APPENDIX 9B

STEENSBY PORT FUEL SPILL MODELLING

Steensby Inlet
Spill Trajectory Modelling
for the
Mary River Project

Final Report

Prepared for

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November 2010

AMEC Project: TC101507.7000

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EXECUTIVE SUMMARY

As related study for the Environmental Assessment for the Baffinland Mary River Iron Ore Project, AMEC Earth & Environmental (AMEC), a division of AMEC Americas Limited, has undertaken a diesel fuel spill assessment for Steensby Inlet, Foxe Basin, in the Canadian Arctic. It is currently proposed that diesel fuel for the Mary River Project will be transported by tanker to the ore loading port.

The hypothetical accidental release of 5 ML diesel fuel at the proposed port in Steensby Inlet during the open water season has been modelled for the purpose of estimating the marine and coastal areas potentially affected together with the initial weathering fate of the diesel fuel. A port site near the proposed freight dock and fuel unloading and a site just offshore the ore loading dock locations are considered as potential spill origins.

The analysis of the open water scenarios was accomplished by making use of a numerical computer model developed by AMEC which predicts the behaviour of fuel on the sea surface and determines probabilistic spill trajectories. The model simulates the two-dimensional motion of a surface slick transported under the joint influence of wind-driven surface currents and residual currents. The processes of evaporation and vertical dispersion are simulated to estimate the volume loss of fuel from the surface slick. Individual trajectories evolve under the influence of a deterministic time-series of winds (hourly) and current vectors until such time as the trajectory terminates ashore or on an external boundary to the model grid, the trajectory has drifted for more than 30 days, or until the slick volume drops to less than 5% of its initial volume.

The advection or transport of spilled fuel on the sea surface was modelled using wind and ocean current data. A 30-year time-series of gridded winds from the NCEP/NCAR reanalysis project were selected for use. These data are near-surface modelled winds and were found to compare favourably with measured winds from the nearby Steensby met station from 2006 to 2009. The NCAR/NCEP winds long time-series length ensures good statistical reliability in the predicted spill probability distributions. Estimation of ocean currents in Steensby Inlet were made following analysis of Acoustic Doppler Current Profiler (ADCP) measurements from field programs in September 2008.

Principle results are fuel spill distribution probability maps of Steensby Inlet developed by superimposing all possible spill trajectories, for a given month, over the 30-year distribution of selected wind data. The Steensby Inlet is divided into 10 geographical regions and for each monthly spill scenario a companion set of shore impact statistics are calculated to report the percent of trajectories impacting the shoreline and the earliest times to impact in any of the regions.

The vast majority or trajectories, 86%, reach shore in the port site area, as soon as 15 minutes and on average in two hours. Just over 9% of trajectories end on the western side of Steensby Inlet about 12 to 20 km away. Times to shore are as early as 7 hours, 29 hours on average, and up to 150 hours (just over six days), where 54% of the fuel is estimated to be remaining.

Other regions, farther removed in the inlet are reached, though generally less than 1% of the time. The Rocky East region is reached as soon as six hours, and 56 hours on average. The Coastal Plain West is reached as soon as seven hours, and 29 hours on average. The Inlet Islands are reached as soon as 18 hours, and 56 hours on average. Koch Island, with one trajectory, at the mouth of Steensby Inlet, is reached in just over two days. To the north, the Rocky Northeast region is reached as soon as 34 hours, and 52 hours on average. The Lagoon Complex to the head of the inlet is reached within 52 hours, and 66 hours on average.

The collection of spill probability plots and shore impact statistics presented define the probable distribution of any hypothetical, uncontained, and unmanaged spill for the Project domain of operations in Steensby Inlet for the open water season.

A qualitative assessment of shoreline fuel retention based on review of the modelling results and understanding of the shoreline habitats in the region has also been prepared.

The initial modeling results suggest that impact to shoreline resources would be comparatively short term (days to weeks) largely because of the volatile nature of diesel fuel. Shorelines close to the port location have fine-sediment matrix in the immediate subsurface which will limit fuel penetration and overall retention. Stranded fuel would continue to evaporate on the surface of beaches.

Key macrobiota on these shorelines include salt marshes and rockweed. Salt marshes are in the upper intertidal and supratidal zones and are vulnerable to fuel contact. Salt marsh substrate is typically fine-grained sediment and organics, which have low permeability so significant volumetric retention would not be expected. However, diesel does stick to organics so some residual fuel may be incorporated into the organic substrate. It is likely that salt marshes close to the spill site would experience a combination of lethal effects and some sublethal effects. New plant shoots would be expected during spring melt so it is likely that the most effects would be limited to a single generation. The estimated duration of impact would be weeks to months with normal growth rates returning the following spring; some marsh areas very close to the spill site could have reduced growth rates for longer periods of time.

Rockweed occurs in the lower intertidal and shallow subtidal. Rockweed would only be exposed during spring tides so is not vulnerable at all times. There are likely to be a combination of lethal and sublethal affects for rockweed located with a 5 km of the spill location. The life stages of rockweed in this region are unknown but the extensive occurrence along the shore probably represents first year growth and the rockweed also occurs offshore where it is not vulnerable to contact with sheens. As such, it is likely that effects of a diesel spill on rockweed would be limited to a single generation and that rockweed growth at breakup during the following year would be normal. As such, the effect of a spill on rockweed is likely to be moderate (weeks to months).

ACKNOWLEDGEMENTS

AMEC gratefully acknowledges the assistance and contributions of the following.

- John Harper and Brian Bornhold, Coastal & Ocean Resources, Inc., for provision of ADCP, CTD, and current drifter data and related Steensby Inlet marine activity documentation and study insights. Special thanks to John Harper for providing the Section for qualitative assessment of fuel retention for shorelines of Steensby Inlet
- Richard Cook and Shannon Roach, Knight Piésold Ltd., and Matthew Pickard, Baffinland, for provision of Steensby met station data
- Charles Ramcharan, Department Biology and Cooperative Freshwater Ecology Unit, Laurentian University, for confirmation of Steensby met station data particulars
- NCEP Reanalysis data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd/

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VERSION TRACKING

Date	Person	Change
10-Sep-2010	John McClintock	Rev 0: Draft report issued.
10-Nov-2010	John McClintock	Rev 1: Final report issued. Added short sections on ice considerations and comparison of current drifter drogue and spill model trajectory paths.

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1. INTRODUCTION

1.1 Objectives

As related study for the Environmental Assessment for the Baffinland Mary River Iron Ore Project, AMEC Earth & Environmental (AMEC), a division of AMEC Americas Limited, has undertaken a diesel fuel spill assessment for Steensby Inlet, Foxe Basin, in the Canadian Arctic. It is currently proposed that diesel fuel for the Mary River Project will be transported by tanker to the ore loading port at Steensby.

The specific requirement is to model a hypothetical accidental release of diesel fuel at the proposed port in Steensby Inlet during the open water season. Objectives include estimation of the marine and coastal areas potentially affected together with the initial weathering fate of the diesel fuel. This report presents the results of the modelling study.

1.2 Spill Scenario Selection

It is currently proposed that diesel fuel for the Mary River Project will be transported by offshore ocean-going tanker through Foxe Basin to Steensby Inlet (Figure 1-1).

Figure 1-1: Eastern Arctic Reference Map with Steensby Inlet, Foxe Basin, Study Area highlighted. (Source: CIS 2010a).

While an unlikely event, an accidental fuel spill could hypothetically occur as a result of collision or accident or while transferring fuel between an ocean tanker and shore base. This spill assessment considers open water season, e.g., September, when transport of diesel fuel to Steensby Inlet may be considered. Shipping of fuel in pack ice or under landfast ice conditions is not planned (Some discussion of the open water season which might be encountered and the bordering ice conditions is presented in Section 3.3).

The proposed fuel unloading location is illustrated in Figure 1-2. In the figure, the distance between grid lines is 500 m. The red border identifies the port area specifically considered in the spill model grid setup (Section 2.2).

An open water season spill scenario was developed through discussion with Baffinland (Pickard, 2010). The starting point was an assumed total cargo volume of 50 ML (50 million litres or 5,000 m^3) arctic diesel fuel coming to Steensby Inlet port. The total amount of 50 ML spilled was judged to be too large a spill and not a credible amount. Instead, three possible 'modes' of release or estimating the amount were put forward:

a) for a hypothetical fuel transfer loss at the port (Figure 1-2). Assuming a 3 ML/h transfer rate (equates to about 16.7 h where the entire offloading might be typically expected to take about 24 h), there would be potential release of 50,000 L/min. Assuming a period of 10 minutes before the spill is stopped this would represent a spill volume of 0.5ML. Clearly the assumed time before spill stoppage is a key factor;
b) if one assumes six or seven tanker compartments and complete loss of one, this would release from 7.1 to 8.3 ML. Again, the number of compartments damaged is a factor; and
c) historical spill statistics can also be considered. Some research/review (e.g., McKenna and McClintock, 2005) indicates spill amount is best expressed as a proportion of fuel transported, with 5% a most likely estimate, and 10% a conservative one: 10% yields 5 ML

From this workup, it was agreed that an amount on the order of 5 ML was a worst case amount worth carrying forward. It was felt that the Port site was a reasonable location to take for the spill; as it matches scenario a) above and could be considered possible even for b) for a collision and hull damage accident.

Two spill scenario locations are identified in Table 1-1 and also shown in Figure 1-3. The three major coastal regions of Steensby Inlet identified during coastal habitat surveys for the Baffinland Mary River Project (CORI, 2007) are labeled in purple in the figure. They serve to help define the northern domain of the spill model (Section 2.2) as well as the regions for tabulation of spill statistics (Section 4.1 where the regions are defined based on shoreline type).

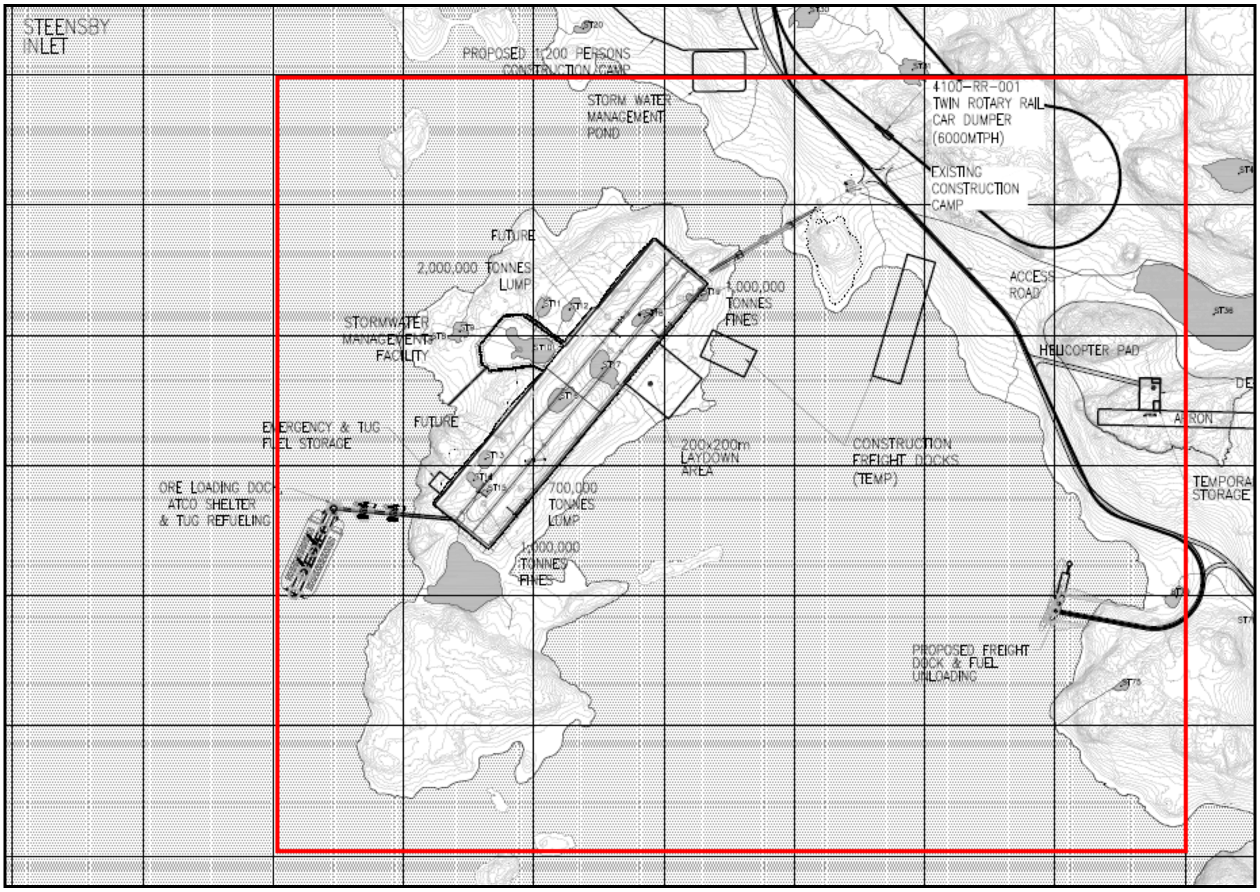


Figure 1-2: Mary River Project: Steensby Inlet Site Plan (Source: AMEC Progress Print Drawing # A1-164512-8120-121-0900 Rev. A).

Table 1-1: Spill Scenario Locations

Spill Scenario Location	Latitude (N)	Longitude (W)
Port Site, about 750 m west of the fuel unloading berth in the port area east of ore loading island	70° 16.90'	78° 28.60'
Drogue Site, about 1 km west of the ore loading dock on western shore of ore loading island; taken as the average location of the current drogue drifter release points (Section 5.2)	70° 16.55'	78° 33.54'

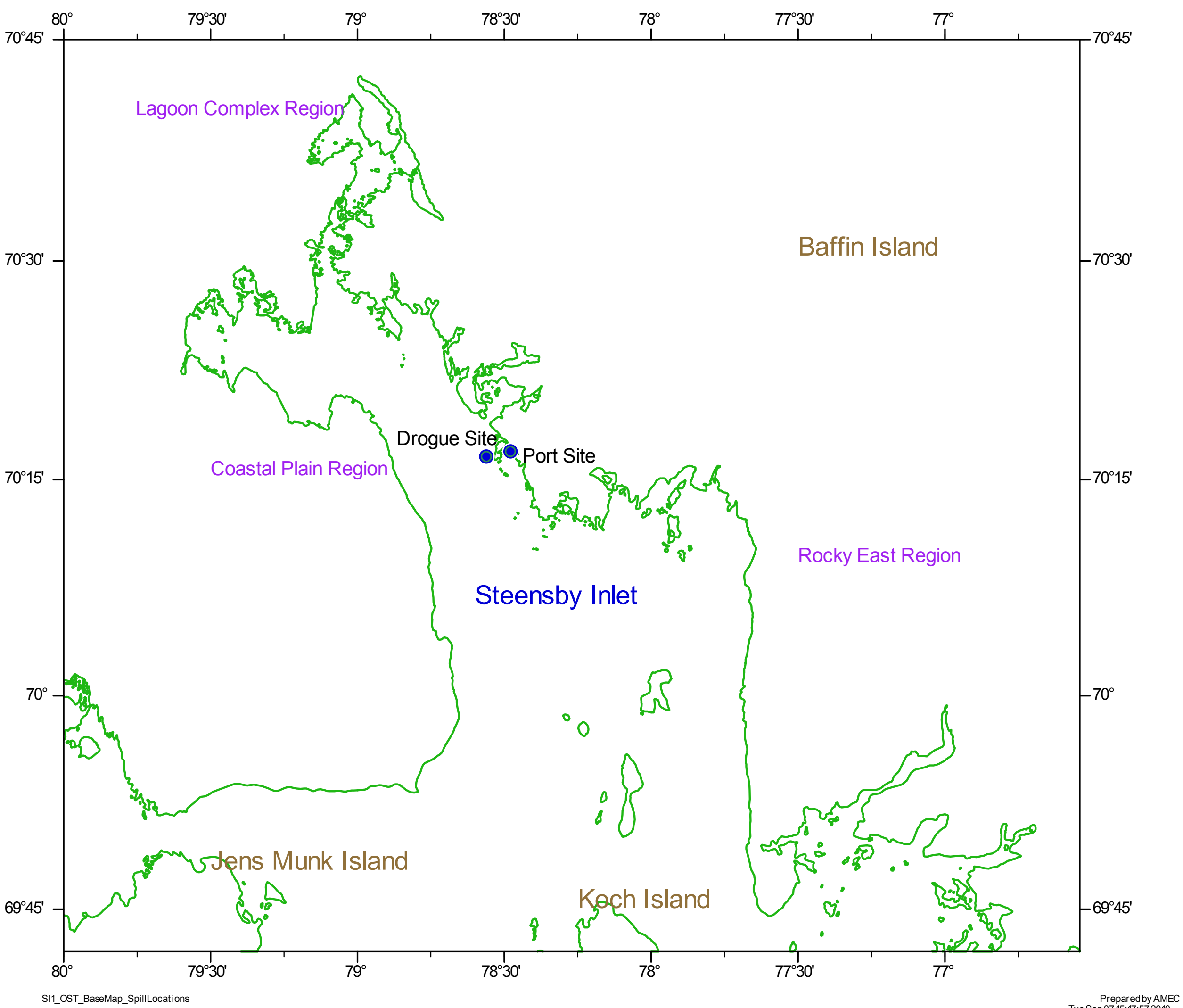


Figure 1-3: Steensby Inlet Spill Scenario Locations

1.3 Steensby Inlet Met-Ocean Data Sources

To provide orientation for the reader before detailed discussion of the model setup and various model inputs, Steensby Inlet met-ocean measurement data applicable for the open water season study are introduced. The data sources are summarized in Table 1-2. The corresponding data coverage timeline is given in Figure 1-4 and measurement locations are shown in Figure 1-5.

Data collection commenced in June 2006 with weather station installation near the port site. Measurements from the weather station include hourly wind speed and direction, and air temperature. Details of the weather station winds and their utility for input to the spill model are presented in Sections 3.1.1 and 3.1.3.

Acoustic Doppler Current Profilers (ADCPs) were deployed as part of a number of measurement programs with focused efforts conducted during September and October 2008. Details of the data collection, and subsequent analysis and interpretation of results for input to the spill model are presented in Section 3.2.1.

As also noted in Table 1-2 a surface current drifter study was also completed in September 2008. A comparison of the drifter measurements with model trajectory predictions for the corresponding times is presented in Section 5.3.

CTD profiles were also carried out 8-10 September 2008 at 23 stations near the proposed port location. As presented in Section 2.4 these provide indication of sea surface temperature as input to fuel weathering estimation.

Table 1-2: Steensby Inlet Met-Ocean Data for Spill Modelling Summary

Source	Data	ID/Location	Period of Record
RWDI (digital data provided by Knight Piésold) (RWDI, 2008)	1-hourly wind speed and direction[1], air temperature[2]	Steensby Inlet Met Station 70° 17.68' N, 78° 25.54' W	22-Jun-2006 to 21-Sep-2008 26h gap 14-15 Sep 2006 for met station relocation
ASL	ADCP 10-minute current speed and direction	BLT_1 ~70° 16.55' N, 78° 32.25' W ~35 m depth ADCP deployed downlooking from sea ice	03-May-2008 to 07-Jun-2008
(ASL, 2008)		BLT_2 ~70° 16.45' N, 78° 32.75' W ~52 m depth bottom-mounted ADCP[4]	03-May-2008 to 07-Oct-2008
AMEC (AMEC, 2009)	ADCP[3] 10-minute current speed and direction	Site 1 69° 42.372' N, 77° 45.438' W 72.3 m depth bottom-mounted ADCP[4]	06-Sep-2008 to 11-Oct-2008
		Site 3 69° 49.672' N, 78° 36.725' W 96.5 m depth bottom-mounted ADCP[4]	05-Sep-2008 to 13-Oct-2008

[1] RM Young 5103 anemometer
[2] Campbell Scientific HMP45C212 Temperature and Relative Humidity probe
[3] Additional parameters include sea temperature, pitch, roll, pressure, and compass heading
[4] 300 kHz

Source	Data	ID/Location	Period of Record
		Site 4 70° 17.488' N, 78° 29.527' W 12.3 m depth bottom-mounted ADCP[5]	06-Sep-2008 to 10-Oct-2008
	+ 20-minute waves	Site 5 70° 16.993' N, 78° 32.272' W 30.0 m depth bottom-mounted ADCP[6]	06-Sep-2008 to 08-Oct-2008
CORI (CORI, 2010a)	Drifter study	*"A surface current drifter program was developed to characterize potential spill trajectories in the Steensby Port vicinity. In early September, one to four drifters were released most days near the proposed ore loading docks and allowed to drift for 20-24 hours, when they were retrieved and reset. The drifters consisted of a float, a sail and a GPS satellite transmitter (SPOT Messenger units) that provided approximately 0.5 hour fixes. Ten drifters were constructed and during the program four were lost. Overall the drifter design worked extremely well. … A summary plot of all the drifter runs is shown in Figure [*Figure 5-8*]" (CORI, 2010a)*	07 to 28-Sep-2008
(CORI, 2010b)	CTD (sea temperature and salinity vs. depth profiles)	CTD profiles at 23 stations near the proposed port location (Figure 4)	9/10-Sep-2008

5 600 kHz
6 600 kHz waves array

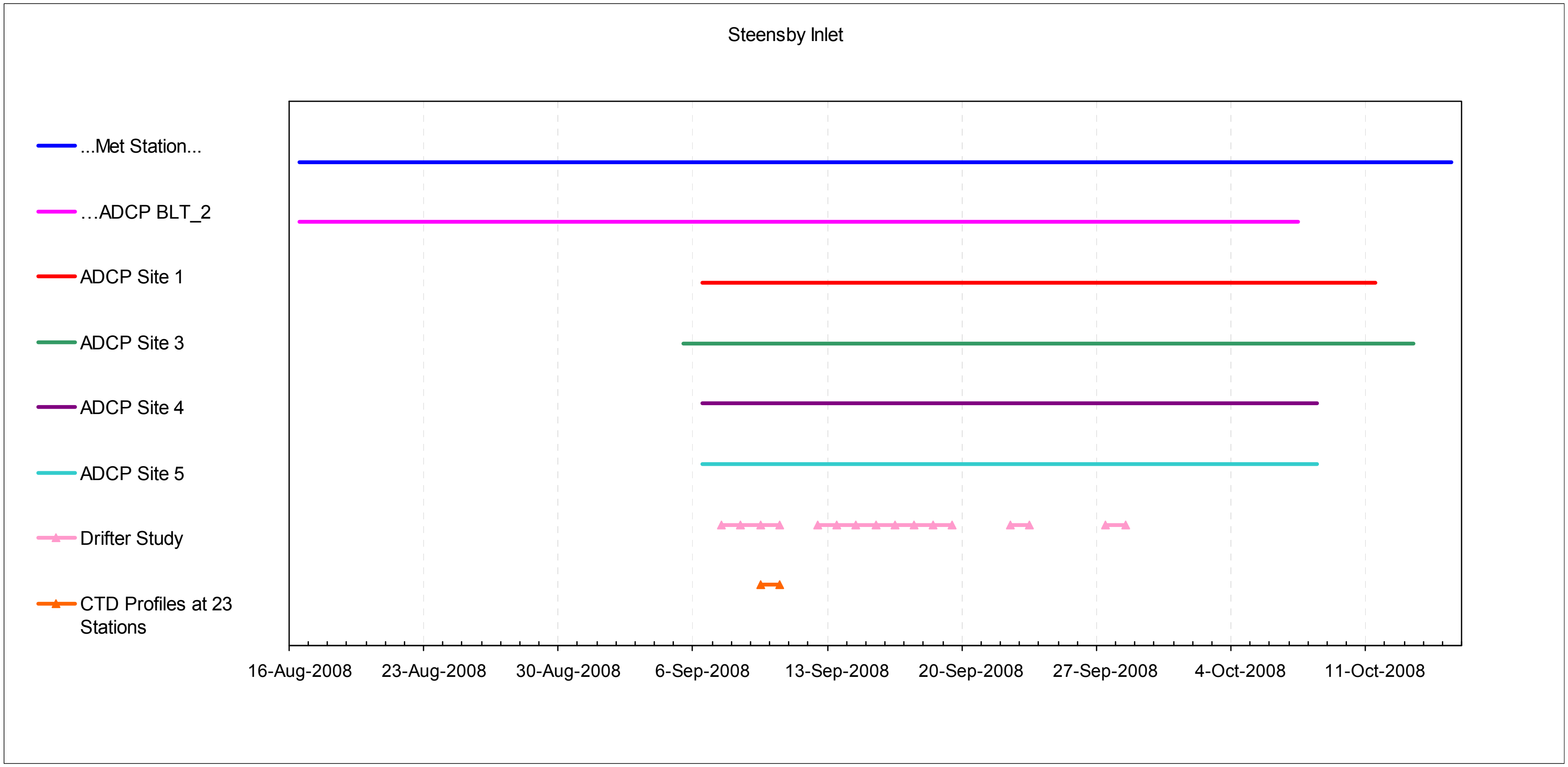


Figure 1-4: Steensby Inlet Met-Ocean Data Open Water Season 2008 Coverage

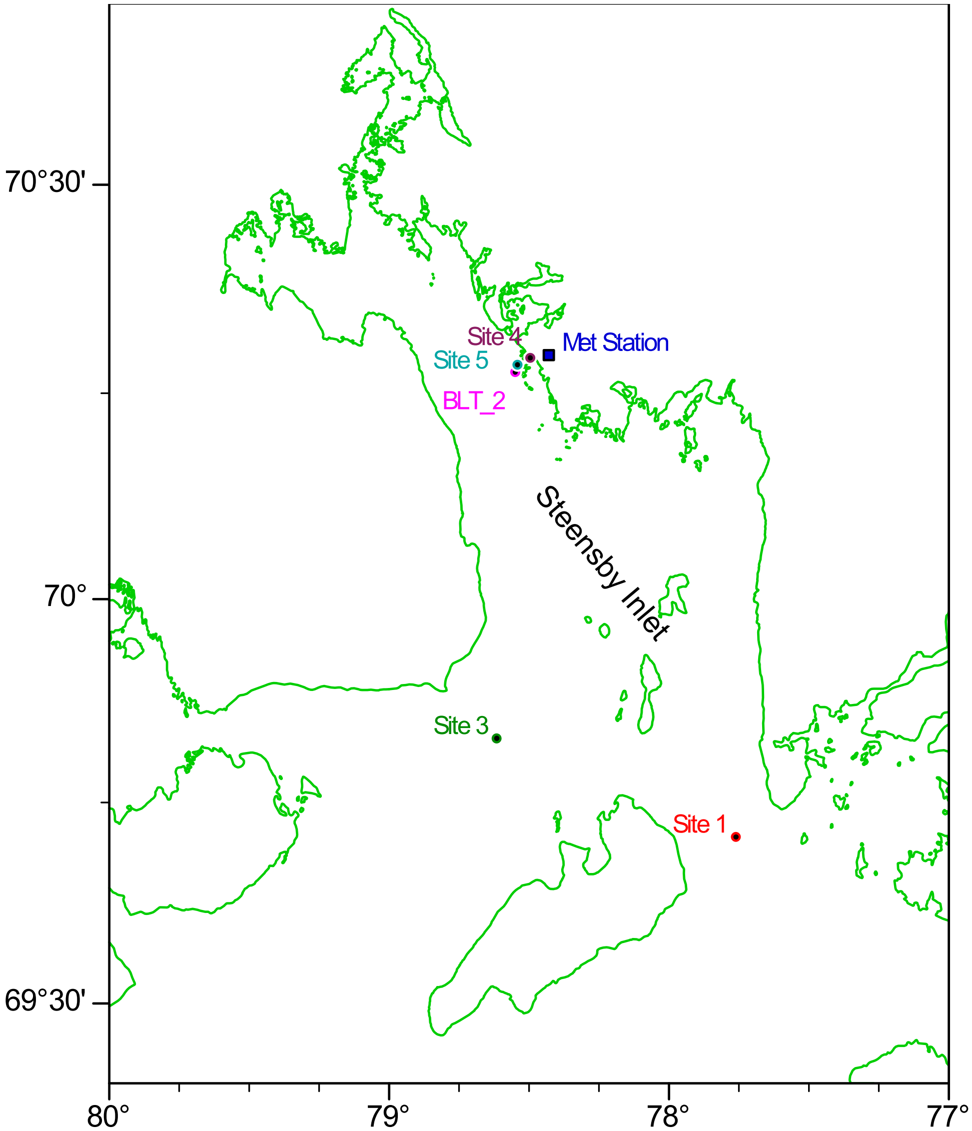


Figure 1-5: Steensby Inlet Met-Ocean Measurement Locations

1.4 Report Structure

Pertinent details of model theory and model input data are presented respectively in Sections 2 and 3. A description of model output formats and interpretations, an understanding of which is essential for a reader to rationally employ model results, follows as Section 4. The modelling results including some model validation use of the current drifter measurements, are presented in Section 5. Section 6 presents a qualitative assessment of shoreline fuel retention. Additional investigations using the OILMAP spill software are presented in Section 7. References are presented in Section 8.

2. MODEL SETUP

The analysis of the open water scenarios was accomplished by making use of the numerical computer model OST developed by AMEC to determine probabilistic spill trajectories. To accompany the delivery of the fuel spill trajectory results, a description of the model and techniques used, and observations based on the modelling activity are presented.

2.1 Model Theory Overview

An oil spill trajectory model is defined for purposes of the present discussion as a computerized sequence of calculations designed to predict some aspects of the behaviour of oil spilled on the surface of water. Such behavioural aspects may include the transport (advection), and/or the spreading, and/or the weathering of spills. Attention is generally restricted to the behaviour of oil on the sea surface.

Oil spill trajectory scenario models (as distinguished from real-time models) are typically employed to provide a prediction of potential spill behaviour. Scenario models attempt to predict typical (or most probable) and extreme answers, for a given spill site, to such questions as:

- What is the likely speed and direction of slick motion?
- What combination of environmental (wind and current) conditions generates the most severe spill scenario?
- How frequently do such conditions occur?

A distinction is drawn between the two basic types of scenario models: deterministic and statistical. The differences relate not so much to the mechanics of the model but to the nature of wind and current data input to the model. A deterministic scenario model employs actual or hindcast data as input to the advection aspect of its calculations. These data may possibly be modified to be made more representative of the site under consideration, but the root of the input is a measured or hindcast time-series of values. Deterministic scenario model mechanics are such that input of a given data series will always yield the identical predicted output. Thus, to gain statistical significance in the interpretation of output, deterministic models must be run on a variety of input data sets or must group predictions by some appropriate time average (such as monthly). With 30 years of conditions for each of 30 days in a month yields 900 individual trajectories. This large number yields good confidence in the overall resultant statistics.

In contrast, the statistical variety of scenario model employs some volume of measured data as a standard or guide to creating a synthetic input data set. This approach is most commonly encountered with wind input. The synthetic data, generated by some statistical process (Monte Carlo simulation, Markov chain) employing a random number generator, are the input to the scenario model. Each iteration of the model, commencing with a specific set of fixed parameters except for the random number seed used in the synthesis, which changes each time, will generate a distinctly different predicted output. Such models must also be run a sufficient number of times to assure statistical significance in the interpretation of the output data.

The AMEC spill trajectory model, OST, is a scenario model of the deterministic variety. It was developed initially for use offshore eastern Canada in the early 1980's and has been used on numerous occasions since, e.g.,

- for the Newfoundland Transshipment Terminal Project, Placentia Bay (Newfoundland, Environmental Assessment, 1996)
- as part of the Voisey's Bay, Labrador nickel and copper mine project, including a number of oil spill in ice scenarios (McKenna and McClintock, 2005)
- in the domain of James Bay during the Environmental Assessment for the De Beers Victor Diamond Project (McClintock, 2004)
- as part of delineation drilling screening for the Norsk Hydro and Husky Energy 2006 program at West Bonne Bay F-12, Offshore Newfoundland (AMEC, 2006)
- nearshore, in Placentia Bay in support of the Long Harbour Commercial Nickel Processing Plant (AMEC, 2007).

2.2 Model Geometry

The transport (and spatial extent) and fate of a spill is modelled as a function of time. A spill time step is assigned which is appropriate for the geographic scale and model grid of the study area and the wind and current conditions which will be used in the model to transport the spill. At each time step in the model a new location and spill volume is calculated. Selection of too large a time step may yield to inaccurate results. Too small a time step makes for overly intensive computations in the model. For the Steensby Inlet domain, a time step of 15 minutes is appropriate (using winds for the given hour over each of those four time steps).

A grid is employed in the model to track the spatial extent of the spill. The grid serves three simultaneous purposes, these being: (i) it serves as the gridded coordinate system for the computation of successive displacements of the slick over each time step; (ii) it is the spatial grid upon which the winds and surface current vectors are mapped; and (iii) it provides a coordinate system for summarizing the predicted first contacts with the shorelines. This single grid is therefore referenced at various times as the model or computational grid, the wind or current grid, and the external grid.

The model grid is a Cartesian grid which includes Steensby Inlet as far as the mouth of the Lagoon Complex Region (Figure 1-3) taken as the northern limit of the marine area (CORI, 2007), as far south as Koch Island just outside the mouth of Steensby Inlet, and west about 45 km to Jens Munk Island. The model grid has its origin at 70° 32' N latitude, 79° 45' W longitude, and extends eastward to 77° 33' W longitude and southward to 69° 44' N latitude.

Grid element dimensions are defined as 16” latitude, or 493 m in the north-south (Y) direction and 48” longitude, or 503 m in the east-west direction. i.e., on the order of 500 m x 500 m. The choice of a Cartesian grid requires the specification of a fixed east-west (X) grid scale, and consequently demands the Mercator projection of land elements on the grid. The computational grid is of minimal consequence to the model user who is simply interested in viewing printed and plotted model output. All results appearing as printed output refer to geographical coordinates and distances which are exactly computed and are independent of grid dimensions. Model output plots of oil distribution probabilities represent all computational grid elements as appropriately scaled rectangles and thus are valid as representing correct relative positions.

Along with the geographical (longitude, latitude) coordinates and the Cartesian (X, Y) coordinates employed with the computational grid, a column (J) and row (I) coordinate system is also imposed to identify grid elements. In the present case, with the grid spanning 2° 12' of longitude and 48' of latitude, and with 16" row by 48" column grid element definitions, these latter coordinates range as follows:

Column	(J)	1 - 165
Row	(I)	1 - 180

The model grid is summarized in Table 2-1 and illustrated in Figure 2-1 where lines for every second row and column are drawn. The computational grid boundaries are shown as a gold rectangle in the spill probability figures in Section 5.

Since the model grid cells are 500 m x 500 m in size and the open water between the ore loading island and Baffin Island in the region of the proposed conveyor bridge (Figure 1-2: grid square at row 2 and column 4 of the 7x6 square region outlined in red) is only on the order of 150-200 m, a strict mapping of grid cells to land or water, according to which is present in the majority in the cell, would effectively block off this potential passageway out of the Port. A small refinement in the land/water grid was therefore made to allow for a three grid cell waterway through to the northern regions. This area of note is illustrated in Figure 2-2 where the 'opened' grid cells are highlighted, though due to the coastline, including the small islands immediately to the west of the pink circle, the cells appear 'closed': they are set in the model to be open so that a spill can pass to the north and west through this opening at the top of the ore loading island. The Port Site and Drogue Site (Table 1-1) spill origins are plotted with blue circles; the Steensby Site met station is shown with a purple square; Walrus Bay is immediately to the north.

It is also evident in the figure that some of the small inlet islands are mapped as land (corresponding grid cells are filled in green), thereby halting the fuel trajectory in the model at that location, and others are mapped as water (corresponding grid cells are unfilled, except for coastlines drawn in green), thereby allowing the trajectory to drift or advect (Section 2.3) unimpeded. In constructing the land/water grid, a balance was attempted in this regard to allow for potential fuel drift far afield into the inlet though so that not every island was 'charted'. Clearly for Steensby Inlet the potential will exist for fuel reaching some of the smaller islands, even if not accounted for in the model.

Table 2-1: Spill Model Grid Setup

	Grid Size						**Cell Size (latitude x longitude)**	
Domain	*latitude*	*longitude*	*# rows*	*# columns*	*latitude (km)*	*longitude (km)*	*latitude*	*longitude*
Steensby Inlet	48’ 69° 44' to 70° 32' N	2° 12’ 79° 45' to 77° 33' W	180	165	88.8	83 (at 70° 8’ N)	16” or 493 m	48” or 503 m
	grid mid-latitude is at 70° 8’N							

2.3 Transport (Advection)

A simple transport computation is employed to simulate the advection of a point (assumed to represent the centroid of a slick) through two-dimensional space (representing the sea surface).

At any given time the point is assumed to be subject to two independent displacing forces. The presence of an ocean surface current is assumed to displace the point (centroid) in the direction of the current at 100% of the current speed. Simultaneously, but independently, the presence of wind is assumed to generate an instantaneous surface current directed 10° (Westeng, et al., 1977) to the right of the wind (in the northern hemisphere) and having a magnitude of 3.0 to 3.5% of the wind speed. A value of 3.5% is used in the model. This current is also assumed to directly transport the slick. Over the time-step of the available wind data the displacements due to surface current and due to wind-driven surface currents are vectorially added to yield a new slick position. Sequential vector additions are computed over each successive time-step until the simulation terminates on one of two endpoint conditions:

- a coastal boundary is reached; or
- an external grid boundary is reached.

A third possibility for ending a trajectory in the model is if the percent oil weathered rises above 95%. The selection of the current vector and the wind vector to be employed in the transport computation at any given time during the simulation is determined strictly by the present location of the slick centroid.

For the present model implementation, the wind velocity is available hourly. Due to the short distances to shore, a sub interval of 15 minutes is employed, where the winds and currents for a given hour are used at each of the four substeps in that hour.

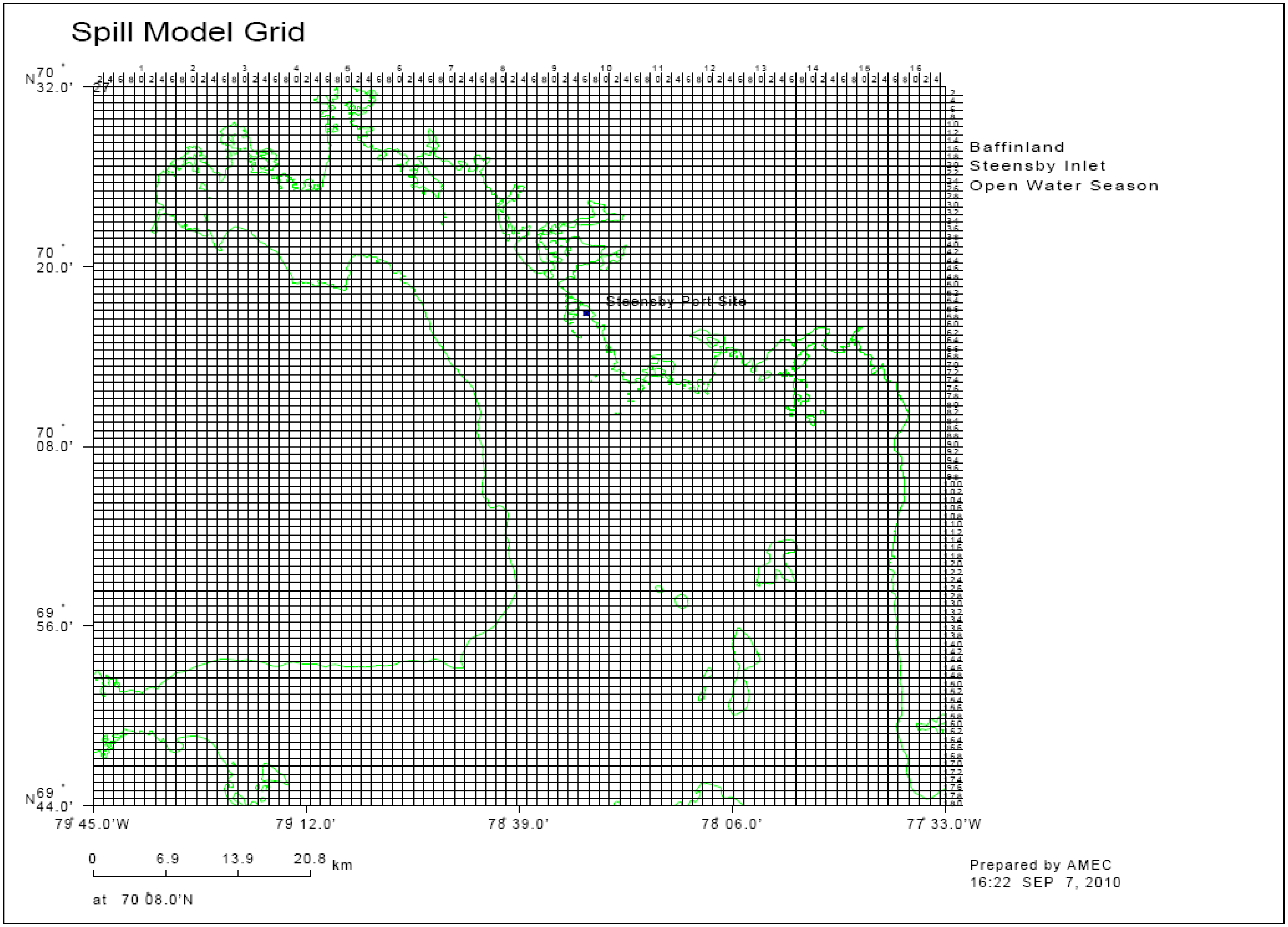


Figure 2-1: OST Spill Model Grid

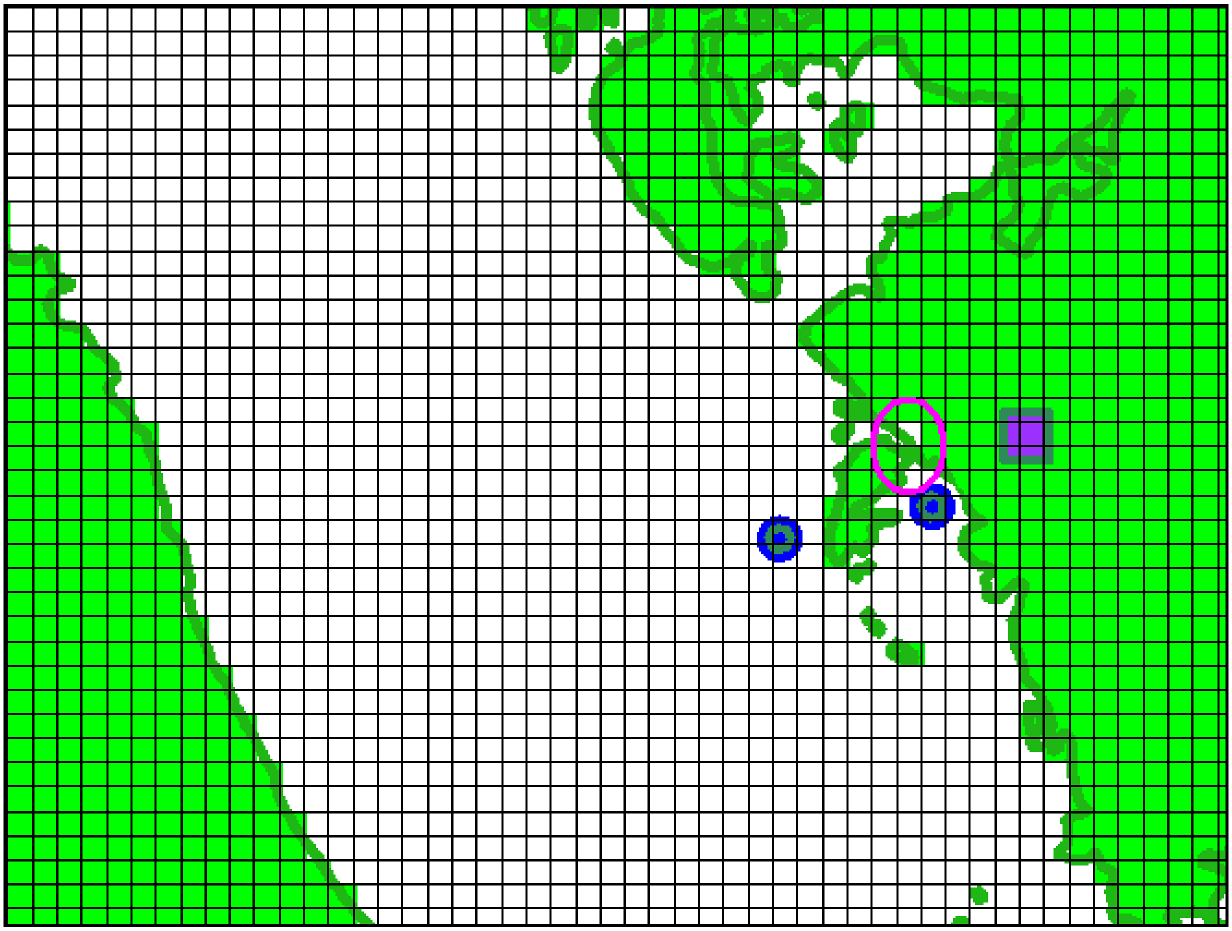


Figure 2-2: OST Spill Model Grid: Port Site and Ore Loading Island Area

2.4 Weathering

The scenario trajectory model is provided with a switch to globally control the use of weathering routines. If weathering routines are enabled, a series of subroutines are executed after the displacement computation (described above) is completed in each time step. The processes of evaporation and vertical dispersion or loss into the water column, are simulated to yield estimates of the total volume of oil remaining. This is expressed as a percentage of initial spill volume. If weathering is switched off, these calculations are omitted.

Background
Arctic diesel fuel is to be transported as cargo, which may vary slightly in composition depending on source.

Upon release in the marine environment, fuel oil is subject to weathering processes, including spreading, evaporation, dissolution, dispersion of oil droplets into the water column, photochemical oxidation, emulsification, microbial degradation, adsorption onto particulate matter, ingestion by aquatic organisms, sinking and sedimentation (Payne et al., 1991).

Immediately after the oil is spilled, it starts spreading over the sea surface, at a rate that is largely dependent on the viscosity (resistance to flow) of the oil. The rate of spreading also depends on the wind speed, significant wave height, as well as the presence of tidal and mean currents. The dynamic viscosity of diesel fuel changes drastically with temperature, from 2 mPa·s at 25° C to 4 mPa·s at 0° C (ESTD, Environment Canada, 2010). Another property of oil that is especially significant in Arctic conditions is the pour point, which is the lowest temperature at which the oil will flow, typically at -30° C (ESTD, Environment Canada, 2010). At temperatures below the pour point, the oil solidifies rapidly and the spreading is minimized. During periods of high winds and waves, the oil can form narrow bands that are aligned with the wind direction, a state in which the slick movement is controlled by the sea state rather than the oil properties (ITOPF, 2010).

Another major weathering process within the first days of a spill is evaporation. According to ITOPF (2010), most of the oil components with a boiling point less than 200° C tend to evaporate within the first few days. For diesel fuel, these components represent 34% of the weight (ESTD, Environment Canada, 2010). Therefore, due to the higher volatility of diesel fuel compared to crude oil, a comparatively higher fraction of the amount of spilled oil would evaporate. Evaporation is facilitated by the ambient temperature and the presence of wind.

The oil fraction that is not lost to evaporation or dilution in water is eventually broken up into droplets of varying sizes which are subject to dispersion. The process of dispersion, often accelerated by the application of dispersants, contributes towards faster biodegradation, dissolution and sedimentation of the spilled oil. Dispersion can be hindered by emulsification of the oil under the action of waves, which is a common cause for the persistence of spilled oil in the marine environment. On a timescale longer than a week, the dominant weathering processes become biodegradation by microorganisms and sedimentation and sinking processes (ITOPF 2010).

While a spill in ice is not considered in this study, it is noted that in ice-covered waters, the different forms of sea ice can impact drastic changes to the rates and relative importance of the weathering processes. Thus, during growing slush ice conditions (late fall and early winter), the oil is subject to stranding on the ice surfaces and rapid emulsification, followed by submersion and incorporation into the ice canopy (Payne et al., 1991). Thus, the oil found on the upper ice surface weathers predominantly through evaporation, but the portion incorporated in the ice does not undergo weathering until the melting season.

In practice, the presence of sea ice will tend to slow the advection of a fuel spill and to reduce evaporation and dispersion. McKenna and McClintock (2005) modelled spills in landfast and moving sea ice for Voisey's Bay, Labrador. In that work, a range of sea ice concentrations were considered. For ice concentrations below 3/10ths coverage, spill advection was calculated using an open water spill model (essentially that employed here). For ice concentrations between 3/10ths and 8/10ths, advection was the weighted average of open water spill and sea ice drift velocities. Above 8/10ths concentration, spill advection was governed entirely by sea ice drift. In the presence of sea ice, the evaporation rate is reduced and can be approximated to consider only the open water fraction, while the dispersion rate also is reduced due to the ice's damping effect on motion of the sea surface.

Where ice is present in significant concentrations, potential spills will be transported with and fully integrated into the ice. Recovery of any remaining fuel may only be possible by restraining the sea ice using ice booms and removing the fuel when the ice melts.

While oil in ice effects were not explicitly modelled in this exercise these observations should be generally applicable for the Steensby Inlet region.

<u>Model Implementation</u>

The weathering algorithm for diesel fuel is based on simulations with the OILMAP software[7] (ASA, 2009). OILMAP will calculate the evaporation, dispersion, and remaining percentage for a given spill scenario where the user defines an oil product type, weather conditions, properties of the receiving water, and the amount of oil released. The characterization of diesel fuel properties is given in Figure 2-3.

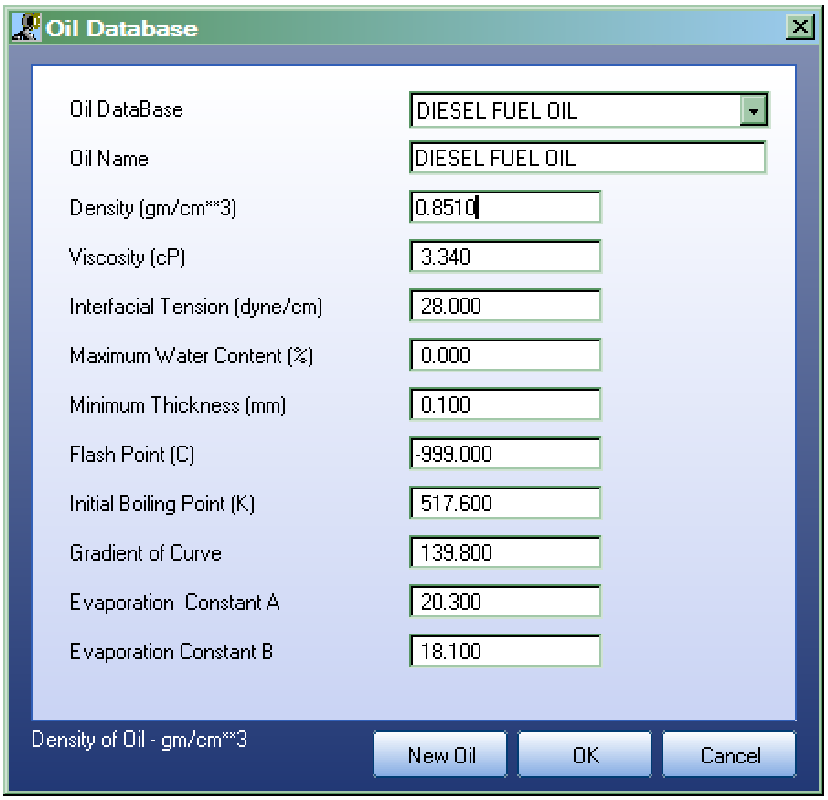


Figure 2-3: Diesel Fuel Oil Physical Parameters (Source: OILMAP v 6.4.0)

For this study, scenarios of a diesel fuel amount of 5 ML released under a range of wind speed conditions and constant water temperature were considered.

An estimate of sea surface temperature was obtained from review of the September 2008 CTD profiles completed at locations near the Steensby Port site (Figure 2-4) by CORI (CORI, 2010b),

[7] OILMAP is a user-friendly, Windows-based, oil spill model system suitable for use in oil spill response and contingency planning. It includes simple graphical procedures for entering both wind and hydrodynamic data and specifying the spill scenario. The standard system is delivered with an oil spill trajectory and fates model, environmental data tools and visualization tool. The oil spill model predicts the surface trajectory of spilled oil for either instantaneous or continuous release spills. The model includes algorithms for oil spreading, evaporation, emulsification, entrainment, and oil shoreline interaction. The distribution and mass balance of oil with respect to time are predicted for the type of oil spilled.

The profiles indicate near-surface (about 1 m depth) temperatures range from about 0.5 °C, e.g., at station 3 near the southern tip of the Port island (Figure 2-5) to 0.8 °C, e.g., at station 11 in the middle of the inlet. A representative temperature of 0.7 °C, e.g., the value at station 1 near the proposed fuel unloading dock, was selected as a mean condition. In turn, a nearest resolution of 1.0 °C was employed in the OILMAP simulations.

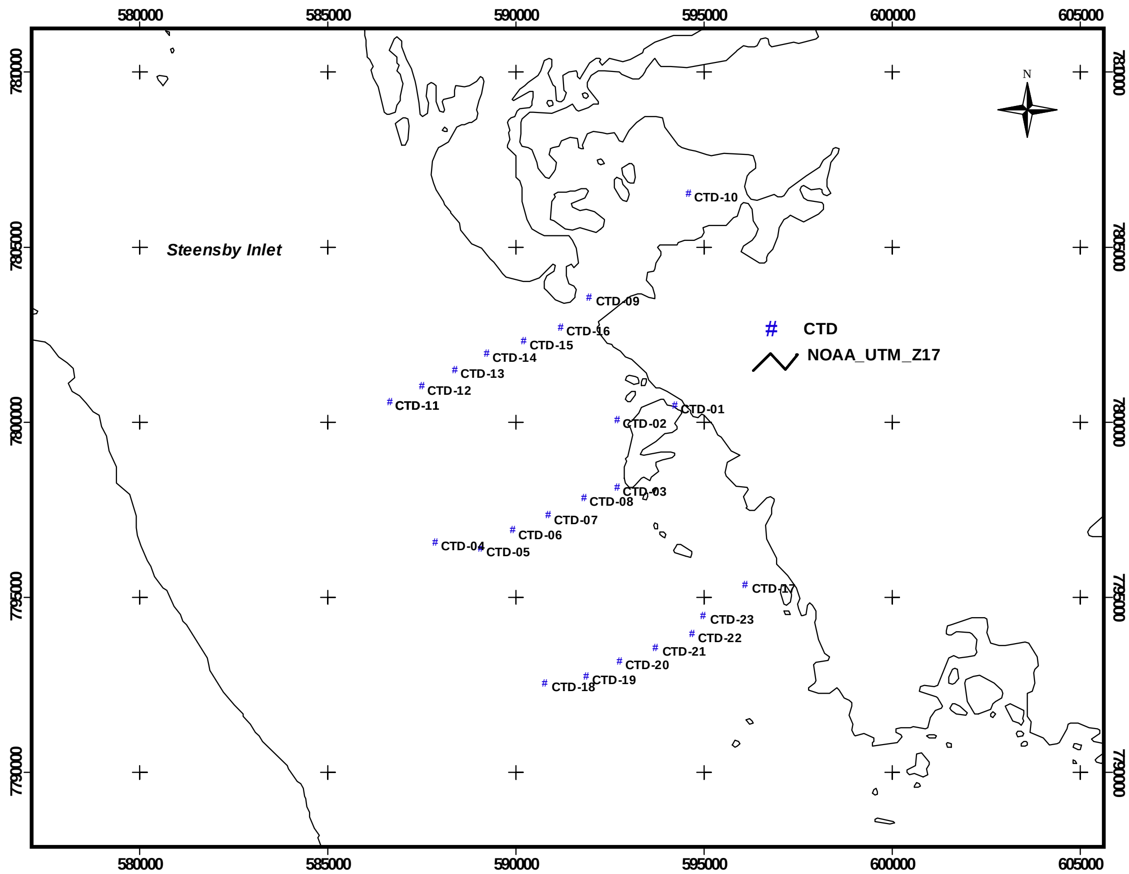


Figure 2-4: Steensby Inlet CTD Stations, September 2008 (Source: CORI, 2010b)

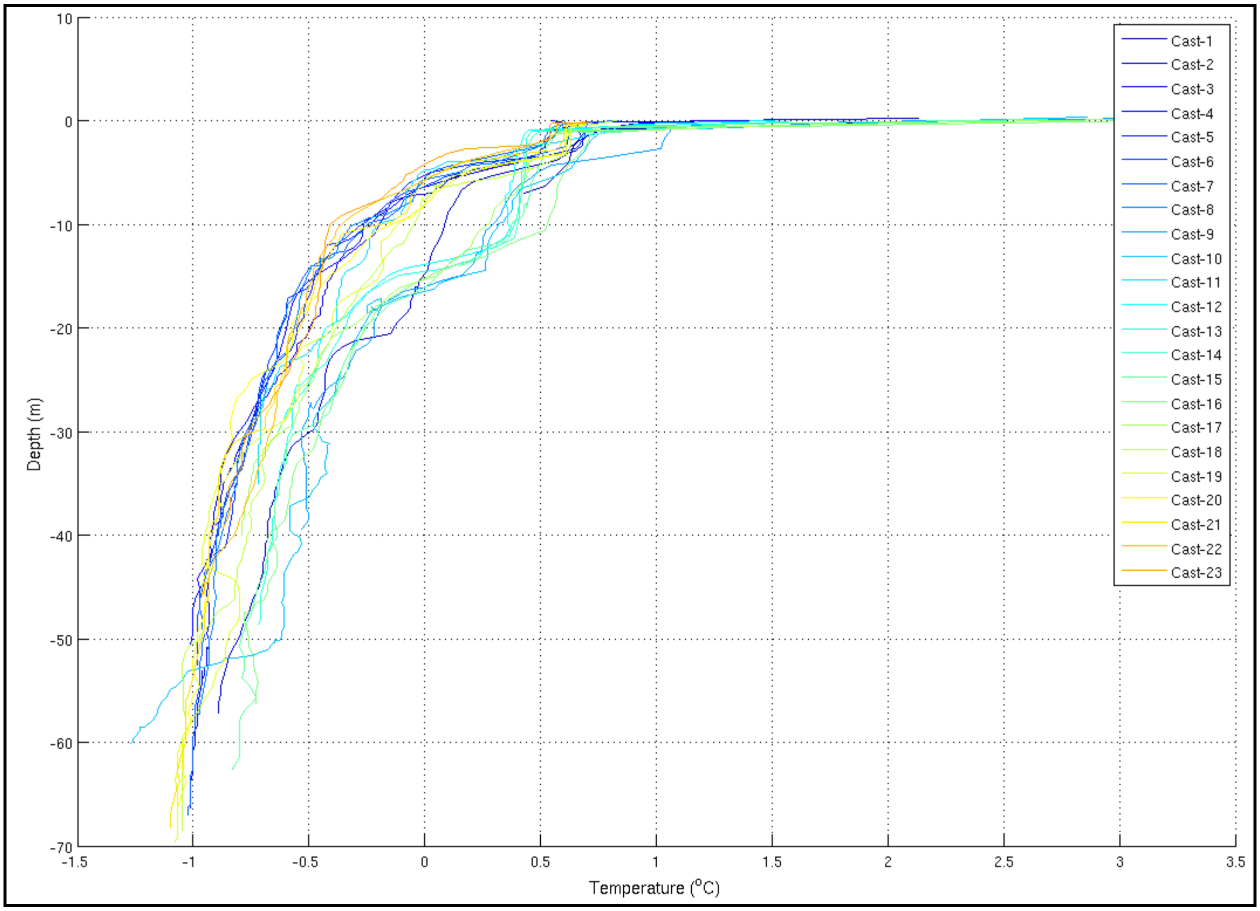


Figure 2-5: CTD Temperature Profiles (Based on Data from: CORI, 2010b)

A wind speed range of 0 to 10 m/s was considered. Mean winds in September are 4.9 m/s and the 95% upper limit is 11.7 m/s (see Section 3.1.1 for Steensby Inlet wind statistics and discussion).

Figure 2-6 and Figure 2-7 illustrate outputs from two scenario runs, for 2 m/s and 6 m/s respectively[8]. An assumed horizontal dispersion coefficient of 3 m^2/s intended to be representative of a low energy level environment (ASA, 2004) was selected. All runs are with 5,000,000L (5 ML) and run for 30 days and water temperature of 1.0 °C (greater evaporation occurs at warmer surface temperatures). The figures show the slick trajectory path including thickness (three slick thicknesses: 0.1 to 20 mm, 0.01 to 0.1 mm, and 0.001 to 0.01 mm are shown), and the fuel weathering fate.

For the constant 2 m/s winds, after 30 days the slick diameter is about 20 km diameter and has travelled about 186 km. For the constant 6 m/s winds, at about four and a half days (the time step shown in Figure 2-7) the slick diameter is about 9km diameter after travelling a distance of about 86 km. On the subsequent time step, all fuel is removed from the sea surface, i.e., has been lost due to evaporation and dispersion and entrainment into the water column. The

[8] Note that these are simulations in open water (the latitude/longitude domain happens to be the North Atlantic though there is nothing special other than it is open ocean with no shoreline or other constraints or containment)

released fuel is apportioned over a number of ‘spillets’, in this case, 500, for the simulation. The model is set, by a user parameter, not to track spillets smaller than 10% of their initial mass. This accounts for the ‘not tracked’ amount in the weathering graph in Figure 2-7.

Figure 2-8 and Figure 2-9 present the weathering losses due to evaporation and water column entrainment for the six constant wind speed scenarios. It is seen that evaporation increases with wind speed, on the order of 2.4% per day under calm conditions to 8.1% per day for winds of 10 m/s. Loss of diesel fuel into the water column is even more strongly influenced by wind speed. While there are very small water column losses for wind speeds of 4 m/s, on the order of 0.1 %, and negligible losses for winds lighter than 4 m/s, for the 5 m/s simulation, about 1.7% per day is lost over the first five days. This increases slightly to about 2.6% per day by day 20. For the simulated larger wind speeds of 6, 8, and 10 m/s, the loss rates are on the order of 15, 60, and 119% per day, respectively.

These results are tabulated in Table 2-2 and Table 2-3 which in turn were implemented in the OST weathering routine. A simple lookup based on time into the spill, and wind speed, was used to calculate the percentage weathering losses, at each time step in the trajectory simulation.

The spill modelling does not treat a specific volume of oil, rather the percentage oil remaining is estimated, and provided in the OST listings (Section 4.2), and so one can apply the percentages to any chosen volume.

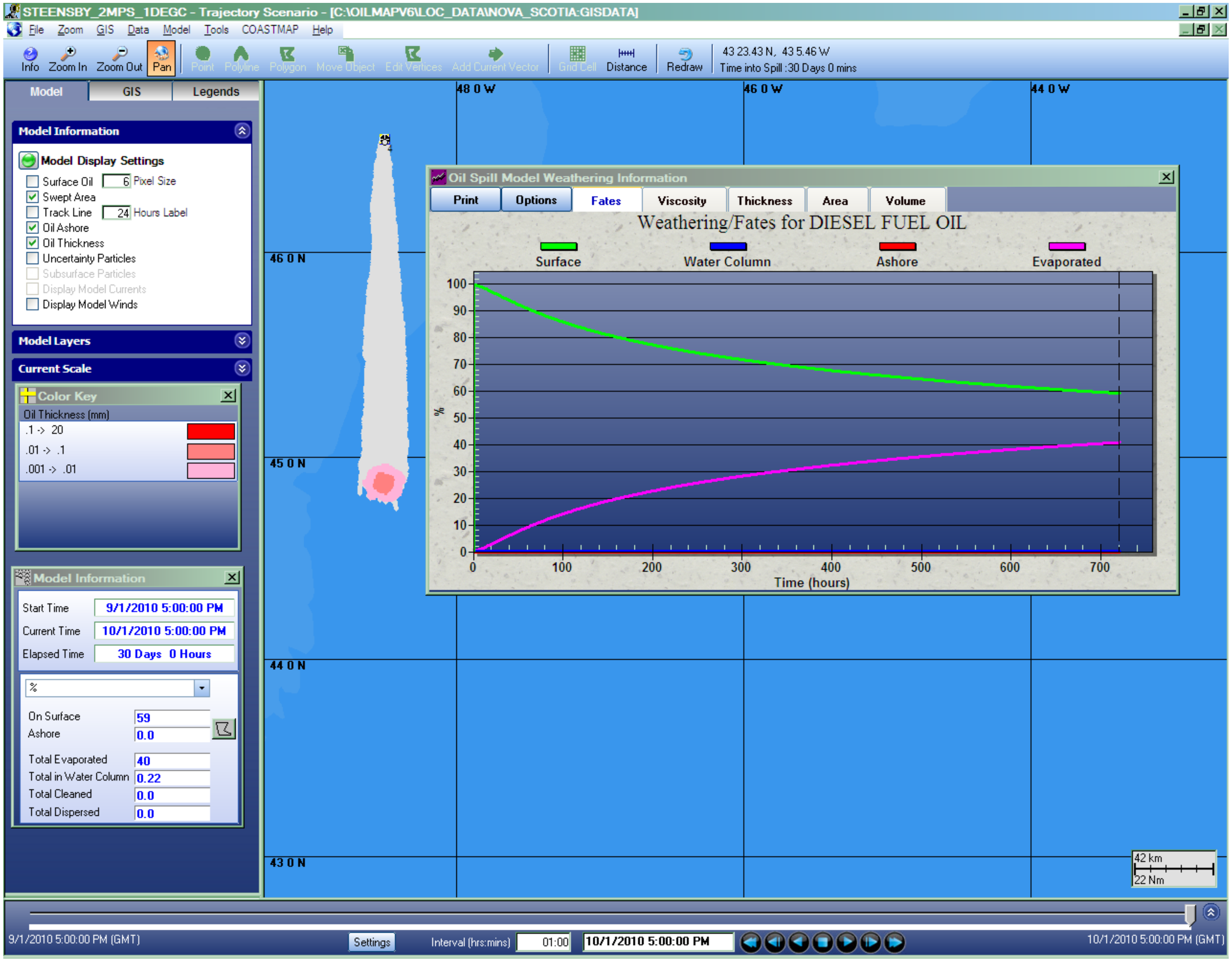


Figure 2-6: OILMAP Weathering Simulation, Wind Speed of 2 m/s

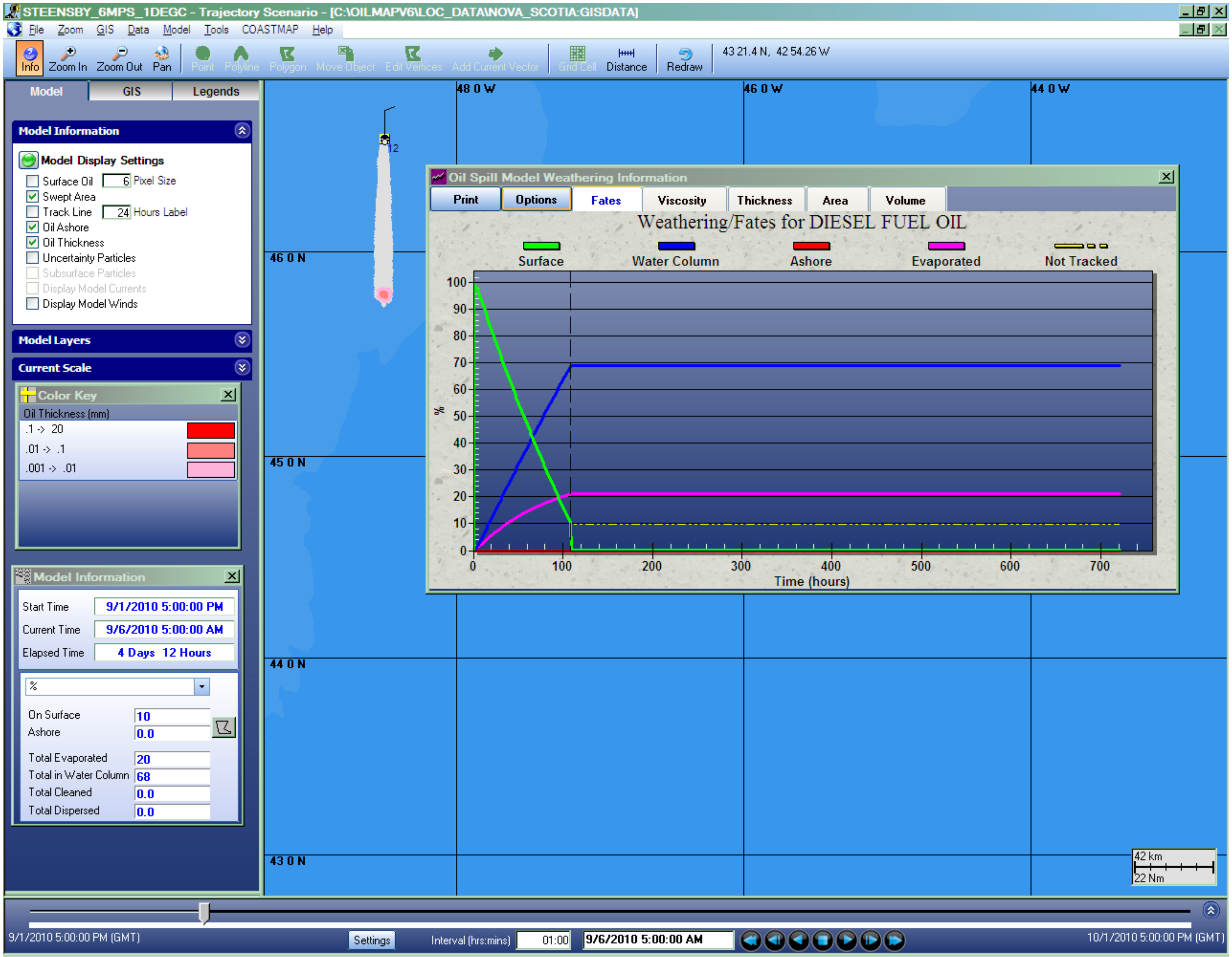


Figure 2-7: OILMAP Weathering Simulation, Wind Speed of 6 m/s

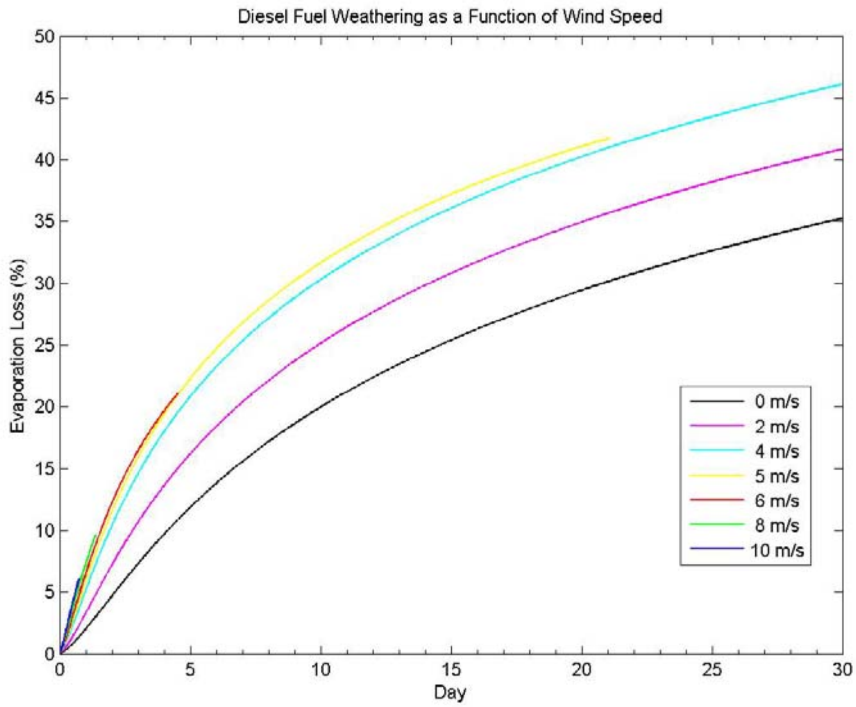


Figure 2-8: Diesel Fuel Weathering: Evaporation Loss as a Function of Wind Speed (Source: OILMAP v 6.4.0)

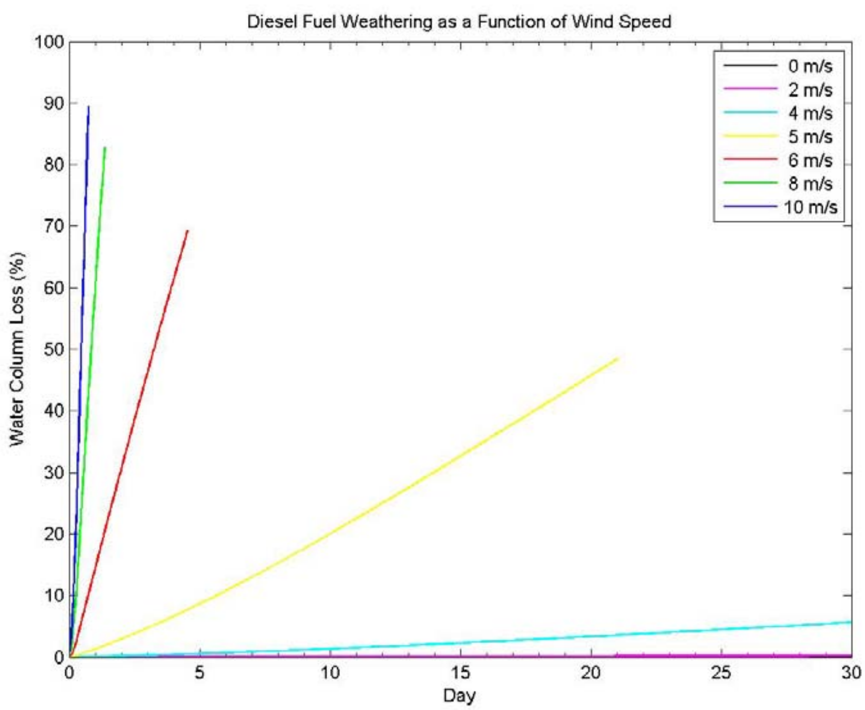


Figure 2-9: Diesel Fuel Weathering: Water Column Loss as a Function of Wind Speed (Source: OILMAP v 6.4.0)

Table 2-2: Diesel Fuel Weathering: Evaporation Loss as a Function of Wind Speed

Wind Speed (m/s)	Evaporation Loss Rate (% per day) for time into Spill (days)			
	0-5 days	**5-10**	**10-20**	**20+**
0-1	2.4	1.6	0.9	0.6
1-3	3.2	1.8	1.0	0.6
3-4.5	4.2	1.9	1.0	0.6
4.5-5.5	4.5	1.9	0.9	0.1
5.5-7	4.6	3.1	0.9	0.9
7-9	7.0	4.7	1.4	1.4
9+	8.1	5.4	1.6	1.6

Table 2-3: Diesel Fuel Weathering: Water Column Loss as a Function of Wind Speed

Wind Speed (m/s)	Water Column Loss Rate (% per day) for time into Spill (days)			
	0-5 days	**5-10**	**10-20**	**20+**
0-1	0	0	0	0
1-3	0.004	0.006	0.008	0.009
3-4.5	0.1	0.2	0.2	0.2
4.5-5.5	1.7	2.3	2.6	0.3
5.5-7	15.2	15.2	15.2	15.2
7-9	60.2	60.2	60.2	60.2
9+	119.2	119.2	119.2	119.2

A concise summary, prepared by NOAA, of characteristics of small diesel spills is also presented in Figure 2-10 and Figure 2-11 which may assist in assessing potential weathering fates and related consequences. While the Steensby scenario spill size of 5 ML, or 5000 m^3, is much larger than the 5000 gallon (19 m^3) value noted here, the information should still have applicability in particular for any small releases which might occur. Diesel is also not very viscous or sticky, so that while porous shoreline sediments may be oiled, less-porous shorelines, e.g., those with a lower oil residence index time, may tend to be washed off due to wave or tidal flushing. For some regions of Steensby Inlet such as the rocky shorelines of the Rocky Eastern Region, this may be a likely scenario.

Small Diesel Spills (500-5000 gallons)

Small Diesel Spills (500-5000 gallons)

Diesel fuel is most often a light, refined petroleum product. Small diesel spills will usually evaporate and disperse within a day or less. This is particularly true for typical spills from a fishing vessel (500-5,000 gallons), even in cold water. Thus, seldom is there any oil on the surface for responders to recover. However, what is commonly referred to as "marine diesel" is often a heavier intermediate fuel oil that will persist longer when spilled. When spilled on water, diesel oil spreads very quickly to a thin film of rainbow and silver sheens except for marine diesel, which may form a thicker film of dull or dark colors.

Characteristics of Small Diesel Spills (500-5000 gallons)

- Diesel oil has a very low viscosity and is readily dispersed into the water column when winds reach 5-7 knots or with breaking waves.
- Diesel oil is much lighter than water (specific gravity is between 0.83 and 0.88), compared to 1.03 for seawater). It is not possible for this oil to sink and accumulate on the seafloor as pooled or free oil unless adsorption occurs with sediment.
- However, it is possible for the diesel oil that is dispersed by wave action, to form droplets that are small enough be kept in suspension and moved by the currents.
- Oil dispersed in the water column can adhere to fine-grained suspended sediments(adsorption) which then settle out and get deposited on the seafloor. This process is more likely to occur near river mouths where fine-grained sediment are carried in by rivers. It is less likely to occur in open marine settings. This process is not likely to result in measurable sediment contamination for small spills.
- Diesel oil is not very sticky or viscous, compared to black oils. When small spills do strand on the shoreline, the oil tends to penetrate porous sediments quickly, but also tend to be washed off quickly by waves and tidal flushing. Thus, shoreline cleanup is usually not needed.
- Diesel oil is readily and completely degraded by naturally occurring microbes, under time frames of one to two months.
- In terms of toxicity to water-column organisms, diesel is considered to be one of the most acutely toxic oil types. Fish, invertebrates and seaweed that come in direct contact with a diesel spill may be killed. However, small spills in open water are so rapidly diluted that fish kills have never been reported. Fish kills have been reported for small spills in confined, shallow water.
- Crabs and shellfish can be tainted from small diesel spills in shallow, nearshore areas. These organisms bioaccumulate the oil, but will also depurate the oil, usually over a period of several weeks after exposure.
- Small diesel spills can affect marine birds by direct contact, though the number of birds affected is usually small because of the short time the oil is on the water surface. Mortality is caused by ingestion during preening as well as to hypothermia from matted feathers. Experience over the last 10 years in Alaska, with hundreds of small diesel spills, is that few birds are directly affected by diesel spills from fishing vessels. However, small spills could result in serious impacts to birds under the "wrong" conditions, such as a grounding right next to a large nesting colony or transport of sheens into a high bird concentration area.

National Oceanic and Atmospheric Administration • NOAA's National Ocean Service • Office of Response and Restoration

Figure 2-10: Small Diesel Spills (500-5000 gallons): Characteristics (Source: NOAA, 2006)

Small Diesel Spills (500-5000 gallons)

Over 90% of the diesel in a small spill incident into the marine environment is either evaporated or naturally dispersed into the water column in time frames of a couple of hours to a couple of days. Percent ranges, in parentheses above, represent effects of winds ranging from 5 to 30 knots.

Adsorption (sedimentation) The process by which one substance is attracted to and adheres to the surface of another substance without actually penetrating its internal structure

Biodegradation The degradation of substances resulting from their use as food energy sources by certain micro-organisms including bacteria, fungi, and yeasts

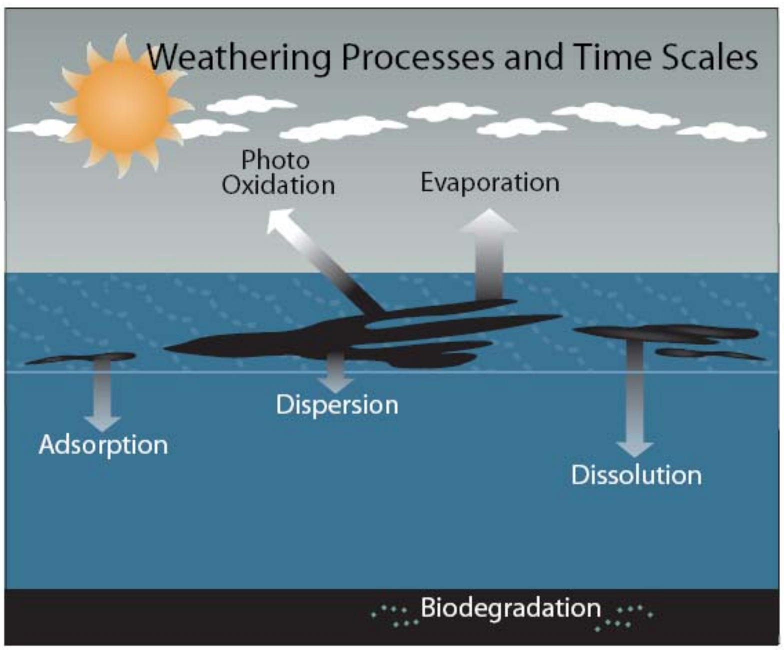
Dispersion The distribution of spilled oil into the upper layers of the water column by natural wave action or application of chemical dispersants

Dissolution The act or process of dissolving one substance in another

Emulsification The process whereby one liquid is dispersed into another liquid in the form of small droplets

Evaporation The process whereby any substance is converted from a liquid state to become part of the surrounding atmosphere in the form of a vapor

Photo Oxidation Sunlight-promoted chemical reaction of oxygen in the air and oil



For more information:
NOAA's Office of Response and Restoration
Emergency Response Division
7600 Sand Point Way NE
Seattle, Washington 98115
206.526.6317

November 2006

Figure 2-11: Small Diesel Spills (500-5000 gallons): Weathering Processes and Time Scales (Source: NOAA, 2006)

3. MODEL INPUT

3.1 Wind

As wind is the key factor in determining how far fuel may potentially be dispersed in the event of a spill, it is important to employ a good characterization of local wind behaviour as a driving force for the trajectory model. It is essential that any wind information be representative of the spill site and its surroundings, and that the wind data be available in the form of long (many year) time-series of speed and direction pairs, regularly spaced in time (hourly, three-hourly, six-hourly, etc.).

To be representative, the wind data must reasonably reflect conditions at or near the sea surface in the vicinity of any particular scenario spill site. The length of the record is important because it dictates the statistical reliability of conclusions drawn from its analysis. The regularity of time spacing is essential due to the structure of the advection calculations in the model.

For the winds in Steensby Inlet, two data resources were examined as described in Sections 3.1.1 and 3.1.2.1.: Steensby Met Station and NECEP/NCAR Reanalysis Winds. The selection of winds for model input is presented in Section 3.1.3.

3.1.1 Steensby Met Station

There are wind measurements from the met station at the Steensby camp located near the port site (RWDI, 2008) at position 70° 17.68' N, 78° 25.54' W (Figure 3-1). Primary parameters of interest include 1-hourly mean, minimum and maximum wind speed, and wind direction mean and standard deviation measured with a RM Young 5103 anemometer. Additional hourly parameters from the met station include the following:

- hourly and 24 hour total rainfall
- air temperature
- minimum and maximum relative humidity
- mean and total solar radiation
- wind direction
- std. dev. wind direction
- total rainfall
- dew point
- mean heat index
- hours of sunshine
- mean, minimum and maximum wind chill

Measurements from the station are available for the period 22 June 2006 to 16 August 2009. This includes a 26 hour gap 14-15 September 2006 for met station relocation.

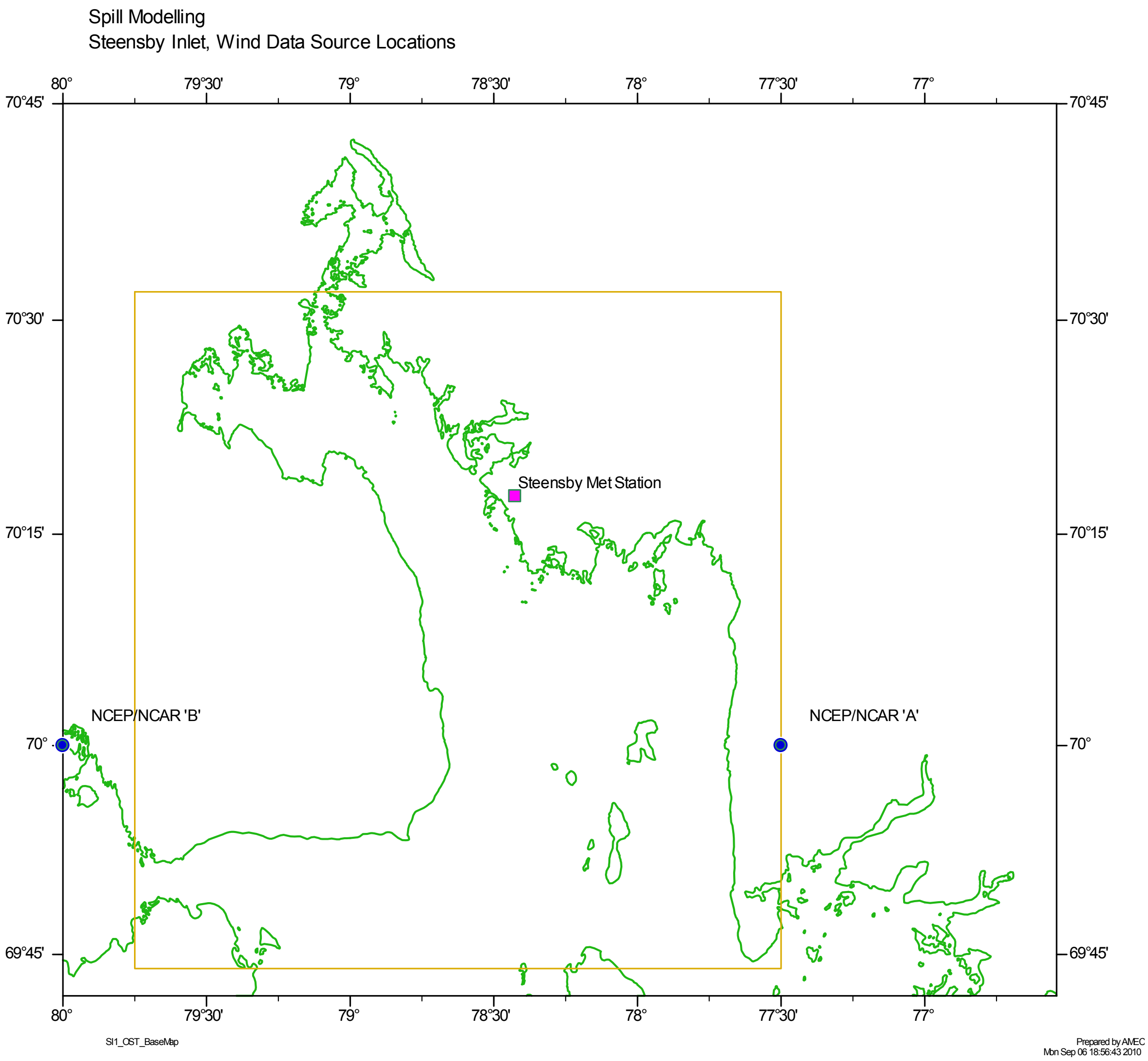


Figure 3-1: Steensby Inlet, Wind Data Source Locations

AMEC assembled and reviewed the digital data for a quality control check. A few duplicate record were removed; and the following records were also removed.

- removed due to likely wind speed sensor freeze-up:
  - 2006 Nov 4 1400 – 2006 Nov 13 2100h (times are UTC)
  - 2007 Nov 2 1700 – 2007 Nov 4 0500h

- removed due to spikes:
  - 2007 Oct 12 1200h
  - 2008 Jul 22 2300h
  - 2008 Oct 4 2200h
  - 2009 Jul 26 1500h

Linear interpolation of wind gaps of length one hour to as long as one day was completed. A total of 1755 interpolated records were added. Gaps remain for several periods including the following: 13-14 Sep 2006; 3-5 and 10-15 Nov 2008; 19 Nov 2008 to 11 Feb 2009; 13-16 and 19-21 Feb 2009; 13-21 Jul 2009; and 28 Jul to 1 August 2009.

Mean monthly wind speed statistics for the resulting Steensby met station are presented in Table 3-1. Mean speeds range from 4 m/s in May to 6 m/s in October and are 4.9 m/s in September.

Monthly wind roses are presented in Figure 3-2. In September, the focus for open water season, winds are most frequently from the northwest at 19.5% as reported in Table 3-4 and also from the south, north, east, and northeast at 13 to 16%.

3.1.2 NCEP/NCAR Reanalysis Winds

The NCEP/NCAR Reanalysis Project (at the NOAA/ESRL Physical Sciences Division) (Kalnay et al.,1996) is a state-of-the-art analysis/forecast system that performs data assimilation using data from 1948 to the present. The winds are near-surface modelled winds representative of a 10 m elevation. The NCAR/NCEP data consist of six-hourly U (east-west) and V (north-south) components of wind velocity on a 2.5° latitude by 2.5° longitude grid. The nearest grid points for Steensby Inlet are at 70° N, 77.5°W, location ‘A’, and at 70° N, 80°W, location ‘B’ (Figure 3-1). Note that two other gridpoints with the same longitudes which are nearest to the north are at 72° 30’ N though this is on the northern side of Baffin Island and hence not suitable to possible interpolation to the met station site. Nevertheless, the two grid points ‘A’ and ‘B’ are carried forward for consideration.

Given it is the nearest to the Steensby met station at a distance of about 45 km to the southeast, grid point location ‘A’ was selected as the primary NCEP/NCAR location for comparison purposes. Monthly wind speed statistics for ‘A’ are presented in Table 3-2 and Table 3-3. Both the 2006-2009 comparison period and the 30 years of 1980-2009, since it was anticipated that a 30 year record would ultimately be required for the simulation, are presented.

Bivariate tables of wind speed vs. wind direction for September are presented in Table 3-5 and Table 3-6, listed below the Steensby Site table counterpart. Monthly wind roses are presented in Figure 3-3 and Figure 3-4. In September, winds are most frequently from the northeast and northwest for about 16 to 19% of the time depending on the period of record.

Table 3-1: Steensby Inlet Monthly Wind Speed (m/s) and Direction (from) Statistics, 2006-2009

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean hourly speed	5.0	4.7	5.3	4.7	4.0	4.7	4.3	4.9	4.9	6.0	5.4	4.3	4.8
Most frequent direction	NW	NW	NW	NW	NW	SE	SE	SE	NW	NW	NW	NW	NW
Max. hourly speed	16.1	17.6	15.9	14.5	14.7	15.7	36.7	18.3	17.3	19.4	22.0	14.0	36.7
Direction of max. hourly speed	SE	SE	SE	SE	NE	E	SE	SE	E	SE	NE	E	SE

Table 3-2: NCEP/NCAR 'A' Monthly Wind Speed (m/s) and Direction (from) Statistics, 2006-2009

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean hourly speed	4.7	4.5	4.9	5.0	4.6	5.4	5.4	5.3	5.3	6.3	5.2	4.3	5.1
Most frequent direction	NE	NE	NW	NW	E	SE	E	E	NE	NW	NE	NE	NE
Max. hourly speed	14.1	13.2	11.5	13.4	13.6	14.9	13.7	19.3	19.7	17.3	18.2	12.2	19.7
Direction of max. hourly speed	E	NE	SE	SE	NE	SE	E	W	NE	E	NE	NE	NE

Table 3-3: NCEP/NCAR 'A' Monthly Wind Speed (m/s) and Direction (from) Statistics, 1980-2009

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean hourly speed	4.9	4.7	4.8	4.9	5.0	5.0	5.0	5.4	5.6	6.0	5.7	5.0	5.2
Most frequent direction	NE	NE	NE	NW	E	E	E	NW	NW	NW	NE	NE	NE
Max. hourly speed	18.2	20.5	18.8	18.4	19.6	16.6	16.9	20.0	23.1	25.6	22.6	23.6	25.6
Direction of max. hourly speed	NE	N	E	SE	E	E	S	NE	E	E	NE	E	E

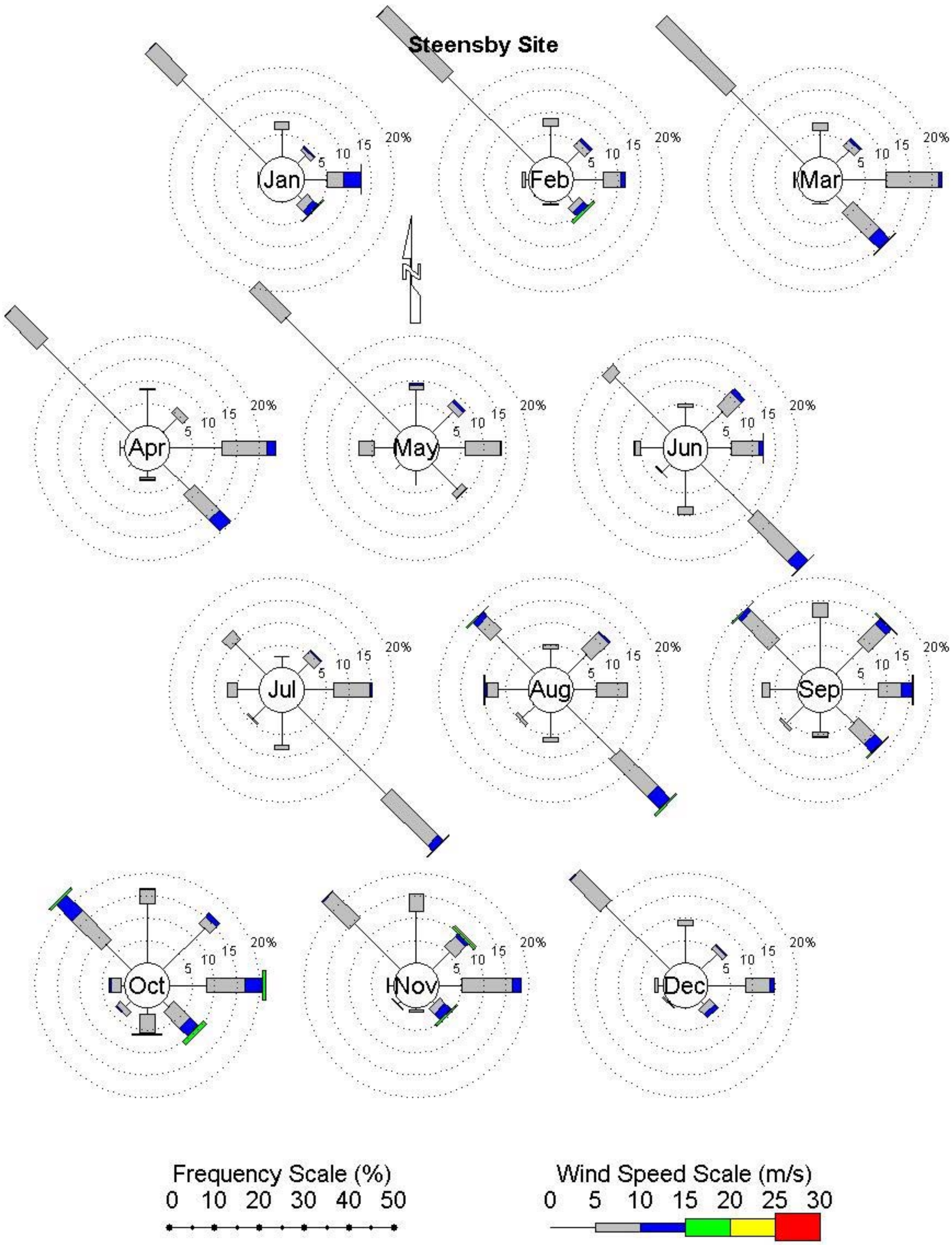


Figure 3-2: Steensby Inlet, Monthly Wind Roses, June 2006- August 2009

Table 3-4: Steensby Inlet Monthly Wind Speed vs. Direction, 2006-2009

Speed (m/s)	Direction (from) N	NE	E	SE	S	SW	W	NW	Total
15-20	0.0	0.2	0.3	0.2	0.0	0.0	0.0	0.2	0.9
10-15	0.1	1.7	2.3	2.5	0.2	0.0	0.0	1.0	7.7
5-10	3.2	5.6	5.1	5.0	1.1	0.6	1.9	8.9	31.2
0- 5	11.2	8.6	8.1	5.7	4.4	5.6	6.1	9.4	59.0
Total	14.4	16.0	15.7	13.2	5.7	6.2	8.0	19.5	98.8

Table 3-5: NCEP/NCAR ‘A’ Monthly Wind Speed vs. Direction, 2006-2009

Speed (m/s)	Direction (from) N	NE	E	SE	S	SW	W	NW	Total
15-20	0.0	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0.9
10-15	0.2	1.2	1.1	2.2	0.1	0.0	0.1	0.7	5.7
5-10	4.4	10.3	6.9	4.8	1.4	2.0	3.4	6.0	39.1
0- 5	6.6	7.4	5.5	5.8	6.9	6.9	5.8	9.5	54.3
Total	11.2	19.4	13.9	12.8	8.4	8.8	9.2	16.3	100.0

Table 3-6: NCEP/NCAR ‘A’ Monthly Wind Speed vs. Direction, 1980-2009

Speed (m/s)	Direction (from) N	NE	E	SE	S	SW	W	NW	Total
20-25	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
15-20	0.0	0.1	0.5	0.1	0.1	0.0	0.0	0.0	0.9
10-15	0.7	1.5	2.3	1.1	0.5	0.3	0.4	1.1	7.8
5-10	4.4	9.1	6.7	4.1	3.8	3.2	3.5	7.8	42.5
0- 5	5.1	6.4	5.9	5.3	5.6	5.9	6.1	8.5	48.7
Total	10.1	17.1	15.4	10.7	10.0	9.4	10.0	17.4	100.0

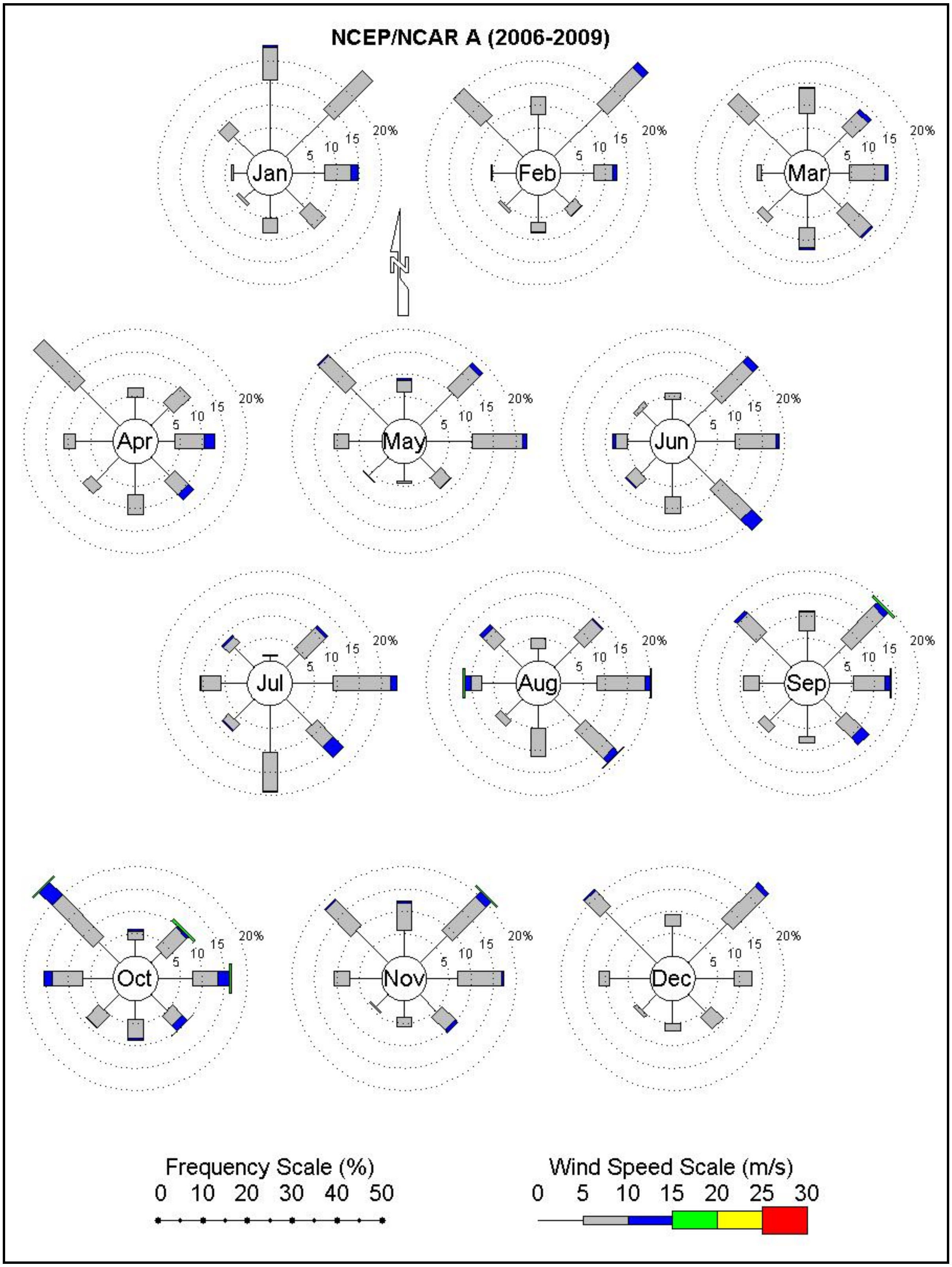


Figure 3-3: NCEP/NCAR 'A', Monthly Wind Roses, 2006-2009

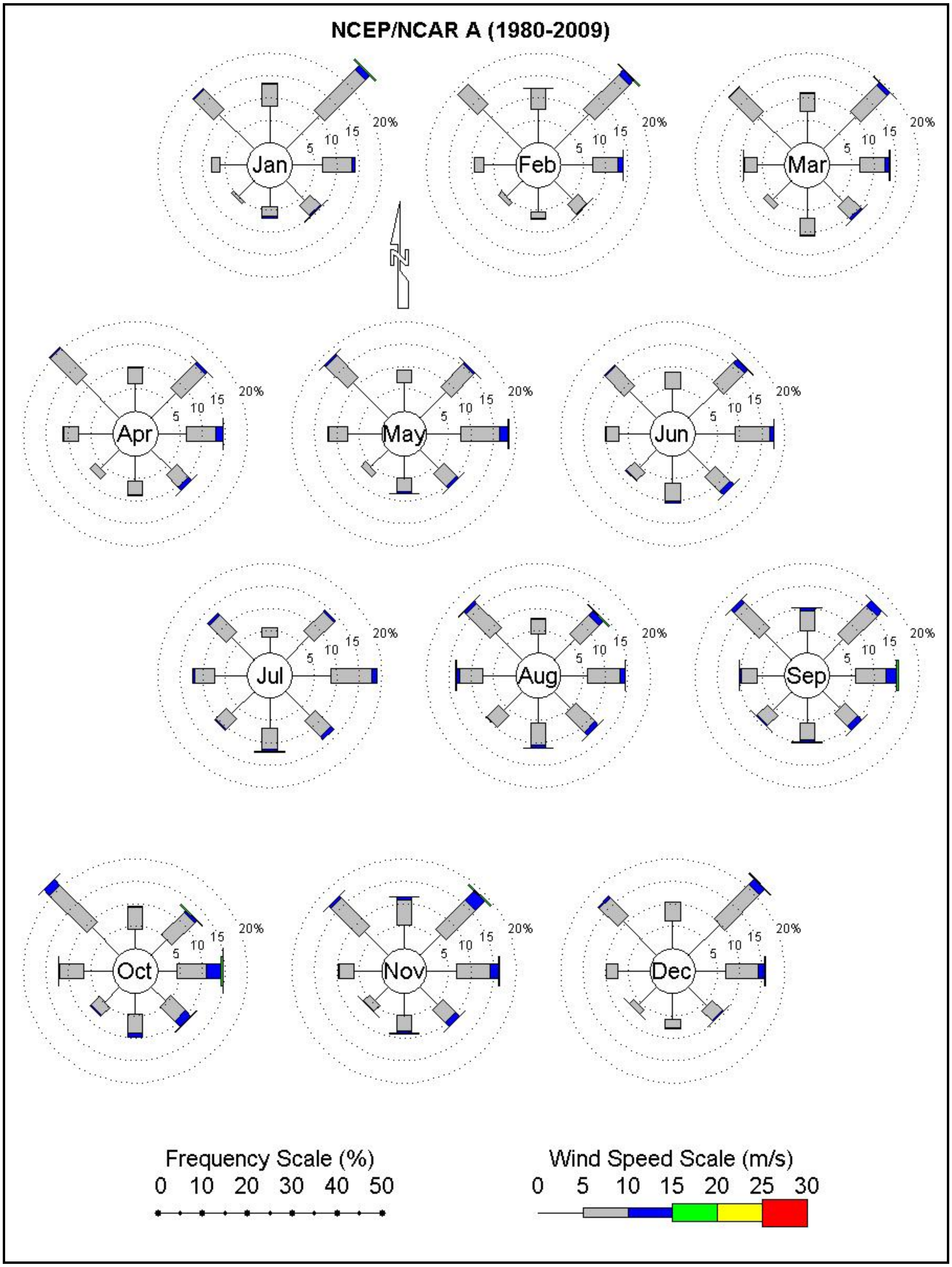


Figure 3-4: NCEP/NCAR 'A', Monthly Wind Roses, 1980-2009

3.1.3 Selection of Wind Inputs

To determine an appropriate wind input data set, it was anticipated that the NCAR/NCEP winds would offer the greatest utility due to their long record length of many years; however, some measure of calibration was required to ensure these winds were appropriate for the study area.

The measured Steensby met station site winds from 2006 to 2009 were compared with the NCAR/NCEP winds (for both 'A' and 'B' grid points) over the same time period. A first comparison between the winds, as shown in Figure 3-5, Figure 3-6, and Figure 3-7 for the September-October time periods in 2006, 2007, and 2008 respectively, indicates generally quite close agreement both in terms of wind speed and wind direction.

A statistical comparison of the winds was next undertaken focusing on the coincident 2006 to 2009 interval.

Monthly mean and 95% upper limit wind speeds are presented in Figure 3-8. There is generally close agreement in mean wind speed values in all months. In July there is the largest difference with the NCEP/NCAR mean being 5.7 m/s, 1.3 m/s greater than at the Steensby Site. In September, the NCEP/NCAR mean of 5.3 m/s is only 0.4 m/s greater than at the Steensby Site. While in some months the NCEP/NCAR and Steensby Site 95% upper limit speeds are up to 2 to 2.5 m/s apart there is overall good agreement. In September, the NCEP/NCAR and Steensby Site values are 11.7 m/s and 10.8 m/s respectively.

Initial comparisons considering all months of the year identified a large difference in the occurrence winds in the northwest-southeast direction. Steensby winds were from the northwest 30.8% of the time compared with 16.5% for the NCEP/NCAR. Conversely winds from the northeast, south, southwest, and south were 5 to 6% more frequent for the NCEP/NCAR 'A'.

A new comparison, considering only September and October, which would be the winds used in the September open water simulation, was completed. Figure 3-9 and Figure 3-10 present mean wind speed by direction and percentage occurrence of wind by direction, respectively.

While mean winds are as much as 1.6 m/s greater from the northeast and 1.2 m/s greater from the north for the NCEP/NCAR 'A', Steensby mean winds are 1.2 m/s greater from the southeast. Considering all directions, the NCEP/NCAR 'A' mean winds are 0.3 m/s greater than those for Steensby.

Figure 3-10 indicates a much improved agreement in the occurrence of most frequent winds from the northwest, within 0.5%. NCEP/NCAR winds from the south, southwest, and west are more frequent by as much as 3 to 5%; whereas Steensby winds from all other directions are 1 to 4.4% more frequent.

It is likely that wind channelling, the tendency of the wind to blow along the axis of a channel or to be deflected by the land, is a major factor contributing to changes in wind direction for Steensby Inlet. Figure 3-11 shows the topography and bathymetry of Steensby Inlet and northern Foxe Basin. Data are taken from the gridded ETOPO1 surface of the earth bathymetry and relief database (http://www.ngdc.noaa.gov/mgg/global/global.html) (Amante and Eakins, 2009). The bathymetry information presented in the figure is not to be used for navigation[9]. The large elevations of land mass to the northwest through southeast of the inlet will likely contribute to this effect. Elevations on the opposite side of the inlet to the west are 100 m and more less, and the NCEP/NCAR locations near the head of the inlet too will be less exposed to the channelling encountered at the Steensby met station site.

[9] It is noted in the GEODAS viewing software Hydro-Plot "THIS DATA IS NOT TO BE USED FOR NAVIGATION Although NOS data are of high quality and useful for planning and modeling purposes, as an historical data set these data do not necessarily reflect current conditions, nor do they depict data which is on a nautical chart. For navigation please refer to the NOS nautical chart series."

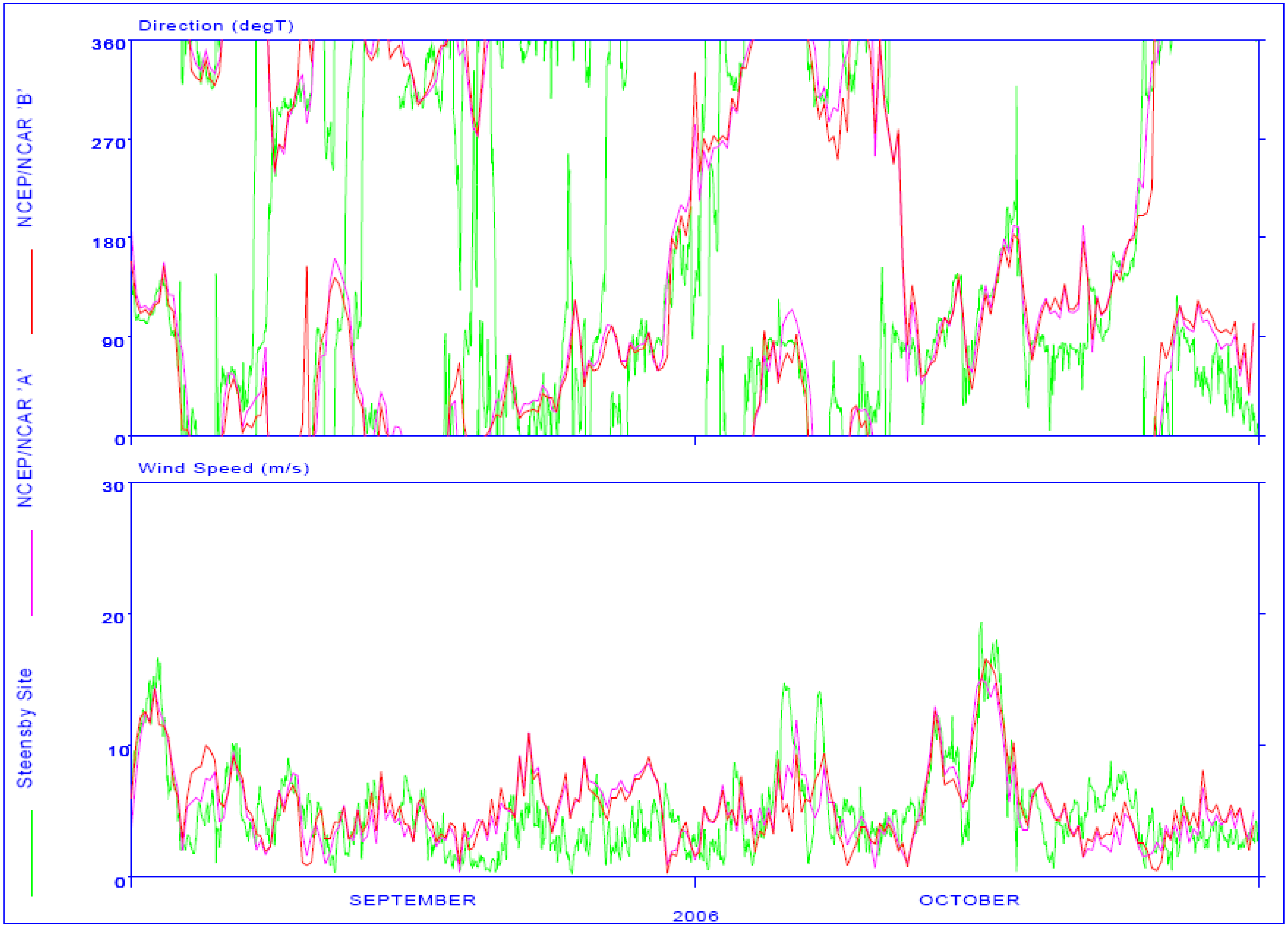


Figure 3-5: Wind Speed Comparison, September-October, 2006, Steensby Site, NCEP/NCAR

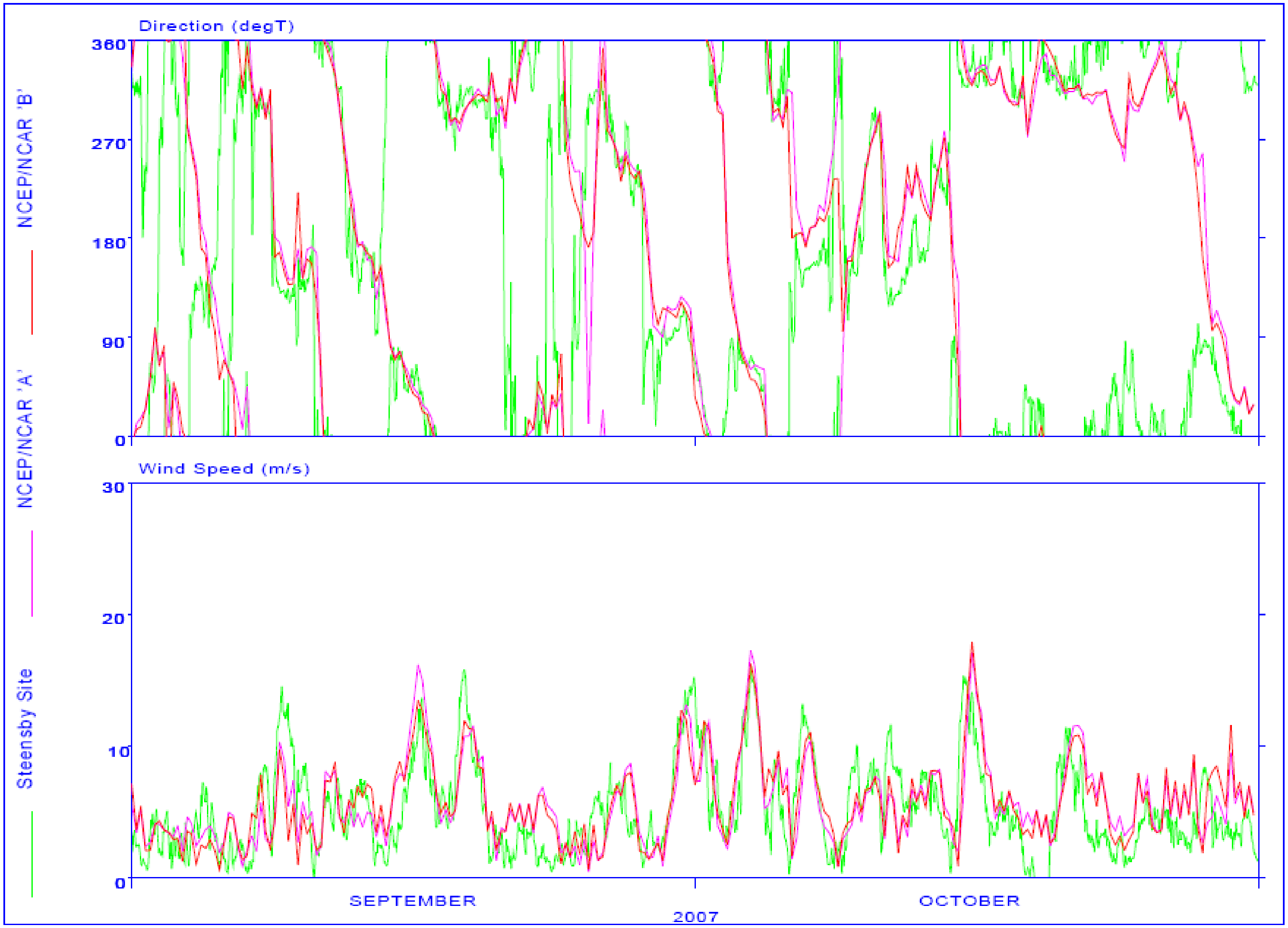


Figure 3-6: Wind Speed Comparison, September-October, 2007, Steensby Site, NCEP/NCAR

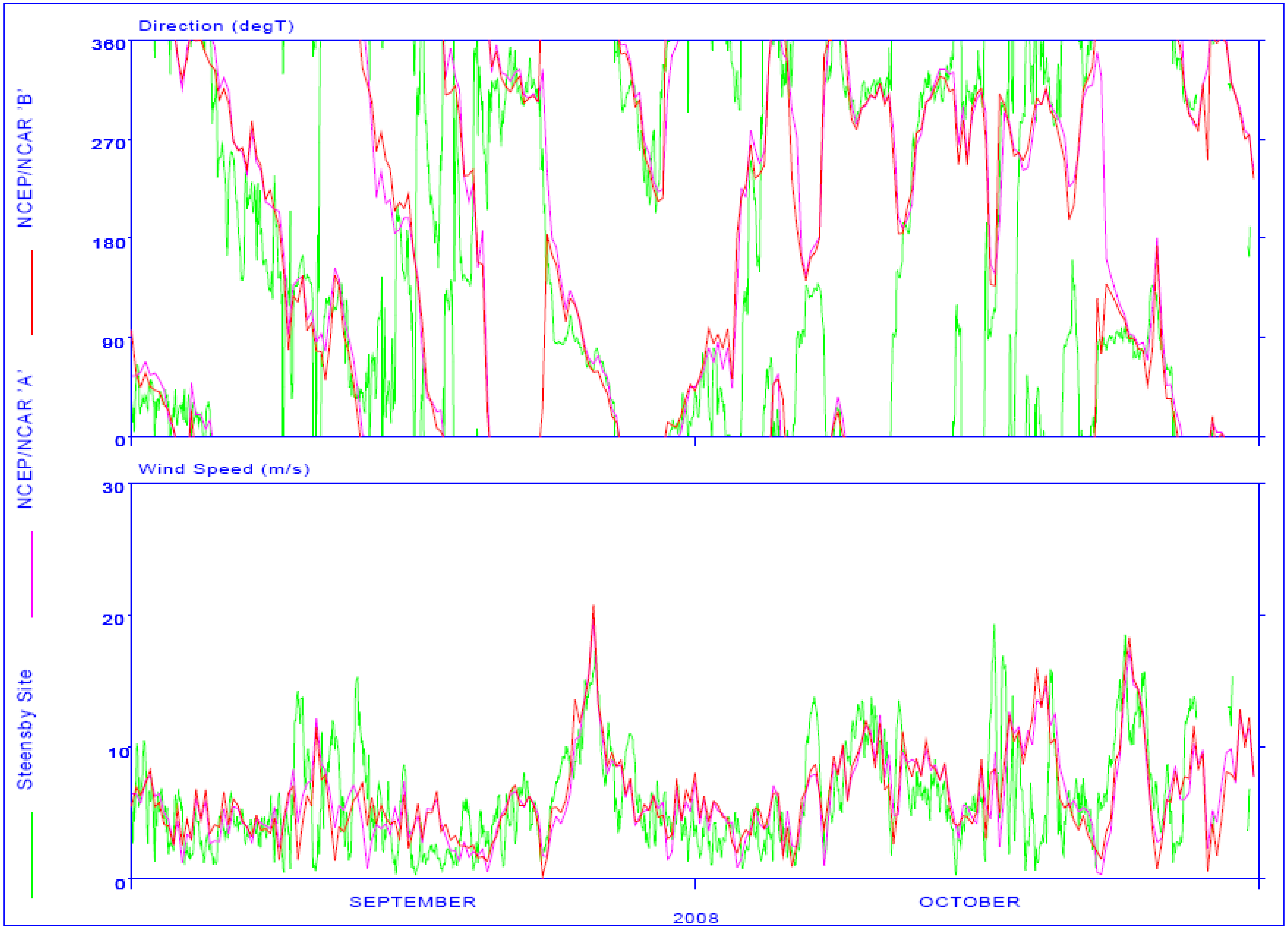


Figure 3-7: Wind Speed Comparison, September-October, 2008, Steensby Site, NCEP/NCAR

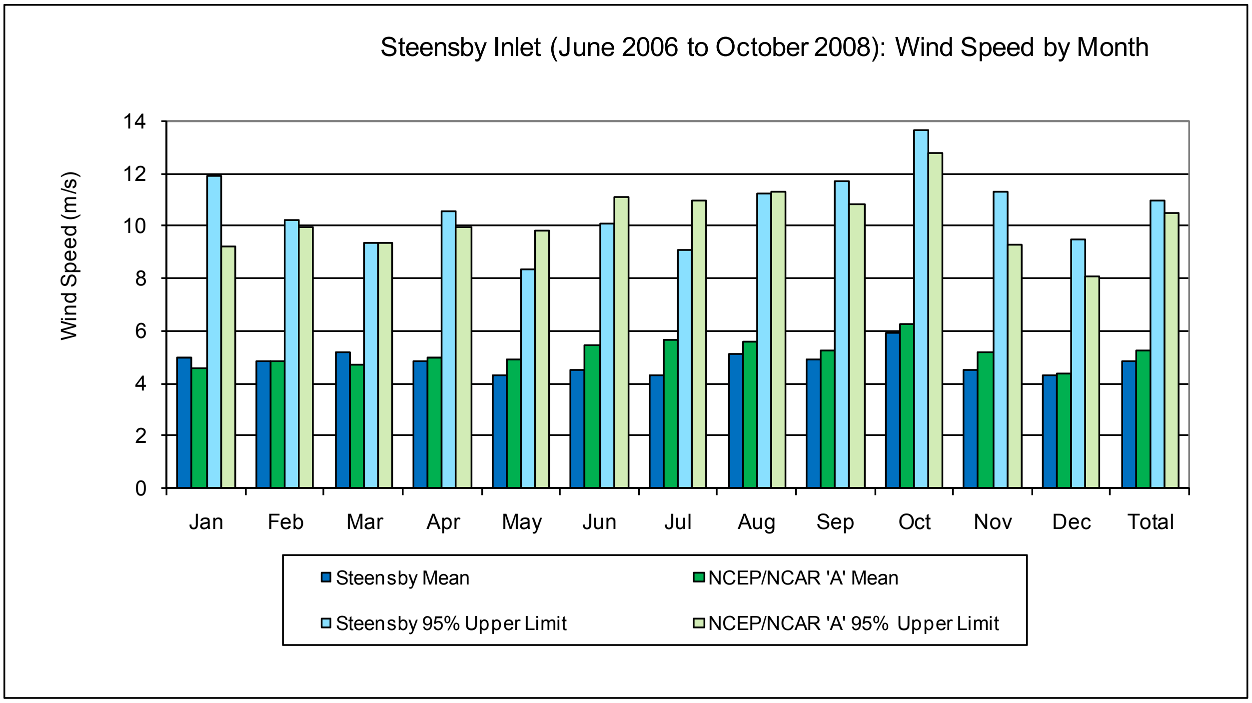


Figure 3-8: Steensby Inlet: Wind Speed by Month (Met Station, NCEP/NCAR ‘A’)

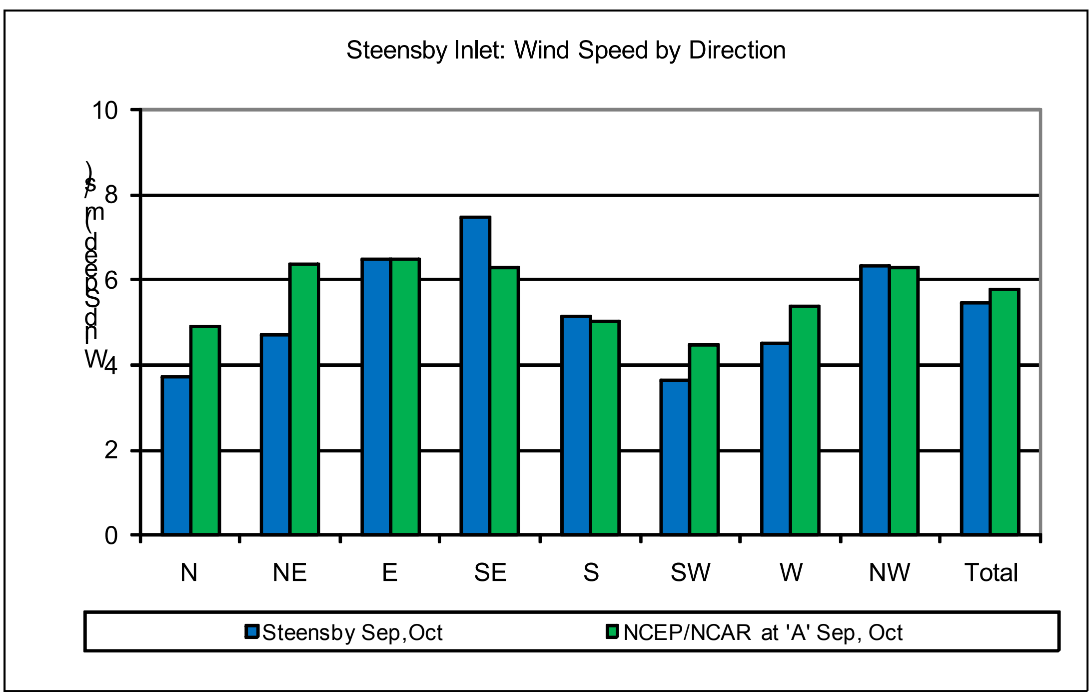


Figure 3-9: Steensby Inlet: Mean Wind Speed by Direction, September-October (Steensby Site, NCEP/NCAR ‘A’)

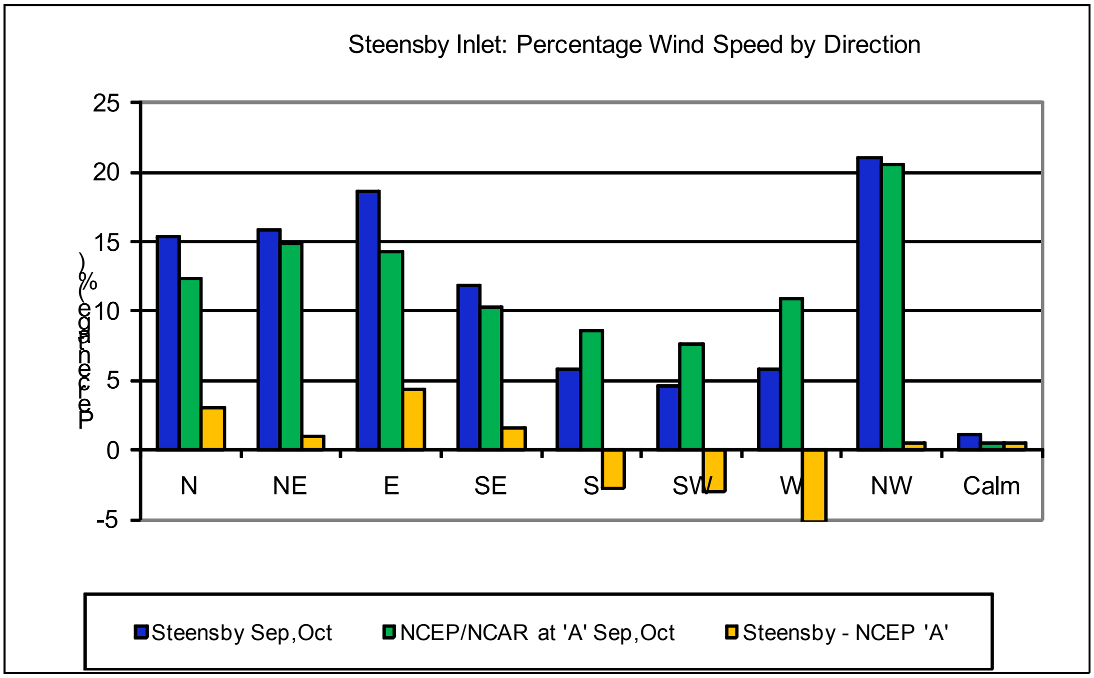


Figure 3-10: Steensby Inlet: Percentage Wind by Direction, September-October (Steensby Site, NCEP/NCAR ‘A’)

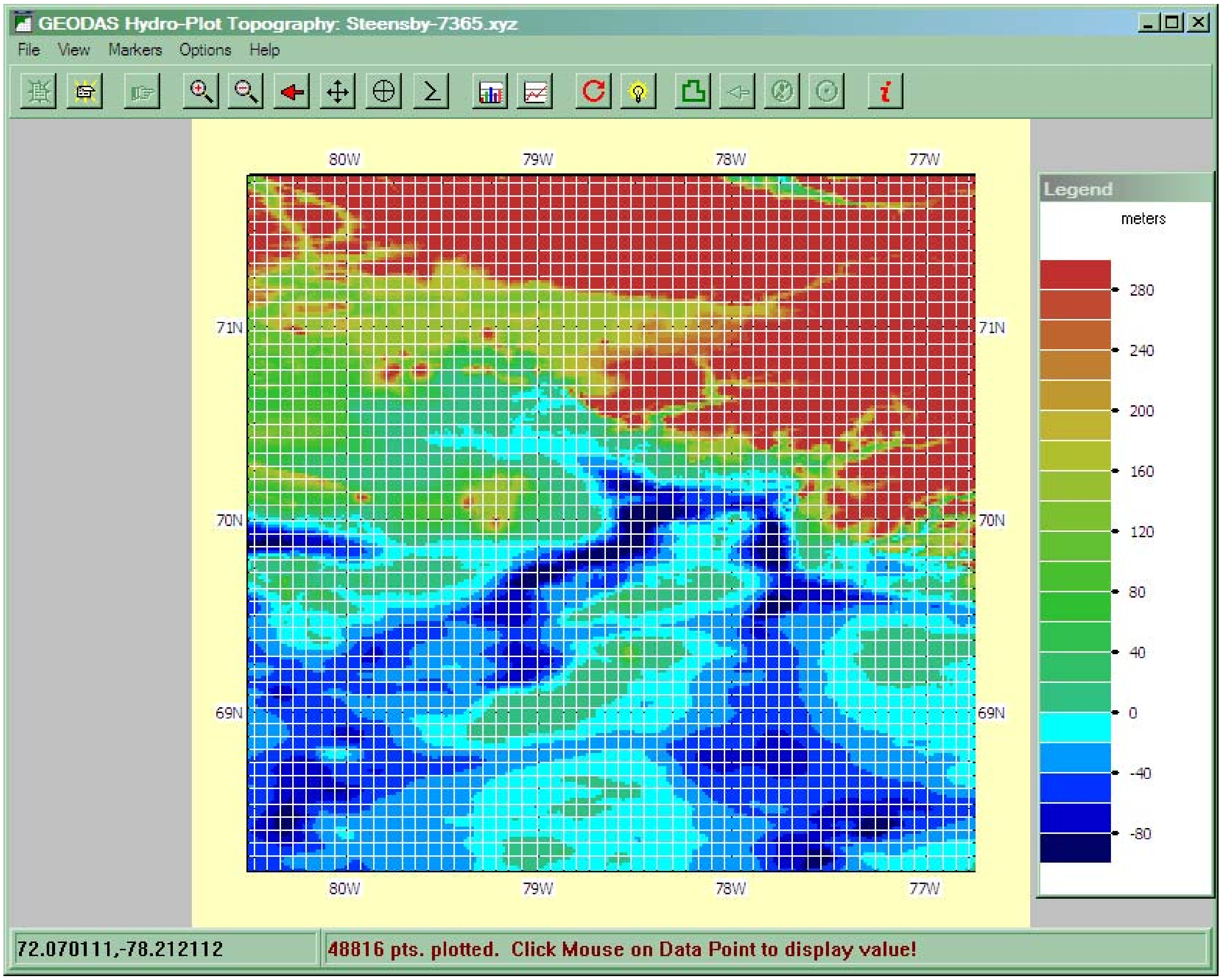


Figure 3-11: Steensby Inlet, Foxe Basin, Baffin Island Topography (Source: National Geophysical Data Center)

In an attempt to find an adjustment which could be applied to the NCEP/NCAR to bring them more in line, wind direction-wise, with the Steensby Site winds, a wind correlation using the WindFarm[10] software was performed. The two time-series were considered with winds binned by one of 12 directional sectors (Figure 3-12). This yielded both a linear regression and a veer correction matrix. If the wind directions were perfectly aligned by directional sector, the matrix would be diagonal. While the diagonal entries are the largest for many of the directions, there is generally some veering and backing of winds to the neighbouring sectors. In practice there did not appear to be an obvious application of this matrix for the wind time-series data. Also given the low regression coefficient values, it was judged that any attempt to adjust the NCEP/NCAR winds to make them more representative of the Steensby Site might well introduce differences of the same order of magnitude as those that already existed.

The overall good agreement between the winds and the ability to select a 30 year record of the NCEP/NCAR grid point ‘A’ winds justified their selection. For the modelling, the NCAR/NCEP grid point ‘A’ winds were interpolated in time to a one hour time interval.

[10] WindFarm software by ReSoft Ltd. is a system for wind farm development.

WSTEENSBY001.txt

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Time : 15:16:35, 27 Aug 2010

INPUT DATA FILES
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Concurrent met data : ..\..\STEENSBY\NC_A0809.INT
Historical met data : ..\..\STEENSBY\NC_A8009.INT

OUTPUT FILE Wind distribution data : RSTEENSBY001.WFR

CORRELATION BASED ON MET STATION DIRECTION

Direction	Gradient	Intercept (m/s)	Regression Coefficient	No of Points
0.00	1.695	-3.06	0.3787	1144
30.00	1.233	-1.85	0.5504	2444
60.00	1.106	-1.75	0.5528	3084
90.00	1.685	-5.13	0.4602	2915
120.00	1.184	-1.41	0.6457	2604
150.00	3.307	-10.28	0.3845	1859
180.00	1.948	-3.33	0.4678	1739
210.00	1.467	-1.01	0.3565	1235
240.00	7.847	-26.94	0.1554	1309
270.00	3.109	-10.07	0.2737	1529
300.00	2.553	-8.29	0.3462	2705
330.00	4.382	-16.14	0.2247	2549
Total points				25116

ANALYSIS RESULTS (m/s)
Mean of concurrent site data : 4.886
Mean of concurrent met data : 5.130
Mean of long term prediction : 5.706
Mean of input historical data : 5.169

SECTOR DATA FOR LONG TERM PREDICTION

Sector Number	Sector Start Angle	Turbulence (%)	Exponent	Frequency (%)	Mean Wind Speed	Weibull Scale Factor	Weibull Shape Factor
1	-15.00	10.000	0.1430	7.424	5.581	5.581	1.000
2	15.00	10.000	0.1430	6.919	5.261	5.261	1.000
3	45.00	10.000	0.1430	6.915	5.275	5.275	1.000
4	75.00	10.000	0.1430	12.097	5.626	5.626	1.000
5	105.00	10.000	0.1430	10.574	6.049	6.049	1.000
6	135.00	10.000	0.1430	10.323	6.125	6.125	1.000
7	165.00	10.000	0.1430	2.597	5.897	5.897	1.000
8	195.00	10.000	0.1430	1.647	5.878	5.878	1.000
9	225.00	10.000	0.1430	1.670	5.914	5.914	1.000
10	255.00	10.000	0.1430	2.724	5.546	5.546	1.000
11	285.00	10.000	0.1430	18.825	5.718	5.718	1.000
12	315.00	10.000	0.1430	18.181	5.688	5.688	1.000

VEER CORRECTION MATRIX (x 1000)

Site dir.	Met direction (start) -15.0	15.0	45.0	75.0	105.0	135.0	165.0	195.0	225.0	255.0	285.0	315.0
-15.0	99	133	79	61	34	31	28	17	53	65	104	103
15.0	66	172	148	72	44	25	20	29	37	33	47	30
45.0	26	103	190	131	55	31	21	23	47	32	26	15
75.0	31	34	124	278	276	162	109	116	112	117	65	27
105.0	18	15	31	97	257	304	243	223	136	98	39	25
135.0	10	15	33	83	133	280	338	300	160	107	37	17
165.0	11	10	10	24	25	29	55	68	57	51	17	9
195.0	2	6	4	12	9	12	20	42	41	52	15	11
225.0	12	10	7	9	2	8	5	25	62	59	17	11
255.0	8	16	21	18	9	9	14	27	40	74	63	18
285.0	402	250	121	76	66	50	68	66	140	196	332	374
315.0	311	230	227	134	84	53	74	59	109	110	231	356

Page 1

Figure 3-12: Steensby Inlet Wind Correlation

3.2 Ocean Currents

3.2.1 Steensby Inlet Oceanographic Programs

Since Steensby Inlet is remote as well as subject to severe ice and weather conditions, until recently, little of the physical oceanography character, the tides and currents, was know. In 2008, several oceanographic monitoring programs took place as part of ongoing environmental and engineering studies for the development of the Baffinland Mary River Iron Mine Project.

As part of these monitoring programs, tide gauges, Acoustic Doppler Current Profilers (ADCPs) and drifters were deployed (CORI, 2008a, b, c and AMEC, 2009). Additional analysis and interpretation of these data, subsequent to the data reporting completed to date, was completed to support the spill modelling effort. This work is summarized in Appendix A. Application of the information for the modelling is described in Section 3.2.2.

3.2.2 Selection of Current Inputs

For the spill model, ocean currents, including tidal current and residual components were approximated using a simple lookup based on location of the spill in Steensby Inlet. At each time step in the simulation the source of current data was determined based on the lookup regions as illustrated in Figure 3-13, Regions 1 to 4 correspond to ADCP Sites 1/3/4 and 5, respectively. Regions 6 to 8 correspond to three transition zones described below. Region 5, not explicitly drawn out, is the default region chosen, represents ADCP at BLT2, and is assigned if no lookup match is found for the other regions. The transition zones are:

- 6, northwestern part east-west directed inlet at head; where the currents at location denoted by the magenta-coloured square in Figure 3-13 are set to currents of BLT 2 rotated 60° counter-clockwise to .
- 7, southwestern part/western half of main inlet - between BLT2 and Site3
- 8, southeastern part/eastern half of main inlet - between BLT2 and Site1

Tidal currents for each of the ADCP locations Site 1/3/4/5 and BLT2 were predicted for the year of 2008 following the analysis detailed in Appendix A. The month of September is shown in Figure 3-14 to Figure 3-17. These predictions enabled the model to select the corresponding day and hour for the simulation. Residual currents, again as presented in the analysis of Section 3.2.1, are summarized in Table 3-7: these were added to the tidal current prediction.

At each time step in the model, the current associated with the present location of the spill is determined and added to the wind component to calculate the trajectory displacement for that time step.

Clearly a spill originating on the tidal flood will have a greater chance of reaching the shoreline sooner than one originating on the tidal ebb out into the inlet. Given one year, 2008, of predictions, a random hour offset from 0 to 23 was employed for each of the 30 years in the simulation. This meant that the tide for a given calendar day, e.g., September 1st, would start at a slightly different time each year, e.g., all days in a 1980 simulation were offset by 9 hours; all days in a 1981 simulation were offset by 14 hours, and so in. In this way, it was considered that a given day's currents would be simulated to start at a range of possible tidal phases.

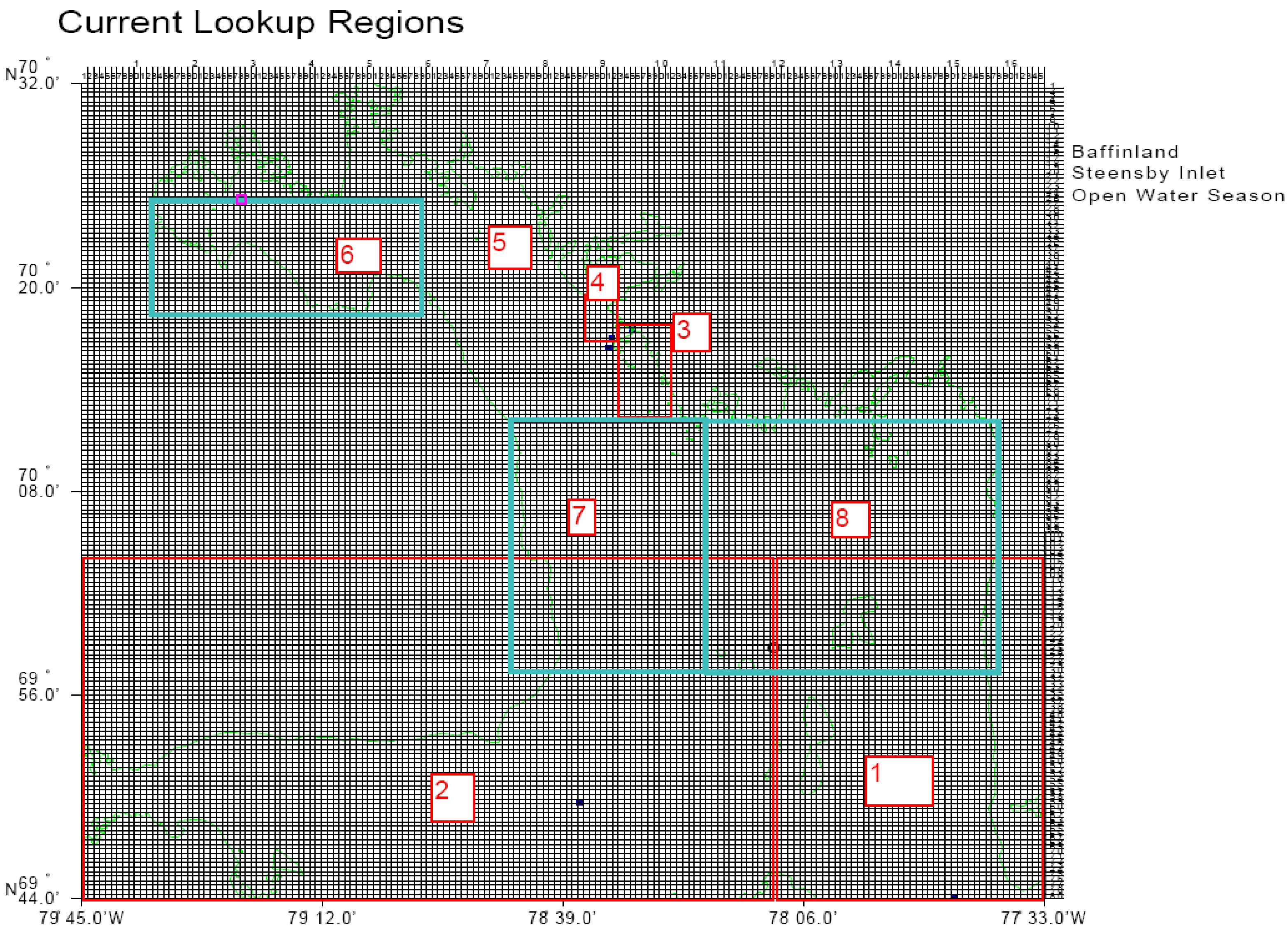

Figure 3-13: Current Lookup Regions: 1-5 for ADCP Sites 1, 3, 4, 5, BLT 2 (red); 6-8 for Three Transition Zones (blue)

It is acknowledged the current scheme, though based on site measurements, is a simple approximation, particularly for areas of the inlet removed from the ADCP sites; however, it is intended to provide a reasonable treatment of the currents likely to be encountered. To achieve a more robust treatment of the currents would require development of a hydrodynamic model for Steensby Inlet.

Table 3-7: Residual Current Approximations: ADCP Sites 1, 3, 4, 5 and BLT 2

Site	East-West current component, u (m/s)	North-South current component, v (m/s)	Speed (m/s)	Direction (°T towards)
1	-0.155	0.069	0.17	294
3	-0.035	-0.115	0.12	197
4	0.027	-0.042	0.05	147
5	-0.002	-0.070	0.07	182
BLT 2	-0.059	0.010	0.06	280

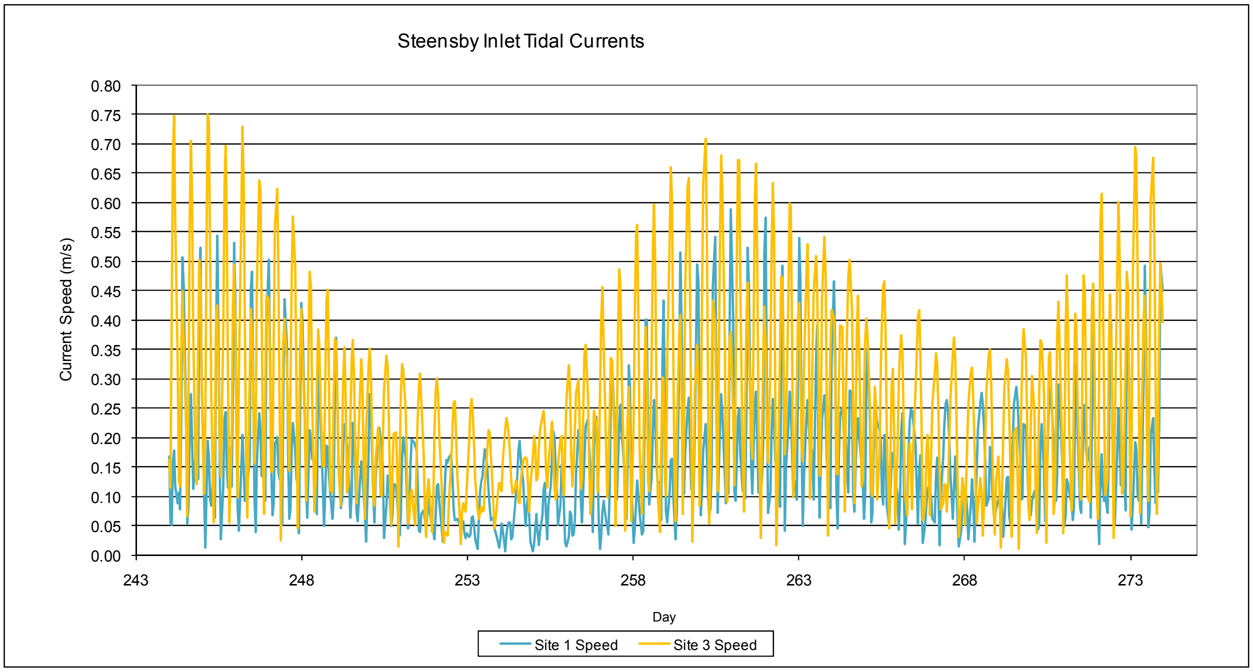

Figure 3-14: Current Speed Predictions: ADCP Sites 1 and 3

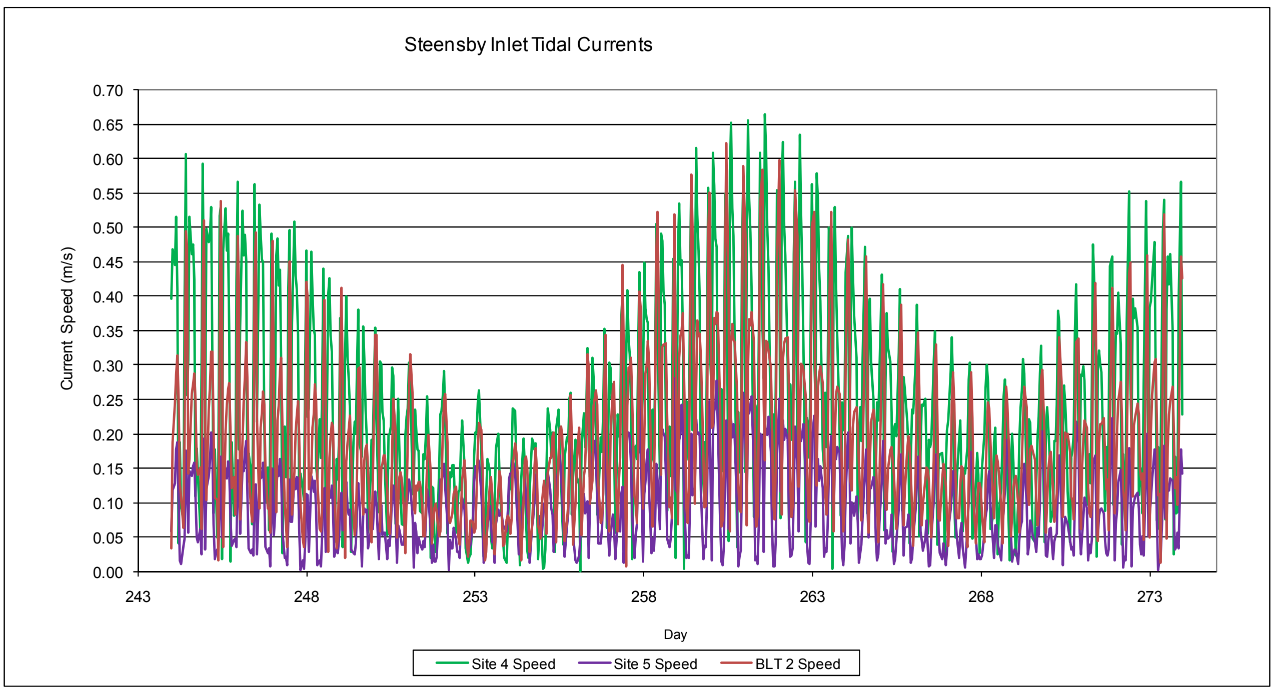

Figure 3-15: Current Speed Predictions: ADCP Sites 4, 5 and BLT 2

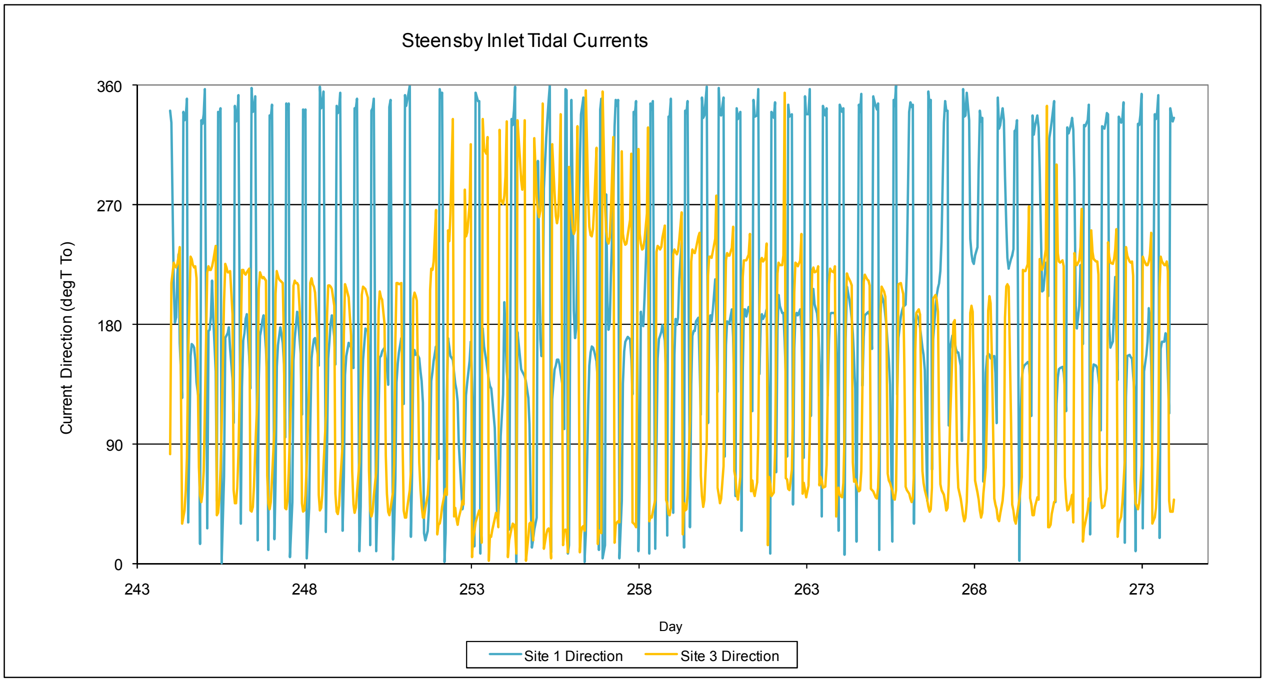

Figure 3-16: Current Direction Predictions: ADCP Sites 1 and 3

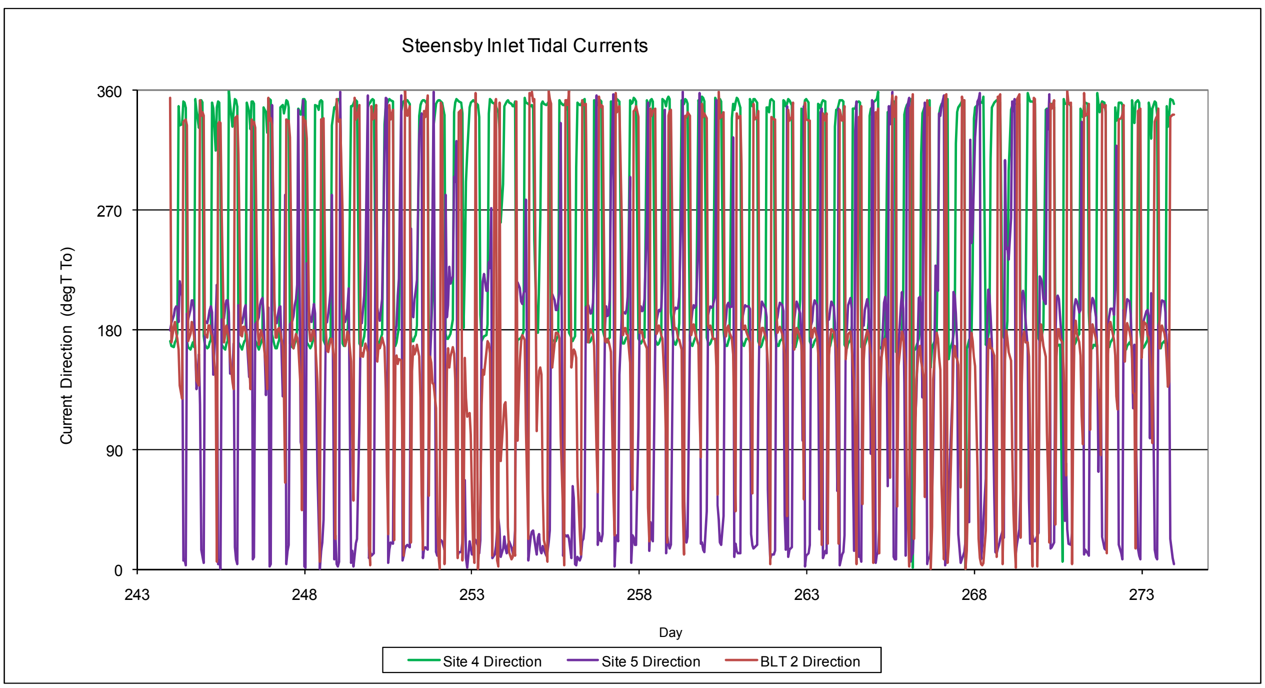

Figure 3-17: Current Direction Predictions: ADCP Sites 4, 5 and BLT 2

3.3 Ice Considerations

While not intended to be an exhaustive discussion of landfast and sea (or pack) ice conditions in the Steensby Inlet region and factors affecting its formation, this Section provides an illustration of the likely September open water (spill scenario) season period and ice conditions which might be expected near that time.

The following general description of the ice regime in Foxe Basin is taken from the Sailing Directions (CHS, 2009):

> *"Ice in Foxe Basin is characterized by its extreme roughness and muddy appearance, large areas of landfast ice and the fact that the pack ice appears to be in constant motion and stress produced by currents, winds, thermal expansion, and particularly to the large tidal ranges. Its muddy appearance is due to the freezing of muddy water, large tidal ranges, and winds; which keep a large amount of bottom deposits suspended. New ice forms in northern Foxe Basin normally during the second week of October. It spreads southward more rapidly along the coasts than seaward to completely cover Foxe Basin and Foxe Channel early in November…."*

The Canadian Ice Service (CIS) Sea Ice Climatic Atlas, Eastern Arctic (CIS 2010a) provides descriptions of the ice regime for Baffin Island and approaches. The products in the atlas were obtained from a statistical compilation of the regional charts for the years 1971 to 2000.

On average, for Steensby Inlet, freeze-up occurs around the week of October 8 for the head of inlet and near the Port Site and around the week of Oct 22 for the outer half and mouth of the inlet (Figure 3-18). Break up occurs by July 30 (Figure 3-19)[11].

An illustration of the timing and break-up and development of sea ice in Steensby Inlet is provided in Figure 3-20 and Figure 3-21 which present median ice concentration[12]. For the week of August 6, there is some ice at 1/10 to 6/10 concentrations outside the mouth of Steensby Inlet. No ice is present until about October 8 when there is 4/10 to 6/10 ice concentration at the head of the inlet and south to near the Ore Loading Island. Concentrations of 1/10 to 3/10 are present farther south along the eastern shore of the inlet. By October 15, ice is present over the entire inlet at concentrations of 4/10 to 6/10 and by October 22 this has reached 9/10 to 9+/10.

Young ice, with thickness 10-30 cm, is present in the early season in Steensby Inlet. Figure 3-22 shows the median of predominant ice type when ice is present for the week of October 8. For Steensby Inlet this consists of new (< 10 cm) and grey (10-15 cm) ice. By October 29 most ice in the inlet will be grey with some grey-white (15-30 cm) ice present at the very head of the inlet.

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[11] Dates of Freeze-up and Break-up: The "Dates of Freeze-up and Break-up" depicts the extent of ice on a bi-weekly basis during the freeze-up and break-up seasons. They provide a pictorial representation of the evolution of ice during those periods. These products are constructed using the Median of Ice Concentration charts and thus the confidence level is high. (CIS 2010a, Chapter 1 "Regional Ice Charts and The Atlas Products")

[12] The ice concentration legend shows: blue, less than 1/10; green, 1-3/10; yellow, 4-6/10; tan, 7-8/10; red, 9-9+/10; black, 10/10; and land, light brown.

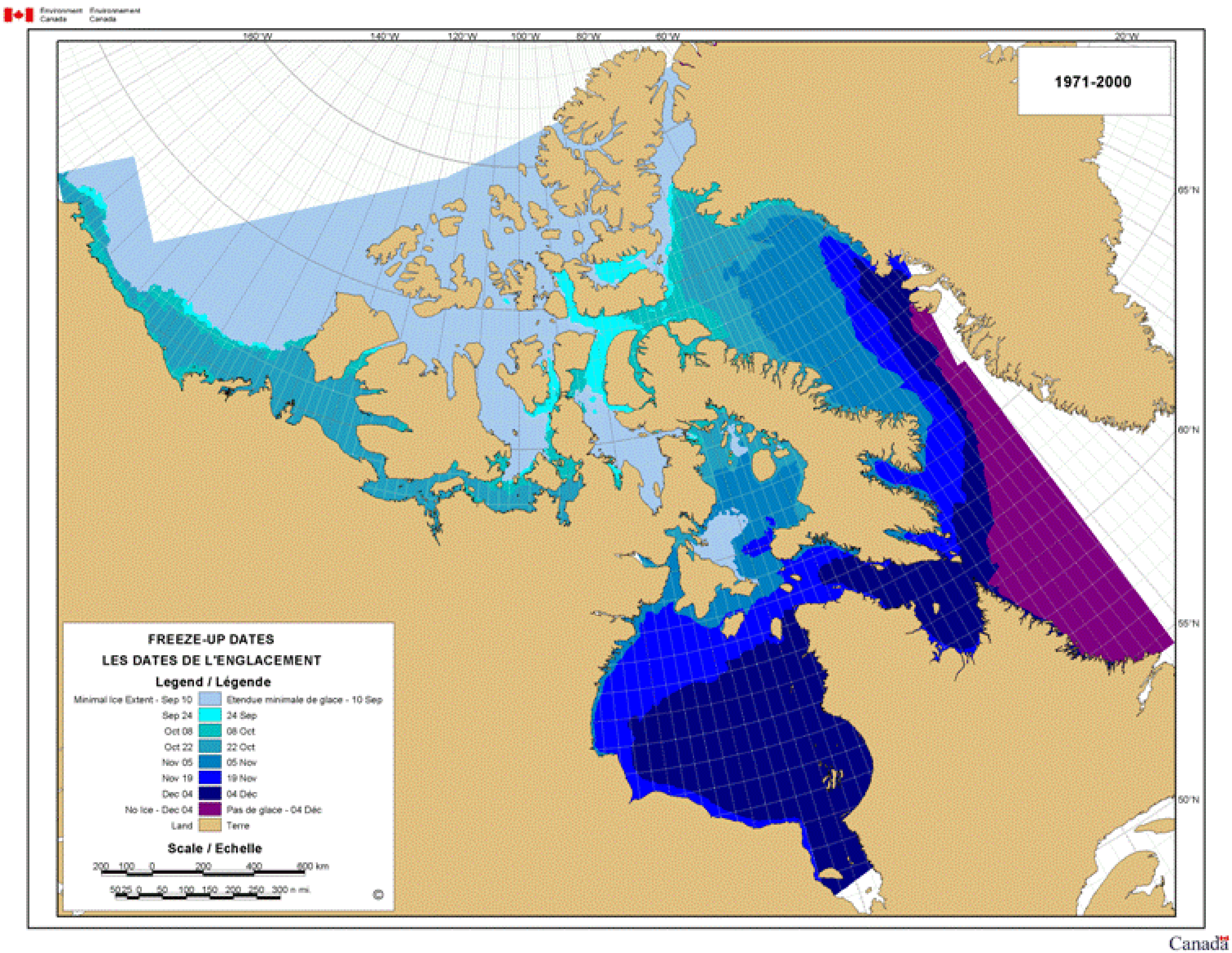

Figure 3-18: Eastern Arctic: Freeze-up Dates (Source: CIS 2010a)

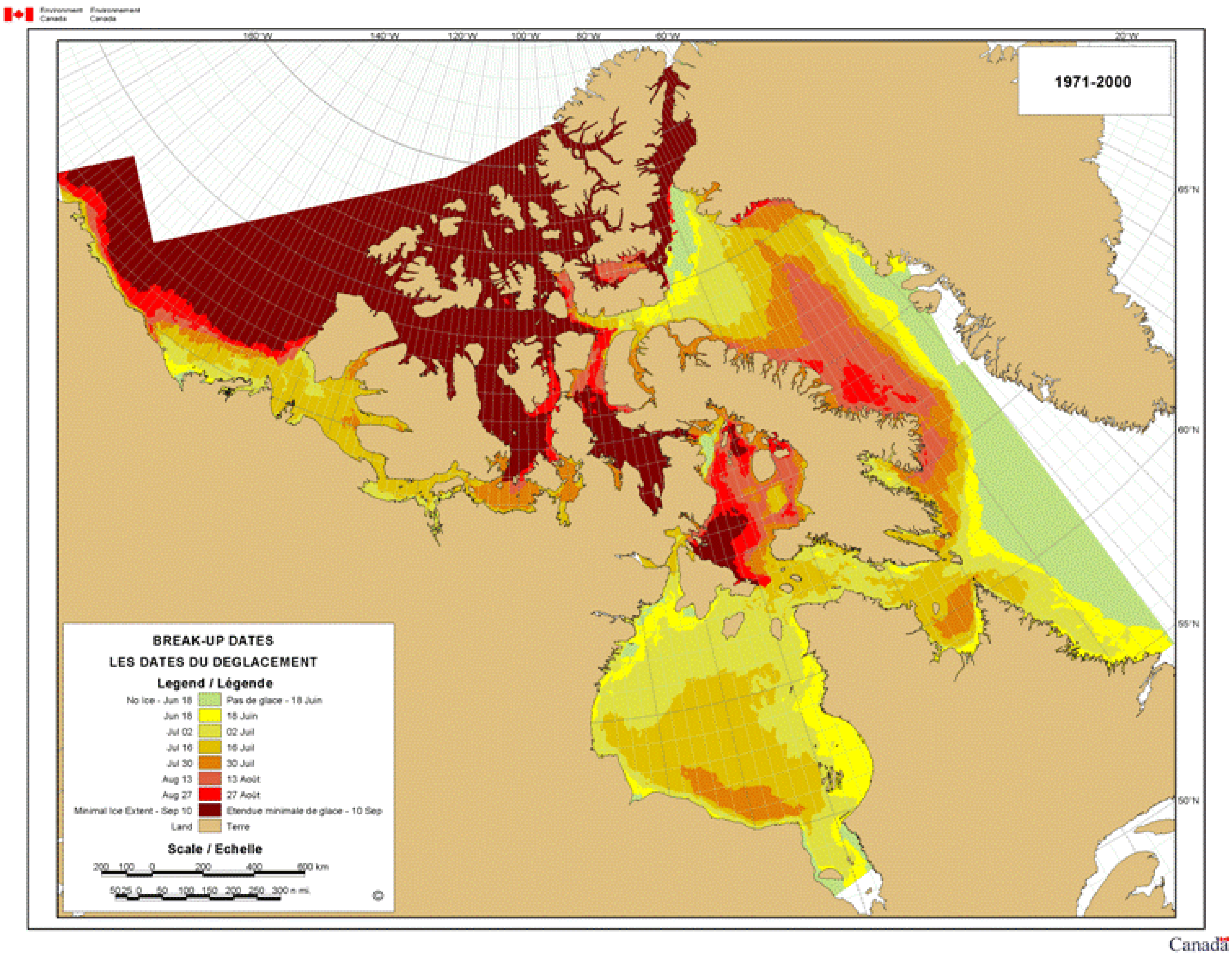

Figure 3-19: Eastern Arctic: Break-up Dates (Source: CIS 2010a)

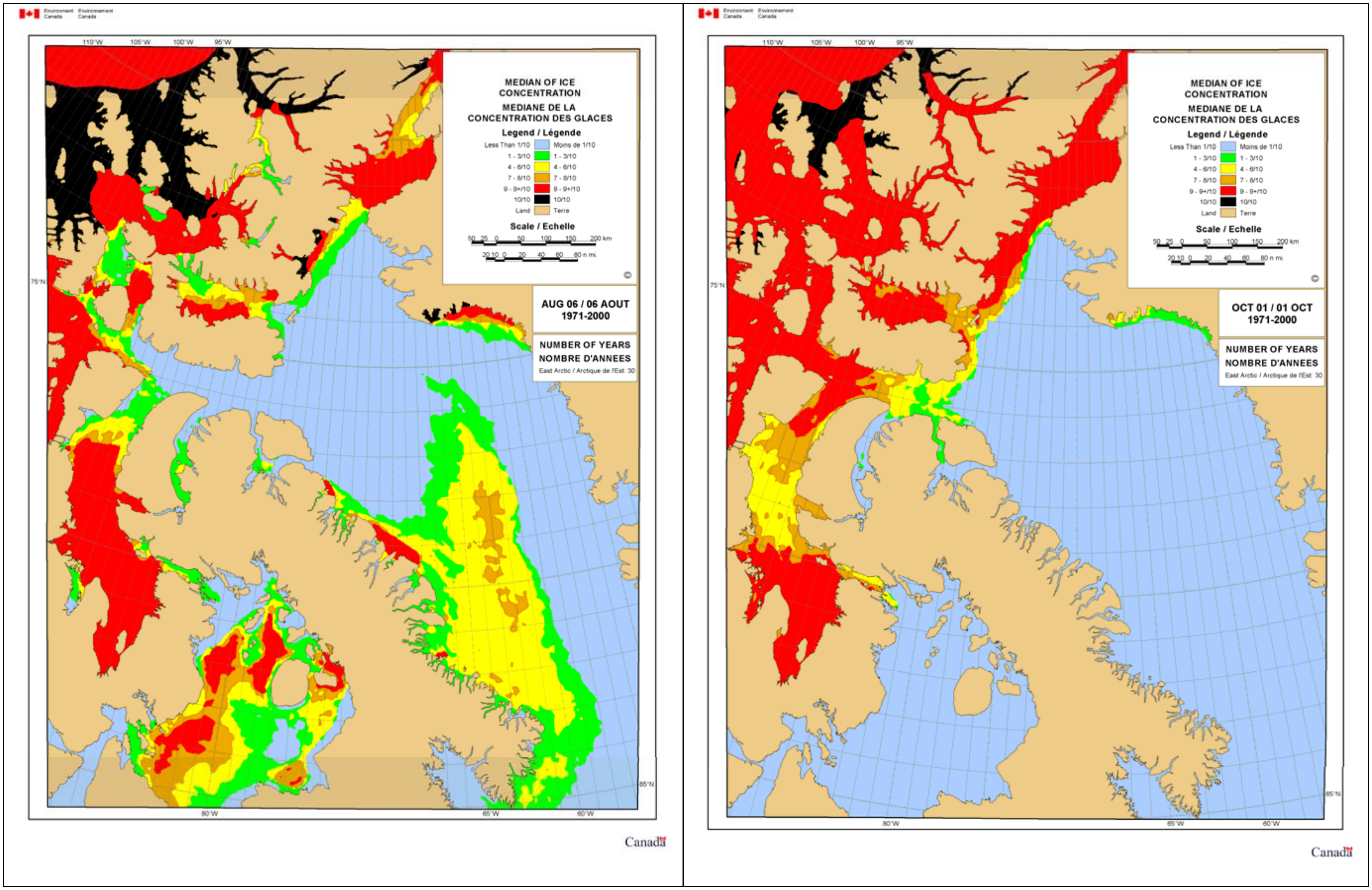

Figure 3-20: Median of Ice Concentration: Weeks of August 6 and October 1 (Source: CIS 2010a).

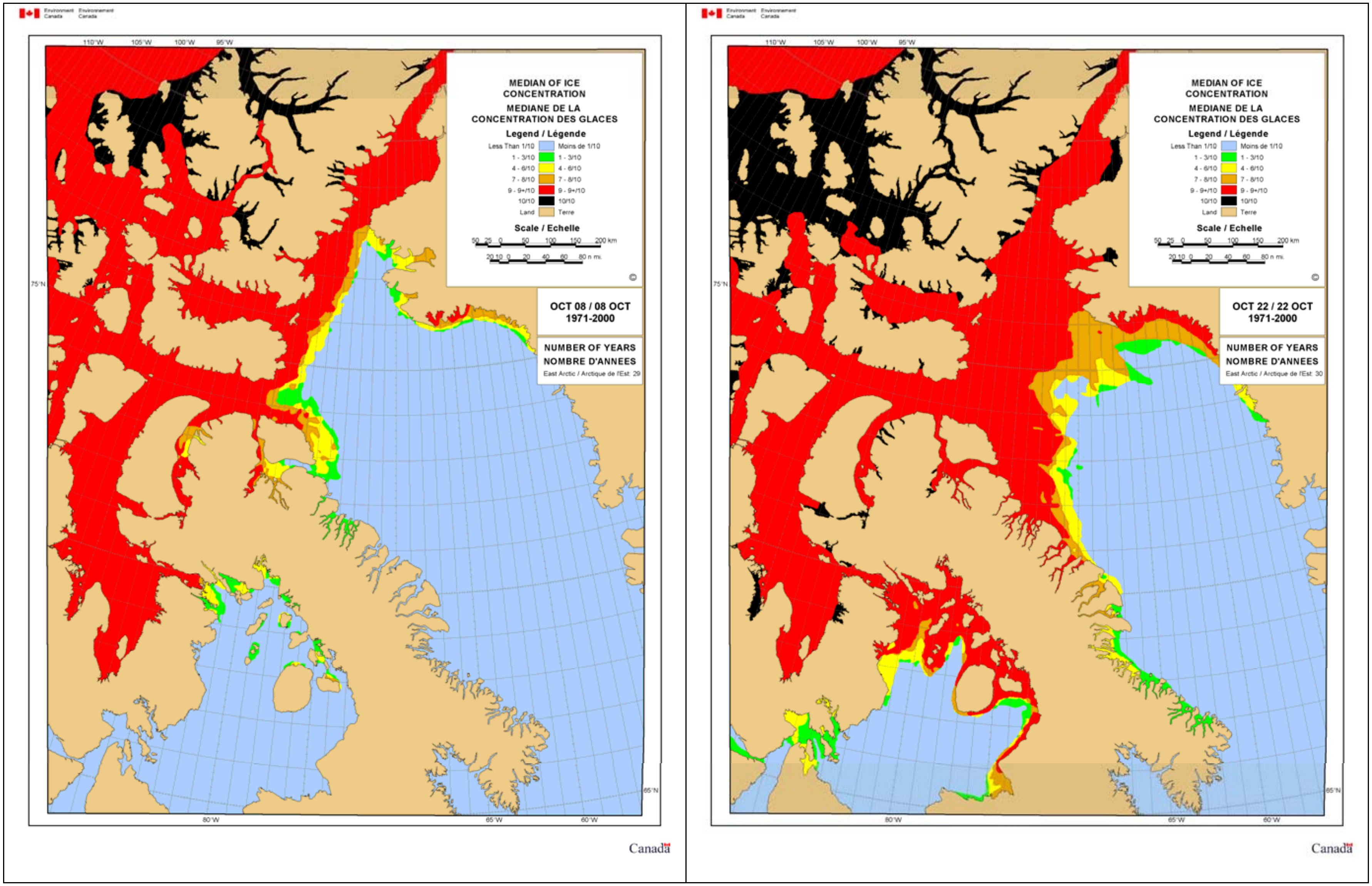

Figure 3-21: Median of Ice Concentration: Weeks of October 8 and 22 (Source: CIS 2010a).

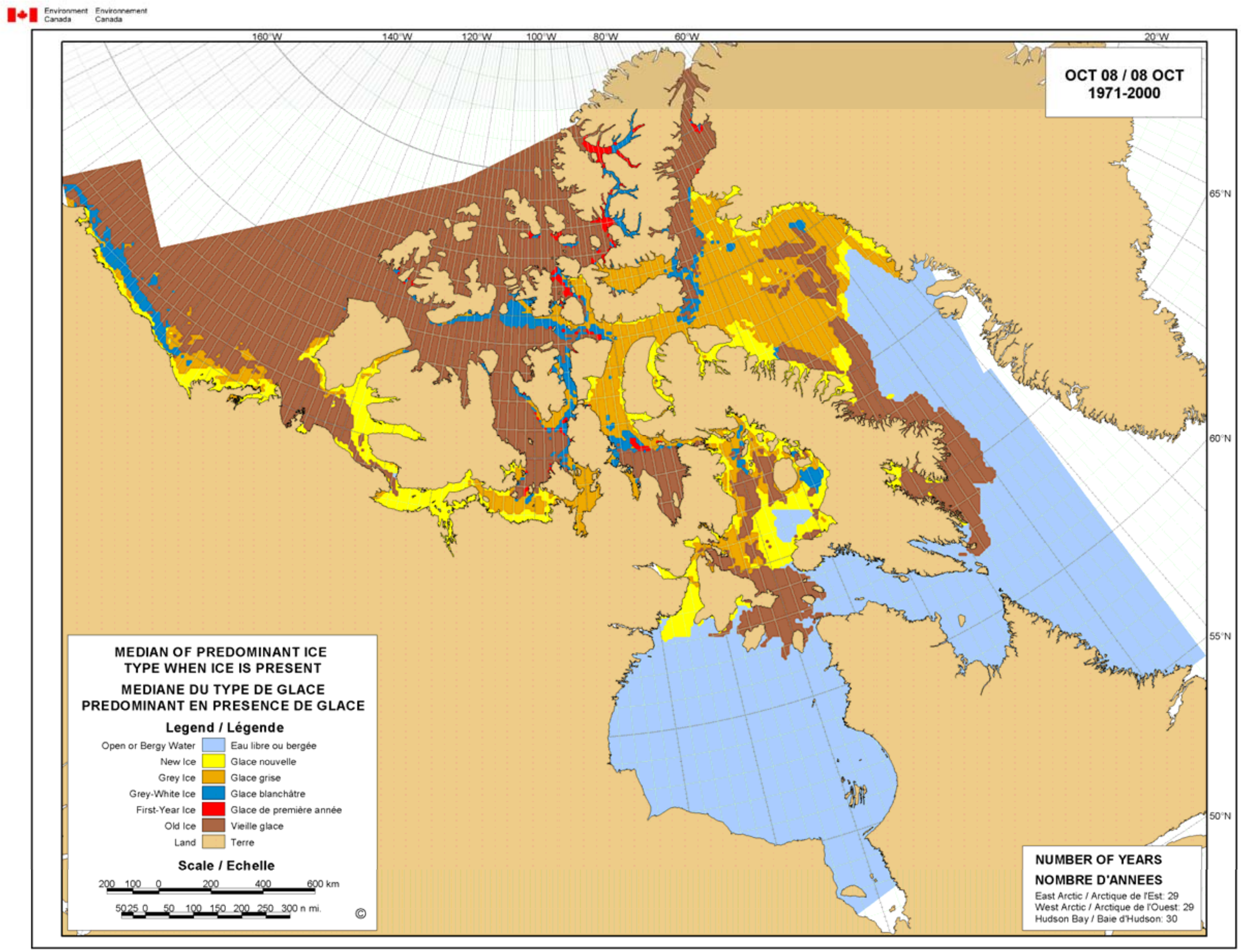

Figure 3-22: Median of Predominant Ice Type When Ice is Present (Source: CIS 2010b).

4. MODEL OUTPUT

4.1 Individual Day Spill Trajectory Plots

The basic spill modelling result is generated by introducing a spill on any given day of a given month, e.g., September, of any year, at the scenario location. The trajectory of the spill is computed over an ensuing time interval until the trajectory eventually terminates on a coastline or on an external boundary (e.g., latitude 70° 32'N at the north of the model grid) or until a maximum duration of thirty days is reached. For example, a spill initiated on 1 September 1980 would take as input the portion of the 1980-2009 wind time-series that commences on 1 September 1980 (thirty years is taken as a representative period to characterize the wind climate for this study). The model trajectory then traces out the path the spill would take over the subsequent thirty days: 1 September, 2 September ..., 30 September or until, as noted above, the trajectory terminates on a coastline or model grid boundary. (Any spills that continue into October utilize the corresponding October winds.) This trajectory is one "representative case" and illustrates the possible geographical distribution of fuel which could have evolved for a spill originating on that day in the given month and year (e.g., 1 September 1980).

Shoreline Zone Definitions

For a scenario in which at least one trajectory terminates ashore, the fuel distribution probability calculations yield an accompanying set of shoreline summary statistics (e.g., at the end of Table 4-1 and Table 4-2). These statistics identify, by geographical region, the percentage of trajectories that reach shore, and the earliest, mean, and latest times to shore. For the Steensby Inlet study area 10 regions are defined expanding on the habit shoreline types of CORI (2007) as noted in Figure 1-3 and to cover the entire model domain. These regions are illustrated in Figure 4-1.

The basic underlying result of the model is illustrated through two examples in Figure 4-2 and Figure 4-3 which show spills originating from the Port Site for all 30 days in September 2008, and all September 27ths for each of the 30 years 1980 to 2009, respectively. The end point of each trajectory is labeled with that trajectory's day, or year as the case may be. A plus sign, '+', is marked at midnight of each day.

Companion model output listings presented in Table 4-1 and Table 4-2 report statistics for each day/year trajectory as follows:

- row and column of the grid cell where the trajectory ended
- "ORI" land ('I') or water ('O') designation of the end point
- range, bearing, and latitude and longitude or the end point
- whether the trajectory reached shore or a model boundary
- elapsed time of the trajectory, until it ended
- path length and mean speed
- percent of original fuel volume remaining after weathering

Upon close examination of the September 2008 trajectories, one can see for a spill originating on 1 September the trajectory reaches the western shore of Steensby Inlet 14 km southwest of the Port Site in a time of 15 hours. A spill two days later on 3 September reaches a shoreline location south of the 1 September end point, 25 km from the Port Site. Due to the variation in wind and current encountered en route, the journey takes three times as long. Just one day later, for 4 September, the trajectory takes a circuitous route out into Steensby Inlet, covering 108 km, almost to the western shore but then southeast, finally returning north to reach shore in the Rocky East region 15 km to the southeast of the Port Site spill origin. The 13 September spill reaches the Rocky Northeast region shore at the head of the inlet 23 km to the northwest. For 27 September, the spill drifts for just over four days until, at 30 km south of the Port Site, the fuel volume weathering loss reaches 95% and so the trajectory 'ends'. Inspection of the wind record for 27 September shows winds of 7-9 m/s (14-17 knots) for the first day (see also Figure 3-7; the wind peak of almost 20 m/s (39 knots) occurs one day earlier) which result in significant weathering loss. All of the other September day spills reach shore within 3 km of the Port Site origin, which is not unexpected given the proximity to shore. It is the day-to-day variations in wind speed and direction that are the primary factor in driving the trajectory.

A similar range of trajectory fates are shown for the September 27th, all 30 years, scenarios (Figure 4-3). For example, in 1981, and 2008 (as described immediately above), after just 18 hours the trajectory is terminated due to 95% weathering loss, 26 km south-southeast of the Port Site. The 1980 trajectory travels the farthest, a path length of 76 km until it reaches Koch Island 60 km to the south. 25 of the 30 trajectories reach shore in the Port Site region in times ranging from 45 minutes to 7.5 hours.

These examples illustrate the individual day trajectories. By introducing a spill at the beginning of each day of September for each of the 30 years of wind data, and superimposing the resulting 900 daily trajectories on a single plot, a representative indication of possible slick motion for that month is achieved. This is quantified through a count of the number of individual trajectories that travel through a given square, e.g., 18 is 2% of the 900 trajectories so that one can estimate a 2% probability of fuel reaching that grid square. This is described further in Section 4.2.

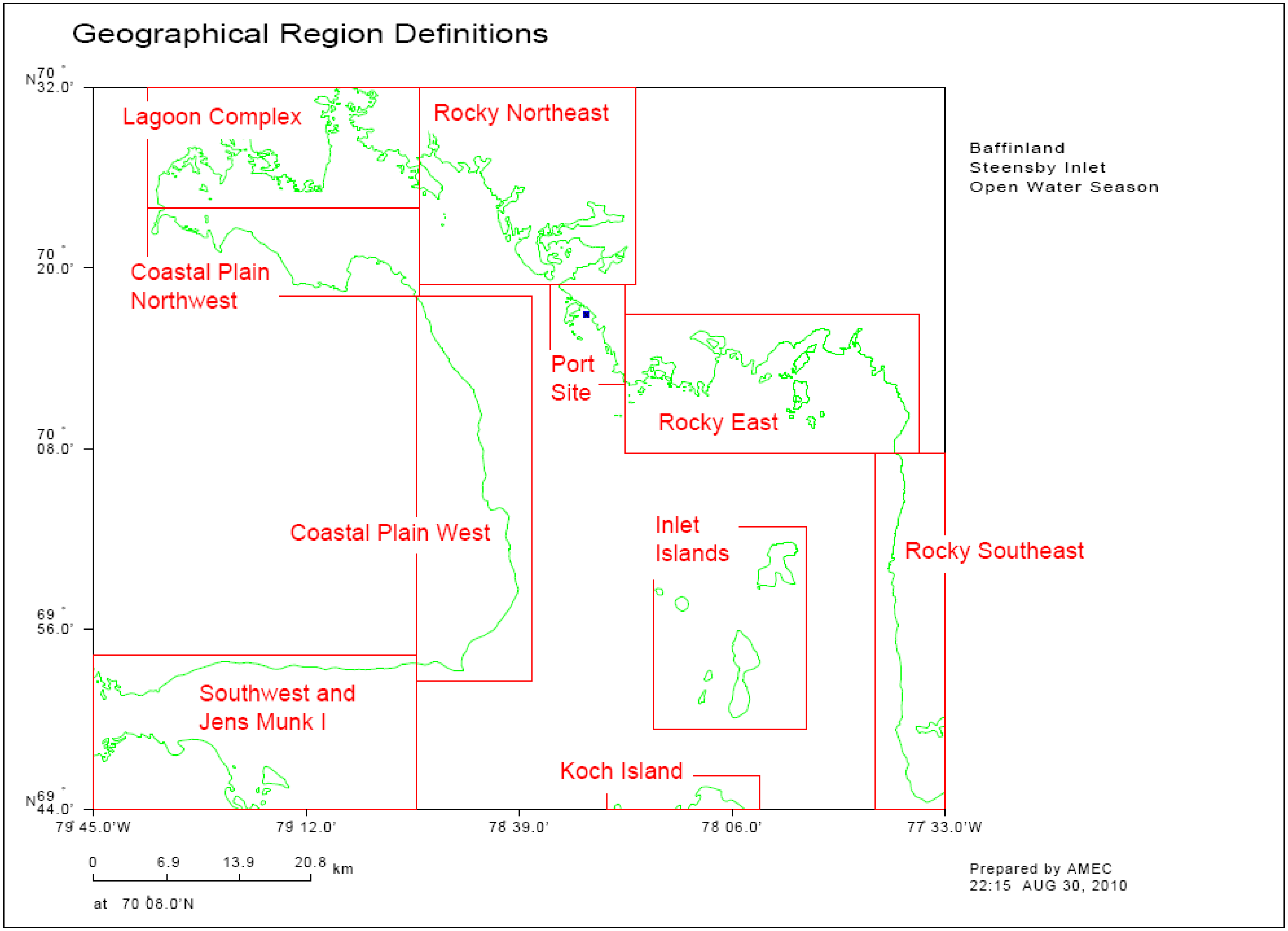

Figure 4-1: Definition of Geographical Regions for Interpretation of Shoreline Statistics

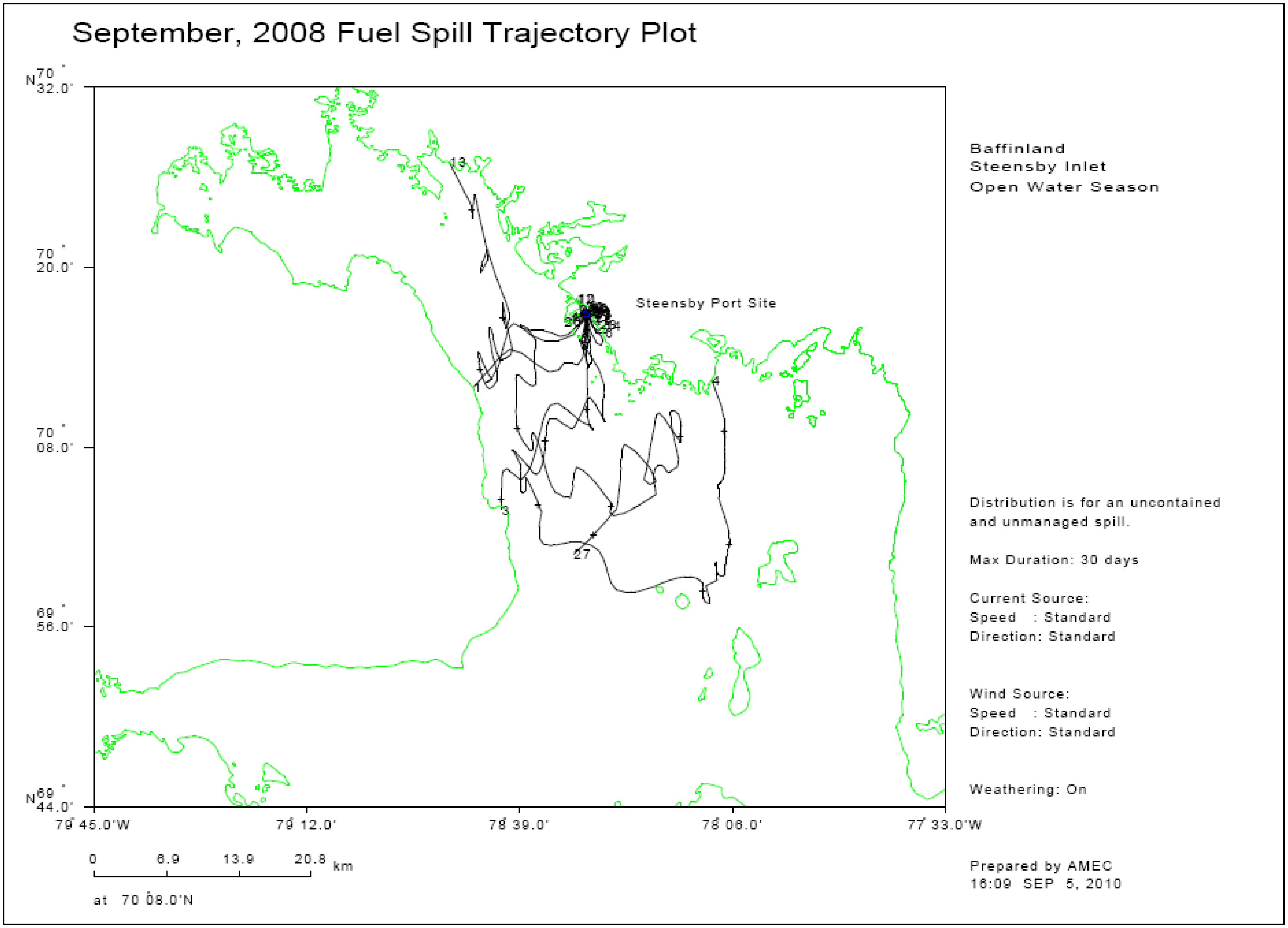

Figure 4-2: September 2008 Fuel Spill Trajectory Plot, Port Site

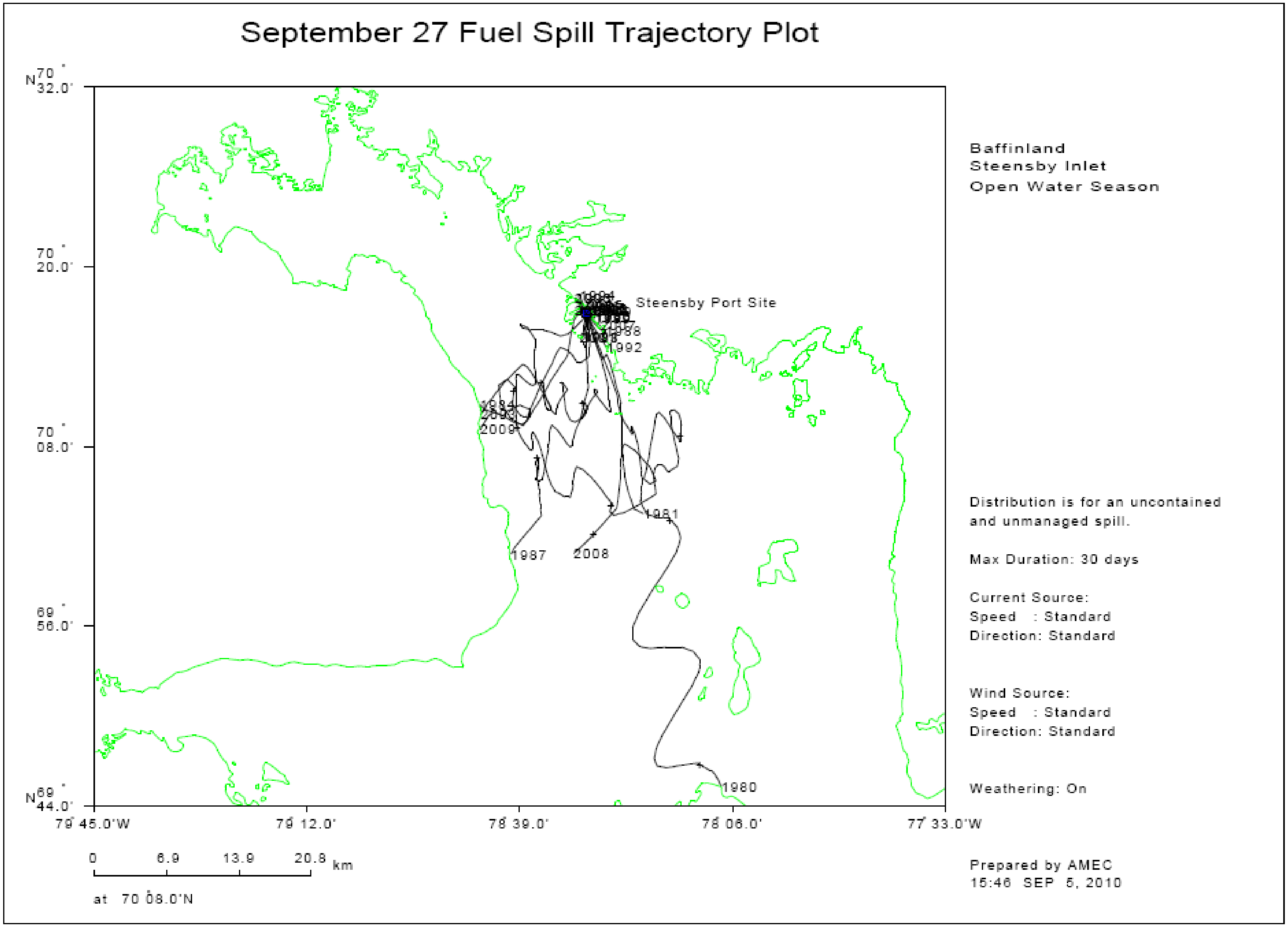

Figure 4-3: September 27, 1980-2009 Fuel Spill Trajectory Plot, Port Site

Table 4-1: September 2008, Trajectory Results, Port Site

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 27 SEPTEMBER

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
										1 SEPTEMBER		
2008	76	74	I	14.	230.	70.20	78.76	YES	15.00	20.4	32.63	90.0
										2 SEPTEMBER		
2008	63	95	I	3.	188.	70.26	78.49	YES	1.25	3.0	56.76	96.5
										3 SEPTEMBER		
2008	106	79	I	25.	198.	70.06	78.68	YES	49.00	50.9	24.94	86.4
										4 SEPTEMBER		
2008	74	120	I	15.	124.	70.21	78.15	YES	127.50	108.2	20.36	69.2
										5 SEPTEMBER		
2008	63	95	I	3.	190.	70.26	78.49	YES	7.50	6.2	19.68	97.9
										6 SEPTEMBER		
2008	62	100	I	3.	141.	70.26	78.43	YES	4.50	3.4	18.08	99.0
										7 SEPTEMBER		
2008	58	98	I	1.	107.	70.28	78.46	YES	1.25	0.8	15.96	99.8
										8 SEPTEMBER		
2008	56	97	I	1.	60.	70.28	78.46	YES	1.25	0.8	14.70	99.8
										9 SEPTEMBER		
2008	55	97	I	1.	13.	70.29	78.47	YES	1.75	1.0	14.03	99.8
										10 SEPTEMBER		
2008	53	94	I	2.	335.	70.30	78.50	YES	2.75	2.0	17.74	99.4
										11 SEPTEMBER		
2008	58	93	I	1.	259.	70.28	78.51	YES	1.00	1.5	35.01	94.7
										12 SEPTEMBER		
2008	53	94	I	2.	332.	70.30	78.50	YES	4.75	2.8	14.04	98.9
										13 SEPTEMBER		
2008	19	69	I	23.	324.	70.45	78.84	YES	79.25	83.1	25.18	69.5
										14 SEPTEMBER		
2008	60	99	I	2.	131.	70.27	78.43	YES	3.25	3.4	25.02	99.4
										15 SEPTEMBER		
2008	59	98	I	1.	136.	70.27	78.46	YES	2.00	1.6	18.75	99.6
										16 SEPTEMBER		
2008	56	97	I	1.	47.	70.29	78.46	YES	2.25	1.8	18.97	99.6

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
										17 SEPTEMBER		
2008	58	93	I	2.	249.	70.28	78.52	YES	4.50	2.6	14.10	98.8
										18 SEPTEMBER		
2008	56	97	I	1.	57.	70.28	78.46	YES	2.75	1.1	9.27	99.5
										19 SEPTEMBER		
2008	56	97	I	1.	26.	70.29	78.47	YES	1.00	0.7	15.67	99.9
										20 SEPTEMBER		
2008	55	96	I	1.	358.	70.29	78.48	YES	1.00	0.8	19.61	99.9
										21 SEPTEMBER		
2008	57	98	I	1.	68.	70.28	78.46	YES	3.50	0.9	6.15	99.1
										22 SEPTEMBER		
2008	58	98	I	1.	116.	70.28	78.45	YES	2.75	0.9	8.03	97.7
										23 SEPTEMBER		
2008	57	98	I	1.	88.	70.28	78.45	YES	1.75	0.8	10.73	99.6
										24 SEPTEMBER		
2008	55	96	I	1.	355.	70.29	78.48	YES	1.25	1.0	18.60	99.7
										25 SEPTEMBER		
2008	56	94	I	1.	303.	70.29	78.50	YES	0.75	0.9	30.17	96.0
										26 SEPTEMBER		
2008	59	92	I	2.	245.	70.27	78.53	YES	1.00	2.4	57.06	94.7
										27 SEPTEMBER		
2008	117	93	O	30.	181.	70.01	78.49	NO	97.50	109.5	26.96	4.9
										28 SEPTEMBER		
2008	60	99	I	2.	134.	70.27	78.44	YES	3.75	2.1	13.63	94.9
										29 SEPTEMBER		
2008	56	97	I	1.	47.	70.29	78.46	YES	0.75	0.6	20.57	99.8
										30 SEPTEMBER		
2008	56	97	I	1.	30.	70.29	78.47	YES	3.25	1.1	8.34	99.6

SEPTEMBER SHORE IMPACT STATISTICS FOR Rocky Northeast

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
19	69	I	1	69.	69.	69.00	79.25	79.25	79.25

SEPTEMBER SHORE IMPACT STATISTICS FOR Port Site

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
53	94	I	2	98.	99.	98.50	2.75	4.75	3.75
55	96	I	2	99.	99.	99.00	1.00	1.25	1.13
55	97	I	1	99.	99.	99.00	1.75	1.75	1.75
56	94	I	1	96.	96.	96.00	0.75	0.75	0.75
56	97	I	6	99.	99.	99.00	0.75	3.25	1.88
57	98	I	2	99.	99.	99.00	1.75	3.50	2.63
58	93	I	2	94.	98.	96.00	1.00	4.50	2.75
58	98	I	2	97.	99.	98.00	1.25	2.75	2.00
59	92	I	1	94.	94.	94.00	1.00	1.00	1.00
59	98	I	1	99.	99.	99.00	2.00	2.00	2.00
60	99	I	2	94.	99.	96.50	3.25	3.75	3.50
62	100	I	1	98.	98.	98.00	4.50	4.50	4.50
63	95	I	2	96.	97.	96.50	1.25	7.50	4.38

SEPTEMBER SHORE IMPACT STATISTICS FOR Rocky East

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
74	120	I	1	69.	69.	69.00	127.50	127.50	127.50

SEPTEMBER SHORE IMPACT STATISTICS FOR Coastal Plain West

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
76	74	I	1	89.	89.	89.00	15.00	15.00	15.00
106	79	I	1	86.	86.	86.00	49.00	49.00	49.00

Table 4-2: September 27, 1980-2009, Trajectory Results, Port Site

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 27 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	176	122	I	60.	166.	69.76	78.09	YES	53.00	76.3	34.56	13.7
1981	107	107	O	26.	166.	70.06	78.32	NO	18.00	27.2	36.21	4.5
1982	56	97	I	0.	39.	70.28	78.47	YES	1.50	1.1	17.52	99.7
1983	63	95	I	3.	186.	70.25	78.48	YES	1.50	3.0	47.83	95.8
1984	80	75	I	15.	222.	70.18	78.75	YES	32.25	39.7	29.53	31.0
1985	55	94	I	1.	314.	70.29	78.50	YES	0.75	1.4	43.59	96.0
1986	58	98	I	1.	114.	70.28	78.46	YES	0.75	0.9	28.53	97.9
1987	117	81	I	31.	193.	70.01	78.66	YES	55.50	55.3	23.91	90.9
1988	62	100	I	3.	140.	70.26	78.43	YES	2.50	3.0	28.85	99.5
1989	58	98	I	1.	130.	70.28	78.46	YES	1.50	1.0	16.15	95.8
1990	58	98	I	1.	123.	70.28	78.46	YES	1.50	1.1	17.03	99.7
1991	63	95	I	3.	187.	70.26	78.49	YES	1.75	2.9	39.53	99.5
1992	66	100	I	5.	155.	70.24	78.42	YES	2.75	4.7	40.78	99.5
1993	53	94	I	2.	331.	70.30	78.51	YES	1.50	2.2	35.86	99.6
1994	52	95	I	2.	342.	70.30	78.50	YES	1.00	2.4	57.67	94.7
1995	56	97	I	1.	41.	70.29	78.47	YES	1.50	0.9	13.62	98.8
1996	56	97	I	1.	50.	70.29	78.46	YES	1.00	0.6	14.06	99.8
1997	56	97	I	1.	17.	70.29	78.47	YES	1.00	0.8	19.66	99.9
1998	55	96	I	1.	347.	70.29	78.48	YES	0.50	0.8	40.08	98.6
1999	57	98	I	1.	76.	70.28	78.45	YES	1.00	0.9	21.49	94.7
2000	56	94	I	1.	288.	70.29	78.51	YES	1.75	1.3	18.17	99.5
2001	63	95	I	3.	191.	70.25	78.49	YES	8.75	5.5	15.09	98.6
2002	56	97	I	0.	32.	70.29	78.47	YES	1.00	0.5	11.66	99.8
2003	82	75	I	16.	219.	70.17	78.74	YES	44.75	45.8	24.59	82.5
2004	56	97	I	1.	62.	70.28	78.46	YES	1.50	0.8	13.18	99.6
2005	55	96	I	1.	1.	70.29	78.48	YES	0.75	1.1	34.10	97.9
2006	53	94	I	2.	328.	70.30	78.51	YES	1.25	2.3	44.26	99.0
2007	60	99	I	2.	138.	70.27	78.44	YES	1.50	2.1	32.82	99.6
2008	117	93	O	30.	181.	70.01	78.49	NO	97.50	109.5	26.96	4.9
2009	86	75	I	18.	215.	70.15	78.74	YES	16.50	21.7	31.60	64.9

SEPTEMBER SHORE IMPACT STATISTICS FOR Port Site

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
52	95	I	1	94.	94.	94.00	1.00	1.00	1.00
53	94	I	2	98.	99.	98.50	1.25	1.50	1.38
55	94	I	1	96.	96.	96.00	0.75	0.75	0.75
55	96	I	2	97.	98.	97.50	0.50	0.75	0.63
56	94	I	1	99.	99.	99.00	1.75	1.75	1.75
56	97	I	6	98.	99.	98.83	1.00	1.50	1.25
57	98	I	1	94.	94.	94.00	1.00	1.00	1.00
58	98	I	3	95.	99.	97.00	0.75	1.50	1.25
60	99	I	1	99.	99.	99.00	1.50	1.50	1.50
62	100	I	1	99.	99.	99.00	2.50	2.50	2.50
63	95	I	3	95.	99.	97.33	1.50	8.75	4.00
66	100	I	1	99.	99.	99.00	2.75	2.75	2.75

SEPTEMBER SHORE IMPACT STATISTICS FOR Koch Island

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
176	122	I	1	13.	13.	13.00	53.00	53.00	53.00

SEPTEMBER SHORE IMPACT STATISTICS FOR Coastal Plain West

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
80	75	I	1	31.	31.	31.00	32.25	32.25	32.25
82	75	I	1	82.	82.	82.00	44.75	44.75	44.75
86	75	I	1	64.	64.	64.00	16.50	16.50	16.50
117	81	I	1	90.	90.	90.00	55.50	55.50	55.50

4.2 Composite Monthly Fuel Distribution Probability Maps

To define the probability of oil distribution by month, every possible spill originating each day over the 30 year duration of the wind record is considered. That is, all possible trajectories (up to 30 days at 30 per day) for the month of September are simulated. Note that any month may be modelled. Thus, for September there are a total of 900 trajectories. For each element or cell of the computational grid (165 columns by 180 rows) a record of the number of (monthly) trajectories passing through that element is maintained. By knowing the total number of trajectories simulated for a given month, it is thus possible to identify the percentage of those trajectories which passed through any particular grid element. Due to the large number of trajectories simulated for a given month this percentage can be interpreted as the probability that fuel released at the spill site in the given month, would reach the particular grid element. Grid elements having similar levels of probability can be grouped to present a contoured display of fuel distribution probabilities.

The probable directions of slick motion and probable spill destinations are now more precisely defined by the probability plots than by the representative case, or individual day, scenarios described in the previous section. The basic probability plots have been developed from simulations of every possible day spill over the duration of the available 30-year wind record.

5. PRESENTATION AND INTERPRETATION OF RESULTS

The September, Port Site, probability map is shown in Figure 5-1, and is discussed in detail in Section 5.1. In the map, the following probability colour code is used.

Probability Range	*Colour*
25% < P ≤ 100%	Orange
15% < P ≤ 25%	Red
5% < P ≤ 15%	Pink
2% < P ≤ 5%	Yellow
1% < P ≤ 2%	Light Blue
0% < P ≤ 1%	Grey

Baffin Island, Koch Island and other islands in, and outside of, Steensby Inlet appear in green.

The percentages can be interpreted as presenting the probability that fuel would reach any particular location on the map, given a spill originating on any day of the particular calendar month. In this instance, the 25%, 15%, 5%, 2%, 1%, and 0% contours of probability are illustrated.

Orange contours indicate that 25 to 100% of all trajectories (in the case of 900 simulations, 225 to 900 trajectories) will pass through that location (grid cell in the model). Grey contours indicate that 1% or less of all trajectories (in the case of 900 simulations, 1 to 9 of 900 trajectories) will pass through that location.

There is no implication that a spill could cover the entire zone enclosed by a contour, only that the fuel would drift through or be located at some position within this zone. The contours represent the maximum possible affected zone and in reality any spill would be likely to affect only some modest subset of the region, depending on wind and current conditions over the duration of the spill, and the weathered fate of the spill slick. These probabilities are derived from scenarios in which the hypothetical spills are both uncontained and unmanaged, conditions that would be limited given an appropriate oil spill emergency contingency planning and response plan in place.

5.1 Port Site

The essential results of this study of potential spill distribution in Steensby Inlet are illustrated in the September spill distribution probability map presented in Figure 5-1 for a spill originating at the Port Site. Companion model output listings are presented in Appendix A.

As indicated by the yellow contours, it is estimated that 2 to 5% of the time a fuel spill will drift through any 500 m x 500 m ‘square’ within the immediate Port Site area and within about 5 to 6 km along the eastern coast to the south and 3 to 4 km out into the inlet. Any particular location along the Coastal Plain West region might be expected to see a spill trajectory up to 1% of the time.

Figure 5-2 reports the percentage of trajectories reaching shore. Figure 5-3 reports the earliest, mean, and latest time to shore for each region.

Of the 900 trajectory simulations, six reached the model boundary at the south, and 13 ended due to weathering loss of 95% of the spill volume. There was no shoreline reached for either the Rocky Southeast or Southwest and Jens Munk Island regions.

The vast majority or trajectories, 86%, reach shore in the Port Site area, as soon as 15 minutes and on average in 2 hours. Just over 9% of trajectories end on the western side of Steensby Inlet about 12 to 20 km away. Times to shore are as early as 7 hours, 29 hours on average, and up to 150 hours (just over six days), where 54% of the fuel is estimated to be remaining.

Each of the six regions are reached, though less than 1% of the time. The Rocky East region is reached as soon as 6 hours, and 56 hours on average. The Coastal Plain West is reached as soon as 7 hours, and 29 hours on average. The Inlet Islands are reached as soon as 18 hours, and 56 hours on average. Koch Island, with one trajectory, at the mouth of Steensby Inlet, is reached in just over two days (53 hours). To the north, the Rocky Northeast region is reached as soon as 34 hours, and 52 hours on average. The Lagoon Complex is reached within 52 hours, and 66 hours on average.

In addition to which regions have the potential to be at risk from an accidental spill, times to shore are relevant for response considerations and for weathering processes of the fuel.

Figure 5-4 shows statistics for the percent amount of oil remaining at the end of each trajectory. The minimum percent remaining ranges from 4% for a trajectory reaching the Inlet Islands to 67% for the Port Site. Maximum amounts remaining range from 96 to 99% for the Port Site, Rocky East, and both Coastal Plain regions on the western side of the Inlet. Maximum amounts are 69 to 81% for the Rocky Northeast and Lagoon Complex to the north. Excluding the Port Site, were the mean percent of fuel remaining is 96% due to short times to shore, the mean percent of fuel remaining is 13% for Koch Island and ranges from 46 % (Inlet Islands) to 77 % (Lagoon Complex) elsewhere.

The collection of spill probability plots, and associated derived statistics for a spill to reach shore, presented, provide a basic definition of the probable geographic distributions of any hypothetical, uncontained, and unmanaged spill for the Project domain of operations at the Port Site and in Steensby Inlet.

In viewing these figures, the reader should keep in mind that there is no implication that a spill would cover the entire zone enclosed by a contour, only that the oil would be located at some position within this zone. Most importantly of course is the essential observation that these probabilities are derived from scenarios in which the hypothetical spills are both uncontained and unmanaged, conditions which should they occur would be mitigated through the Project spill emergency contingency planning and response plans.

The sets of oil spill distribution plots well-illustrate the wind and current-driven natures of the model. Basic characteristics of the shapes and spatial distributions of the probabilities away from the spill site can be substantiated from the seasonal patterns of currents and winds.

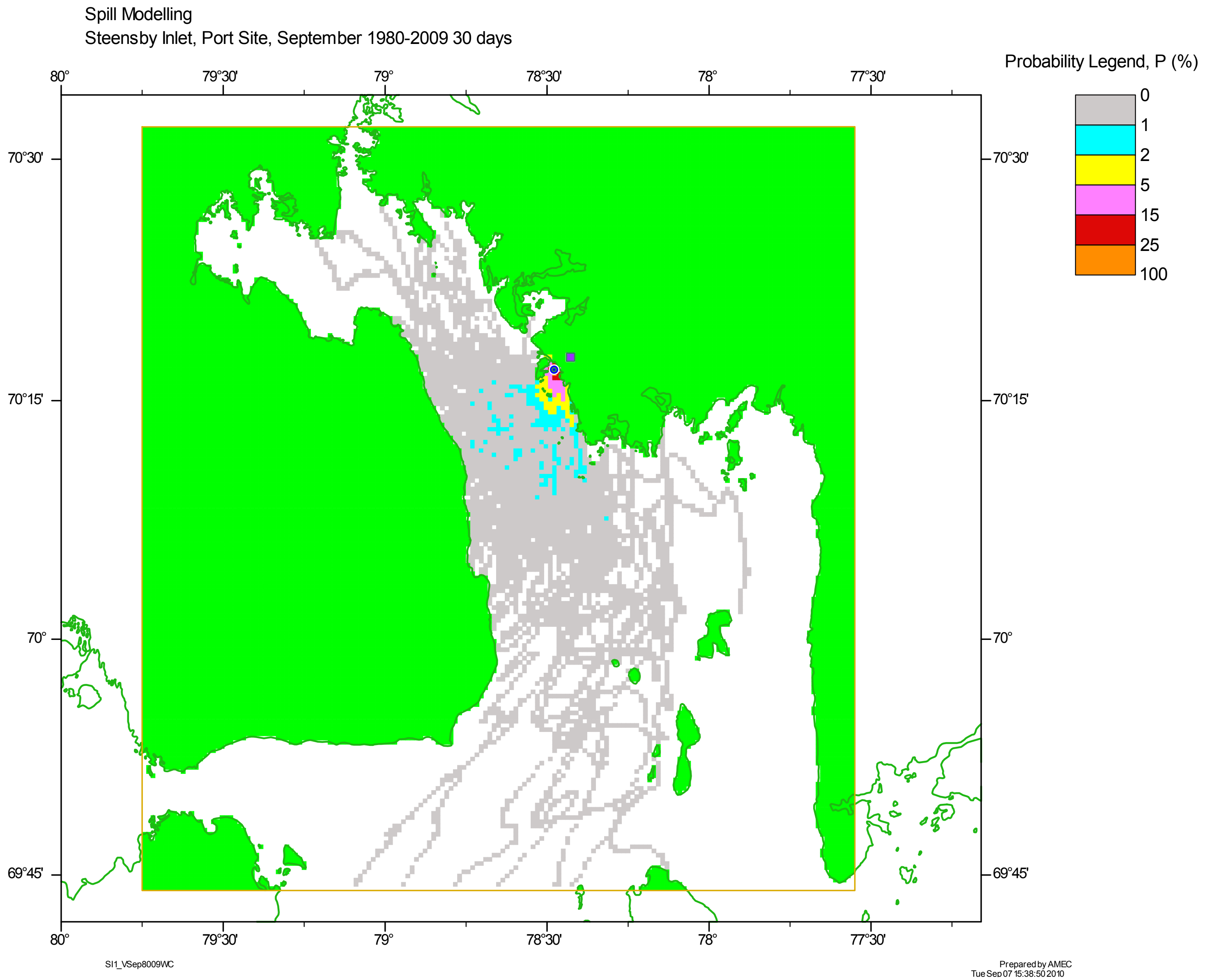

Figure 5-1: Spill Distribution Probability Plot, Port Site Scenario, September

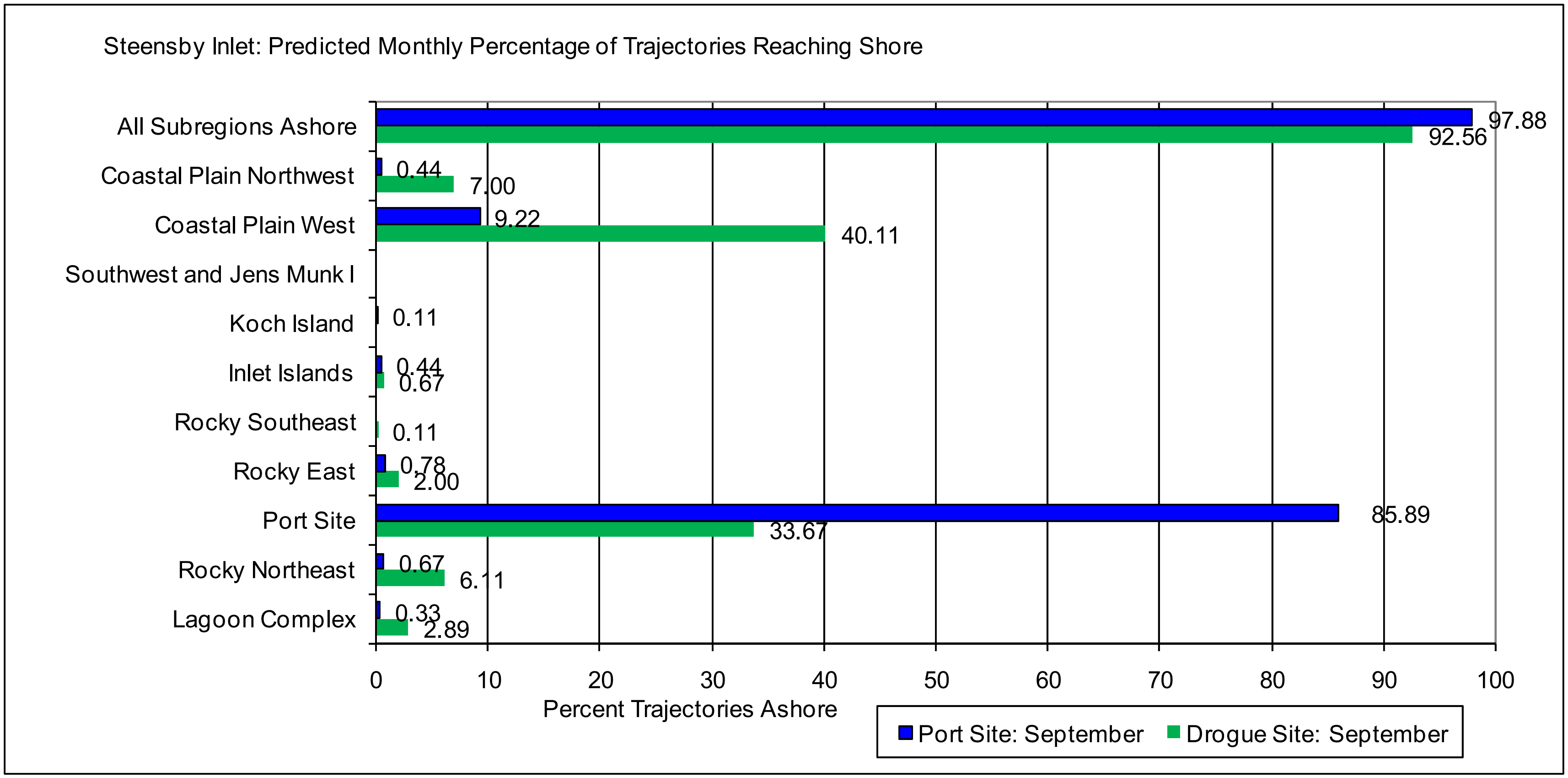

Figure 5-2: Predicted September Percentage of Trajectories Reaching Shore, Port and Drogue Site Scenarios, By Geographical Region

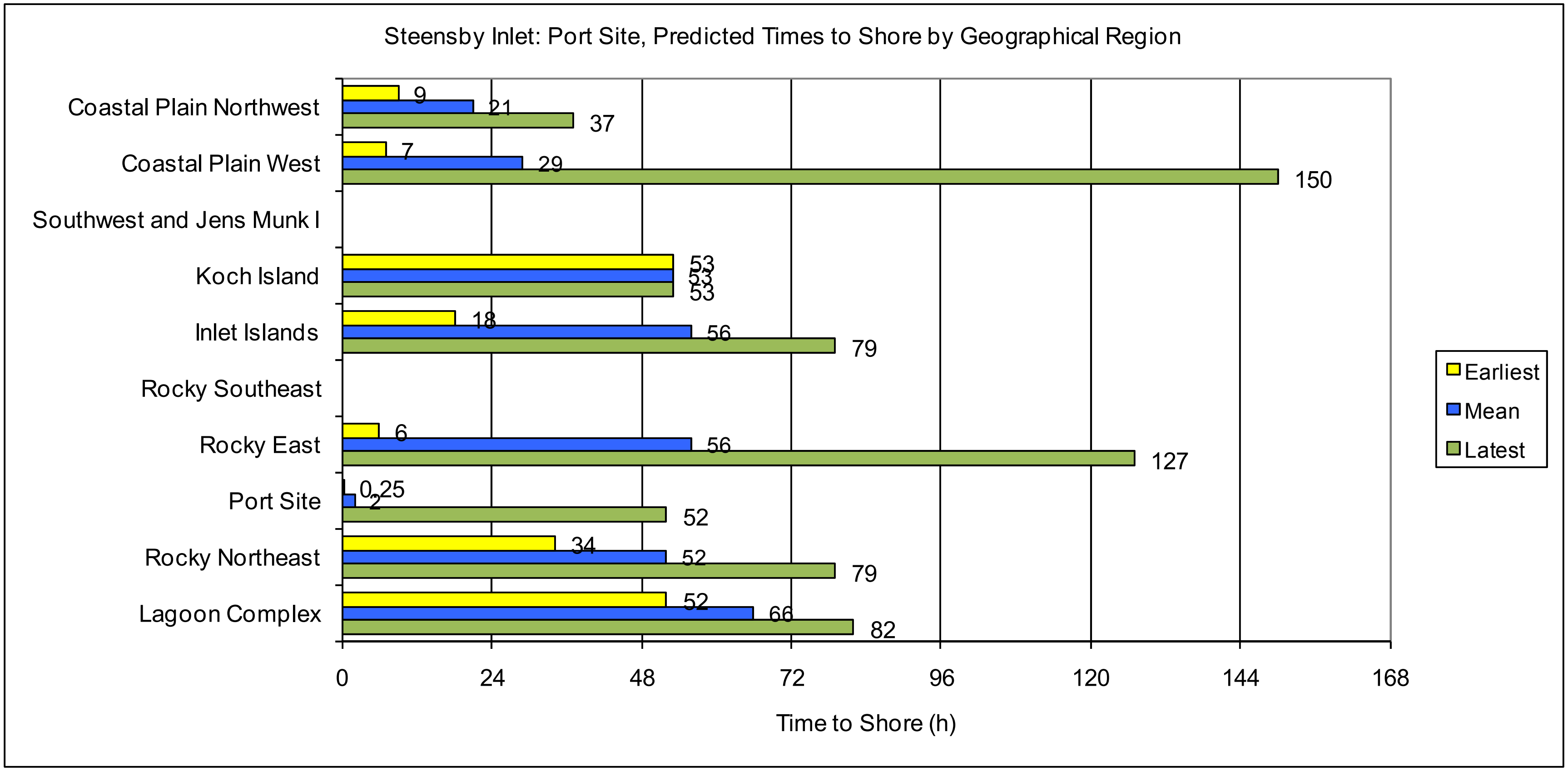

Figure 5-3: Predicted September Times to Shore, Port Site Scenario, By Geographical Region

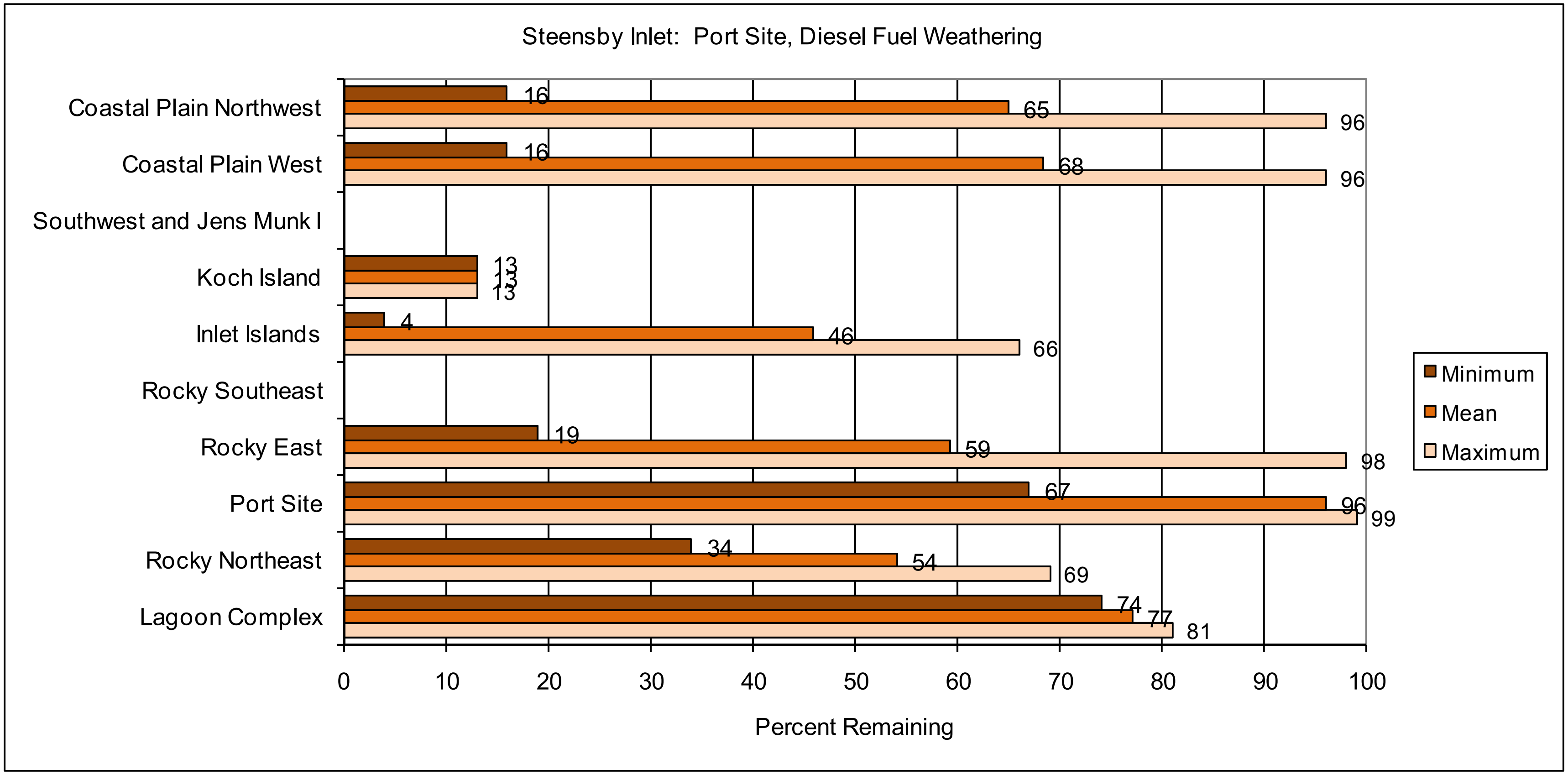

Figure 5-4: Diesel Fuel Weathering: Percent Remaining, Port Site Scenario, By Geographical Region

5.2 Drogue Site

As a sensitivity to spill release location, the Drogue Site just west of the ore loading island was selected. The September spill distribution probability map is presented in Figure 5-5.

As indicated by the pink contours, it is estimated that 5 to 15% of the time a fuel spill will drift through any 500 m x 500 m 'square' within the area of about 30 to 40 km^2 near the Drogue Site origin west of the ore loading island. There is a 2 to 5% chance that areas along about a 10 km stretch on the adjacent the western shore will see a spill. This yellow patch exhibits somewhat of a skew to the southwest quadrant, due to the predominant winds and also partially to some shelter afforded the Port region and to the east and southeast.

Any particular locations within the inlet, either as far as 10 to 15 km to the north, or as far as 20 to 25 km to the south might be expected to see a spill trajectory up to 2% of the time (light blue contours). Numerous shoreline areas at the upper quarter of the Inlet, including at the mouth of the Lagoon Complex, the mouth of Walrus Bay (immediately north-northeast of the Drogue Site), and the several other river and bay mouth entrances, might be expected to have a 1% or less chance of seeing a spill.

Other than two trajectories that make their way into the eastern portion of the Inlet, one reaching shore in Rocky East (in just less than 7 days), one reaching shore in Rocky Southeast (in just over 5 days), where both exhibit about 60% weathering loss, there is little indication that a spill would reach this far.

Figure 5-2 reports the percentage of trajectories reaching shore, where results are shown together with the Port Site scenario. Figure 5-6 reports the earliest, mean, and latest time to shore for each region. Of the 900 trajectory simulations, 21 reached the model boundary at the south, and 46 ended due to weathering loss of 95% of the spill volume. There was no shoreline reached for either the Southwest and Jens Munk Island, and Koch Island regions. This leaves about 93% of all trajectories reaching shore.

For a spill originating at the Port Site the majority of trajectories reached shores in the Port Site region. Now, for a Drogue Site spill origin, the majority of trajectories, 40%, first reach shore on the western side of the inlet for the Coastal Plain West region, in times as soon as 5 hours, and 22 hours on average. 34% now first reach shore for the Port Site region, in as soon as 30 minutes, and 9 hours on average, and as long as about five days. To the north, the Rocky Northeast and Coastal Plain Northwest regions receive trajectories 6 and 7% of the time, respectively, as soon as about 10 to 15 hours, and in two days on average. The Inlet Islands (six trajectories) are reached as soon as 44 hours, and 61 hours on average.

Figure 5-7 shows statistics for the percent amount of oil remaining at the end of each trajectory. The minimum percent remaining ranges from 4 to 12% for all regions except for the Rocky Southeast region which has one trajectory weathering to 41% remaining, and the Port Site which has a minimum percent remaining of 53%. Maximum amounts remaining range from 96 to 99% for the Port Site, Rocky East, and both Coastal Plain regions on the western side of the Inlet. Maximum amounts are 69 to 81% for the Rocky Northeast and Lagoon Complex to the north. Excluding the Port Site, were the mean percent of fuel remaining is 91% due to short times to shore, the mean percent of fuel remaining ranges from about 40% for the Inlet Islands, Rocky Southeast, and Lagoon Complex, to 72 to 75% for the Rocky Northeast and two Coastal regions.

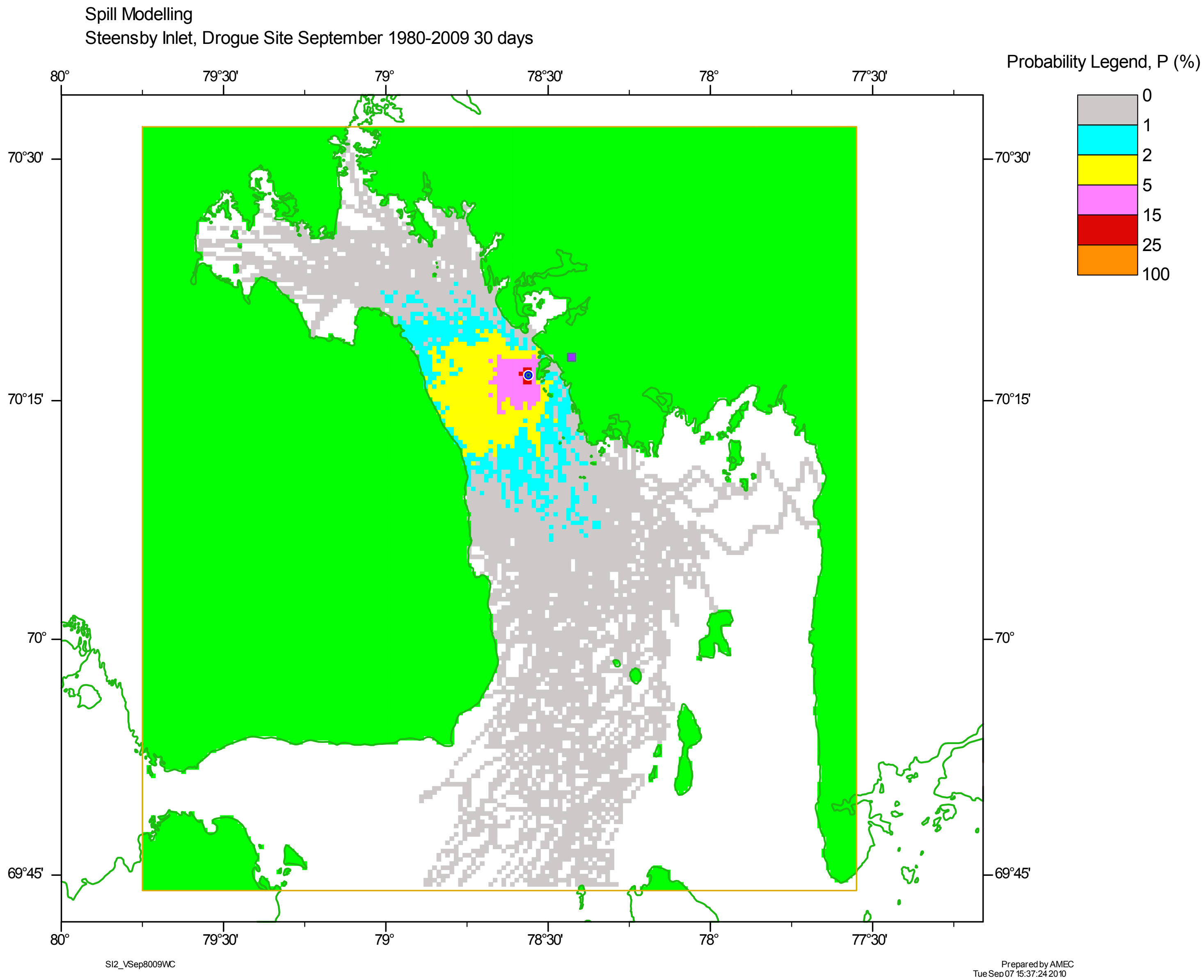

Figure 5-5: Spill Distribution Probability Plot, Drogue Site, September

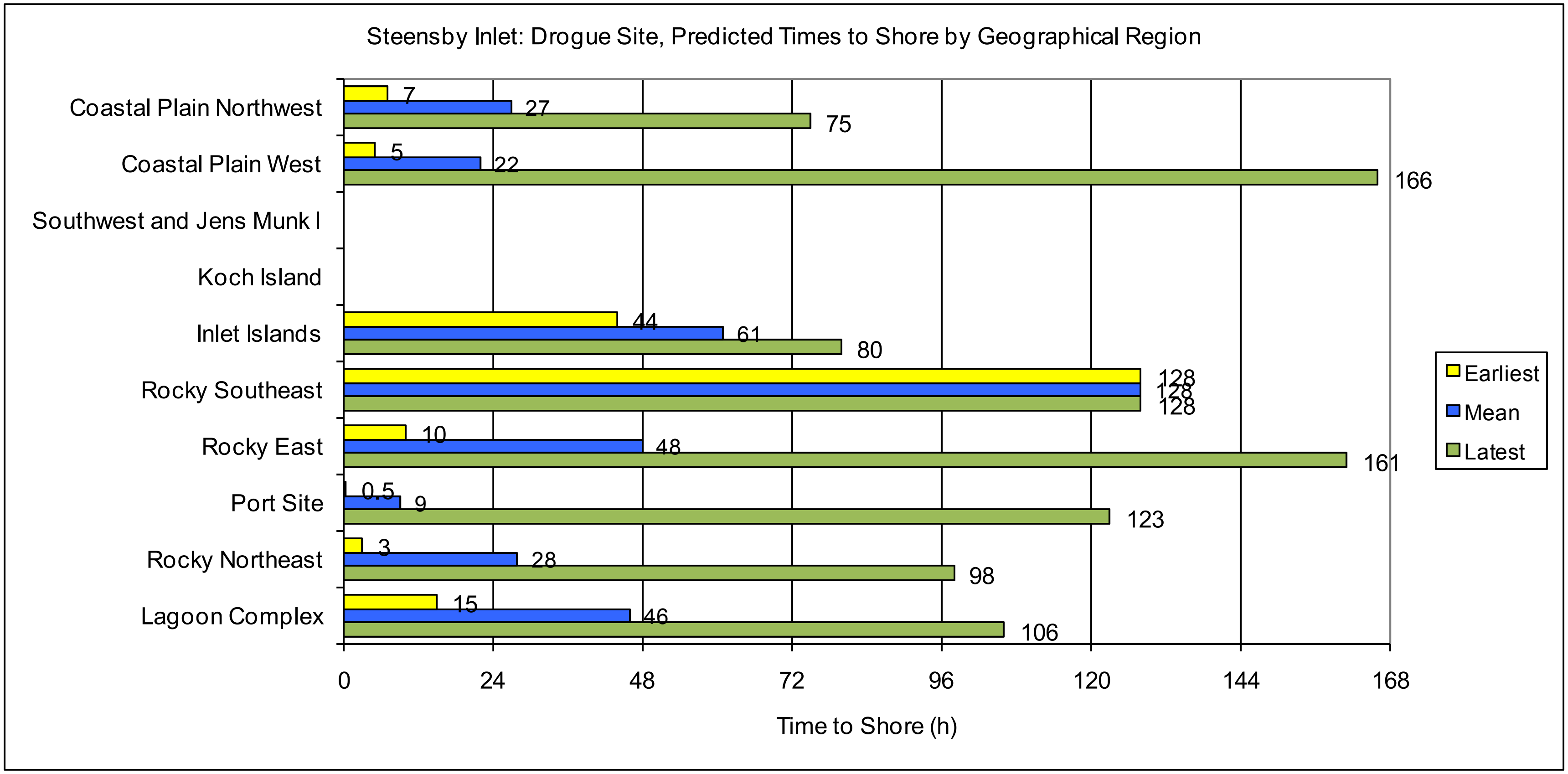

Figure 5-6: Predicted September Times to Shore, Drogue Site Scenario, By Geographical Region

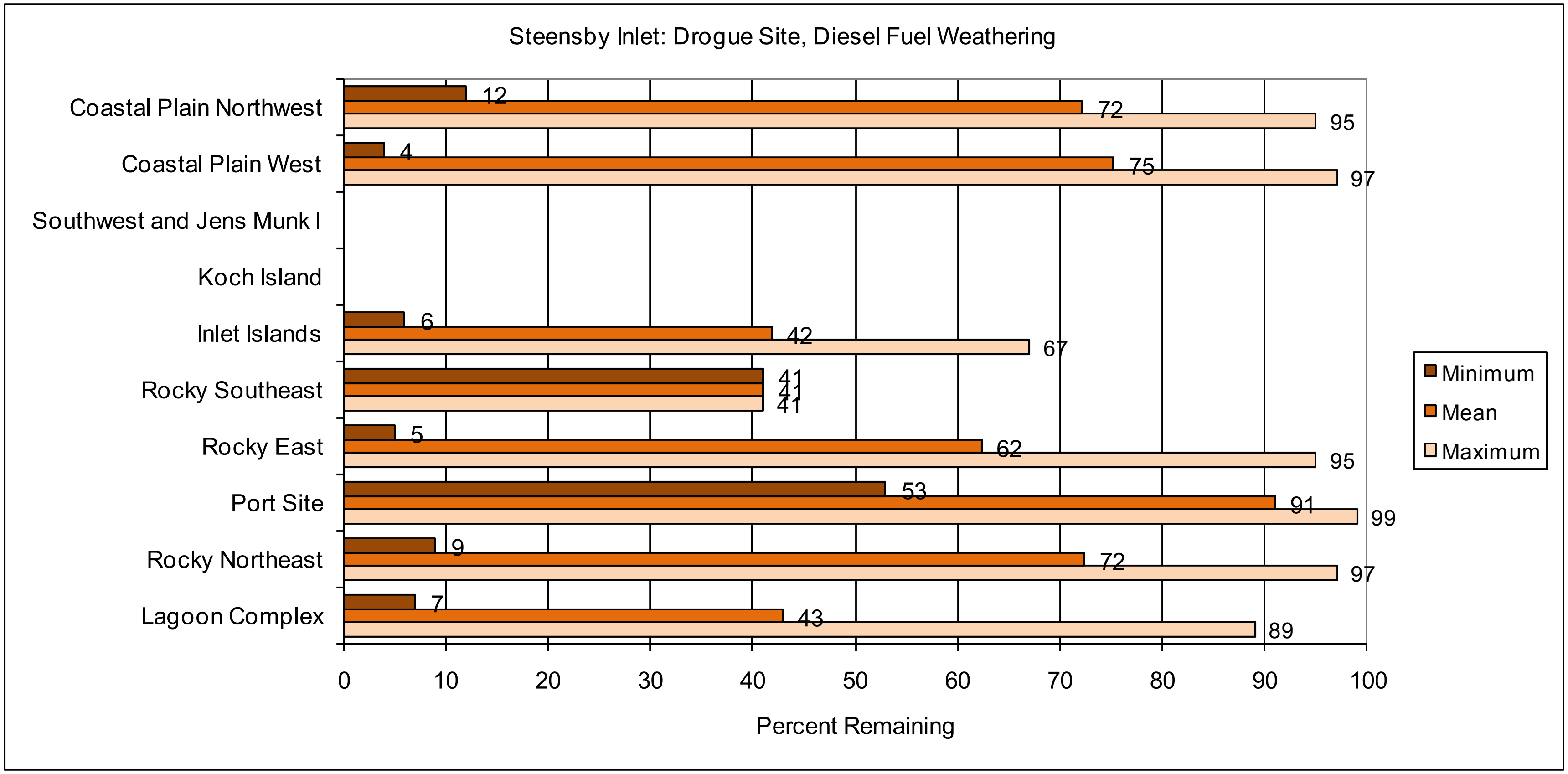

Figure 5-7: Diesel Fuel Weathering: Percent Remaining, Drogue Site Scenario, By Geographical Region

5.3 Current Drogue Drifter and Spill Model Comparison

As a preliminary validation of the OST spill model and further investigation of the CORI current drifter study, the spill model was run for each drogue released (Figure 5-8 and Table 5-1). The model employed the Steensby met station winds for September 2008 (
Figure 5-9) as opposed to the NCEP/NCAR winds, and the same currents as described above for the 30-year runs. Each drogue run commenced on the nearest hour to that of the drogue's release and was allowed to run for the duration for which drogue position fixes were recorded. Drogues that were released at about the same time are highlighted by colour in the table: OST runs therefore have the same inputs and yield the same trajectory prediction. OST-related additions of mean wind speed over the run duration and a subjective measure of how the model trajectory compared with the drogue path, in terms of direction and distance covered, are included.

Figure 5-10 presents two runs for which there is generally good agreement in trajectory paths. The drogue positions are shown with blue crosses, while the spill model positions are shown with red open circles. A complete set of the plots is provided in Appendix C. Run 8 occurs during a moderate breeze from the southeast. The two paths match closely for the first 18 to 20 hours after which the OST trajectory drifts apart ending about 2 to 3 km to the west of the final drogue position. While the drogue and OST trajectories for Run 21 follow slightly different paths, they end within less than 1 km of each other about 8 km southwest of the ore loading island.

Clearly some runs are in less agreement (see Table 5-1 and Appendix C). This may be due to several factors such as: differences in timing of the model start times and the drogue release; an inability of the model to exactly or adequately characterize the tides and currents as one moves away from the ADCP measurement locations and as currents respond to forcing by the wind; and variations in wind over the inlet compared with the met station measurements. A visual comparison of all runs was performed in an attempt to evaluate how well the OST model predictions matched those of the drogue path; both in terms of direction followed and distance travelled. A very subjective assessment of poor, fair-poor, fair, or good was made (Table 5-2: two short runs 36 and 37 were excluded). While not a definitive validation, trajectory direction was judged to match well in half the runs; trajectory distance was judged to be fair or good for a little less than half the runs.

As was noted in Section 3.2.2, the OST model's current scheme is based on site measurements and as such is a simple approximation, particularly for areas of the inlet removed from the ADCP sites. Inspection of the model predictions confirms that under some environmental conditions and drifter drogue locations and paths in the inlet, the true current and/or wind forcings of the model are limited. Nevertheless, this exercise suggests that under most of the runs considered the OST model yields predictions that are generally of the same order of magnitude as observed with the drogues.

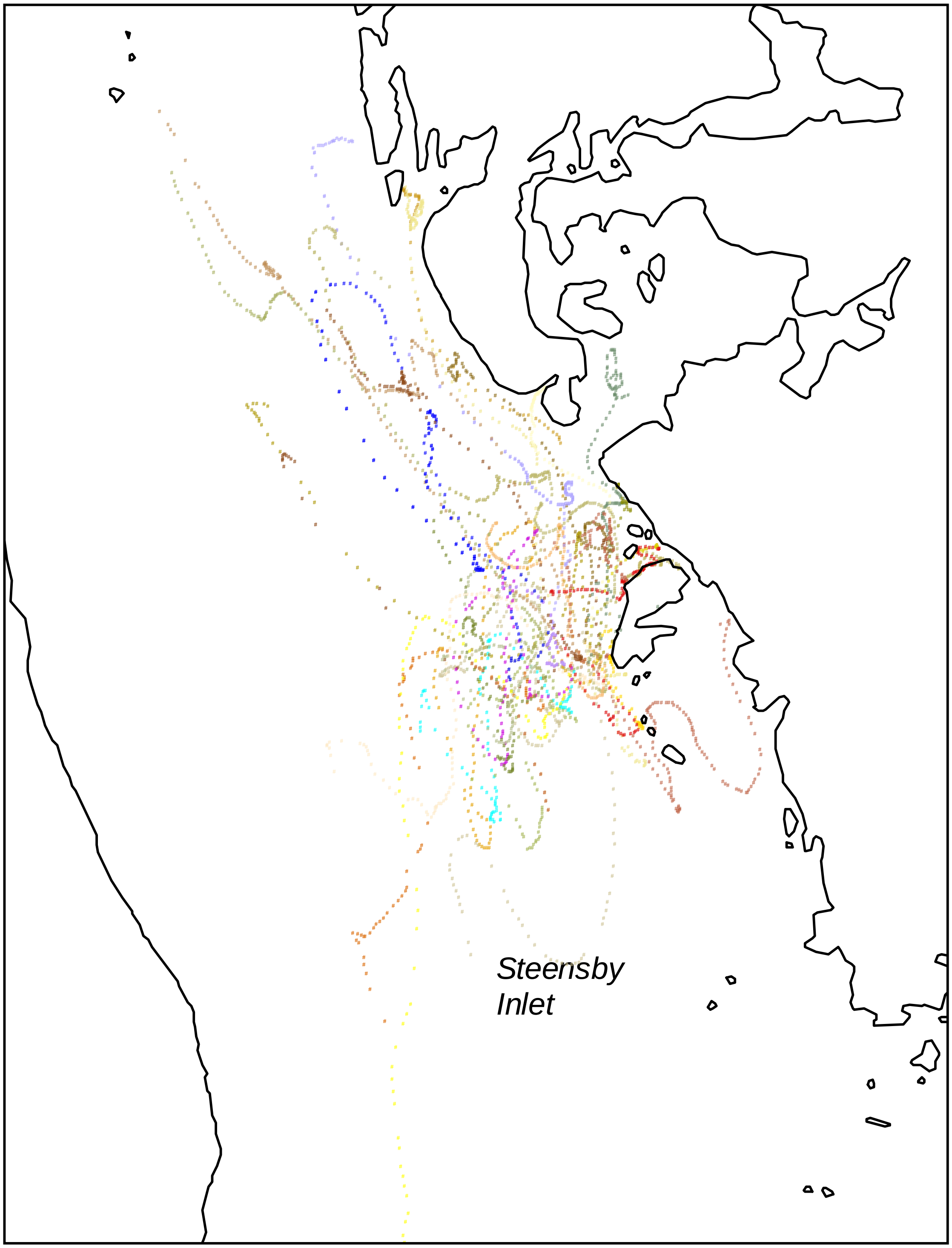

Figure 5-8: Summary of all drifter runs based on individual fix points (Source: CORI, 2010a)

Table 5-1: Steensby Inlet Drifter Drogue Runs. (Source: CORI, 2010a, with additional OST run results in italics)

Drogue Drifter Run #	**Weather at Start**	**Start date**	**End date**	**Elapsed Time (d:h:mm)**	***OST Elapsed Hours***	***OST Mean wind speed (m/s)***	***Compare with OST direction?***	***Compare with OST distance?***	**Weather at End**	**Comments**
1	light southerlies	9/7/2008 15:49	9/8/2008 15:49	1:0:00	*24*	*4.0*	*poor*	*fair*	12 knots S	recovered aground
2	light southerlies	9/7/2008 3:57	9/8/2008 7:37	1:3:40	*28*	*3.8*	*poor*	*fair-poor*	12 knots S	recovered on SW corner loading dock island
3	light southerlies	9/8/2008 19:35	9/9/2008 13:23	0:17:48	*18*	*3.6*	*good*	*fair-poor*	light southeast	
4	light southerlies	9/8/2008 19:41	9/9/2008 13:38	0:17:57	*18*	*3.6*	*good*	*fair-poor*	light southeast	drifter pipe broke at joint on recovery
5	light southerlies	9/8/2008 19:46	9/9/2008 13:25	0:17:39	*18*	*3.6*	*fair*	*fair-poor*	light southeast	
6	SE 25 knt	9/9/2008 18:31	9/10/2008 18:20	0:23:48	*24*	*9.4*	*good*	*fair-poor*	SE 20 knt	stranded on shore in Cockburg River estuary
7	SE 25 knt	9/9/2008 19:45	9/10/2008 18:22	0:22:37	*23*	*9.2*	*good*	*fair-poor*	SE 20 knt	stranded on shore in Cockburg River estuary
8	SE 20 knt	9/10/2008 20:31	9/11/2008 20:31	1:0:00	*24*	*7.3*	*good*	*good*	SE 25-30 knt	recovery not possible due to SE storm
9	SE 20 knt	9/10/2008 21:18	9/11/2008 20:35	0:23:16	*24*	*7.3*	*good*	*good*	SE 25-30 knt	recovery not possible due to SE storm; found at Theo's Lagoon 16 Sep
10	light winds	9/12/2008 20:10	9/13/2008 13:38	0:17:28	*18*	*10.9*	*good*	*fair*	15 knt SE	strong winds in night - SE?; moderate Se at pickup
11	light winds	9/12/2008 20:13	9/13/2008 13:42	0:17:28	*18*	*10.9*	*good*	*fair*	15 knt SE	strong winds in night - SE?; moderate Se at pickup
12	light southerlies	9/13/2008 20:12	9/14/2008 19:02	0:22:50	*23*	*4.7*	*poor*	*fair-poor*		
13	light southerlies	9/13/2008 20:05	9/14/2008 18:45	0:22:39	*23*	*4.7*	*poor*	*fair-poor*		
14	moderate southerlies	9/14/2008 19:35	9/15/2008 13:24	0:17:49	*18*	*4.3*	*poor*	*poor*		recovered at south end of Theo's lagoon, aground
15	moderate southerlies	9/14/2008 19:39	9/15/2008 13:38	0:17:58	*18*	*4.3*	*poor*	*fair*		recovered in "Mary Bay", north of Walrus Bay, aground
16	light SW	9/15/2008 22:01	9/16/2008 15:37	0:17:36	*18*	*1.8*	*fair-poor*	*fair-poor*		grounded inside island, near camp
17	light SW	9/15/2008 22:12	9/16/2008 13:00	0:14:48	*15*	*1.5*	*fair-poor*	*fair-poor*		grounded inside island, near camp
18	calm	9/16/2008 17:55	9/17/2008 14:44	0:20:48	*21*	*1.9*	*good*	*good*		
19	calm	9/16/2008 18:08	9/17/2008 14:59	0:20:50	*21*	*1.9*	*good*	*fair*		
20	calm	9/16/2008 18:04	9/17/2008 15:12	0:21:07	*22*	*1.9*	*good*	*fair-poor*		
21	calm	9/16/2008 18:09	9/17/2008 13:57	0:19:47	*20*	*2.0*	*good*	*good*		
22	light NE	9/17/2008 20:51	9/18/2008 21:40	1:0:48	*25*	*2.5*	*fair*	*fair*		
23	light NE	9/17/2008 20:55	9/18/2008 21:44	1:0:48	*25*	*2.5*	*fair*	*fair-poor*		
24	light NE	9/17/2008 20:59	9/18/2008 21:47	1:0:48	*25*	*2.5*	*fair*	*fair-poor*		
25	light NE	9/17/2008 21:02	9/18/2008 21:29	1:0:27	*25*	*2.5*	*fair*	*poor*		
26		9/18/2008 14:51	9/19/2008 18:13	1:3:22	*28*	*3.7*	*fair-poor*	*poor*		
27		9/18/2008 14:44	9/19/2008 18:07	1:3:22	*28*	*3.7*	*good*	*good*		
28		9/18/2008 14:58	9/19/2008 18:04	1:3:05	*28*	*3.7*	*good*	*fair*		
29		9/18/2008 15:12	9/19/2008 17:47	1:2:34	*27*	*3.6*	*good*	*good*		
30		9/19/2008 19:41	9/20/2008 18:22	0:22:41	*23*	*3.8*	*good*	*fair*		
31		9/19/2008 19:44	9/20/2008 19:44	1:0:00	*24*	*3.9*	*fair-poor*	*poor*		
32		9/22/2008 20:35	9/23/2008 18:14	0:21:39	*22*	*3.6*	*fair*	*poor*		
33		9/22/2008 20:03	9/23/2008 19:51	0:23:47	*24*	*3.5*	*poor*	*fair*		
34	light sse	9/23/2008 20:41	9/24/2008 17:43	0:21:02	*22*	*8.7*	*good*	*fair-poor*		
35	light sse	9/23/2008 20:34	9/24/2008 17:44	0:21:09	*22*	*8.7*	*good*	*fair-poor*		
36		9/27/2008 19:08	9/27/2008 20:46	0:1:38	*2*	*10.9*	*too short*	*too short*		
37		9/27/2008 19:31	9/28/2008 1:22	0:5:50	*6*	*10.7*	*poor - short*	*too short*		

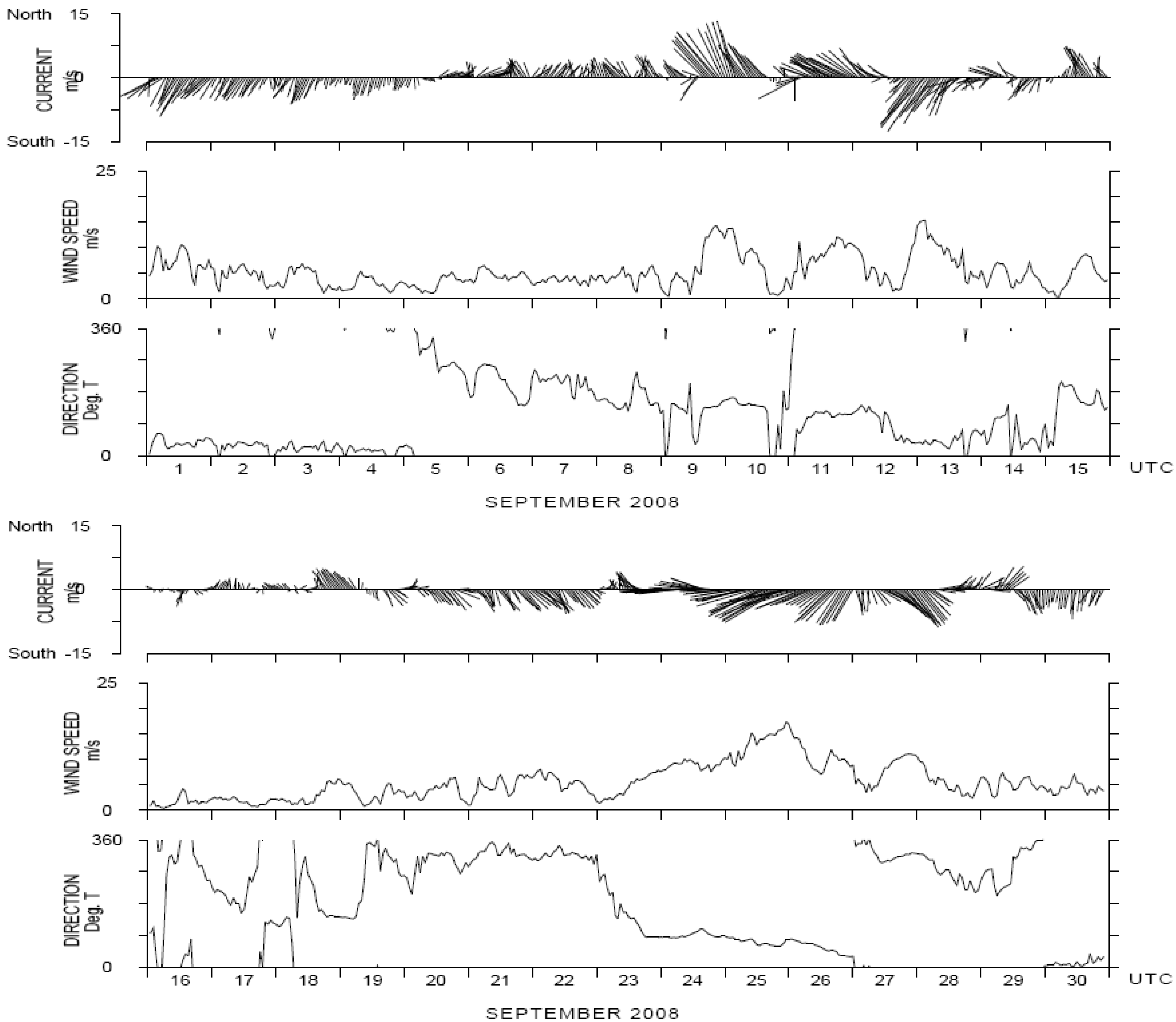

Figure 5-9: Steensby Met Station Winds, September 2008

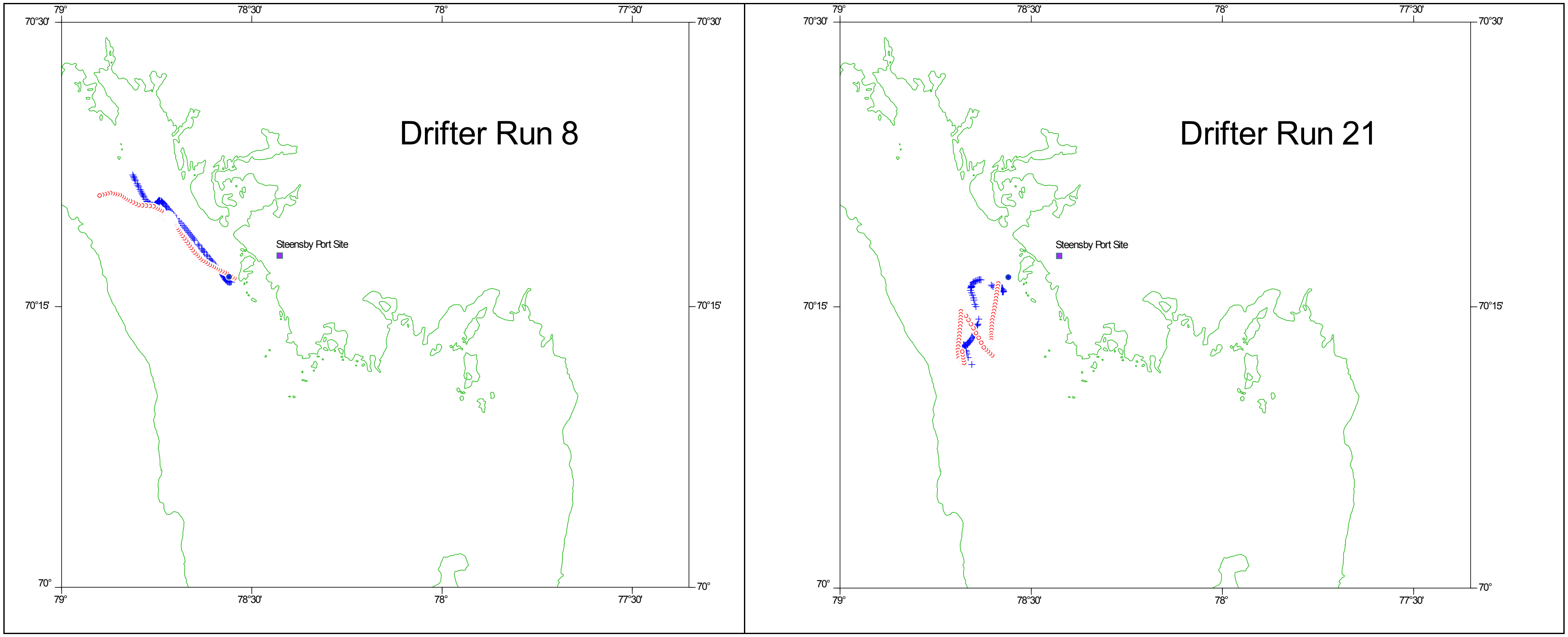

Figure 5-10: Drifter Drogue Runs # 8 and 21

Table 5-2: Subjective Summary Comparison of Current Drogue Runs

Compare with OST direction?		***Compare with OST distance?***	
poor	*7*	*5*	*poor (x 3+)*
fair-poor	*4*	*15*	*fair-poor (x 2)*
fair	*6*	*9*	*fair (within about 50%)*
good	*18*	*6*	*good*
	35	*35*	

6. QUALITATIVE ASSESSMENT OF SHORELINE FUEL RETENTION

The spill trajectory modeling for open-water conditions in Steensby Inlet indicates that fuel from a large (30,000 bbl) accidental diesel spill could reach shorelines within the inlet. The trajectory modeling, when combined with knowledge about the surrounding shoreline conditions (CORI, 2007) provides the basis for estimating potential residence and impacts of shore resources.

Spills Originating from the Proposed Fuel Terminal

The modeled spills from the proposed terminal site are high constrained by surrounding islands and the most probable stranding locations are in immediately adjacent shoreline. The dominant shore types in the port area are reported in Table 6-1.

Table 6-1: Shore Types in Port Area

Attributes	Shore Type	Occurrence	Retention/Impact
Physical s	rock cliffs	10 %	rock cliffs are largely impermeable; little retention likely
	rock cliffs with coarse sediment beaches	55 %	beaches associated with cliffs are coarse pebble, cobble, and boulder (Fig. 1). Moderate penetration would be limited due to finer sand-mud matrix in shallow subsurface (Fig. 2,3); stranded sheens likely to continue to evaporate
	alluvial fans	30 %	beaches associated with cliffs are coarse pebble, cobble, and boulder. Moderate penetration would be limited due to finer sand-mud matrix in shallow subsurface; stranded sheens likely to continue to evaporate
	lagoon complexes	5 %	fuel may be captured in lagoon complexes during high tides; lagoon complexes often contain salt marsh where some mortality could occur, although most of growing season is over by September.
Bio-logical	salt marsh	19 %	these marshes occur in upper intertidal and are vulnerable to spill contact. Most of growing season is over by September. Given the associated organic substrate, penetration is likely to be limited but sheens would be retained as surface coatings. Residual fuel retained on grass blades and stocks likely to be detached during winter and replaced by new shoots during the winter.
	rockweed	70 %	rockweed occurs in the lower intertidal (see Fig. 1) and depending on tides (spring or neap) at the time of the spill, may not be affected (neap tides). Fresh diesel contact during spring tides likely to be lethal to sub-lethal.
	kelp	40 %	kelp is in the subtidal and unlikely to be exposed to sheen contact. Little impact likely.

Sheen contact with shorelines outside the Port Site region (Figure 4-1) is shown to be a relatively low probability with shores along the west side of Steensby Inlet more likely to be contacted (probability of contact for any particular grid cell or stretch of ~ 500 m <5% (Figure 5-1). Shore types in the western coastal plain area are mostly (~90% occurrence) *wide flats* with wide intertidal extent (often 1 km) of muds and sands (Figure 6-4). Upper intertidal berms may be coarser pebble-cobble material. Sheens reaching these shores would be expected to be extremely thin (a few microns in thickness) so loading levels would be very low. Sheens would also be very well-weathered (average travel time before contact is 29 h; light ends likely to be evaporated), so most toxic components would be missing. Although salt marsh is estimated to occur on about 24% of this coast, much of that salt marsh is of the *fluvial type* and occurs in the backshore which is only inundated occasionally by spring tides and storm surges, making probable contact even lower (<1%). Rockweed occurs along 60% of this coast but usually as isolated pockets in the lower intertidal.

Figure 6-1: Coarse sediment shoreline near the port sill location. Although the beach includes boulders, cobbles and pebbles, there is considerable fine sediment matrix (sand in foreground; mud at left centre) that would limit fuel penetration in event of a spill. The golden-coloured seaweed is rockweed near the low-water line (photo by John Harper, 2008)

Figure 6-2: Close up of pebble-cobble veneer on beach surface near the proposed fuel transfer site. Compare to photo below. (Photo by John Harper)

Figure 6-3: Close up as same location with surface veneer scraped away. Immediate subsurface of beach has a muddy sand matrix. (Photo by John Harper)

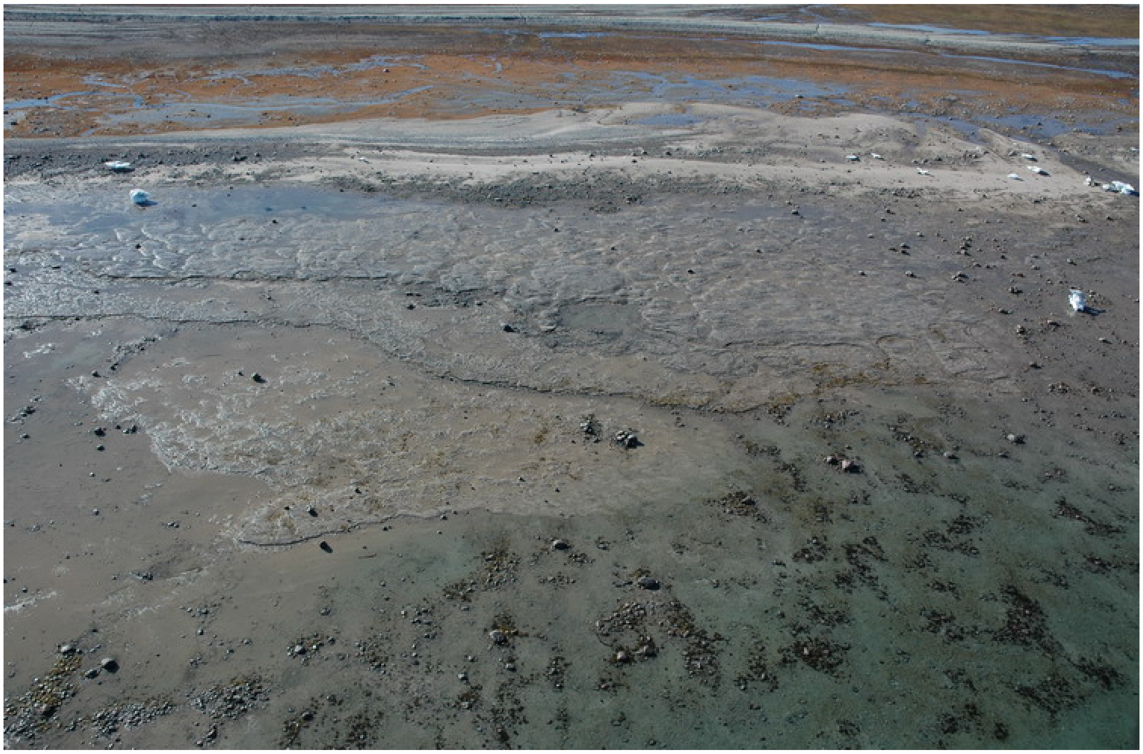

Figure 6-4: Aerial photograph of tidal flat shoreline along the western portion of Steensby Inlet (low-water line in foreground). Note the fine nature of the tidal flat sediments in the foreground, the isolated clumps of rockweed attached to boulders and cobbles on the flat, the narrow beach-face and berm in the upper intertidal zone and the associated salt marsh (golden colour) along the backshore in the supratidal. (Photo by Mary Morris, 2007)

Spills Originating from Ore Dock Location

Spills originating from near the ore loading dock show a much wider distribution, although the highest probability (> 5% probability of occurrence are confined to a comparatively small area near the dock site. The most likely area for spills to contact the shoreline (albeit < 5% probability at any particular location) is along the western shore of Steensby Inlet. As previously mentioned, this shoreline is mostly a wide flats (CORI 2007) that are fine sediment in the lower and middle intertidal zone (Figure 6-4). Berms may be coarse (pebble-cobble) and salt marsh is common (24%) in the supratidal zones, which are only occasionally flooded. Rockweed is also common (60%) but usually as isolated pockets in the lower intertidal zone (Figure 6-4).

Modeling data suggest that most diesel sheens that reach this shoreline would be weathered around 24 h before they reached the shore. Sheens of this age are typically a few microns thick. Given the fine nature of mid and lower intertidal sediments, very little retention would be expected in these zones. Some moderate retention would likely occur in berms but the sheens are thin so overall loading potential is low. Sheens would be even less likely to reach salt marshes in the supratidal as extremely high tides or storm surges would be necessary to inundate these areas.

Summary of Potential Shore Impacts from Diesel Spills

The initial modeling results suggest that impact to shoreline resources would be comparatively short term (days to weeks) largely because of the volatile nature of diesel fuel. Shorelines close to the port location have fine-sediment matrix in the immediate subsurface which will limit fuel penetration and overall retention. Stranded fuel would continue to evaporate on the surface of beaches.

Key macrobiota on these shorelines include salt marshes and rockweed. Salt marshes are in the upper intertidal and supratidal zones and are vulnerable to fuel contact. Salt marsh substrate is typically fine-grained sediment and organics, which have low permeability so significant volumetric retention would not be expected. However, diesel does stick to organics so some residual fuel may be incorporated into the organic substrate. It is likely that salt marshes close to the spill site would experience a combination of lethal effects and some sublethal effects. New plant shoots would be expected during spring melt so it is likely that the most effects would be limited to a single generation. The estimated duration of impact would be weeks to months with normal growth rates returning the following spring; some marsh areas very close to the spill site could have reduced growth rates for longer periods of time.

Rockweed occurs in the lower intertidal and shallow subtidal. Rockweed would only be exposed during spring tides so is not vulnerable at all times. There are likely to be a combination of lethal and sublethal affects for rockweed located with a 5 km of the spill location. The life stages of rockweed in this region are unknown but the extensive occurrence along the shore probably represents first year growth and the rockweed also occurs offshore where it is not vulnerable to contact with sheens. As such, it is likely that effects of a diesel spill on rockweed would be limited to a single generation and that rockweed growth at breakup during the following year would be normal. As such, the effect of a spill on rockweed is likely to be moderate (weeks to months).

7. ADDITIONAL SPILL FATE SCENARIOS: OILMAP

The OILMAP oil spill model system introduced in Section 2.4 was used to provide additional estimates of spilled fuel fate, in particular, slick characteristics and weathering. OILMAP will calculate the evaporation, dispersion and remaining percentage for a given spill scenario where the user defines an oil product type, weather conditions, properties of the receiving water, and the amount of oil released. The same 5 ML diesel fuel scenario, released from the Port Site over a period of 15 minutes, was simulated for seven days, with a 1° C water temperature.

The fate or weathering processes considered were evaporation, the conversion of liquid oil into a gaseous component, and natural dispersion, the breakup of an oil slick into small droplets that are mixed into the sea by wave action. These are two important weathering processes that typically occur over the first five days following a spill and act to remove oil from the sea surface. Consideration of the amounts lost due to these processes yields an estimate of the remaining amount of oil.

Note that the modeled spills assume no containment or recovery of the spilled oil.

A 100 x 100 cell land/water grid of cell size ~ 750 m east-west x ~850 north-south was created as shown in Figure 7-1. The grid took advantage of OILMAP's ability to characterize shore types. An oil, or fuel, handling capacity based on oil type, beach or shore type is calculated (ASA, 2004). The OILMAP shore types are noted in italics in Table 7-1 , together with the original shore type description, maximum oil thickness, and corresponding portion of the model domain where that type was assigned.

Table 7-1 Maximum Surface Oil Thicknesses for OILMAP Shore Types as a Function of Oil Viscosity (Source: ASA 2004)

Shore Type	**Oil Thickness (mm) for Light Oils (< 30 cSt), e.g., diesel**	**Steensby Domain (following shoreline types characterized by CORI, 2007, see also Figure 4-1**
Coarse Sand, Fine Sand / *Sandy Beach*	0.5	Rocky Northeast, East, Southeast, Port Site, Inlet Islands, Koch Island
Exposed Tidal flats / *Tidal Flat*	4	Coastal Plain Northwest, West
Sheltered Marsh / *Marsh, Mangrove*	2	Lagoon Complex

Input wind scenarios for two times in September 2008 were selected for study with OILMAP. This time period enabled use of the Steensby Site met station data directly (
Figure 5-9), compared with the NCEP/NCAR winds for the OST 30-year probability model runs above. For illustration of possible shoreline oiling on the western and eastern shores of the inlet, spills originating on September 1st and 27th were modeled as presented below.

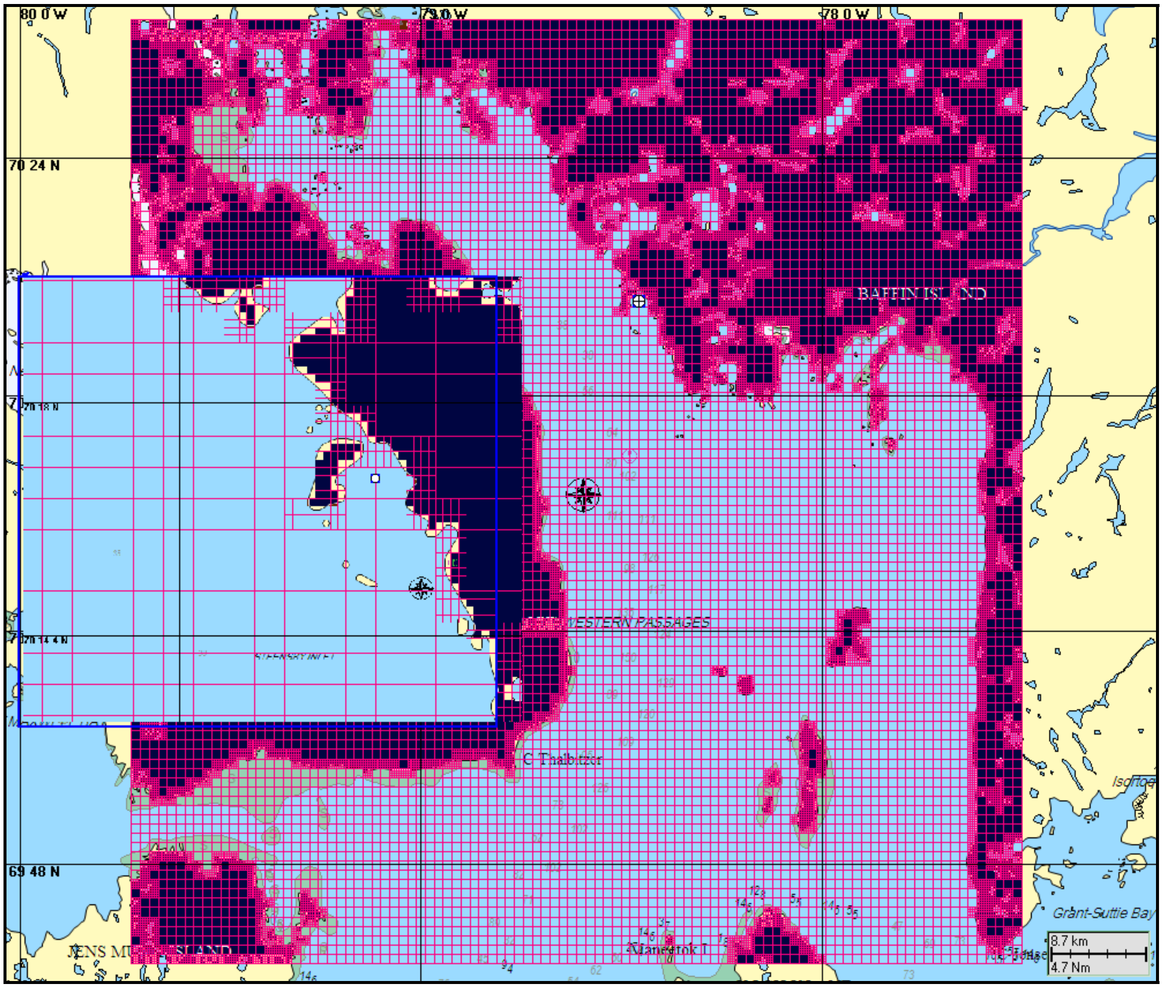

Figure 7-1 Steensby Inlet, OILMAP Land/Water Grid, with Port Site Area Inset.

<u>1 Sep 2008</u>

The September 1 event considers winds that average 7 m/s (13.6 knots) over the first day and that blow for the first four days from the north-northeast and northeast. As shown in Figure 7-2 after three hours, the slick diameter is ~1.7 km. For illustration, the slick thickness (three levels: red 0.1 to 20 mm; rose 0.01 to 0.1 mm; and light pink 0.001 to 0.01 mm[13]) and swept area (in grey) and trajectory track line of the centre of the slick are shown.

After 15 hours (Figure 7-3) fuel first comes ashore on the western side, where the slick diameter is ~4 km.

After two days (Figure 7-4) the fuel still resides along the western shore: 40% on the surface, 35% ashore (shown in bright magenta), 10% evaporated, and 13% dispersed into the water column. The slick size is ~7x1 km along the coast.

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[13] 0.001 mm corresponds to spilled oil which might appear to be silvery or barely visible on the surface; 0.01 mm might appear dull coloured; 0.1 mm might be black or dark brown in appearance.

After four days and five hours, less than 1% of the fuel remains on the surface. 71% is ashore, 15% has evaporated, and 12% is in the water column. The slick size is ~3x2 km along the coast, 20 km southwest of the Port Site.

12 hours later, the winds come around to the west and begin to blow what remains of the slick back to the east. The weathering fates chart in the upper right of each trajectory snapshot shows the amount or % of fuel on the surface, in the water column, ashore, or evaporated (the spill volume is apportioned to a number of ‘spillets’, in this simulation, 100, which are each modeled separately; spillets with volume less than 10% are not tracked further).

Just after six days (Figure 7-5), the slick reaches the eastern shore. At that time, for an estimated 5 ML spill, with no containment or recovery, the model estimates 23,000 L remaining on the surface, about 3.5 ML on the western shore, almost 875,000 L evaporated, and 610,000 L in the water column.

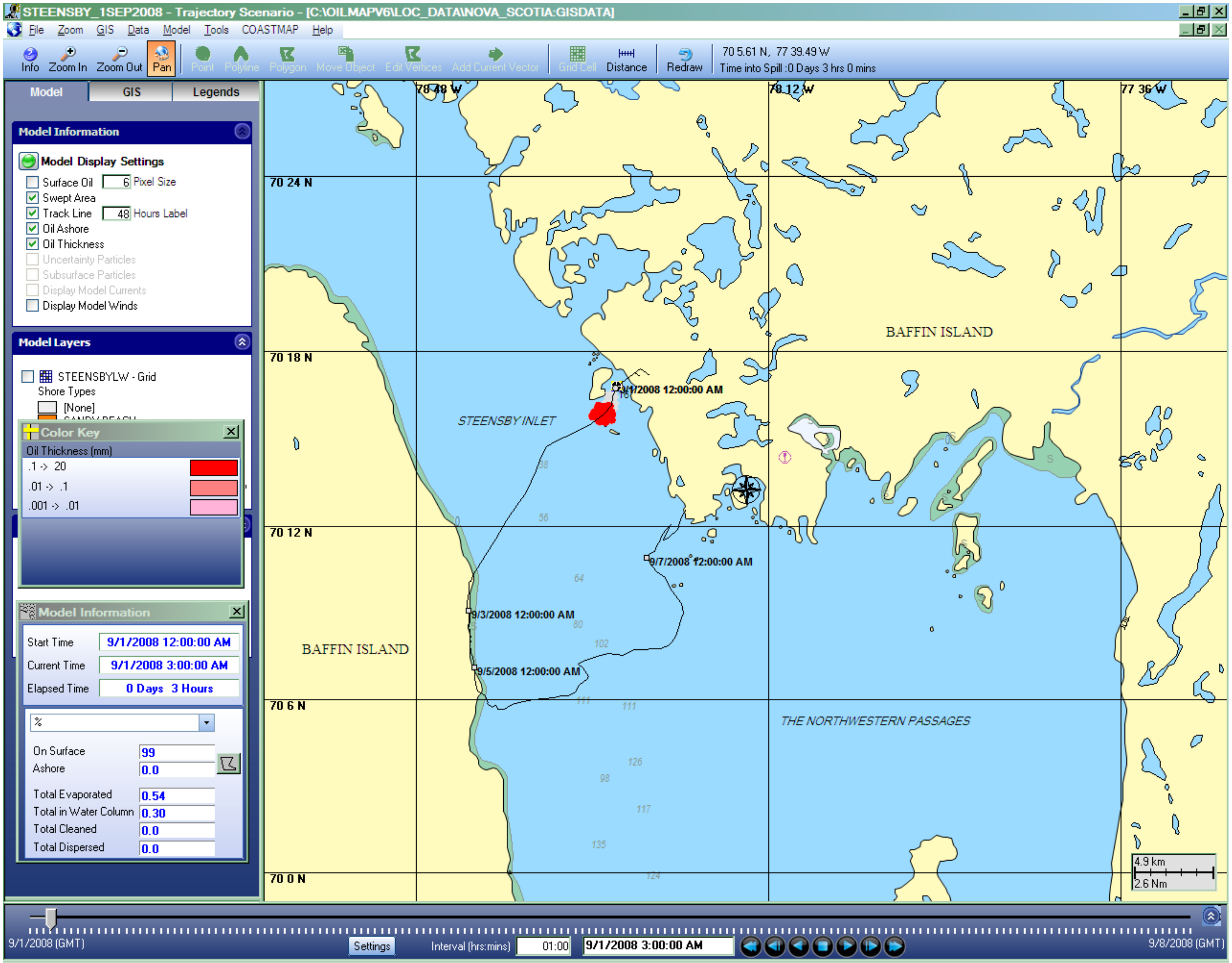

Figure 7-2 OILMAP Spill Simulation: 1 September 2008, after 3 hours.

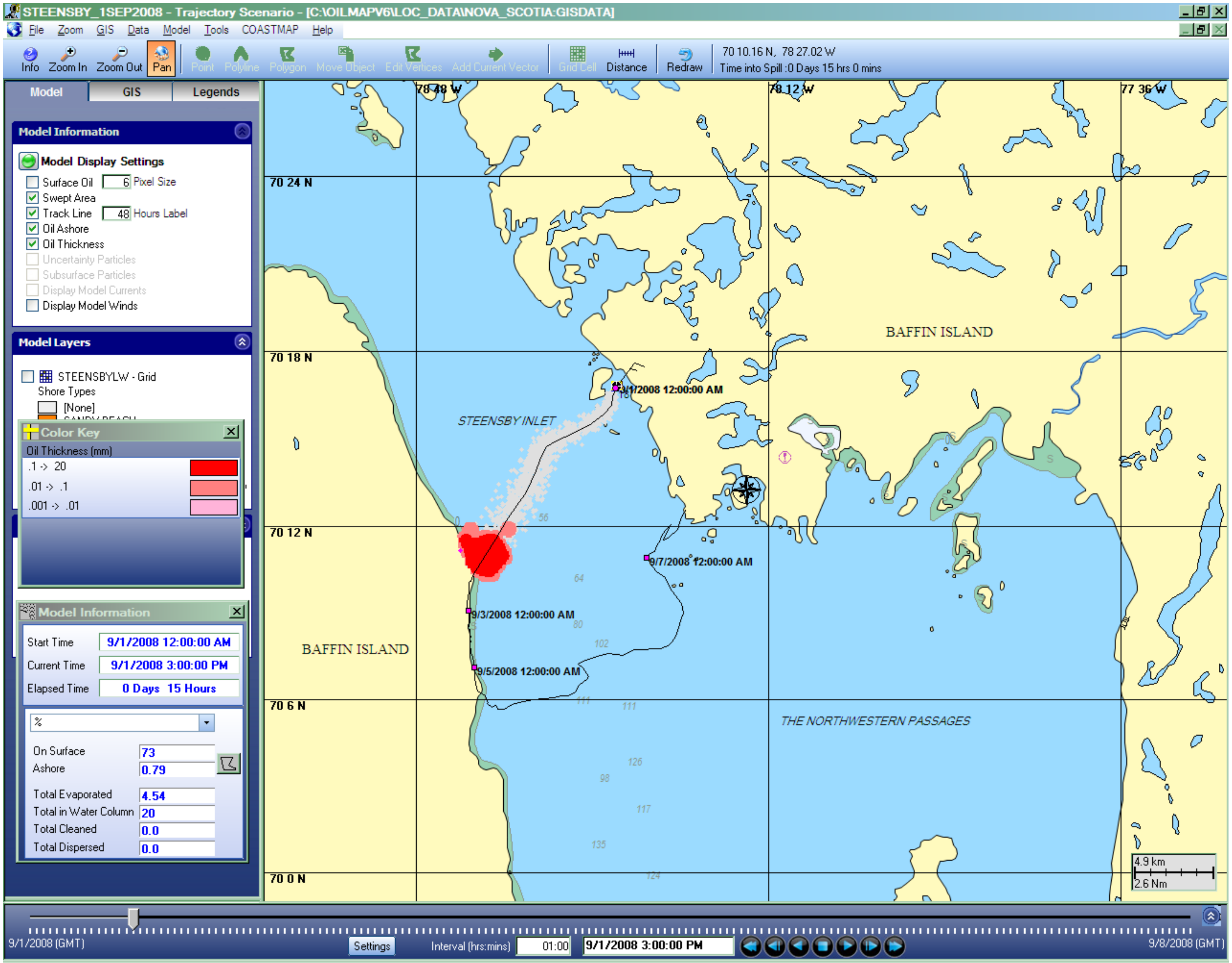

Figure 7-3 OILMAP Spill Simulation: 1 September 2008, after 15 hours.

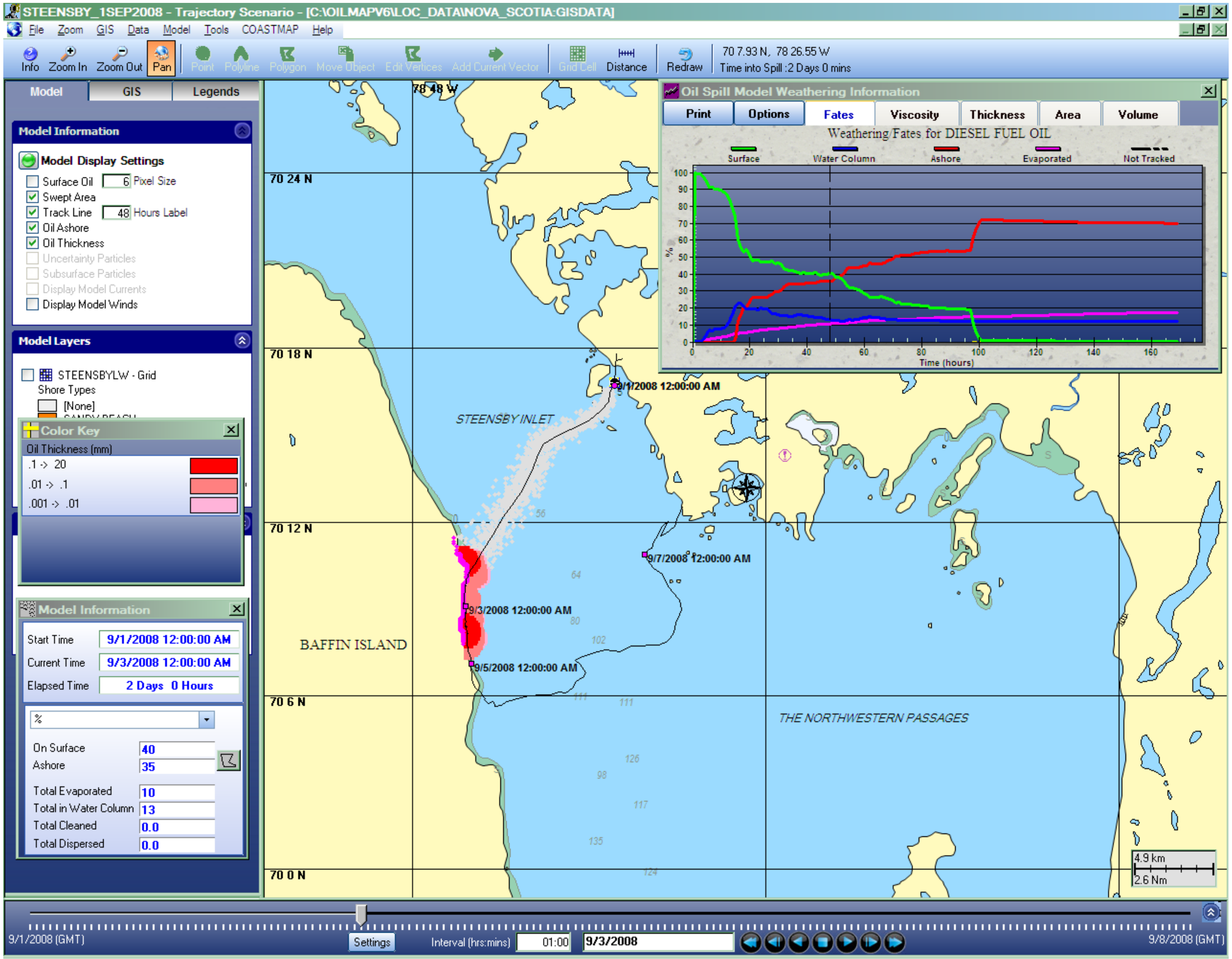

Figure 7-4 OILMAP Spill Simulation: 1 September 2008, after 48 hours.

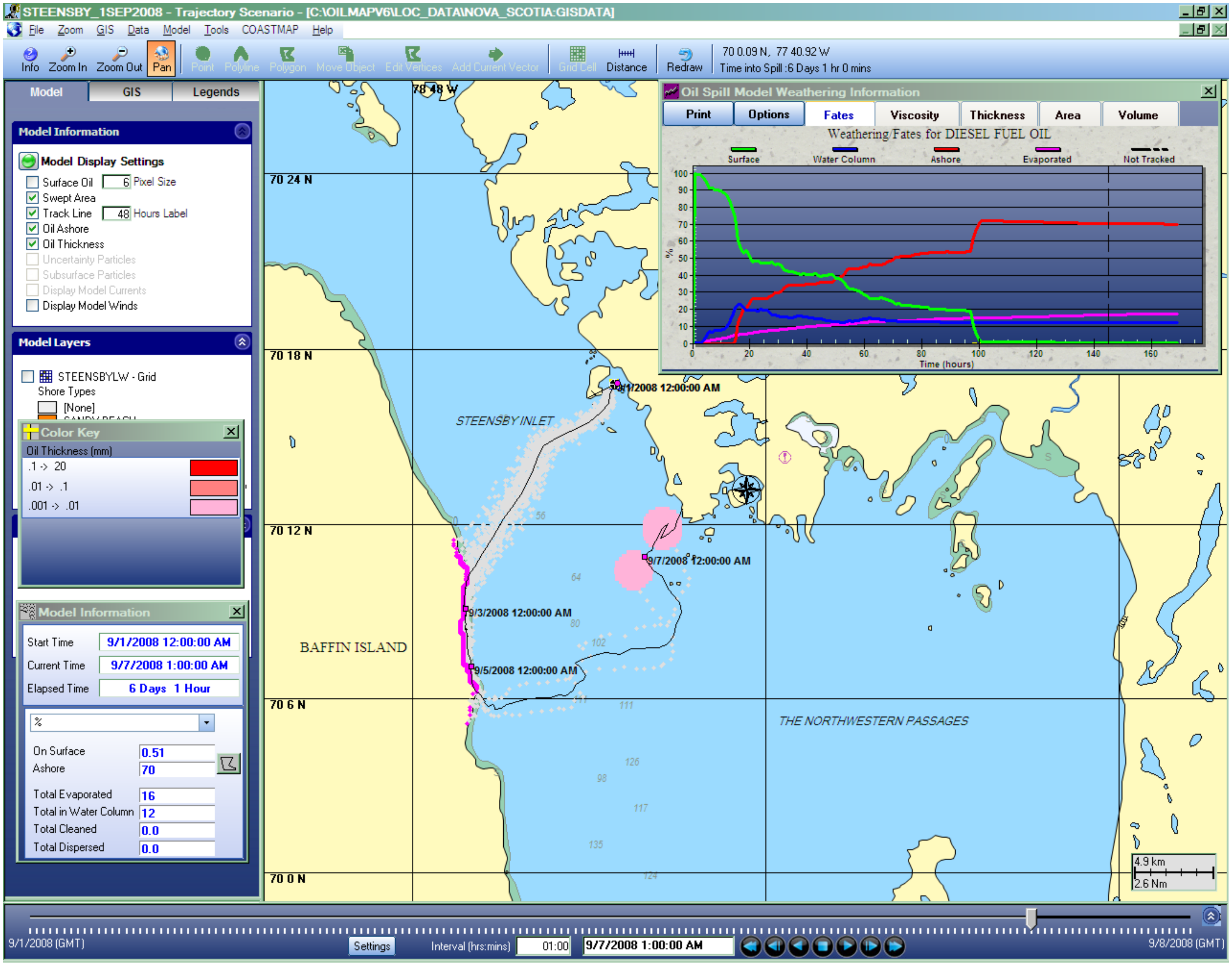

Figure 7-5 OILMAP Spill Simulation: 1 September 2008, after 6 days and 1 hour.

27Sep 2008

On September 27 (some discussion of the OST simulation is provided in Section 4.1) winds are from the north at about 5 to 6 m/s. Within two to three hours the slick has drifted outside the Port area. While spill response details are beyond the scope of this study, clearly pre-booming during offloading, within the close quarters and relatively sheltered port region, would be a sound preventative and mitigating measure for spill risk.

After about nine hours the winds change to the northwest, and the slick drifts towards shore. The shore is reached about three hours later. Winds continue blowing to the southeast. Figure 7-6 shows the trajectory after 13 h. Figure 7-7 shows the trajectory after one day. After 27 h less than 1% of the fuel is predicted to remain on the surface. As illustrated in the weathering chart, the majority of fuel is lost to the water column due to the winds which reach 11 m/s by the evening of the 27th.

Summary

The OILMAP simulations, albeit only a small sample size generally confirm the distances and times for a fuel spill to reach shores in the inlet as predicted by the OST probability model.

Simulations for any given day can include either historical wind and current data or forecasts. The ability to characterize shore types (which could be characterized to a higher resolution than the three broad regions initially resolved here may offer additional value) and quantify fuel amounts for particular regions, may be of utility in the event of an actual spill incident. Additional features of note include incorporation of fuel recovery, overflight, and response activities. As noted earlier, development of a hydrodynamic model is required to properly estimate tide and current effects in the inlet.

For each OILMAP spill scenario, a dBase format (.dbf) file is output which lists mass balance, weathering, and selected environmental information. The file format is shown in Figure 7-8. The collection of .dbf files offer in particular the following parameters which may be of interest for consideration of biophysical effects:

- Slick width, W (km) (equation 1)
- Amount of fuel evaporated (m^3)
- Estimate of fuel concentration, C (ppm) (equation 2)
- Total oil volume including water incorporation due to emulsification (m^3)

$$W = 2\sqrt{A/\pi} \qquad (1)$$

where A = surface area with oil > 0.001 mm thick (m^2)

$$C = (WaterCol \times 1{,}000{,}000)/(A \times h) \qquad (2)$$

where WaterCol = total oil volume in water column (m^3)

h = depth of well-mixed surface layer estimated for oil entrainment, assumed = 0.5 m (ASA, 2004)

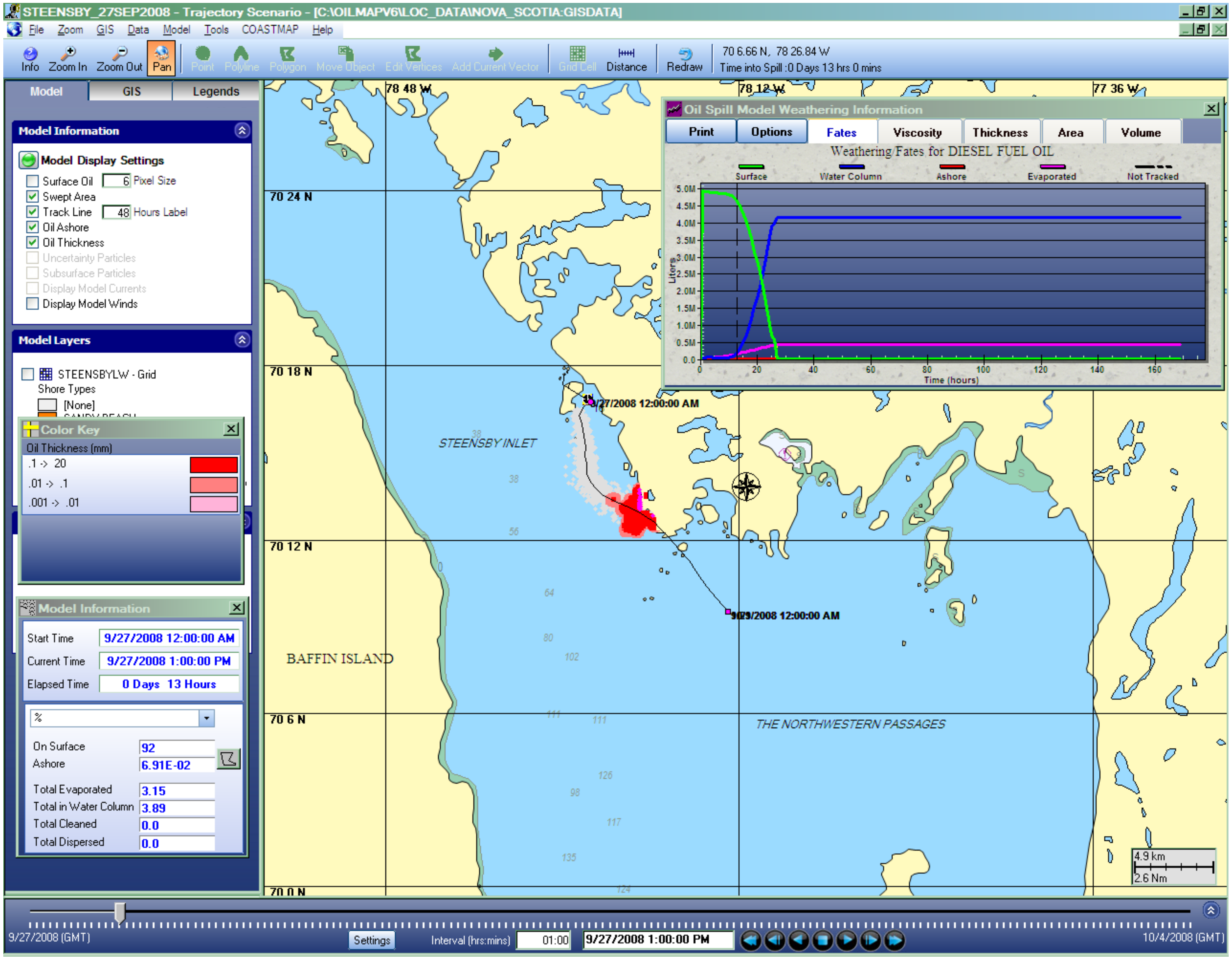

Figure 7-6 OILMAP Spill Simulation: 27 September 2008, after 13 hours.

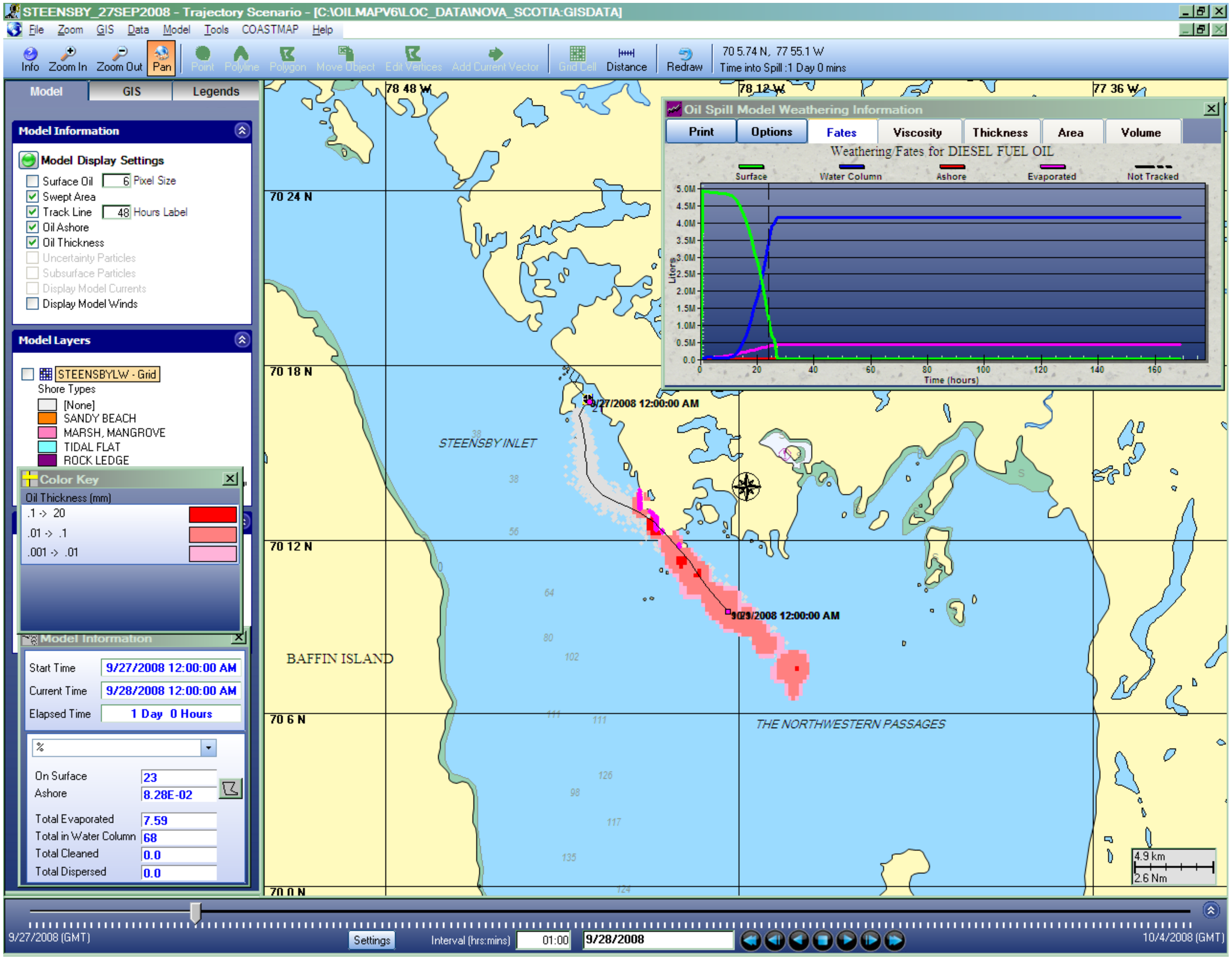

Figure 7-7 OILMAP Spill Simulation: 27 September 2008, after 1 day.

Data available in the *location*\FATES*scenario*.DBF file

Field Name	Description	Units
Time	Time since start of simulation	hours
Surface	Total oil mass on water surface	metric tons
WaterCol	Total oil mass in water column	metric tons
Ashore	Total oil mass on shoreline	metric tons
Evaporated	Total oil mass evaporated	metric tons
UnderIce	Total oil mass in >80% ice-covered water	metric tons
Outside	Total oil mass transported beyond grid boundaries	metric tons
Cleaned	Total oil mass boomed, dispersed, skimmed, or collected by sorbent (shoreline)	metric tons
NotTracked	Total oil mass in spillets below the minimum mass to track	metric tons
TotalMass	Total oil mass released (over entire spill duration)	metric tons
Avg%Water	Average water content (mean of all surface spillets)	percent
Thickness	Average oil thickness (mean of all surface spillets)	m
Viscosity	Average kinematic viscosity (mean of all surface spillets)	cSt
TotalArea	Total surface area oiled (based on thickness contours)	m^2
FlashPt	Average flash point (mean of all surface spillets)	^oC
MousseVol	Total oil volume including water incorporation due to emulsification	m^3
Density	Average oil density (mean of all surface spillets)	gm/cm^3
WindSpd	Wind speed at the average spillet location	m/sec
WindDir	Wind direction at the average spillet location	degrees
WaveHgt	RMS wave height at the average spillet location	m
AvgLong	Average longitudinal spillet location	degrees
AvgLat	Average latitudinal spillet location	degrees
ExtentX	Maximum longitudinal distance in which oil is present	m
ExtentY	Maximum latitudinal distance in which oil is present	m
Area>.001	Surface area with oil > 0.001 mm thick (based on thickness contours)	m^2
Area>.01	Surface area with oil > 0.01 mm thick (based on thickness contours)	m^2
Area>.1mm	Surface area with oil > 0.1 mm thick (based on thickness contours)	m^2
"cleanup task"	Oil mass cleaned, listed by cleanup task and division	metric tons

Figure 7-8 OILMAP Weathering Fates Results .DBF file format (Source: ASA 2009)

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APPENDIX A

STEENSBY INLET OCEANOGRAPHIC CIRCULATION SUMMARY

STEENSBY INLET OCEANOGRAPHIC CIRCULATION SUMMARY

Steensby Inlet is a remote inlet located to the North of Foxe Basin a large and shallow inland sea of the Canadian Arctic Archipelago (CAA), on the South West coast of Baffin Inland (Figure A1).

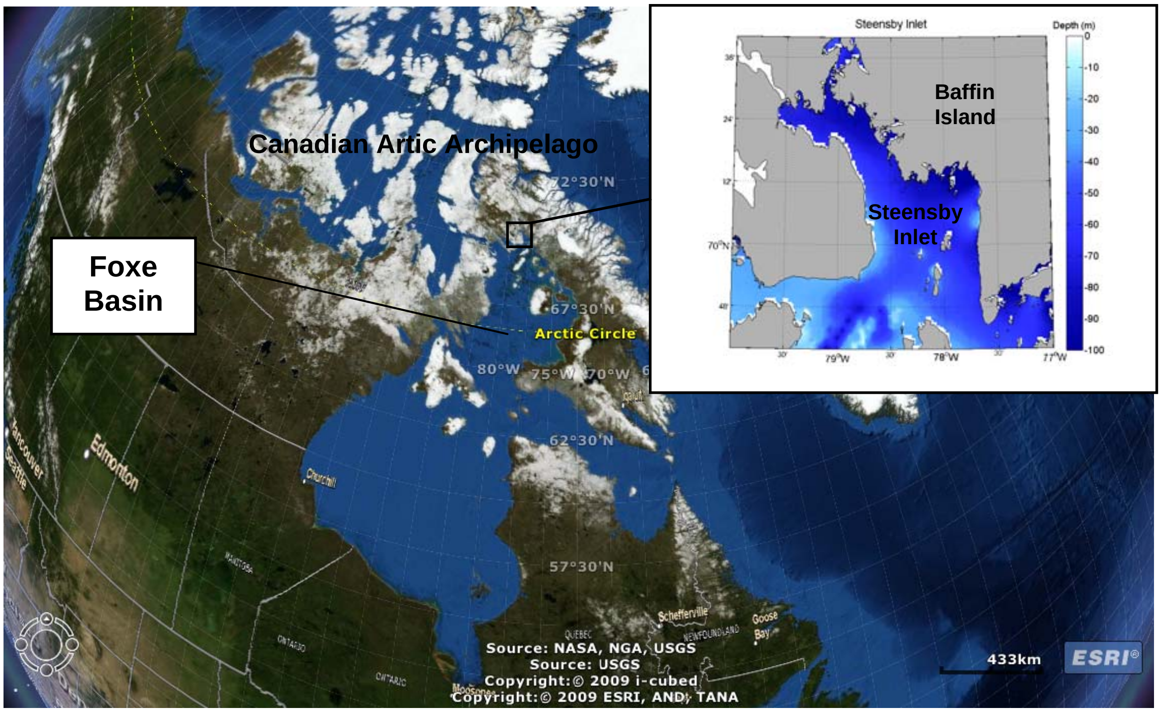


Figure A1 Steensby Inlet Geographic Location

Because of its remoteness as well as severe ice and weather conditions, this area is one of the most unknown regions of the CAA. Recently however, several oceanographic monitoring programs took place as part of on-going environmental and engineering studies for the development of the Baffinland Mary River Iron Mine Project.

As part of these monitoring programs, tide gauges, Acoustic Doppler Current Profilers (ADCPs) and drifters were deployed (CORI, 2008a, b, c and AMEC, 2009). The scope of this document is to present a description of the currents regime in Steensby Inlet based on the ADCP data, with anticipation to their application in fuel spill trajectory modelling.

DATA COLLECTION

In all, seven ADCPs were deployed at different locations in Steensby Inlet in 2008 (A2). Two in May by Coastal & Ocean Resources Inc. (CORI) and five in September during the ice free season by AMEC Earth & Environmental (AMEC 2009).

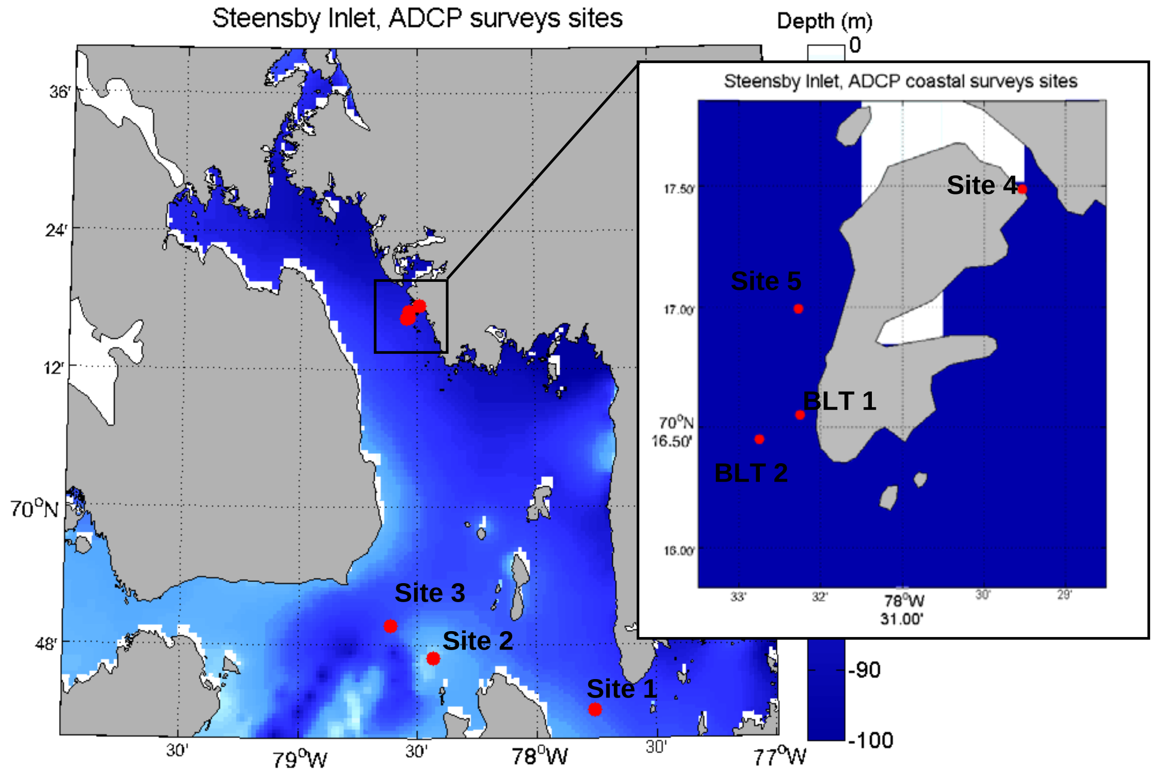


Figure A2 Steensby Inlet 2008 ADCP sites

One instrument was lost at sea during recovery (AMEC, 2009). Dates of deployment and recovery of the instruments as well as data return are summarized in Table A1 and Figure A3.

Table A1 Summary of ADCP deployment and recovery

Site Name	Company	Latitude (GRS80 or WGS84)	Longitude (GRS80 or WGS84)	Site Depth (m)*	First Data	Last Data
Site 1	AMEC E&E	69º42.372' N	077º45.438' W	72.5	06 Sep.2008	11 Oct. 2008
Site 2	AMEC E&E	69º 46.807' N	078º25.896' W	19.5	none	none
Site 3	AMEC E&E	69º 49.672' N	078º 36.725' W	99.5	05 Sep. 2008	13 Oct. 2008
Site 4	AMEC E&E	70º17.488' N	078º29.527' W	12.5	06 Sep. 2008	10 Oct. 2008
Site 5	AMEC E&E	70º16.993' N	078º32.272' W	30	06 Sep. 2008	08 Oct. 2008
BLT 1	CORI	70º 16.55' N**	78º32.25' W**	35**	02 May 2008	07 Jun 2008
BLT 2	CORI	70º 16.45' N**	78º32.75' W**	52**	03 May 2008	07 Oct. 2008

* Estimated from transducer depth and mooring configuration
** From CORI data summary

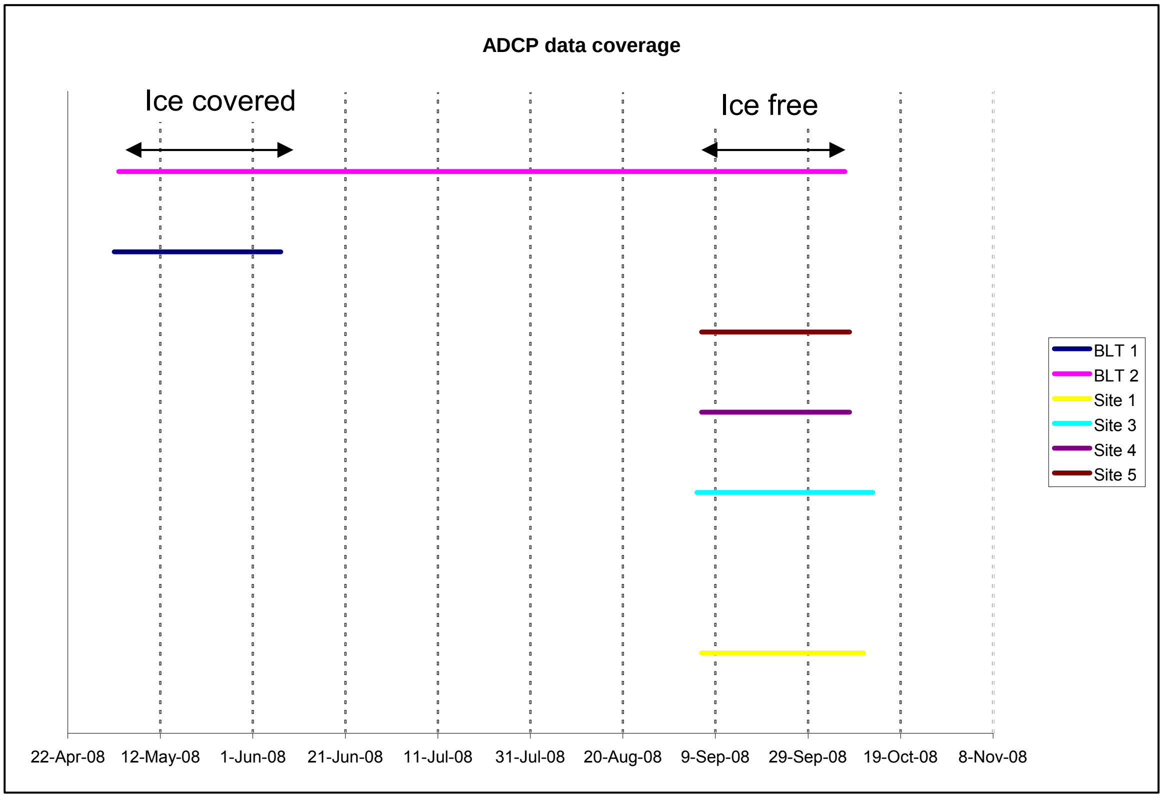


Figure A3 ADCP data coverage

DATA ANALYSIS AND RESULTS

Basic statistical analysis and classic tidal harmonic analysis were performed on all the datasets. Only a brief summary highlighting the main processes is given here: more detailed information and illustration of the analysis site by site is available AMEC data product appendices. Also, because the goal of this study was to provide input data to oil spill modelling, focus was on surface circulation.

The ADCP bin closest to the surface was selected using data-quality control variables such as echo intensity, beam correlation and percent good. Data were selected to cover full days, truncating the first and last uncompleted days of data. Data duration covers, respectively, 34, 34, 32, 32, 36 and 157 days for Site 1, Site 3, Site 4, Site 5, BLT 1 and BLT 2. No truncation was made on BLT 1 and BLT 2 though (data were provided already pre-processed and used 'as-is') but as BLT 1 measurement enclosed both ice covered and ice free condition, two additional analysis were conducted with this dataset in order to separate these two distinct environmental conditions. These periods cover, respectively, about 34 and 30 days for ice covered and ice free conditions (Figure A3). All these records are longer than 29 days and therefore allow standard harmonic tidal analysis to resolve the main semi-diurnal and diurnal constituents.

All the individual surface bin time series data were analysed using Matlab tidal analysis package T_tide (Pawlowicz et al., 2002). Complete results are presented in the Appendices. Table A2 gives a summary of the characteristics of tidal and residual currents for the bin closest to the surface of each ADCP. The fourth column gives the minimum and maximum current speed in each record. Tidal constituents from tidal analysis were used to generate 1 year time series of predicted tidal currents at each site. The minimum and maximum current speed of the East and North components over the 1 year period were extracted and are presented in the fifth column. Figure A4 shows the tidal excursions of the 1 year predicted tides at each site in green. The double headed black arrows indicate the main directions of the tidal motions but their size is not representative of any speed or distance scale. The single headed black arrows indicate the direction of the residual currents but their size is not representative of any speed or distance scale.

Table A2 Summary of ADCP data Tidal Analysis

	Depth (below MSL*) of ADCP bin closest to surface (m)	**Portion of total current variance explained by the tides (%)**	**Currents magnitude in data record (minimum to maximum) (m/s)**	**Magnitude of the East and North components of predicted tidal currents (minimum and maximum over a 1 year period) (m/s)**	**Residual currents magnitude and direction (m/s, ^{o} to N)**
Site 1	8.3	76.3	0.002 to 0.87	-0.31 to 0.22 East -0.37 to 0.58 North	0.17 m/s at 294ºN
Site 3	9.4	84.5	0.002 to 0.92	-0.56 to 0.43 East -0.62 to 0.39 North	0.12 m/s at 197ºN
Site 4	3.05	90.4	0.004 to 0.69	-0.10 to 0.15 East -0.67 to 0.65 North	0.05 m/s at 147ºN
Site 5	4.15	51.4	0 to 0.51	-0.09 to 0.09 East -0.29 to 0.28 North	0.07 m/s at 182ºN
BLT 1(ice covered)	5**	92.0	0 to 0.33	-0.06 to 0.07 East -0.22 to 0.22 North	0.04 m/s at 155ºN
BLT 2	8**				
whole period		71.7	0 to 0.93	-0.18 to 0.10 East -0.36 to 0.52 North	0.05 m/s at 285ºN
ice covered		86.6	0.001 to 0.37	-0.08 to 0.07 East -0.25 to 0.30 North	0.02 m/s at 292ºN
ice free		79.9	0.002 to 0.49	-0.24 to 0.12 East -0.39 to 0.61 North	0.06 m/s at 280ºN

* MSL: Mean Sea Level

** First available bin was used, that is bin 1 for downward looking ADCP-BLT1 and bin 18 for upward looking ADCP-BLT2.

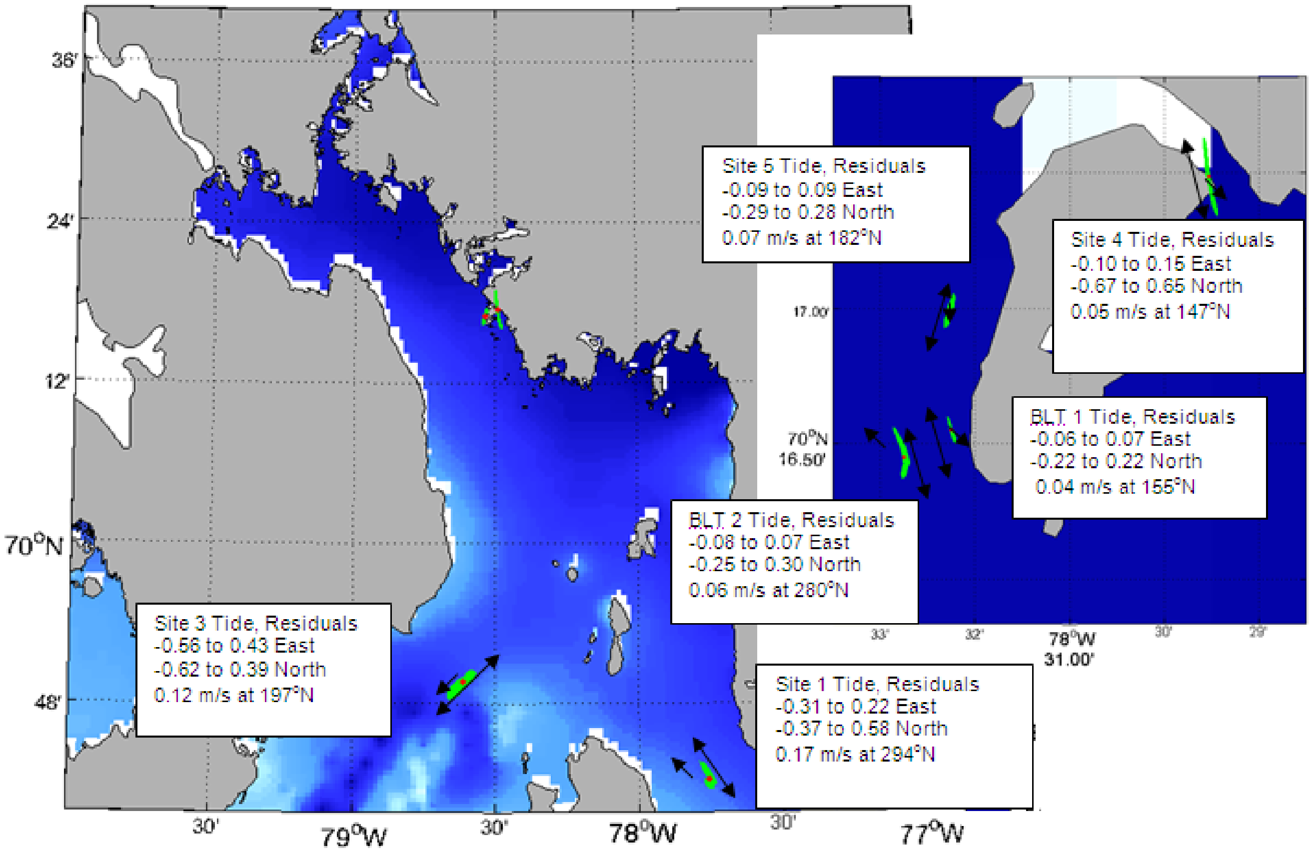


Figure A4 Steensby Inlet, ADCP Survey Sites and Tidal Currents, with Ore Loading Island Inset.

Overall, with a tidal signal accounting for more than 70% at all sites except Site 5, Steensby Inlet can be described as a strongly tide-influenced inlet. Tidal range, discussed in detail in Rabinovich (2008a, b, 2010) is of the order of 4 m to 4.5 m (increasing northward to the inlet head) and is influenced by ice cover. Except at the two sites close to the western shore of the island (BLT1 and Site 5) tidal currents are of the order or in excess of 0.5 m/s. Direction of tidal currents follow the general North-South orientation of the inlet. At Site 4 currents are increased due to the constriction of the narrow channel between shore and the island.

The influence of ice cover on the currents are outside the scope of this study but it shall be noted that it seems to significantly decrease tidal streams by almost a factor of 2 (-0.39 to 0.61 m/s North component during ice-free season vs. -0.25 to 0.30 m/s North component during ice covered season at BLT 2). As noted by Rabinovich (2010), phases of the main constituents are also affected by ice cover (see appendices)

Residual circulation is more noticeable in the south of the domain than in the North with currents magnitudes above 0.10 m/s at Site 1 and 3 and significantly less at Site 4, Site 5, BLT 1 and BLT 2. Inflow at Site 1 and outflow at Site 3 could suggest a counter clockwise circulation in the southern part of the inlet while circulation is somewhat less clear in the Northern part with a mostly southward flow at Site 4, Site 5 and BLT 1 and a northward flow at BLT 2. Whether processes associated with ice melting influence the circulation in this are is not known and is outside the scope of this study.

Finally, the vertical current profiles of all ADCP sites seem to indicate a relatively homogeneous water column, even though Site 1 and 3 do present some differences in current strength below 30-40 m (mostly on the Eastward -u- velocity component) that could either be due to bathymetric constriction and/or changes in water column characteristics (temperature and salinity, i.e. density). Sites 4 and 5 on the other hand seem to be remarkably homogeneous (regular ‘stripes’ of current strength). However, as surface bins of Site 4 and 5 might have been affected by ice floats and lower than usual surface bin had to be used for this analysis. Different (fresher and lighter) surface water could be present in this area (Northern part of the inlet) which might affect near surface currents. CTD profiles would provide valuable insight.

APPENDIX B

OST SPILL MODEL LISTINGS

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 1 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	56	94	I	1.	292.	70.28	78.50	YES	2.25	1.8	18.69	98.1
1981	73	71	I	14.	238.	70.21	78.80	YES	18.75	25.5	32.67	75.9
1982	56	97	I	1.	55.	70.29	78.46	YES	2.75	1.3	11.73	99.5
1983	25	68	I	21.	318.	70.42	78.85	YES	36.00	36.5	24.31	69.6
1984	62	66	I	15.	261.	70.26	78.87	YES	40.50	41.6	24.68	84.7
1985	56	94	I	1.	294.	70.29	78.50	YES	1.00	1.1	25.50	97.2
1986	64	100	I	4.	151.	70.25	78.43	YES	1.50	3.8	60.50	95.8
1987	56	97	I	1.	36.	70.29	78.47	YES	0.75	0.6	19.76	99.4
1988	59	98	I	1.	127.	70.27	78.45	YES	10.75	12.9	28.91	97.9
1989	78	74	I	15.	226.	70.19	78.76	YES	10.25	18.8	43.97	48.8
1990	180	59	O	64.	196.	69.73	78.92	BNDR	98.50	119.3	29.06	71.9
1991	56	97	I	1.	52.	70.29	78.46	YES	0.75	0.7	23.18	99.4
1992	55	96	I	1.	355.	70.29	78.48	YES	0.75	1.2	37.10	99.9
1993	56	94	I	1.	309.	70.29	78.50	YES	1.00	1.1	25.61	99.2
1994	126	110	I	35.	167.	69.97	78.27	YES	18.00	36.8	49.02	4.5
1995	53	94	I	2.	330.	70.30	78.51	YES	3.00	2.2	17.93	98.7
1996	62	100	I	3.	142.	70.26	78.43	YES	2.75	4.5	39.20	95.8
1997	57	92	I	2.	277.	70.28	78.53	YES	4.50	7.1	38.02	76.1
1998	57	93	I	1.	275.	70.28	78.51	YES	2.25	1.7	18.51	98.9
1999	58	98	I	1.	113.	70.28	78.45	YES	0.50	1.2	55.74	98.6
2000	79	74	I	15.	225.	70.19	78.76	YES	29.25	29.0	23.81	89.9
2001	53	95	I	2.	339.	70.30	78.50	YES	1.50	2.1	34.15	99.7
2002	56	94	I	1.	291.	70.28	78.50	YES	1.50	1.1	18.21	98.8
2003	55	96	I	1.	358.	70.29	78.48	YES	1.50	0.9	13.79	99.0
2004	63	95	I	3.	189.	70.26	78.49	YES	5.00	3.4	16.09	99.3
2005	60	99	I	2.	136.	70.27	78.44	YES	7.75	10.4	32.31	76.4
2006	55	96	I	1.	4.	70.29	78.47	YES	1.00	1.0	23.28	99.8
2007	66	100	I	5.	155.	70.24	78.42	YES	2.25	4.7	50.53	98.9
2008	76	74	I	14.	230.	70.20	78.76	YES	15.00	20.4	32.63	90.0
2009	55	96	I	1.	354.	70.29	78.48	YES	1.00	1.0	23.51	99.2

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 2 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	53	94	I	2.	332.	70.30	78.51	YES	2.25	2.4	26.04	99.6
1981	89	133	O	25.	130.	70.14	77.97	NO	18.75	32.0	40.92	4.9
1982	55	96	I	1.	9.	70.29	78.47	YES	2.25	1.3	13.48	99.7
1983	55	96	I	1.	12.	70.29	78.47	YES	9.75	11.3	27.89	90.5
1984	59	98	I	1.	135.	70.27	78.45	YES	1.50	1.3	21.41	99.6
1985	53	94	I	2.	330.	70.30	78.50	YES	1.75	2.1	28.82	95.1
1986	64	100	I	4.	151.	70.25	78.43	YES	1.75	3.9	53.24	99.5
1987	55	97	I	1.	15.	70.29	78.47	YES	1.00	1.1	26.28	97.2
1988	63	100	I	4.	147.	70.25	78.42	YES	2.00	3.7	44.91	99.5
1989	26	68	I	21.	317.	70.42	78.85	YES	53.75	51.1	22.81	49.4
1990	66	100	I	5.	158.	70.24	78.43	YES	2.25	5.0	53.42	99.6
1991	55	96	I	1.	11.	70.29	78.47	YES	0.75	1.0	30.89	99.9

1992	55	96	I	1.	343.	70.29	78.48	YES	0.50	0.9	42.74	99.9
1993	57	93	I	1.	266.	70.28	78.52	YES	1.00	1.5	35.46	94.7
1994	140	117	O	43.	164.	69.91	78.17	NO	84.25	105.7	30.12	4.3
1995	56	97	I	0.	44.	70.28	78.47	YES	1.25	0.5	9.23	99.8
1996	59	98	I	1.	127.	70.27	78.45	YES	5.50	3.4	14.79	99.3
1997	76	74	I	14.	229.	70.20	78.76	YES	46.50	50.9	26.28	17.5
1998	56	94	I	1.	290.	70.28	78.50	YES	2.00	1.1	13.75	99.6
1999	59	98	I	1.	143.	70.27	78.46	YES	0.75	1.3	41.43	97.9
2000	57	93	I	1.	276.	70.28	78.51	YES	7.00	5.3	18.15	98.7
2001	55	96	I	1.	1.	70.29	78.48	YES	0.50	0.9	41.20	99.9
2002	56	94	I	1.	296.	70.29	78.50	YES	1.50	1.0	15.44	99.6
2003	56	97	I	1.	47.	70.28	78.47	YES	0.75	0.5	17.00	97.9
2004	59	98	I	1.	129.	70.27	78.45	YES	5.50	3.3	14.24	99.2
2005	66	100	I	5.	157.	70.24	78.43	YES	2.25	4.9	52.38	98.3
2006	55	94	I	1.	309.	70.29	78.50	YES	0.75	1.3	42.86	96.0
2007	84	75	I	17.	217.	70.16	78.74	YES	19.25	25.3	31.55	96.6
2008	63	95	I	3.	188.	70.26	78.49	YES	1.25	3.0	56.76	96.5
2009	57	93	I	1.	283.	70.28	78.51	YES	0.75	1.3	42.58	96.0

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 3 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	53	95	I	2.	343.	70.30	78.49	YES	2.25	2.0	21.81	99.6
1981	56	93	I	1.	286.	70.29	78.51	YES	6.50	6.5	23.90	80.0
1982	55	96	I	1.	3.	70.29	78.48	YES	1.50	1.1	17.74	99.7
1983	55	97	I	1.	15.	70.29	78.47	YES	9.25	9.6	25.02	94.2
1984	73	104	I	9.	153.	70.21	78.37	YES	6.75	10.3	36.53	98.9
1985	55	94	I	1.	319.	70.29	78.50	YES	1.75	1.3	17.18	99.7
1986	59	98	I	2.	136.	70.27	78.45	YES	0.75	1.5	48.34	97.9
1987	56	97	I	1.	24.	70.29	78.47	YES	0.75	0.7	21.22	99.9
1988	58	98	I	1.	126.	70.28	78.45	YES	0.75	1.1	33.79	96.0
1989	64	100	I	4.	153.	70.25	78.43	YES	3.00	4.2	33.26	99.6
1990	66	100	I	5.	156.	70.24	78.42	YES	7.25	8.3	27.47	99.0
1991	55	96	I	1.	348.	70.29	78.48	YES	0.50	0.9	41.89	99.9
1992	55	94	I	1.	320.	70.29	78.50	YES	1.00	1.4	33.12	99.2
1993	57	93	I	1.	273.	70.28	78.52	YES	1.25	1.5	28.72	93.4
1994	67	101	I	5.	153.	70.24	78.41	YES	4.25	5.8	32.69	99.2
1995	56	97	I	1.	37.	70.29	78.46	YES	4.50	1.5	8.23	99.4
1996	59	98	I	1.	133.	70.28	78.46	YES	0.75	1.0	33.57	97.9
1997	55	96	I	1.	1.	70.29	78.48	YES	1.00	0.9	22.11	99.2
1998	55	96	I	1.	349.	70.29	78.48	YES	1.25	0.8	15.87	99.8
1999	63	100	I	3.	144.	70.26	78.42	YES	1.50	3.4	55.15	95.8
2000	75	114	I	13.	134.	70.20	78.23	YES	87.25	70.6	19.41	73.0
2001	55	96	I	1.	359.	70.29	78.48	YES	0.50	0.8	39.56	99.9
2002	55	94	I	1.	315.	70.29	78.50	YES	1.75	1.2	16.74	99.7
2003	56	97	I	1.	28.	70.29	78.47	YES	0.50	0.6	28.74	99.6
2004	57	98	I	1.	94.	70.28	78.46	YES	1.75	1.3	17.39	99.7
2005	66	100	I	5.	156.	70.24	78.42	YES	12.25	15.3	29.94	97.5
2006	55	94	I	1.	317.	70.29	78.50	YES	0.75	1.2	37.85	96.0
2007	63	66	I	15.	258.	70.25	78.87	YES	72.50	64.5	21.34	87.8
2008	106	79	I	25.	198.	70.06	78.68	YES	49.00	50.9	24.94	86.4
2009	56	94	I	1.	290.	70.29	78.51	YES	2.25	1.7	18.29	99.4

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 4 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	53	95	I	2.	344.	70.30	78.49	YES	1.25	1.9	37.19	99.8
1981	52	62	I	17.	279.	70.31	78.93	YES	9.25	19.4	50.31	50.9
1982	55	96	I	1.	15.	70.29	78.47	YES	0.75	0.8	26.94	99.4
1983	46	58	I	20.	286.	70.33	78.98	YES	25.00	29.9	28.67	89.8
1984	62	100	I	3.	142.	70.26	78.43	YES	1.50	3.0	47.90	98.8
1985	56	94	I	1.	303.	70.29	78.50	YES	0.75	1.1	35.23	96.0
1986	66	101	I	5.	151.	70.24	78.41	YES	2.00	4.9	58.48	94.4
1987	55	96	I	1.	348.	70.29	78.48	YES	0.75	0.9	29.94	99.9
1988	66	100	I	5.	152.	70.24	78.42	YES	2.50	5.0	47.68	99.4
1989	59	98	I	1.	131.	70.28	78.46	YES	1.25	1.1	20.72	96.5
1990	55	94	I	1.	325.	70.29	78.50	YES	9.25	8.7	22.58	98.7
1991	56	94	I	1.	309.	70.29	78.50	YES	0.75	1.1	35.40	96.0
1992	58	93	I	2.	258.	70.28	78.52	YES	1.00	1.6	39.33	94.7
1993	57	93	I	1.	278.	70.28	78.51	YES	1.25	1.4	27.64	96.5
1994	61	100	I	3.	139.	70.26	78.43	YES	4.75	5.0	25.24	99.3
1995	55	96	I	1.	360.	70.29	78.48	YES	0.75	1.0	32.81	97.9
1996	58	93	I	1.	260.	70.28	78.51	YES	3.25	1.6	12.04	99.3
1997	58	98	I	1.	124.	70.28	78.46	YES	1.25	0.9	18.00	96.5
1998	55	96	I	1.	345.	70.29	78.48	YES	2.75	0.9	7.78	99.7
1999	72	103	I	8.	154.	70.21	78.38	YES	7.25	9.4	31.01	99.0
2000	57	98	I	1.	85.	70.28	78.46	YES	2.00	1.1	12.62	99.6
2001	56	97	I	1.	26.	70.29	78.47	YES	0.50	0.6	28.41	98.6
2002	56	97	I	1.	45.	70.29	78.47	YES	0.75	0.5	17.53	99.8
2003	55	96	I	1.	360.	70.29	78.48	YES	1.00	0.9	21.95	99.7
2004	56	97	I	1.	46.	70.29	78.47	YES	0.75	0.5	17.48	99.4
2005	55	64	I	16.	274.	70.29	78.90	YES	22.50	23.5	25.09	95.5
2006	56	93	I	1.	292.	70.29	78.51	YES	2.50	2.0	18.75	99.1
2007	64	100	I	4.	151.	70.25	78.43	YES	1.75	3.9	53.07	99.5
2008	74	120	I	15.	124.	70.21	78.15	YES	127.50	108.2	20.36	69.2
2009	56	97	I	1.	31.	70.29	78.47	YES	1.75	0.8	11.08	99.5

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 5 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	55	96	I	1.	350.	70.29	78.48	YES	0.75	1.0	31.90	99.9
1981	57	92	I	2.	276.	70.28	78.52	YES	23.25	25.3	26.13	67.3
1982	55	96	I	1.	353.	70.29	78.48	YES	1.25	1.1	20.40	99.9
1983	50	61	I	18.	282.	70.32	78.93	YES	37.50	32.2	20.61	94.5
1984	63	100	I	3.	146.	70.26	78.43	YES	1.50	3.2	51.96	98.8
1985	56	94	I	1.	313.	70.29	78.50	YES	0.75	1.0	33.50	97.9
1986	69	102	I	6.	153.	70.23	78.40	YES	4.00	6.5	39.20	94.7
1987	56	97	I	1.	22.	70.29	78.47	YES	1.75	0.7	9.83	98.6
1988	66	100	I	5.	157.	70.24	78.43	YES	1.75	5.0	68.34	90.7
1989	62	100	I	3.	143.	70.26	78.43	YES	2.00	3.1	37.07	98.3
1990	63	95	I	3.	189.	70.25	78.49	YES	1.50	3.1	49.47	95.8
1991	56	94	I	1.	295.	70.29	78.50	YES	0.50	0.9	43.20	97.3
1992	58	93	I	1.	256.	70.28	78.51	YES	0.75	1.4	44.44	96.0
1993	58	93	I	1.	255.	70.28	78.51	YES	2.25	1.4	15.00	95.7
1994	59	98	I	1.	131.	70.28	78.45	YES	2.00	1.2	14.82	98.3
1995	56	94	I	1.	294.	70.29	78.50	YES	1.50	0.9	14.94	99.7
1996	56	94	I	1.	292.	70.28	78.50	YES	2.50	1.2	11.87	99.5

1997	57	98	I	1.	73.	70.28	78.45	YES	2.25	1.0	10.72	99.5
1998	57	93	I	1.	267.	70.28	78.51	YES	1.50	1.4	21.93	95.8
1999	66	100	I	5.	156.	70.24	78.43	YES	2.25	4.8	50.90	99.4
2000	57	98	I	1.	75.	70.28	78.46	YES	1.25	0.9	16.48	99.0
2001	55	96	I	1.	7.	70.29	78.47	YES	0.75	1.1	35.91	99.9
2002	56	97	I	1.	23.	70.29	78.47	YES	0.75	0.7	22.83	99.9
2003	53	95	I	2.	339.	70.30	78.50	YES	1.75	2.0	27.13	99.5
2004	56	97	I	1.	26.	70.29	78.47	YES	1.00	0.6	14.45	99.9
2005	56	97	I	1.	51.	70.28	78.47	YES	2.25	1.2	12.69	99.6
2006	59	98	I	1.	131.	70.28	78.45	YES	4.25	2.0	11.05	88.1
2007	53	94	I	2.	335.	70.30	78.50	YES	9.75	9.2	22.66	98.3
2008	63	95	I	3.	190.	70.26	78.49	YES	7.50	6.2	19.68	97.9
2009	57	98	I	1.	70.	70.28	78.46	YES	1.50	1.0	15.73	95.8

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 6 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	RANGE	END POSITION BEARING	LAT	LONG	ASHORE?	ELAPSED TIME	PATH LENGTH	MEAN SPEED	% AT ENDPT
				KM	DEG. T	NORTH	WEST		HOURS	KM	KM/DAY	
1980	55	96	I	1.	2.	70.29	78.48	YES	1.00	1.0	24.82	99.9
1981	59	98	I	1.	129.	70.27	78.45	YES	0.75	1.2	38.12	97.9
1982	56	97	I	1.	23.	70.29	78.47	YES	0.75	0.6	20.36	99.9
1983	58	93	I	1.	249.	70.28	78.51	YES	7.75	6.8	21.19	98.9
1984	63	100	I	3.	145.	70.26	78.42	YES	1.75	3.4	46.29	98.6
1985	53	94	I	2.	336.	70.30	78.50	YES	1.75	2.1	29.00	99.5
1986	66	100	I	5.	156.	70.24	78.43	YES	3.25	4.6	34.27	98.0
1987	55	96	I	1.	348.	70.29	78.48	YES	0.75	1.1	36.71	99.9
1988	90	75	I	19.	211.	70.13	78.74	YES	17.25	22.4	31.18	41.7
1989	60	99	I	2.	138.	70.27	78.44	YES	3.00	2.6	20.59	99.5
1990	18	56	I	28.	313.	70.45	79.01	YES	52.25	42.3	19.45	74.0
1991	56	94	I	1.	292.	70.29	78.51	YES	0.75	1.2	37.23	96.0
1992	78	74	I	15.	226.	70.19	78.76	YES	11.25	15.7	33.51	58.5
1993	57	93	I	1.	271.	70.28	78.51	YES	1.25	1.4	26.78	93.4
1994	64	100	I	4.	150.	70.25	78.43	YES	3.25	3.8	28.02	91.4
1995	57	98	I	1.	71.	70.28	78.45	YES	1.75	1.0	13.44	99.0
1996	57	98	I	1.	70.	70.28	78.46	YES	1.00	0.8	20.30	99.2
1997	57	98	I	1.	71.	70.28	78.46	YES	2.25	1.1	12.15	98.9
1998	56	94	I	1.	287.	70.29	78.51	YES	1.00	1.3	30.59	94.7
1999	66	100	I	5.	155.	70.24	78.42	YES	5.50	6.3	27.63	99.2
2000	56	97	I	0.	38.	70.28	78.47	YES	0.50	0.4	19.24	99.9
2001	56	97	I	1.	24.	70.29	78.47	YES	0.50	0.7	35.51	98.6
2002	57	98	I	1.	95.	70.28	78.45	YES	2.50	0.9	8.68	97.9
2003	31	73	O	18.	318.	70.40	78.79	NO	114.00	79.7	16.78	4.1
2004	55	96	I	1.	354.	70.29	78.48	YES	1.00	0.9	22.33	99.8
2005	55	96	I	1.	353.	70.29	78.48	YES	2.50	1.1	10.53	99.7
2006	56	94	I	1.	302.	70.29	78.50	YES	2.25	1.0	10.50	99.4
2007	63	95	I	3.	184.	70.26	78.48	YES	2.25	2.7	28.80	99.6
2008	62	100	I	3.	141.	70.26	78.43	YES	4.50	3.4	18.08	99.0
2009	56	97	I	1.	44.	70.29	78.46	YES	0.50	0.8	38.95	97.3

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 7 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	RANGE	END POSITION BEARING	LAT	LONG	ASHORE?	ELAPSED TIME	PATH LENGTH	MEAN SPEED	% AT ENDPT
				KM	DEG. T	NORTH	WEST		HOURS	KM	KM/DAY	

1980	63	95	I	3.	184.	70.25	78.48	YES	10.50	8.2	18.74	98.4
1981	57	93	I	1.	267.	70.28	78.51	YES	2.75	1.5	12.87	99.3
1982	56	97	I	1.	26.	70.29	78.47	YES	0.75	0.6	19.09	99.9
1983	56	94	I	1.	294.	70.29	78.51	YES	8.75	6.5	17.77	98.9
1984	60	99	I	2.	135.	70.27	78.43	YES	9.25	7.7	19.96	98.8
1985	55	94	I	1.	324.	70.29	78.50	YES	1.25	1.4	26.52	99.5
1986	70	70	I	14.	245.	70.23	78.82	YES	11.50	15.7	32.70	51.5
1987	55	97	I	1.	17.	70.29	78.47	YES	0.50	0.9	41.74	98.6
1988	75	73	I	14.	232.	70.20	78.78	YES	17.50	17.5	23.94	82.8
1989	56	97	I	1.	63.	70.28	78.46	YES	3.75	2.5	15.69	99.5
1990	53	95	I	2.	345.	70.30	78.49	YES	6.50	4.8	17.75	99.1
1991	56	97	I	0.	36.	70.28	78.47	YES	2.00	0.8	10.11	99.7
1992	63	100	I	4.	149.	70.25	78.43	YES	24.00	19.8	19.76	93.9
1993	53	94	I	2.	330.	70.30	78.50	YES	2.75	2.1	18.40	99.6
1994	58	93	I	1.	243.	70.28	78.51	YES	1.50	1.5	23.68	95.8
1995	57	98	I	1.	98.	70.28	78.45	YES	1.75	1.2	15.80	95.1
1996	57	98	I	1.	88.	70.28	78.45	YES	1.25	0.8	15.50	97.0
1997	55	96	I	1.	3.	70.29	78.48	YES	2.00	0.9	10.33	99.7
1998	56	94	I	1.	294.	70.28	78.50	YES	2.75	0.9	8.05	98.7
1999	51	62	I	17.	280.	70.31	78.93	YES	13.25	18.9	34.15	37.9
2000	55	96	I	1.	14.	70.29	78.47	YES	1.00	0.8	20.27	99.8
2001	56	94	I	1.	303.	70.29	78.50	YES	6.50	2.5	9.30	95.8
2002	58	98	I	1.	112.	70.28	78.46	YES	3.25	1.0	7.24	97.3
2003	60	99	I	2.	138.	70.27	78.44	YES	9.50	5.2	13.14	98.7
2004	55	94	I	2.	321.	70.29	78.50	YES	1.00	1.6	37.83	94.7
2005	55	97	I	1.	18.	70.29	78.47	YES	3.25	1.0	7.73	99.6
2006	63	95	I	3.	192.	70.25	78.49	YES	53.00	32.7	14.80	81.2
2007	55	94	I	1.	319.	70.29	78.50	YES	8.75	5.6	15.29	98.9
2008	58	98	I	1.	107.	70.28	78.46	YES	1.25	0.8	15.96	99.8
2009	58	98	I	1.	118.	70.28	78.45	YES	0.75	0.9	30.05	96.0

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 8 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

				END POSITION				ASHORE?	ELAPSED	PATH	MEAN	% AT
YEAR	ROW	COL	ORI	RANGE	BEARING	LAT	LONG		TIME	LENGTH	SPEED	ENDPT
				KM	DEG. T	NORTH	WEST		HOURS	KM	KM/DAY	
1980	56	97	I	1.	22.	70.29	78.47	YES	1.50	0.9	13.81	99.8
1981	55	94	I	1.	323.	70.29	78.50	YES	4.00	1.7	10.48	99.4
1982	55	96	I	1.	355.	70.29	78.48	YES	0.75	0.9	29.01	99.9
1983	59	92	I	2.	243.	70.27	78.53	YES	5.75	4.0	16.73	99.0
1984	65	101	I	5.	150.	70.25	78.41	YES	5.00	4.7	22.79	99.1
1985	56	94	I	1.	307.	70.29	78.50	YES	1.25	1.1	20.23	99.5
1986	74	72	I	14.	235.	70.21	78.79	YES	8.50	15.0	42.41	54.9
1987	59	98	I	1.	132.	70.28	78.46	YES	1.75	1.1	15.72	95.1
1988	56	64	I	16.	272.	70.29	78.90	YES	44.25	24.0	13.00	92.7
1989	56	94	I	1.	286.	70.28	78.51	YES	5.50	2.4	10.40	99.3
1990	53	95	I	2.	343.	70.30	78.49	YES	3.50	2.2	15.21	92.2
1991	53	94	I	2.	333.	70.30	78.50	YES	12.25	4.6	9.05	98.1
1992	59	98	I	1.	136.	70.27	78.45	YES	1.50	1.3	20.57	99.7
1993	56	94	I	1.	312.	70.29	78.50	YES	1.50	1.1	17.28	99.6
1994	58	93	I	1.	251.	70.28	78.51	YES	1.25	1.5	28.30	94.0
1995	57	93	I	1.	271.	70.28	78.51	YES	2.25	1.3	13.94	93.7
1996	55	94	I	2.	327.	70.29	78.50	YES	2.00	1.5	18.52	99.6
1997	57	98	I	1.	70.	70.28	78.45	YES	2.00	0.9	10.58	98.9
1998	56	97	I	0.	36.	70.28	78.47	YES	0.50	0.4	20.10	99.9
1999	58	93	I	1.	253.	70.28	78.51	YES	2.00	1.5	17.41	94.4
2000	55	96	I	1.	14.	70.29	78.47	YES	1.00	0.9	22.13	99.8
2001	58	93	I	2.	245.	70.28	78.51	YES	2.25	1.6	17.14	98.1

2002	57	98	I	1.	101.	70.28	78.46	YES	0.75	0.8	24.63	96.0
2003	59	98	I	1.	138.	70.27	78.45	YES	1.50	1.3	20.49	99.0
2004	57	93	I	1.	281.	70.28	78.51	YES	1.25	1.4	26.10	96.5
2005	57	98	I	1.	72.	70.28	78.46	YES	1.50	0.8	13.56	99.6
2006	55	94	I	2.	317.	70.29	78.51	YES	4.50	2.3	12.51	99.4
2007	61	100	I	3.	137.	70.26	78.43	YES	3.50	2.8	19.45	98.6
2008	56	97	I	1.	60.	70.28	78.46	YES	1.25	0.8	14.70	99.8
2009	59	98	I	1.	132.	70.28	78.46	YES	2.75	1.1	9.63	97.7

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 9 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	55	96	I	1.	10.	70.29	78.47	YES	0.50	0.9	44.26	97.3
1981	58	93	I	2.	254.	70.28	78.52	YES	0.75	1.5	49.34	96.0
1982	55	94	I	1.	315.	70.29	78.50	YES	1.00	1.2	29.76	97.2
1983	59	92	I	2.	239.	70.27	78.53	YES	6.75	3.8	13.67	99.0
1984	56	97	I	1.	48.	70.28	78.47	YES	11.00	8.1	17.75	97.4
1985	55	94	I	1.	315.	70.29	78.50	YES	2.25	1.2	13.02	99.6
1986	72	71	I	14.	239.	70.22	78.80	YES	11.25	14.9	31.88	46.5
1987	56	97	I	1.	32.	70.29	78.47	YES	1.75	0.6	8.36	99.8
1988	56	94	I	1.	301.	70.29	78.50	YES	6.00	1.7	6.82	99.2
1989	57	98	I	1.	78.	70.28	78.46	YES	7.50	2.1	6.84	99.0
1990	57	93	I	1.	273.	70.28	78.51	YES	1.75	1.3	17.90	95.1
1991	58	98	I	1.	119.	70.28	78.46	YES	3.00	1.0	7.79	99.6
1992	55	96	I	1.	345.	70.29	78.48	YES	7.75	1.9	5.96	98.6
1993	55	94	I	1.	317.	70.29	78.50	YES	1.25	1.3	24.06	99.7
1994	59	98	I	1.	133.	70.27	78.45	YES	3.75	1.5	9.48	99.5
1995	57	93	I	1.	265.	70.28	78.51	YES	1.75	1.4	18.69	95.1
1996	56	94	I	1.	297.	70.29	78.50	YES	2.25	1.2	12.67	99.6
1997	56	97	I	0.	46.	70.28	78.47	YES	1.00	0.5	10.98	99.8
1998	55	96	I	1.	9.	70.29	78.47	YES	1.00	1.0	25.20	99.8
1999	59	98	I	1.	137.	70.27	78.45	YES	1.25	1.3	25.90	99.7
2000	57	98	I	1.	76.	70.28	78.45	YES	1.25	0.9	17.62	99.7
2001	59	92	I	2.	238.	70.27	78.53	YES	2.50	2.2	21.45	95.0
2002	59	98	I	1.	138.	70.27	78.46	YES	1.75	1.2	15.96	95.1
2003	72	103	I	8.	155.	70.21	78.38	YES	20.00	10.9	13.06	96.6
2004	57	93	I	1.	266.	70.28	78.52	YES	1.25	1.5	28.49	93.4
2005	56	97	I	1.	27.	70.29	78.47	YES	0.75	0.7	23.44	99.8
2006	56	97	I	1.	45.	70.29	78.47	YES	0.50	0.6	27.02	99.6
2007	55	96	I	1.	357.	70.29	78.48	YES	0.75	0.9	28.18	96.0
2008	55	97	I	1.	13.	70.29	78.47	YES	1.75	1.0	14.03	99.8
2009	56	97	I	0.	35.	70.29	78.47	YES	0.50	0.5	21.68	99.9

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 10 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	57	98	I	1.	94.	70.28	78.46	YES	1.75	0.8	11.25	99.7
1981	57	93	I	2.	278.	70.28	78.52	YES	1.00	1.6	39.26	94.7
1982	57	93	I	1.	279.	70.28	78.51	YES	1.25	1.4	27.16	94.0
1983	56	97	I	1.	26.	70.29	78.47	YES	32.50	12.7	9.36	95.8

1984	71	102	I	8.	157.	70.22	78.40	YES	8.50	8.1	22.81	94.7
1985	58	93	I	2.	247.	70.28	78.52	YES	8.75	2.4	6.58	98.6
1986	55	94	I	1.	315.	70.29	78.50	YES	2.75	1.2	10.45	97.7
1987	56	97	I	0.	29.	70.29	78.47	YES	0.50	0.5	23.82	99.6
1988	59	98	I	1.	132.	70.27	78.45	YES	2.75	1.7	14.49	99.5
1989	63	100	I	3.	147.	70.26	78.43	YES	2.75	3.4	29.47	92.3
1990	58	98	I	1.	125.	70.28	78.45	YES	1.75	1.1	14.49	99.7
1991	55	96	I	1.	6.	70.29	78.47	YES	2.00	0.8	10.15	99.7
1992	70	70	I	14.	244.	70.23	78.82	YES	20.50	16.1	18.90	91.5
1993	53	95	I	2.	341.	70.30	78.49	YES	2.50	2.0	19.14	99.7
1994	60	99	I	2.	132.	70.27	78.44	YES	2.25	2.1	22.80	98.3
1995	81	75	I	16.	221.	70.18	78.75	YES	14.25	15.9	26.77	47.0
1996	58	98	I	1.	118.	70.28	78.45	YES	1.00	1.0	24.39	97.2
1997	55	96	I	1.	354.	70.29	78.48	YES	1.50	0.9	14.89	99.8
1998	53	95	I	2.	341.	70.30	78.50	YES	1.50	2.3	36.56	95.8
1999	57	98	I	1.	100.	70.28	78.45	YES	1.50	0.9	13.62	99.6
2000	58	98	I	1.	109.	70.28	78.46	YES	1.25	0.8	15.92	99.7
2001	64	100	I	4.	149.	70.25	78.43	YES	9.00	4.3	11.52	97.6
2002	83	75	I	16.	218.	70.17	78.75	YES	25.00	17.6	16.90	78.7
2003	55	96	I	1.	352.	70.29	78.48	YES	1.00	1.0	23.92	99.2
2004	57	98	I	1.	92.	70.28	78.46	YES	4.75	1.2	5.93	99.3
2005	58	98	I	1.	106.	70.28	78.46	YES	5.50	1.5	6.72	98.9
2006	57	98	I	1.	94.	70.28	78.46	YES	1.50	0.8	13.42	95.8
2007	55	96	I	1.	349.	70.29	78.48	YES	2.75	0.9	7.65	99.6
2008	53	94	I	2.	335.	70.30	78.50	YES	2.75	2.0	17.74	99.4
2009	55	94	I	1.	320.	70.29	78.50	YES	2.25	1.5	15.91	99.6

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 11 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

				END POSITION				ASHORE?	ELAPSED	PATH	MEAN	% AT
YEAR	ROW	COL	ORI	RANGE	BEARING	LAT	LONG		TIME	LENGTH	SPEED	ENDPT
				KM	DEG. T	NORTH	WEST		HOURS	KM	KM/DAY	
1980	56	97	I	1.	44.	70.28	78.47	YES	9.75	3.0	7.46	98.8
1981	53	95	I	2.	344.	70.30	78.49	YES	3.00	1.9	14.96	95.5
1982	58	93	I	2.	245.	70.28	78.51	YES	2.00	1.5	18.50	94.4
1983	59	98	I	1.	142.	70.27	78.46	YES	8.25	3.9	11.27	98.9
1984	59	98	I	1.	142.	70.27	78.46	YES	1.00	1.3	30.58	99.2
1985	56	97	I	0.	49.	70.28	78.47	YES	1.00	0.5	12.00	99.8
1986	62	66	I	15.	262.	70.26	78.87	YES	26.50	20.2	18.27	90.0
1987	56	97	I	1.	25.	70.29	78.47	YES	1.00	0.7	15.73	99.9
1988	63	100	I	3.	146.	70.26	78.43	YES	10.25	4.9	11.57	98.2
1989	57	98	I	1.	99.	70.28	78.45	YES	0.75	1.1	35.78	96.0
1990	58	98	I	1.	129.	70.28	78.46	YES	1.75	1.1	14.47	99.7
1991	56	94	I	1.	303.	70.29	78.50	YES	1.25	1.0	19.46	99.1
1992	58	93	I	1.	252.	70.28	78.51	YES	2.25	1.7	18.03	98.1
1993	55	94	I	1.	322.	70.29	78.50	YES	1.75	1.4	19.72	99.7
1994	56	97	I	1.	34.	70.29	78.47	YES	4.25	1.3	7.56	99.4
1995	57	93	I	2.	270.	70.28	78.52	YES	1.25	1.5	29.49	93.4
1996	56	97	I	1.	66.	70.28	78.46	YES	3.25	1.3	9.29	99.6
1997	57	93	I	1.	268.	70.28	78.51	YES	1.75	1.3	18.33	95.1
1998	55	94	I	1.	317.	70.29	78.50	YES	1.00	1.2	28.95	97.2
1999	58	98	I	1.	117.	70.28	78.45	YES	1.25	1.0	19.88	99.7
2000	57	93	I	1.	270.	70.28	78.52	YES	1.75	1.5	20.58	97.1
2001	57	98	I	1.	98.	70.28	78.46	YES	1.75	0.8	11.10	99.0
2002	59	92	I	2.	240.	70.27	78.52	YES	3.00	2.1	16.65	91.6
2003	55	97	I	1.	17.	70.29	78.47	YES	0.75	0.9	29.77	99.4
2004	59	98	I	1.	135.	70.27	78.46	YES	0.75	1.1	35.31	96.0
2005	56	97	I	1.	24.	70.29	78.47	YES	0.75	0.6	19.25	97.9
2006	56	94	I	1.	308.	70.29	78.50	YES	4.25	1.1	6.05	99.2

2007	56	94	I	1.	287.	70.28	78.51	YES	7.50	2.1	6.81	99.0
2008	58	93	I	1.	259.	70.28	78.51	YES	1.00	1.5	35.01	94.7
2009	57	98	I	1.	97.	70.28	78.45	YES	0.75	1.0	31.28	96.0

Baffinland   Steensby Port   SPILL BEGINS AT 0000 HRS, 12 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	91	76	I	19.	210.	70.13	78.73	YES	20.50	22.1	25.89	64.3
1981	63	100	I	4.	148.	70.25	78.43	YES	3.50	3.6	24.80	99.4
1982	64	66	I	15.	257.	70.25	78.88	YES	18.25	19.5	25.64	69.8
1983	63	95	I	3.	192.	70.26	78.49	YES	10.50	9.1	20.70	98.0
1984	59	98	I	1.	138.	70.27	78.45	YES	1.00	1.5	35.13	99.2
1985	56	97	I	1.	29.	70.29	78.47	YES	0.50	0.9	41.78	97.3
1986	55	93	I	2.	305.	70.29	78.52	YES	47.75	35.1	17.63	87.1
1987	55	97	I	1.	19.	70.29	78.47	YES	0.50	0.9	42.20	97.3
1988	63	100	I	4.	149.	70.25	78.43	YES	3.50	3.6	24.81	99.4
1989	62	100	I	3.	142.	70.26	78.43	YES	2.50	3.2	30.55	96.9
1990	80	75	I	15.	222.	70.18	78.75	YES	21.25	19.7	22.22	76.8
1991	55	96	I	1.	351.	70.29	78.48	YES	1.00	0.9	21.08	99.9
1992	63	95	I	3.	193.	70.26	78.49	YES	3.75	3.6	23.11	99.5
1993	56	94	I	1.	290.	70.29	78.50	YES	1.00	1.1	26.90	97.2
1994	56	94	I	1.	303.	70.29	78.50	YES	0.75	0.9	29.41	96.0
1995	58	93	I	1.	262.	70.28	78.51	YES	1.00	1.4	34.40	94.7
1996	56	97	I	0.	31.	70.29	78.47	YES	0.75	0.5	15.42	99.8
1997	56	97	I	1.	62.	70.28	78.46	YES	5.00	1.3	6.13	98.2
1998	56	94	I	1.	308.	70.29	78.50	YES	0.75	1.2	37.83	96.0
1999	66	100	I	5.	156.	70.24	78.43	YES	2.50	4.8	45.63	93.0
2000	58	93	I	2.	260.	70.28	78.52	YES	1.00	1.5	36.91	94.7
2001	78	74	I	15.	226.	70.19	78.76	YES	66.75	56.5	20.32	86.5
2002	57	93	I	1.	271.	70.28	78.51	YES	1.50	1.4	21.87	95.8
2003	55	94	I	1.	310.	70.29	78.50	YES	0.75	1.2	39.60	96.0
2004	59	98	I	1.	137.	70.27	78.45	YES	1.50	1.3	20.22	96.8
2005	57	98	I	1.	95.	70.28	78.45	YES	0.75	1.1	34.65	96.0
2006	55	96	I	1.	349.	70.29	78.48	YES	1.00	1.1	26.02	99.8
2007	66	100	I	5.	155.	70.24	78.42	YES	3.00	4.9	39.33	93.6
2008	53	94	I	2.	332.	70.30	78.50	YES	4.75	2.8	14.04	98.9
2009	57	98	I	1.	98.	70.28	78.45	YES	1.00	1.0	22.84	94.7

Baffinland   Steensby Port   SPILL BEGINS AT 0000 HRS, 13 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	106	80	I	25.	198.	70.06	78.68	YES	19.00	28.1	35.48	16.8
1981	76	74	I	14.	229.	70.20	78.76	YES	15.50	20.2	31.22	88.3
1982	58	93	I	1.	261.	70.28	78.51	YES	1.50	1.3	21.10	92.0
1983	68	102	I	6.	152.	70.23	78.40	YES	7.75	7.1	21.92	98.4
1984	63	100	I	3.	146.	70.26	78.42	YES	2.25	3.5	36.98	99.4
1985	58	98	I	1.	101.	70.28	78.45	YES	0.75	1.1	35.12	96.0
1986	59	98	I	1.	138.	70.27	78.45	YES	4.25	2.7	15.24	99.4
1987	55	96	I	1.	11.	70.29	78.47	YES	0.75	1.1	36.52	99.9
1988	59	98	I	2.	131.	70.27	78.44	YES	9.00	7.3	19.36	98.8

1989	60	100	I	2.	130.	70.27	78.43	YES	3.25	3.0	22.31	99.3
1990	126	111	O	35.	166.	69.97	78.26	NO	46.75	57.0	29.26	4.5
1991	55	96	I	1.	356.	70.29	78.48	YES	0.75	0.9	30.20	99.9
1992	180	72	O	62.	190.	69.73	78.76	BNDR	77.25	98.2	30.49	75.8
1993	56	93	I	1.	285.	70.28	78.51	YES	1.25	1.4	27.31	96.5
1994	55	94	I	1.	315.	70.29	78.50	YES	1.50	1.2	19.69	92.0
1995	56	97	I	1.	51.	70.28	78.47	YES	2.00	0.6	7.04	99.5
1996	55	96	I	1.	351.	70.29	78.48	YES	0.75	0.8	26.93	97.9
1997	56	97	I	0.	37.	70.28	78.47	YES	1.75	0.4	5.85	99.7
1998	55	94	I	1.	319.	70.29	78.50	YES	1.50	1.3	20.22	99.7
1999	66	100	I	5.	152.	70.24	78.42	YES	2.75	4.9	42.78	98.2
2000	57	93	I	2.	270.	70.28	78.52	YES	1.25	1.5	29.22	93.4
2001	56	97	I	1.	30.	70.29	78.47	YES	1.25	0.8	14.57	99.8
2002	57	93	I	1.	284.	70.28	78.51	YES	1.75	1.3	17.95	98.6
2003	56	94	I	1.	305.	70.29	78.50	YES	0.75	1.3	41.20	96.0
2004	56	97	I	0.	34.	70.29	78.47	YES	0.75	0.5	15.58	99.9
2005	56	98	I	1.	63.	70.29	78.46	YES	1.50	1.1	17.32	95.8
2006	55	94	I	1.	317.	70.29	78.50	YES	2.00	1.1	13.79	99.7
2007	60	99	I	2.	133.	70.27	78.43	YES	5.00	3.4	16.34	99.0
2008	19	69	I	23.	324.	70.45	78.84	YES	79.25	83.1	25.18	69.5
2009	56	97	I	1.	29.	70.29	78.47	YES	0.75	0.6	18.23	99.9

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 14 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	84	75	I	17.	217.	70.16	78.75	YES	12.25	19.7	38.56	50.7
1981	63	95	I	3.	191.	70.26	78.49	YES	1.50	3.0	47.92	98.8
1982	118	92	O	30.	183.	70.01	78.52	NO	20.75	33.6	38.84	4.3
1983	67	101	I	6.	151.	70.24	78.40	YES	8.75	8.5	23.31	98.1
1984	67	102	I	6.	151.	70.24	78.40	YES	8.00	8.2	24.73	98.9
1985	59	98	I	1.	133.	70.27	78.45	YES	1.00	1.3	30.74	94.7
1986	59	98	I	1.	144.	70.27	78.45	YES	1.25	1.4	26.78	99.8
1987	55	96	I	1.	351.	70.29	78.48	YES	0.50	1.2	55.26	99.9
1988	67	101	I	6.	153.	70.24	78.41	YES	6.00	7.4	29.64	99.2
1989	53	94	I	2.	335.	70.30	78.50	YES	4.25	3.2	17.92	99.0
1990	67	101	I	6.	155.	70.24	78.41	YES	5.75	6.0	24.84	96.2
1991	56	97	I	1.	32.	70.29	78.47	YES	0.75	0.6	18.85	99.4
1992	66	100	I	5.	154.	70.24	78.42	YES	2.50	4.7	44.77	99.4
1993	57	93	I	1.	266.	70.28	78.51	YES	2.25	1.6	16.62	93.7
1994	56	97	I	1.	52.	70.29	78.46	YES	1.75	0.9	11.90	95.1
1995	59	98	I	1.	137.	70.27	78.45	YES	2.00	1.2	14.52	94.4
1996	56	93	I	1.	283.	70.28	78.51	YES	2.00	1.4	16.45	98.3
1997	56	97	I	1.	57.	70.28	78.46	YES	1.25	0.6	11.13	99.7
1998	55	96	I	1.	354.	70.29	78.48	YES	0.50	0.8	39.95	98.6
1999	62	100	I	3.	142.	70.26	78.43	YES	2.25	3.0	32.12	99.4
2000	57	93	I	1.	271.	70.28	78.51	YES	3.25	1.4	10.27	99.2
2001	59	98	I	1.	130.	70.27	78.45	YES	1.75	1.5	20.40	99.7
2002	56	94	I	1.	293.	70.29	78.50	YES	1.50	1.0	15.89	99.6
2003	76	107	I	11.	148.	70.20	78.32	YES	13.00	17.7	32.77	95.9
2004	55	96	I	1.	3.	70.29	78.48	YES	1.00	1.0	23.54	99.8
2005	58	93	I	1.	253.	70.28	78.51	YES	1.75	1.6	21.97	98.6
2006	56	97	I	1.	58.	70.29	78.46	YES	2.00	1.1	12.82	99.5
2007	57	93	I	1.	262.	70.28	78.51	YES	7.50	6.3	20.27	98.5
2008	60	99	I	2.	131.	70.27	78.43	YES	3.25	3.4	25.02	99.4
2009	55	96	I	1.	10.	70.29	78.47	YES	1.50	1.1	16.84	99.7

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 15 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	55	94	I	1.	318.	70.29	78.50	YES	1.00	1.2	27.96	97.2
1981	122	82	I	33.	191.	69.99	78.65	YES	72.50	88.0	29.13	83.2
1982	56	97	I	0.	33.	70.29	78.47	YES	0.50	0.5	22.19	98.6
1983	60	99	I	2.	140.	70.27	78.44	YES	6.25	5.7	21.70	99.2
1984	76	74	I	14.	229.	70.20	78.77	YES	14.50	21.5	35.57	88.0
1985	57	98	I	1.	95.	70.28	78.45	YES	1.00	0.9	21.53	97.2
1986	103	76	I	25.	203.	70.08	78.73	YES	36.75	45.2	29.55	93.3
1987	55	96	I	1.	352.	70.29	78.48	YES	0.50	1.2	57.27	99.9
1988	66	100	I	5.	154.	70.24	78.42	YES	7.75	8.6	26.64	98.8
1989	58	98	I	1.	114.	70.28	78.45	YES	2.25	1.5	16.37	99.7
1990	64	100	I	4.	149.	70.25	78.42	YES	1.75	3.8	51.99	95.1
1991	66	100	I	5.	155.	70.24	78.42	YES	2.75	5.2	45.55	95.8
1992	110	80	I	27.	196.	70.05	78.67	YES	28.75	46.8	39.10	85.2
1993	53	94	I	2.	333.	70.30	78.50	YES	2.50	2.3	21.77	99.6
1994	59	98	I	1.	137.	70.27	78.45	YES	0.75	1.2	38.90	97.9
1995	57	98	I	1.	89.	70.28	78.46	YES	0.75	0.8	24.18	96.0
1996	55	94	I	1.	319.	70.29	78.50	YES	1.25	1.4	27.21	99.0
1997	57	98	I	1.	81.	70.28	78.45	YES	1.25	0.9	17.33	99.0
1998	55	96	I	1.	7.	70.29	78.47	YES	1.25	0.9	17.50	99.8
1999	59	98	I	1.	131.	70.27	78.45	YES	1.00	1.3	30.36	94.7
2000	58	98	I	1.	104.	70.28	78.45	YES	1.75	0.9	12.21	98.6
2001	63	95	I	3.	194.	70.26	78.50	YES	3.25	3.6	26.79	97.3
2002	57	93	I	1.	272.	70.28	78.51	YES	1.50	1.3	21.27	95.8
2003	56	97	I	1.	32.	70.29	78.47	YES	0.75	0.6	17.98	99.9
2004	55	96	I	1.	3.	70.29	78.48	YES	1.00	1.0	23.67	99.8
2005	55	96	I	1.	5.	70.29	78.47	YES	1.50	1.1	17.63	99.7
2006	56	97	I	1.	33.	70.29	78.47	YES	1.75	1.1	14.58	99.5
2007	63	95	I	3.	186.	70.26	78.48	YES	1.50	2.7	43.36	99.7
2008	59	98	I	1.	136.	70.27	78.46	YES	2.00	1.6	18.75	99.6
2009	55	96	I	1.	7.	70.29	78.47	YES	0.75	1.2	38.34	99.9

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 16 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	79	74	I	15.	225.	70.19	78.76	YES	26.25	32.4	29.61	96.1
1981	59	98	I	1.	145.	70.27	78.46	YES	9.00	8.4	22.29	98.6
1982	56	97	I	1.	28.	70.29	78.47	YES	0.50	0.9	41.30	98.6
1983	60	99	I	2.	135.	70.27	78.44	YES	5.00	5.0	23.82	99.3
1984	63	95	I	3.	189.	70.26	78.49	YES	1.25	2.9	55.94	97.0
1985	56	97	I	1.	20.	70.29	78.47	YES	0.75	0.8	26.62	99.9
1986	63	95	I	3.	191.	70.25	78.49	YES	5.75	4.4	18.57	98.8
1987	55	96	I	1.	359.	70.29	78.48	YES	0.50	0.9	42.37	99.9
1988	64	100	I	4.	151.	70.25	78.43	YES	7.25	7.5	24.86	99.0
1989	58	98	I	1.	110.	70.28	78.46	YES	1.50	1.1	18.24	99.7
1990	60	99	I	2.	131.	70.27	78.43	YES	3.25	3.4	25.21	99.4
1991	66	100	I	5.	157.	70.24	78.43	YES	2.50	4.9	47.02	99.6
1992	180	49	O	65.	201.	69.73	79.08	BNDR	89.00	113.7	30.67	77.5
1993	55	96	I	1.	10.	70.29	78.47	YES	1.75	1.1	15.33	99.5

1994	57	98	I	1.	88.	70.28	78.46	YES	2.50	1.9	18.28	99.7
1995	56	97	I	1.	36.	70.29	78.47	YES	0.75	0.6	18.71	99.9
1996	53	94	I	2.	336.	70.30	78.50	YES	3.25	2.2	15.92	99.6
1997	56	97	I	1.	49.	70.29	78.46	YES	2.25	1.1	12.20	99.6
1998	56	94	I	1.	289.	70.28	78.50	YES	0.75	1.1	34.36	96.0
1999	63	100	I	4.	149.	70.25	78.43	YES	3.75	3.8	24.34	97.3
2000	55	96	I	1.	12.	70.29	78.47	YES	1.50	0.9	13.89	99.8
2001	25	45	I	30.	302.	70.43	79.16	YES	65.00	59.9	22.13	81.5
2002	56	93	I	1.	286.	70.28	78.51	YES	2.25	1.7	18.08	98.1
2003	66	100	I	5.	156.	70.24	78.43	YES	2.50	4.7	45.26	99.4
2004	55	97	I	1.	18.	70.29	78.47	YES	0.75	0.9	28.52	99.4
2005	56	97	I	0.	35.	70.29	78.47	YES	1.25	0.5	9.41	99.8
2006	55	96	I	1.	10.	70.29	78.47	YES	1.50	1.0	15.27	99.7
2007	79	74	I	15.	226.	70.19	78.77	YES	8.75	18.0	49.26	53.6
2008	56	97	I	1.	47.	70.29	78.46	YES	2.25	1.8	18.97	99.6
2009	55	96	I	1.	355.	70.29	78.48	YES	0.50	1.2	58.56	99.9

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 17 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	63	95	I	3.	190.	70.25	78.49	YES	2.50	3.7	35.52	99.6
1981	59	98	I	2.	129.	70.27	78.44	YES	3.50	3.6	24.35	99.5
1982	55	96	I	1.	9.	70.29	78.47	YES	0.50	0.9	45.18	99.9
1983	59	98	I	1.	140.	70.27	78.46	YES	4.25	4.3	24.50	99.3
1984	76	74	I	14.	228.	70.20	78.76	YES	36.25	42.9	28.40	95.3
1985	55	96	I	1.	355.	70.29	78.48	YES	0.50	1.2	56.52	98.6
1986	76	74	I	14.	228.	70.20	78.76	YES	13.25	19.8	35.84	73.4
1987	73	71	I	14.	237.	70.21	78.80	YES	16.75	25.8	37.03	94.1
1988	63	100	I	3.	146.	70.26	78.43	YES	3.50	4.3	29.25	99.4
1989	56	98	I	1.	56.	70.29	78.46	YES	1.25	1.0	19.06	99.7
1990	53	95	I	2.	345.	70.30	78.49	YES	3.00	3.0	23.65	95.5
1991	148	119	I	47.	164.	69.88	78.14	YES	71.50	102.6	34.46	66.4
1992	91	76	I	19.	210.	70.13	78.73	YES	37.00	45.8	29.68	92.7
1993	56	97	I	1.	29.	70.29	78.47	YES	0.50	0.5	25.01	99.9
1994	59	92	I	2.	241.	70.27	78.53	YES	4.75	3.5	17.85	90.2
1995	56	97	I	1.	41.	70.29	78.47	YES	1.25	0.7	12.51	99.8
1996	56	98	I	1.	52.	70.29	78.45	YES	2.50	1.9	18.12	98.8
1997	57	98	I	1.	96.	70.28	78.45	YES	1.00	0.8	20.03	97.2
1998	56	94	I	1.	310.	70.29	78.50	YES	0.75	1.1	33.81	96.0
1999	62	100	I	3.	144.	70.26	78.43	YES	1.50	3.2	51.25	98.8
2000	55	94	I	1.	324.	70.29	78.50	YES	1.00	1.4	34.12	94.7
2001	70	102	I	7.	156.	70.22	78.40	YES	5.75	7.4	31.06	98.5
2002	56	93	I	1.	288.	70.29	78.51	YES	1.50	1.6	26.16	95.8
2003	150	108	O	46.	171.	69.87	78.29	NO	32.25	55.7	41.42	4.8
2004	58	98	I	1.	107.	70.28	78.45	YES	1.00	1.0	25.15	94.7
2005	56	98	I	1.	62.	70.29	78.46	YES	1.00	0.8	20.29	99.2
2006	56	97	I	1.	22.	70.29	78.47	YES	0.75	0.7	20.94	99.9
2007	96	111	O	21.	158.	70.11	78.25	NO	48.75	64.9	31.94	4.8
2008	58	93	I	2.	249.	70.28	78.52	YES	4.50	2.6	14.10	98.8
2009	55	96	I	1.	345.	70.29	78.48	YES	0.75	1.0	31.45	99.8

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 18 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

END POSITION ASHORE? ELAPSED PATH MEAN % AT

YEAR	ROW	COL	ORI	RANGE	BEARING	LAT	LONG		TIME	LENGTH	SPEED	ENDPT
				KM	DEG. T	NORTH	WEST		HOURS	KM	KM/DAY	
1980	63	95	I	3.	194.	70.26	78.49	YES	1.50	2.9	46.68	95.8
1981	56	94	I	1.	309.	70.29	78.50	YES	3.00	2.6	20.41	99.5
1982	55	96	I	1.	6.	70.29	78.47	YES	0.50	1.3	61.94	98.6
1983	61	100	I	3.	136.	70.26	78.43	YES	3.00	3.5	27.64	99.5
1984	58	93	I	2.	257.	70.28	78.52	YES	8.50	9.6	27.17	98.9
1985	53	94	I	3.	332.	70.30	78.51	YES	1.00	2.5	60.54	94.7
1986	56	94	I	1.	304.	70.29	78.50	YES	4.25	3.6	20.61	99.3
1987	63	95	I	3.	189.	70.25	78.49	YES	7.25	7.3	24.30	90.1
1988	59	98	I	2.	127.	70.27	78.44	YES	3.75	3.9	24.91	99.3
1989	55	96	I	1.	14.	70.29	78.47	YES	1.00	0.9	20.73	99.8
1990	96	76	I	21.	207.	70.11	78.72	YES	44.25	50.6	27.45	56.5
1991	70	121	I	14.	117.	70.22	78.14	YES	60.50	78.0	30.93	21.2
1992	79	74	I	15.	224.	70.18	78.76	YES	17.25	25.4	35.39	96.0
1993	53	95	I	2.	339.	70.30	78.50	YES	1.25	2.2	41.65	99.8
1994	58	93	I	1.	261.	70.28	78.51	YES	2.25	1.4	15.31	98.1
1995	53	94	I	2.	334.	70.30	78.51	YES	2.25	2.5	26.67	99.6
1996	55	96	I	1.	10.	70.29	78.47	YES	2.00	0.9	11.29	99.7
1997	57	98	I	1.	83.	70.28	78.45	YES	1.00	0.9	22.25	97.2
1998	56	94	I	1.	306.	70.29	78.50	YES	0.75	1.2	36.89	96.0
1999	66	101	I	5.	152.	70.24	78.41	YES	4.00	7.1	42.88	97.3
2000	58	93	I	2.	246.	70.28	78.52	YES	1.50	1.6	26.14	92.0
2001	58	92	I	2.	261.	70.28	78.52	YES	11.00	14.6	31.87	97.9
2002	53	94	I	2.	329.	70.30	78.51	YES	2.25	2.4	25.15	99.4
2003	144	120	O	45.	163.	69.89	78.13	NO	48.75	64.4	31.69	5.0
2004	57	98	I	1.	94.	70.28	78.45	YES	1.25	0.9	18.00	99.0
2005	56	97	I	1.	50.	70.28	78.47	YES	0.75	0.5	16.93	99.8
2006	55	96	I	1.	356.	70.29	78.48	YES	0.75	0.9	27.48	99.9
2007	65	101	I	5.	148.	70.25	78.41	YES	3.50	5.1	35.30	99.1
2008	56	97	I	1.	57.	70.28	78.46	YES	2.75	1.1	9.27	99.5
2009	56	97	I	0.	36.	70.29	78.47	YES	0.50	0.5	22.39	98.6

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 19 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

				END POSITION				ASHORE?	ELAPSED	PATH	MEAN	% AT
YEAR	ROW	COL	ORI	RANGE	BEARING	LAT	LONG		TIME	LENGTH	SPEED	ENDPT
				KM	DEG. T	NORTH	WEST		HOURS	KM	KM/DAY	
1980	27	67	I	21.	315.	70.42	78.87	YES	66.25	68.1	24.67	34.6
1981	56	94	I	1.	299.	70.29	78.50	YES	6.00	3.8	15.34	98.9
1982	56	97	I	0.	38.	70.28	78.47	YES	0.25	0.4	39.48	98.7
1983	59	98	I	1.	142.	70.27	78.46	YES	1.75	1.5	20.37	99.7
1984	63	95	I	3.	188.	70.26	78.49	YES	1.75	3.0	40.90	99.7
1985	55	96	I	1.	2.	70.29	78.48	YES	0.50	1.1	53.83	99.9
1986	56	97	I	1.	52.	70.29	78.46	YES	2.25	1.4	15.10	99.7
1987	66	100	I	5.	154.	70.24	78.42	YES	3.25	5.0	36.63	99.6
1988	63	95	I	3.	185.	70.26	78.48	YES	1.25	2.8	54.35	96.5
1989	55	94	I	1.	317.	70.29	78.50	YES	1.00	1.4	33.20	97.2
1990	56	93	I	1.	290.	70.29	78.51	YES	4.25	2.6	14.43	99.3
1991	66	100	I	5.	154.	70.24	78.42	YES	2.00	4.8	57.67	99.5
1992	63	95	I	3.	187.	70.26	78.49	YES	1.50	2.9	47.01	98.8
1993	55	94	I	2.	321.	70.29	78.50	YES	1.00	1.6	37.91	97.2
1994	55	94	I	1.	318.	70.29	78.50	YES	2.25	1.2	13.33	99.7
1995	55	96	I	1.	3.	70.29	78.48	YES	1.50	1.1	17.27	99.8
1996	56	97	I	1.	25.	70.29	78.47	YES	1.75	0.8	11.15	99.7
1997	56	97	I	0.	46.	70.28	78.47	YES	0.50	0.5	22.83	99.6
1998	53	94	I	2.	327.	70.30	78.51	YES	1.50	2.2	35.30	98.8

1999	78	74	I	15.	226.	70.19	78.76	YES	15.25	21.4	33.66	77.5
2000	58	98	I	1.	123.	70.28	78.46	YES	2.75	1.7	14.84	85.4
2001	55	94	I	1.	323.	70.29	78.50	YES	10.25	12.8	29.91	97.9
2002	55	96	I	1.	3.	70.29	78.48	YES	0.75	1.0	33.10	99.9
2003	66	100	I	5.	155.	70.24	78.43	YES	1.75	4.6	62.46	98.6
2004	58	98	I	1.	108.	70.28	78.45	YES	1.00	0.9	22.29	94.7
2005	55	97	I	1.	16.	70.29	78.47	YES	1.00	1.1	25.40	99.8
2006	55	96	I	1.	357.	70.29	78.48	YES	0.75	0.9	29.32	99.9
2007	59	98	I	1.	143.	70.27	78.46	YES	0.50	1.3	62.36	97.3
2008	56	97	I	1.	26.	70.29	78.47	YES	1.00	0.7	15.67	99.9
2009	55	96	I	1.	14.	70.29	78.47	YES	0.75	0.9	28.61	99.9

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 20 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

				END POSITION				ASHORE?	ELAPSED	PATH	MEAN	% AT
YEAR	ROW	COL	ORI	RANGE	BEARING	LAT	LONG		TIME	LENGTH	SPEED	ENDPT
				KM	DEG. T	NORTH	WEST		HOURS	KM	KM/DAY	
1980	66	100	I	5.	157.	70.24	78.43	YES	2.75	4.8	41.69	99.6
1981	55	96	I	1.	1.	70.29	78.48	YES	5.50	2.7	11.66	99.2
1982	114	139	O	36.	142.	70.03	77.87	NO	52.75	53.7	24.42	4.4
1983	59	98	I	1.	137.	70.27	78.45	YES	0.75	1.2	38.83	97.9
1984	64	67	I	15.	256.	70.25	78.86	YES	24.25	24.9	24.64	95.6
1985	57	98	I	1.	88.	70.28	78.45	YES	1.25	1.1	20.36	93.4
1986	58	93	I	1.	258.	70.28	78.51	YES	3.00	1.6	12.51	99.2
1987	35	68	I	18.	307.	70.38	78.85	YES	34.00	32.9	23.23	68.7
1988	63	95	I	3.	191.	70.26	78.49	YES	1.50	2.7	43.77	95.8
1989	57	93	I	1.	266.	70.28	78.52	YES	0.75	1.5	46.87	96.0
1990	79	105	I	12.	157.	70.19	78.35	YES	44.50	44.0	23.74	19.3
1991	58	98	I	1.	125.	70.28	78.46	YES	1.00	1.0	23.58	97.2
1992	63	95	I	3.	189.	70.26	78.49	YES	1.75	2.8	38.59	99.5
1993	55	96	I	1.	342.	70.29	78.48	YES	0.50	0.9	41.05	99.9
1994	58	98	I	1.	122.	70.28	78.45	YES	2.00	1.6	18.90	89.4
1995	56	97	I	0.	46.	70.28	78.47	YES	0.50	0.4	21.30	99.6
1996	53	94	I	2.	332.	70.30	78.50	YES	3.00	2.3	18.63	99.2
1997	55	94	I	1.	321.	70.29	78.50	YES	2.00	1.4	16.86	98.3
1998	53	95	I	2.	344.	70.30	78.49	YES	2.00	1.9	22.59	99.7
1999	63	95	I	3.	187.	70.26	78.49	YES	2.00	2.7	32.40	99.6
2000	57	93	I	1.	267.	70.28	78.51	YES	2.00	2.3	27.31	89.4
2001	54	64	I	16.	275.	70.29	78.90	YES	28.75	27.9	23.28	93.4
2002	55	96	I	1.	350.	70.29	78.48	YES	0.50	1.0	46.96	99.9
2003	66	100	I	5.	157.	70.24	78.43	YES	2.50	5.0	48.39	99.4
2004	57	98	I	1.	87.	70.28	78.45	YES	1.00	0.9	20.96	97.2
2005	56	94	I	1.	297.	70.29	78.50	YES	0.50	0.9	43.87	97.3
2006	55	96	I	1.	11.	70.29	78.47	YES	0.75	0.9	27.92	99.9
2007	63	100	I	4.	147.	70.25	78.42	YES	2.00	3.7	44.43	91.9
2008	55	96	I	1.	358.	70.29	78.48	YES	1.00	0.8	19.61	99.9
2009	56	94	I	1.	300.	70.29	78.50	YES	2.00	1.9	22.50	96.4

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 21 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

				END POSITION				ASHORE?	ELAPSED	PATH	MEAN	% AT
YEAR	ROW	COL	ORI	RANGE	BEARING	LAT	LONG		TIME	LENGTH	SPEED	ENDPT
				KM	DEG. T	NORTH	WEST		HOURS	KM	KM/DAY	
1980	58	93	I	1.	247.	70.28	78.51	YES	7.00	4.7	16.22	92.2

1981	53	94	I	2.	335.	70.30	78.50	YES	4.25	2.6	14.61	99.4
1982	57	98	I	1.	91.	70.28	78.45	YES	1.00	0.9	21.79	99.2
1983	59	98	I	1.	138.	70.27	78.45	YES	1.50	1.4	21.84	99.0
1984	59	92	I	2.	239.	70.27	78.53	YES	4.75	3.8	19.24	99.1
1985	106	83	O	25.	194.	70.06	78.64	NO	18.00	27.0	36.03	4.5
1986	53	94	I	2.	338.	70.30	78.50	YES	3.50	2.2	14.83	99.5
1987	56	97	I	1.	47.	70.29	78.46	YES	9.75	6.5	16.07	98.7
1988	56	97	I	1.	62.	70.28	78.46	YES	3.50	2.2	15.16	99.5
1989	53	94	I	2.	334.	70.30	78.50	YES	3.25	2.3	16.89	99.6
1990	57	98	I	1.	90.	70.28	78.46	YES	1.75	0.9	12.03	98.6
1991	63	95	I	3.	184.	70.26	78.48	YES	5.50	3.8	16.49	99.2
1992	63	95	I	3.	191.	70.26	78.49	YES	1.50	2.8	44.64	95.8
1993	55	96	I	1.	357.	70.29	78.48	YES	0.50	0.9	42.40	99.9
1994	56	97	I	1.	58.	70.29	78.46	YES	4.00	1.4	8.44	94.7
1995	56	97	I	0.	46.	70.28	78.47	YES	0.50	0.5	22.89	99.6
1996	55	96	I	1.	358.	70.29	78.48	YES	0.75	1.0	31.16	99.9
1997	56	94	I	1.	310.	70.29	78.50	YES	1.25	1.2	23.74	99.0
1998	55	96	I	1.	358.	70.29	78.48	YES	1.00	1.0	23.77	99.9
1999	60	65	I	15.	264.	70.27	78.89	YES	19.25	21.0	26.21	88.8
2000	103	76	I	24.	203.	70.08	78.73	YES	35.25	33.6	22.87	75.1
2001	71	70	I	14.	243.	70.22	78.82	YES	20.75	22.0	25.43	89.9
2002	56	94	I	1.	309.	70.29	78.50	YES	0.50	1.2	57.40	97.3
2003	75	73	I	14.	232.	70.20	78.78	YES	7.25	14.8	48.94	61.5
2004	55	96	I	1.	346.	70.29	78.48	YES	0.75	0.9	28.64	99.9
2005	57	93	I	1.	264.	70.28	78.51	YES	1.00	1.4	34.71	94.7
2006	56	94	I	1.	314.	70.29	78.50	YES	1.75	1.2	16.47	98.6
2007	60	99	I	2.	133.	70.27	78.44	YES	3.00	2.4	19.33	99.5
2008	57	98	I	1.	68.	70.28	78.46	YES	3.50	0.9	6.15	99.1
2009	59	98	I	1.	136.	70.27	78.45	YES	1.00	1.4	33.93	94.7

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 22 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

				END POSITION				ASHORE?	ELAPSED	PATH	MEAN	% AT
YEAR	ROW	COL	ORI	RANGE	BEARING	LAT	LONG		TIME	LENGTH	SPEED	ENDPT
				KM	DEG. T	NORTH	WEST		HOURS	KM	KM/DAY	
1980	57	98	I	1.	91.	70.28	78.45	YES	0.75	0.9	28.01	96.0
1981	55	96	I	1.	13.	70.29	78.47	YES	2.25	0.9	9.45	99.7
1982	66	100	I	5.	156.	70.24	78.42	YES	2.75	4.9	42.63	87.3
1983	58	98	I	1.	112.	70.28	78.45	YES	2.50	1.9	18.22	99.4
1984	64	67	I	15.	256.	70.25	78.86	YES	15.00	17.1	27.30	65.9
1985	122	82	I	33.	191.	69.99	78.64	YES	86.50	61.3	17.00	35.4
1986	55	96	I	1.	9.	70.29	78.47	YES	1.25	0.8	15.96	99.8
1987	58	93	I	1.	251.	70.28	78.51	YES	1.25	1.4	27.02	93.4
1988	56	97	I	1.	65.	70.28	78.46	YES	2.25	1.2	13.21	99.6
1989	55	96	I	1.	10.	70.29	78.47	YES	2.50	0.9	8.42	99.6
1990	57	98	I	1.	95.	70.28	78.45	YES	1.75	0.9	12.06	98.6
1991	63	95	I	3.	188.	70.26	78.49	YES	4.25	2.7	15.38	99.4
1992	70	70	I	14.	243.	70.22	78.81	YES	15.00	17.2	27.51	69.9
1993	53	94	I	2.	332.	70.30	78.50	YES	1.75	2.2	30.01	99.5
1994	57	98	I	1.	72.	70.28	78.46	YES	1.50	0.8	12.59	98.8
1995	96	76	I	21.	206.	70.11	78.73	YES	48.75	37.5	18.46	61.6
1996	55	96	I	1.	356.	70.29	78.48	YES	0.75	0.9	28.91	99.9
1997	56	94	I	1.	287.	70.28	78.50	YES	2.00	1.1	12.80	94.4
1998	55	96	I	1.	355.	70.29	78.48	YES	0.75	1.0	32.38	99.9
1999	56	94	I	1.	287.	70.28	78.51	YES	4.00	4.0	24.23	99.2
2000	89	75	I	19.	213.	70.14	78.75	YES	39.50	30.3	18.40	88.2
2001	58	65	I	15.	269.	70.28	78.87	YES	71.50	45.3	15.20	84.3
2002	53	94	I	2.	336.	70.30	78.50	YES	1.00	2.3	54.94	94.7
2003	77	74	I	15.	227.	70.19	78.76	YES	8.00	14.6	43.74	57.6

2004	56	93	I	2.	299.	70.29	78.52	YES	0.50	1.7	79.22	97.3
2005	56	93	I	1.	284.	70.28	78.51	YES	2.00	1.4	16.64	98.9
2006	91	76	I	19.	210.	70.13	78.74	YES	18.25	21.1	27.70	33.3
2007	59	98	I	2.	135.	70.27	78.45	YES	7.25	3.7	12.36	97.7
2008	58	98	I	1.	116.	70.28	78.45	YES	2.75	0.9	8.03	97.7
2009	58	98	I	1.	115.	70.28	78.45	YES	0.75	1.0	31.49	96.0

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 23 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	58	98	I	1.	115.	70.28	78.46	YES	1.25	0.9	17.12	99.8
1981	58	98	I	1.	124.	70.28	78.46	YES	6.00	2.3	9.11	98.0
1982	56	97	I	0.	41.	70.28	78.47	YES	0.75	0.5	15.78	99.9
1983	58	93	I	1.	245.	70.28	78.51	YES	1.75	1.5	20.41	98.6
1984	59	92	I	2.	241.	70.27	78.53	YES	2.00	2.2	26.45	94.4
1985	58	98	I	1.	107.	70.28	78.45	YES	2.50	1.3	12.04	99.6
1986	53	95	I	2.	345.	70.30	78.49	YES	1.75	2.0	27.83	98.6
1987	80	75	I	15.	222.	70.18	78.75	YES	22.75	17.9	18.91	75.7
1988	55	96	I	1.	11.	70.29	78.47	YES	3.00	1.3	10.45	99.5
1989	57	98	I	1.	95.	70.28	78.46	YES	1.50	0.8	12.50	98.8
1990	56	97	I	0.	48.	70.28	78.47	YES	0.50	0.5	22.55	99.6
1991	63	66	I	15.	259.	70.25	78.87	YES	18.00	17.8	23.80	79.2
1992	63	95	I	3.	193.	70.26	78.49	YES	2.75	2.8	24.76	99.5
1993	96	76	I	22.	206.	70.11	78.73	YES	60.00	47.5	18.99	70.3
1994	55	94	I	1.	325.	70.29	78.50	YES	3.25	1.4	10.18	99.4
1995	56	97	I	0.	38.	70.28	78.47	YES	2.50	0.5	4.75	98.2
1996	56	97	I	0.	43.	70.28	78.47	YES	1.25	0.5	9.50	99.0
1997	56	97	I	0.	38.	70.28	78.47	YES	2.25	0.5	5.07	98.3
1998	53	94	I	2.	334.	70.30	78.50	YES	2.75	2.0	17.60	99.6
1999	58	98	I	1.	120.	70.28	78.46	YES	2.25	1.2	12.42	99.7
2000	55	94	I	1.	319.	70.29	78.50	YES	2.25	1.3	13.81	99.4
2001	65	101	I	5.	149.	70.25	78.41	YES	5.50	4.8	21.15	99.1
2002	55	94	I	2.	319.	70.29	78.51	YES	0.75	1.7	53.25	96.0
2003	63	95	I	3.	187.	70.25	78.49	YES	7.50	4.5	14.52	99.0
2004	53	94	I	2.	334.	70.30	78.50	YES	1.50	2.4	37.88	98.8
2005	55	94	I	1.	317.	70.29	78.50	YES	1.50	1.2	19.93	99.6
2006	58	93	I	1.	251.	70.28	78.51	YES	2.25	1.4	15.43	93.7
2007	79	74	I	15.	224.	70.18	78.76	YES	25.50	19.3	18.18	85.5
2008	57	98	I	1.	88.	70.28	78.45	YES	1.75	0.8	10.73	99.6
2009	58	98	I	1.	112.	70.28	78.45	YES	1.00	1.0	23.45	97.2

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 24 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	82	75	I	16.	220.	70.17	78.75	YES	12.50	17.8	34.20	33.7
1981	56	94	I	1.	297.	70.29	78.50	YES	2.50	1.0	9.55	99.6
1982	63	95	I	3.	189.	70.26	78.49	YES	5.50	3.8	16.75	99.2
1983	59	92	I	2.	237.	70.27	78.53	YES	4.00	2.3	13.80	98.4
1984	65	67	I	15.	254.	70.24	78.86	YES	36.75	24.2	15.81	89.3
1985	56	97	I	1.	24.	70.29	78.47	YES	1.00	0.7	15.99	99.8

1986	55	96	I	1.	3.	70.29	78.48	YES	1.75	0.9	12.71	99.8
1987	63	95	I	3.	185.	70.26	78.48	YES	3.25	2.7	20.08	99.2
1988	58	93	I	2.	247.	70.28	78.52	YES	4.75	2.5	12.46	99.2
1989	58	98	I	1.	121.	70.28	78.46	YES	1.25	1.0	18.24	96.5
1990	56	97	I	1.	30.	70.29	78.47	YES	0.75	0.6	18.18	99.8
1991	60	65	I	16.	265.	70.27	78.89	YES	14.25	18.5	31.08	52.0
1992	93	76	I	20.	208.	70.12	78.73	YES	11.75	20.2	41.32	37.7
1993	57	98	I	1.	89.	70.28	78.46	YES	3.00	1.0	7.96	98.1
1994	56	94	I	1.	295.	70.29	78.50	YES	1.75	0.9	12.08	99.7
1995	58	93	I	1.	256.	70.28	78.51	YES	3.50	1.4	9.36	95.1
1996	57	98	I	1.	73.	70.28	78.46	YES	1.25	0.8	15.78	96.5
1997	55	96	I	1.	9.	70.29	78.47	YES	1.50	0.9	14.67	99.8
1998	55	94	I	1.	320.	70.29	78.50	YES	1.25	1.3	25.88	99.5
1999	56	97	I	1.	52.	70.29	78.46	YES	5.25	3.0	13.57	99.3
2000	53	94	I	2.	333.	70.30	78.50	YES	1.75	2.1	28.97	99.6
2001	57	93	I	1.	263.	70.28	78.51	YES	10.50	7.1	16.34	98.1
2002	55	94	I	1.	319.	70.29	78.50	YES	0.50	1.3	64.05	97.3
2003	63	95	I	3.	185.	70.26	78.48	YES	4.75	3.0	15.03	99.4
2004	55	96	I	1.	356.	70.29	78.48	YES	1.25	0.8	15.50	99.8
2005	56	94	I	1.	306.	70.29	78.50	YES	0.75	1.0	33.31	96.0
2006	56	94	I	1.	292.	70.28	78.50	YES	3.00	1.1	8.76	99.3
2007	58	93	I	1.	246.	70.28	78.51	YES	7.00	3.8	12.96	98.8
2008	55	96	I	1.	355.	70.29	78.48	YES	1.25	1.0	18.60	99.7
2009	57	98	I	1.	99.	70.28	78.46	YES	0.75	0.8	25.59	96.0

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 25 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	80	75	I	15.	223.	70.18	78.75	YES	19.75	18.1	22.02	93.0
1981	60	65	I	16.	265.	70.27	78.89	YES	11.25	16.9	35.95	40.3
1982	56	94	I	1.	298.	70.29	78.50	YES	1.00	0.9	20.90	99.2
1983	55	96	I	1.	346.	70.29	78.48	YES	5.00	3.1	14.72	99.3
1984	113	80	I	29.	195.	70.03	78.68	YES	62.00	53.7	20.78	73.8
1985	74	72	I	14.	235.	70.21	78.79	YES	15.25	18.5	29.10	62.1
1986	58	98	I	1.	121.	70.28	78.46	YES	2.00	1.0	11.46	99.6
1987	91	76	I	20.	211.	70.13	78.74	YES	15.75	20.6	31.43	34.0
1988	53	95	I	2.	346.	70.30	78.49	YES	6.25	3.1	11.77	99.2
1989	56	97	I	1.	50.	70.29	78.46	YES	1.25	0.7	12.93	99.8
1990	58	93	I	1.	258.	70.28	78.51	YES	2.50	1.4	13.89	99.4
1991	58	93	I	1.	248.	70.28	78.51	YES	1.25	1.4	26.75	96.5
1992	59	98	I	1.	131.	70.27	78.45	YES	0.50	1.3	60.88	97.3
1993	56	94	I	1.	302.	70.29	78.50	YES	1.25	0.9	17.61	99.0
1994	58	93	I	1.	254.	70.28	78.51	YES	3.50	1.5	10.53	97.4
1995	56	97	I	1.	52.	70.29	78.46	YES	0.75	0.7	22.70	99.4
1996	56	97	I	1.	45.	70.29	78.46	YES	1.50	0.7	10.71	99.6
1997	56	97	I	1.	29.	70.29	78.47	YES	0.75	0.6	18.23	99.9
1998	58	93	I	1.	259.	70.28	78.51	YES	1.00	1.4	33.42	94.7
1999	56	93	I	1.	289.	70.29	78.51	YES	3.25	1.8	13.52	97.9
2000	53	94	I	2.	332.	70.30	78.51	YES	1.25	2.4	46.39	93.4
2001	26	40	I	32.	299.	70.42	79.23	YES	82.25	50.0	14.58	76.6
2002	55	96	I	1.	12.	70.29	78.47	YES	1.00	1.0	23.25	99.9
2003	58	93	I	1.	252.	70.28	78.51	YES	1.75	1.6	21.81	95.1
2004	56	97	I	1.	64.	70.28	78.46	YES	1.00	0.8	18.50	99.2
2005	55	96	I	1.	6.	70.29	78.47	YES	1.00	0.9	21.13	99.8
2006	53	94	I	2.	332.	70.30	78.50	YES	1.50	2.2	35.22	98.8
2007	58	98	I	1.	131.	70.28	78.46	YES	2.00	1.0	12.57	99.7
2008	56	94	I	1.	303.	70.29	78.50	YES	0.75	0.9	30.17	96.0

2009	56	97	I	1.	48.	70.28	78.47	YES	0.50	0.5	24.57	99.6

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 26 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	63	95	I	3.	192.	70.26	78.49	YES	4.25	3.4	19.38	92.5
1981	59	92	I	2.	239.	70.27	78.53	YES	2.00	2.3	27.91	89.4
1982	56	97	I	1.	41.	70.29	78.47	YES	0.75	0.6	17.85	99.4
1983	59	98	I	1.	141.	70.27	78.45	YES	3.25	2.6	19.25	99.5
1984	109	80	I	27.	196.	70.05	78.67	YES	54.00	58.8	26.13	36.4
1985	56	94	I	1.	289.	70.28	78.50	YES	0.50	1.1	52.10	97.3
1986	58	98	I	1.	124.	70.28	78.46	YES	3.75	2.1	13.49	99.4
1987	111	80	I	28.	195.	70.04	78.67	YES	65.00	61.1	22.57	51.7
1988	60	99	I	2.	140.	70.27	78.44	YES	4.00	2.6	15.53	99.5
1989	76	107	I	11.	150.	70.20	78.33	YES	53.25	44.8	20.18	57.1
1990	56	94	I	1.	287.	70.29	78.51	YES	4.50	2.3	12.45	99.4
1991	63	95	I	3.	188.	70.25	78.49	YES	1.75	3.2	43.51	95.1
1992	59	98	I	1.	140.	70.27	78.46	YES	0.50	1.2	57.51	97.3
1993	56	94	I	1.	312.	70.29	78.50	YES	1.00	1.2	28.46	99.2
1994	53	94	I	2.	332.	70.30	78.50	YES	3.50	2.2	15.15	99.5
1995	57	98	I	1.	82.	70.28	78.45	YES	1.50	0.9	14.91	96.8
1996	56	97	I	1.	59.	70.29	78.46	YES	1.25	0.7	14.29	99.7
1997	56	97	I	1.	60.	70.28	78.46	YES	1.75	0.8	10.60	98.6
1998	55	94	I	2.	320.	70.29	78.50	YES	0.75	1.5	49.17	96.0
1999	53	94	I	2.	336.	70.30	78.50	YES	2.50	2.1	19.73	86.7
2000	56	94	I	1.	290.	70.28	78.50	YES	1.00	1.0	23.72	99.2
2001	63	95	I	3.	186.	70.26	78.48	YES	3.25	2.7	20.28	99.5
2002	55	96	I	1.	353.	70.29	78.48	YES	0.75	0.8	27.17	99.9
2003	91	76	I	19.	210.	70.13	78.73	YES	18.50	23.3	30.23	77.4
2004	56	98	I	1.	66.	70.28	78.46	YES	1.25	0.9	16.45	99.0
2005	55	94	I	1.	321.	70.29	78.50	YES	1.75	1.4	19.02	99.7
2006	56	94	I	1.	306.	70.29	78.50	YES	1.00	1.1	27.02	97.2
2007	59	98	I	1.	132.	70.28	78.46	YES	2.50	1.2	11.54	99.7
2008	59	92	I	2.	245.	70.27	78.53	YES	1.00	2.4	57.06	94.7
2009	55	94	I	1.	314.	70.29	78.50	YES	0.75	1.4	43.62	96.0

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 27 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	176	122	I	60.	166.	69.76	78.09	YES	53.00	76.3	34.56	13.7
1981	107	107	O	26.	166.	70.06	78.32	NO	18.00	27.2	36.21	4.5
1982	56	97	I	0.	39.	70.28	78.47	YES	1.50	1.1	17.52	99.7
1983	63	95	I	3.	186.	70.25	78.48	YES	1.50	3.0	47.83	95.8
1984	80	75	I	15.	222.	70.18	78.75	YES	32.25	39.7	29.53	31.0
1985	55	94	I	1.	314.	70.29	78.50	YES	0.75	1.4	43.59	96.0
1986	58	98	I	1.	114.	70.28	78.46	YES	0.75	0.9	28.53	97.9
1987	117	81	I	31.	193.	70.01	78.66	YES	55.50	55.3	23.91	90.9
1988	62	100	I	3.	140.	70.26	78.43	YES	2.50	3.0	28.85	99.5
1989	58	98	I	1.	130.	70.28	78.46	YES	1.50	1.0	16.15	95.8
1990	58	98	I	1.	123.	70.28	78.46	YES	1.50	1.1	17.03	99.7

1991	63	95	I	3.	187.	70.26	78.49	YES	1.75	2.9	39.53	99.5
1992	66	100	I	5.	155.	70.24	78.42	YES	2.75	4.7	40.78	99.5
1993	53	94	I	2.	331.	70.30	78.51	YES	1.50	2.2	35.86	99.6
1994	52	95	I	2.	342.	70.30	78.50	YES	1.00	2.4	57.67	94.7
1995	56	97	I	1.	41.	70.29	78.47	YES	1.50	0.9	13.62	98.8
1996	56	97	I	1.	50.	70.29	78.46	YES	1.00	0.6	14.06	99.8
1997	56	97	I	1.	17.	70.29	78.47	YES	1.00	0.8	19.66	99.9
1998	55	96	I	1.	347.	70.29	78.48	YES	0.50	0.8	40.08	98.6
1999	57	98	I	1.	76.	70.28	78.45	YES	1.00	0.9	21.49	94.7
2000	56	94	I	1.	288.	70.29	78.51	YES	1.75	1.3	18.17	99.5
2001	63	95	I	3.	191.	70.25	78.49	YES	8.75	5.5	15.09	98.6
2002	56	97	I	0.	32.	70.29	78.47	YES	1.00	0.5	11.66	99.8
2003	82	75	I	16.	219.	70.17	78.74	YES	44.75	45.8	24.59	82.5
2004	56	97	I	1.	62.	70.28	78.46	YES	1.50	0.8	13.18	99.6
2005	55	96	I	1.	1.	70.29	78.48	YES	0.75	1.1	34.10	97.9
2006	53	94	I	2.	328.	70.30	78.51	YES	1.25	2.3	44.26	99.0
2007	60	99	I	2.	138.	70.27	78.44	YES	1.50	2.1	32.82	99.6
2008	117	93	O	30.	181.	70.01	78.49	NO	97.50	109.5	26.96	4.9
2009	86	75	I	18.	215.	70.15	78.74	YES	16.50	21.7	31.60	64.9

Baffinland   Steensby Port   SPILL BEGINS AT 0000 HRS, 28 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

				END POSITION				ASHORE?	ELAPSED	PATH	MEAN	% AT
YEAR	ROW	COL	ORI	RANGE	BEARING	LAT	LONG		TIME	LENGTH	SPEED	ENDPT
				KM	DEG. T	NORTH	WEST		HOURS	KM	KM/DAY	
1980	126	110	I	35.	167.	69.98	78.27	YES	56.00	63.1	27.03	51.0
1981	63	100	I	4.	149.	70.25	78.43	YES	5.50	4.6	20.01	85.6
1982	119	81	I	31.	193.	70.01	78.66	YES	150.25	153.5	24.53	54.3
1983	80	75	I	15.	222.	70.18	78.75	YES	17.25	20.2	28.10	85.8
1984	66	100	I	5.	158.	70.24	78.43	YES	2.25	5.3	56.48	90.6
1985	53	94	I	2.	336.	70.30	78.50	YES	1.25	2.2	41.80	99.8
1986	59	98	I	1.	134.	70.28	78.46	YES	0.75	1.1	34.17	96.0
1987	66	100	I	5.	155.	70.24	78.42	YES	3.25	4.6	34.25	99.4
1988	60	99	I	2.	139.	70.27	78.44	YES	3.25	2.7	20.30	99.6
1989	55	96	I	1.	3.	70.29	78.48	YES	0.75	0.9	29.35	99.4
1990	59	98	I	1.	142.	70.27	78.46	YES	1.75	1.4	18.86	98.6
1991	180	98	O	61.	178.	69.73	78.40	BNDR	81.25	113.8	33.63	85.8
1992	55	64	I	16.	273.	70.29	78.90	YES	9.25	18.3	47.43	50.9
1993	56	97	I	1.	20.	70.29	78.47	YES	0.75	0.8	26.27	97.9
1994	58	98	I	1.	114.	70.28	78.45	YES	2.50	1.3	12.25	97.9
1995	55	97	I	1.	18.	70.29	78.47	YES	1.75	1.2	15.87	98.6
1996	55	96	I	1.	346.	70.29	78.48	YES	0.75	1.0	32.54	96.0
1997	56	97	I	1.	33.	70.29	78.47	YES	1.25	0.6	12.28	99.0
1998	55	96	I	1.	350.	70.29	78.48	YES	0.75	1.1	33.71	99.8
1999	70	102	I	7.	156.	70.22	78.40	YES	5.25	7.7	35.02	89.3
2000	56	94	I	1.	299.	70.29	78.50	YES	2.00	1.2	14.74	99.6
2001	53	95	I	2.	346.	70.30	78.49	YES	10.25	11.8	27.68	96.6
2002	55	96	I	1.	6.	70.29	78.47	YES	1.25	1.1	20.63	99.8
2003	64	100	I	4.	152.	70.25	78.43	YES	2.75	4.1	35.62	99.5
2004	56	97	I	1.	61.	70.28	78.46	YES	1.25	0.7	14.34	99.8
2005	56	97	I	1.	19.	70.29	78.47	YES	0.75	0.8	24.11	99.4
2006	53	94	I	2.	329.	70.30	78.51	YES	1.25	2.3	45.04	99.0
2007	59	98	I	1.	127.	70.28	78.45	YES	0.75	1.2	39.33	97.9
2008	60	99	I	2.	134.	70.27	78.44	YES	3.75	2.1	13.63	94.9
2009	67	101	I	5.	151.	70.24	78.41	YES	11.50	10.1	21.00	98.4

Baffinland   Steensby Port   SPILL BEGINS AT 0000 HRS, 29 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	66	100	I	5.	151.	70.24	78.42	YES	2.00	4.8	57.36	96.4
1981	79	74	I	15.	225.	70.19	78.76	YES	14.75	19.1	31.11	76.5
1982	59	98	I	1.	131.	70.27	78.45	YES	1.25	1.3	25.59	99.0
1983	59	92	I	2.	241.	70.27	78.53	YES	2.00	2.7	32.73	89.4
1984	64	100	I	4.	148.	70.25	78.42	YES	3.25	5.6	41.27	97.5
1985	55	96	I	1.	357.	70.29	78.48	YES	0.75	0.9	30.29	99.9
1986	55	96	I	1.	3.	70.29	78.48	YES	1.50	0.9	13.72	99.8
1987	180	81	O	62.	186.	69.73	78.63	BNDR	58.75	91.2	37.26	75.8
1988	59	99	I	2.	131.	70.27	78.44	YES	2.75	2.4	21.11	99.6
1989	55	97	I	1.	16.	70.29	78.47	YES	0.75	1.0	31.18	99.4
1990	56	97	I	1.	24.	70.29	78.47	YES	0.75	0.8	26.59	97.9
1991	180	97	O	61.	178.	69.73	78.42	BNDR	95.75	118.6	29.73	81.5
1992	59	92	I	2.	245.	70.27	78.53	YES	5.00	4.4	21.34	78.5
1993	56	97	I	1.	27.	70.29	78.47	YES	0.75	0.8	24.01	96.0
1994	56	93	I	1.	292.	70.29	78.51	YES	4.25	2.6	14.68	98.9
1995	55	96	I	1.	351.	70.29	78.48	YES	1.25	1.2	22.58	99.8
1996	53	94	I	2.	333.	70.30	78.50	YES	1.25	2.1	39.90	96.5
1997	55	97	I	1.	12.	70.29	78.47	YES	1.50	1.1	17.84	98.8
1998	53	94	I	2.	334.	70.30	78.50	YES	1.50	2.3	37.48	99.6
1999	59	98	I	1.	134.	70.27	78.46	YES	0.50	1.1	52.10	97.3
2000	56	97	I	1.	35.	70.29	78.47	YES	1.75	1.1	15.31	99.0
2001	37	66	O	18.	303.	70.37	78.89	NO	18.00	21.6	28.79	4.5
2002	55	96	I	1.	349.	70.29	78.48	YES	0.50	1.0	46.77	99.9
2003	117	81	I	30.	193.	70.01	78.66	YES	28.00	44.8	38.42	75.9
2004	56	97	I	1.	29.	70.29	78.47	YES	1.25	0.7	13.17	99.8
2005	56	97	I	1.	40.	70.29	78.47	YES	1.00	0.5	12.70	99.8
2006	53	94	I	2.	327.	70.30	78.51	YES	1.00	2.3	55.34	97.2
2007	53	95	I	2.	344.	70.30	78.49	YES	6.50	4.9	17.96	99.1
2008	56	97	I	1.	47.	70.29	78.46	YES	0.75	0.6	20.57	99.8
2009	59	98	I	1.	137.	70.27	78.45	YES	1.50	1.4	23.19	99.7

Baffinland Steensby Port SPILL BEGINS AT 0000 HRS, 30 SEPTEMBER

WIND SOURCE: DIRECTION STANDARD WITH SPEED STANDARD
CURRENT SOURCE: DIRECTION STANDARD WITH SPEED STANDARD

YEAR	ROW	COL	ORI	END POSITION RANGE KM	BEARING DEG. T	LAT NORTH	LONG WEST	ASHORE?	ELAPSED TIME HOURS	PATH LENGTH KM	MEAN SPEED KM/DAY	% AT ENDPT
1980	129	115	I	37.	164.	69.96	78.20	YES	79.25	85.6	25.91	44.2
1981	58	93	I	1.	242.	70.28	78.51	YES	1.25	1.4	27.32	93.4
1982	66	100	I	5.	155.	70.24	78.42	YES	2.50	5.0	48.13	99.4
1983	57	93	I	1.	274.	70.28	78.51	YES	1.25	1.5	28.14	93.4
1984	55	96	I	1.	357.	70.29	78.48	YES	6.00	5.1	20.37	99.2
1985	55	96	I	1.	3.	70.29	78.48	YES	1.00	0.8	19.69	99.8
1986	55	96	I	1.	345.	70.29	78.48	YES	1.50	0.9	14.61	99.8
1987	105	77	I	26.	201.	70.07	78.72	YES	44.50	57.7	31.09	85.6
1988	55	96	I	1.	0.	70.29	78.48	YES	5.25	3.2	14.54	99.3
1989	56	94	I	1.	298.	70.29	78.50	YES	3.50	2.3	15.47	99.3
1990	55	96	I	1.	358.	70.29	78.48	YES	0.75	0.8	26.81	99.8
1991	66	100	I	5.	156.	70.24	78.42	YES	2.25	5.0	53.09	99.6
1992	66	100	I	5.	155.	70.24	78.42	YES	2.50	4.9	47.25	99.6
1993	56	97	I	1.	18.	70.29	78.47	YES	0.50	0.8	39.79	99.9
1994	85	75	I	17.	217.	70.16	78.75	YES	11.75	19.8	40.52	37.7
1995	55	96	I	1.	2.	70.29	78.48	YES	0.50	0.9	45.28	99.9

1996	56	93	I	2.	282.	70.28	78.52	YES	0.75	1.7	55.73	96.0
1997	56	97	I	1.	40.	70.29	78.47	YES	0.50	0.6	29.41	98.6
1998	55	94	I	1.	324.	70.29	78.50	YES	0.75	1.3	42.80	97.9
1999	60	99	I	2.	137.	70.27	78.44	YES	1.50	2.1	33.28	98.8
2000	56	97	I	1.	43.	70.29	78.47	YES	1.00	0.5	12.87	99.7
2001	63	95	I	3.	189.	70.25	78.49	YES	4.75	4.3	21.97	96.1
2002	55	96	I	1.	349.	70.29	78.48	YES	0.50	0.9	44.73	99.9
2003	103	76	I	25.	203.	70.08	78.73	YES	78.75	76.2	23.22	85.9
2004	55	96	I	1.	350.	70.29	78.48	YES	1.50	1.0	16.68	99.7
2005	56	94	I	1.	291.	70.29	78.51	YES	1.50	1.3	20.56	98.8
2006	55	96	I	1.	353.	70.29	78.48	YES	0.50	0.8	39.89	99.9
2007	57	93	I	1.	275.	70.28	78.51	YES	3.50	2.5	16.91	99.4
2008	56	97	I	1.	30.	70.29	78.47	YES	3.25	1.1	8.34	99.6
2009	44	91	I	7.	338.	70.34	78.55	YES	43.75	45.7	25.06	35.9

SEPTEMBER SHORE IMPACT STATISTICS FOR Lagoon Complex

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
18	56	I	1	74.	74.	74.00	52.25	52.25	52.25
25	45	I	1	81.	81.	81.00	65.00	65.00	65.00
26	40	I	1	76.	76.	76.00	82.25	82.25	82.25

SEPTEMBER SHORE IMPACT STATISTICS FOR Rocky Northeast

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
19	69	I	1	69.	69.	69.00	79.25	79.25	79.25
25	68	I	1	69.	69.	69.00	36.00	36.00	36.00
26	68	I	1	49.	49.	49.00	53.75	53.75	53.75
27	67	I	1	34.	34.	34.00	66.25	66.25	66.25
35	68	I	1	68.	68.	68.00	34.00	34.00	34.00
44	91	I	1	35.	35.	35.00	43.75	43.75	43.75

SEPTEMBER SHORE IMPACT STATISTICS FOR Port Site

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
52	95	I	1	94.	94.	94.00	1.00	1.00	1.00
53	94	I	36	86.	99.	97.69	1.00	12.25	2.74
53	95	I	16	92.	99.	97.56	1.25	10.25	3.42
55	93	I	1	87.	87.	87.00	47.75	47.75	47.75
55	94	I	42	92.	99.	97.57	0.50	10.25	2.11
55	96	I	111	90.	99.	98.75	0.50	9.75	1.34
55	97	I	12	94.	99.	98.00	0.50	9.25	1.90
56	93	I	12	80.	99.	95.92	0.50	6.50	2.58
56	94	I	61	94.	99.	97.75	0.50	8.75	2.13
56	97	I	115	94.	99.	98.58	0.25	32.50	1.83
56	98	I	5	95.	99.	97.80	1.00	2.50	1.50
57	92	I	2	67.	76.	71.50	4.50	23.25	13.88
57	93	I	32	89.	99.	95.19	0.75	10.50	2.26
57	98	I	47	93.	99.	97.28	0.75	7.50	1.68
58	92	I	1	97.	97.	97.00	11.00	11.00	11.00
58	93	I	36	92.	99.	95.75	0.75	8.75	2.79
58	98	I	38	85.	99.	97.05	0.50	6.00	1.88
59	92	I	12	78.	99.	92.83	1.00	6.75	3.63
59	98	I	53	88.	99.	97.40	0.50	10.75	2.50
59	99	I	1	99.	99.	99.00	2.75	2.75	2.75
60	99	I	16	76.	99.	97.00	1.50	9.50	4.47
60	100	I	1	99.	99.	99.00	3.25	3.25	3.25
61	100	I	3	98.	99.	98.67	3.00	4.75	3.75

62	100	I	8	95.	99.	97.63	1.50	4.50	2.44
63	95	I	38	81.	99.	96.87	1.25	53.00	5.01
63	100	I	14	85.	99.	95.86	1.50	24.00	4.84
64	100	I	10	91.	99.	97.00	1.50	9.00	3.53
65	101	I	3	99.	99.	99.00	3.50	5.50	4.67
66	100	I	31	87.	99.	97.16	1.75	12.25	3.23
66	101	I	2	94.	97.	95.50	2.00	4.00	3.00
67	101	I	5	96.	99.	98.00	4.25	11.50	7.25
67	102	I	1	98.	98.	98.00	8.00	8.00	8.00
68	102	I	1	98.	98.	98.00	7.75	7.75	7.75
69	102	I	1	94.	94.	94.00	4.00	4.00	4.00
70	102	I	2	89.	98.	93.50	5.25	5.75	5.50
71	102	I	1	94.	94.	94.00	8.50	8.50	8.50
72	103	I	2	96.	99.	97.50	7.25	20.00	13.63

SEPTEMBER SHORE IMPACT STATISTICS FOR Rocky East

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
70	121	I	1	21.	21.	21.00	60.50	60.50	60.50
73	104	I	1	98.	98.	98.00	6.75	6.75	6.75
74	120	I	1	69.	69.	69.00	127.50	127.50	127.50
75	114	I	1	72.	72.	72.00	87.25	87.25	87.25
76	107	I	2	57.	95.	76.00	13.00	53.25	33.13
79	105	I	1	19.	19.	19.00	44.50	44.50	44.50

SEPTEMBER SHORE IMPACT STATISTICS FOR Inlet Islands

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
126	110	I	2	4.	51.	27.50	18.00	56.00	37.00
129	115	I	1	44.	44.	44.00	79.25	79.25	79.25
148	119	I	1	66.	66.	66.00	71.50	71.50	71.50

SEPTEMBER SHORE IMPACT STATISTICS FOR Koch Island

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
176	122	I	1	13.	13.	13.00	53.00	53.00	53.00

SEPTEMBER SHORE IMPACT STATISTICS FOR Coastal Plain West

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
54	64	I	1	93.	93.	93.00	28.75	28.75	28.75
55	64	I	2	50.	95.	72.50	9.25	22.50	15.88
56	64	I	1	92.	92.	92.00	44.25	44.25	44.25
58	65	I	1	84.	84.	84.00	71.50	71.50	71.50
60	65	I	3	40.	88.	59.67	11.25	19.25	14.92
62	66	I	2	84.	89.	86.50	26.50	40.50	33.50
63	66	I	2	79.	87.	83.00	18.00	72.50	45.25
64	66	I	1	69.	69.	69.00	18.25	18.25	18.25
64	67	I	2	65.	95.	80.00	15.00	24.25	19.63
65	67	I	1	89.	89.	89.00	36.75	36.75	36.75
70	70	I	3	51.	91.	70.33	11.50	20.50	15.67
71	70	I	1	89.	89.	89.00	20.75	20.75	20.75
72	71	I	1	46.	46.	46.00	11.25	11.25	11.25
73	71	I	2	75.	94.	84.50	16.75	18.75	17.75
74	72	I	2	54.	62.	58.00	8.50	15.25	11.88
75	73	I	2	61.	82.	71.50	7.25	17.50	12.38

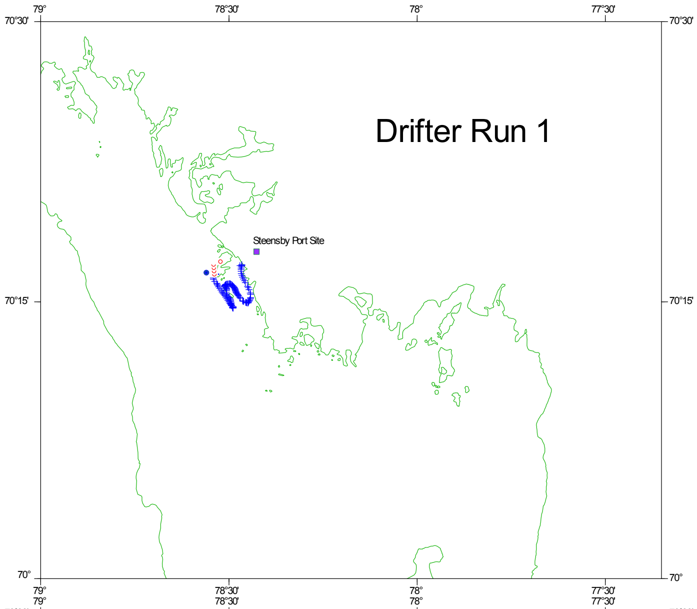
76	74	I	6	17.	95.	75.00	13.25	46.50	23.50
77	74	I	1	57.	57.	57.00	8.00	8.00	8.00
78	74	I	4	48.	86.	67.25	10.25	66.75	25.88
79	74	I	6	53.	96.	82.50	8.75	29.25	20.29
80	75	I	5	31.	93.	72.00	17.25	32.25	22.65
81	75	I	1	46.	46.	46.00	14.25	14.25	14.25
82	75	I	2	33.	82.	57.50	12.50	44.75	28.63
83	75	I	1	78.	78.	78.00	25.00	25.00	25.00
84	75	I	2	50.	96.	73.00	12.25	19.25	15.75
85	75	I	1	37.	37.	37.00	11.75	11.75	11.75
86	75	I	1	64.	64.	64.00	16.50	16.50	16.50
89	75	I	1	88.	88.	88.00	39.50	39.50	39.50
90	75	I	1	41.	41.	41.00	17.25	17.25	17.25
91	76	I	5	33.	92.	59.80	15.75	37.00	22.00
93	76	I	1	37.	37.	37.00	11.75	11.75	11.75
96	76	I	3	56.	70.	62.33	44.25	60.00	51.00
103	76	I	3	75.	93.	84.33	35.25	78.75	50.25
105	77	I	1	85.	85.	85.00	44.50	44.50	44.50
106	79	I	1	86.	86.	86.00	49.00	49.00	49.00
106	80	I	1	16.	16.	16.00	19.00	19.00	19.00
109	80	I	1	36.	36.	36.00	54.00	54.00	54.00
110	80	I	1	85.	85.	85.00	28.75	28.75	28.75
111	80	I	1	51.	51.	51.00	65.00	65.00	65.00
113	80	I	1	73.	73.	73.00	62.00	62.00	62.00
117	81	I	2	75.	90.	82.50	28.00	55.50	41.75
119	81	I	1	54.	54.	54.00	150.25	150.25	150.25
122	82	I	2	35.	83.	59.00	72.50	86.50	79.50

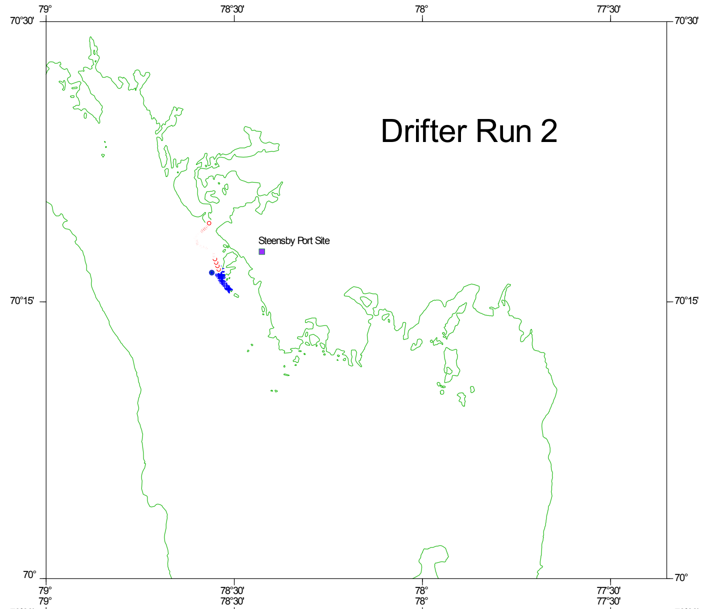
SEPTEMBER SHORE IMPACT STATISTICS FOR Coastal Plain Northwest

POSITION ROW	COL	ORI	NUMBER IMPACTS	MIN. VOL. PER CENT	MAX. VOL. PER CENT	MEAN VOL. PER CENT	EARLIEST TIME (HR)	LATEST TIME (HR)	MEAN TIME (HR)
46	58	I	1	89.	89.	89.00	25.00	25.00	25.00
50	61	I	1	94.	94.	94.00	37.50	37.50	37.50
51	62	I	1	37.	37.	37.00	13.25	13.25	13.25
52	62	I	1	50.	50.	50.00	9.25	9.25	9.25

APPENDIX C

OST CURRENT DROGUE DRIFTER MODEL PLOTS


Drifter Run 1
Steensby Port Site
79°
78°30'
78°
77°30'
70°30'
70°15'
70°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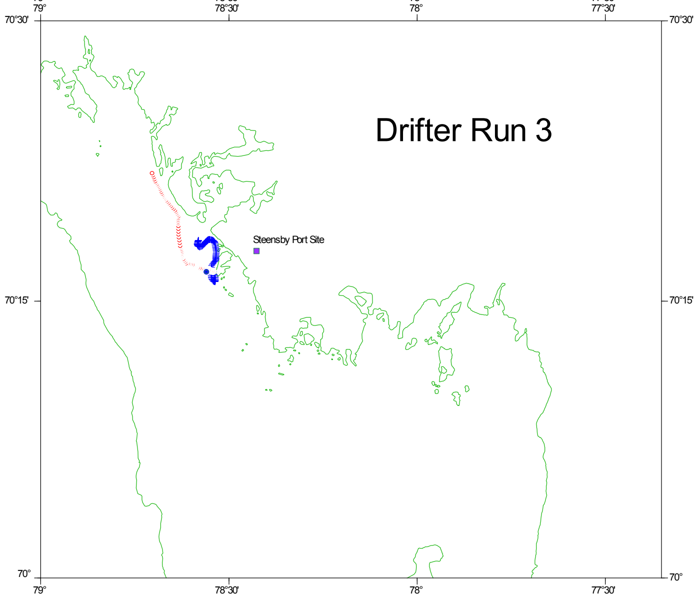
70°30'
70°15'
70°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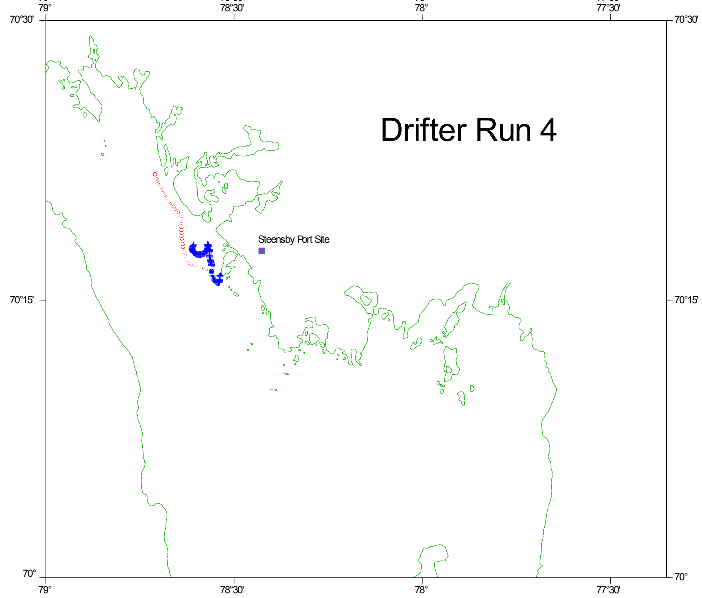
70°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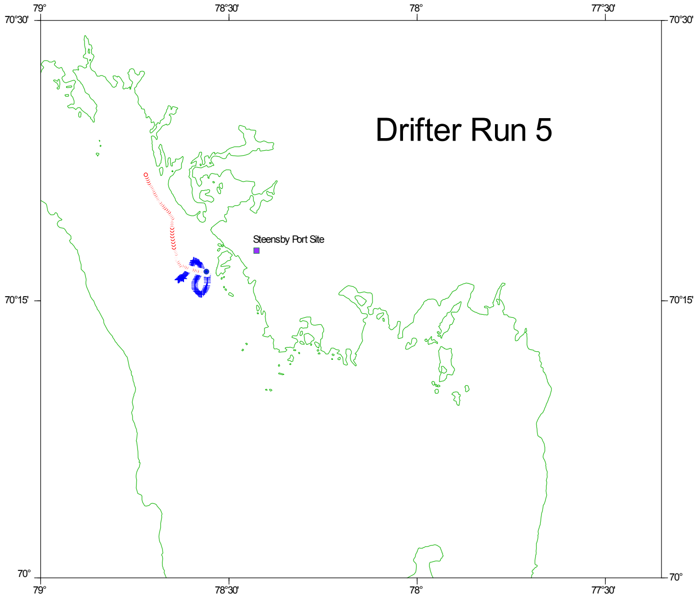
70°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Steensby Port Site
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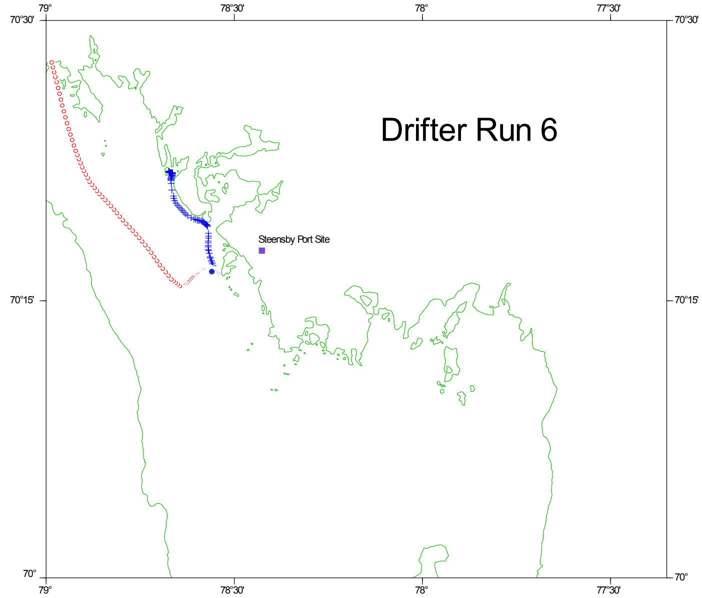
77°30'
70°30'
70°15'
70°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Steensby Port Site
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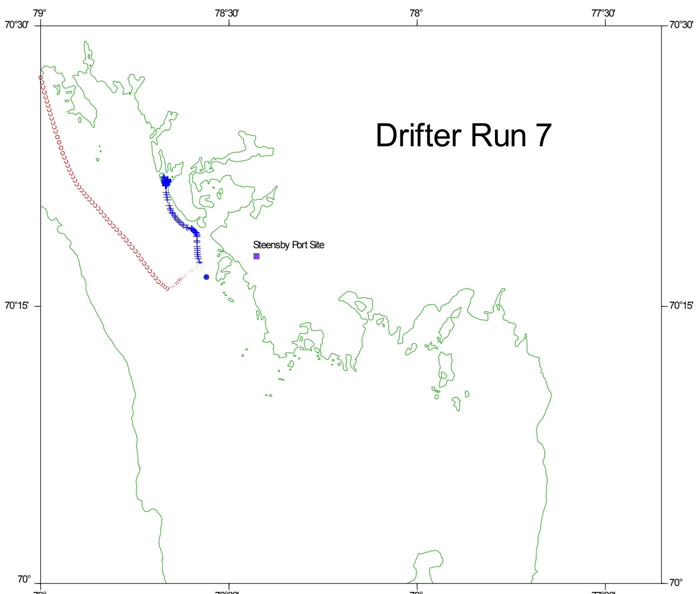
70°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Steensby Port Site
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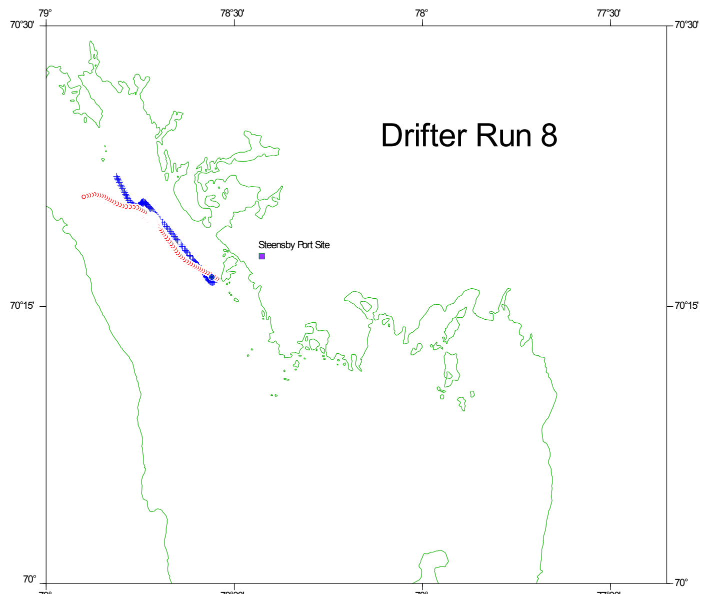
77°30'
70°30'
70°15'
70°


Drifter Run 8
Steensby Port Site
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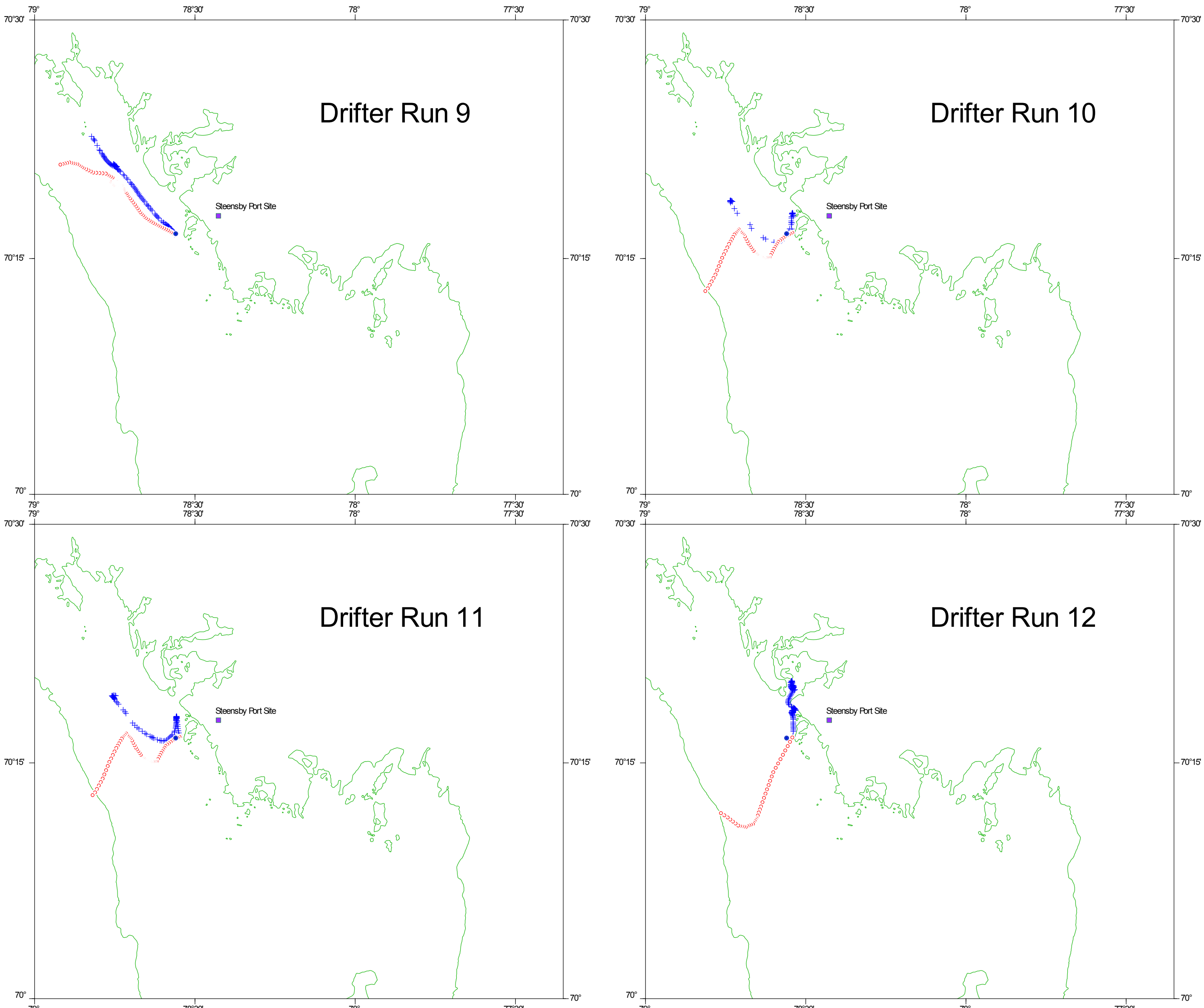
77°30'
70°30'
70°15'
70°


Drifter Run 9
Steensby Port Site
Drifter Run 10
Steensby Port Site
Drifter Run 11
Steensby Port Site
Drifter Run 12
Steensby Port Site
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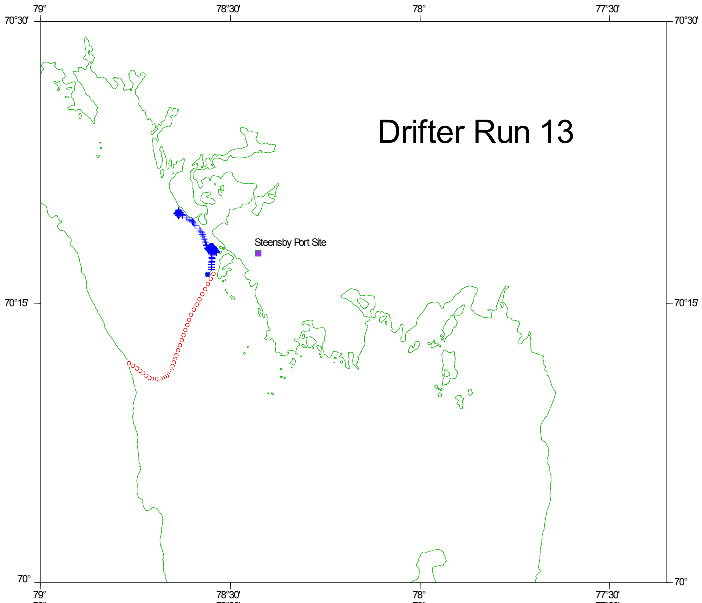
78°30'
78°
77°30'
70°30'
70°15'
70°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Steensby Port Site
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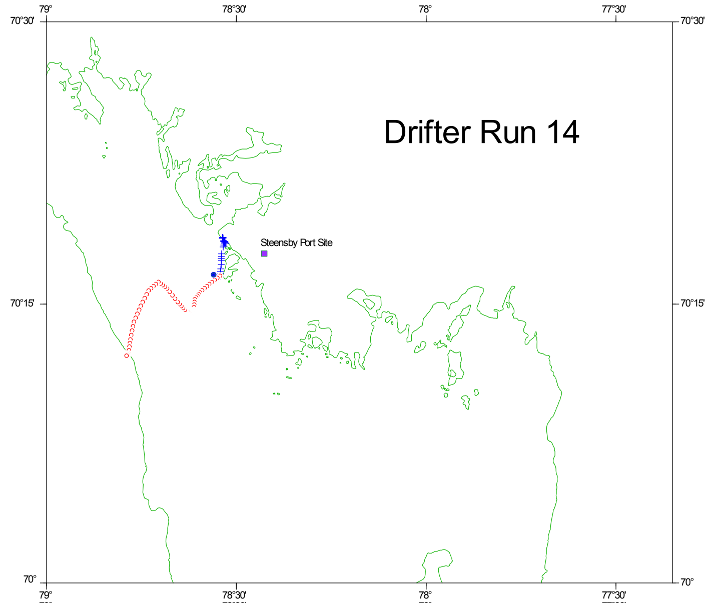
78°
77°30'
70°30'
70°15'
70°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Steensby Port Site
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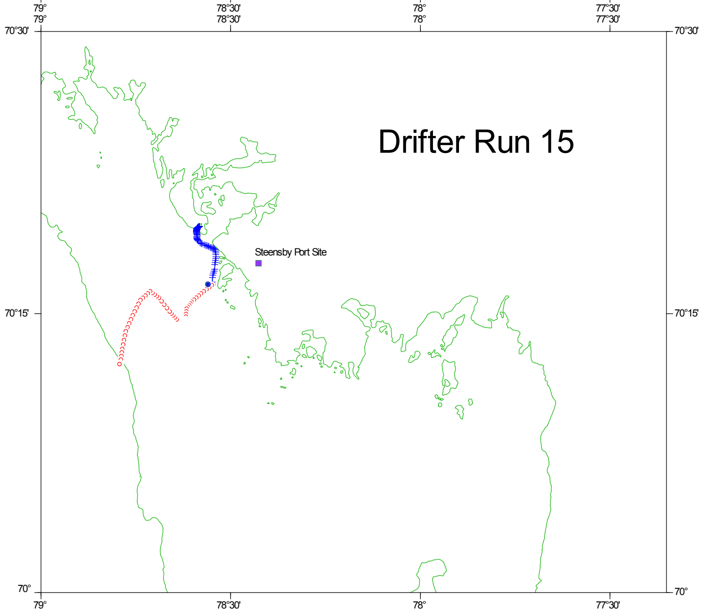
70°15'
70°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Steensby Port Site
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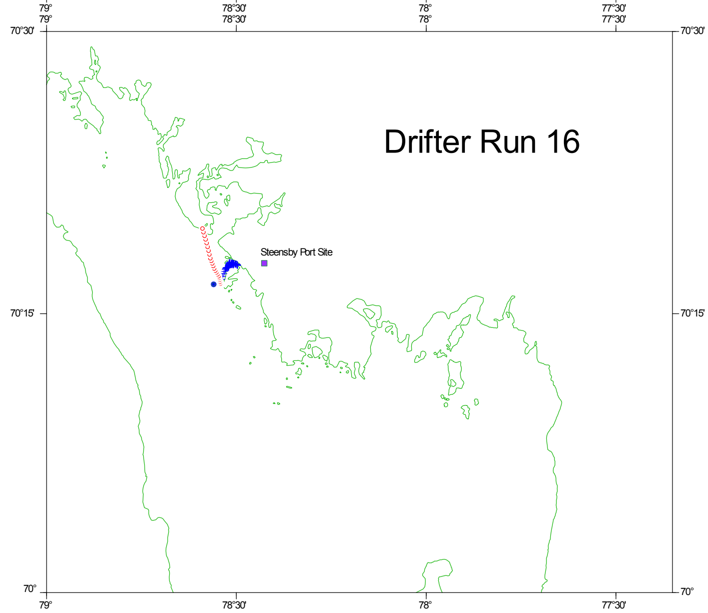
70°15'
70°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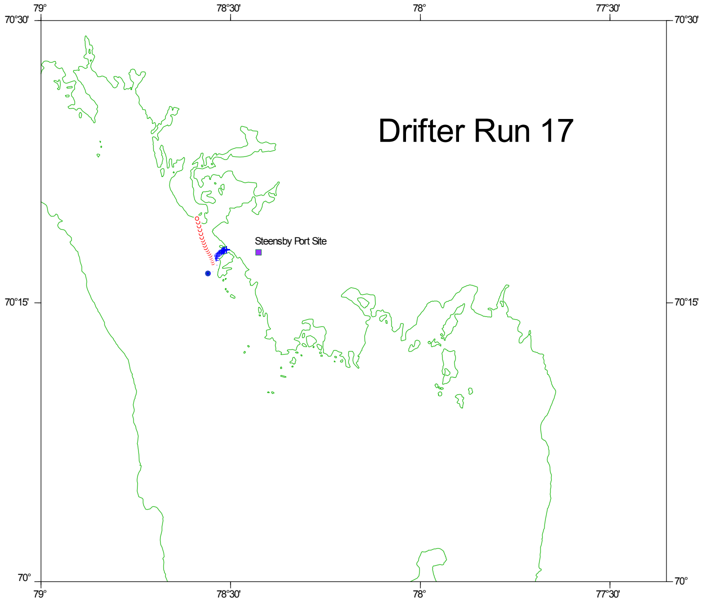
70°15'
70°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Steensby Port Site
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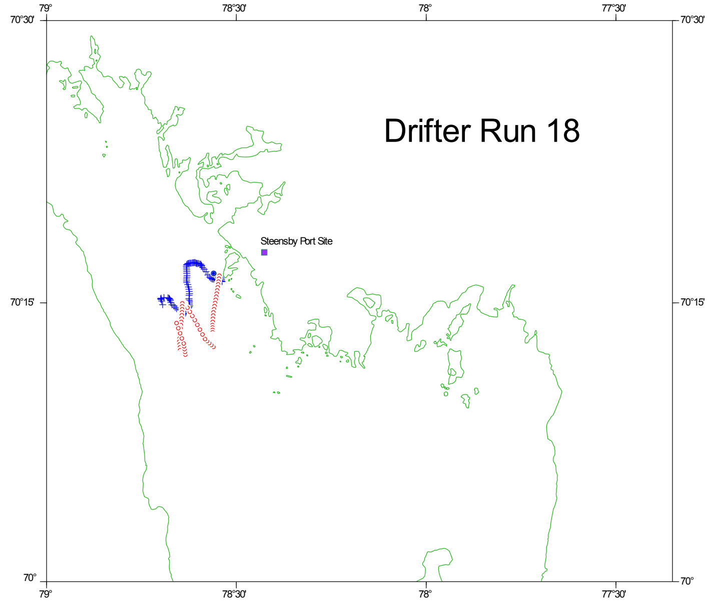
78°30'
78°
77°30'
70°30'
70°15'
70°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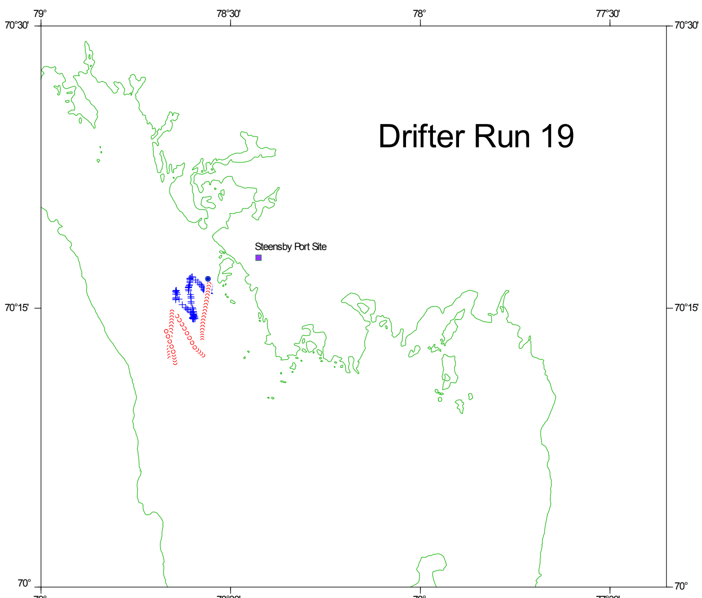
Steensby Port Site
79°
78°30'
78°
77°30'
70°30'
70°15'
70°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Steensby Port Site
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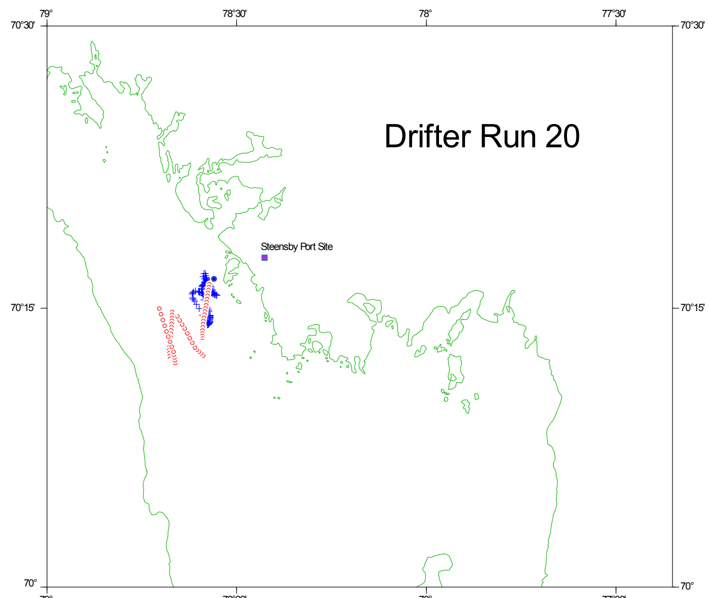
78°30'
78°
77°30'
70°30'
70°15'
70°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Steensby Port Site
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77°30'
70°30'
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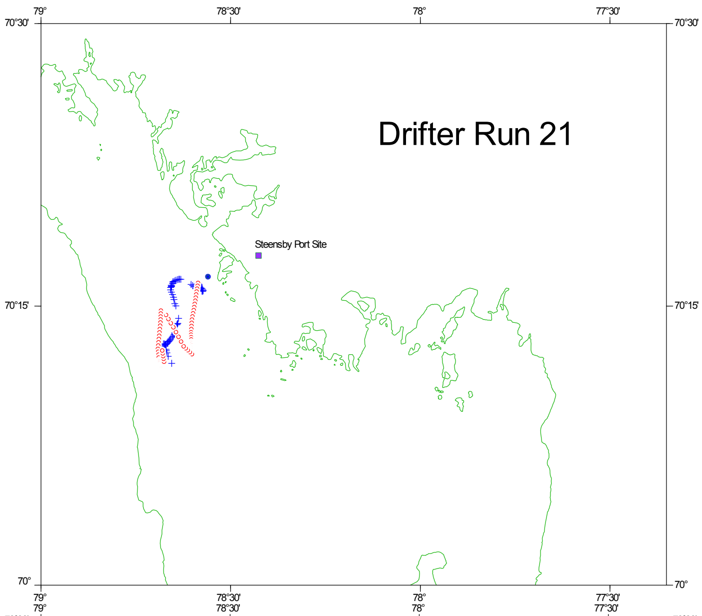
70°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Steensby Port Site
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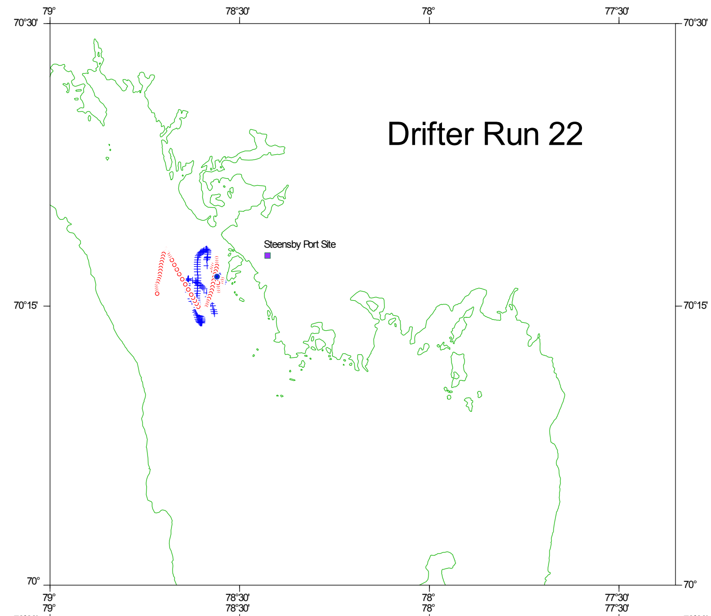
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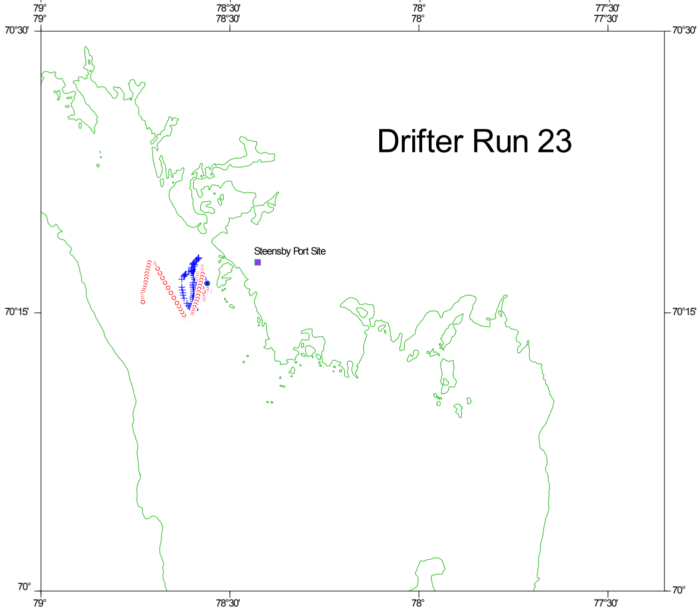
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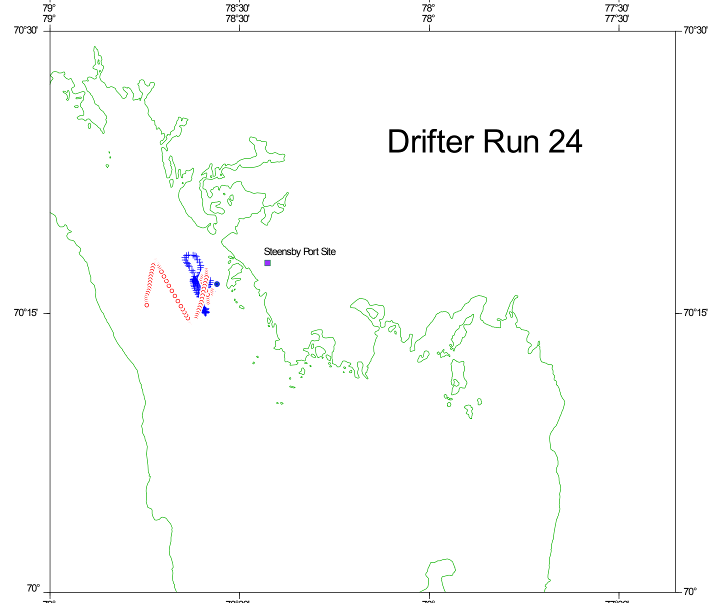
70°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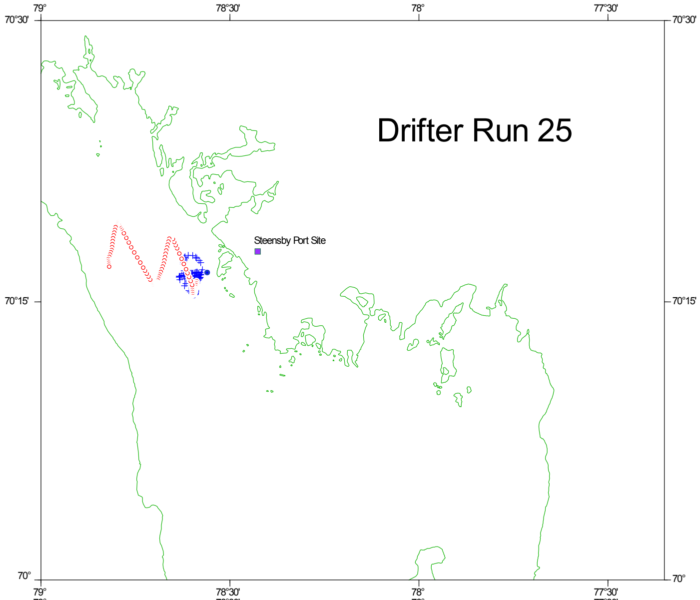
78°
77°30'
70°30'
70°15'
70°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Steensby Port Site
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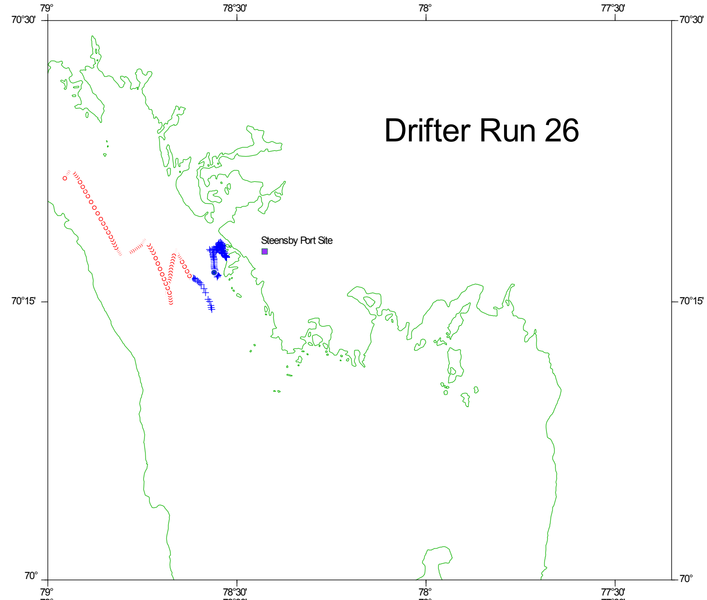
78°
77°30'
70°30'
70°15'
70°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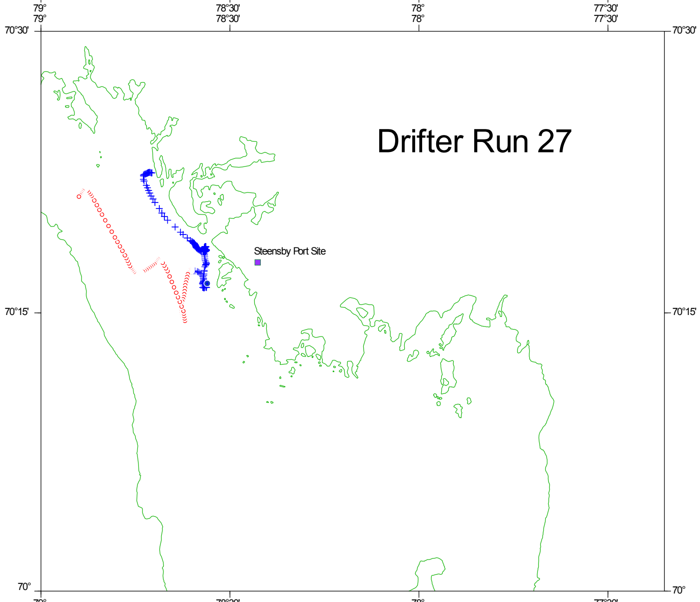
78°
77°30'
70°30'
70°15'
70°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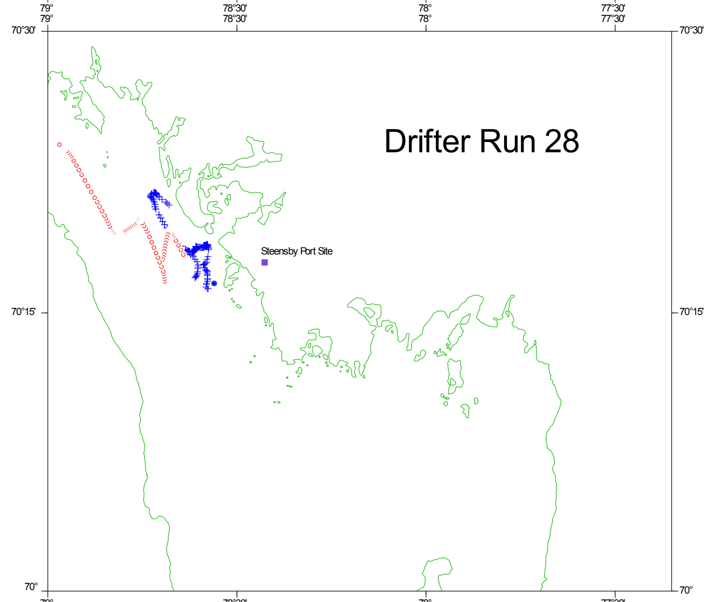
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78°
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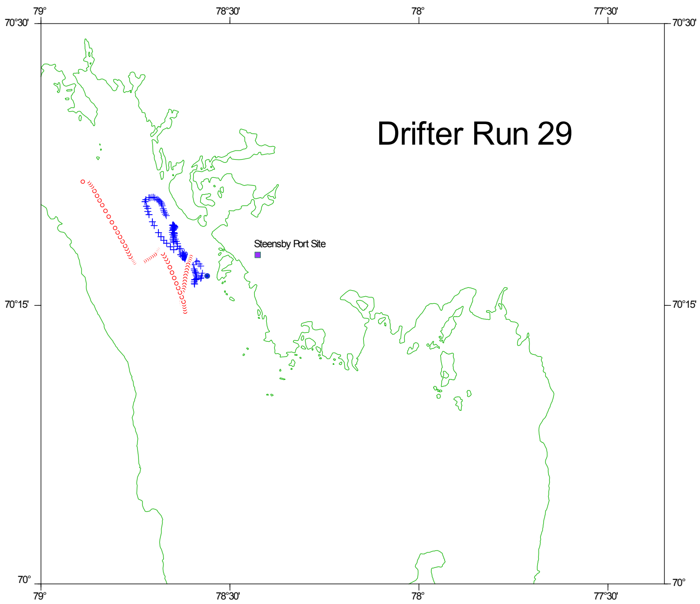
70°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Steensby Port Site
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78°
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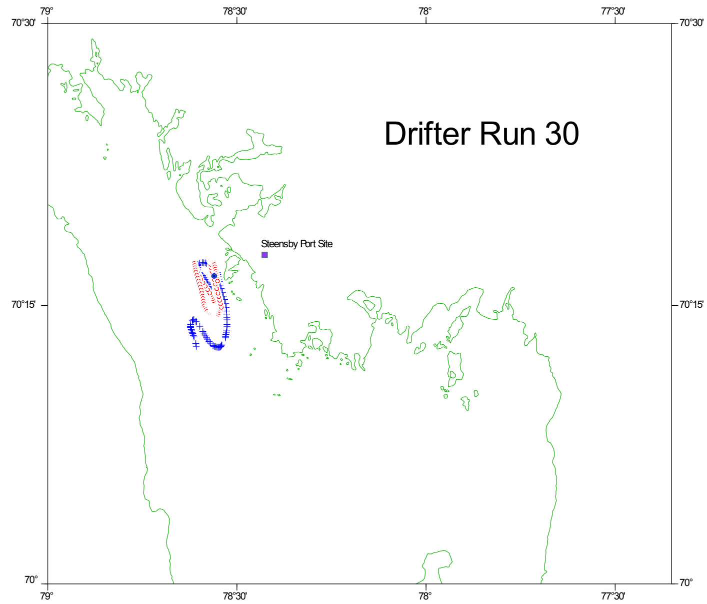
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Steensby Port Site
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78°
77°30'
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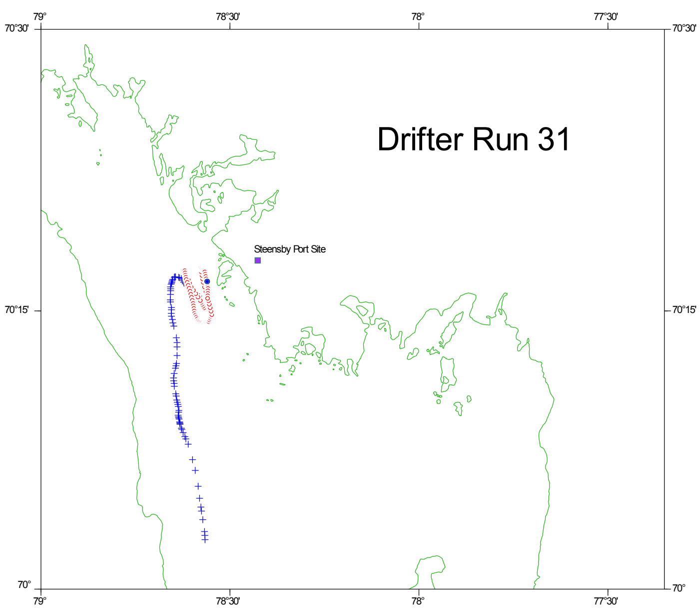
70°15'
70°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Steensby Port Site
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78°
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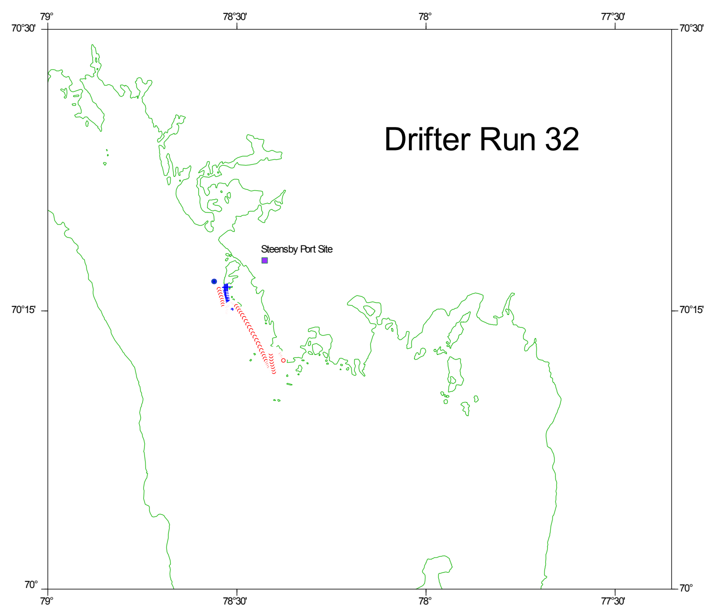
70°30'
70°15'
70°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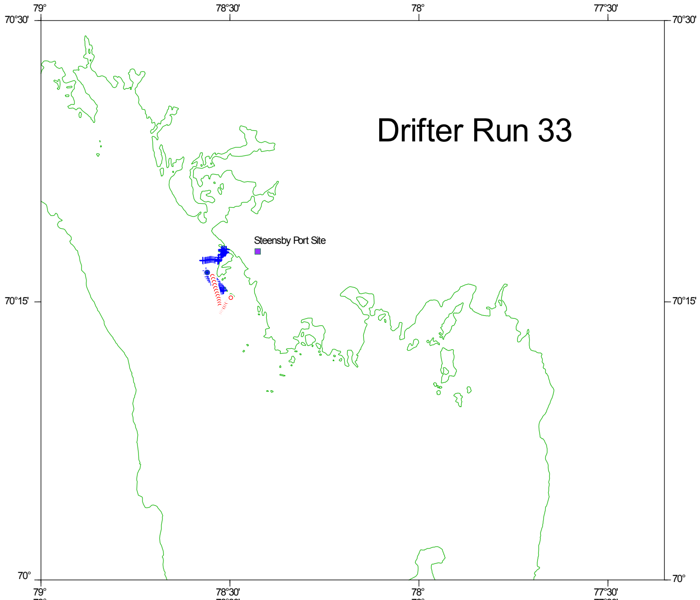
70°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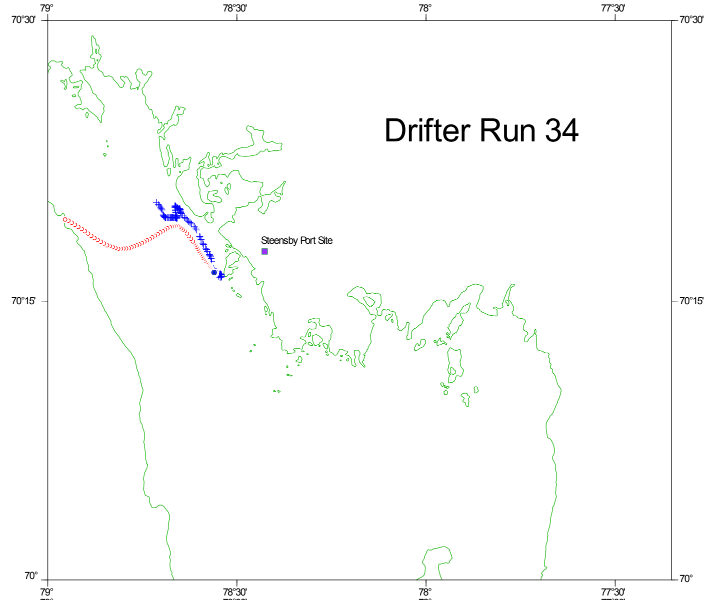
78°
77°30'
70°30'
70°15'
70°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Steensby Port Site
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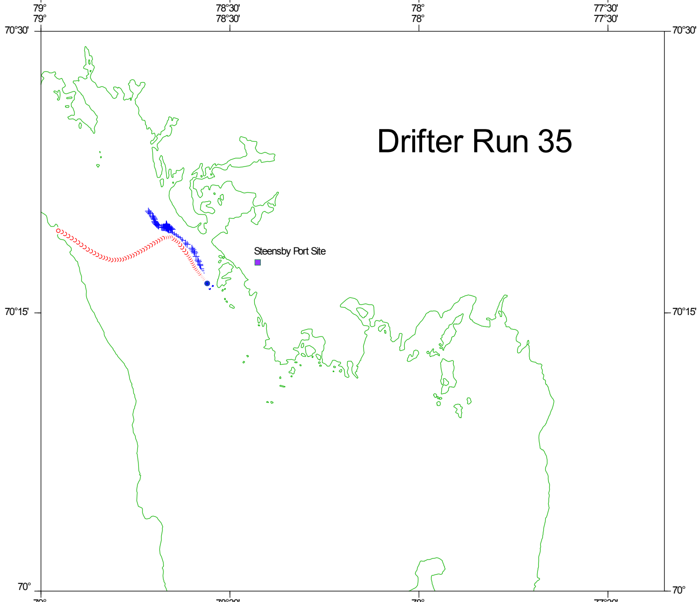
78°
77°30'
70°30'
70°15'
70°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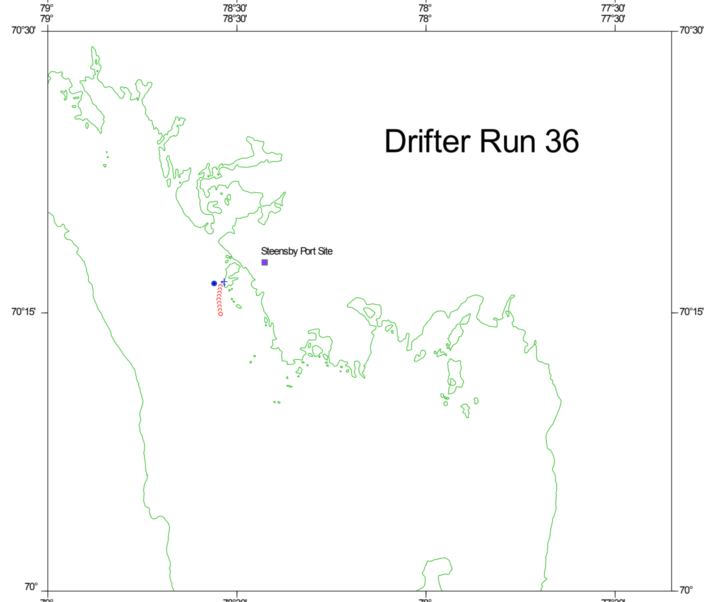
70°


Drifter Run 36
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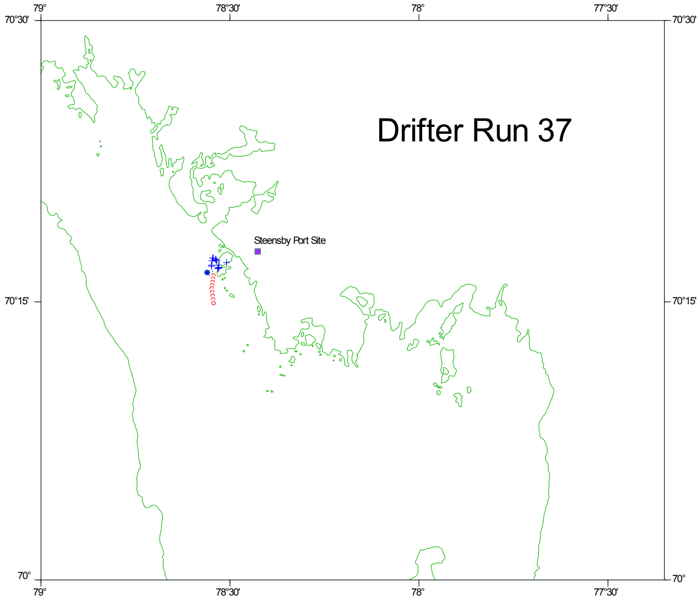
70°15'
70°



Drifter Run 37
Steensby Port Site
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70°30'
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70°