narwhals are likely found as far north and west (within the Canadian high Arctic region) as ice conditions permit. Thirty year median ice charts, produced by the Canadian Ice Service, were used in applying the ecological sensitivities (as described by Laidre, *et al.* 2008, and others) and known ice distribution.

Lastly, a maximum sensitivity approach was used in differentiating between narwhal habitat types. In other words, if an area could be considered as having two different sensitivity rankings (for one or more months), only the highest sensitivity ranking was mapped. Sensitivity ranking for narwhal in the High Arctic study area is summarized in Figure 10.

High Sensitivity (5)

Areas identified as highly sensitive includes areas designated as critical for narwhals and a spatially limited area (< 100 km^2) during the summer months that provides specific ecological function essential to narwhals. Highly sensitive summer narwhal habitat was not identified within the High Arctic study area.

Moderate/High Sensitivity (4)

Areas with moderate to high sensitivity in the summer include habitat with loose or dense annual pack ice, shear-zone/leads, fjords, shelf-break, or deep ocean basins.

Moderate to highly sensitive summer narwhal habitat was identified primarily for those regions of loose pack ice in July – September. These regions include waters near King Christian Island and Penny Strait; as well as south of Prince Patrick and Melville Island (though narwhals have not been observed in these last two western regions).

Moderate Sensitivity (3)

Moderate sensitivity during the summer months was given to areas of open water, shelf-break, and the ice-edge (pack ice next to open water). This rating would also apply to areas that contain moderate to large numbers of narwhals.

Moderately sensitive narwhal summer habitat was described primarily to capture the ice edge (pack ice next to open water) region of Queens Channel north of Cornwallis Island. Narwhal have been sighted in this region.

Low/Moderate Sensitivity (2)

Multiyear pack ice in summer is considered low to moderately sensitive habitat for narwhal. This sensitivity rating also applies to areas with low densities of toothed whales and areas of multiyear pack ice in winter.

Much of the southern region of the High Arctic study area contains multi-year ice and hence is considered as low to moderately sensitive habitat. No records of narwhal in this region were located however 30 year median ice charts suggest summer open water habitat is common and therefore narwhals may occur in those areas.

Low Sensitivity (1)

Low sensitivity habitat includes areas where no narwhal habitat is identified, offshore (> 100km) regions in the open water (summer) season.

Multi-year pack ice and 100% ice concentrations are expected to be more common and consistent in the northern region of the High Arctic study area; hence narwhal presence during the summer here is less likely.

Migratory Birds

The sensitivity ratings for migratory birds in the High Arctic study area follow the same rationale as in the Eastern Arctic (see Section 2.5.2.1 above), with some differences as highlighted below. Sensitivity ranking for migratory birds in the High Arctic study area is summarized in Figure 11.

High Sensitivity (5)

High sensitivity habitat was determined by the same criteria as for the Eastern Arctic above.

In the High Arctic study area during the summer season these areas include: Seymour Island, North Kent Island and Eastern Prince Patrick Island Coast.

Moderate/High Sensitivity (4)

Moderate/high sensitivity habitat was determined by the same criteria as for the Eastern Arctic above.

In the High Arctic study area during the summer season these areas include Cheyne Islands, Nasaruvaalik Island, key migratory bird marine and terrestrial habitat sites, and biological hotspots.

Moderate Sensitivity (3)

Moderate sensitivity habitat was determined by the same criteria as for the Eastern Arctic above.

In the study area, these areas include areas of moderate to high densities but less than 1% of the Canadian population: 1) coastal areas; 2) offshore areas to the limit of summer pack ice; 3) floodplains; 4) upland areas; and, 5) areas within the known range migratory birds whose populations are heavily dependent on the Canadian Arctic.

Low/Moderate Sensitivity (2)

Low to moderate sensitivity was given to areas considered locally important to migratory birds. In the study area, these areas include areas with low to moderate densities. This includes areas that, while not permanently covered in ice, are outside the usual ranges of most migratory birds.

Low Sensitivity (1)

Low sensitivity was given to areas that have very limited or no use by migratory birds. In the study area these areas include areas of permanent ice (the summer extent of pack ice and terrestrial ice caps).

Species of Conservation Concern—Peary Caribou

Sensitivity ranking for species of conservation concern is based on the presence or absence of populations, colonies or important seasonal habitat of any species identified as sensitive by COSEWIC, SARA, or IUCN. Summer sensitivity ratings are presented Figure 12. Peary caribou was chosen to represent the High Arctic species of conservation concern.

Moderate/High Sensitivity (4)

A rating of moderate/high sensitivity represents areas that overlap with the range or important habitat of any species identified as endangered under SARA, COSEWIC or IUCN. Areas identified as moderate/high sensitivity include the range of Peary caribou.

Traditional Harvest

In developing a sensitivity layer for traditional harvesting, consideration was given to the Areas of Importance identified in Appendix G of the NBRLUP, the land use categories presented in the Olokhaktomiut Community Conservation Plan (OCCP) (OCCP 2000) and the frequency and amount of documented harvesting activity. Four levels of importance are defined for areas in the NBRLUP, based on a combination of importance to community harvesting and wildlife productivity. Five categories of lands are designated in the Olokhaktomiut Community Conservation Plan. The Areas of Importance presented in the NBRLUP and the land use categories included in the Olokhaktomiut Community Conservation Plan cover part of the current study area. For that portion of the study area not covered by the NBRLUP or the Olokhaktomiut Community Conservation Plan, sensitivity is considered to be low. Sensitivity ranking for traditional harvest in the High Arctic study area is summarized in Figure 13.

Sensitivity levels for traditional harvest are defined as follows.

High Sensitivity (5)

Highly sensitive ratings are given to those areas deemed essential harvesting locations (community cannot survive without the area), an area that provides essential habitat with no alternative available, or an area that supports rare, threatened or endangered species or is protected or proposed for legislative protection (NBRLUP). This rating is also given to Lands and waters where cultural or renewable resources are of extreme significance and sensitivity and no development should be allowed (OCCP).

Moderate/High Sensitivity (4)

Areas of great importance to the community and where much of the community's harvest comes from the area, are rated moderately to highly sensitive. This rating also applies to areas that provide important wildlife habitat (however, alternate habitat is available) (NBRLUP), and lands and waters where cultural or renewable resources are of particular significance and sensitivity throughout the year (OCCP).

Moderate Sensitivity (3)

Moderate sensitivity was applied to areas of general harvesting use by the community or where a smaller proportion of harvest comes from these areas than more important areas. Generally there are fewer species present, key habitat for harvested species is not present, and alternate habitat is available (NBRLUP). This rating also applies to lands and waters where cultural or renewable resources are of particular significance and sensitivity during specific times of the year (OCCP).

Low/Moderate Sensitivity (2)

This rating applies to lands where there are cultural or renewable resources of some significance and sensitivity (OCCP), and areas where species of harvest interest may be present, but there is limited documented harvesting.

Low Sensitivity (1)

These areas are not used much by the community and little information exists to assess its importance to wildlife (NBRLUP). This includes lands where there are no known significant or sensitive cultural or renewable resources (OCCP).

3 RESULTS AND DISCUSSION

At this stage in development, the risk assessment tool only provides a method for achieving an additional level of information on risk that can be illustrated with the PEMT tool. Therefore, results are not provided in this report.

The results figures for the Eastern Arctic and High Arctic cumulative effects hypothetical development scenarios (maximum and minimum effects) can be found in Appendix F (Figures 14 – 39).

3.1 Eastern Arctic

3.1.1 Bowhead Whale

The updated scenario resulted in very similar results to the initial model (Nunami Stantec Ltd. 2011b). The current iteration increased the area of 2D seismic program substantially and adjusted for the distance of the seismic lines to 30 km. These changes increased the area of potential interaction for bowhead whales with seismic activities. As before, the area of seismic activities are the areas of highest concern and vessel traffic is anticipated to result in minimal effects. In instances where cumulative effects are anticipated, mitigation programs may be effective in minimizing effects to marine mammal populations, as discussed in Nunami Stantec (2011a). Minimum and maximum results of the analysis are shown in Figure 14 and 15 respectively.

3.1.2 Toothed Whales

The updated distribution data and corresponding adjustments to the sensitivity layers did not influence the development scenario since the development activities did not overlap with any of the distribution/sensitivity revisions. The model results were similar to the original analysis, except for the increased 2D seismic activity area. Even considering the ‘maximum effect’ model, the risk of cumulative effects is anticipated to be minimal for most of the activity area. Minimum and maximum results of the analysis are shown in Figure 16 and 17, respectively. Cumulative effects are predicted to be higher along the coast where 2D seismic activity overlaps with toothed whale habitat that has been identified as moderate to high sensitivity.

3.1.3 Thick-billed Murre

Potential areas where cumulative effects on thick-billed murres may occur are considerably less than those experienced by whales even with the increased 2D seismic activity area. Consistent with the original analysis, even the ‘maximum effect’ model for thick-billed murre was less than the ‘minimum effect’ model for the bowhead whale or toothed whale VCs. Minimum and maximum results of the analysis are shown in Figure 18 and 19, respectively.

The vessel and flight path for the south block was adjusted for the model; however, the potential for cumulative effects in all blocks remains very low. There is potential for some disturbance to offshore foraging areas, but distance from shore should preclude any other effects. In the 2D seismic area, cumulative effects are low - moderate. There is some disturbance to offshore foraging areas, and parts of the block may also be close enough to the coast for activities in that area to affect nesting colonies.

3.1.4 Commercial Turbot Fishery

The offshore turbot fishery is a deep water fishery often conducted in depths of 1,000 m or greater. The depth of the fishery in conjunction with the pelagic and migratory nature of turbot reduces the potential for effects on this species from routine oil and gas activities, as well as the potential for cumulative effects. The largest potential for cumulative effects on the commercial turbot fishery is from space conflicts between fishing vessels, and where there is both operating seismic and drill ships. Space conflicts occur when a fishing vessel is unable to access a fishing location due to the presence of either an operating seismic vessel or locations of operating drill ships. The increase in any of the number of fishing vessels, seismic and drilling vessels or all three could potentially lead to increased cumulative effects on the fishery.

The potential for cumulative effects for the four hypothetical lease areas range from low to nil (Figures 20 and 21). The updates to the development scenario modeled did not change the risk of potential cumulative effects. The increased 2D seismic survey area encompassed low sensitivity areas for the fishery and, as a result, the risk of cumulative effects is minimal. Further details and discussion of mitigation measures can be reviewed in the original report (Nunami-Stantec 2011).

3.1.5 Polar Bear

As expected, the results of the model indicate that effects of oil and gas activities on polar bear were minimal overall (Figures 22 and 23). Polar bear interaction with oil and gas activities in open water habitat are generally considered unlikely. The potential for interaction with polar bears is increased during the shoulder seasons when ice is in a state of flux and polar bears may be present further offshore. The North Block is located in an area rated as low sensitivity for polar bear, offshore in open water; therefore anticipated cumulative effects are very low. The 3D seismic activity occurring in the South Central Block is unlikely to interact with polar bear. However, because there is uncertainty surrounding the effects of underwater noise on a swimming bear, the model incorporated some effect to be conservative.

In the open-water summer season, the Eastern Arctic study area is mostly free of ice. In early and late summer, there are variable ice formations allowing for access to prey (seals). Springtime landfast ice on the east coast of Baffin Island also provides important foraging habitat. These areas were rated as moderate to high sensitivity for polar bears and this sensitivity rating is reflected in the ‘maximum effect’ model where the 2D operations are close to the coast.

Mitigation strategies employed for a swimming polar bear during seismic activities typically follow those for bowhead whale. Other than minimum flight altitude restrictions, no additional mitigation measures are employed for bears on ice.

3.1.6 Arctic Char

A conservative approach was taken when estimating the zone of influence for the development scenario activities and their effects on Arctic char because there is very little information on the effects of underwater noise on anadromous fish. Even with conservative estimates, the effects of seismic activities and vessel traffic are not predicted to have a substantial effect on habitat or behaviour of Arctic char (Figures 24 and 25). Routine operations from drilling and production are expected to have even less of an effect, particularly because they occur offshore and are relatively stationary. The results of the cumulative effects analysis reflect these predictions. The 3D block is predicted to have a greater effect; however, the location of the survey occurs offshore, whereas Arctic char are typically in coastal areas in the summer, making the probability of interaction low.

Although there have been reports of some species exhibiting startle responses and avoidance behaviours to underwater noise, due to the transient nature of the 2D seismic vessel traffic and the large spatial area in which the programs typically occur, the interaction between the activities and the Arctic char are predicted to be minimal. Activities which occur in coastal waters, such as the mouths and estuaries of Arctic char rivers, have a greater potential to affect char during their short feeding season. Activities which occur in these important aggregation areas have the potential to affect a large proportion of the adult population.

3.1.7 Walrus

Walrus' preferred shallow, coastal habitat and restricted seasonal distributions mean their spatial overlap with development activities is generally restricted. Walrus are included in the pinniped hearing category and are not as reliant as cetaceans on underwater communication and hearing over expansive areas. Therefore, they are not expected to be as sensitive to underwater noise as cetaceans. Walrus is considered a species of conservation concern by COSEWIC and so known walrus range and habitat is considered low/moderate sensitivity. The 3D seismic block occurs in a walrus transition zone, as well as a summer concentration area for walrus. Given the uncertainties surrounding the effects of these activities on walrus, and the importance of the habitat, the conservative 'maximum effects' approach results in the maximum level of possible cumulative effects in the area of 3D seismic exploration which overlaps with walrus summer habitat, as well as coastal summer habitat at the northeast corner of Baffin Island which overlaps with the 2D program area. Minimum and maximum results of the analysis are shown in Figure 26 and 27, respectively.

At current levels of industrial activity, the potential threats to walrus are low. As more research is completed on the effects of underwater noise on walrus, it can be added to the model and areas of overlap may need to consider further mitigations specific to species of conservation concern, such as the walrus.

3.1.8 Traditional Harvest

Traditional harvest is prevalent in the Eastern Arctic study area, with seal and Arctic char considered staple items (along with caribou on land). Numerous additional species are harvested including polar bear, seabirds and their eggs, walrus, narwhal and beluga. Traditional harvest occurs throughout both the winter and summer seasons. The data on locations and intensity of traditional harvest used is both limited and dated and harvesting practices are known to shift over time. As a result, areas that are not used much or where little information is known were ranked as low sensitivity. The area of highest concern for cumulative effects for both the minimum and maximum scenarios was in the coastal area of northeast Baffin Island (Figures 28 and 29). These results highlight areas to be used as a starting point for discussions between the proponent and community members on necessary mitigations. These mitigations may include operating outside of specific times or locations.

3.2 High Arctic

3.2.1 Polar Bear

The High Arctic study area consists of a greater range of polar bear habitat relative to the Eastern Arctic. The offshore areas of seismic operation overlap with the summer range of polar bear. There may be ice breaking in these areas which has the potential to interact with polar bear. As in the Eastern Arctic, bears on ice are generally considered to be unaffected by marine seismic activities.. As a conservative approach, offshore areas which include the summer distribution of polar bear are considered to be low sensitivity. The results of the cumulative effects analysis range from minimum to moderate level of effects based on the 'minimum effects' and 'maximum effects' models in the offshore areas (Figures 30 and 31).

Onshore 2D seismic activity overlaps with polar bear habitat and results in minimum to moderate predicted effects. The south end of the 2D area of Ellef Ringes Island overlaps with polar bear denning area and summer retreat resulting in maximum potential effects. This area for polar bear is rated with a higher sensitivity and the resulting overlap with development activities suggests a high potential for cumulative effects. The useful application of this tool is exemplified in this analysis. The area identified as high sensitivity for polar bear is small relative to the rest of the 2D development activity. The preliminary analysis allows a proponent to consider the potential effects of the proposed activity before the boundaries of the activity are finalized. If possible, the proponent may decide to alter the 2D seismic area to avoid polar bear sensitive habitat.

3.2.2 Narwhal

Narwhal prefer deep or offshore water which is reflected in the moderate cumulative effects results in the 2D and 3D offshore program areas. Although, this area is only identified as 'potential' narwhal range, it was conservatively ranked as low sensitivity habitat in the summer. Traditional Knowledge and scientific literature indicate that narwhal are sensitive to underwater noise, supporting the model results indicating minimum cumulative effects for transiting vessel and moderate effects in areas of 3D seismic activity.

The 3D inshore survey overlaps with habitat identified for narwhal as moderate to highly sensitive because it is a region of loose pack ice in the summer months (July through September). Vessel transit routes overlap with areas identified as low to moderate sensitivity, which results in minimal risk of cumulative effects along these routes. Mitigation measures typically employed for bowhead whale (see above) are applicable for narwhal. Minimum and maximum results of the analysis are shown in Figure 32 and 33 respectively.

3.2.3 Migratory Birds

Cumulative effects model results for migratory birds in the High Arctic study area indicate that potential effects would be minimal. While much of the study area is rated from moderate to high sensitivity, none of the development scenarios occur in areas considered important for birds (MBAs, IBAs).

Along all the flight paths, there is some possibility for disturbance, resulting in minimum predicted effects. Offshore activities overlap with important marine habitat for seabirds such as polynas. This potential for interaction is indicated in the minimal potential effects for the area of hypothetical offshore development activity. Maximum potential effects are shown along the 2D track line for the land-based seismic activity which overlaps with moderately sensitive bird habitat.

Mitigation measures for migratory birds include flight altitude minimums, flight restrictions over colonies, using standard flight corridors, moving activities from sensitive bird areas, and routing marine traffic to avoid concentrations of marine birds, especially during sensitive times.

3.2.4 Species of Conservation Concern—Peary Caribou

Peary caribou spend the short summer season foraging for sedges, shrubs, and flowers on the High Arctic islands. Successful foraging during this time is critical for growth and survival over the winter months. The sensitivity of caribou during this time is reflected in the results of the effects analysis in areas of overlap with the on land 2D seismic activity. Both the minimum and maximum cumulative effects results indicate maximum potential effects in the areas of overlap between the caribou and the 2D activity. The variation between these results lies in the buffer area surrounding the activity, indicating the uncertainty surrounding the zone of influence of the activity on caribou. The maximum effects analysis shows almost the entire Ellef Ringes Island has the potential for cumulative effects. This type of analysis will aid in determining appropriate mitigation measures.

Peary caribou are known to move between the arctic islands during the summer, to optimize use of ice-free habitat. Caribou have been documented to swim several kilometers between islands; therefore, the possibility exists for an interaction between a vessel and swimming animals. Although slight, the possibility is considered in the model and the resulting effects are predictably minimal along the shipping route. The sensitivity data does not include typical inter-island crossing areas and has been identified as a data gap. When this type of data is available, it will help to refine the model to indicate where in particular there is potential for a swimming caribou to interact with a vessel in transit.

Mitigation measures for Peary caribou include avoiding sensitive life stages and noise disturbance from aircraft, land vehicles, and construction activities. Additional studies need to be implemented to fill in data gaps about specific seasonal habitat use of Peary caribou in the arctic islands.

3.2.5 Traditional Harvest

Polar bear, caribou, and Arctic char are harvested species within the High Arctic study area; however, information on the locations of harvesting activities is limited. Much of the polar bear and caribou harvest is reported to occur during the winter months, when areas are more accessible by snowmobile. The sensitivity layers were built on limited and dated data sets; therefore, where information was unknown, a rating of low sensitivity was applied. Because of this, the results indicate minimum to moderate levels of potential cumulative effects on traditional harvesting activities. However, these results should be approached with caution. The model is only as useful as the data input and results would improve with more accurate harvest location and harvest intensity data. Interaction between oil and gas activity on wildlife populations and wildlife habitat could potentially indirectly interact with traditional harvesting, as it can affect the availability of a species to be harvested.

Traditional harvesting is dependent on the availability of species to harvest and the opportunity to practice harvesting. Access to species of interest and harvesting areas can be maintained by avoidance of harvesting areas completely, or at times of the year when harvesting activities occur. Compensation may be considered to provide resources for harvesters to travel to different areas or compensate for the loss of access when avoidance is not possible. Consultation with communities can serve to provide up to date information and improve mitigation.

4 CONCLUSIONS

The results described here suggest that the cumulative effects of development on VCs may vary considerably. At one end of the spectrum, bowhead whales are sensitive to development, particularly underwater noise generated by seismic exploration and vessel traffic. Seabirds such as thick-billed murre can be sensitive to disturbances to their breeding colonies, particularly if aircraft come in close proximity (although this should generally be avoided as a result of routine flight rules). Based on this simple analysis, it seems likely that thick-billed murre may experience less cumulative effects resulting from oil and gas development than species such as bowhead whale and polar bear which may be more sensitive to direct effects from development.

The modification of the Eastern Arctic development scenario did not have a substantial effect on the results of the initial four Eastern Arctic VCs (bowhead whale, toothed whales, migratory birds, and commercial turbot fishing), other than to increase the area of 2D seismic activity, and therefore the potential area that may be subject to potential effects. Slight alteration of the flight and vessel paths resulted in no change in the potential for cumulative effects. Of the additional Eastern Arctic VCs analyzed, the walrus had the greatest potential for cumulative effects because one of the 3D seismic blocks and the coastal area of the 2D seismic block overlapped with walrus summer habitat. Arctic char was negligibly affected, as was predicted by its typical coastal, shallow water distribution during the summer. In the middle of those two extremes was traditional harvest. Areas along the coast had the highest potential for overlap of activities. Traditional harvesting is dependent on the availability of species to harvest and the opportunity to practice harvesting. Interaction between oil and gas activity on wildlife populations and habitat may interact indirectly with traditional harvesting as it can affect the availability of a species to be harvested.

Results of the analysis on High Arctic VC's were similar to those in the Eastern Arctic. The High Arctic study area presents some additional aspects to consider including increased variability in ice concentrations in the summer season and the inclusion of terrestrial habitat that needs to be considered in the cumulative effects model. The land component of the study area adds additional possibilities for activities which may have an effect on polar bear, migratory birds, and Peary caribou. Ice breaking activity potentially changes the magnitude and zone of influence of the potential effects of shipping experienced on marine mammals and presents possible health and safety concerns for traditional harvesters (due to alteration of access routes to harvesting locations). Polar bear had the largest spatial extent of potential cumulative effects, and the maximum potential occurred where the terrestrial 2D seismic activity overlapped with polar bear denning and summer retreat habitat. Migratory birds had little overlap and therefore minimal potential for cumulative effects. The Peary caribou showed potential effects where the 2D seismic overlapped with their range as well as some minimal effects from shipping.

5 RECOMMENDATIONS

The development and application of the cumulative effects model has been an iterative process and continues to present opportunities for refinement. In applying the model to additional VC's and in a different study area, several opportunities for model improvement were identified and described below.

Perhaps the most substantive recommendation is associated with the original identification of sensitivity ratings for the VC's. Applying the model to the Peary Caribou in the High Arctic illustrated errors associated with aspects of VC distribution. In the case of the Peary Caribou, their distribution is generally restricted to the islands and areas of marine and ice covered habitat in between. They would not be present in offshore areas. However, because the scale of sensitivity ratings is only 1 – 5, where 1 indicates low sensitivity, areas where Peary caribou do not exist (i.e. Beaufort Sea) were rated as 1. This sensitivity rating translates into a cumulative effect on Peary Caribou in the Beaufort Sea where there are vessel and helicopter routes. This is an artifact of the model as it associates any area where VC's have a sensitivity rating with a potential for cumulative effects. Figure 37 (Appendix F) provides an illustration of this issue and how it leads to false conclusions on cumulative effects. This error could be resolved with the inclusion of an additional sensitivity rating that is applied in areas that are not inhabited or used by a VC. If areas where VC's do not occur were rated as "0" (VC not present) rather than 1, the model would recognize that there is no interaction with the VC and therefore no potential for cumulative effects.

Because the cumulative effects model uses buffers to indicate a zone of influence around the activity, it sometimes leads to false indication of potential cumulative effects in areas where VC's do not occur. This is most common for marine mammals, where an activity may be marine based but the associated buffer may overlap with terrestrial habitat. This error can be resolved using the same method as described above. Where species do not occur, habitat should be rated as 0 rather than 1 so that the model recognizes no interaction.

Several recommendations for improving the architecture and usability of the geomatics model are provided in Appendix B. Additional amendments that are recommended for the refinement of the model include:

- Include aspects of production activities in the development scenarios
- Run scenarios in the High Arctic study area for winter season, given the potential for winter exploration activities on land
- Incorporate aspects of uncertainty regarding ice distribution and correlated distribution of VCs. Potential options include adding 30 year medians for ice distribution as a layer of data to be considered and developing VC sensitivity ratings for shoulder seasons where VC distribution is closely linked with sea ice dynamics.

Results of the analyses reported here were as varied as the natural history and known distribution data of the chosen VCs. The tool highlights areas of concern and potential overlap and conflict between potential development activities and the VCs. As research continues, clear thresholds separating an acceptable environmental effect from one that is not will be of key consideration in creating a strong analysis for potential cumulative effects. Given the available information, the results presented show the greatest potential for cumulative effects in the Eastern Arctic on whales. The High Arctic is highly dependent on marine or land-based activities, but overall polar bear shows the greatest potential for cumulative effects.

This iterative and exploratory approach could be used to generate discussion on the merits of different development options. It may also focus attention on what information would best contribute to a better understanding of cumulative effects. Both should benefit resource management in the Arctic.

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APPENDIX A

Risk Analysis

NUNAMI STANTEC

PEMT Effects Pathways and Risk Ratings

Anthropogenic Activities				Polar Bear						Risk Scales				Arctic Char						Risk Scales				Traditional Harvest						Risk Scales			
	Occur During:			Habitat Quality		Water Quality			Health		Five Level			Habitat Quality		Water Quality			Health		Five Level			Habitat Quality		Water Quality			Human		Five Level		
	Routine Vessel Traffic	Exploration: Seismic	Exploration: Drilling	Change in behaviour	Displacement	Disturbances of seabed	Discharge: sea	Discharge: runoff	Change in health/injury	Simple Three Level	Probability	Consequence	Scale	Change in Behavior	Displacement	Disturbances of seabed	Discharge: sea	Discharge: runoff	Change in health/injury	Simple Three Level	Probability	Consequence	Scale	Change in Behavior	Displacement	Disturbances of seabed	Discharge: sea	Discharge: runoff	Space Conflict & Reduced Harvest	Simple Three Level	Probability	Consequence	Scale
											P	C	S								P	C	S								P	C	S
Vessel Traffic																																	
Transport/supply ships	*	*	*	*	*					0	0.05	1	0.1	*						1	0.20	1	0.2	*	*				*	1	0.10	1	0.1
Seismic ship and support vessel(s)		*	*	*	*					0	0.05	1	0.1	*						1	0.20	1	0.2	*	*				*	1	0.05	1	0.1
Icebreaker		*	*	*	*				*	2	0.50	5	2.5											*	*				*	1	0.10	1	0.1
Seismic acquisition (use of airguns)		*		*	*				*	2	0.05	1	0.1	*	*				*	2	0.80	1	0.8	*	*				*	2	0.80	5	4
Aircraft Traffic																																	
Fixed wing				*						1	0.20	1	0.2											*	*					1	0.10	1	0.1
Helicopter		*	*	*						1	0.20	1	0.2											*	*					1	0.10	1	0.1
Ground-based Support Infrastructure																																	
Use of existing infrastructure	*	*	*																														
Development of New Instrastructure																																	
Land clearing		Varies	Varies	*	*					1	0.05	1	0.1	*	*			*		2	0.10	5	0.5	*	*				*	1	0.10	5	0.5
Pile driving		Varies	Varies	*	*			*		1	0.10	5	0.5											*	*				*	1	0.10	5	0.5
Construction activities		Varies		*	*					1	0.10	5	0.5											*	*				*	1	0.10	5	0.5
Waste Water Treatment and Discharge																																	
Sewage	*	*	*														*			1	0.05	1	0.1				*			0	0.01	1	0
Grey water (shower, sinks, etc.)	*	*	*														*			1	0.05	1	0.1				*			0	0.01	1	0
Solid waste	*	*	*														*			1	0.05	1	0.1				*			0	0.01	1	0
Drilling wastes (drilling muds, well cuttings)			*														*		*	1	0.05	1	0.1				*			0	0.01	1	0
Drilling			*	*	*					1	0.50	5	2.5		*	*				1	0.20	1	0.2						*	1	0.10	5	0.5

PEMT Effects Pathways and Risk Ratings

Anthrpogenic Activities				Walrus						Risk Scales				Caribou						Risk Scales			
	Occur During:			Habitat Quality		Water Quality			Health		Five Level			Habitat Quality		Water Quality			Health		Five Level		
	Routine Vessel Traffic	Exploration: Seismic	Exploration: Drilling	Change in Behavior	Displacement	Disturbances of seabed	Discharge: sea	Discharge: runoff	Change in health/injury	Simple Three Level	Probability	Consequence	Scale	Change in Behavior	Displacement	Disturbances of seabed	Discharge: sea	Discharge: runoff	Change in health/injury	Simple Three Level	Probability	Consequence	Scale
											P	C	S								P	C	S
Vessel Traffic																							
Transport/supply ships	*	*	*	*	*				*	1	0.10	1	0.1	*	*				*	1	0.05	1	0.1
Seismic ship and support vessel(s)		*	*	*	*				*	1	0.10	1	0.1	*	*				*	1	0.05	1	0.1
Icebreaker		*	*	*	*				*	2	0.25	5	1.3	*	*				*	2	0.25	5	1.3
Seismic acquisition (use of airguns)		*		*	*				*	2	0.20	5	1	*	*				*	1	0.05	5	0.3
Aircraft Traffic																							
Fixed wing				*	*				*	2	0.05	5	0.3	*	*				*	1	0.05	1	0.1
Helicopter		*	*	*	*				*	2	0.05	5	0.3	*	*				*	1	0.05	1	0.1
Ground-based Support Infrastructure																							
Use of existing infrastructure	*	*	*											*	*				*	1	0.10	1	0.1
Development of New Instrastructure																							
Land clearing		Varies	Varies											*	*				*	2	1.00	5	5
Pile driving		Varies	Varies											*	*				*	2	1.00	5	5
Construction activities		Varies												*	*				*	2	1.00	5	5
Waste Water Treatment and Discharge																							
Sewage	*	*	*				*			0	0.01	1	0					*		0	0.01	1	0
Grey water (shower, sinks, etc.)	*	*	*				*			0	0.01	1	0					*		0	0.01	1	0
Solid waste	*	*	*				*			0	0.01	1	0					*		0	0.01	1	0
Drilling wastes (drilling muds, well cuttings)			*				*			0	0.01	1	0					*		0	0.01	1	0
Drilling			*	*	*				*	0	0.05	1	0.1	*	*				*	0	0.05	1	0.1

PEMT Effects Pathways and Risk Ratings

Anthropogenic Activities				Whales						Scale of Effect				Marine Birds					Scale of Effect				Commercial Turbot Fishery						Scale of Effect			
	Occur During:			Habitat Quality		Water Quality			Health		Five Level			Habitat Quality		Water Quality				Five Level			Habitat Quality		Water Quality			Human		Five Level		
	Routine Vessel Traffic	Exploration: Seismic	Exploration: Drilling	Communication Masking (underwater)	Change in Behavior (underwater)	Disturbances of Seabed	Discharge: Sea	Discharge: Runoff	Change in Health/Injury	Simple Three Level	Probability	Consequence	Scale	Change in Behavior	Terrestrial Habitat Conversion	Disturbances of Seabed	Discharge: Sea	Discharge: Runoff	Simple Three Level	Probability	Consequence	Scale	Change in Behavior	Displacement	Disturbances of Seabed	Discharge Sea	Discharge: Runoff	Vessel Space Conflict and Reduced Fisheries	Simple Three Level	Probability	Consequence	Scale
											P	C	S							P	C	S								P	C	S
Vessel Traffic																																
Transport/supply ships	*	*	*	*	*				*	1	0.90	1	0.9	*					1	0.20	1	0.2						*	1	0.25	1	0.3
Seismic ship and support vessel(s)		*	*	*	*				*	1	0.90	1	0.9	*					1	0.20	1	0.2						*	1	0.25	1	0.3
Icebreaker		*	*	*	*				*	1	0.50	1	0.5	*					1	0.20	1	0.2						*	1	0.25	1	0.3
Exploration Activities																																
Seismic acquisition (use of airguns)				*	*					2	1.00	5	5										*	*				*	1	0.80	5	4
Drilling			*	*	*					2	0.70	5	3.5															*	1	0.10	5	0.5
Aircraft Traffic																																
Fixed wing											0.05	1	0.1	*					2	0.80	5	4										
Helicopter		*	*								0.05	1	0.1	*					2	0.80	5	4										
Shore-based Support Infrastructure																																
Use of existing infrastructure	*	*	*								0.05	0	0	*						0.10	1	0.1										
Development of new infrastructure																																
▪ Shoreline disturbance		Varies	Varies								0.10	1	0.1		*				1	0.10	1	0.1										
▪ Pile driving		Varies	Varies	*	*			*		2	0.90	5	4.5																			
▪ Construction activities		Varies									0.10	1	0.1	*						0.10	1	0.1										
Waste Water Treatment and Discharge																																
▪ Sewage	*	*	*				*				0.01	1	0				*			0.05	1	0.1				*			1	0.01	1	0
▪ Grey water (shower, sinks, etc.)	*	*	*				*				0.01	1	0				*			0.05	1	0.1				*			1	0.01	1	0
▪ Solid waste	*	*	*				*				0.01	1	0				*			0.05	1	0.1				*			1	0.01	1	0
▪ Drilling wastes (drilling muds, well cuttings)			*								0.01	1	0				*			0.05	1	0.1				*			1	0.01	1	0

APPENDIX B

Geomatics Aspects and Recommendations for Improvement

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The oil and gas exploration scenario model was developed in ArcGIS 9.3.1 using the Model Builder Tool. The model is a vector based analysis which contains 65 operations. The tool uses a series of buffers, unions and tabular calculations to generate a final output which shows cumulative effects of different hypothetical environmental disturbances. The Scenario Tool can be added into any Map Document (MXD), and is designed to run off the local (C) drive. However, it can be manipulated to run of a server for multi-user access.

The model is based on four sources of information, as described in the body of this report.

1. Environmental sensitivity. The sensitivity of an area for a given Valued Component (VC, such as bowhead whale or commercial turbot fishery). This information is drawn from the sensitivity layers contained in the PEMT.
2. The development scenario layer developed for the model.
3. Effects parameters. An estimate of the residual effect of the anthropogenic disturbances (in 2 above) on a given VC. This is characterized by two values, the:
    a) Zone of influence of an effect (in kilometres) and
    b) Scope of an effect (measured on a scale of zero to ten).
4. A full list of these values is provided in Appendix B.

The model is broken down into parts depending on the number of VCs (two for each VC, one for minimum estimated effect and one for the maximum effect), which have the same structure but use different default values.

The model can be modified in a number of ways.

1. **Sensitivity layers.** Any of the sensitivity layers can be edited (e.g., change the shape of the bowhead summer sensitivity areas) by simply swapping the file for another with the same name.
2. **Development scenario layer.** Any of the scenario layers can be edited (e.g., change the shape or location of vessel tracks) or swapped for another file with the same name. To do this the GIS user would create a new disturbance layer and save it into the model's geodatabase, replacing the old layer.
3. **Effects parameters.** By double-clicking on the tool in ArcGIS, the parameters window appears allowing the user to enter new parameter values or use the default values. All buffer values are entered in meters and must be whole numbers (i.e., decimal fractions are not permitted). Values for the intensity ratings can be any number. The model does not accept buffer distances of zero. However, if the user wishes to make a disturbance nil, zeros are accepted in the 'rating' value field, thus nullifying the disturbance from the model.

These options for modification allow the model to be easily adjusted to fit many different scenarios.

All base data is contained with an accompanying file geodatabase (.gdb) in a feature dataset called 'Base Data'. The geodatabase should be stored in the root of the C drive, in order for the tool to run. The model's output files and intermediate files are also stored in the geodatabase. The final resultant file will have the suffix "_final". The final output file can be symbolized in many ways, for this report we used a color scale with ten equal intervals.

By right-clicking on the model tool and selecting 'Help', one can see an explanation for each of the parameters and operations in the model.

The Key Steps to Run the Model

Step 1—Open the Scenario_Model.mxd file in ArcGIS. Or you may open any ArcGIS map document and add the model tool to the toolbox.

Step 2—Open the red toolbox and click on the INAC_Scenario_Tool. Seven models should appear underneath it.

Step 3—Double-click on one of the models depending on which VC you are interested in. A parameters window will appear.

Step 4—Click OK to run the model with the default parameters or enter new parameters (remember whole numbers in metres for buffer distances).

Step 5—Open ArcCatalog. Browse to the C drive where the Scenario geodatabase is stored. There will be a feature in the geodatabase with the suffix "_final". This is the model's output. Drag it to a map document to symbolize.

Step 6—Right-click on the model output you just dragged in. Select properties > Symbology Tab > Quantities > Graduated color. In the Value drop down select Rating_Adj2. In the color ramp drop down, select the color scheme. In the Classification box click, classify > method > Equal Interval. Select 10 Classes. Click OK, now you can view your model output.

2012 Model Recommendations

Upon completing the risk analysis for the remaining Eastern Arctic VCs and the High Arctic scenarios, a number of recommendations were developed to improve the model and make it more user-friendly and efficient:

> **Challenge 1**—In order to update the effect parameter values, the user needs to enter the parameter values manually through the parameter window which takes time depending on the number of changes. The changes made to these parameters are not automatically saved in the model. Each time the user runs the model with the new values, they must be re-entered to update the default values. In order to save the new parameters values, the GIS technician needs to edit the model and update the default effect parameters manually in the model editing session.
>
> *Recommendation*—A more efficient data entry method such as adjusting the model to allow loading a table containing all the effect parameter values, rather than manually entering the values. Taking this approach would allow any user without a GIS background to update the default effect parameters all at once. This data entry method would also reduce the risk of

human error inherent in entering numerous values manually, and would save the user a great deal of time.

Challenge 2—The tool is designed to run off the local C: drive and currently recommends that the working geodatabase be stored in the root of the C drive. The tool does not allow the user to change the location, name or date of the geodatabase interactively. If the user wishes to modify the location and name of the working geodatabase, the model has to be edited by the GIS technician to incorporate the data source changes.

Recommendation—Create an option to select the working geodatabase through the interface window before running the model. This way any geodatabase regardless of its name or location on the computer could be selected.

Challenge 3—Currently if the Sensitivity and Disturbances layers are updated, they need to be modified in the model editing session rather than though the parameter window.

Recommendation: Create an option to enter the Sensitivity and Disturbance layers as inputs through the interface window by the user to allow for simplicity and efficiency.

Challenge 4—Step 5 and 6 in 'The key steps to run the model' above, can be incorporated into the model so the user does not have to add and symbolize the output files manually.

Recommendation—Incorporate these steps into the model to make it more user-friendly.

APPENDIX C

High Arctic Development Scenario

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Table C1: Summary of the High Arctic Development Scenario

Elements		Number/Rate	Movement To	Movement From	Description/Rationale
3D Seismic Exploration (per block)	**Seismic Vessel**				
	Exploration	1 vessel; 10 weeks			2,000 km^2 of seismic shot
	Refueling	Twice	Shallow areas (30 – 40 m) near closest community	Lease	Return trip
	Ice-breaking Support Vessel				
	Support to seismic	1 vessel; 10 weeks	Seismic		Within 2 nautical miles of seismic ship (approximately 4 km)
	Refueling	Twice			Supply ships will transport supplies, muds, etc. but not fuel.
	Supply Vessels				
	Early season supply	1 trip/season	Towns listed below	Newfoundland	
	Local resupply	1 round trip every 3 weeks	Seismic vessel	Nearest community	Vessels to ferry supplies from nearest community to seismic ship. Travel path: **West Block:** to/from Tuktoyaktuk **Central:** to/from Resolute
	Helicopter Support				
	Ice reconnaissance	1h/day	Within 5 – 10 NM of seismic vessel		
	Crew change	No crew change during summer season			
	Marine mammal surveys	Daily @ altitude > 450 m	Lease area and control areas outside the lease area	Nearest community	Three to four weeks, flying 6 hours a day.

Elements		Number/Rate	Movement: To	Movement: From	Description/Rationale
2D Seismic	**Seismic Vessel**				
	Exploration	1 vessel; 10 weeks	Shooting 75,000 km^2 of seismic		
	Refueling	Three times	Nearest community	Seismic area	
	Ice-breaking Support Vessel				
	Support to seismic	1 vessel; 10 weeks			Generally within 2 nautical miles of the seismic ship, so we will assume in the same area as seismic.
	Refueling	Three times			Supply ships do not bring fuel, just supplies, muds, etc.
	Supply vessels	Same as 3D			Same as 3D
	Helicopter support	Same as 3D			Same as 3D
	Land-based Seismic				
	Helicopter seismic	2 times per day	Seismic track	Land base	
	Helicopter support	2 times per week	Land base	Resolute	2D seismic operation on Ellef Ringnes Island will be supported by helicopter.
Exploration Drilling	Drilling vessels	2			One drill ship for same season relief well. Under current regulations, at depths >40 both ships would need to be drilling to allow a same season relief. The two vessel model is drawing from the Cairn program – where three wells were drilled and each rig provided the support to drill a relief well.
	Ice management vessels	6			
	Emergency response and rescue vessels	2			
	Supply vessels	2 vessels making one trip/week	Drill ships	Nearest community	Assume that fuel will be ferried to the site (unlike seismic) and that drill ships will not move. **Travel path:** West block to Tuktoyaktuk **Central block:** to Resolute

Elements		Number/Rate	Movement To	Movement From	Description/Rationale
	Support vessels	1			Generally within 2 nautical miles of the drill ships, so we will assume in the same area.
	Wareship	1			Like a floating warehouse. Generally within 2 nautical miles of the drill ships, so we will assume in the same area.
	Helicopter support	3	Vessels in lease		Three helicopters dedicated to operations Crew change every 3 weeks; flight to nearest community: **West block** to Tuktoyaktuk **Central block** to Resolute. **Ice reconnaissance:** daily flight for 1 hour **Between ship helicopter support:** 1 hour/day
Shipping (commercial and coast guard)	Vessel traffic	30/mo	Lancaster Sound and M'Clure Strait		Assumes an increase in shipping in this future scenario. Shipping lanes will reflect the current marine transport routes that we have developed for the PEMT. Shipping includes supply barges to communities, transport to mining operations, +5 cruise ships but not inter-oceanic shipping through the northwest passage.
Other low flying aircraft (scientific research, etc.)		5 trips/week			The model assumes commercial flights are generally above 3,000 m and do not need to be considered.

APPENDIX D

Zones of Influence and Scope of Potential Effects

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Table D1: Zones of Influence and the Scope of an Effect on Eastern Arctic VC—Polar Bear

Activity	Impact	Effect	Polar Bear						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Seismic									
Vessel traffic – seismic refueling and supply	Underwater Acoustic disturbance	Change in habitat	190 dB	0.25	1	0.004	0.50	1	**0.002**
	Acoustic disturbance	Change in behavior/displacement	190 dB	0.25	1	0.004	0.20	1	**0.001**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.004	0.01	1	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic –seismic vessel and support vessel	Acoustic disturbance	Change in habitat	190 dB	0.25	1	1.000	0.10	1	**0.100**
	Acoustic disturbance	Change in behavior	190 dB	0.25	1	1.000	0.20	1	**0.200**
	Vessel strikes	Change in health	N/A	0.025	0.025	1.000	0.01	1	**0.010**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition –3D	Acoustic disturbance	Change in habitat	190 dB	1.5	30	0.750	0.50	1	**0.375**
	Acoustic disturbance	Change in behavior	190 dB	1.5	30	0.750	0.50	1	**0.375**
	Acoustic disturbance	Change in health	N/A	1.5	3	0.750	0.50	1	**0.375**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition –2D	Acoustic disturbance	Change in habitat	190 dB	1.5	30	0.750	0.50	1	**0.375**
	Acoustic disturbance	Change in behavior	190 dB	1.5	30	0.750	0.50	1	**0.375**
	Acoustic disturbance	Change in health	N/A	1.5	3	0.750	0.50	1	**0.375**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Polar Bear						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Exploration Drilling									
Vessel traffic – drilling refueling and supply	Acoustic disturbance	Change in habitat	190 dB	0.25	1	0.016	0.10	1	**0.002**
	Acoustic disturbance	Change in behavior	190 dB	0.25	1	0.016	0.20	1	**0.003**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.016	0.01	1	**0.000**
	Exclusion of human use activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – drilling	Acoustic disturbance	Change in habitat	190 dB	0.25	1	1.000	0.20	1	**0.200**
	Acoustic disturbance	Change in behavior	190 dB	0.25	1	1.000	0.10	1	**0.100**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.050	0.01	1	**0.001**
	Exclusion of human use activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Drilling	Acoustic disturbance	Change in habitat	190 dB	0.25	1	1.000	0.20	1	**0.200**
	Acoustic disturbance	Change in behavior	190 dB	0.25	1	1.000	0.10	1	**0.100**
	Contaminants – disposal drilling muds etc.	Change in health	N/A	0.25	0.5	0.750	0.01	1	**0.008**
	Tainting, exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Overflights	Acoustic disturbance	Change in habitat	N/A	0	0.65	0.02	0.2	1	**0.004**
	Acoustic disturbance	Change in behavior	<300m	0	0.65	0.02	0.05	1	**0.001**
	Acoustic disturbance	Change in health	N/A	0	0.65	0.02	0.01	1	**0.000**
Operation of structures	Visual and acoustic disturbance	Change in habitat	N/A	0	0.5	1.000	0.01	0	**0.000**
		Change in health	N/A	0	0	0.000	0.01	0	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Polar Bear						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Other Activities									
Non-exploration vessel traffic - shipping	Acoustic disturbance	Change in habitat	190 dB	0.25	1	0.000	1.00	1	**0.000**
	Acoustic disturbance	Change in behavior	190 dB	0.25	1	0.000	0.20	1	**0.000**
	Vessel strikes/ underwater noise	Change in health	N/A	0.025	0.025	0.000	0.01	1	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Waste water treatment and discharge from routine ship operations	Pollution	Change in habitat	N/A	0	0	0.800	0.01	0	**0.000**
		Change in behavior	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

NOTES AND KEY
It is assumed that industry standard mitigation measures are applied
Any "not applicable" categories scored a "0"

COMPONENTS OF THE SCOPE OF AN EFFECT
Duration of Effect—estimated proportion of the season the effect lasts
Scale of Effect—Probability of Effect x Consequence of Effect

Consequence of Effect:
0 = Negligible
1 = Temporary and local adverse effect unlikely to be of high consequence
5 = Potential adverse effect that is regional (study area) or seasonal
10 = Regional long-term change

Table D2: Zones of Influence and the Scope of an Effect on Eastern Arctic VC—Arctic Char

Activity	Impact	Effect	Arctic Char						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Seismic									
Vessel traffic – seismic refuelling and supply	Underwater Acoustic disturbance	Change in habitat	180 dB	0.2	1	0.004	1.00	1	**0.004**
	Acoustic disturbance	Change in behavior/displacement	180 dB	0.2	1	0.004	0.70	1	**0.003**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – seismic vessel and support vessel	Acoustic disturbance	Change in habitat	180 dB	0.2	1	1.000	1.00	1	**1.000**
	Acoustic disturbance	Change in behavior	180 dB	0.2	1	1.000	0.70	1	**0.700**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 3D	Acoustic disturbance	Change in habitat	180 dB	0.1	5	0.75	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	180 dB	0.1	3	0.75	0.70	5	**2.625**
	Acoustic disturbance	Change in health/injury/mortality risk – larvae only	190 dB	0.1	0.5	0.75	0.50	5	**1.875**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 2D	Acoustic disturbance	Change in habitat	180 dB	0.1	5	0.75	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	180 dB	0.1	3	0.75	0.70	5	**2.625**
	Acoustic disturbance	Change in health	190 dB	0.1	0.5	0.75	0.50	5	**1.875**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Arctic Char						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Exploration Drilling									
Vessel traffic – drilling refueling and supply	Acoustic disturbance	Change in habitat	180 dB	0.2	1	0.016	1.00	1	**0.016**
	Acoustic disturbance	Change in behavior	180 dB	0.2	1	0.016	0.70	1	**0.011**
	Vessel strikes	Change in health/injury/mortality risk – larvae only	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
	Exclusion of human use activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – drill Ship (thrusters)	Acoustic disturbance	Change in habitat	180 dB	0.2	1	1.000	1.00	1	**1.000**
	Acoustic disturbance	Change in behavior	180 dB	0.2	1	1.000	0.70	1	**0.700**
	Vessel strikes	Change in health/injury/mortality risk – larvae only	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
	Exclusion of human use activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Drilling	Acoustic disturbance	Change in habitat	180 dB	0.2	1	0.75	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	180 dB	0.2	1	0.75	1.00	1	**0.750**
	Contaminants – disposal drilling muds etc.	Change in health/injury/mortality risk	180 dB	0.25	0.5	0.75	0.01	5	**0.038**
	Tainting, exclusion of human use activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Overflights	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in health/injury/mortality risk	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Operation of structures	Visual and acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Arctic Char						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Other Activities									
Non-exploration vessel traffic – shipping	Acoustic disturbance	Change in habitat	180 dB	0.2	1	0.000	1.00	1	**0.000**
	Acoustic disturbance	Change in behavior	180 dB	0.2	1	0.000	0.70	1	**0.000**
	Vessel strikes/ underwater noise	Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Waste water treatment and discharge from routine ship operations	Pollution	Change in habitat	N/A	0	0	0.80	0.01	0	**0.000**
		Change in behavior	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

NOTES AND KEY
It is assumed that industry standard mitigation measures are applied
Any "not applicable" categories scored a "0"

COMPONENTS OF THE SCOPE OF AN EFFECT
Duration of Effect—estimated proportion of the season the effect lasts
Scale of Effect—Probability of Effect x Consequence of Effect

Consequence of Effect:
0 = Negligible
1 = Temporary and local adverse effect unlikely to be of high consequence
5 = Potential adverse effect that is regional (study area) or seasonal
10 = Regional long-term change

Table D3: Zones of Influence and the Scope of an Effect on Eastern Arctic VC—Walrus

Activity	Impact	Effect	Walrus						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Seismic									
Vessel traffic – seismic refueling and supply	Underwater Acoustic disturbance	Change in habitat	190 dB	0.5	10	0.004	1.00	1	**0.004**
	Acoustic disturbance	Change in behavior/displacement	190 dB	0.5	10	0.004	0.70	1	**0.003**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.004	0.02	1	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic –seismic vessel and support vessel	Acoustic disturbance	Change in habitat	190 dB	0.5	10	1.000	1.00	1	**1.000**
	Acoustic disturbance	Change in behavior	190 dB	0.5	10	1.000	0.70	1	**0.700**
	Vessel strikes	Change in health	N/A	0.025	0.025	1.000	0.02	1	**0.020**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 3D	Acoustic disturbance	Change in habitat	190 dB	1.5	30	0.75	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	190 dB	1.5	30	0.75	0.90	1	**0.675**
	Acoustic disturbance	Change in health	N/A	1.5	3	0.75	0.50	1	**0.375**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 2D	Acoustic disturbance	Change in habitat	190 dB	1.5	30	0.75	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	190 dB	1.5	30	0.75	0.90	1	**0.675**
	Acoustic disturbance	Change in health	N/A	1.5	3	0.75	0.50	1	**0.375**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Walrus						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Exploration Drilling									
Vessel traffic – drilling refueling and supply	Acoustic disturbance	Change in habitat	190 dB	0.5	5	1.000	1.00	1	**1.000**
	Acoustic disturbance	Change in behavior	190 dB	0.5	5	1.000	0.70	1	**0.700**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.050	0.02	1	**0.001**
	Exclusion of human use activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – drill Ship	Acoustic disturbance	Change in habitat	190 dB	0.5	5	1.000	1.00	1	**1.000**
	Acoustic disturbance	Change in behavior	190 dB	0.5	5	1.000	0.70	1	**0.700**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.050	0.02	1	**0.001**
	Exclusion of human use activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Drilling	Acoustic disturbance	Change in habitat	190 dB	0.5	20	0.75	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	190 dB	0.5	20	0.75	1.00	1	**0.750**
	Contaminants – disposal drilling muds etc.	Change in health	N/A	0.25	0.5	0.75	0.01	1	**0.008**
	Tainting, exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Overflights	Acoustic disturbance	Change in habitat	N/A	0	0.65	0.02	0.05	1	**0.001**
	Acoustic disturbance	Change in behavior	<300	0	0.65	0.02	0.05	1	**0.001**
	Acoustic disturbance	Change in health	N/A	0	0.65	0.02	0.00	0	**0.000**
Operation of structures	Visual and acoustic disturbance	Change in habitat	N/A	0	0.5	1.00	0.00	0	**0.000**
		Change in health	N/A	0	0	0.00	0.00	0	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Walrus						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Other Activities									
Non-exploration vessel traffic - shipping	Acoustic disturbance	Change in habitat	190 dB	0.5	10	0.000	1.00	1	**0.000**
	Acoustic disturbance	Change in behavior	190 dB	0.5	10	0.000	0.70	1	**0.000**
	Vessel strikes/ underwater noise	Change in health	N/A	0.025	0.025	0.000	0.02	1	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Waste water treatment and discharge from routine ship operations	Pollution	Change in habitat	N/A	0	0	0.80	0.01	0	**0.000**
		Change in behavior	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

NOTES AND KEY

It is assumed that industry standard mitigation measures are applied

Any "not applicable" categories scored a "0"

COMPONENTS OF THE SCOPE OF AN EFFECT

Duration of Effect—estimated proportion of the season the effect lasts

Scale of Effect—Probability of Effect x Consequence of Effect

Consequence of Effect:

0 = Negligible
1 = Temporary and local adverse effect unlikely to be of high consequence
5 = Potential adverse effect that is regional (study area) or seasonal
10 = Regional long-term change

Table D4: Zones of Influence and the Scope of an Effect on Eastern Arctic VC—Traditional Harvest

Activity	Impact	Effect	Traditional Harvest					
			Zone of Influence (km) of Effect		Scope of Effect			
			Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Seismic								
Vessel traffic – seismic refueling and supply	Underwater Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior/displacement	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	1	5	0.25	0.1	1	**0.025**
Vessel traffic – seismic vessel and support vessel	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	1	5	0.250	0.10	1	**0.025**
Seismic acquisition – 3D	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	1	5	0.25	0.25	5	**0.313**
Seismic acquisition – 2D	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	1	5	0.25	0.25	5	**0.313**

Activity	Impact	Effect	Traditional Harvest					
			Zone of Influence (km) of Effect		Scope of Effect			
			Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Exploration Drilling								
Vessel traffic –drilling refueling and supply	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Exclusion of human use activities	Change in access to resources	1	5	0.25	0.10	1	**0.025**
Vessel traffic – drilling (thrusters)	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Exclusion of human use activities	Change in access to resources	0	1	0.10	0.10	1	**0.010**
Drilling	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Contaminants – disposal drilling muds etc.	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Tainting, exclusion of fishing activities	Change in access to resources	0	5	1.00	0.01	1	**0.010**
Overflights	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
Operation of structures	Visual and acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	1	3	0.10	0.05	1	**0.005**

Activity	Impact	Effect	Traditional Harvest					
			Zone of Influence (km) of Effect		Scope of Effect			
			Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Other Activities								
Non-exploration vessel traffic – shipping	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes/ underwater noise	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	1	5	0.050	0.05	1	**0.003**
Waste water treatment and discharge from routine ship operations	Pollution	Change in habitat	1	2	1.00	0.01	1	**0.010**
		Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	1	2	1.00	0.01	1	**0.010**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**

NOTES AND KEY

It is assumed that industry standard mitigation measures are applied

Any "not applicable" categories scored a "0"

COMPONENTS OF THE SCOPE OF AN EFFECT

Duration of Effect—estimated proportion of the season the effect lasts

Scale of Effect—Probability of Effect x Consequence of Effect

Consequence of Effect:

0 = Negligible
1 = Temporary and local adverse effect unlikely to be of high consequence
5 = Potential adverse effect that is regional (study area) or seasonal
10 = Regional long-term change

Table D5: Zones of Influence and the Scope of an Effect on Eastern Arctic VC—Bowhead Whale

Activity	Impact	Effect	Bowhead Whale						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Seismic									
Vessel traffic – seismic refueling and supply	Acoustic disturbance	Change in habitat	180 dB	0.5	10	0.004	1.00	1	**0.004**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	0.004	0.70	5	**0.015**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.004	0.02	5	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – seismic vessel and support vessel	Acoustic disturbance	Change in habitat	180 dB	0.5	10	1.000	1.00	1	**1.000**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	1.000	0.70	5	**3.500**
	Vessel strikes	Change in health	N/A	0.025	0.025	1.000	0.02	5	**0.100**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 3D	Acoustic disturbance	Change in habitat	180 dB	1.5	30	0.750	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	180 dB	1.5	30	0.750	0.90	5	**3.375**
	Acoustic disturbance	Change in health	N/A	1.5	3	0.750	0.50	5	**1.875**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 2D	Acoustic disturbance	Change in habitat	180 dB	1.5	30	0.750	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	180 dB	1.5	30	0.750	0.90	5	**3.375**
	Acoustic disturbance	Change in health	N/A	1.5	3	0.750	0.50	5	**1.875**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Bowhead Whale						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Exploration Drilling									
Vessel traffic – drilling refueling and supply	Acoustic disturbance	Change in habitat	180 dB	0.5	10	0.016	1.00	1	**0.016**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	0.016	0.70	5	**0.057**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.016	0.02	5	**0.002**
	Exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic –drilling	Acoustic disturbance	Change in habitat	180 dB	0.5	10	1.000	1.00	1	**1.000**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	1.000	0.70	5	**3.500**
	Vessel strikes	Change in health	N/A	0.025	0.025	1.000	0.02	5	**0.100**
	Exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Drilling	Acoustic disturbance	Change in habitat	180 dB	0.5	20	0.750	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	180 dB	0.5	20	0.750	1.00	1	**0.750**
	Contaminants – disposal drilling muds etc.	Change in health	180 dB	0.25	0.5	0.750	0.01	5	**0.038**
	Tainting, exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Overflights	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	<300m	0	0.5	0.02	0.05	1	**0.001**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Operation of structures	Visual and acoustic disturbance	Change in habitat	N/A	0	0.5	1.000	0.00	0	**0.000**
		Change in health	N/A	0	0	0.000	0.00	0	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Bowhead Whale						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Other Activities									
Non-exploration Vessel traffic - Shipping	Acoustic disturbance	Change in habitat	180 dB	0.5	10	0.000	1.00	1	**0.000**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	0.000	0.70	5	**0.002**
	Vessel strikes/ underwater noise	Change in health	N/A	0.025	0.025	0.000	0.02	5	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Waste water treatment and discharge from routine ship operations	Pollution	Change in habitat	N/A	0	0	0.800	0.01	0	**0.000**
		Change in behavior	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health/injury	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

NOTES AND KEY
It is assumed that industry standard mitigation measures are applied
Any "not applicable" categories scored a "0"

COMPONENTS OF THE SCOPE OF AN EFFECT
Duration of Effect—estimated proportion of the season the effect lasts
Scale of Effect—Probability of Effect x Consequence of Effect

Consequence of Effect:
0 = Negligible
1 = Temporary and local adverse effect unlikely to be of high consequence
5 = Potential adverse effect that is regional (study area) or seasonal
10 = Regional long-term change

Table D6: Zones of Influence and the Scope of an Effect on Eastern Arctic VC—Toothed Whales

Activity	Impact	Effect	Toothed Whales (Narwhal)						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Seismic									
Vessel traffic – seismic refuelling and supply	Acoustic disturbance	Change in habitat	180 dB	0.5	10	0.004	1.00	1	**0.004**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	0.004	0.70	5	**0.015**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.004	0.02	5	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – seismic vessel and support vessel	Acoustic disturbance	Change in habitat	180 dB	0.5	10	1.000	1.00	1	**1.000**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	1.000	0.70	5	**3.500**
	Vessel strikes	Change in health	N/A	0.025	0.025	1.000	0.02	5	**0.100**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 3D	Acoustic disturbance	Change in habitat	180 dB	1.5	30	0.75	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	180 dB	1.5	30	0.75	0.90	5	**3.375**
	Acoustic disturbance	Change in health	N/A	1.5	3	0.75	0.50	5	**1.875**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 2D	Acoustic disturbance	Change in habitat	180 dB	1.5	30	0.75	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	180 dB	1.5	30	0.75	0.90	5	**3.375**
	Acoustic disturbance	Change in health	N/A	1.5	3	0.75	0.50	5	**1.875**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Exploration Drilling									
Vessel traffic – drilling refueling and supply	Acoustic disturbance	Change in habitat	180 dB	0.5	10	0.016	1.00	1	**0.016**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	0.016	0.70	5	**0.057**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.016	0.02	5	**0.002**
	Exclusion of fishing	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Toothed Whales (Narwhal)						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
	activities								
Vessel traffic – drilling	Acoustic disturbance	Change in habitat	180 dB	0.5	10	1.000	1.00	1	**1.000**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	1.000	0.70	5	**3.500**
	Vessel strikes	Change in health	N/A	0.025	0.025	1.000	0.02	5	**0.100**
	Exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Drilling	Acoustic disturbance	Change in habitat	180 dB	0.5	20	0.75	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	180 dB	0.5	20	0.75	1.00	1	**0.750**
	Contaminants – disposal drilling muds etc.	Change in health	180 dB	0.25	0.5	0.75	0.01	5	**0.038**
	Tainting, exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Overflights	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	<300 m	0	0.5	0.02	0.05	1	**0.001**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Operation of structures	Visual and acoustic disturbance	Change in habitat	N/A	0	0.5	1.00	0.00	0	**0.000**
		Change in health	N/A	0	0	0.00	0.00	0	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Toothed Whales (Narwhal)						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Other Activities									
Non-exploration vessel traffic – shipping	Acoustic disturbance	Change in habitat	180 dB	0.5	10	0.000	1.00	1	**0.000**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	0.000	0.70	5	**0.002**
	Vessel strikes/ underwater noise	Change in health	N/A	0.025	0.025	0.000	0.02	5	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Waste water treatment and discharge from routine ship operations	Pollution	Change in habitat	N/A	0	0	0.80	0.01	0	**0.000**
		Change in behavior	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

NOTES AND KEY

It is assumed that industry standard mitigation measures are applied

Any "not applicable" categories scored a "0"

COMPONENTS OF THE SCOPE OF AN EFFECT

Duration of Effect—estimated proportion of the season the effect lasts

Scale of Effect—Probability of Effect x Consequence of Effect

Consequence of Effect:

0 = Negligible
1 = Temporary and local adverse effect unlikely to be of high consequence
5 = Potential adverse effect that is regional (study area) or seasonal
10 = Regional long-term change

Table D7: Zones of Influence and the Scope of an Effect on Eastern Arctic VC—Commercial Turbot Fishery

Activity	Impact	Effect	Commercial Turbot Fishery					
			Zone of Influence (km)		Scope of Effect			
			Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Seismic								
Vessel traffic – seismic refueling and supply	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	1	5	0.250	0.10	1	**0.025**
Vessel traffic – seismic vessel and support vessel	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	1	5	0.250	0.10	1	**0.025**
Seismic acquisition – 3D	Acoustic disturbance	Change in habitat	1	10	1.00	0.02	5	**0.100**
	Acoustic disturbance	Change in behavior	1	30	1.00	0.50	1	**0.500**
	Acoustic disturbance	Change in health	0	0.01	1.00	0.25	1	**0.250**
	Space conflict	Change in access to resources	1	5	0.25	0.25	5	**0.313**
Seismic acquisition – 2D	Acoustic disturbance	Change in habitat	1	10	0.25	0.01	1	**0.003**
	Acoustic disturbance	Change in behavior	1	30	1.00	0.25	1	**0.250**
	Acoustic disturbance	Change in health	0	0.5	1.00	0.10	1	**0.100**
	Space conflict	Change in access to resources	1	5	0.25	0.10	1	**0.025**

Activity	Impact	Effect	Commercial Turbot Fishery					
			Zone of Influence (km)		Scope of Effect			
			Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Exploration Drilling								
Vessel traffic – drilling refueling and supply	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Exclusion of fishing activities	Change in access to resources	0	1	0.10	0.10	1	**0.010**
Vessel traffic – drilling	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Exclusion of fishing activities	Change in access to resources	0	1	0.10	0.10	1	**0.010**
Drilling	Acoustic disturbance	Change in habitat	0	1	0.75	0.20	1	**0.150**
	Acoustic disturbance	Change in behavior	0	2	0.75	0.20	1	**0.150**
	Contaminants – disposal drilling muds etc.	Change in health	0	1	0.00	0.00	0	**0.000**
	Tainting, exclusion of fishing activities	Change in access to resources	0	5	1.00	0.01	1	**0.010**
Overflights	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
Operation of structures	Visual and acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	1	3	0.10	0.05	1	**0.005**

Activity	Impact	Effect	Commercial Turbot Fishery					
			Zone of Influence (km)		Scope of Effect			
			Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Other Activities								
Non-exploration vessel traffic - shipping	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes/underwater noise	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	1	5	0.050	0.05	1	**0.003**
Waste water treatment and discharge from routine ship operations	Pollution	Change in habitat	1	2	1.00	0.01	1	**0.010**
		Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	1	2	1.00	0.01	1	**0.010**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**

NOTES AND KEY

It is assumed that industry standard mitigation measures are applied

Any "not applicable" categories scored a "0"

COMPONENTS OF THE SCOPE OF AN EFFECT

Duration of Effect—estimated proportion of the season the effect lasts

Scale of Effect—Probability of Effect x Consequence of Effect

Consequence of Effect:

0 = Negligible
1 = Temporary and local adverse effect unlikely to be of high consequence
5 = Potential adverse effect that is regional (study area) or seasonal
10 = Regional long-term change

Table D8: Zones of Influence and the Scope of an Effect on Eastern Arctic VC—Thick-billed Murre

Activity	Impact	Effect	Thick-billed Murre						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Seismic									
Vessel traffic – seismic refueling and supply	Acoustic disturbance	Change in habitat	Unlikely	0	0.1	0.004	0.00	0	**0.000**
	Acoustic disturbance	Change in behavior	Not documented	0	1	0.004	0.20	1	**0.001**
	Vessel strikes	Change in health	unlikely	0	0.05	0.004	0.00	0	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – seismic vessel and support vessel	Acoustic disturbance	Change in habitat	Unlikely	0	0.1	1.000	0.01	0	**0.000**
	Acoustic disturbance	Change in behavior	Not documented	0	1	1.000	0.20	1	**0.200**
	Vessel strikes	Change in health	Unlikely	0	0.05	1.000	0.01	0	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 3D	Acoustic disturbance	Change in habitat	Not documented	0	0	0.75	0.00	0	**0.000**
	Acoustic disturbance	Change in behavior	Not documented	0	1	0.75	0.01	1	**0.008**
	Acoustic disturbance	Change in health	N/A	0	0	0.75	0.00	0	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 2D	Acoustic disturbance	Change in habitat	Not documented	0	0.1	0.75	0.00	0	**0.000**
	Acoustic disturbance	Change in behavior	Not documented	0	1	0.75	0.01	1	**0.008**
	Acoustic disturbance	Change in health	N/A	0	0	0.75	0.00	0	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Thick-billed Murre						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Exploration Drilling									
Vessel traffic – drilling refueling and supply	Acoustic disturbance	Change in habitat	Unlikely	0	0.1	0.016	0.00	0	**0.000**
	Acoustic disturbance	Change in behavior	Not documented	0	1	0.016	0.20	1	**0.003**
	Vessel strikes	Change in health	Unlikely	0	0.05	0.016	0.00	0	**0.000**
	Exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – drilling	Acoustic disturbance	Change in habitat	Unlikely	0	0.1	1.000	0.00	0	**0.000**
	Acoustic disturbance	Change in behavior	Not documented	0	1	1.000	0.20	1	**0.200**
	Vessel strikes	Change in health	Unlikely	0	0.05	1.000	0.00	0	**0.000**
	Exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Drilling	Acoustic disturbance	Change in habitat	Unlikely	0	0.1	0.75	0.00	0	**0.000**
	Acoustic disturbance	Change in behavior	N/A						
	Contaminants – disposal drilling muds etc.	Change in health	Unlikely	0	2	0.01	0.01	5	**0.001**
	Tainting, exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Overflights	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	Captured below	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in health	Up to 1	0.2	1	0.05	0.05	5	**0.013**

Activity	Impact	Effect	Thick-billed Murre						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Operation of structures	Visual and acoustic disturbance	Change in habitat	Up to 1	0.2	1	1.00	0.20	1	**0.200**
		Change in health	Unlikely	0	0	0.00	0.01	5	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Other Activities									
Non-exploration vessel traffic – shipping	Acoustic disturbance	Change in habitat	Unlikely	0	0.1	0.000	0.00	0	**0.000**
	Acoustic disturbance	Change in behavior	Not documented	0	1	0.000	0.20	1	**0.000**
	Vessel strikes/ underwater noise	Change in health	Unlikely	0	0.05	0.000	0.00	0	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Waste water treatment and discharge from routine ship operations	Pollution	Change in habitat	N/A	0.1	1	0.80	0.05	1	**0.040**
		Change in behavior	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

NOTES AND KEY

It is assumed that industry standard mitigation measures are applied

Any "not applicable" categories scored a "0"

COMPONENTS OF THE SCOPE OF AN EFFECT

Duration of Effect—estimated proportion of the season the effect lasts

Scale of Effect—Probability of Effect x Consequence of Effect

Consequence of Effect:

0 = Negligible
1 = Temporary and local adverse effect unlikely to be of high consequence
5 = Potential adverse effect that is regional (study area) or seasonal
10 = Regional long-term change

Table D9: Zones of Influence and the Scope of an Effect on High Arctic VC—Polar Bear

Activity	Impact	Effect	Polar Bear						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Seismic									
Vessel traffic – seismic refueling and supply	Acoustic disturbance	Change in habitat	190 dB	0.25	1	0.004	0.50	1	**0.002**
	Acoustic disturbance	Change in behavior	190 dB	0.25	1	0.004	0.20	1	**0.001**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.004	0.01	1	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – seismic vessel and support vessel	Acoustic disturbance	Change in habitat	190 dB	0.25	1	1.000	0.01	1	**0.100**
	Acoustic disturbance	Change in behavior	190 dB	0.25	1	1.000	0.20	1	**0.200**
	Vessel strikes	Change in health	N/A	0.025	0.025	1.000	0.01	1	**0.010**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Open-water seismic acquisition – 3D	Acoustic disturbance	Change in habitat	190 dB	1.5	30	0.750	0.50	1	**0.375**
	Acoustic disturbance	Change in behavior	190 dB	1.5	30	0.750	0.50	1	**0.375**
	Acoustic disturbance	Change in health	N/A	1.5	3	0.750	0.50	1	**0.375**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Open-water seismic acquisition – 2D	Acoustic disturbance	Change in habitat	190 dB	1.5	30	0.750	0.50	1	**0.375**
	Acoustic disturbance	Change in behavior	190 dB	1.5	30	0.750	0.50	1	**0.375**
	Acoustic disturbance	Change in health	N/A	1.5	3	0.750	0.50	1	**0.375**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Land-based seismic acquisition – 2D	Acoustic disturbance	Change in habitat	N/A	0.50	10	0.750	0.50	1	**0.375**
	Acoustic disturbance	Change in behavior	N/A	0.50	10	0.750	0.70	1	**0.525**
	Acoustic disturbance	Change in health	N/A	0.50	1	0.750	0.20	1	**0.150**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Polar Bear						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Exploration Drilling									
Vessel traffic – drilling refueling and supply	Acoustic disturbance	Change in habitat	190 dB	0.25	1	0.016	0.10	1	**0.002**
	Acoustic disturbance	Change in behavior	190 dB	0.25	1	0.016	0.20	1	**0.003**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.016	0.01	1	**0.000**
	Exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic –drilling	Acoustic disturbance	Change in habitat	190 dB	0.25	1	1.000	0.20	1	**0.200**
	Acoustic disturbance	Change in behavior	190 dB	0.25	1	1.000	0.10	1	**0.100**
	Vessel strikes	Change in health	N/A	0.025	0.025	1.000	0.01	1	**0.001**
	Exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Drilling	Acoustic disturbance	Change in habitat	190 dB	0.5	1	0.750	0.50	1	**0.375**
	Acoustic disturbance	Change in behavior	190 dB	0.5	1	0.750	0.20	1	**0.150**
	Contaminants – disposal drilling muds etc.	Change in health	N/A	0.25	0.5	0.750	0.01	1	**0.008**
	Tainting, exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Overflights	Acoustic disturbance	Change in habitat	N/A	0	0.65	0.02	.2	1	**.004**
	Acoustic disturbance	Change in behavior	<300m	0	0.65	0.02	0.05	1	**0.001**
	Acoustic disturbance	Change in health	N/A	0	0.65	0.02	0.01	1	**0.000**
Operation of structures	Visual and acoustic disturbance	Change in habitat	N/A	0	0.5	1.000	0.01	0	**0.000**
		Change in health	N/A	0	0	0.000	0.01	0	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Polar Bear						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Other Activities									
Non-exploration vessel traffic - shipping	Acoustic disturbance	Change in habitat	190 dB	0.25	1	0.000	0.10	1	**0.000**
	Acoustic disturbance	Change in behavior	190 dB	0.25	1	0.000	0.20	1	**0.000**
	Vessel strikes/ underwater noise	Change in health	N/A	0.025	0.025	0.000	0.02	5	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Waste water treatment and discharge from routine ship operations	Pollution	Change in habitat	N/A	0	0	0.800	0.01	0	**0.000**
		Change in behavior	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

NOTES AND KEY
It is assumed that industry standard mitigation measures are applied
Any "not applicable" categories scored a "0"

COMPONENTS OF THE SCOPE OF AN EFFECT
Duration of Effect—estimated proportion of the season the effect lasts
Scale of Effect—Probability of Effect x Consequence of Effect

Consequence of Effect:
0 = Negligible
1 = Temporary and local adverse effect unlikely to be of high consequence
5 = Potential adverse effect that is regional (study area) or seasonal
10 = Regional long-term change

Table D10: Zones of Influence and the Scope of an Effect on High Arctic VC—Narwhal

Activity	Impact	Effect	Narwhal						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Seismic									
Vessel traffic – seismic refueling and supply	Acoustic disturbance	Change in habitat	180 dB	0.5	10	0.004	1.00	1	**0.004**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	0.004	0.70	5	**0.015**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.004	0.02	5	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – seismic vessel and support vessel	Acoustic disturbance	Change in habitat	180 dB	0.5	10	1.000	1.00	1	**1.000**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	1.000	0.70	5	**3.500**
	Vessel strikes	Change in health	N/A	0.025	0.025	1.000	0.02	5	**0.100**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Open-water seismic acquisition – 3D	Acoustic disturbance	Change in habitat	180 dB	1.5	30	0.750	0.50	1	**0.750**
	Acoustic disturbance	Change in behavior	180 dB	1.5	30	0.750	0.50	1	**3.375**
	Acoustic disturbance	Change in health	N/A	1.5	3	0.750	0.50	1	**1.875**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Open-water seismic acquisition – 2D	Acoustic disturbance	Change in habitat	180 dB	1.5	30	0.750	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	180 dB	1.5	30	0.750	0.90	5	**3.375**
	Acoustic disturbance	Change in health	N/A	1.5	3	0.750	0.50	5	**1.875**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Land-based seismic acquisition – 2D	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Narwhal						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Exploration Drilling									
Vessel traffic –drilling refueling and supply	Acoustic disturbance	Change in habitat	180 dB	0.5	10	0.016	1.00	1	**0.016**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	0.016	0.70	5	**0.057**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.016	0.02	5	**0.002**
	Exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – drilling	Acoustic disturbance	Change in habitat	180 dB	0.5	10	1.000	1.00	1	**1.000**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	1.000	0.70	5	**3.500**
	Vessel strikes	Change in health	N/A	0.025	0.025	0.500	0.02	5	**0.050**
	Exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Drilling	Acoustic disturbance	Change in habitat	180 dB	0.5	10	0.750	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	0.750	1.00	1	**0.750**
	Contaminants – disposal drilling muds etc.	Change in health	N/A	0.25	0.5	0.750	0.01	5	**0.038**
	Tainting, exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Overflights	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	<300m	0	0.5	0.02	0.05	1	**0.001**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Operation of structures	Visual and acoustic disturbance	Change in habitat	N/A	0	0.5	1.000	0.00	0	**0.000**
		Change in health	N/A	0	0	0.000	0.00	0	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Narwhal						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Other Activities									
Non-exploration vessel traffic - shipping	Acoustic disturbance	Change in habitat	180 dB	0.5	10	0.000	1.00	1	**0.000**
	Acoustic disturbance	Change in behavior	180 dB	0.5	10	0.000	0.70	1	**0.000**
	Vessel strikes/ underwater noise	Change in health	N/A	0.025	0.025	0.000	0.02	5	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Waste water treatment and discharge from routine ship operations	Pollution	Change in habitat	N/A	0	0	0.800	0.01	0	**0.000**
		Change in behavior	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

NOTES AND KEY
It is assumed that industry standard mitigation measures are applied
Any "not applicable" categories scored a "0"

COMPONENTS OF THE SCOPE OF AN EFFECT
Duration of Effect—estimated proportion of the season the effect lasts
Scale of Effect—Probability of Effect x Consequence of Effect

Consequence of Effect:
0 = Negligible
1 = Temporary and local adverse effect unlikely to be of high consequence
5 = Potential adverse effect that is regional (study area) or seasonal
10 = Regional long-term change

Table D11 Zones of Influence and the Scope of an Effect on High Arctic VC—Migratory Birds

Activity	Impact	Effect	Migratory Birds						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Seismic									
Vessel traffic – seismic refuelling and supply	Acoustic disturbance	Change in habitat	N/A	0	0.1	0.004	0.10	0	**0.000**
	Acoustic disturbance	Change in behavior	N/A	0	1	0.004	0.10	1	**0.000**
	Vessel strikes	Change in health	N/A	0	0.05	0.004	0.01	0	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – seismic vessel and support vessel	Acoustic disturbance	Change in habitat	N/A	0	0.1	1.000	0.01	0	**0.000**
	Acoustic disturbance	Change in behavior	N/A	0	1	1.000	0.10	1	**0.100**
	Vessel strikes	Change in health	N/A	0	0.05	1.000	0.01	0	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 3D	Acoustic disturbance	Change in habitat	N/A	0	0.1	0.75	0.01	0	**0.000**
	Acoustic disturbance	Change in behavior	N/A	0	1	0.75	0.01	1	**0.008**
	Acoustic disturbance	Change in health	N/A	0	0	0.75	0.00	0	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 2D	Acoustic disturbance	Change in habitat	N/A	0	0.1	0.75	0.01	0	**0.000**
	Acoustic disturbance	Change in behavior	N/A	0	1	0.75	0.01	1	**0.008**
	Acoustic disturbance	Change in health	N/A	0	0	0.75	0.00	0	**0.000**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Land-based seismic acquisition – 2D	Acoustic disturbance	Change in habitat	1.5	0	3	0.75	1.00	1	**0.750**
	Acoustic disturbance	Change in behavior	N/A	0	1.5	0.75	0.50	5	**1.875**
	Acoustic disturbance	Change in health	N/A	0	1.5	0.75	0.50	5	**1.875**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Migratory Birds						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Exploration Drilling									
Vessel traffic – drilling refueling and supply	Acoustic disturbance	Change in habitat	N/A	0	0.1	0.016	0.10	0	**0.000**
	Acoustic disturbance	Change in behavior	N/A	0	1	0.016	0.10	1	**0.002**
	Vessel strikes	Change in health	N/A	0	0.05	0.016	0.00	0	**0.000**
	Exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – drilling	Acoustic disturbance	Change in habitat	N/A	0	0.1	1.000	0.05	0	**0.000**
	Acoustic disturbance	Change in behavior	N/A	0	1	1.000	0.10	1	**0.100**
	Vessel strikes	Change in health	N/A	0	0.05	1.000	0.00	0	**0.000**
	Exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Drilling	Acoustic disturbance	Change in habitat	N/A	0	0.1	0.75	0	0	**0.000**
	Acoustic disturbance	Change in behavior	N/A	0	0.1	0.75	0.01	0	**0.000**
	Contaminants – disposal drilling muds etc.	Change in health	N/A	0	2	0.75	0.01	5	**0.001**
	Tainting, exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Overflights	Acoustic disturbance	Change in habitat	N/A	0.65	1.1	0.05	0.05	5	**0.013**
	Acoustic disturbance	Change in behavior	N/A	0.65	1.1	0.05	0.05	5	**0.013**
	Acoustic disturbance	Change in health	N/A	0.65	1.1	0.05	0.05	5	**0.013**
	Tainting, exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Operation of structures	Visual and acoustic disturbance	Change in habitat	N/A	0.2	1	0.00	0.20	1	**0.000**
		Change in health	N/A	0	0	0.00	0.01	5	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Migratory Birds						
			Zone of Influence (km) of Effect			Scope of Effect			
			Literature Values	Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Other Activities									
Non-exploration vessel traffic – shipping	Acoustic disturbance	Change in habitat	N/A	0	0.1	0.000	0.10	0	**0.000**
	Acoustic disturbance	Change in behavior	N/A	0	1	0.000	0.10	1	**0.000**
	Vessel strikes/ underwater noise	Change in health	N/A	0	0.05	0.000	0.00	0	**0.000**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
Waste water treatment and discharge from routine ship operations	Pollution	Change in habitat	N/A	0.1	1	0.00	0.05	1	**0.000**
		Change in behavior	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

NOTES AND KEY

It is assumed that industry standard mitigation measures are applied
Any "not applicable" categories scored a "0"

COMPONENTS OF THE SCOPE OF AN EFFECT

Duration of Effect—estimated proportion of the season the effect lasts
Scale of Effect—Probability of Effect x Consequence of Effect

Consequence of Effect:

0 = Negligible
1 = Temporary and local adverse effect unlikely to be of high consequence
5 = Potential adverse effect that is regional (study area) or seasonal
10 = Regional long-term change

Table D12: Zones of Influence and the Scope of an Effect on High Arctic VC—Peary Caribou

Activity	Impact	Effect	Peary Caribou					
			Zone of Influence (km)		Scope of Effect			
			Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Seismic								
Vessel traffic – seismic refueling and supply	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – seismic vessel and support vessel	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 3D	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**
Seismic acquisition – 2D	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**
Land-based seismic acquisition – 2D	Acoustic disturbance	Change in habitat	0.5	10	0.75	1.00	1	**0.75**
	Acoustic disturbance	Change in behavior	0.5	10	0.75	0.90	1	**0.675**
	Acoustic disturbance	Change in health	0.5	1	0.75	0.50	1	**0.375**
	Space conflict	Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Peary Caribou					
			Zone of Influence (km)		Scope of Effect			
			Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Exploration Drilling								
Vessel traffic – drilling refueling and supply	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**
Vessel traffic – drilling	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**
Drilling	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Contaminants – disposal drilling muds etc.	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Tainting, exclusion of fishing activities	Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**
Overflights	Acoustic disturbance	Change in habitat	0	0.65	0.02	0.20	1	**N/A**
	Acoustic disturbance	Change in behavior	0	0.65	0.02	0.10	5	**N/A**
	Acoustic disturbance	Change in health	0	0.65	0.02	0.01	5	**N/A**
Operation of structures	Visual and acoustic disturbance	Change in habitat	0	.5	0.00	0.00	0	**0.00**
		Change in health	0	0	0.00	0.00	0	**0.00**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**

Activity	Impact	Effect	Peary Caribou					
			Zone of Influence (km)		Scope of Effect			
			Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Other Activities								
Non-exploration vessel traffic - shipping	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes/underwater noise	Change in health/injury/mortality risk	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**
Waste water treatment and discharge from routine ship operations	Pollution	Change in habitat	0	0	0.00	0.01	0	**0.010**
		Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health/injury/mortality risk	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**

NOTES AND KEY

It is assumed that industry standard mitigation measures are applied

Any "not applicable" categories scored a "0"

COMPONENTS OF THE SCOPE OF AN EFFECT

Duration of Effect—estimated proportion of the season the effect lasts

Scale of Effect—Probability of Effect x Consequence of Effect

Consequence of Effect:

0 = Negligible
1 = Temporary and local adverse effect unlikely to be of high consequence
5 = Potential adverse effect that is regional (study area) or seasonal
10 = Regional long-term change

Table D13: Zones of Influence and the Scope of an Effect on High Arctic VC—Traditional Harvest

Activity	Impact	Effect	Traditional Harvest					
			Zone of Influence (km) of Effect		Scope of Effect			
			Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Seismic								
Vessel traffic – seismic refueling and supply	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	1	5	0.25	0.1	1	**0.025**
Vessel traffic – seismic vessel and support vessel	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	1	5	0.25	0.10	1	**0.025**
Seismic acquisition – 3D	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	1	5	0.25	0.25	5	**0.313**
Seismic acquisition – 2D	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	1	5	0.25	0.25	5	**0.313**
Land-based seismic acquisition – 2D	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Space conflict	Change in access to resources	1	10	0.25	0.25	5	**0.313**

Activity	Impact	Effect	Traditional Harvest					
			Zone of Influence (km) of Effect		Scope of Effect			
			Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Exploration Drilling								
Vessel traffic – drilling refueling and supply	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Exclusion of fishing activities	Change in access to resources	1	5	0.25	0.1	1	**0.025**
Vessel traffic – drilling	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Exclusion of fishing activities	Change in access to resources	0	1	0.1	0.1	1	**0.01**
Drilling	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Contaminants – disposal drilling muds etc.	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Tainting, exclusion of fishing activities	Change in access to resources	0	5	1.00	0.01	1	**0.010**
Overflights	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
	Exclusion of activities	Change in access to resources	0	0.5	0.02	0.05	1	**0.001**
Operation of structures	Visual and acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	1	3	0.10	0.05	1	**0.005**

Activity	Impact	Effect	Traditional Harvest					
			Zone of Influence (km) of Effect		Scope of Effect			
			Minimum (10%)	Max (90%)	Duration of Effect (Proportion of Season)	Probability of an Effect	Consequence of Effect	Scope
Other Activities								
Non-exploration vessel traffic – shipping	Acoustic disturbance	Change in habitat	N/A	N/A	N/A	N/A	N/A	**N/A**
	Acoustic disturbance	Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
	Vessel strikes/ underwater noise	Change in health	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in access to resources	1	5	0.05	0.05	1	**0.003**
Waste water treatment and discharge from routine ship operations	Pollution	Change in habitat	1	2	1.00	0.01	1	**0.010**
		Change in behavior	N/A	N/A	N/A	N/A	N/A	**N/A**
		Change in health	1	2	1.00	0.01	1	**0.01**
		Change in access to resources	N/A	N/A	N/A	N/A	N/A	**N/A**

NOTES AND KEY

It is assumed that industry standard mitigation measures are applied

Any "not applicable" categories scored a "0"

COMPONENTS OF THE SCOPE OF AN EFFECT

Duration of Effect—estimated proportion of the season the effect lasts

Scale of Effect—Probability of Effect x Consequence of Effect

Consequence of Effect:

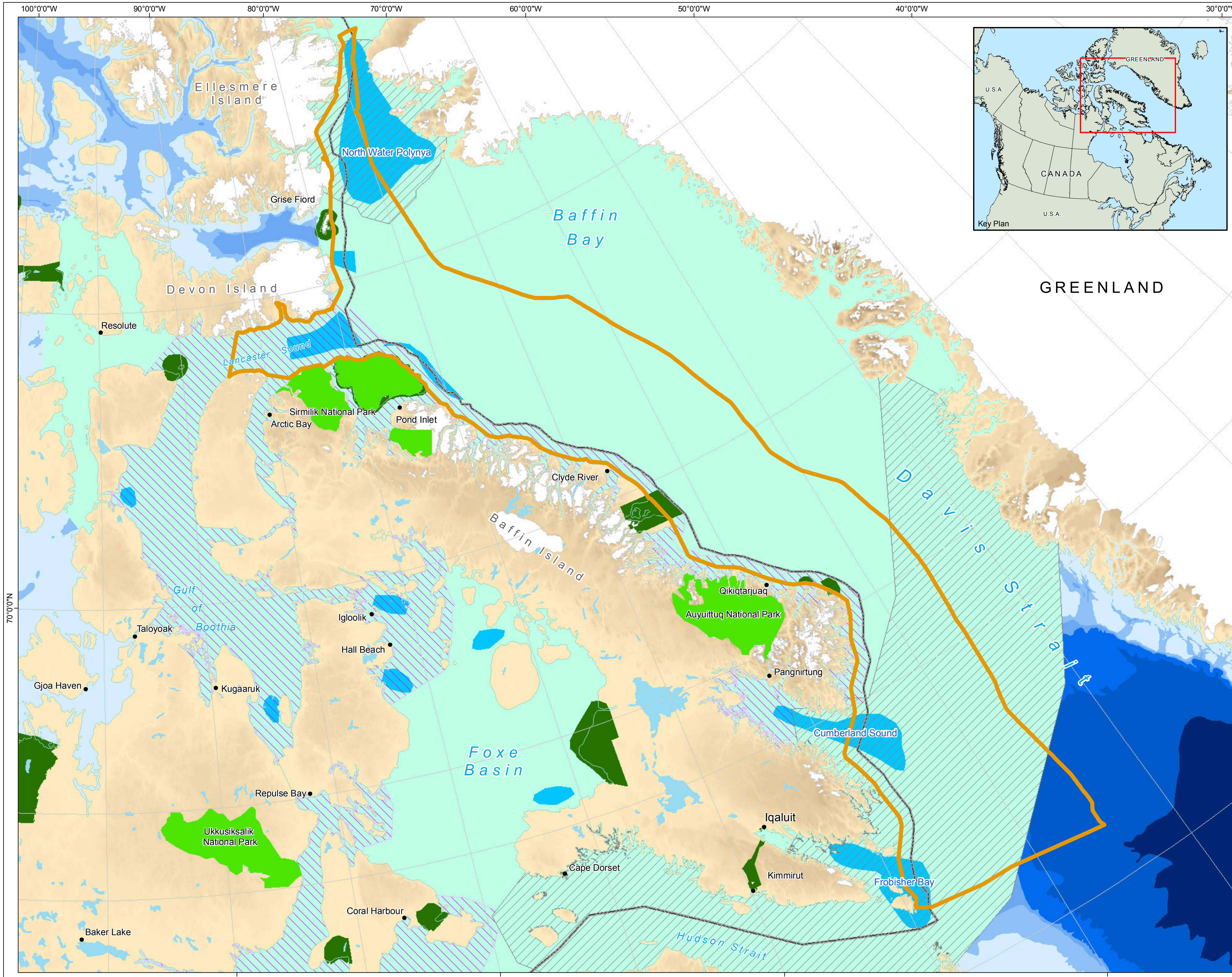
0 = Negligible
1 = Temporary and local adverse effect unlikely to be of high consequence
5 = Potential adverse effect that is regional (study area) or seasonal
10 = Regional long-term change

APPENDIX E

Eastern Arctic Updated Distribution Data Maps

Eastern Arctic, Nunavut, Canada Bowhead Whale Distribution and Key Seasonal Habitat

Figure 1



Bowhead Whale Distribution[1, 4]

Bowhead Whale Summer Aggregation Areas[1, 4]

Bowhead Whale Wintering Areas[1, 2, 3, 4]

Base Features

- Community
- Grid Line
- Ice Cap
- Eastern Arctic Study Area
- Nunavut Regional Boundary
- Conservation Area
- National Park
- Lakes / River
- Polynyas

Depth (m)

- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:7,000,000

50 25 0 50 100 150 200

Kilometres

Prepared By:
Nunami - Stantec

References:

[1]COSEWIC. 2009. COSEWIC assessment and update status report on the bowhead whale *Balaena mysticetus*, Bering-Chukchi-Beaufort population and Eastern Canada-West Greenland population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 49 pp
*digitized by Nunami Stantec 2010

[2]Dueck, L., S. Ferguson, B. Wheeler, S.P. Luque and M. Gilbert. (in press). Habitat Use By Bowhead Whales of the Eastern Canadian Arctic.
*digitized by Nunami Stantec 2010

[3]Richard, P.R., J.R. Orr, R. Dietz and L. Dueck.1998. Sightings of Belugas and other marine mammals in the North Water, late March 1993. Arctic 51:1-4.
*digitized by Nunami Stantec 2010

[4]Stephenson, S.A. and Hartwig, L. 2010. The Arctic Marine Workshop. Fisheries and Oceans Canada, Freshwater Institute. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2934. 67 pp. (shape files provided by DFO to Nunami Stantec) January 20, 2012

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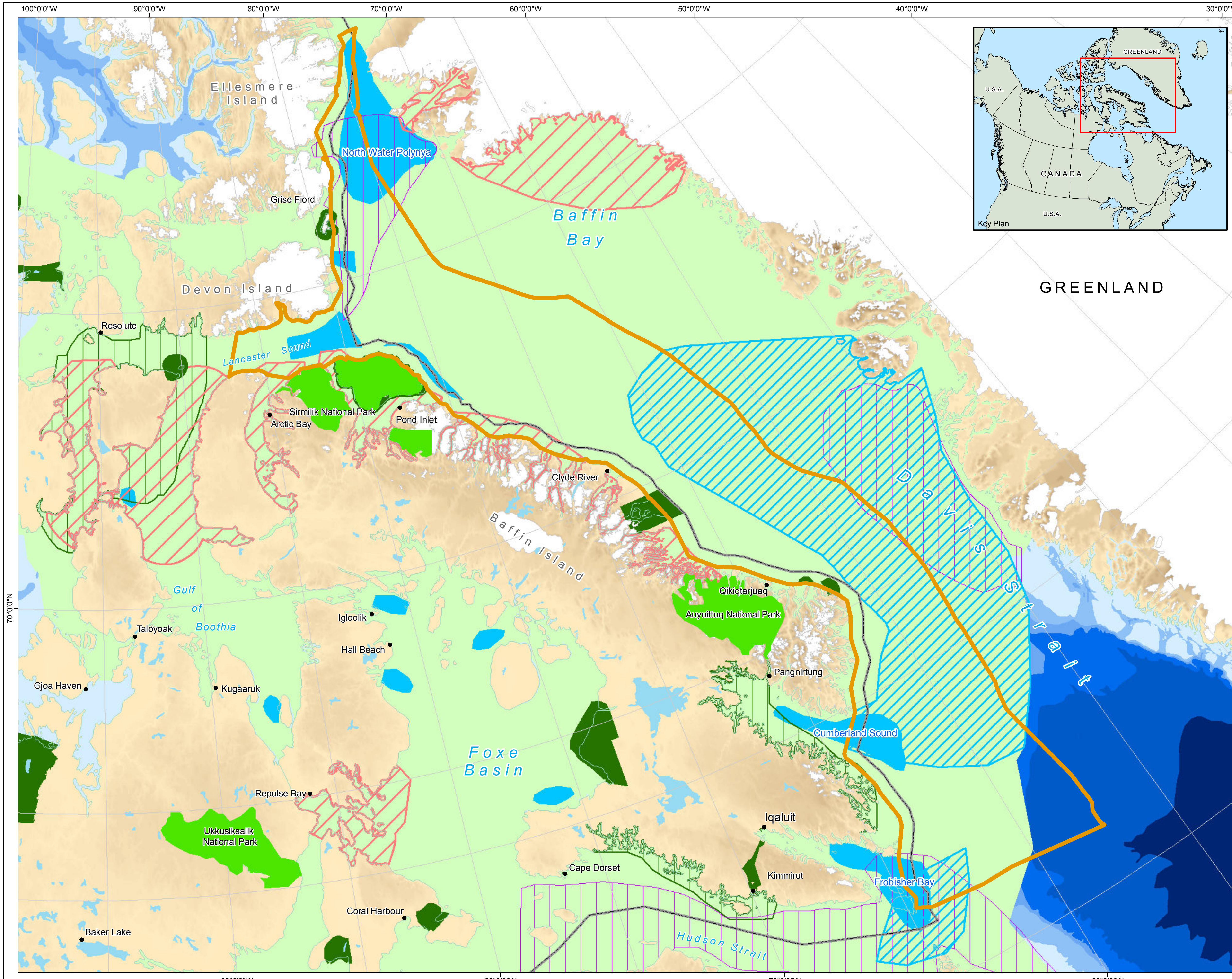

Eastern Arctic, Nunavut, Canada Toothed Whales Seasonal Distribution

Figure 2

- Toothed Whale Distribution [1,2,3,5]
- Beluga Summer Core Area [2,3,5]
- Beluga Winter Range [3]
- Narwhal Summer High Density [1,5]
- Narwhal Winter Concentration [1,5]

Base Features

- Community
- Grid Line
- Ice Cap
- Eastern Arctic Study Area
- Nunavut Regional Boundary
- Conservation Area
- National Park
- Lakes / River
- Polynyas

Depth (m)

- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:7,000,000

50 25 0 50 100 150 200

Kilometres

Prepared By:
Nunami - Stantec

References:

[1]COSEWIC. 2004. Assessment and Update Status Report on the Narwhal *Monodon monoceros* in Canada. Ottawa. vii + 50 pp. (Canadian Wildlife Service, Environment Canada)
*digitized by Nunami Stantec 2010

[2]COSEWIC. 2004. COSEWIC assessment and update status report on the beluga whale, *Delphinapterus leucas*, in Canada. Ottawa. ix + 70 pp. (Canadian Wildlife Service, Environment Canada)
*digitized by Nunami Stantec 2010

[3]DFO. 2002. Beluga. Department of Fisheries and Oceans. Underwater World Series. 8 pp
*digitized by Nunami Stantec 2010

[4]Mallory, M.L. and A.J. Fontaine. 2004. Key marine habitat sites for migratory birds in Nunavut and the NorthwestTerritories. Canadian Wildlife Service Occasional Papers 109.
*digital data provided by CWS, reproduced with the permission of Environment Canada

[5]Stephenson, S.A. and Hartwig, L. 2010. The Arctic Marine Workshop. Fisheries and Oceans Canada, Freshwater Institute. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2934. 67 pp. (shape files provided by DFO to Nunami Stantec) January 20, 2012

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Revision: 02
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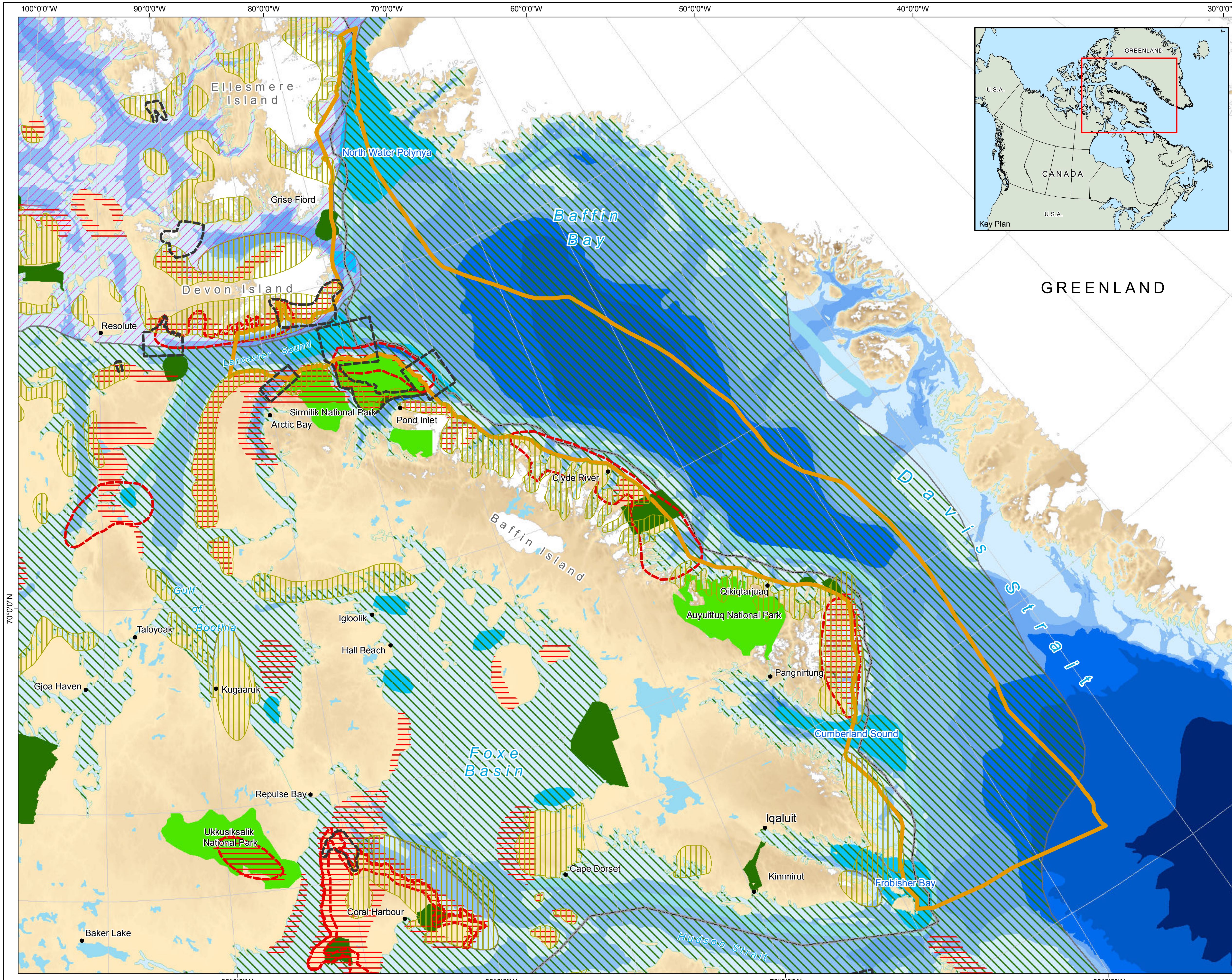

Eastern Arctic, Nunavut, Canada
Polar Bear Range and Key Seasonal Habitat

Figure 03

- WASI - Polar Bear Site [1]
- Shore Lead [5]
- Summer Range [7]
- Winter Range [7]
- Polar Bear Denning Area [3,6,7]
- IBP - Polar Bear Habitat [4]
- Summer Retreat [6]

Base Features

- Community
- Grid Line
- Ice Cap
- Eastern Arctic Study Area
- Nunavut Regional Boundary
- Conservation Area
- National Park
- Lakes / River
- Polynyas

Depth (m)

- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:7,000,000

50 25 0 50 100 150 200

Kilometres

Prepared By:
Nunami - Stantec

References:

[1]Ferguson, S.H. 1995. Wildlife Areas of Special Interest to the Department of Renewable Resources. Wildlife Management Division, Department of Renewable Resources, Government of the Northwest Territories. Nunavut Wildlife Management Board version adapted from original 1987 publications. 80 pp
*digitized by Government of Nunavut 2005

[2]Mallory, M.L. and A.J. Fontaine. 2004. Key marine habitat sites for migratory birds in Nunavut and the Northwest Territories. Canadian Wildlife Service Occasional Papers 109.
*digital data provided by CWS, reproduced with the permission of Environment Canada

[3]Mercier, F., F. Rennie, D. Harvey and C.A. Lewis (Eds.). 1994. Arctic Marine Workshop Proceedings. Winnipeg, Manitoba. Park Establishment Branch, National Parks Directorate, Parks Canada Department of Canadian Heritage.
*digitized by Nunami Stantec 2008

[4]Nettleship, D.N. and P.A. Smith. 1975. Ecological sites in northern Canada. Canadian Committee for the International Biological Programme. 330 pp
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[5]Stirling, I. 1998. Polar Bears. The University of Michigan Press. Ann Arbor, Michigan.
*digitized by Nunami Stantec 2010

[6]Urquhart, D.R. and R.E. Schweinsburg. 1984. Polar bear life history and known distribution of polar bear in the Northwest Territories up to 1981. Northwest Territories Renewable Resources. Yellowknife NWT. 70 pp
*digitized by Government of Nunavut 2005

[7]Stephenson, S.A. and Hartwig, L. 2010. The Arctic Marine Workshop. Fisheries and Oceans Canada, Freshwater Institute. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2934. 67 pp.
(shape files provided by DFO to Nunami Stantec). January 20, 2012

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Revision: 02
Figure ID: 123110432-015

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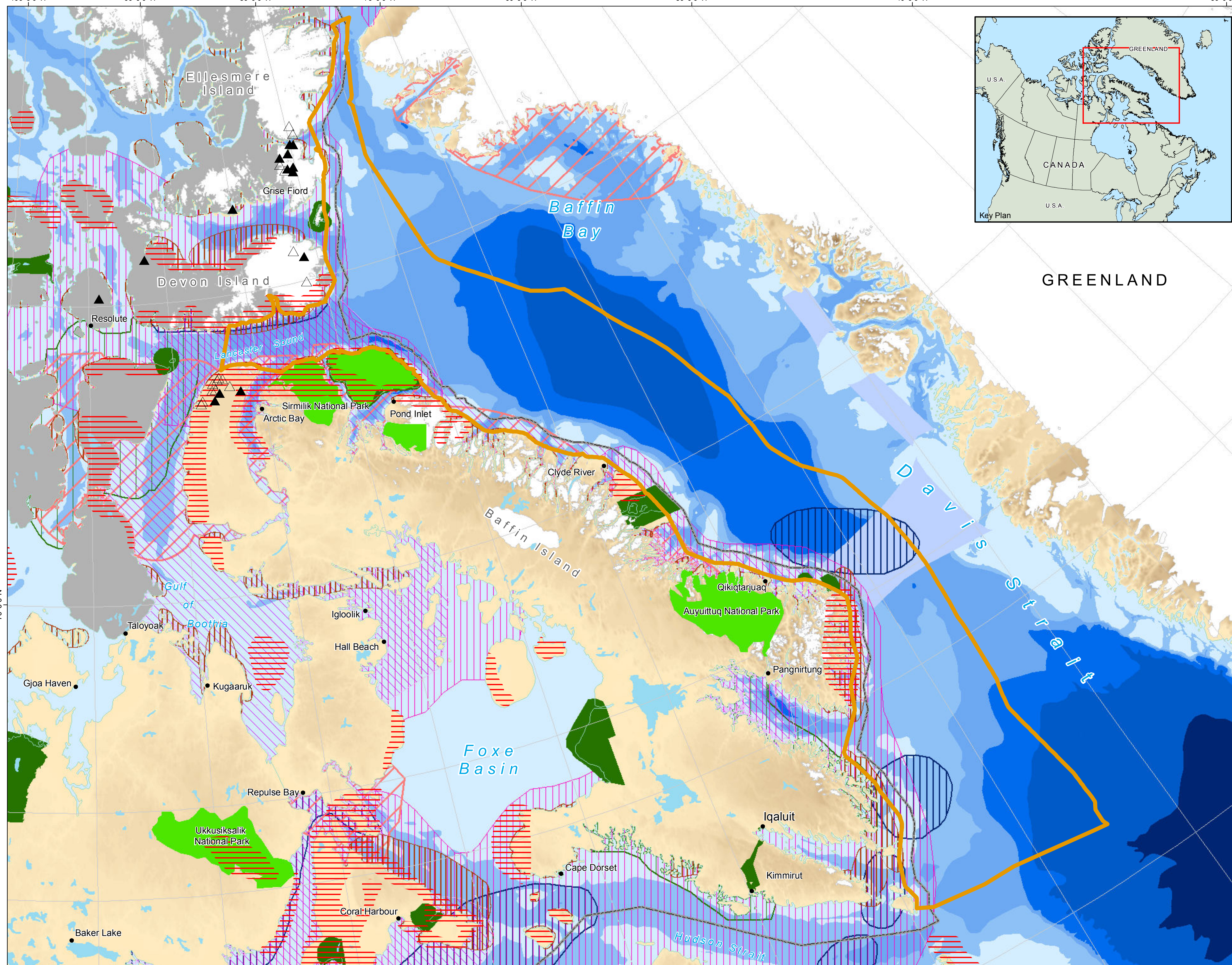

Eastern Arctic, Nunavut, Canada Species Of Conservation Concern Summer Distribution

Figure 04

Beluga Summer Core Area [1,6,9]
Bowhead Whale Summer Aggregation Areas [1,5,9]
Known Ivory Gull Colony [4]
Potential Ivory Gull Colony [4]
Narwhal Summer Concentration [1,9]
Peary Caribou Range
Polar Bear Denning Area [7,8]
Polar Bear Summer Retreat
Walrus Summer Distribution [3]
Walrus Summer Concentration Area [7]
Walrus Transition Zone [9]

Base Features
Community
Grid Line
Ice Cap
Eastern Arctic Study Area
Nunavut Regional Boundary
Conservation Area
National Park
Lakes / River

Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000

1:7,000,000

50 25 0 50 100 150 200
Kilometres

Prepared By:
Nunami - Stantec

References:

[1]COSEWIC. 2004. COSEWIC assessment and update status report on the beluga whale, *Delphinapterus leucas*, in Canada. Ottawa. ix + 70 pp. (Canadian Wildlife Service, Environment Canada)
*digitized by Nunami Stantec 2010

[2]COSEWIC. 2004. Assessment and update status report on the Narwhal *Monodon monoceros* in Canada. Ottawa. vii + 50 pp. (Canadian Wildlife Service, Environment Canada)
*digitized by Nunami Stantec 2010

[3]COSEWIC. 2006. Assessment and update status report on the Atlantic Walrus *Odobenus rosmarus rosmarus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 65pp.
*digitized by Nunami Stantec 2010

[4]COSEWIC. 2006. COSEWIC assessment and update status report on the ivory gull *Pagophila eburnea* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, ON. vi + 42 pp
*digitized by Nunami Stantec 2010

[5]COSEWIC. 2009. COSEWIC assessment and update status report on the bowhead whale *Balaena mysticetus*, Bering-Chukchi-Beaufort population and Eastern Canada-West Greenland population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 49 pp
*digitized by Nunami Stantec 2010

[6]DFO. 2002. Beluga. Department of Fisheries and Oceans. Underwater World Series. 8 pp
*digitized by Nunami Stantec 2010

[7]Mercier, F., F. Rennie, D. Harvey and C.A. Lewis (Eds.). 1994. Arctic Marine Workshop Proceedings. Winnipeg, Manitoba. Park Establishment Branch, National Parks Directorate, Parks Canada Department of Canadian Heritage.
*digitized by Nunami Stantec 2008

[8]Urquhart, D.R. and R.E. Schweinsburg. 1984. Polar bear life history and known distribution of polar bear in the Northwest Territories up to 1981. Northwest Terrotories Renewable Resources. Yellowknife NWT. 70 pp
*digitized by Government of Nunavut 2005

[9]Stephenson, S.A. and Hartwig, L. 2010. The Arctic Marine Workshop. Fisheries and Oceans Canada, Freshwater Institute. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2934. 67 pp.
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Revision: 02
Figure ID: 123110432-021

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APPENDIX F

Cumulative Effects Scenario Results Figures

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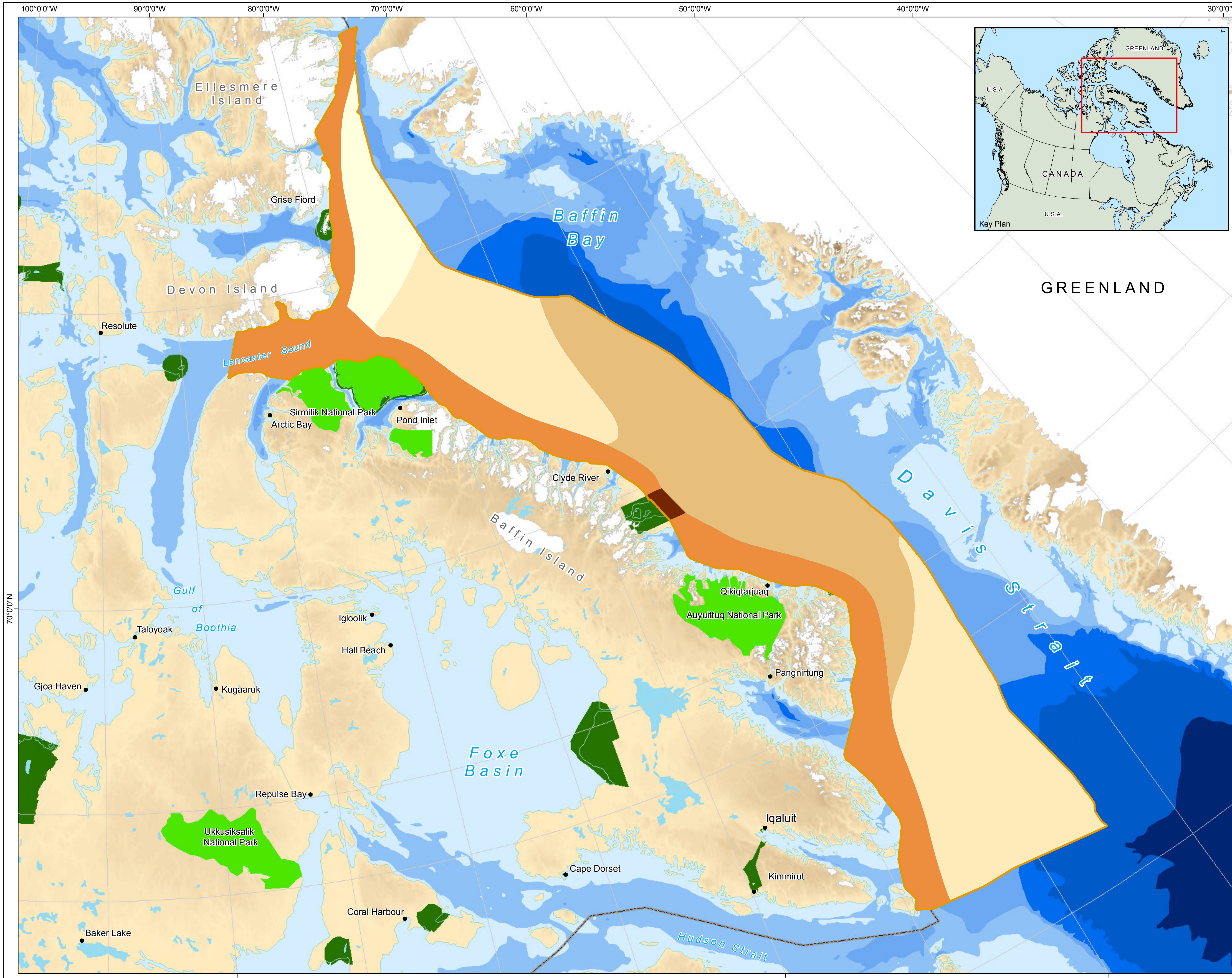
Eastern Arctic, Nunavut, Canada
Bowhead Whale
Summer Sensitivity Rating

Figure 1



Sensitivity Rating
- High
- Moderate / High
- Moderate
- Low / Moderate
- Low

Base Features
- Community
- Grid Line
- Ice Cap
- Eastern Arctic Study Area
- Nunavut Regional Boundary
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:7,000,000

50 25 0 50 100 150 200
Kilometres

Prepared By:
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Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada

Projection: Canada Lambert Conformal Conic, NAD83
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Verified By: JB
Revision: 02
Figure ID: 123110162-006

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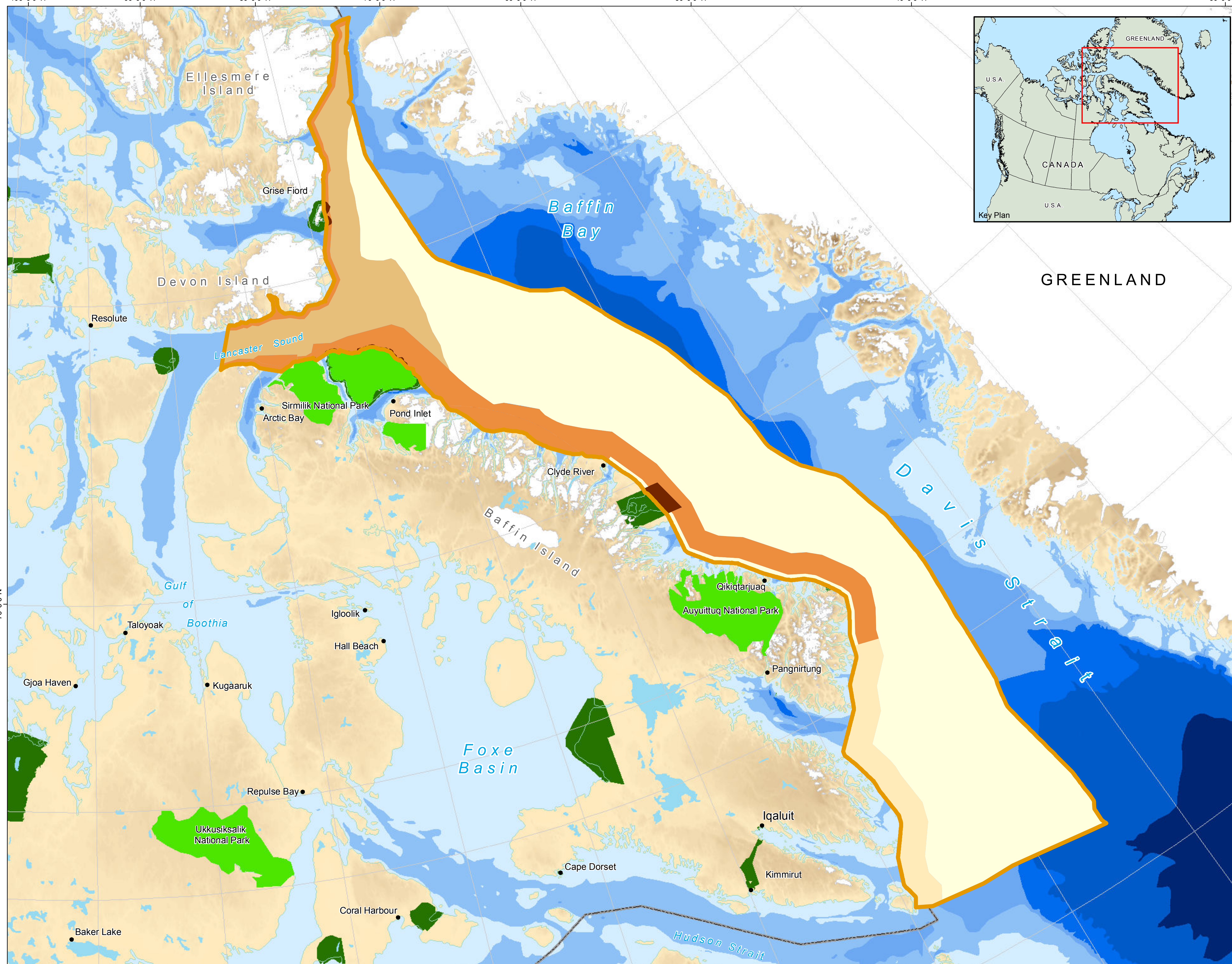
Eastern Arctic, Nunavut, Canada
Toothed Whale
Summer Sensitivity Rating

Figure 2



Sensitivity Rating
- High
- Moderate / High
- Moderate
- Low / Moderate
- Low

Base Features
- Community
- Grid Line
- Ice Cap
- Eastern Arctic Study Area
- Nunavut Regional Boundary
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:7,000,000

50 25 0 50 100 150 200
Kilometres

Prepared By:
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Affaires autochtones et Développement du Nord Canada

Projection: Canada Lambert Conformal Conic, NAD83
Date: 23 Mar 2012
Produced By: B Alleyne
Verified By: JB
Revision: 01
Figure ID: 123110162-026

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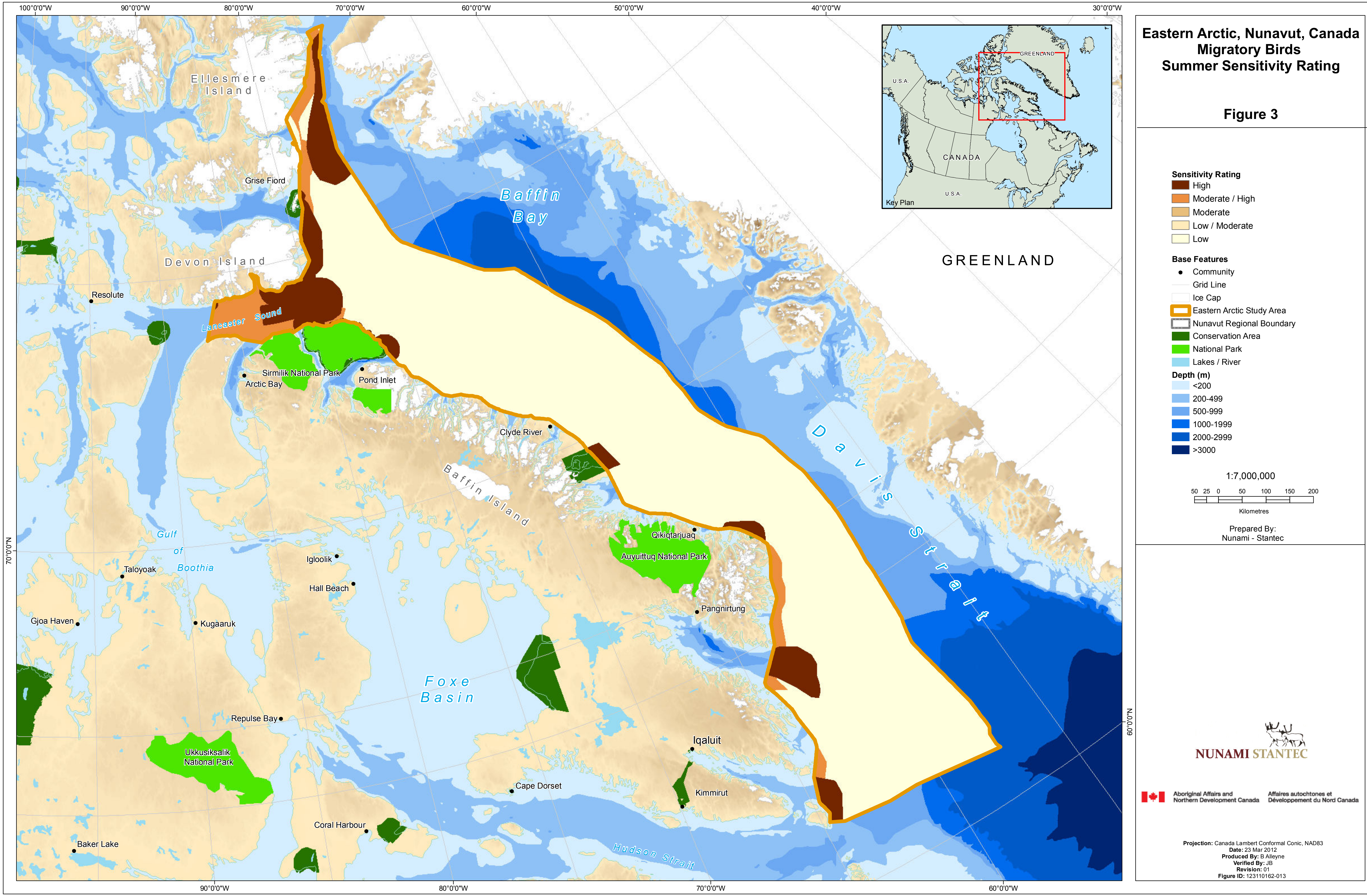

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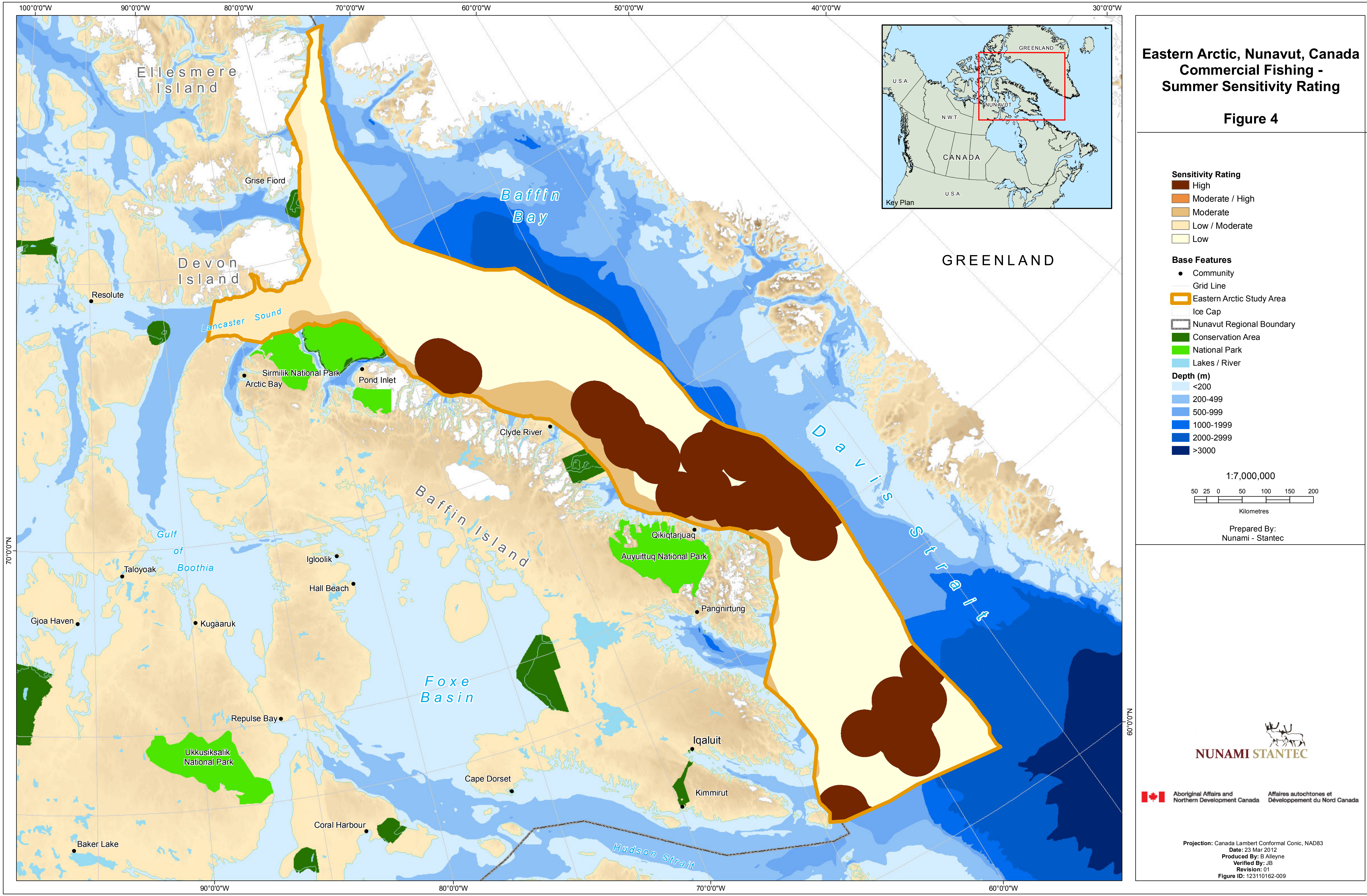

Eastern Arctic, Nunavut, Canada
Commercial Fishing -
Summer Sensitivity Rating
Figure 4
Sensitivity Rating
High
Moderate / High
Moderate
Low / Moderate
Low
Base Features
Community
Grid Line
Eastern Arctic Study Area
Ice Cap
Nunavut Regional Boundary
Conservation Area
National Park
Lakes / River
Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000
1:7,000,000
Kilometres
Prepared By:
Nunami - Stantec
Key Plan
GREENLAND
NUNAVUT
N.W.T.
CANADA
U.S.A.
Ellesmere Island
Devon Island
Baffin Bay
GREENLAND
Davis Strait
Baffin Island
Gulf of Boothia
Foxe Basin
Hudson Strait
Lancaster Sound
Grise Fiord
Resolute
Sirmilik National Park
Arctic Bay
Pond Inlet
Clyde River
Qikiqtarjuaq
Auyuittuq National Park
Pangnirtung
Igloolik
Hall Beach
Taloyoak
Gjoa Haven
Kugaaruk
Repulse Bay
Ukkusiksalik National Park
Iqaluit
Cape Dorset
Kimmirut
Coral Harbour
Baker Lake
100°0'0"W
90°0'0"W
80°0'0"W
70°0'0"W
60°0'0"W
50°0'0"W
40°0'0"W
30°0'0"W
70°0'0"N
60°0'0"N
NUNAMI STANTEC
Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada
Projection: Canada Lambert Conformal Conic, NAD83
Date: 23 Mar 2012
Produced By: B Alleyne
Verified By: JB
Revision: 01
Figure ID: 123110162-009
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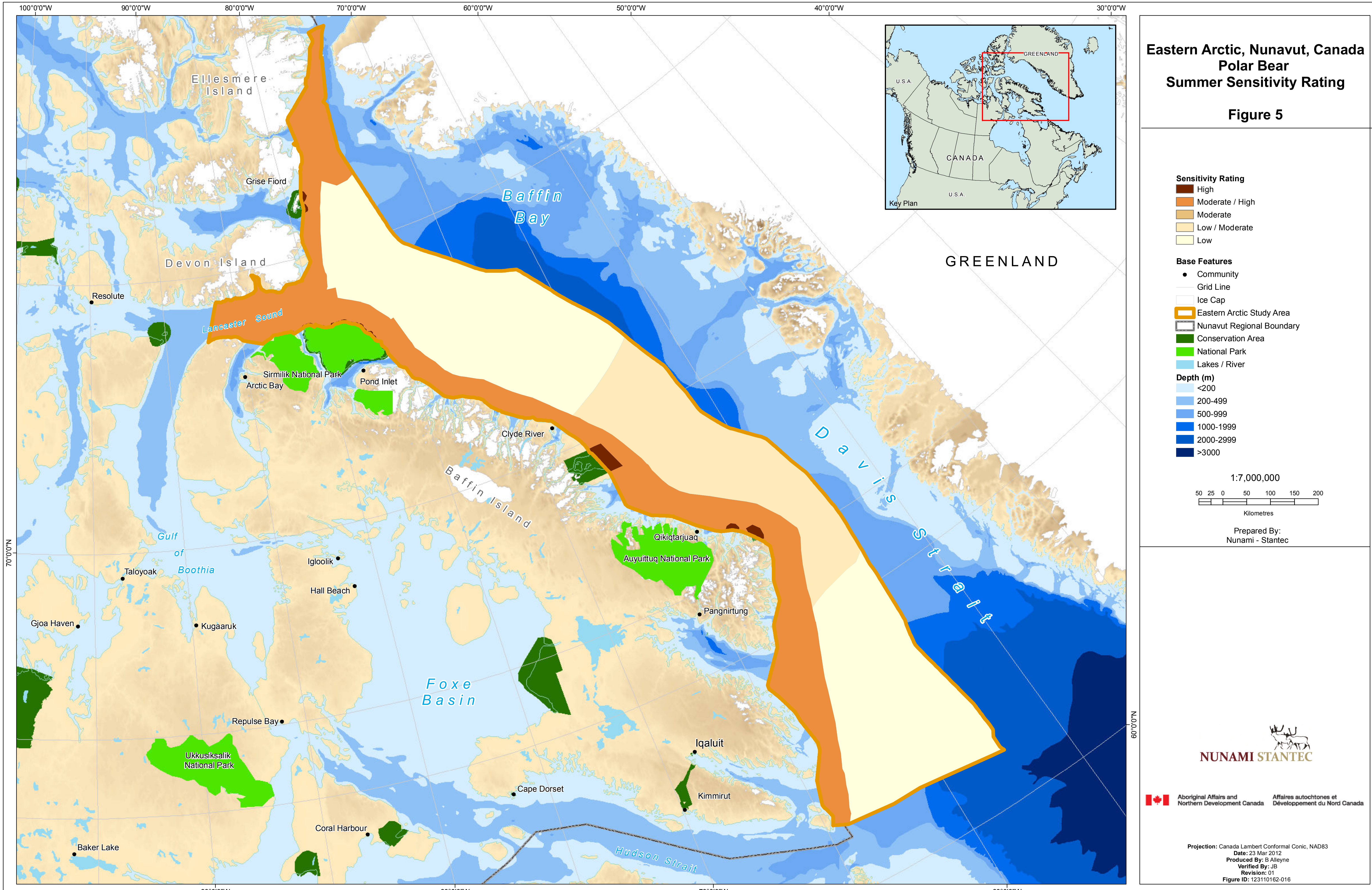

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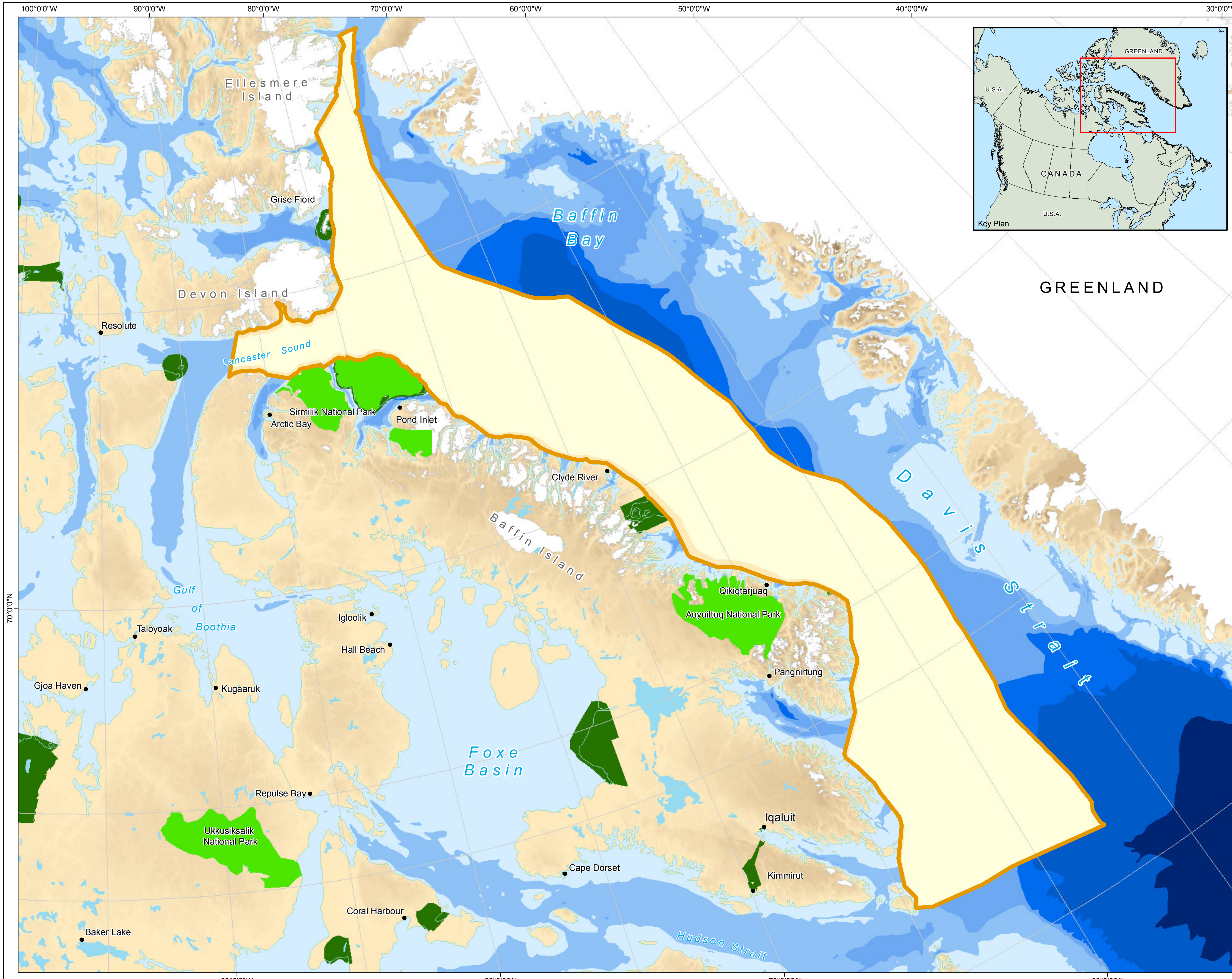
Eastern Arctic, Nunavut, Canada
Arctic Char
Summer Sensitivity Rating

Figure 6



Sensitivity Rating
- High
- Moderate / High
- Moderate
- Low / Moderate
- Low

Base Features
- Community
- Grid Line
- Ice Cap
- Eastern Arctic Study Area
- Nunavut Regional Boundary
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:7,000,000

50 25 0 50 100 150 200

Kilometres

Prepared By:
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Revision: 02
Figure ID: 123110162-003

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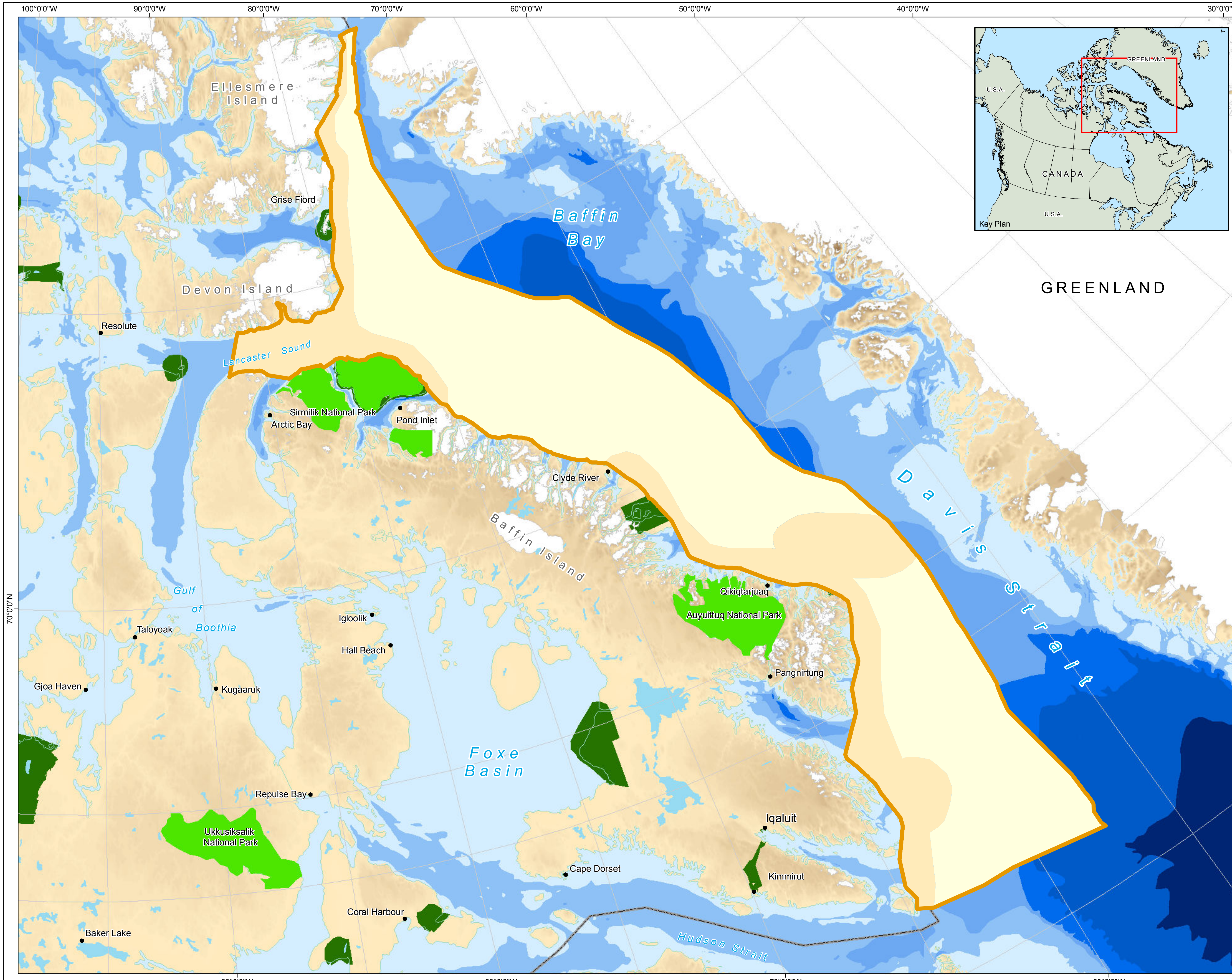
Eastern Arctic, Nunavut, Canada
Walrus
Summer Sensitivity Rating

Figure 7



Sensitivity Rating
- High
- Moderate / High
- Moderate
- Low / Moderate
- Low

Base Features
- Community
- Grid Line
- Ice Cap
- Eastern Arctic Study Area
- Nunavut Regional Boundary
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:7,000,000

50 25 0 50 100 150 200
Kilometres

Prepared By:
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Revision: 01
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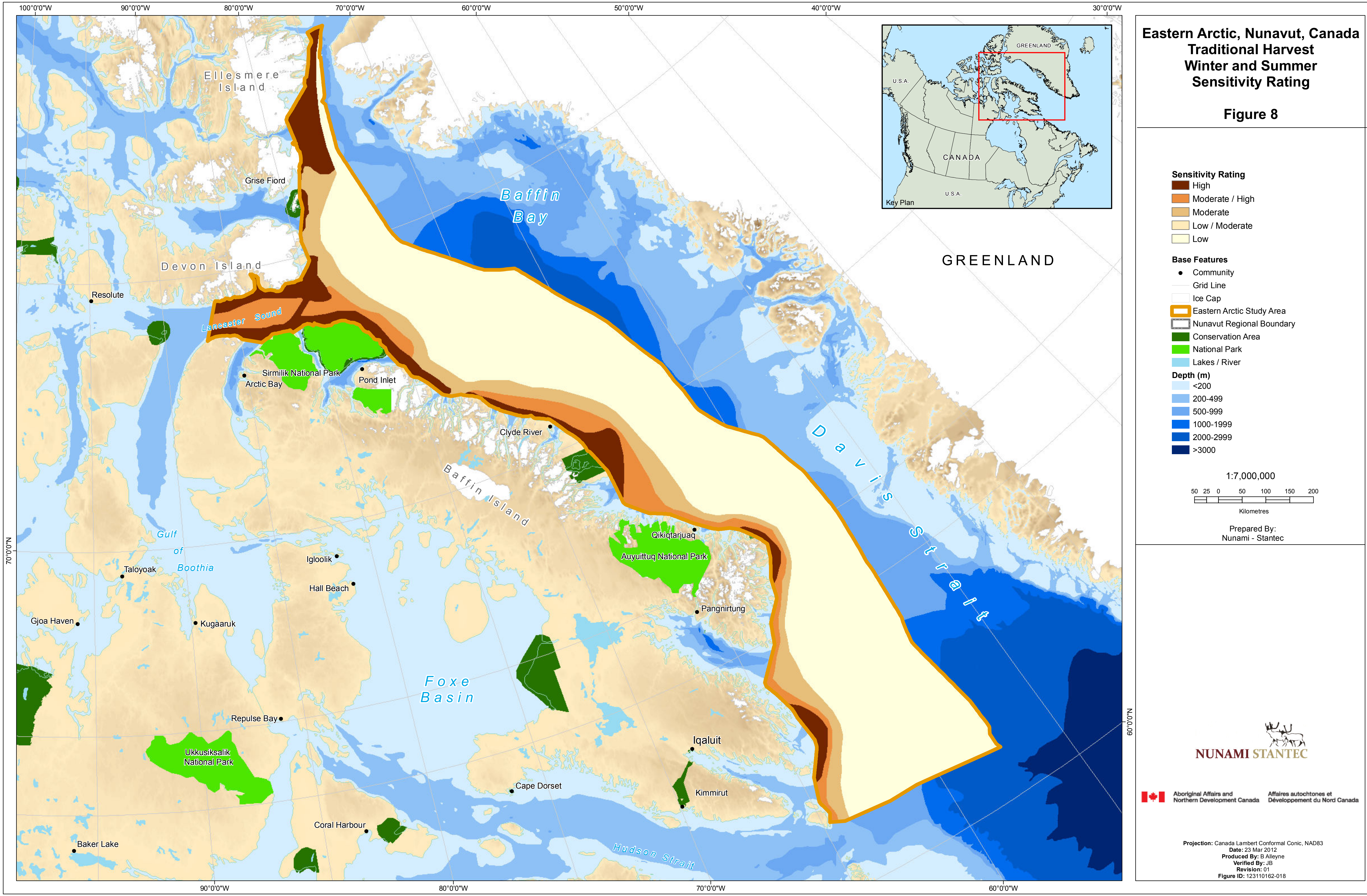

Eastern Arctic, Nunavut, Canada
Traditional Harvest
Winter and Summer
Sensitivity Rating
Figure 8
Sensitivity Rating
High
Moderate / High
Moderate
Low / Moderate
Low
Base Features
Community
Grid Line
Ice Cap
Eastern Arctic Study Area
Nunavut Regional Boundary
Conservation Area
National Park
Lakes / River
Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000
1:7,000,000
50 25 0 50 100 150 200
Kilometres
Prepared By:
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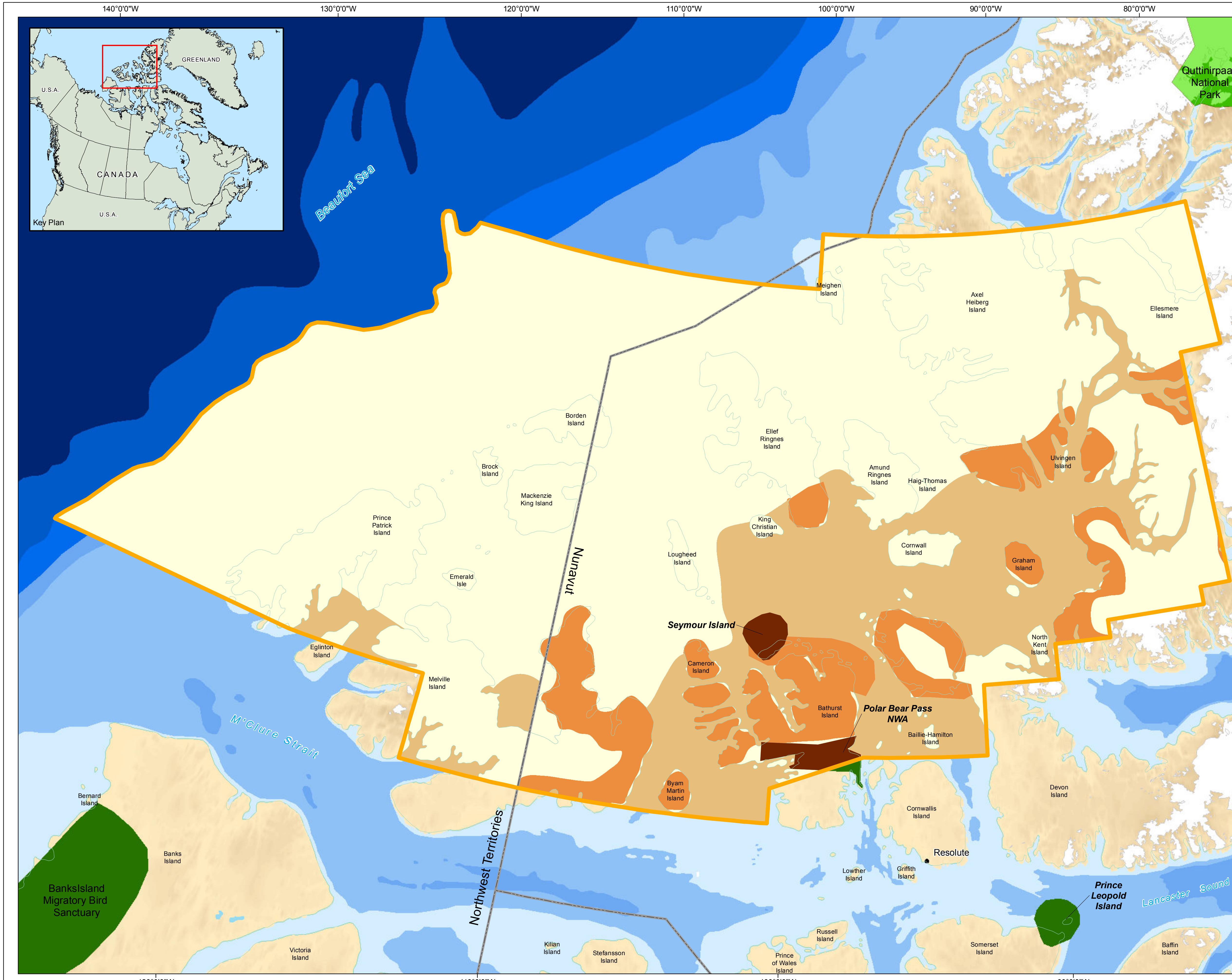
Affaires autochtones et Développement du Nord Canada
Projection: Canada Lambert Conformal Conic, NAD83
Date: 23 Mar 2012
Produced By: B Alleyne
Verified By: JB
Revision: 01
Figure ID: 123110162-018
Key Plan
GREENLAND
U.S.A.
CANADA
U.S.A.
GREENLAND
Ellesmere Island
Devon Island
Baffin Bay
Davis Strait
Lancaster Sound
Baffin Island
Gulf of Boothia
Foxe Basin
Hudson Strait
Grise Fiord
Resolute
Sirmilik National Park
Arctic Bay
Pond Inlet
Clyde River
Qikiqtarjuaq
Auyuittuq National Park
Pangnirtung
Igloolik
Hall Beach
Taloyoak
Gjoa Haven
Kugaaruk
Repulse Bay
Ukkusiksalik National Park
Iqaluit
Cape Dorset
Kimmirut
Coral Harbour
Baker Lake
100°0'0"W
90°0'0"W
80°0'0"W
70°0'0"W
60°0'0"W
50°0'0"W
40°0'0"W
30°0'0"W
70°0'0"N
60°0'0"N
Filepath: R:\2010Stantec\123110162_INAC_EasternArctic\gis\Figures\Sensitivity\20120321\123110162_INAC_Fig08_EasternArctic_TraditionalHarvest_Sensitivity.mxd

High Arctic Study Area
Polar Bear
Summer and Winter
Sensitivity Rating
Figure 9



Sensitivity Rating
- High
- Moderate / High
- Moderate
- Low / Moderate
- Low

Base Features
- Community
- High Arctic Study Area
- Ice Cap
- Nunavut Regional Boundary
- National Park
- Conservation Area

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:4,000,000

25 12.5 0 25 50 75 100

Kilometres

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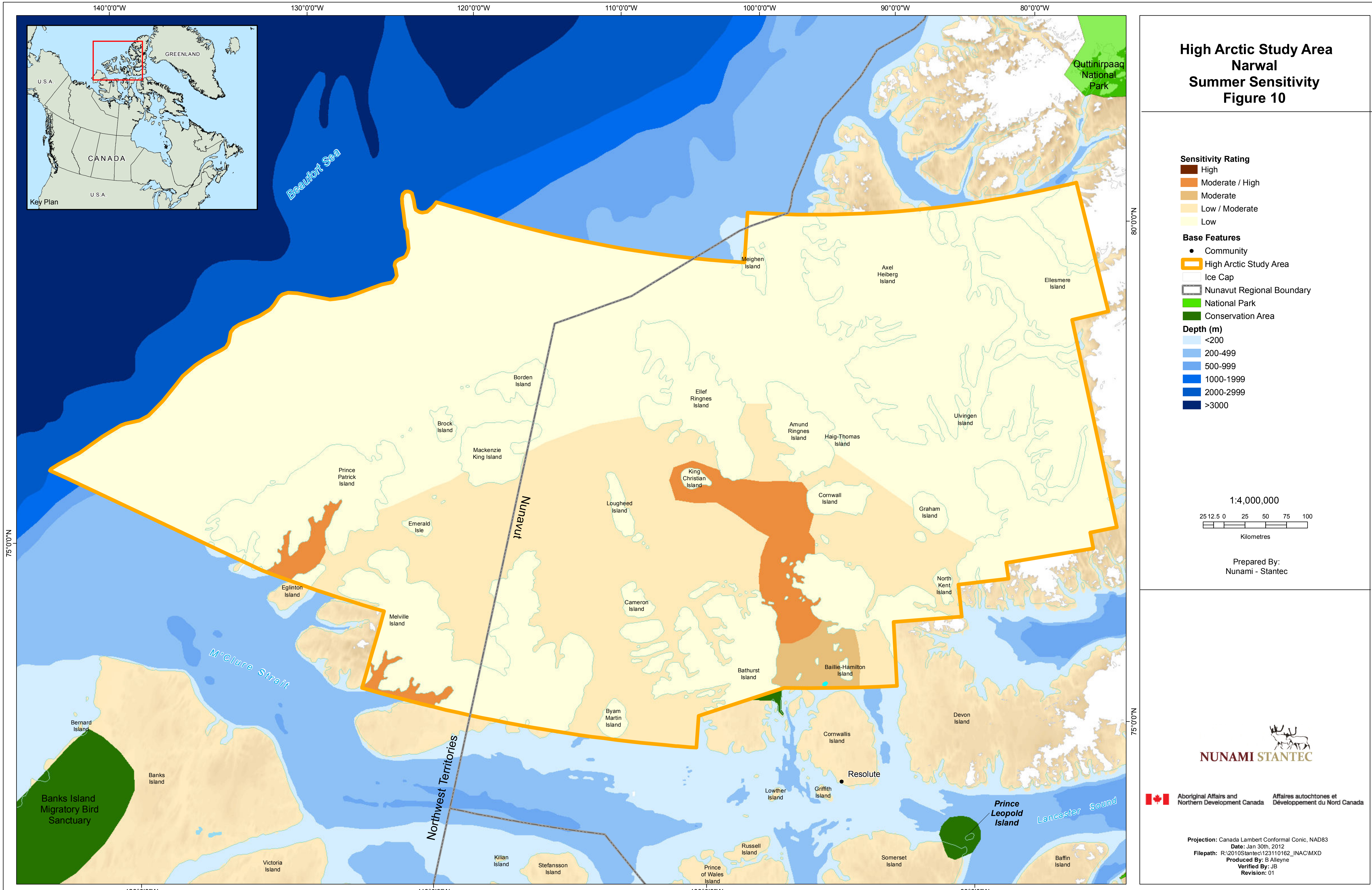
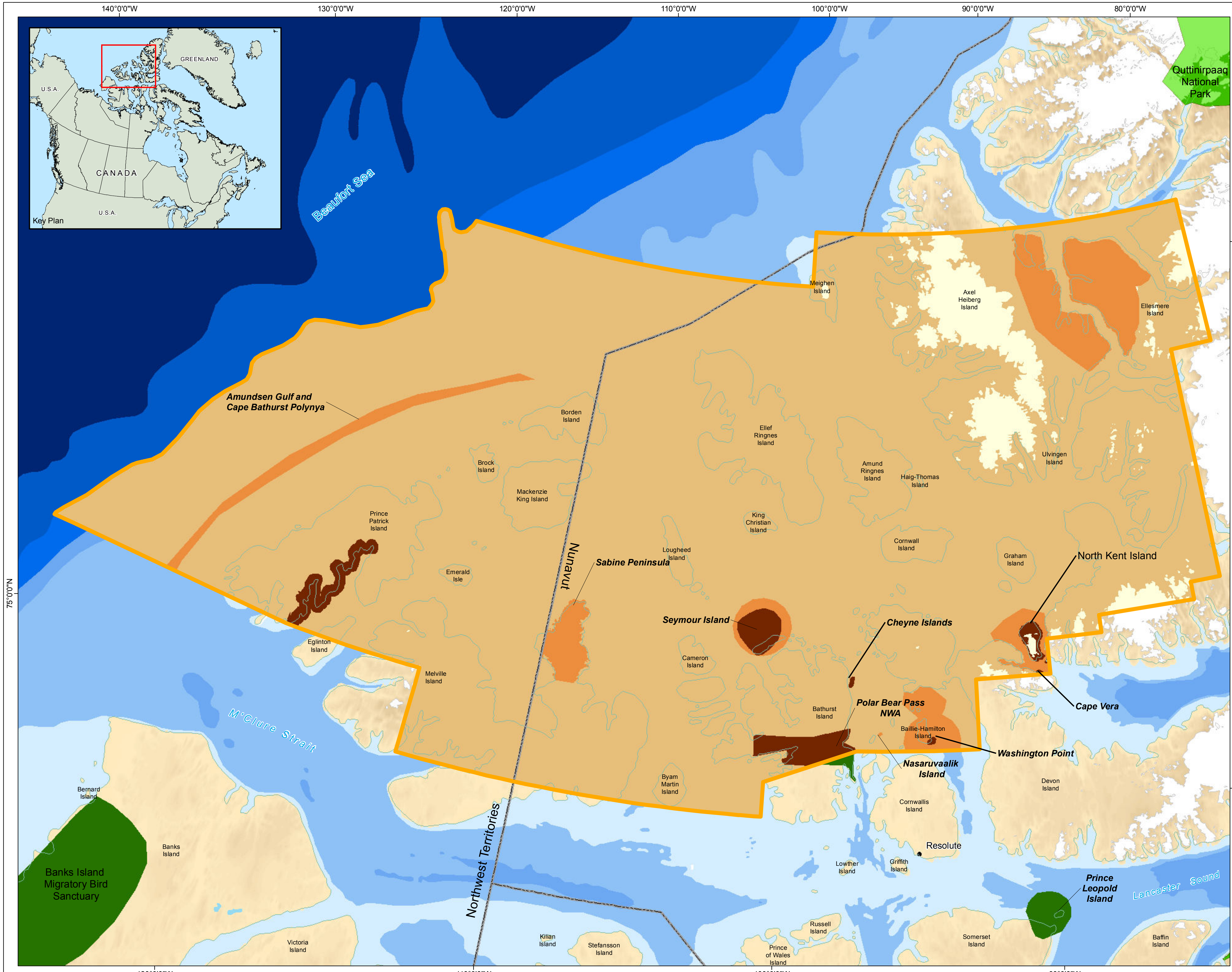

High Arctic Study Area
Narwal
Summer Sensitivity
Figure 10
Sensitivity Rating
High
Moderate / High
Moderate
Low / Moderate
Low
Base Features
Community
High Arctic Study Area
Ice Cap
Nunavut Regional Boundary
National Park
Conservation Area
Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000
1:4,000,000
25 12.5 0 25 50 75 100
Kilometres
Prepared By:
Nunami - Stantec
NUNAMI STANTEC
Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada
Projection: Canada Lambert Conformal Conic, NAD83
Date: Jan 30th, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: B Alleyne
Verified By: JB
Revision: 01
Key Plan
GREENLAND
U.S.A.
CANADA
U.S.A.
Beaufort Sea
M'Clure Strait
Lancaster Sound
Quttinirpaaq National Park
Banks Island Migratory Bird Sanctuary
Nunavut
Northwest Territories
Meighen Island
Axel Heiberg Island
Ellesmere Island
Borden Island
Ellef Ringnes Island
Brock Island
Mackenzie King Island
Amund Ringnes Island
Haig-Thomas Island
Ulvingen Island
Prince Patrick Island
King Christian Island
Cornwall Island
Lougheed Island
Graham Island
Emerald Isle
Eglinton Island
Melville Island
Cameron Island
North Kent Island
Bathurst Island
Baillie-Hamilton Island
Byam Martin Island
Bernard Island
Banks Island
Cornwallis Island
Devon Island
Resolute
Lowther Island
Griffith Island
Prince Leopold Island
Russell Island
Prince of Wales Island
Somerset Island
Baffin Island
Kilian Island
Stefansson Island
Victoria Island
140°0'0"W
130°0'0"W
120°0'0"W
110°0'0"W
100°0'0"W
90°0'0"W
80°0'0"W
80°0'0"N
75°0'0"N



High Arctic Study Area Migratory Birds Summer Sensitivity Rating Figure 11

Sensitivity Rating
- High
- Moderate / High
- Moderate
- Low / Moderate
- Low

Base Features
- Community
- High Arctic Study Area
- Ice Cap
- Nunavut Regional Boundary
- National Park
- Conservation Area

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:4,000,000

25 12.5 0 25 50 75 100
Kilometres

Prepared By:
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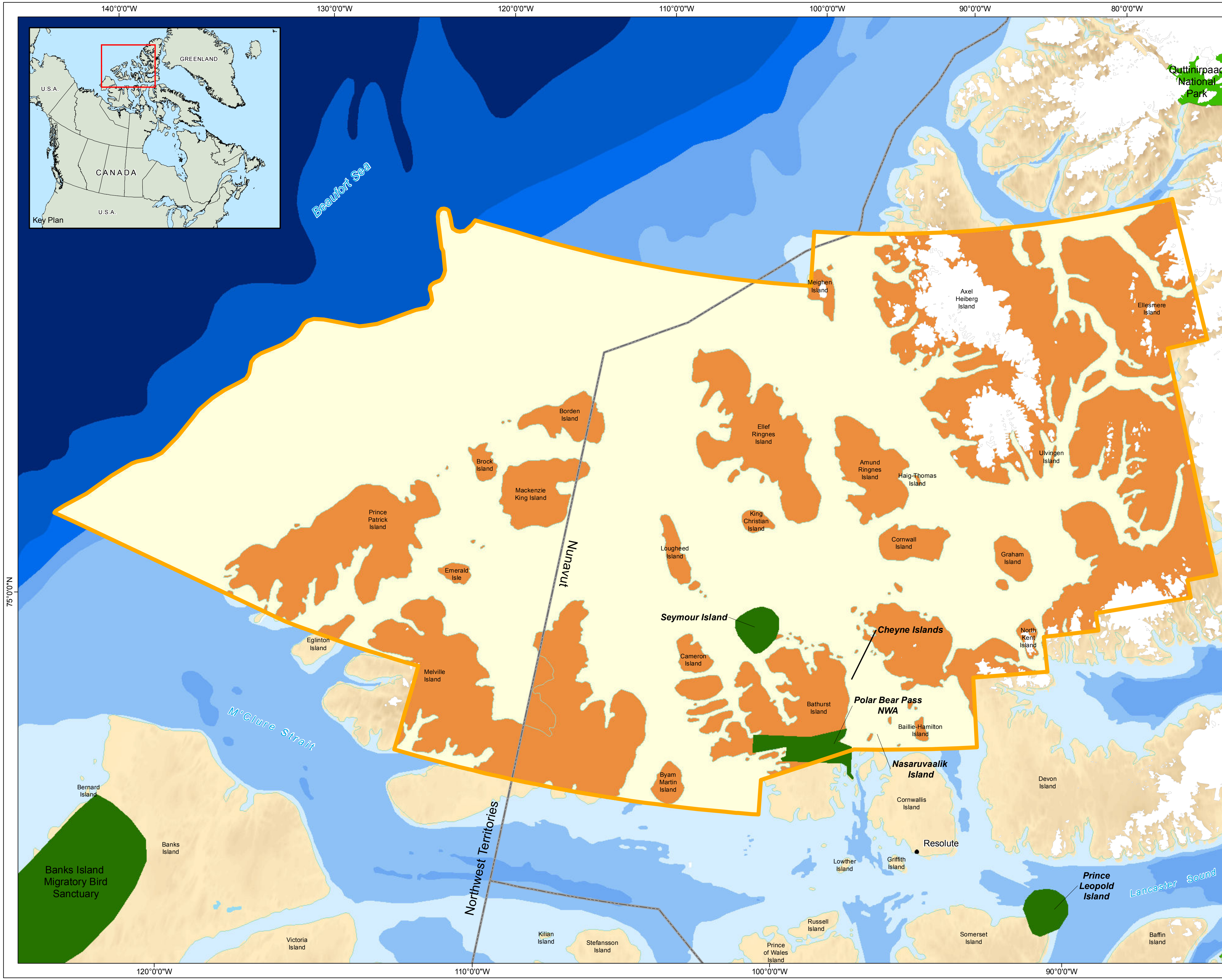
Revision: 01



High Arctic Study Area
Peary Caribou
Summer and Winter Sensitivity
Figure 12

Sensitivity Rating
- High
- Moderate / High
- Moderate
- Low / Moderate
- Low

Base Features
- Community
- High Arctic Study Area
- Ice Cap
- Nunavut Regional Boundary
- National Park
- Conservation Area

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:4,000,000

25 12.5 0 25 50 75 100
Kilometres

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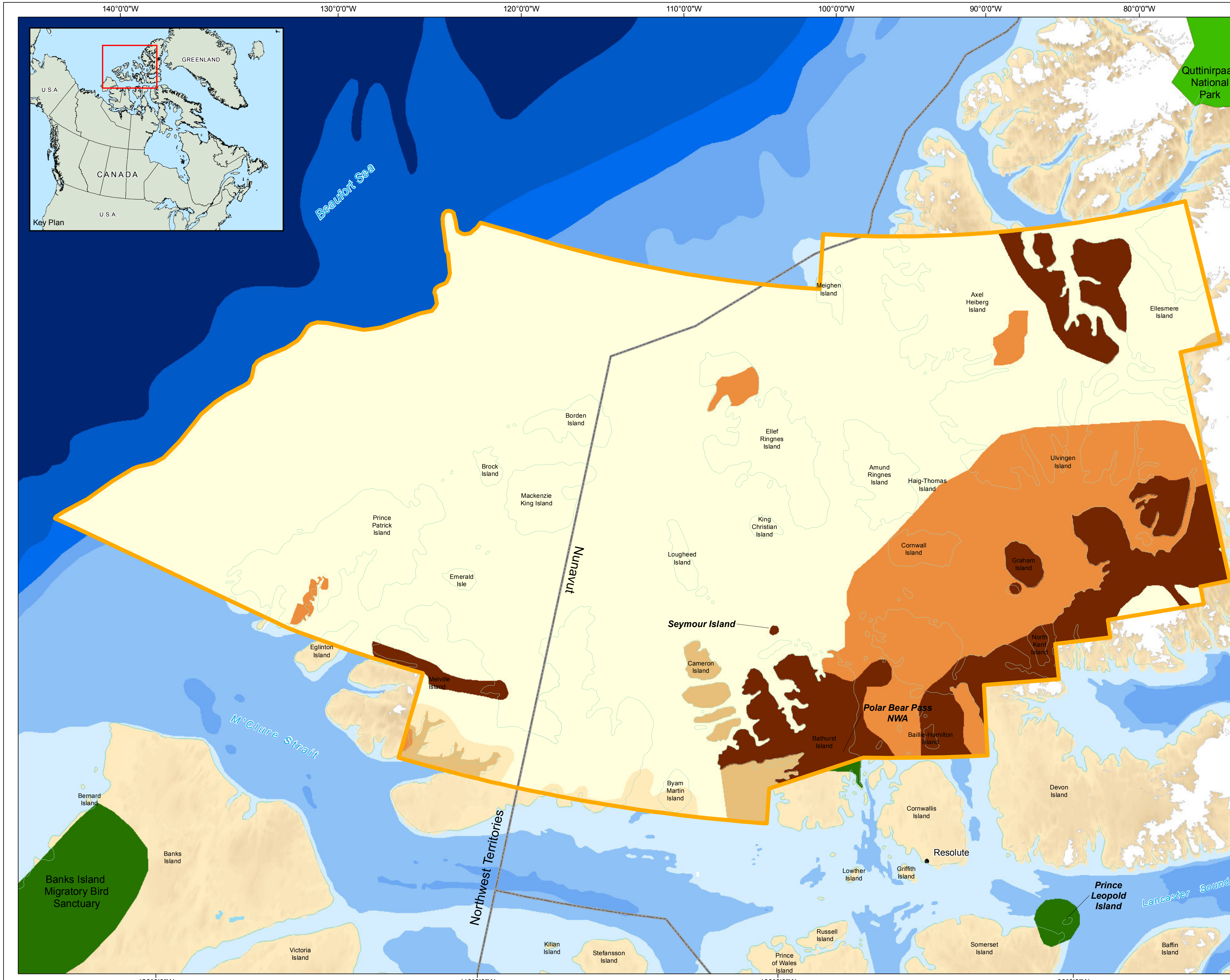
Revision: 01

High Arctic Study Area Traditional Harvest Winter and Summer Sensitivity Rating
Figure 13



Sensitivity Rating
- High
- Moderate / High
- Moderate
- Low / Moderate
- Low

Base Features
- Community
- High Arctic Study Area
- Ice Cap
- Nunavut Regional Boundary
- National Park
- Conservation Area

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:4,000,000

25 12.5 0 25 50 75 100
Kilometres

Prepared By:
Nunami - Stantec

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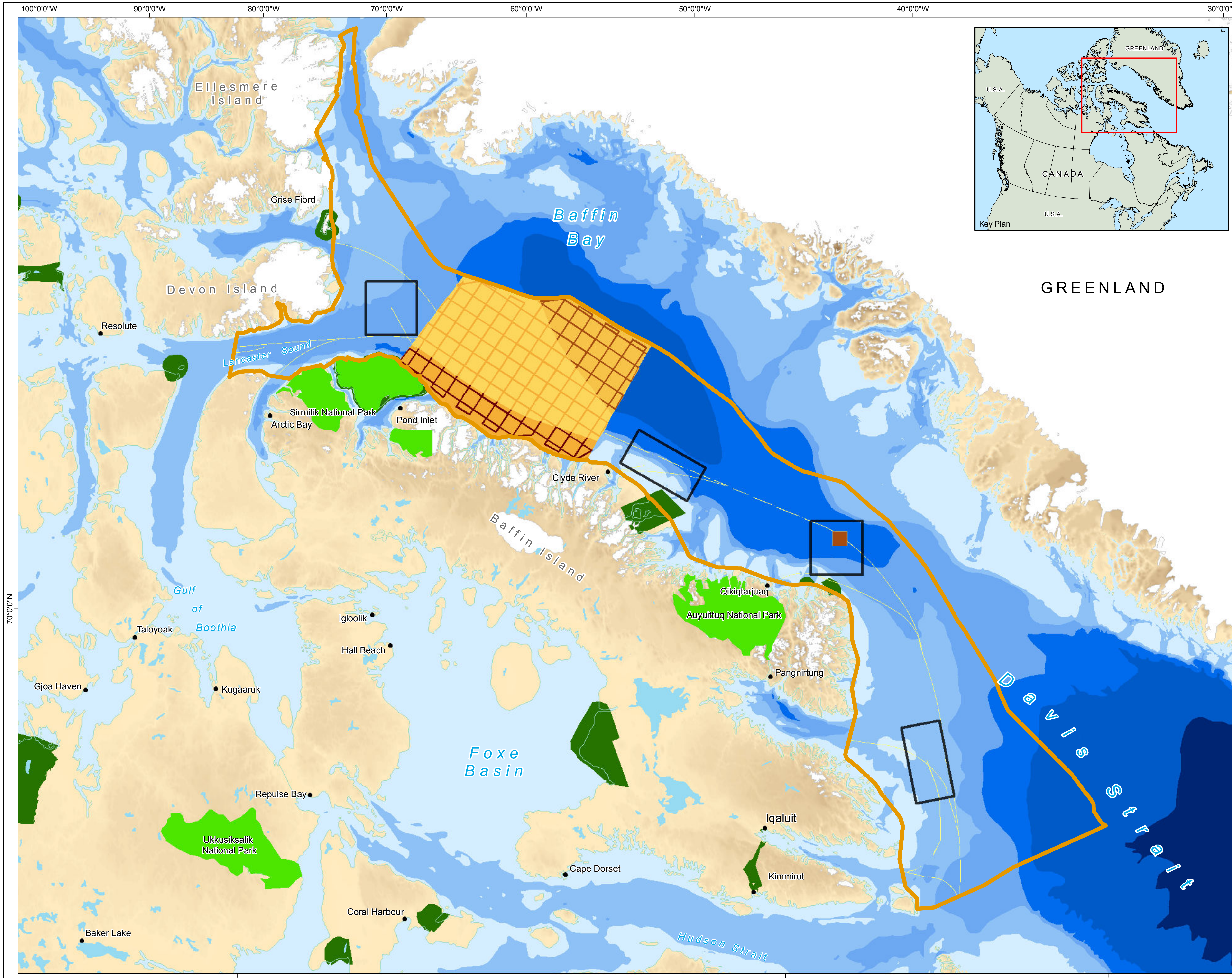
Affaires autochtones et Développement du Nord Canada

Projection: Canada Lambert Conformal Conic, NAD83
Date: Jan 30th, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: B Alleyne
Verified By: JB
Revision: 01

Eastern Arctic
PEMT Cumulative Effects Scenario
Bowhead
Summer Minimum Effect

Figure 14



Cumulative Effects
- Minimum
- Maximum

Base Features
- Community
- Scenario Block
- Ice Cap
- Eastern Arctic Study Area
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:7,000,000

50 25 0 50 100 150 200
Kilometres

Prepared By:
Nunami - Stantec

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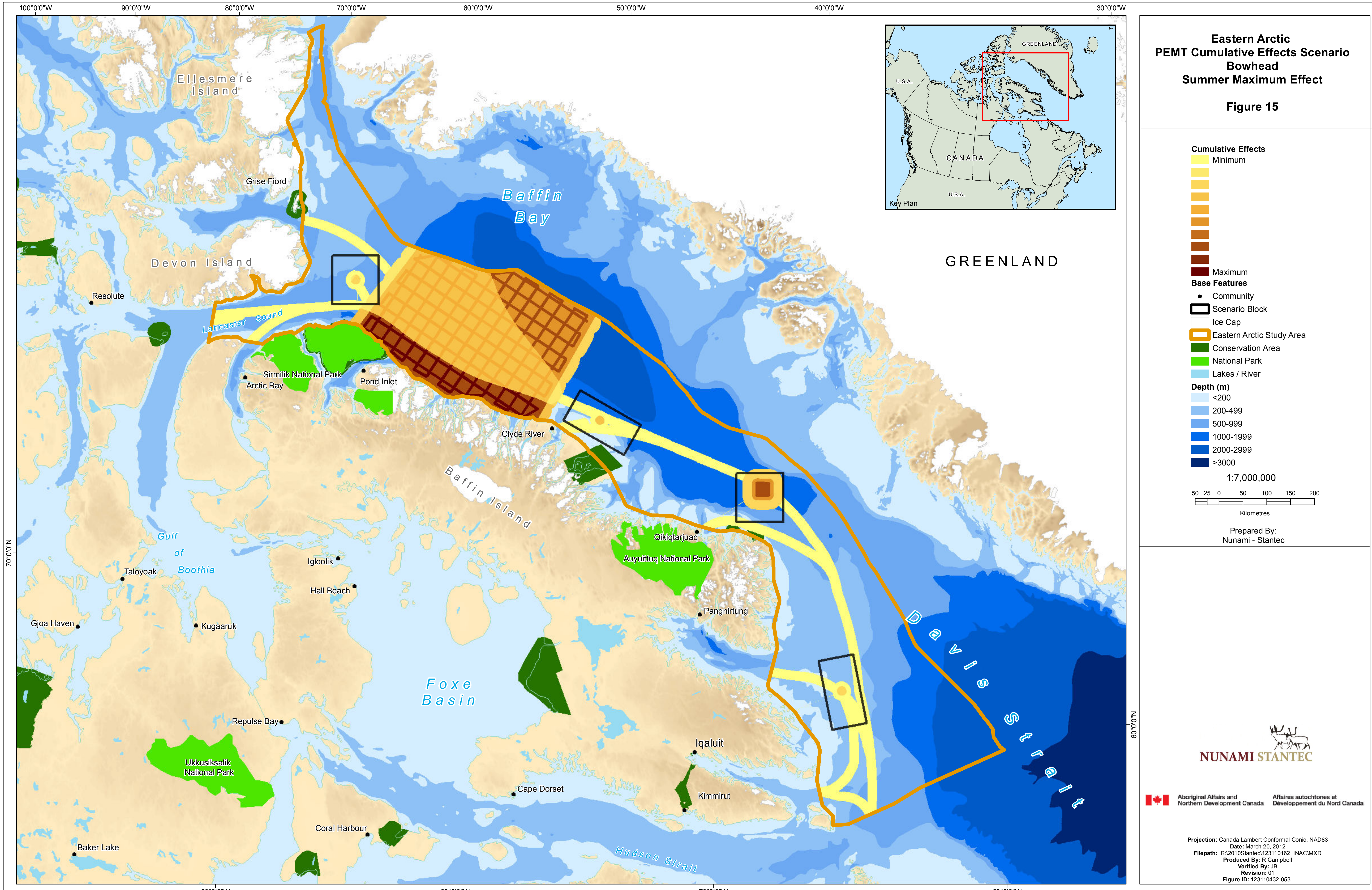
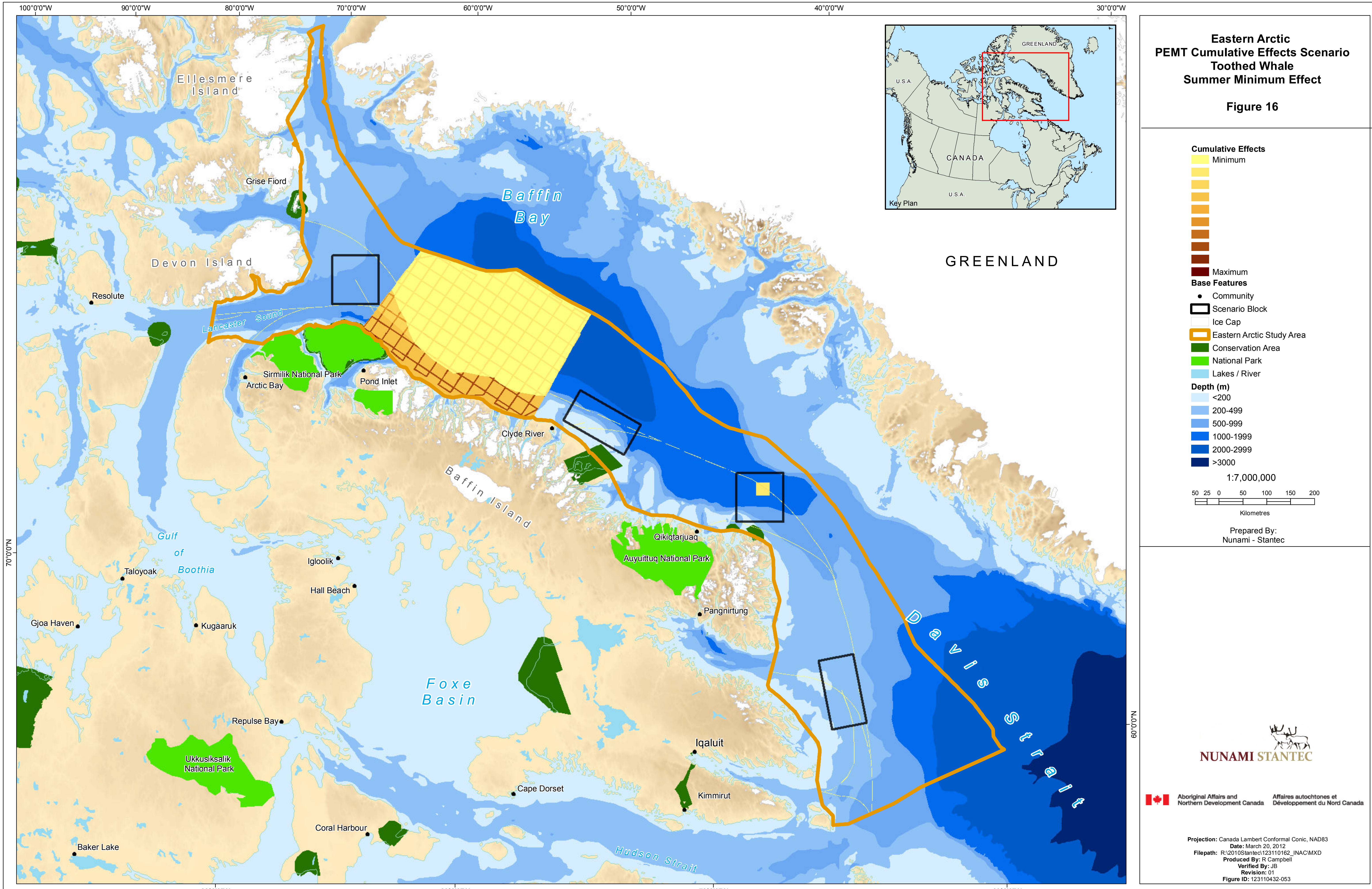
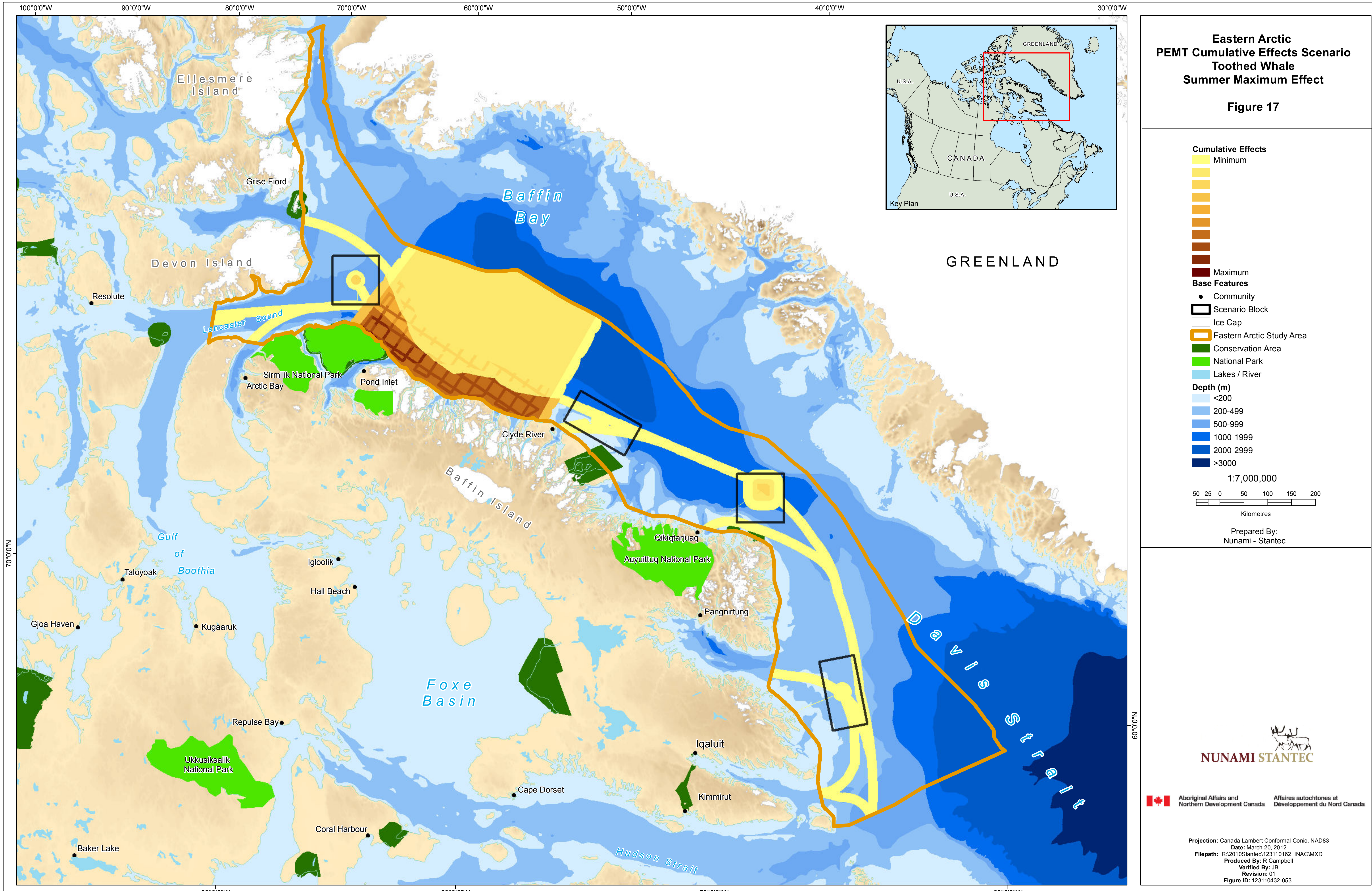
Projection: Canada Lambert Conformal Conic, NAD83
Date: March 20, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-053



Eastern Arctic
PEMT Cumulative Effects Scenario
Bowhead
Summer Maximum Effect
Figure 15
Cumulative Effects
Minimum
Maximum
Base Features
Community
Scenario Block
Ice Cap
Eastern Arctic Study Area
Conservation Area
National Park
Lakes / River
Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000
1:7,000,000
50 25 0 50 100 150 200
Kilometres
Prepared By:
Nunami - Stantec
NUNAMI STANTEC
Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada
Projection: Canada Lambert Conformal Conic, NAD83
Date: March 20, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-053
GREENLAND
U.S.A.
CANADA
U.S.A.
Key Plan
100°0'0"W
90°0'0"W
80°0'0"W
70°0'0"W
60°0'0"W
50°0'0"W
40°0'0"W
30°0'0"W
70°0'0"N
60°0'0"N
Ellesmere Island
Grise Fiord
Baffin Bay
Devon Island
Resolute
Lancaster Sound
Sirmilik National Park
Arctic Bay
Pond Inlet
Clyde River
Baffin Island
Qikiqtarjuaq
Auyuittuq National Park
Pangnirtung
Davis Strait
Gulf of Boothia
Taloyoak
Igloolik
Hall Beach
Gjoa Haven
Kugaaruk
Foxe Basin
Repulse Bay
Ukkusiksalik National Park
Iqaluit
Cape Dorset
Kimmirut
Coral Harbour
Baker Lake
Hudson Strait



Eastern Arctic
PEMT Cumulative Effects Scenario
Toothed Whale
Summer Minimum Effect
Figure 16
Cumulative Effects
Minimum
Maximum
Base Features
Community
Scenario Block
Ice Cap
Eastern Arctic Study Area
Conservation Area
National Park
Lakes / River
Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000
1:7,000,000
50 25 0 50 100 150 200
Kilometres
Prepared By:
Nunami - Stantec
NUNAMI STANTEC
Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada
Projection: Canada Lambert Conformal Conic, NAD83
Date: March 20, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-053
Key Plan
GREENLAND
U.S.A.
CANADA
U.S.A.
100°0'0"W
90°0'0"W
80°0'0"W
70°0'0"W
60°0'0"W
50°0'0"W
40°0'0"W
30°0'0"W
70°0'0"N
60°0'0"N
Ellesmere Island
Grise Fiord
Baffin Bay
Devon Island
Resolute
Lancaster Sound
Sirmilik National Park
Arctic Bay
Pond Inlet
Clyde River
Baffin Island
GREENLAND
Qikiqtarjuaq
Auyuittuq National Park
Pangnirtung
Davis Strait
Gulf of Boothia
Taloyoak
Igloolik
Hall Beach
Gjoa Haven
Kugaaruk
Foxe Basin
Repulse Bay
Iqaluit
Ukkusiksalik National Park
Cape Dorset
Kimmirut
Coral Harbour
Baker Lake
Hudson Strait



Eastern Arctic
PEMT Cumulative Effects Scenario
Toothed Whale
Summer Maximum Effect
Figure 17
Cumulative Effects
Minimum
Maximum
Base Features
Community
Scenario Block
Ice Cap
Eastern Arctic Study Area
Conservation Area
National Park
Lakes / River
Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000
1:7,000,000
50 25 0 50 100 150 200
Kilometres
Prepared By:
Nunami - Stantec
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Aboriginal Affairs and Northern Development Canada
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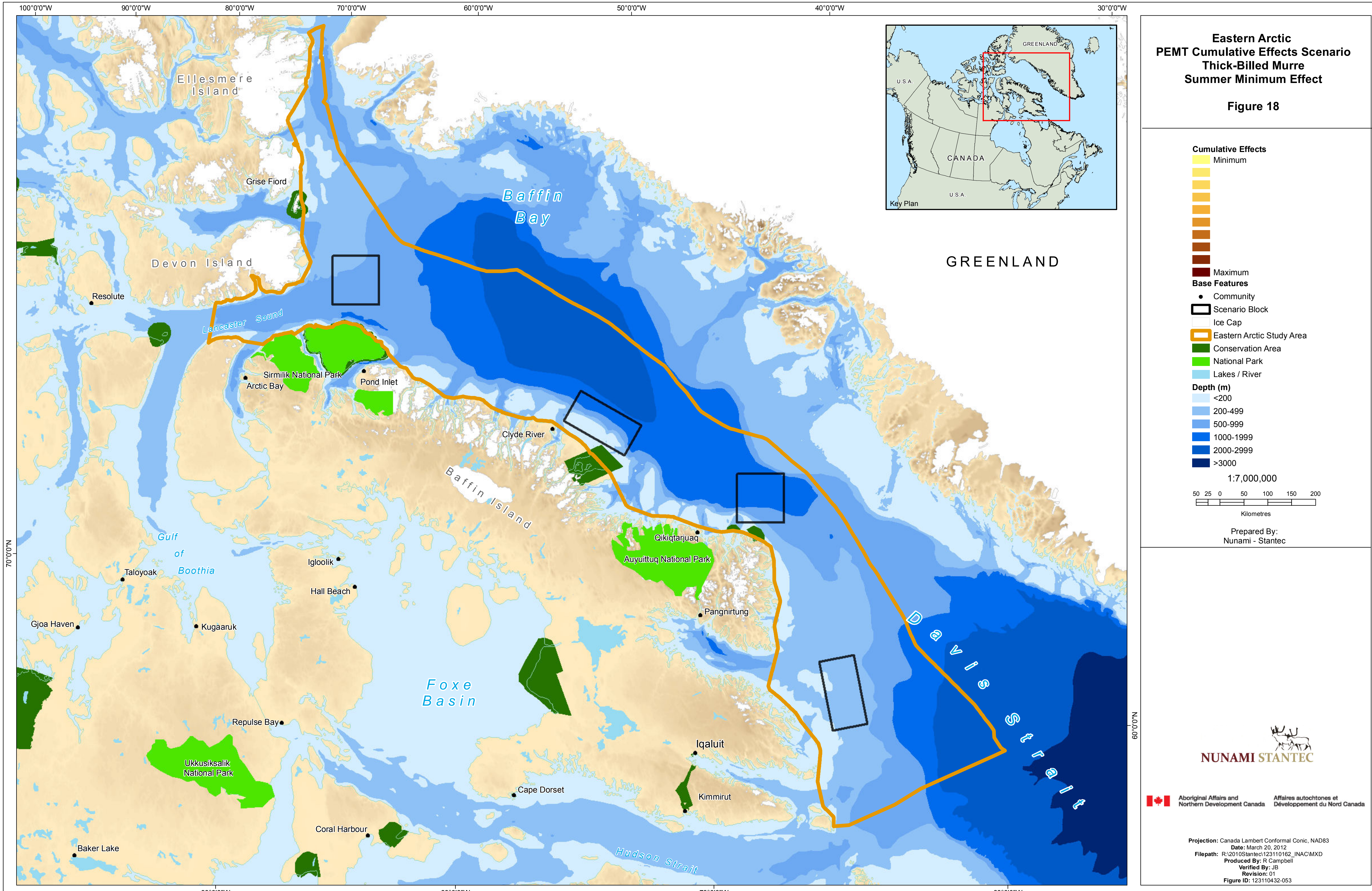
Projection: Canada Lambert Conformal Conic, NAD83
Date: March 20, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-053
Key Plan
GREENLAND
U.S.A.
CANADA
Ellesmere Island
Grise Fiord
Devon Island
Resolute
Lancaster Sound
Baffin Bay
GREENLAND
Sirmilik National Park
Arctic Bay
Pond Inlet
Clyde River
Baffin Island
Qikiqtarjuaq
Auyuittuq National Park
Pangnirtung
Davis Strait
Gulf of Boothia
Taloyoak
Igloolik
Hall Beach
Gjoa Haven
Kugaaruk
Foxe Basin
Repulse Bay
Ukkusiksalik National Park
Iqaluit
Cape Dorset
Kimmirut
Coral Harbour
Baker Lake
Hudson Strait
100°0'0"W
90°0'0"W
80°0'0"W
70°0'0"W
60°0'0"W
50°0'0"W
40°0'0"W
30°0'0"W
70°0'0"N
60°0'0"N



Eastern Arctic
PEMT Cumulative Effects Scenario
Thick-Billed Murre
Summer Minimum Effect
Figure 18
Cumulative Effects
Minimum
Maximum
Base Features
Community
Scenario Block
Ice Cap
Eastern Arctic Study Area
Conservation Area
National Park
Lakes / River
Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000
1:7,000,000
50 25 0 50 100 150 200
Kilometres
Prepared By:
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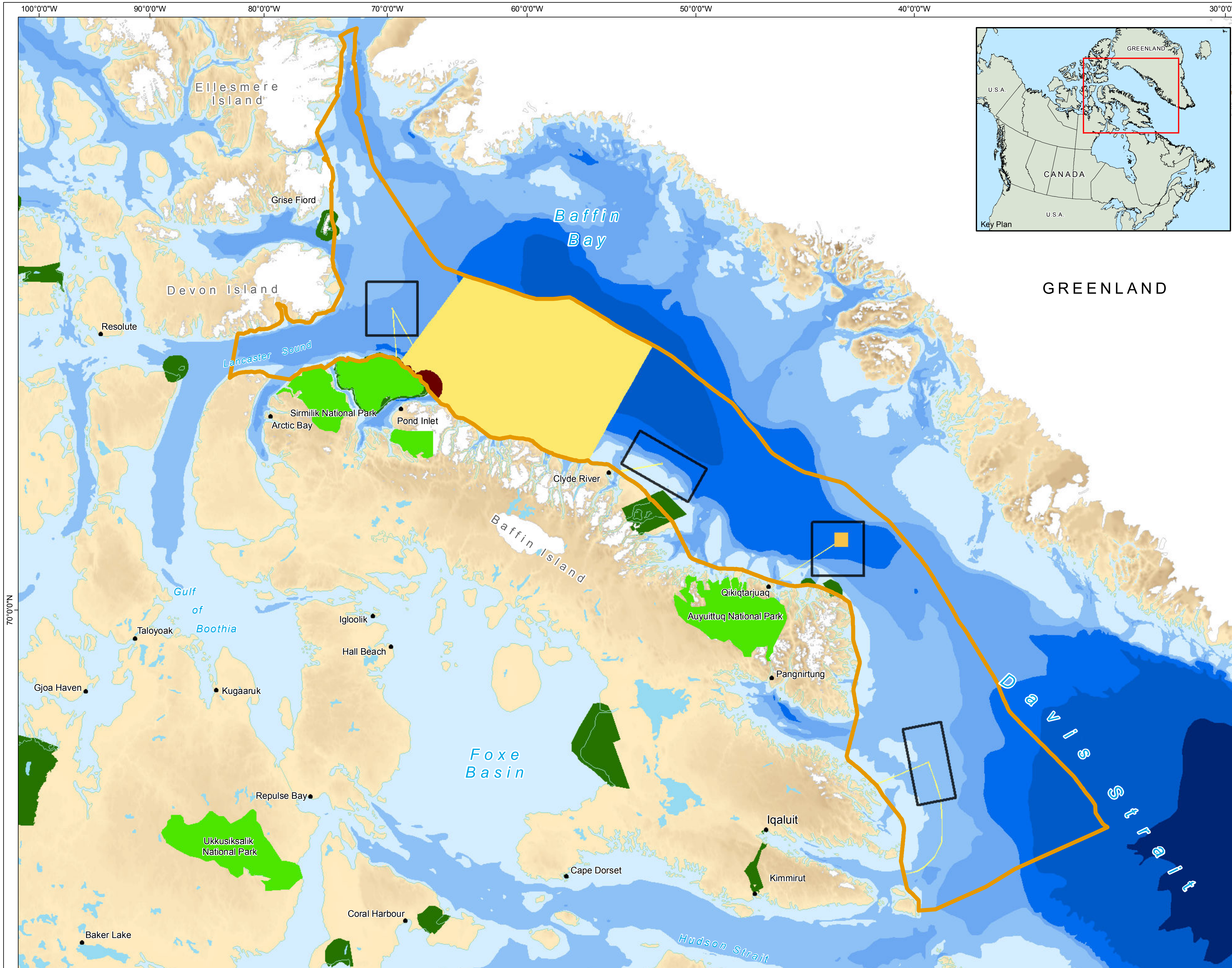
Projection: Canada Lambert Conformal Conic, NAD83
Date: March 20, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-053
GREENLAND
U.S.A.
CANADA
U.S.A.
Key Plan
100°0'0"W
90°0'0"W
80°0'0"W
70°0'0"W
60°0'0"W
50°0'0"W
40°0'0"W
30°0'0"W
70°0'0"N
60°0'0"N
Ellesmere Island
Grise Fiord
Devon Island
Resolute
Lancaster Sound
Baffin Bay
GREENLAND
Sirmilik National Park
Arctic Bay
Pond Inlet
Clyde River
Baffin Island
Qikiqtarjuaq
Auyuittuq National Park
Pangnirtung
Davis Strait
Gulf of Boothia
Taloyoak
Igloolik
Hall Beach
Gjoa Haven
Kugaaruk
Foxe Basin
Repulse Bay
Iqaluit
Ukkusiksalik National Park
Cape Dorset
Kimmirut
Coral Harbour
Baker Lake
Hudson Strait



Eastern Arctic
PEMT Cumulative Effects Scenario
Thick-Billed Murre
Summer Maximum Effect

Figure 19

Cumulative Effects
- Minimum
- Maximum

Base Features
- Community
- Scenario Block
- Ice Cap
- Eastern Arctic Study Area
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:7,000,000

50 25 0 50 100 150 200

Kilometres

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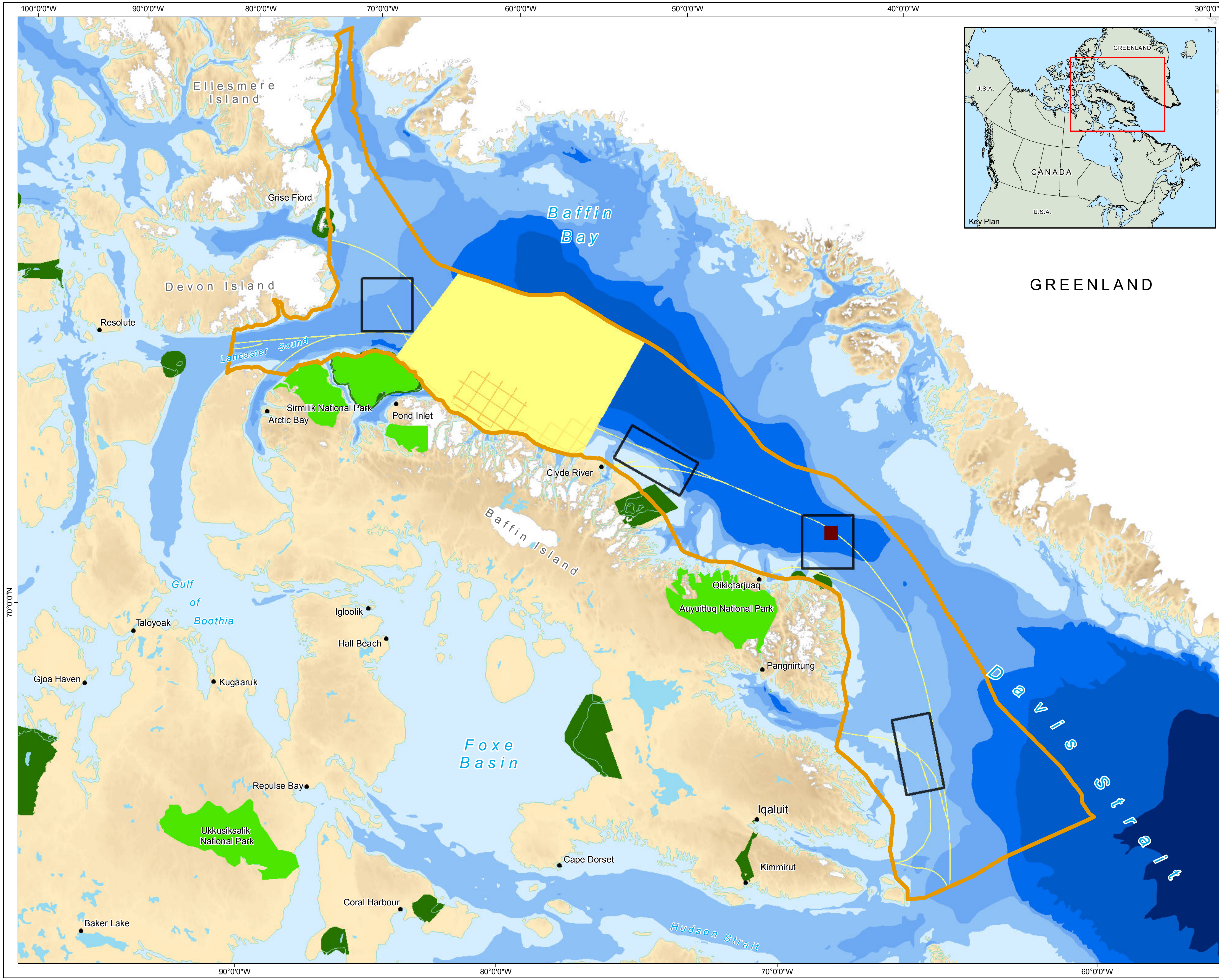
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-053



Eastern Arctic
PEMT Cumulative Effects Scenario
Commercial Turbot Fishing
Summer Minimum Effect

Figure 20

Cumulative Effects
Minimum
Maximum

Base Features
Community
Scenario Block
Ice Cap
Eastern Arctic Study Area
Conservation Area
National Park
Lakes / River

Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000

1:7,000,000

50 25 0 50 100 150 200
Kilometres

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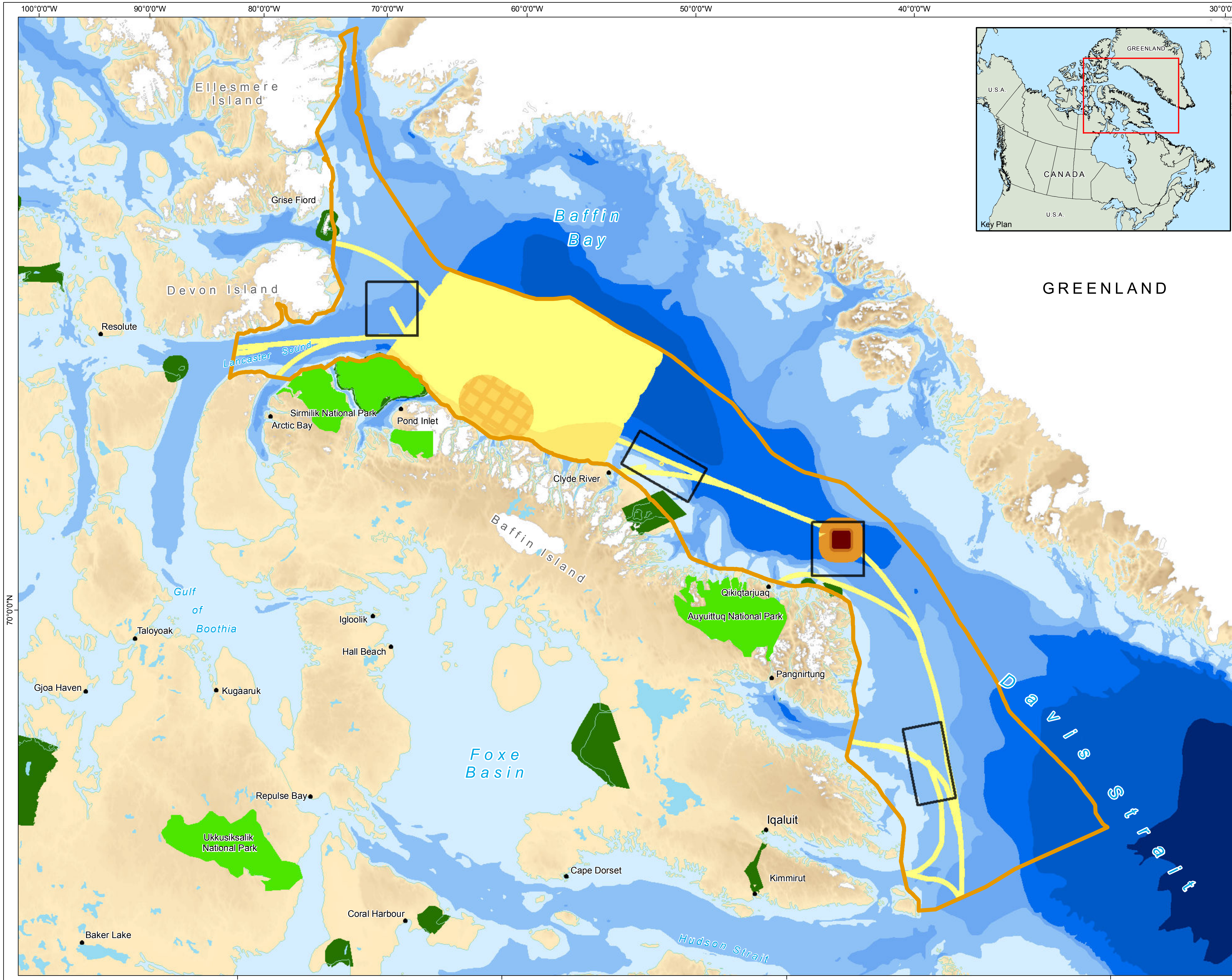
Date: March 20, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-053

Eastern Arctic
PEMT Cumulative Effects Scenario
Commercial Turbot Fishing
Summer Maximum Effect

Figure 21



Cumulative Effects
- Minimum
- Maximum

Base Features
- Community
- Scenario Block
- Ice Cap
- Eastern Arctic Study Area
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:7,000,000

50 25 0 50 100 150 200
Kilometres

Prepared By:
Nunami - Stantec

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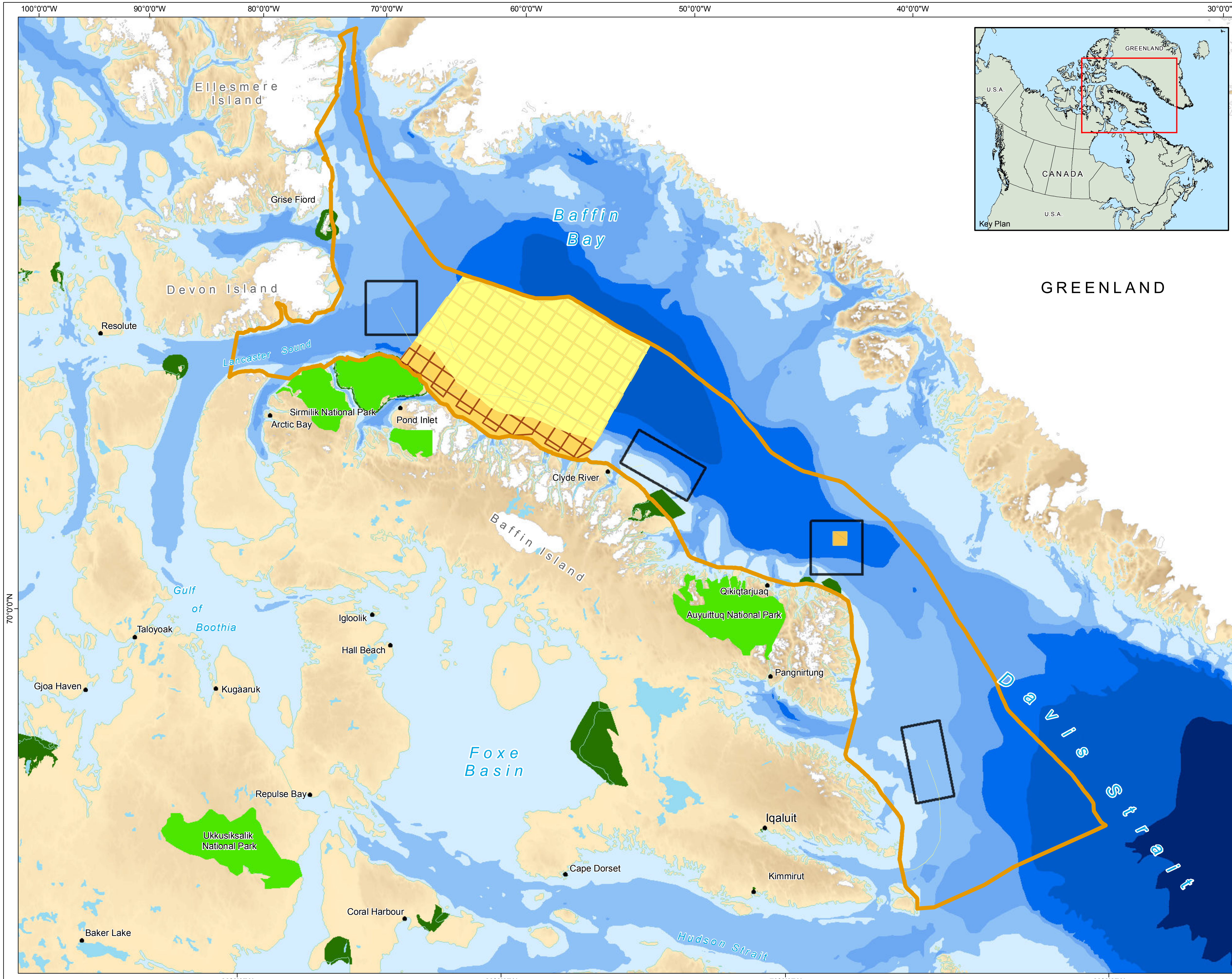
Projection: Canada Lambert Conformal Conic, NAD83
Date: March 20, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-053



Eastern Arctic
PEMT Cumulative Effects Scenario
Polar Bear
Summer Minimum Effect

Figure 22

Cumulative Effects
Minimum
Maximum

Base Features
Community
Scenario Block
Ice Cap
Eastern Arctic Study Area
Conservation Area
National Park
Lakes / River

Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000

1:7,000,000

50 25 0 50 100 150 200
Kilometres

Prepared By:
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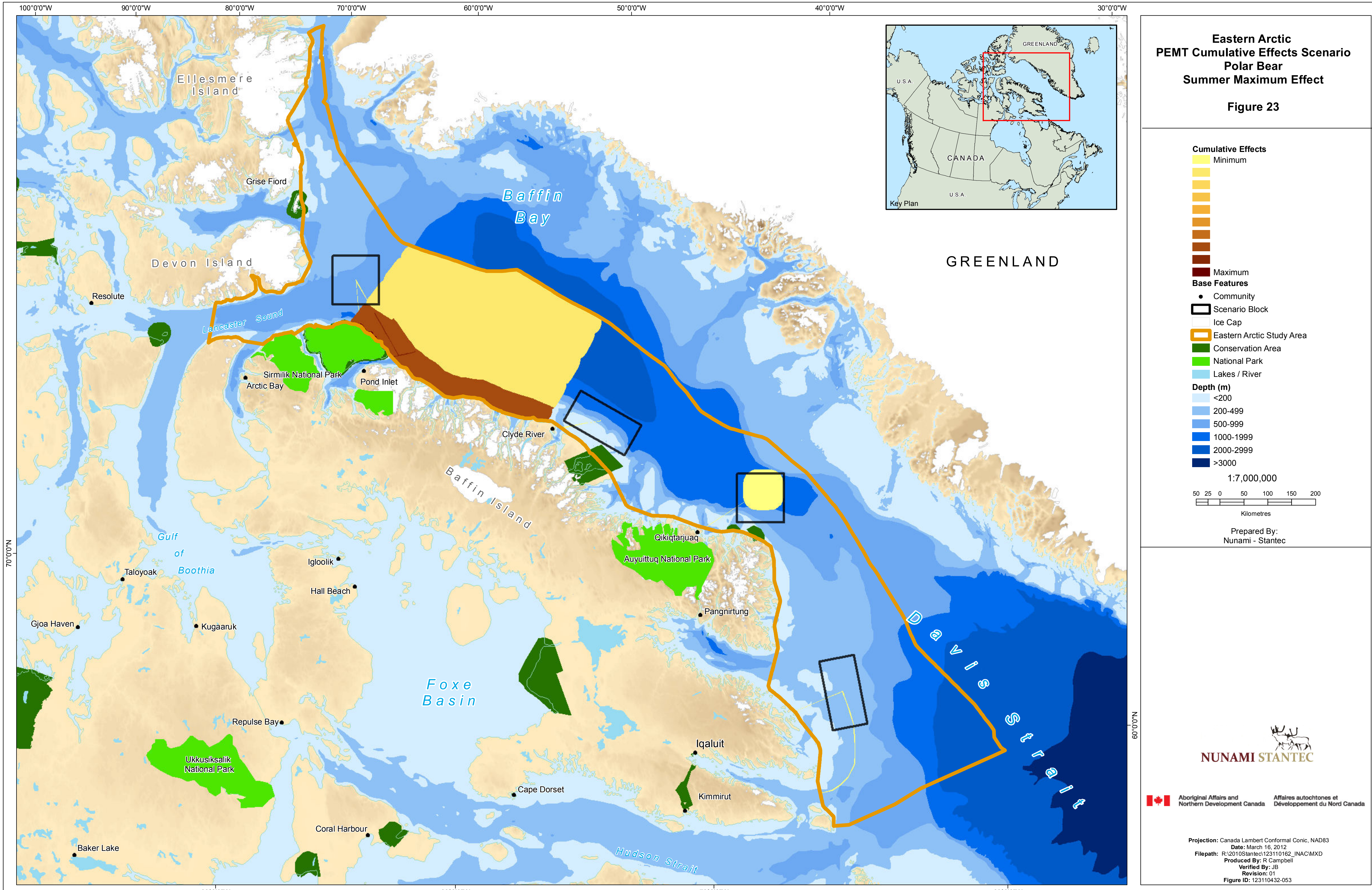
Date: March 16, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-053



Eastern Arctic
PEMT Cumulative Effects Scenario
Polar Bear
Summer Maximum Effect
Figure 23
Cumulative Effects
Minimum
Maximum
Base Features
Community
Scenario Block
Ice Cap
Eastern Arctic Study Area
Conservation Area
National Park
Lakes / River
Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000
1:7,000,000
50 25 0 50 100 150 200
Kilometres
Prepared By:
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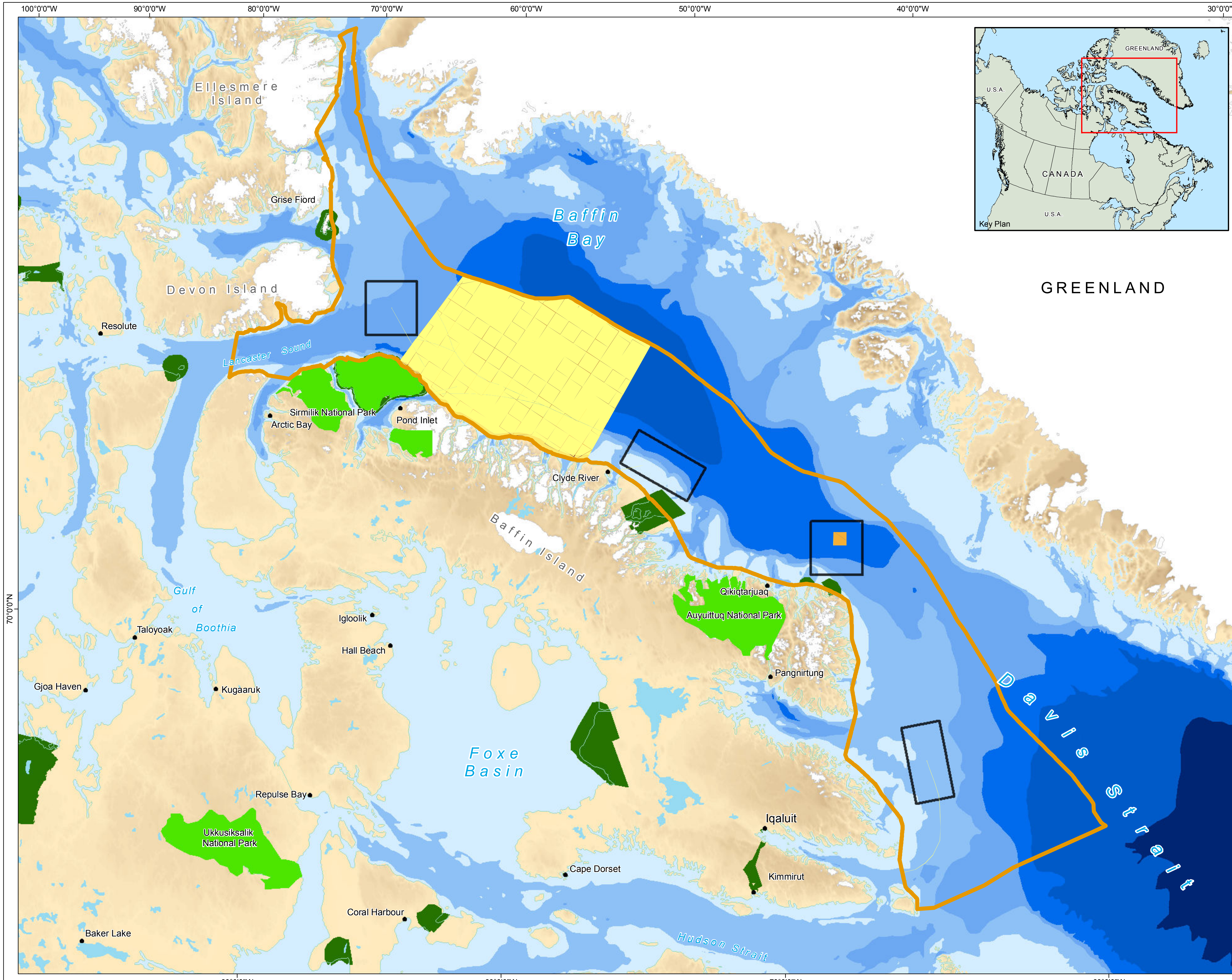
Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada
Projection: Canada Lambert Conformal Conic, NAD83
Date: March 16, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-053
GREENLAND
U.S.A.
CANADA
U.S.A.
Key Plan
Ellesmere Island
Grise Fiord
Devon Island
Resolute
Lancaster Sound
Baffin Bay
Sirmilik National Park
Arctic Bay
Pond Inlet
Clyde River
Baffin Island
Qikiqtarjuaq
Auyuittuq National Park
Pangnirtung
Davis Strait
Gulf of Boothia
Taloyoak
Igloolik
Hall Beach
Gjoa Haven
Kugaaruk
Foxe Basin
Repulse Bay
Ukkusiksalik National Park
Iqaluit
Cape Dorset
Kimmirut
Coral Harbour
Baker Lake
Hudson Strait
100°0'0"W
90°0'0"W
80°0'0"W
70°0'0"W
60°0'0"W
50°0'0"W
40°0'0"W
30°0'0"W
70°0'0"N
60°0'0"N

Eastern Arctic
PEMT Cumulative Effects Scenario
Arctic Char
Summer Minimum Effect

Figure 24



Cumulative Effects
- Minimum
- Maximum

Base Features
- Community
- Scenario Block
- Ice Cap
- Eastern Arctic Study Area
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:7,000,000

50 25 0 50 100 150 200
Kilometres

Prepared By:
Nunami - Stantec

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Aboriginal Affairs and Northern Development Canada / Affaires autochtones et Développement du Nord Canada

Projection: Canada Lambert Conformal Conic, NAD83
Date: March 20, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
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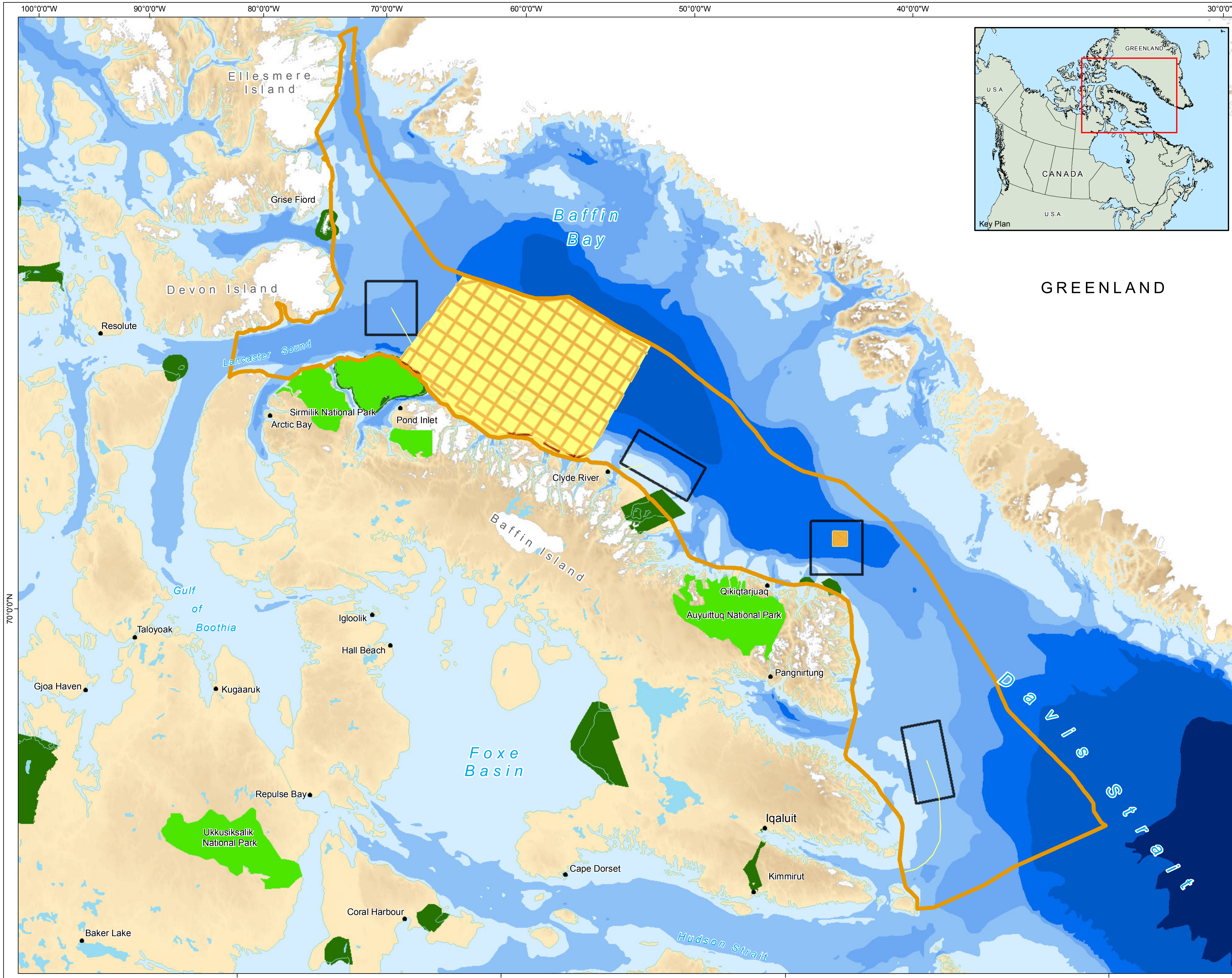
Revision: 01
Figure ID: 123110432-053

Eastern Arctic
PEMT Cumulative Effects Scenario
Arctic Char
Summer Maximum Effect

Figure 25



Cumulative Effects
Minimum
Maximum

Base Features
Community
Scenario Block
Ice Cap
Eastern Arctic Study Area
Conservation Area
National Park
Lakes / River

Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000

1:7,000,000
50 25 0 50 100 150 200
Kilometres

Prepared By:
Nunami - Stantec

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Projection: Canada Lambert Conformal Conic, NAD83
Date: March 20, 2012
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Produced By: R Campbell
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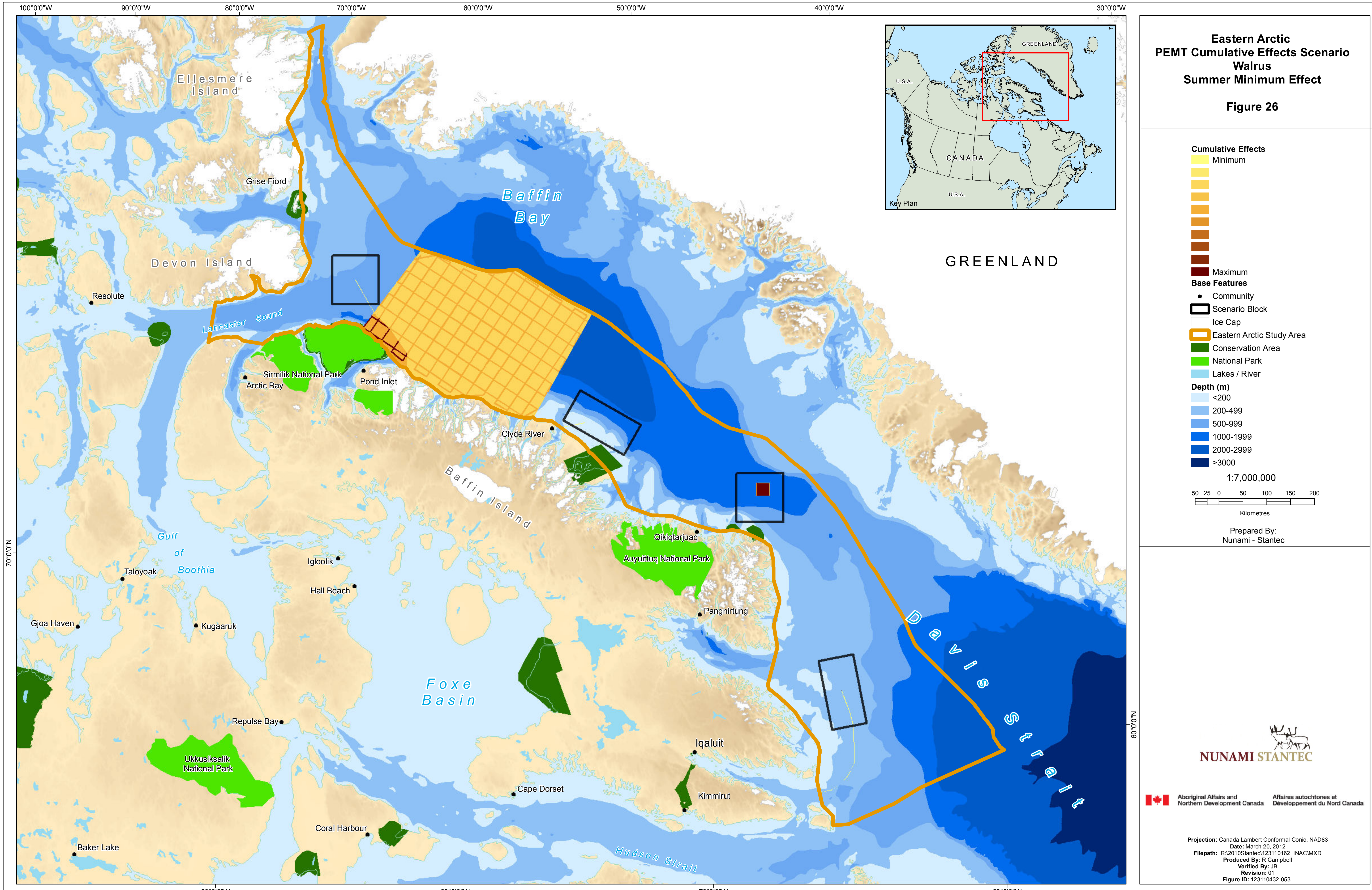
Revision: 01
Figure ID: 123110432-053



Eastern Arctic
PEMT Cumulative Effects Scenario
Walrus
Summer Minimum Effect
Figure 26
Cumulative Effects
Minimum
Maximum
Base Features
Community
Scenario Block
Ice Cap
Eastern Arctic Study Area
Conservation Area
National Park
Lakes / River
Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000
1:7,000,000
50 25 0 50 100 150 200
Kilometres
Prepared By:
Nunami - Stantec
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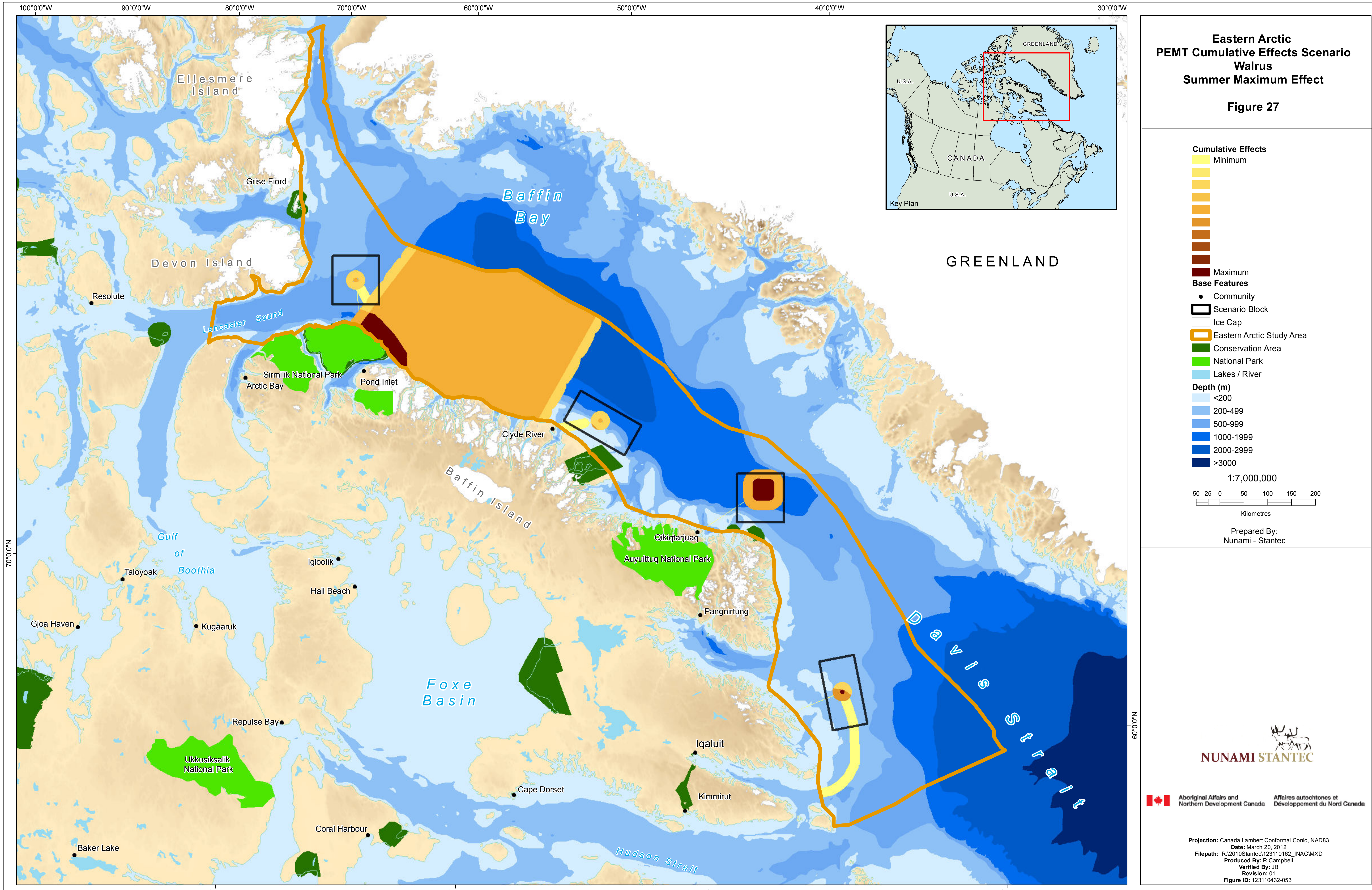
Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada
Projection: Canada Lambert Conformal Conic, NAD83
Date: March 20, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-053
GREENLAND
Key Plan
U.S.A.
CANADA
Ellesmere Island
Devon Island
Grise Fiord
Resolute
Lancaster Sound
Baffin Bay
Sirmilik National Park
Arctic Bay
Pond Inlet
Clyde River
Baffin Island
Qikiqtarjuaq
Auyuittuq National Park
Pangnirtung
Davis Strait
Gulf of Boothia
Taloyoak
Igloolik
Hall Beach
Gjoa Haven
Kugaaruk
Foxe Basin
Repulse Bay
Ukkusiksalik National Park
Iqaluit
Cape Dorset
Kimmirut
Coral Harbour
Baker Lake
Hudson Strait
100°0'0"W
90°0'0"W
80°0'0"W
70°0'0"W
60°0'0"W
50°0'0"W
40°0'0"W
30°0'0"W
70°0'0"N
60°0'0"N



Eastern Arctic
PEMT Cumulative Effects Scenario
Walrus
Summer Maximum Effect
Figure 27
Cumulative Effects
Minimum
Maximum
Base Features
Community
Scenario Block
Ice Cap
Eastern Arctic Study Area
Conservation Area
National Park
Lakes / River
Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000
1:7,000,000
50 25 0 50 100 150 200
Kilometres
Prepared By:
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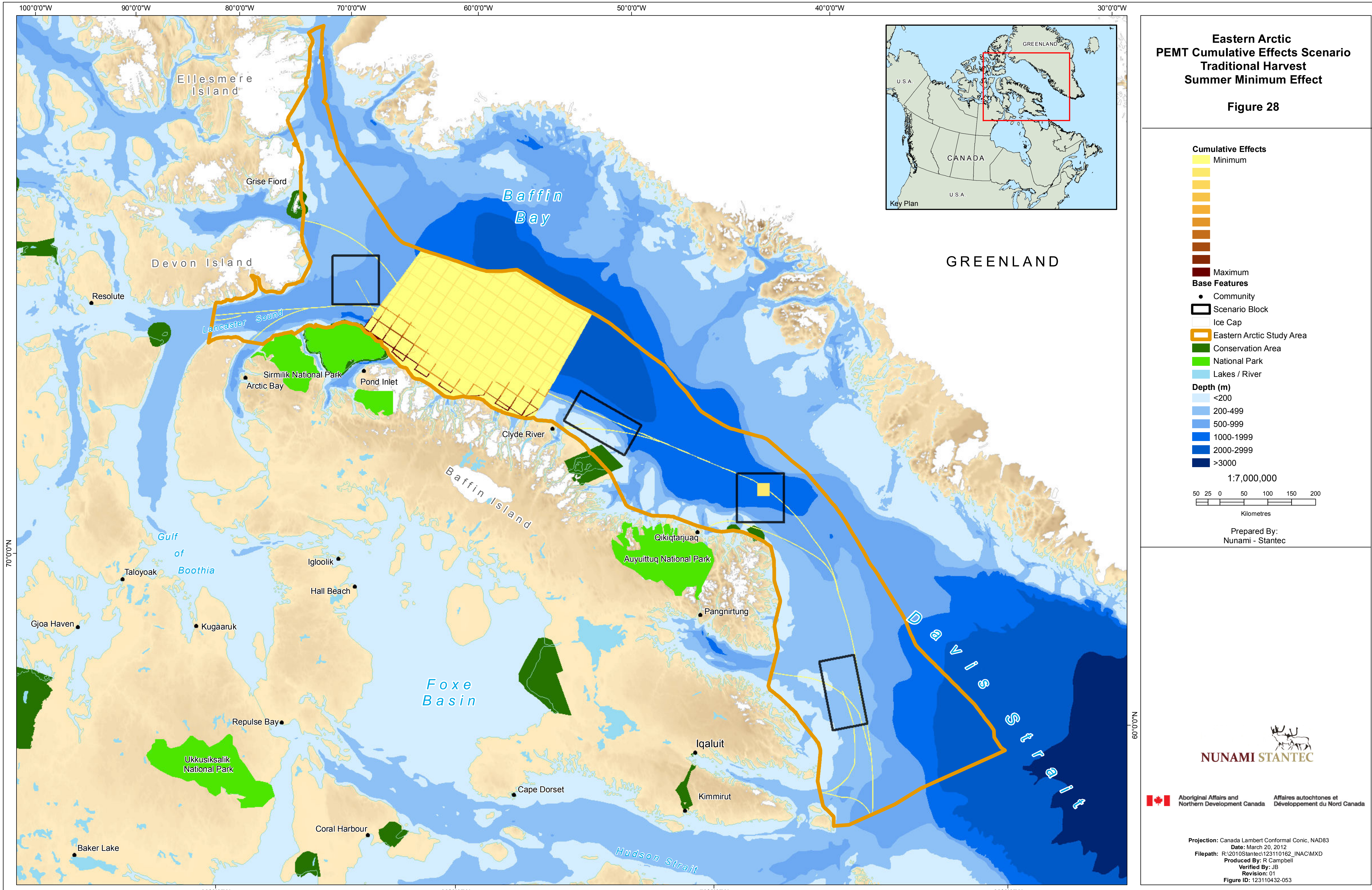
Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada
Projection: Canada Lambert Conformal Conic, NAD83
Date: March 20, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-053
Key Plan
GREENLAND
U.S.A.
CANADA
U.S.A.
100°0'0"W
90°0'0"W
80°0'0"W
70°0'0"W
60°0'0"W
50°0'0"W
40°0'0"W
30°0'0"W
70°0'0"N
60°0'0"N
Ellesmere Island
Grise Fiord
Devon Island
Resolute
Lancaster Sound
Baffin Bay
GREENLAND
Sirmilik National Park
Arctic Bay
Pond Inlet
Clyde River
Baffin Island
Qikiqtarjuaq
Auyuittuq National Park
Pangnirtung
Davis Strait
Gulf of Boothia
Taloyoak
Igloolik
Hall Beach
Gjoa Haven
Kugaaruk
Foxe Basin
Repulse Bay
Ukkusiksalik National Park
Iqaluit
Cape Dorset
Kimmirut
Coral Harbour
Baker Lake
Hudson Strait


Eastern Arctic
PEMT Cumulative Effects Scenario
Traditional Harvest
Summer Minimum Effect
Figure 28
Cumulative Effects
Minimum
Maximum
Base Features
Community
Scenario Block
Ice Cap
Eastern Arctic Study Area
Conservation Area
National Park
Lakes / River
Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000
1:7,000,000
50 25 0 50 100 150 200
Kilometres
Prepared By:
Nunami - Stantec
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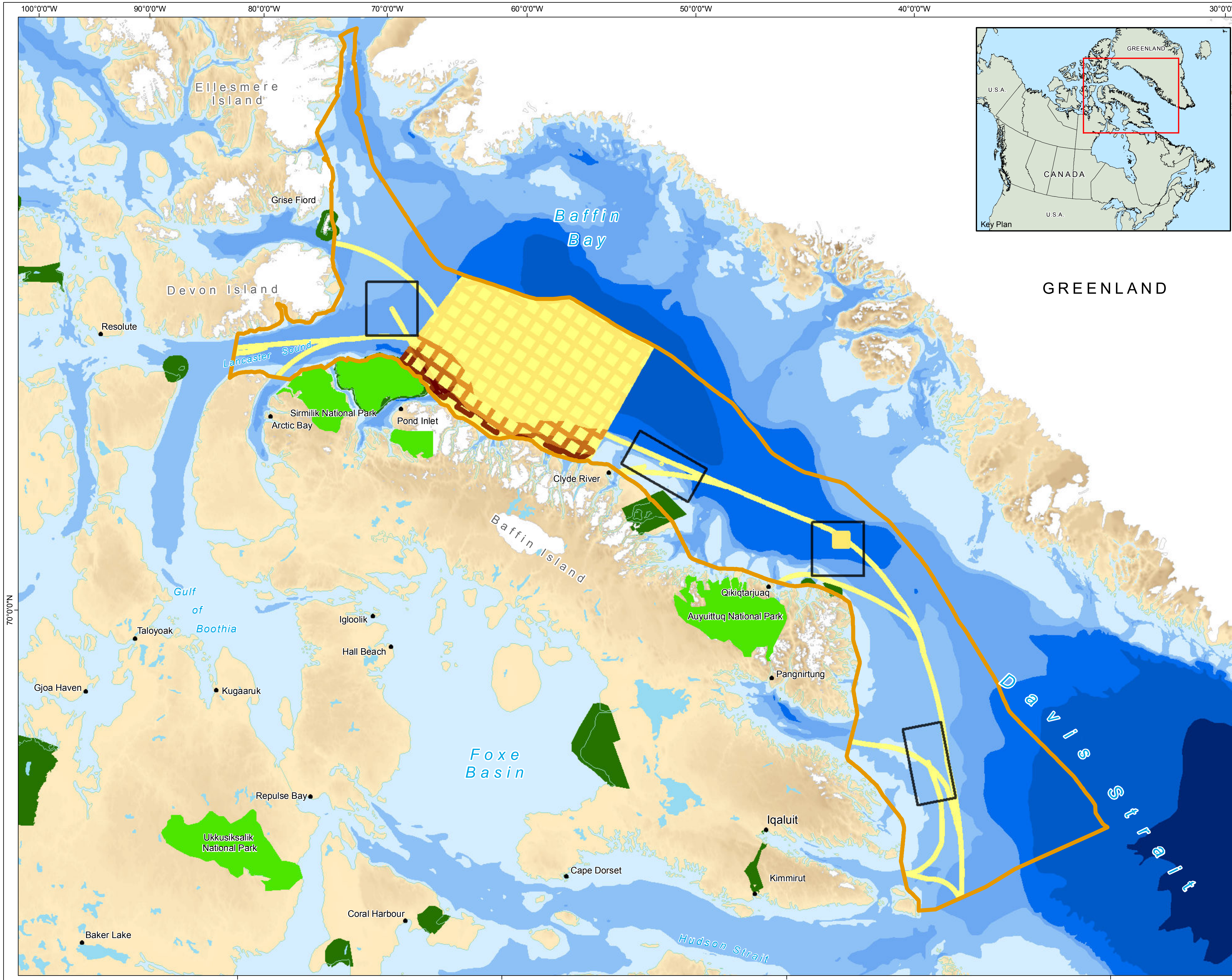
Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada
Projection: Canada Lambert Conformal Conic, NAD83
Date: March 20, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01
Figure ID: 123110432-053
GREENLAND
U.S.A.
CANADA
Key Plan
Ellesmere Island
Grise Fiord
Devon Island
Resolute
Lancaster Sound
Baffin Bay
Sirmilik National Park
Arctic Bay
Pond Inlet
Clyde River
Baffin Island
Qikiqtarjuaq
Auyuittuq National Park
Pangnirtung
Gulf of Boothia
Taloyoak
Igloolik
Hall Beach
Gjoa Haven
Kugaaruk
Foxe Basin
Repulse Bay
Ukkusiksalik National Park
Iqaluit
Cape Dorset
Kimmirut
Coral Harbour
Baker Lake
Hudson Strait
Davis Strait
100°0'0"W
90°0'0"W
80°0'0"W
70°0'0"W
60°0'0"W
50°0'0"W
40°0'0"W
30°0'0"W
70°0'0"N
60°0'0"N



Eastern Arctic
PEMT Cumulative Effects Scenario
Traditional Harvest
Summer Maximum Effect

Figure 29

Cumulative Effects
- Minimum
- Maximum

Base Features
- Community
- Scenario Block
- Ice Cap
- Eastern Arctic Study Area
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:7,000,000

50 25 0 50 100 150 200
Kilometres

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Produced By: R Campbell
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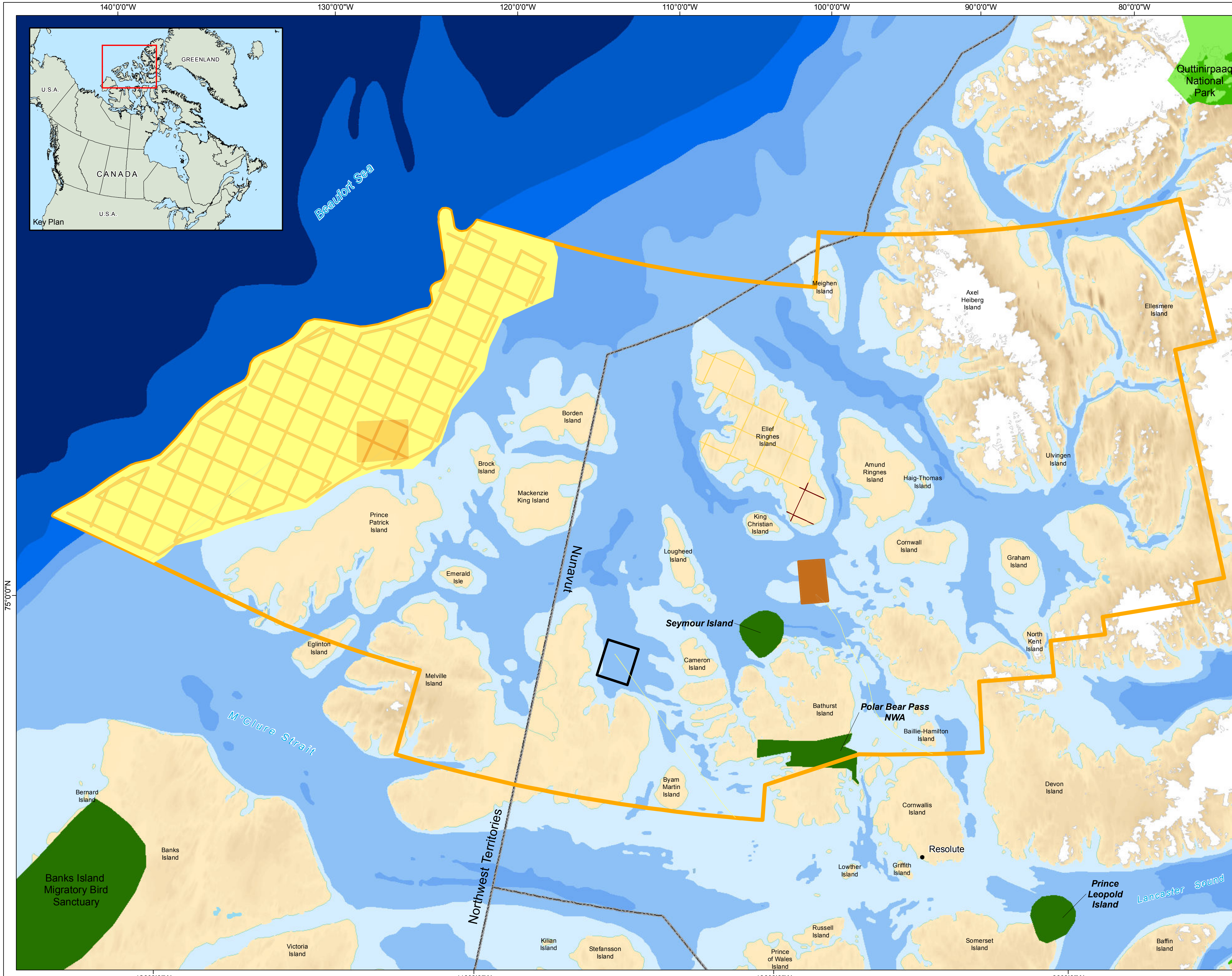
Figure ID: 123110432-053



High Arctic
Cumulative Effectst Scenario
Polar Bear
Summer Minimum Effect

Figure 30

Cumulative Effects
- Minimum
- Maximum

Base Features
- Community
- Scenario Block
- Ice Cap
- High Arctic Study Area
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:4,000,000

25 12.5 0 25 50 75 100
Kilometres

Prepared By:
Nunami - Stantec

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Projection: Canada Lambert Conformal Conic, NAD83
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Produced By: R Campbell
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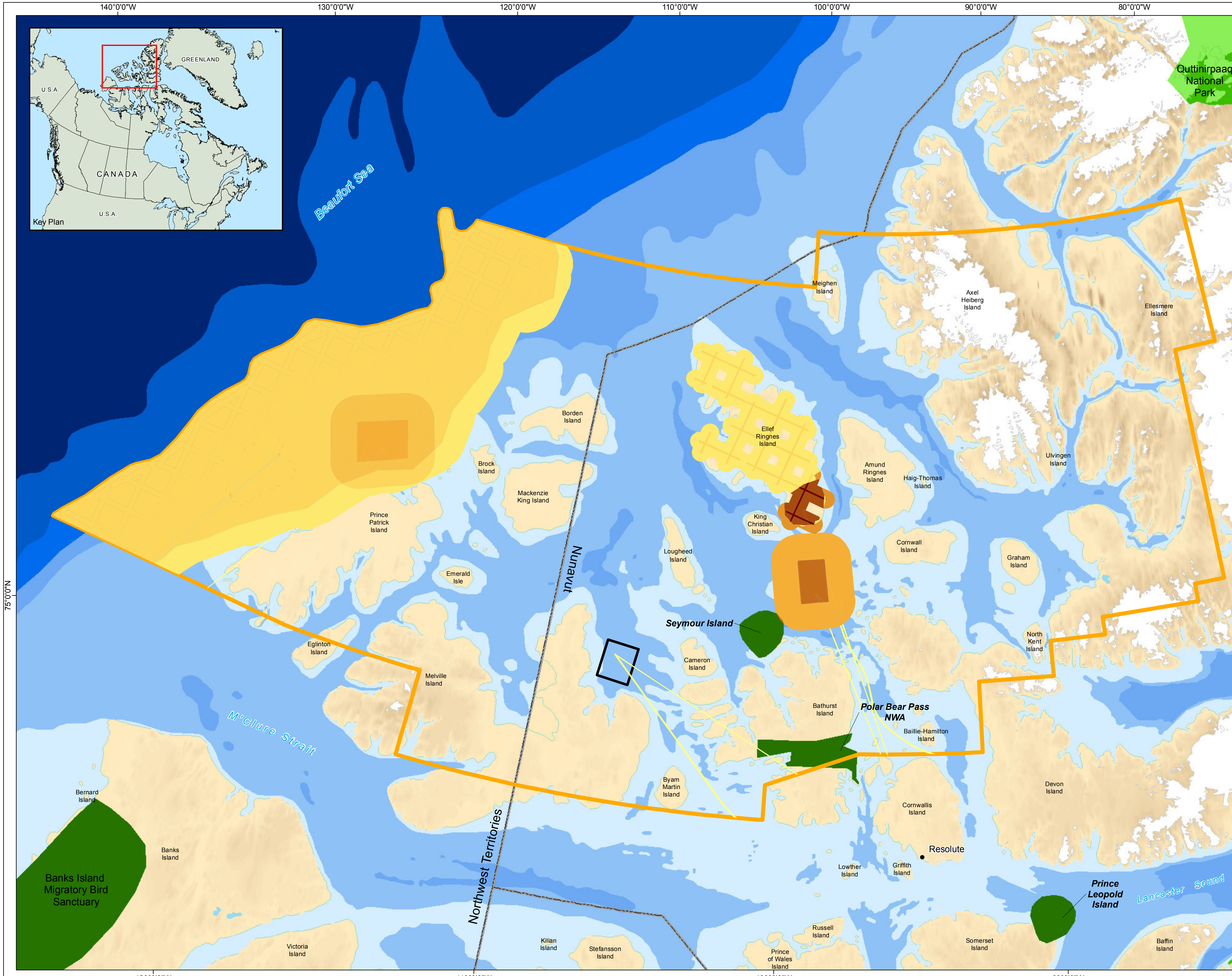
Revision: 01



High Arctic Cumulative Effectst Scenario Polar Bear Summer Maximum Effect

Figure 31

Cumulative Effects
- Minimum
- Maximum

Base Features
- Community
- Scenario Block
- Ice Cap
- High Arctic Study Area
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:4,000,000

25 12.5 0 25 50 75 100

Kilometres

Prepared By:
Nunami - Stantec

NUNAMI STANTEC

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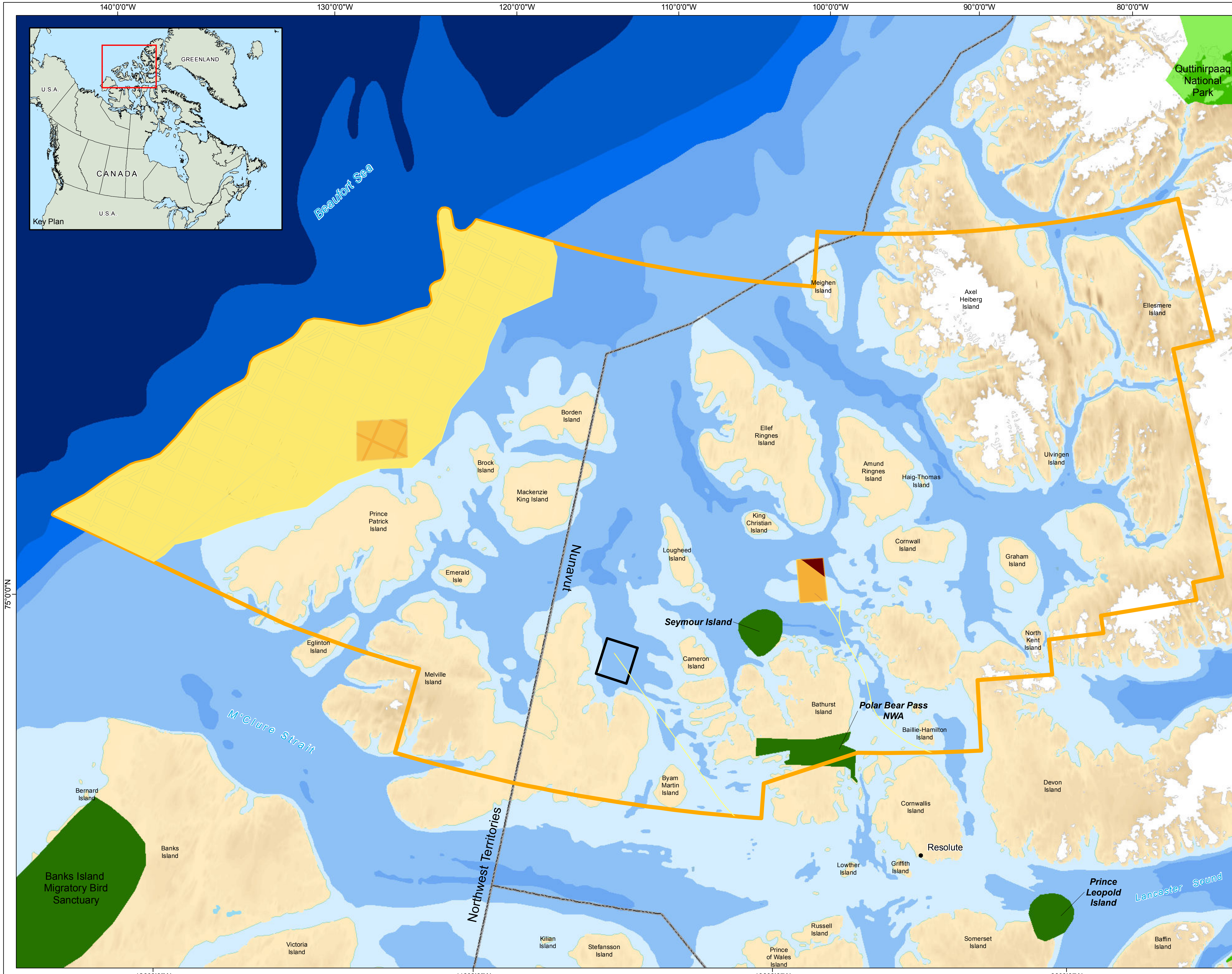
Projection: Canada Lambert Conformal Conic, NAD83
Date: March 19, 2012
Filepath: R:\2010Stantec\123110162_INAC\MXD
Produced By: R Campbell
Verified By: JB
Revision: 01

High Arctic
Cumulative Effectst Scenario
Narwhal
Summer Minimum Effect

Figure 32



Cumulative Effects
- Minimum
- Maximum

Base Features
- Community
- Scenario Polygons
- Ice Cap
- High Arctic Study Area
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:4,000,000

25 12.5 0 25 50 75 100
Kilometres

Prepared By:
Nunami - Stantec

NUNAMI STANTEC

Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada

Projection: Canada Lambert Conformal Conic, NAD83
Date: March 19, 2012
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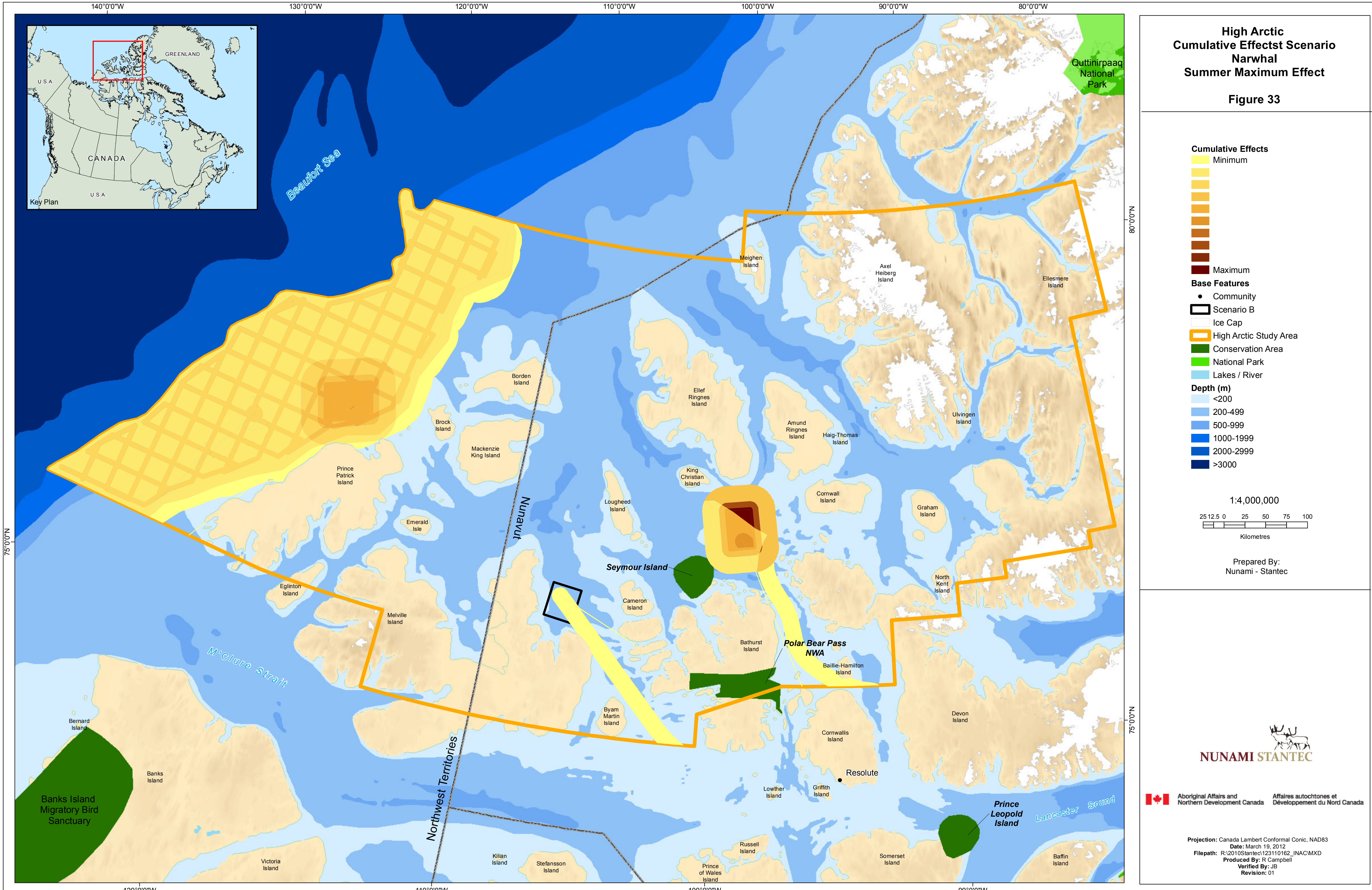
High Arctic
Cumulative Effectst Scenario
Narwhal
Summer Maximum Effect
Figure 33
Cumulative Effects
Minimum
Maximum
Base Features
Community
Scenario B
Ice Cap
High Arctic Study Area
Conservation Area
National Park
Lakes / River
Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000
1:4,000,000
25 12.5 0 25 50 75 100
Kilometres
Prepared By:
Nunami - Stantec
NUNAMI STANTEC
Aboriginal Affairs and Northern Development Canada
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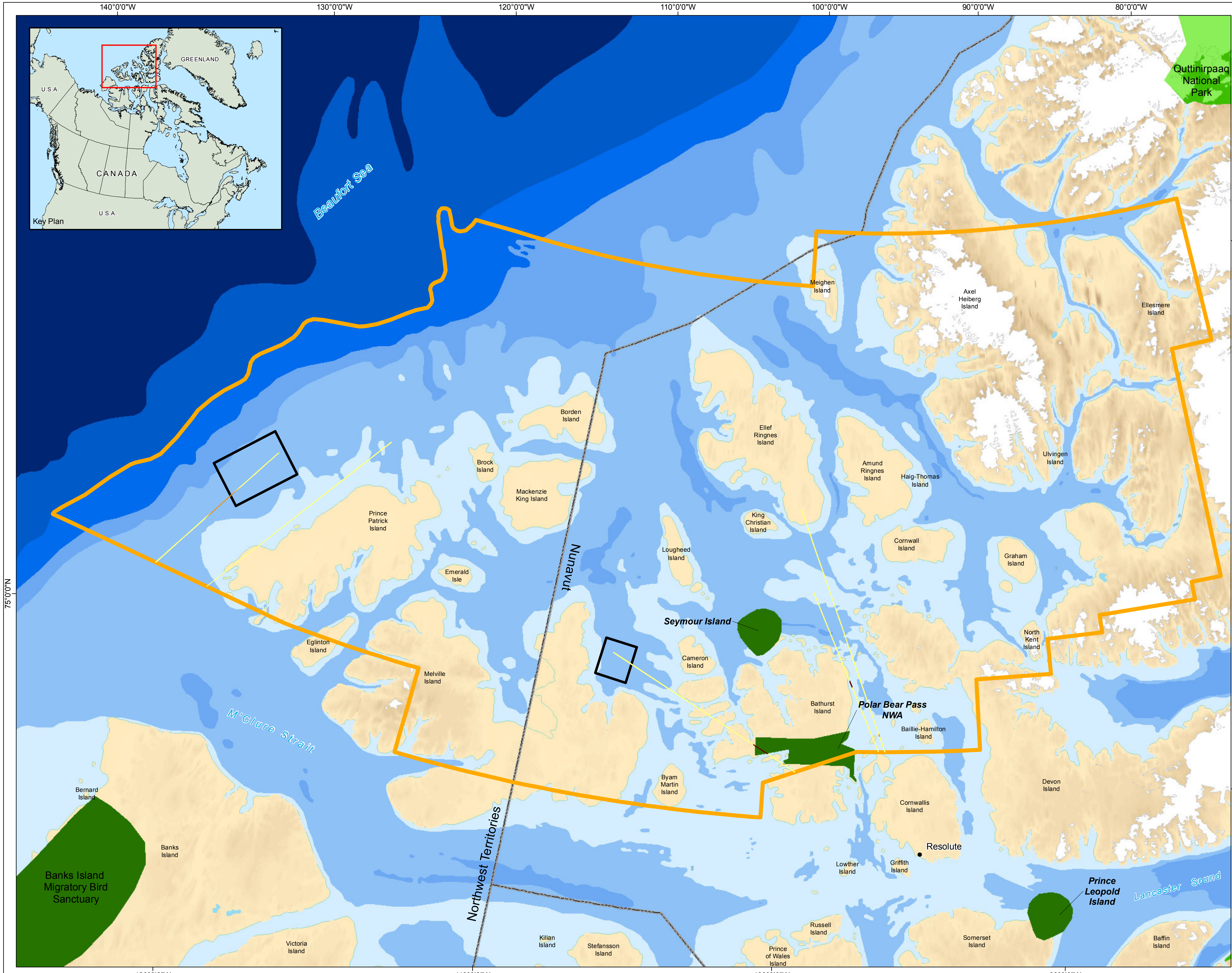
Key Plan
GREENLAND
U.S.A.
CANADA
U.S.A.
Beaufort Sea
M'Clure Strait
Lancaster Sound
Nunavut
Northwest Territories
Quttinirpaaq National Park
Seymour Island
Polar Bear Pass NWA
Banks Island Migratory Bird Sanctuary
Prince Leopold Island
Resolute
Meighen Island
Axel Heiberg Island
Ellesmere Island
Borden Island
Brock Island
Mackenzie King Island
Prince Patrick Island
Emerald Isle
Eglinton Island
Melville Island
Ellef Ringnes Island
Amund Ringnes Island
Haig-Thomas Island
King Christian Island
Lougheed Island
Cornwall Island
Graham Island
Ulvingen Island
North Kent Island
Cameron Island
Bathurst Island
Baillie-Hamilton Island
Byam Martin Island
Cornwallis Island
Devon Island
Lowther Island
Griffith Island
Bernard Island
Banks Island
Victoria Island
Kilian Island
Stefansson Island
Russell Island
Prince of Wales Island
Somerset Island
Baffin Island
140°0'0"W
130°0'0"W
120°0'0"W
110°0'0"W
100°0'0"W
90°0'0"W
80°0'0"W
80°0'0"N
75°0'0"N



High Arctic
Cumulative Effectst Scenario
Migratory Birds
Summer Minimum Effect

Figure 34

Cumulative Effects
- Minimum
- Maximum

Base Features
- Community
- Scenario Block
- Ice Cap
- High Arctic Study Area
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:4,000,000

25 12.5 0 25 50 75 100

Kilometres

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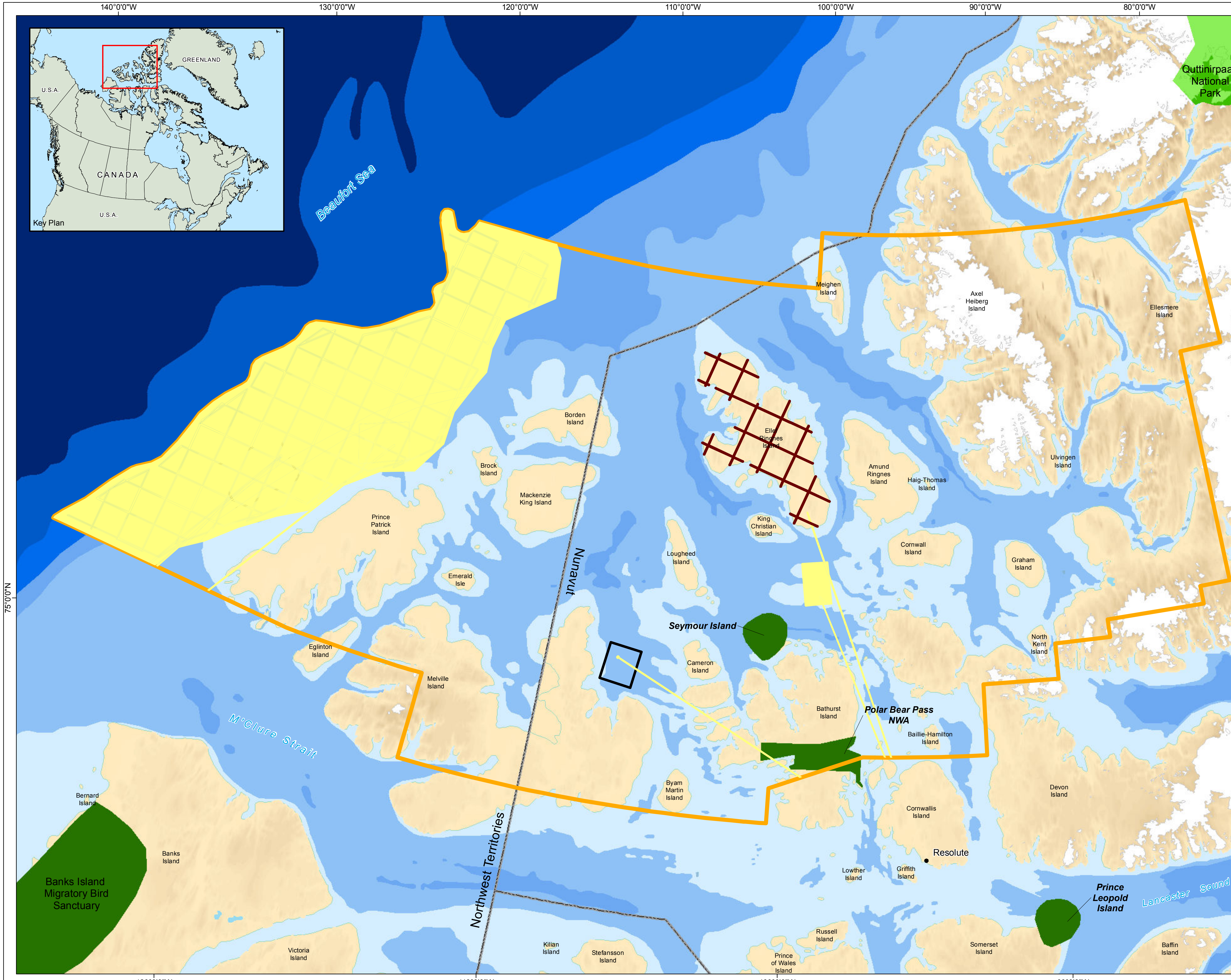

High Arctic Cumulative Effectst Scenario Migratory Birds Summer Maximum Effect

Figure 35

Cumulative Effects
Minimum
Maximum

Base Features
Community
Scenario Block
Ice Cap
High Arctic Study Area
Conservation Area
National Park
Lakes / River

Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000

1:4,000,000

25 12.5 0 25 50 75 100
Kilometres

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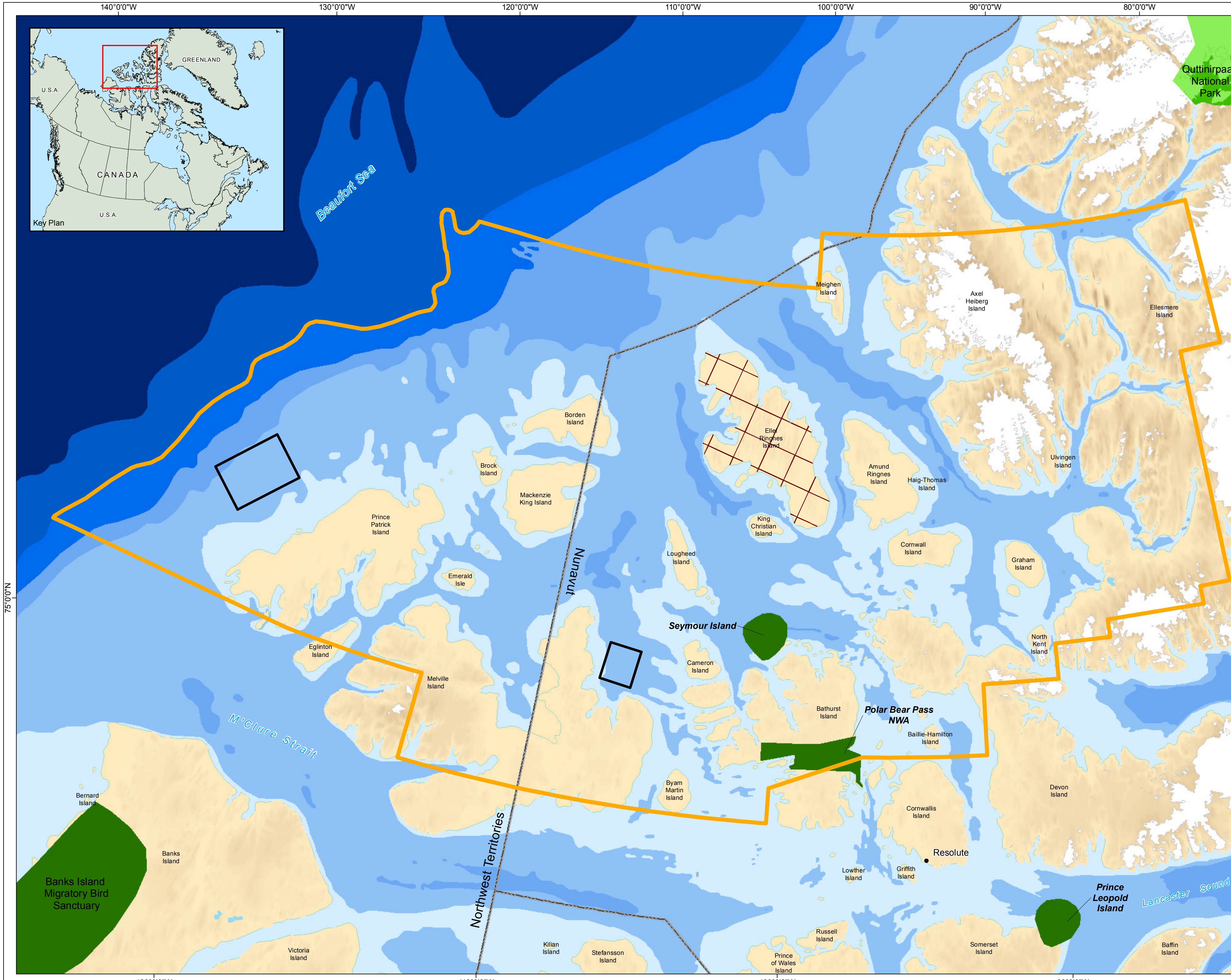
High Arctic Cumulative Effectst Scenario Peary Caribou Summer Minimum Effect

Figure 36



Cumulative Effects
- Minimum
- Maximum

Base Features
- Community
- Scenario Block
- Ice Cap
- High Arctic Study Area
- Conservation Area
- National Park
- Lakes / River

Depth (m)
- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:4,000,000

25 12.5 0 25 50 75 100
Kilometres

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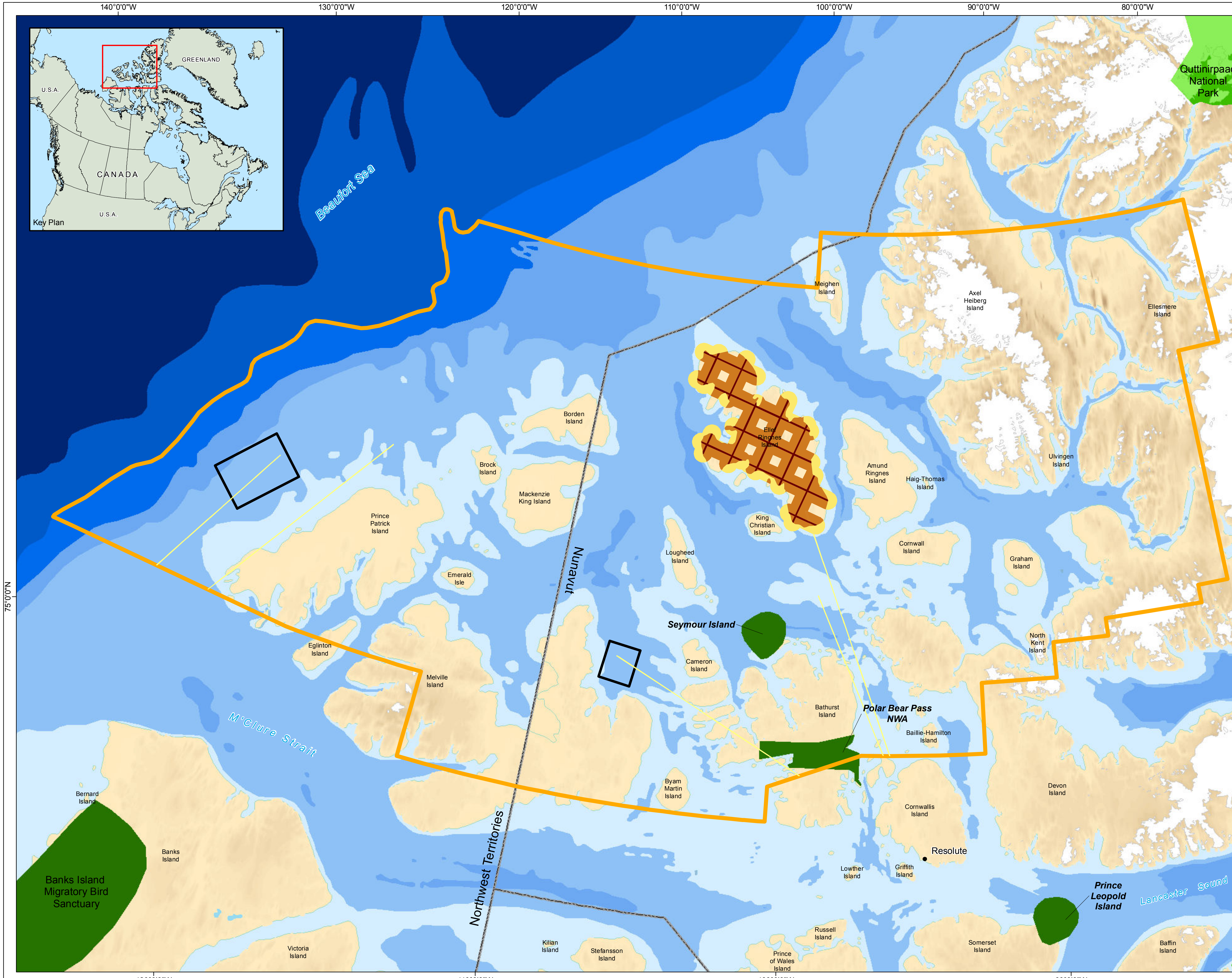

High Arctic Cumulative Effectst Scenario Peary Caribou Summer Maximum Effect

Figure 37

Cumulative Effects

- Minimum
- Maximum

Base Features

- Community
- Scenario Block
- Ice Cap
- High Arctic Study Area
- Conservation Area
- National Park
- Lakes / River

Depth (m)

- <200
- 200-499
- 500-999
- 1000-1999
- 2000-2999
- >3000

1:4,000,000

25 12.5 0 25 50 75 100

Kilometres

Prepared By:
Nunami - Stantec

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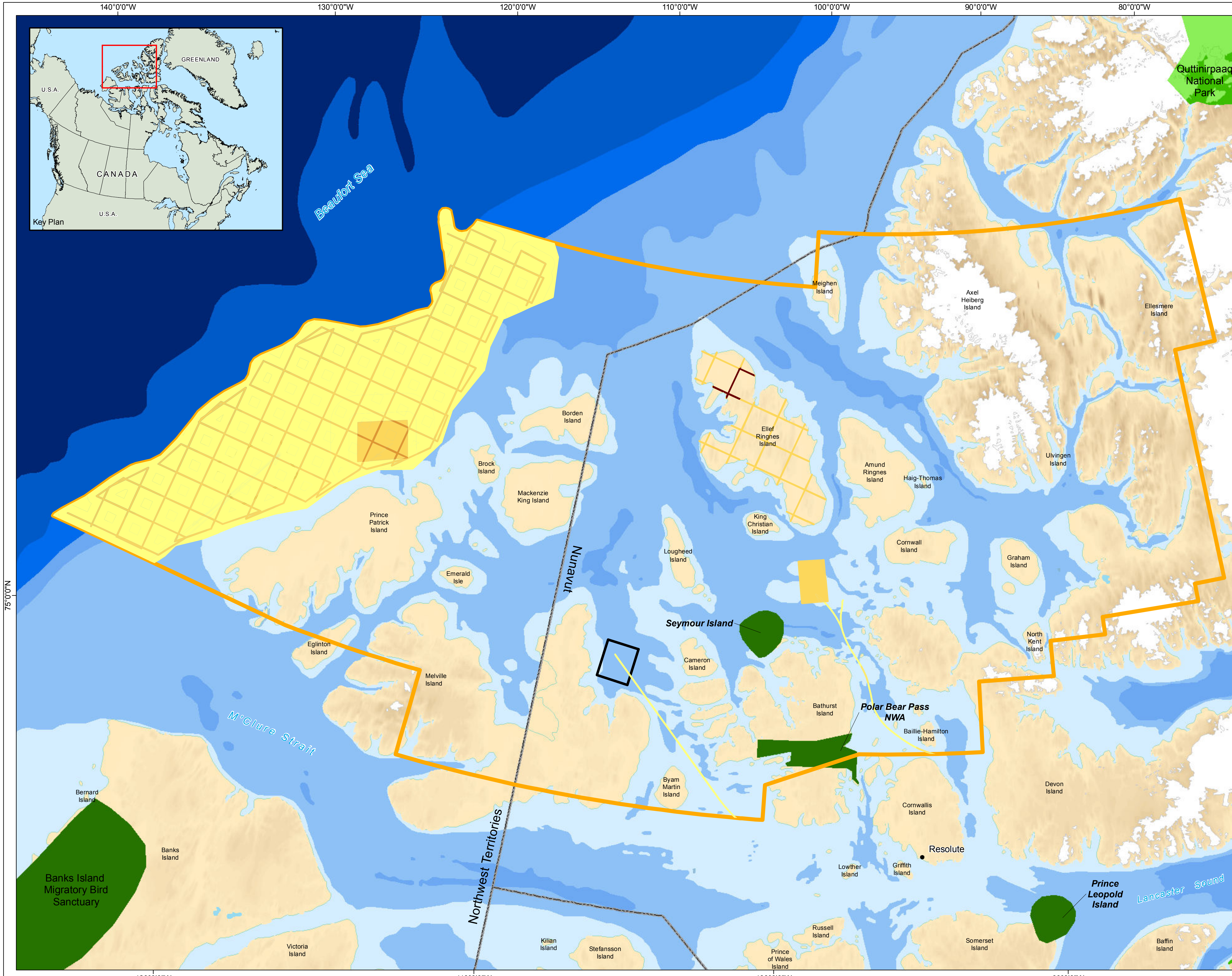

High Arctic Cumulative Effectst Scenario Traditional Harvest Summer Minimum Effect

Figure 38

Cumulative Effects
Minimum
Maximum

Base Features
Community
Scenario Block
Ice Cap
High Arctic Study Area
Conservation Area
National Park
Lakes / River

Depth (m)
<200
200-499
500-999
1000-1999
2000-2999
>3000

1:4,000,000

25 12.5 0 25 50 75 100
Kilometres

Prepared By:
Nunami - Stantec

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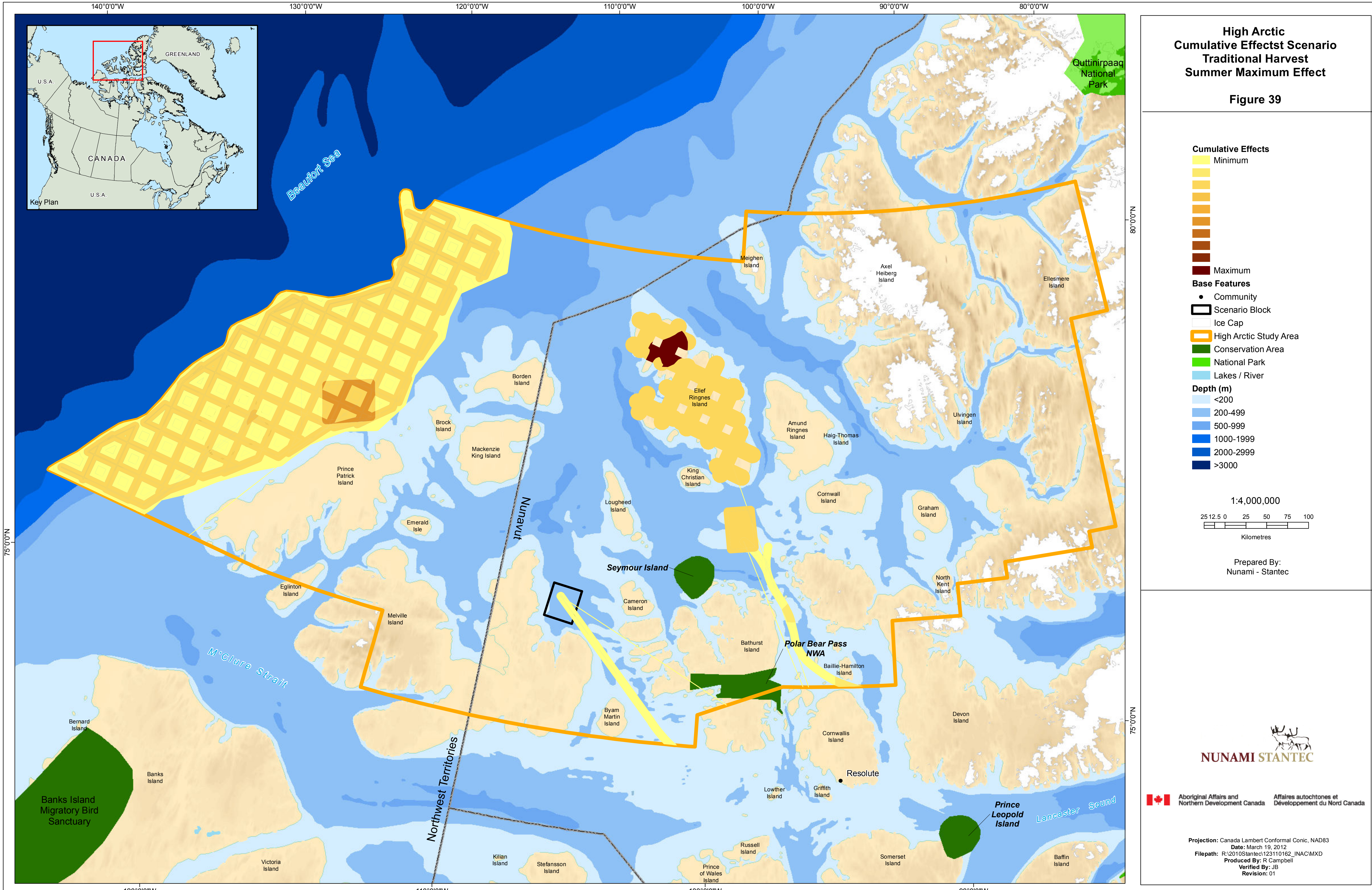

High Arctic
Cumulative Effectst Scenario
Traditional Harvest
Summer Maximum Effect

Figure 39