SENES Consultants Limited

Specialists in Energy, Nuclear and Environmental Sciences

**DELIVERABLE 3: FINAL REPORT**

**Articles of Agreement No: NAR-2005-001/001**

# A STUDY OF THE ANTICIPATED IMPACTS ON CANADA FROM THE DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINALS ON PASSAMAQUODDY BAY

**Prepared for:**

**Government of Canada**
**Ottawa, Ontario**

**Prepared by:**

**SENES Consultants Limited**
901 Bank Street
Ottawa, Ontario
K1S 3W5

Printed on Recycled Paper Containing Post-Consumer Fibre

## IN DEDICATION

The project team members who helped prepare this report would like to honour the memory of Dr. Charles (Chuck) Shom, a dedicated member of the team, who died unexpectedly during the project period. Chuck was a valued expert providing excellent contributions to this report, particularly with respect to whale species, habitat and behaviour in the Quoddy Region.

# TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF TABLES (Cont'd)

## LIST OF TABLES (Cont'd)

## LIST OF FIGURES

## LIST OF ABBREVIATIONS

| | |
|---|---|
| ACCDC | Atlantic Canada Conservation Data Centre |
| AIS | Automatic Information System |
| ASNB | Archaeological Services New Brunswick |
| CCG | Canadian Coast Guard |
| CEPA | *Canadian Environmental Protection Act* |
| CMRMC | Canadian Marine Response Corporation |
| COSEWIC | Committee on the Status of Wildlife in Canada |
| CPPI | Canadian Petroleum Products Institute |
| DFO | Department of Fisheries and Oceans |
| DGPS | Differential Global Positioning System |
| DWT | Deadweight Tonnes |
| ECDIS | Electronic Chart Display Information System |
| ECRC | Eastern Canada Response Corporation |
| EES | Environmental Emergencies Section |
| EIS | Environmental Impact Statement |
| EMO | Emergency Measures Organization |
| ESA | Environmentally Sensitive or Significant Area |
| FEIS | Final Environmental Impact Statement |
| FERC | Federal Energy Regulatory Commission |
| HHWLT | Higher High Water and Large tide |
| HNS | Hazardous and Noxious Substances |
| HP | Horsepower |
| IMDG | International Maritime Dangerous Goods |
| IMO | International Maritime Organization |
| INNAV | Information System on Marine Navigation |
| LFL | Lower Flammable Limit |

| | |
|---|---|
| LNG | Liquified Natural Gas |
| LOA | Length Overall |
| M&NE | Maritimes and Northeast |
| MARPOL | International Convention for the Prevention of Pollution from Ships |
| MCTS | Marine Communications and Traffic Services |
| NBDNRE | New Brunswick Department of Natural Resources and Energy |
| NM | Nautical Miles |
| OPEPs | Oil Pollution Emergency Plans |
| OPPRs | Oil Pollution Prevention Regulations |
| OPRC | Oil Pollution Preparedness, Response and Cooperation |
| PDRR | Pollutant Discharge Reporting Regulations |
| POL | Petroleum, Oil and Lubricant |
| PSEPC | Public Safety and Emergency Preparedness Canada |
| REET | Regional Environmental Emergencies Team |
| RO | Regional Response Organizations |
| RPM | Revolutions Per Minute |
| SARA | *Species at Risk Act* |
| SCAT | Shoreline Cleanup and Assessment Technique |
| US EPA | United States Environmental Protection Agency |
| VEC | Valued Ecosystem Component |
| VOCs | Volatile Organic Compounds |
| WCSC | Waterborne Commerce Statistics Centre |
| WHMIS | Workplace Hazardous Materials information System |

# 1.0 INTRODUCTION

## 1.1 PURPOSE

The purpose of this study is to undertake a qualitative assessment of the potential impacts/risks associated with the development of Liquified Natural Gas (LNG) Terminal(s) on the United States side of Passamaquoddy Bay. This includes, but is not limited to, the impacts that may result from marine traffic through Canadian waters (the approaches to Head Harbour Passage, Head Harbour Passage and Passamaquoddy Bay). The purpose of this report is to document the results of this qualitative risk assessment.

## 1.2 SCOPE

As indicated in the Request for Proposal the scope of this work is to include an assessment of the environmental impacts, marine/navigational safety impacts and socio-economic impacts associated with the development of LNG Terminal(s) on the US side of Passamaquoddy Bay. The assessment needs to consider the potential impacts on the marine environment and, because this is linked through coastal ecosystems and wetlands to the terrestrial environment, potential impacts on local land-based flora and fauna.

## 1.3 BACKGROUND

LNG is an important element of North America's non-renewable energy alternatives and competition to provide facilities for receipt, re-gasification and conveyance is increasing. Experience with the LNG sector is limited and Canada's capacity to control and regulate the sector is being tested. Note that because the LNG Terminal(s) being proposed for the US side of Passamaquoddy Bay fall outside of the Canadian environmental assessment and regulatory process, the ability to respond or make policy decisions regarding these proposals is limited. This has lead to the need for a comprehensive assessment of the potential impacts and risks that may result from these proposed initiatives. Even though the Government of Canada has some experience in this regard, a complete quantitative review of the project, similar to a Strategic Environmental Assessment, is beyond the scope of and allocated resources for this study.

## 1.4 APPROACH AND METHODOLOGY

In general terms, the methodology used for this study consisted of a review of publicly available information on transportation and navigational issues, marine and other environments and socio-economic impacts. Details regarding the approach used for each of these areas are included in the relevant sections.

## 1.5 REPORT LAYOUT

This report details the findings of a qualitative assessment of the potential risks/impacts associated with the development of LNG Terminal(s) on the United States side of Passamaquoddy Bay. The report starts with a short introductory chapter setting the context of the study. It is followed by a chapter outlining three worst case risk scenarios that are used as a basis for determining potential environmental and socio-economic impacts. The subsequent chapters describe the Transportation and Navigational (Chapter 3.0), Marine Environmental (Chapter 4.0), Other Environmental (Chapter 5.0) and Socio-economic (Chapter 6.0) issues of the Quoddy Bay region, as well as assessing the impacts that the risk scenarios may have in each of these areas. Finally, Chapter 7.0 identifies potential effects and policy considerations associated with the construction of LNG Terminals in the region. The report is supported by and extensive reference list (Chapter 8.0) and an appendix consisting of detailed tables and figures.

# 2.0 APPROACH TO RISK ASSESSMENT

As indicated in Chapter 1, the purpose of this study is to provide a qualitative assessment of the potential impacts/risks to Canada associated with the development of LNG Terminal(s) on the United States side of Passamaquoddy Bay. This includes the potential impacts that may arise while vessels are in transit or with vessels alongside (i.e., moored). Given the proximity of shore based facilities to the Canadian border, some consideration has also been given to major hazards at the shore facilities with potential to affect Canada.

## 2.1 BACKGROUND

Liquefied Natural Gas (LNG) is an important element of North America's non-renewable energy alternatives and competition to provide facilities for receipt, re-gasification and conveyance is increasing. While there is considerable experience with LNG worldwide, in the current situation, the proposed LNG Terminal(s) are on the US side of Passamaquoddy Bay and fall outside of the Canadian environmental assessment and regulatory processes. Thus, Canada's ability to evaluate, question, respond or make policy decisions regarding the LNG Terminal proposals is limited. This has lead to the need for a comprehensive assessment of the potential impacts and risks that may result from the proposed LNG facilities. Moreover, even though the Government of Canada has some experience in this regard, Canadian experience with similar facilities is limited. Thus, a review of currently available information concerning the proposed facilities was carried out. The review was performed in the framework of a risk assessment, which attempts to answer the following questions:

- What can go wrong?
- How likely is something to go wrong?
- If something goes wrong, what are the consequences?

This Chapter outlines the risk assessment approach taken in this report. The current risk assessment is qualitative in nature but is intended to provide insight concerning the potential major hazards associated with the proposed LNG facilities that have potential to affect Canada or Canadian waters. The discussions in this chapter are also intended to provide the basis for a preliminary checklist of risk related factors that need to be considered fully in FERC's assessment of the proposed LNG facilities.

Subsequent Sections of this report provide elaboration of many of the issues identified in this Chapter.

### 2.1.1 Project Description

Three locations have been proposed future LNG facilities as shown in Figure 2.1. It is evident from Figure 2.1, that, although unlikely, any major hazards arising from the shipping, transfer of LNG to shore facilities, or onshore processing of LNG, have the potential to impact Canada and/or Canadian waters.

The following sections provide brief descriptions of the proposed facilities. All require ships to transit Canadian waters to supply the proposed Terminals with LNG. Additional information about the each Project is available on the proponents' websites.

#### *2.1.1.1 Quoddy Bay LNG Project (Split Rock)*

Located along the western shore of Western Passage in Pleasant Point and Perry, Washington County, the proposed Quoddy Bay LNG Terminal will supply up to approximately 600 million litres (2.0 billion cubic feet) of natural gas to Maine and the New England region per day (http://www.quoddylng.com/). This facility will consist of the following four main components:

- the LNG Import and Regasification Facility which will consist of a 518.16 meter (1,700 foot) pier with two berths and regasification equipment;
- the Split Rock Support Facility will include offices, control buildings, warehouses, and potentially a nitrogen mitigation plant. The Support facility with the necessary, power, metering, odorizing and other support structures may be located on Split Rock lands. Alternatively, a cogeneration/regasification facility may be located at the pier head on a floating barge;
- the Onshore Storage and Regasification Facility will include three storage tanks having the capacity to store 2.83 billion litres (10.0 billion cubic feet) of natural gas, as well as include additional independent regasification equipment; and
- a Sendout Pipeline which will connect the facilities to the Maritimes and Northeast (M&NE) pipeline system (http://www.quoddylng.com/).

A Notice of Intent to prepare an Environmental Impact Statement (EIS) for this project was filed with the United States Federal Energy Regulatory Commission (US FERC) on 14 March, 2006.

#### 2.1.1.2 Downeast LNG Project (Mill Cove)

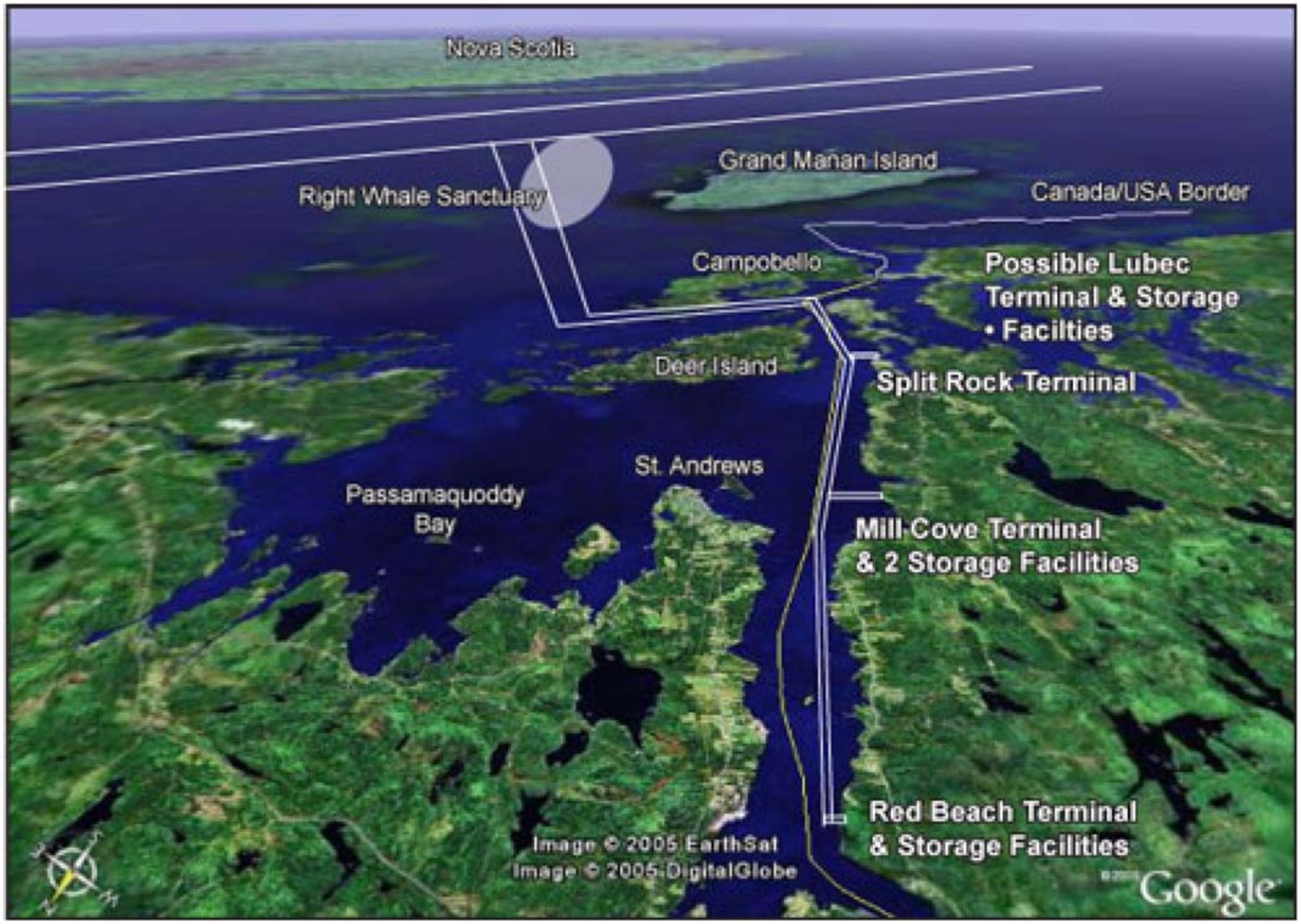
The Downeast LNG Project is sited on the south side of Mill Cove in Robbinston, Maine (http://www.downeastlng.com/). Located near the confluence of the St. Croix River and Passamaquoddy Bay, the proposed facility will consist of the following key components:

- a marine LNG terminal, including a single berth 1177 meter (3862 foot) pier, capable of handling about 50 LNG tankers per year, ranging in size from 70,000 to 220,000 cubic meters per ship;
- three 40.64 cm (16 inch) diameter unloading arms and one vapour return line on the unloading platform, with an unloading capacity rate of 14,000 cubic meters of LNG per hour;
- one insulated LNG storage tank with a capacity of 160,000 cubic meters;
- boil-off gas management system and send out pumps;
- submerged combustion vapourizers to re-vapourize LNG to natural gas;
- electrical power distribution, including substations and transformers;
- ancillary terminal facilities, including control room, maintenance shop, warehouse, office, security, and safety systems,
- measurement controls and natural gas metering facilities; and
- a 49.89 km (31 mile) long, 50.8 cm (20 inch) or 60.96 cm (24 inch) diameter natural gas send out pipeline, extending from the LNG terminal to the existing M&NE pipeline system at Baileyville, Main compressor station. (Federal Register/Vol. 71, No. 54/Tuesday, March 21, 2006/Notices).

A Notice of Intent to prepare an EIS for this project was filed with the U.S. FERC on 13 March, 2006.

Subsequent to submission of this notification, the U.S. EPA has advised FERC that the EIS should consider how many LNG import facilities are required in the New England region and whether other proposed terminals in both the U.S. and Canada obviate the need for this one. U.S. EPA further recommends that FERC treat the Downeast, Quoddy Bay and Calais LNG projects as alternatives to each other and assess the advantages and disadvantages of these alternatives, including providing rationale for preferring one option over another.

## FIGURE 2-1 General Arrangement of Three Proposed LNG Terminal Facilities




Source: www.scep.org/LNG.html.

#### *2.1.1.3 Calais LNG Project (Red Beach)*

The Calais LNG project will consist of an import terminal and storage facilities in the village of Red Beach in Calais, Maine (http://www.cianbro.com/press/newsview.asp?sid=1569). The more than 300-acre site is located between Devil's Head Conservation Park and St. Croix Island. Of the three projects, the Calais LNG Project is closest to the Canadian border and is in the narrowest section of the St. Croix River. Daily send out capacity will be 283 million litres (1.0 billion cubic feet) of natural gas from two 160,000 cubic meter storage tanks (http://www.pr-ac.ca/files/Transportation_Update-PRAC-CERI-FINAL.pdf).

Note that when this report was drafted initially, a Notice of Intent for the Calais LNG project had not been filed with the FERC. During a discussion with Dean Girdis, CEO of Downeast LNG, it was learned that this project has been cancelled in its entirety.

### 2.1.2 LNG Transport Vessels

At this time, specific information about the LNG transport vessels is not available, other than its likely volume capacity of 145,000 $m^3$. Two types of vessels with this capacity are available, the first is a conventional sphere-type model and the second is a membrane-type model both of which are illustrated in Figure 2-2. These two types of vessels have similar features and provide equivalent manoeuvring performance. The only difference that may affect the manoeuvrability of these vessels (membrane versus spherical) is the windage, which differs as the spherical vessels' foredeck is higher off the water than is the foredeck of the membrane vessel.

**FIGURE 2-2 Potential LNG Transport Vessels**

**Spherical Vessel**

**Membrane Vessel**

For illustrative purposes, the specifications of the vessel used as the basis for discussion later in this study are as follows:

| | |
|---|---|
| Length over all (LOA) | 283 m |
| Length between perpendiculars | 270 m |
| Beam | 43.3 m |
| Depth | 26 m |
| Draft | 11.4 m |
| Tanks (capacity) | 145,100 $m^3$ |
| Engine | Steam turbine |
| Spec. Engine | 44500 HP x 90 RPM |
| LNG Storage | GTT Mark III Membrane system |

It should be noted that although specific information concerning the characteristics of the LNG vessels is not available at this time, that LNG tankers are sophisticated vessels. These vessels are built in accordance with construction criteria approved by the International Maritime Organization and supervised by classification societies. Vessels navigating Canadian waters will have to comply with the requirements set out by Transport Canada with respect to certification, safety inspections and other regulatory points of concern.

## 2.2 APPROACH TO RISK ASSESSMENT

In this section, we provide a general discussion of the underlying risk assessment issues. Note that much of the material in Table 2-1 is taken from Lloyd's Register's Risk Assessment Review of the Marine Transportation of Liquefied Natural Gas, STD Report #3000-1-2, September 1992; West, H.H. and M.S. Mannan, Texas A&M University: LNG Safety Practice & Regulation: From 1944 East Ohio Tragedy to Today's Safety Record, AIChE meeting, April 2001 and CH-IV International: Safety History of International LNG Operations, November 2002.

### 2.2.1 What Can Go Wrong?

For proposed marine terminals in Canada, Transport Canada has developed a generic risk assessment process (TERMPOL 2001) that is intended to provide a systematic review of a proponent's assessment of risks either enroute to or docked at a terminal. The TERMPOL reports that threats to the marine environment arise from scenarios that first involve a collision, grounding, explosion or other event that could result in uncontrolled release of bulk cargo into the sea. The TERMPOL report authors also indicate that an evaluation of risks from such an event (i.e., uncontrolled release of bulk cargo) is then dependent on considerations such as the characteristics of the released material (here LNG), the magnitude of release (rate of release and duration) and the dispersion of hazardous plumes, amongst other factors.

In the case of a large release of LNG, potential hazards include:

- The extremely low (cryogenic) temperatures associated with LNG can cause severe freeze burns both to humans and wild animals;
- On contact with some metals, LNG can cause embrittlement and cracking. (It should be noted however, that modern LNG vessels are designed with steel rated for low temperatures in areas where a leak of LNG might come into contact with decking or internal structures (ABS Consulting 2004);
- Formation of a pool of released LNG which absorbs the heat from the surface as it evaporates and consequently forms a vapour cloud of methane. Ignition of the vapour immediately above the pool can result in a pool fire;
- Formation of a methane vapour cloud, the primary component of LNG. Although not poisonous in and of itself, methane is an asphyxiant as it is heavier than air and displaces air/oxygen. Thus, sustained exposure can lead to asphyxiation;
- Being lighter then water, an LNG stream released underwater will absorb heat from the water as it rises, boils, explodes to the surface and then spread across the water surface. Further, according to Patin (1999) it will dissolve in the water as it rises, boils, with the potential of reaching levels lethal especially to marine organisms' early life stages; and
- LNG vapour clouds, once they reach a concentration of methane between 5 and 15% by volume, are flammable. In the absence of an ignition source, the vapour cloud will disperse in the atmosphere causing no further local damage.

### 2.2.2 How Likely is Something to go Wrong?

A 2003 review of historical LNG accidents (University of Houston Law Center) found that maritime incidents with severe LNG releases are very rare and that, up to 2003, there were no ship spills from either a collision or grounding (See Table 2-1 which provides a list of historical LNG incidents from 1944 to 2002).

A July 2003 paper by the California Energy Commission also commented on the safety record of LNG activities in the US and worldwide. The report specifically comments on two LNG incidents, one at a peak-shaving plant in Cleveland in 1944, and a second

1978 accident at the Cove Point Maryland terminal that included the last LNG attributed death in the US. The California Energy Commission report notes that "From 1952 to present, LNG ships have made more than 33,000 voyages worldwide and transported over three billion cubic metres of LNG. Of these voyages, more than 2400 (7%) have been to or from US Ports. Even though there have been tanker accidents including engine room fires, groundings, loss of containment, and temperature embrittlement from cargo spillage there have been no explosions, fires or shipboard deaths attributable to LNG." (citing Safety History of International LNG Operations, Revision 2, CH IV International, 11/2002 http://www.ch-iv.com/).

Thus, while large accidents involving the shipping and handling of LNG are possible, the probability of occurrence is small, especially with Canadian and US regulations in-place and enforced.

### 2.2.3 What are the Consequences of Something Going Wrong?

Although conventional marine hazards such as grounding or collisions with other vessels need to be considered, including the release of oil and bilge contents, the major potential hazards associated with LNG are associated with an uncontrolled release of LNG, with, or without, ignition. The actual risks arising from a large uncontrolled release of LNG depend not only on the particular characteristics of the release but also on the local environment where the release occurs, for example the consequences might be quite different if a major release were to occur near a population centre, in the area of a sensitive ecosystem, or in a confined space rather than an open area remote from people or sensitive environments.

Two recent reports provide considerable insight as to the potential hazards arising from incidents involving the release of LNG from LNG carriers (ABS Consulting 2004 and associated comments in FERC 2004 and Sandia 2004).

**TABLE 2-1 Historical LNG Incidents. Reproduced from the University of Houston Law Centre, Institute for Energy, Law and Enterprise report "LNG Safety and Security" dated October 2003**

| Incident Date | Ship or Facility Name | Location | Ship Status | Injuries or Fatalities | Ship or Property Damage | LNG Spill or Release | Comment |
|---|---|---|---|---|---|---|---|
| I944 | East Ohio Gas LNG Tank | Cleveland | NA | 128 deaths | NA | NA | Tank failure and no earthen berm. Vapour cloud formed and filled the surrounding streets and storm sewer system. Natural gas in the vapourizing LNG pool ignited. |
| 1965 | | Canvey Island, UK | A transfer operation | 1 seriously burned | | Yes | |
| 1965 | Jules Vernet | | Loading | No | Yes | Yes | Overfilling. Tank cover and deck fractures. |
| 1965 | Methane Princess | | Disconnecting after discharge | No | Yes | Yes | Valve leakage. Deck fractures. |
| 1971 | LNG ship Esso Brega, La Spezia LNG Import Terminal | Italy | Unloading LNG into the storage tank | NA | NA | Yes | First documented LNG Rollover incident. Tank developed a sudden increase in pressure. LNG vapour discharged from the tank safety valves and vents. Tank roof slightly damaged. No ignition. |
| 1973 | Texas Eastern Transmission, LNG Tank | Staten Island | NA | 40 killed | No | No | Industrial incident unrelated to the presence of LNG. During the repairs, vapours associated with the cleaning process apparently ignited the mylar liner. Fire caused temperature in the tank to rise, generating enough pressure to dislodge a 6-inch thick concrete roof, which then fell on the workers in the tank. |

**TABLE 2-1. Historical LNG Incidents. Reproduced from the University of Houston Law Centre, Institute for Energy, Law and Enterprise report "LNG Safety and Security" dated October 2003 (Cont'd)**

| Incident Date | Ship or Facility Name | Location | Ship Status | Injuries or Fatalities | Ship or Property Damage | LNG Spill or Release | Comment |
|---|---|---|---|---|---|---|---|
| 1973 | | Canvey Island, UK | NA | No | Yes | Yes | Glass breakage. Small amount of LNG spilled upon a puddle of rainwater, and the resulting flameless vapour explosion, called a rapid phase transition (RPT), caused the loud "booms." No injuries resulted. |
| 1974 | Massachusetts | | Loading | No | Yes | Yes | Valve leakage. Deck fractures. |
| 1974 | Methane Progress | | In port | No | Yes | No | Touched bottom at Arzew. |
| 1975 | Philadelphia Gas Works | | NA | No | Yes | NA | Not caused by LNG. An iso-pentane intermediate heat transfer fluid leak caught fire and burned the entire vapourizer area. |
| 1977 | Arzew | Algeria | NA | 1 worker frozen to death | NA | Yes | Aluminum valve failure on contact with cryogenic temperatures. Wrong aluminum alloy on replacement valve. LNG released, but no vapour ignition. |
| 1977 | LNG Aquarius | | Loading | No | No | Yes | Tank overfilled. |
| 1979 | Columbia Gas LNG Terminal | Cove Point, Maryland | NA | 1 killed 1 seriously injured | Yes | Yes | An explosion occurred within an electrical substation. LNG leaked through LNG pump electrical penetration seal, vapourized, passed through 200 feet of underground electrical conduit, and entered the substation. Since natural gas was never expected in this building, there were no gas detectors installed in the building. The normal arcing contacts of a circuit breaker ignited the natural gas-air mixture, resulting in an explosion. |

**TABLE 2-1. Historical LNG Incidents. Reproduced from the University of Houston Law Centre, Institute for Energy, Law and Enterprise report "LNG Safety and Security" dated October 2003 (Cont'd)**

| Incident Date | Ship or Facility Name | Location | Ship Status | Injuries or Fatalities | Ship or Property Damage | LNG Spill or Release | Comment |
|---|---|---|---|---|---|---|---|
| 1979 | Mostefa Ben-Boulaid Ship | ? | Unloading | No | Yes | Yes | Valve leakage. Deck fractures. |
| 1979 | Pollenger Ship | ? | Unloading | No | Yes | Yes | Valve leakage. Tank cover plate fractures. |
| 1979 | El Paso Paul Kayser Ship | | At sea | No | Yes | No | Stranded. Severe damage to bottom, ballast tanks, motors water damaged, bottom of containment system set up. |
| 1980 | LNG Libra | | At sea | No | Yes | No | Shaft moved against rudder. Tail shaft fractured. |
| 1980 | LNG Taurus | | In port | No | Yes | No | Stranded. Ballast tanks all flooded and listing. Extensive bottom damage. |
| 1984 | Melrose | | At sea | No | Yes | No | Fire in engine room. No structural damage sustained – limited to engine room. |
| 1985 | Gradinia | | In port | No | Not reported | No | Steering gear failure. No details of damage reported. |
| 1985 | Isabella | | Unloading | No | Yes | Yes | Cargo valve failure. Cargo overflow. Deck fractures. |
| 1989 | Tellier | | Loading | No | Yes | Yes | Broke moorings. Hull and deck fractures. |
| 1990 | Bachir Chihani | | At sea | No | Yes | No | Sustained structural cracks allegedly caused by stressing and fatigue in inner hull. |

**TABLE 2-1. Historical LNG Incidents. Reproduced from the University of Houston Law Centre, Institute for Energy, Law and Enterprise report "LNG Safety and Security" dated October 2003 (Cont'd)**

| Incident Date | Ship or Facility Name | Location | Ship Status | Injuries or Fatalities | Ship or Property Damage | LNG Spill or Release | Comment |
|---|---|---|---|---|---|---|---|
| 1993 | Indonesian liquefaction facility | Indonesia | NA | No | NA | NA | LNG leak from open run-down line during a pipe modification project. LNG entered an underground concrete storm sewer system and underwent a rapid vapour expansion that over-pressured and ruptured the sewer pipes. Storm sewer system substantially damaged. |
| 2002 | LNG ship Norman Lady | East of the Strait of Gibraltar | At sea | No | Yes | No | Collision with a U.S. Navy nuclear-powered attack submarine, the U.S.S Oklahoma City. In ballast condition. Ship suffered a leakage of seawater into the double bottom dry tank area. |

## 2.3 ABS CONSULTING AND FERC REPORTS

The ABS Consulting (2004) report was commissioned by FERC to investigate consequence analysis methods for estimating flammable vapour and thermal hazard resulting incidents involving spills of LNG on water. The responses of FERC staff to comments on the ABS Consulting report (FERC 2004) provide additional insight as to credible worst case scenarios arising from an LNG vessel accident or an intentional attack (FERC 2004).

The ABS Consulting (2004) report notes that their study addresses the potential consequences of large scale accidents without regard to the sequence of events leading to the incident or the probability of such an incident. The same observation applies here. While various factors that affect the probability of an incident with potential to result in a release of LNG are discussed in later sections, it is beyond the scope of this study to attempt to quantify how likely such an incident might be other than to note, as already indicated previously, that the risk of incidents leading to a large uncontrolled release of LNG are very small.

The intent of the ABS Consulting (2004) study was to recommend modeling methods to be used by FERC staff in the site specific *National Environmental Policy Act (NEPA)* review of proposed LNG import facilities. The authors note that the results shown do not provide a generic site assessment for all LNG import facilities and that only credible worst-case scenarios based on the most recent information available would be used in site-specific analyses of each proposed LNG import facility. The authors also note that "As stated in the Final Environmental Impact Statement (FEIS) for the Freeport LNG Project (Docket No. CP03-75-000), it should not be assumed that the hazard distances identified are the assured outcome of an LNG vessel accident or attack, given the conservatisms in the models and the level of damage required to yield such large scale releases." The authors further note that these estimated "worst case" scenarios should not be misconstrued as defining an exclusionary zone. Rather, the "worst case" scenarios provide guidance in developing the operating restrictions for LNG vessel movements within each shipping channel, as well as in establishing potential impact areas for emergency response and evacuation planning.

For the present purposes, the revised consequence calculations provided in FERC (2004), rather than the original calculations in ABS Consulting (2004), are used as the basis for characterizing the potential consequences arising from a large uncontrolled release of LNG. In considering these results, it should be noted that, unlike a spill on land where the heat transfer from soil to spilled LNG is limited, LNG spilled on water is likely to have access to a much greater heat flux (from the water) as the result of boiling that mixes the LNG with water increasing the effective boiling area (FERC 2004) and hence the rate of conversion of LNG to vapour.

### 2.3.1 Consequence Assessment Examples for Pool Fires

Example scenarios, examined in FERC (2004), are fires following spills from 1 meter (3.3 feet) and 5 meter (16 feet) holes in an LNG carrier just above the waterline. The FERC (2004) report notes that these example calculations are intended only as demonstrations of the modelling methods and that the results should not be taken as a consequence assessment for any specific facility. For the examples, FERC (2004) assumed that the amount of LNG above the hole is 12,500 $m^3$ ($4.4 \times 10^5$ $ft^3$), and the orifice model was used to estimate outflow, with flow rate dropping as the liquid level above the hole drops. It is assumed that the spill is ignited immediately upon release. Table 2.2 summarizes the results of the pool fire calculations for these scenario parameters.

**TABLE 2-2 Summary of Results for Example Pool Fire Calculations**

| Hole diameter | 1 m (3.3 ft) | 5 m (16 ft) |
|---|---|---|
| Initial spill rate | 3,400 kg/s (7,600 lb/s) | 86,000 kg/s (190,000 lb/s) |
| Total spill duration | 51 min | 2.0 min |
| Maximum pool radius (semicircular pool) | 100 m (340 ft) | 310 m (1,000 ft) |
| Total fire duration | 51 min | 4.2 min |
| Maximum flame length (height) | 280 m (920 ft) | 630 m (2,100 ft) |
| Clear flame length at maximum | 180 m (590 ft) | 270 m (890 ft) |
| Flame tilt at maximum radius | 36 deg | 27 deg |
| Downwind distance to 12,000 BTU/hr/$ft^2$ (38 kW/$m^2$) | 280 m (910 ft) | 620 m (2,000 ft) |
| Downwind distance to 7,900 BTU/hr/$ft^2$ (25 kW/$m^2$) | 340 m (1,100 ft) | 760 m (2,500 ft) |
| Downwind distance to 3,800 BTU/hr/$ft^2$ (12 kW/$m^2$) | 460 m (1,500 ft) | 1,100 m (3,500 ft) |
| Downwind distance to 1,600 BTU/hr/$ft^2$ (5 kW/$m^2$) | 650 m (2,100 ft) | 1,500 m (5,000 ft) |

Source: FERC (2004).

### 2.3.2 Consequences of Vapour Clouds

The same scenarios presented in the previous section for pool fires were also considered for vapour clouds; except in this case, it was assumed that ignition does not occur immediately. As stated above for pool fires, FERC (2004) indicates that these example calculations are intended only as demonstrations of the modeling methods and the results should not be taken as a consequence assessment for any specific facility. Evaluation of a specific facility requires input parameter values based on site-specific conditions and analysis of different or additional scenarios may be appropriate.

**TABLE 2-3 Summary of Results for Example Dispersion Calculations**

| Hole diameter | 1 m (3.3 ft) | 5 m (16 ft) |
|---|---|---|
| Initial spill rate | 3,400 kg/s (7,600 lb/s) | 86,000 kg/s (190,000 lb/s) |
| Total spill duration | 51 min | 2.0 min |
| Maximum pool radius (semicircular pool) | 130 m (420 ft) | 350 m (1,100 ft) |
| Total evaporation duration | 51 min | 5.3 min |
| Downwind distance to LFL | 3,400 m (11,000 ft) | 4,100 m (13,000 ft) |
| Time at which LFL reaches maximum distance | 29 min | 29 min |
| Time at which entire cloud drops below LFL | 54 min | 30 min |
| Downwind distance to ½ LFL | 4,600 m (15,000 ft) | 5,900 m (19,000 ft) |
| Time at which ½ LFL reaches maximum distance | 35 min | 37 min |
| Time at which entire cloud drops below ½ LFL | 56 min | 38 min |

Source: FERC (2004).

## 2.4 SANDIA NATIONAL LABORATORIES STUDY

The US DOE supported a study by Sandia National Laboratories in 2004 that reviewed several existing studies of LNG spills and provides guidance on models, assumptions and risk management issues relative to LNG spills over water.

### 2.4.1 Pool Fire

Table 2.4 shows the results developed by Sandia for an intentional LNG spill. The calculations assume that in such an event, there is a high probability that a source of impurities would be present. The Sandia report also notes that the assessment shown in Table 2.4 considers the effects of corroding damage arising from either cryogenic damage or the fire.

**TABLE 2-4. Intentional Breach — Effect of Parameter Combinations on Pool Diameter (Table 14 of Sandia 2004)**

| HOLE SIZE ($m^2$) | TANKS BREACHED | DISCHARGE COEFFICIENT | BURN RATE (m/s) | SURFACE EMISSIVE POWER ($kW/m^2$) | POOL DIAMETER (m) | BURN TIME (min) | DISTANCE TO 37.5 $kW/m^2$ (m) | DISTANCE TO 5 $kW/m^2$ (m) |
|---|---|---|---|---|---|---|---|---|
| **2** | 3 | 0.6 | $3 \times 10^{-4}$ | 220 | 209 | 20 | 250 | 784 |
| **5** | 3 | 0.6 | $3 \times 10^{-4}$ | 220 | 572 | 8.1 | 630 | 2118 |
| **5*** | 1 | 0.6 | $3 \times 10^{-4}$ | 220 | 330 | 8.1 | 391 | 1305 |
| **5** | 1 | 0.9 | $3 \times 10^{-4}$ | 220 | 405 | 5.4 | 478 | 1579 |
| **5** | 1 | 0.6 | $2 \times 10^{-4}$ | 220 | 395 | 8.1 | 454 | 1538 |
| **5** | 1 | 0.6 | $3 \times 10^{-4}$ | 350 | 330 | 8.1 | 529 | 1652 |
| 12 | 1 | 0.6 | $3 \times 10^{-4}$ | 220 | 512 | 3.4 | 602 | 1920 |

* nominal case.

### 2.4.2 Vapour Cloud

In most of the scenarios identified, the thermal hazards from a spill arise from a pool fire, based on the high probability that an ignition source will be available for an intentional (e.g. terrorist attack) spill. In some instances, such as an intentional spill without a tank breach, an immediate ignition source might not be available and the spilled LNG could, therefore, disperse as a vapour cloud. The Sandia (2004) report indicates that for large spills, the vapour cloud could extend to more than 3600 m, depending on spill location and site atmospheric conditions (see Table 2.5). In congested or highly populated areas, an ignition source would be likely, as opposed to remote areas, in which an ignition source might be less likely.

According to Sandia (2004), if ignited close to the spill and early in the spill, the thermal loading from the vapour cloud ignition might not be significantly different from a pool fire, because the ignited vapour cloud would burn back to the source of liquid LNG and transition into a pool fire. If a large vapour cloud formed the flame could propagate downwind as well as back to the source. If the cloud is ignited at a significant distance from the spill, the thermal hazard zones can be extended significantly. The thermal radiation from the ignition of a vapour cloud can be very high within the ignited cloud and, therefore, particularly hazardous to people.

**TABLE 2-5. Dispersion Distances to LFL for Intentional Spills (Table 15 of Sandia 2004)**

| Hole Size ($m^2$) | Tanks Breached | Pool Diameter (m) | Spill Duration (min) | Distance To LFL (m) |
|---|---|---|---|---|
| **5** | 1 | 330 | 8.1 | 2450 |
| **5** | 3 | 572 | 8.1 | 3614 |

### 2.4.3 Overall Hazards from Large LNG Spill

The Sandia analyses from the fire and vapour dispersion calculations suggest that high thermal hazards from intentional events extend significantly from the spill location. Table 2.6 (Table 16 of Sandia 2004) summarizes the general impacts on both public safety and property for intentional breaches and spills. In this table, high impact would include a thermal intensity in the range of 37.5 $kW/m^2$ and low values would correspond to thermal intensities in the range of 5 $kW/m^2$.

### TABLE 2-6 Estimated Impact of Intentional LNG Breaches and Spills on Public Safety & Property (Table 16 of Sandia 2004)

| EVENT | POTENTIAL SHIP DAMAGE AND SPILL | POTENTIAL HAZARD | POTENTIAL IMPACT ON PUBLIC SAFETY* | | |
|---|---|---|---|---|---|
| | | | ~500 m | ~500 – 1600 m | >1600 m |
| **Insider Threat or Hijacking** | Intentional, 2-7 $m^2$ breach and medium to large spill | • Large fire | High | Medium | Low |
| | | • Damage to ship | High | Medium | Low |
| | | • Fireball | Medium | Low | Very Low |
| | Intentional, large release of LNG | • Large fire | High | Medium | Low |
| | | • Damage to ship | High | Medium | Low |
| | | • Vapour cloud fire | High | High - Med | Medium |
| **Attack on Ship** | Intentional, 2-12$m^2$ breach and medium to large spill | • Large fire | High | Medium | Low |
| | | • Damage to ship | High | Medium | Low |
| | | • Fireball | Medium | Low | Very Low |

* Depends on distance to spill origin, which varies according to site as follows:
Very low – little or no property damage or injuries;
Low – minor property damage and minor injuries;
Medium –potential for injuries and property damage; and
High – major injuries and significant damage to structures.

## 2.5 EVALUATION SCENARIOS

### 2.5.1 Listing of Scenarios

On the basis of the foregoing discussions and the general discussions of hazards from uncontrolled LNG releases the following three scenarios are provided as the basis for subsequent discussion and evaluation in later sections of this report. These are:

**SCENARIO 1:** **Conventional marine hazards.** That is hazards not involving the uncontrolled release of LNG. These include grounding, loss of steering and collision with marine mammals and other vessels, and release of Oil Fuels and Bilge content, etc., for example.

**SCENARIO 2:** **Release of LNG from the LNG vessel.** This has two aspects a) formation of a pool from an uncontrolled release of LNG with ignition and b) an uncontrolled release of LNG resulting in a large vapour cloud attributable to a release either above water or below water.

**SCENARIO 3:** **Release of LNG from the docking and on land facilities.**

**SCENARIO 1: Conventional marine hazards**

There are a variety of potential hazards associated with the shipping and handling of LNG. Many of these do not involve a spill of LNG but rather, commercial marine hazards such as:

- Minor grounding;
- Minor mechanical failure of the ship components;
- Small fire; and
- Collision with other small vessels.

Factors that can contribute to marine accidents include, among others, mechanical or electrical failures that might result in loss of steering, environmental factors such as currents, winds and fog, and human error. All of these potential "causes" of an incident need to be considered fully in analyses supplied to FERC by the proponent or performed by FERC itself. In this report, Chapter 3 elaborates on environmental factors that have potential to affect safe passage of large LNG vessels, including for example:

- strong tidal currents present in Quoddy Bay;
- strong winds that may affect the navigation of large vessels; and
- limited visibility arising from fog in the summer and snow in winter, amongst others.

In addition, there are physical constraints on navigability from open waters to a terminal, including for example:

- channel depth; and
- channel width, especially at the junction of Head Harbour passage and Western passage, where a 110 degree turn is required.

There is considerable marine traffic in the area, including numerous local ferries and fishing vessels as well as recreational boats. Thus, a formal navigability assessment would be an important consideration in assessing potential hazards from any future LNG facility, as the large LNG vessels would add to local traffic.

One safety aspect of LNG transport is providing a clear distance around the LNG vessels. The US Coast Guard has been establishing temporary moving and fixed safety zones around LNG vessels with product aboard. For one case a safety zone of 50 to 150 yards around the carrier was established around the vessels transiting the waters of the Caribbean Sea and Guayanilla Bay, Puerto Rico (Federal Register, 2000). It is important to investigate if such a safety measure is in place for the proposed LNG transportation within the study area.

#### *2.5.1.1 Frequency Analysis*

Estimating the likelihood of conventional marine hazards requires analysis of site specific factors such as marine traffic, meteorological conditions, passageway information, communications infrastructure and ship specifications. By comparing the number of recorded historical loaded LNG transits over the past 50 years, approximately 80,000 (Pitblado *et al*. 2004), that had no release of LNG with the number of loaded port transits that resulted in a release (13 as summarized in Table 2.1) the frequency of conventional hazards resulting in a release of LNG is on the order of $10^{-4}$ per transit. Note that the estimated frequency was derived from historic events recorded since 1950's and recent technological advancements in ship design and navigational tools have made LNG marine transportation much safer. For this reason it is expected that the actual frequency would be smaller than this.

#### *2.5.1.2 Consequence Assessment*

As mentioned above, historical incident records indicate that conventional hazards, as defined above, have not resulted in a significant number of releases of LNG from the cargo ships. Other consequences, such as the release of fuel and oil are limited to the local areas at the vicinity of the ship.

**SCENARIO 2: Release of LNG from the vessel**

Release of LNG from cargo vessels can be categorized as either leaks or minor releases and major leaks from loss of containment of the ship's cargo.

### *2.5.1.3 Leaks or Minor Releases*

Failure of pipes, valves, pumps and other components of the LNG handling facility installed on the ship may result in the release of small quantities of LNG on the ship. Large volume release of LNG is not expected from these incidents.

2.5.1.3.1 Frequency Analysis

Comparing the historical record of incidents involving LNG carriers, summarized in Table 2.1, and the number of loaded port transits indicates that the frequency of a minor release of LNG due to malfunctions and minor failures of process components is on the order of $2x10^{-4}$ per transit. The records indicate that the majority of these incidents occurred before the 1970's. Recent technological advancements in ship safety have made the ship operation much safer and, as such, the actual frequency is expected to be smaller.

2.5.1.3.2 Consequence Assessment

Historical records indicate that the release of such small quantities of LNG may cause minor damage to the deck or other parts of the ship structure, however, a major fire, loss of containment of the vessel or a large vapour cloud is not expected to result from such minor releases. The consequence of such incidents will be bounded by the consequences of more serious events discussed in the next section.

### *2.5.1.4 Major Release of LNG from the Containers*

The following scenarios can result in a breach of the containment and release of a large volume of LNG:

1. Collision at 90º with vessels between 30 – 150,000 dwt;

2. Grounding against a pinnacle rock; and
3. Intentional attack.

Existence of multiple barriers in LNG carriers makes it difficult to estimate the size of a hole arising from the above noted accidents. Typically, there are four or five physical barriers which must be breached to release the LNG cargo. A study by Pitblado *et al*. (2004) indicated that the LNG tank can absorb significant deformation before it fails. The tank material is designed to remain ductile at -162ºC. The tank is typically about 96-97% full when transporting LNG, giving a large vapour space (on the order of 1000$m^3$). As long as the tank is not completely full of liquid and the structure can deform, there is a high probability that no leak will occur. In the El Paso Paul Kayser grounding accident major deformation to the hull occurred, but the vessel barriers limited the membrane LNG tank deformation to around 1m, with no LNG leak (Pitblado *et al*. 2004).

For the purpose of assessment Pitblado *et al.* (2004) reported that a hole size of 250 to 1,500 mm long is possible from the above mentioned causes. The study by Pitblado *et al.* (2004) reported a smaller hazard zone compared with the results from the ABS Consulting and Sandia reports.

A large hole in the container results in the release of significant quantities of LNG. The released LNG can ignite as a pool fire or, alternatively, evaporates to create a vapour cloud that migrates beyond the point of release.

It is pertinent at this point to consider the threat of a cargo hull breach and the probability that it will result in an LNG spill. Sandia (2004) used threat analysis and spill probability modelling to determine that *"… the required velocity to cause a breach of an LNG cargo tank during a 90 degree collision with a large vessel (i.e. 50,000 metric ton class containership) to be 6-7 knots. Collisions at shallower angles would need to be several knots higher in order to penetrate an LNG cargo tank."* Table 2-7 illustrates the impact of accidental collisions between an LNG tanker and small or large vessels, intentional breaches and spills.

### TABLE 2-7 Estimated LNG Ship Damage from Potential Tank Breaches & Spills. (Table 40 of Sandia 2004)

| Breach Event | Breach Size | Tanks Breached | Ship Damage[b] |
|---|---|---|---|
| Accidental collision with small vessel | None | None | Minor[b] |
| Accidental collision with large vessel | 5 – 12 $m^2$ (Spill area 0.5 – 1$m^2$)[a] | 1 | Moderate |
| Accidental Grounding | None | None | Minor |
| Intentional Breach | 0.5 $m^2$ | 1 | Minor |
| Intentional Breach | 2 $m^2$ | 1 | Minor |
| Intentional Breach | 2 $m^2$ | 3 | Moderate |
| Intentional Breach | 12 $m^2$ | 1 | Severe[d] |
| Intentional Breach | 5 $m^2$ | 2 | Severe |
| Intentional Spill | Premature offloading of LNG | None | Moderate-Severe |

Notes: a - Assumes vessels remain joined during spill event and breach is mostly plugged.

b - Minor suggests ship can be moved and unloaded safely.

c - Moderate suggests damage that might impact vessel and cargo integrity.

d - Sever suggests significant structural damage. Ship might not be able to be moved without significant difficulty and includes potential for cascading damage to other tanks.

#### *2.5.1.5 Frequency Analysis*

To date there has been no loss of containment failure resulting in the release of LNG from carriers. There have been two serious groundings, in 1979 and 1980, and one major ship collision in 2004, but none of these resulted in cargo loss. In the El Paso Paul Kayser event, the carrier struck a rock at 19kts with no loss of cargo. This indicates the inherent strength of this type of vessel with its additional barriers and the physical separation of the cargo from the sea. As shown in Table 2.1, LNG vessels have experienced a small number of events in terms of minor collisions, strikings, small leaks and fires. None of these incidents resulted in a containment failure or major release of LNG.

Pitblado *et al.* (2004) concluded that the analysis of oil tanker accident records and records for LNG and LPG gas carriers show that the occurrence of serious incidents has improved by a factor of almost ten since 1980. This is considered to be due to a wide range of regulatory, design, crew competence and ship management improvements.

Considering that there has been no major release of LNG from carriers to date and the number of loaded port transits remains high, indicates that the frequency of a major release of LNG due to ship collision, intentional attack or ship grounding against rocks is less than $10^{-5}$ per transit.

In this context, the risk of breaching the inner hull of an LNG tanker should be put in perspective with the probability of collisions with large vessels. Some of these larger vessels occasionally go to Eastport, Bayside and to a lesser degree, Bliss Island and North Head, as presented in Table 2-8.

#### *2.5.1.6 Consequence Assessment*

A major release of LNG from large can occur above or below the water surface.

**Above Water Releases**

Should an uncontrolled release of large amounts of LNG occur as a result of structural damage to a cargo vessel, overfill, or other causes, the LNG would spread over the water surface before it can evaporate and form a pool of LNG. Rapid evaporation of the LNG creates a vapour cloud which could travel beyond the release point.

Based on the summary of the analysis of the accident scenarios provided in Sections 2.3 and 2.4, and for purpose of evaluating this hazard, a) a fire hazard zone of 1500 m has been assumed for the formation of a pool of LNG from an uncontrolled release with ignition due to the radiation from the pool fire (see table 2-2) and b) a fire hazard zone of 5900 m has been assumed for uncontrolled release of LNG resulting in a large vapour cloud (see Table 2-3). The vapour cloud travels 5900 m away from the sources of release before the methane level drops below half of the LFL of 5%. Beyond this distance the concentration of methane is too low (less than 5%) to ignite or cause harm.

## TABLE 2-8 Large Vessel Traffic in Quoddy Region

| Destination | Vessel type | DWT class | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|---|---|
| North Head | Tanker | 40,000 - 49,999 | | | | 1 | 1 |
| Eastport Harbour | Bulk | 30,000 - 39,999 | 2 | | | 1 | 3 |
| | Bulk | 40,000 - 49,999 | 9 | 7 | 16 | 6 | 38 |
| | General Cargo | 30,000 - 39,999 | 2 | | | | 2 |
| | General Cargo | 40,000 - 49,999 | 7 | 6 | 3 | 2 | 18 |
| | General Cargo | 50,000 - over | | 3 | 2 | | 5 |
| | Container | 40,000 - 49,999 | | 1 | | | 1 |
| Bliss Island | Bulk | 30,000 - 39,999 | | 1 | | | 1 |
| | Bulk | 40,000 - 49,999 | | 6 | 5 | 1 | 12 |
| Bayside | Bulk | 30,000 - 39,999 | 10 | 5 | 2 | 1 | 18 |
| | Bulk | 40,000 - 49,999 | 22 | 39 | 36 | 32 | 129 |
| | Bulk | 50,000 - over | 3 | | | | 3 |
| | General Cargo | 30,000 - 39,999 | 1 | | | | 1 |
| Friars Road Anchorage | Bulk | 30,000 - 39,999 | 1 | | | | 1 |
| | Bulk | 40,000 - 49,999 | 3 | 1 | 2 | | 6 |
| | | Total | 60 | 69 | 66 | 44 | 239 |

The concentrations at which flammable mixtures form (5 – 15% methane) are much lower than the concentration of methane at which asphyxiation can occur. Therefore, the zone where the concentration of methane is high enough to cause asphyxiation is much smaller than the fire hazard zone assumed above. This asphyxiation zone is limited to the close vicinity of the spill area and is not expected to extend to the land on the Canadian side of the border. Also, the area where the temperature of the vapour cloud is dangerously cold is close to the vicinity of the release which is also inside the hazard zone assumed for fire hazard.

The uncontrolled release of a large amount of LNG may cause much lower water temperatures within several meters under the pool compared with the water ambient temperature. Much deeper waters may not be impacted as the currents will mix the warm waters from surrounding areas with the cold water except in areas of significant upwelling. Therefore, the impacted area is limited to the first several meters immediately underneath the released pool of LNG where upwelling does not occur.

Rapid boiling at the water-LNG interface creates a gas barrier which controls the rate of transfer of heat from water to LNG; thus the cooling rate of water columns underneath the pool of boiling LNG decreases.

### Below Water Releases

Released LNG will rise to the surface since it is less dense than water and, depending on the rate of warming, either remain in the liquid state or convert to the gaseous state boiling to the surface. The travel time from release to the water surface is in the order of several seconds. Boiling at the LNG-water interface creates a gas barrier which decreases the rate of heat transfer to the bulk of the released LNG. Thus, it is unlikely that much of the bulk of LNG will evaporate under the water. Irrespective, methane and other elements in the LNG will dissolve in the water. Patin, (1999) argues that both fish behavioural responses and fish mortality evidence, though limited, demonstrates relatively low resistance of ichthyofauna to the presence of natural gas in the water. Further he argues zooplankton and benthos have higher resistance to methane and its homologues then ichthyofauna. Therefore, uncontrolled underwater releases of LNG may have an impact on fish and to a lesser extent on plankton. Nevertheless, as Patin (1999) points out, studies need to be undertaken to determine the exact levels of toxicity and duration in the marine environment.

Irrespective, a toxic underwater plume will be transported away from the release point on the prevailing vertical and horizontal currents. The toxicity levels may exist for anywhere from a few minutes to several hours depending on a number of unknown and untested factors.

Once on the surface the scenarios would be similar to those of a surface release.

#### *2.5.1.7 Heavy Components of LNG*

Typically LNG has 4 to 8 percent ethane, 1 to 3 percent propane and traces of butane and nitrogen. At these concentrations the heavier components of LNG do not change the pool fire characteristics significantly, however, LNG with higher ethane and propane concentrations have a higher heating value and thus the radiation heat flux is slightly higher for heavier LNGs.

Lower Flammable Limits for ethane and propane are 3 and 2 percent respectively. At the distance where the vapour cloud methane concentration drops to 5 percent (LFL for methane) the concentration of ethane and propane will be 0.3 and 0.1 percent, respectively. These concentrations are well below the LFL values for ethane and propane. Therefore, the ignitability of the LNG vapour cloud is dominated by methane and heavier hydrocarbon components do not affect the behaviour of LNG vapour cloud significantly.

In addition, the heaviest component of the LNG with considerable fraction is butane. Butane is a gas at ambient condition and evaporates upon a release. Therefore, release of LNG and subsequent evaporation does not leave any oily residue. Therefore, oiling and coating of birds and shellfish, which is a common problem in oil spills, does not occur after a spill of LNG.

### 2.5.2 SCENARIO 3: Release of LNG from the Docking and on Land Facilities

Release of LNG from docking and land facilities may be from damage or leaks to LNG liquid pipes and/ or the on land LNG storage facilities.

The analysis of the second source of release has not be conducted based on the assumption that the impact zone from these releases would be less than or equal to that from a vessel docked at the terminal which was considered in Scenario 2.

The design of LNG unloading and re-gasification facilities as a matter of good engineering practice, provide for automatic shut off valves as well as isolation valves. These provisions are put in place to minimize the amount of release in case of a catastrophic failure of pipes or pumps. Normally, the major lines from the storage will be isolated within a few minutes from the accident. As such, it is expected that the volume and duration of release of LNG from catastrophic failure of docking and unloading facilities will be much less than the volume and durations assumed for Scenario 2 (uncontrolled release from the LNG vessel). Therefore, the hazard zone associated with the release of LNG from docking and unloading facilities is expected to be similar to the source of the release and is well within the hazard zones assumed for Scenario 2.

It should be noted here that the risk of release of LNG from the docking and on land facilities is greater during offloading operations. This can be seen by considering only the incidents during loading and unloading operations presented in Table 2-1. This means that a docked LNG vessel under Scenario 3 could lead to the same situation as Scenario 2.

## 2.6 LNG HAZARD ZONES

### 2.6.1 Fire Hazards

Based on the foregoing discussion, and for the present purposes, a thermal hazard zone of approximately 1500 m for pool fire and a vapour cloud hazard zone of approximately 5900 m have been assumed as a conservative worst case Zone of Influence that could be affected by a large release. The thermal hazard zone is defined as the downwind distance to 5 kW/$m^2$ radiation and the vapour cloud hazard zone is defined as the downwind distance where the vapour cloud concentration drops to half of the LFL fro methane. These hazard zones are illustrated, as they impact Canada, on Figure 2.3. The ABS Consulting analysis suggests that the duration of the fire from a pool of spilled LNG could last from 4.2 to 51 minutes for 5 and 1-m hole diameters assuming that the fire does not extend to the vessel itself. The same analysis also suggests that it takes between 30 to 54 minutes (for 5 and 1-m hole diameters) before the entire vapour cloud under the conservative worst case scenario drops below the Lower Flammable Limit (LFL) at which time the fire and thermal hazards diminish. Soon after this the environment in the affected zone should return to normal.

As noted by the Sandia report these results should be used as guidance only, bearing in mind that these distances will vary based on site-specific factors and environmental conditions.

### 2.6.2 Cold Gas Hazards

LNG vapour at its normal boiling point -162ºC (-259ºF) is 1.5 times more dense than air at 25ºC (77ºF). Therefore, evaporation of LNG from a pool will initially produce a negatively buoyant vapour cloud (i.e., the cold vapours are more dense than air and stay close to the water surface). Once it warms above approximately -108ºC (-162ºF) it will become less dense than air and tend to rise and disperse more rapidly. Due to rapid heat transfer at these low temperatures, dispersion and rising of the cloud could occur within a few hundred meters from the pool. Beyond this distance, mixing with warm air increases the temperature rapidly. When the entire cloud dilutes below the LFL, the temperature of the cloud is not much different from the ambient temperature. Thus, the hazard zone associated with cold gas is much smaller than the fire hazard zone and is limited to the close vicinity of the spill area.

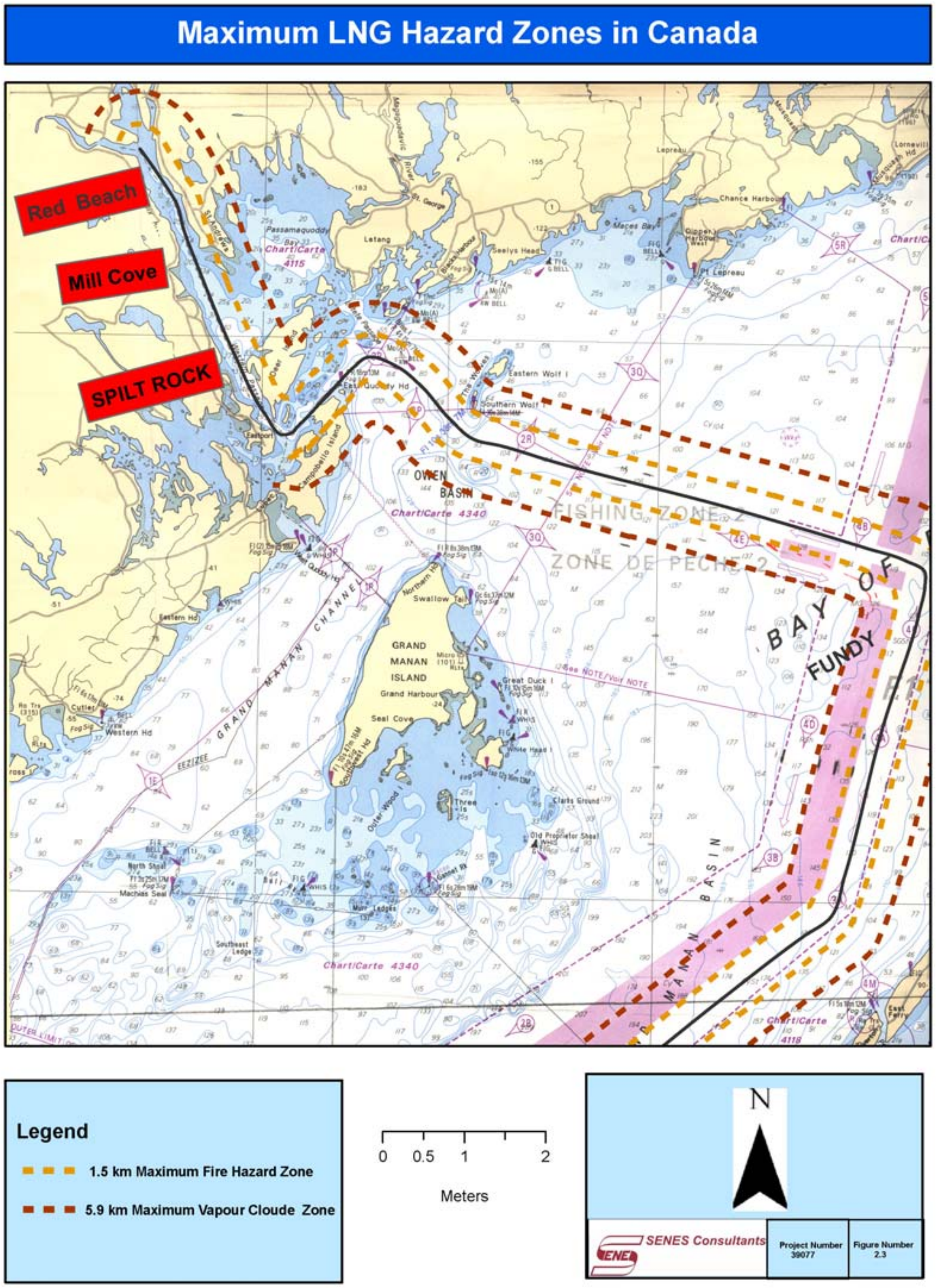
### 2.6.3 Impact on Water of LNG

The density of LNG is less than half of the density of water (approximately 0.425 kg/L) so that after the release it floats to the surface of the water. Rapid evaporation of LNG absorbs a large amount of heat from the water surface. This results in a sudden drop in temperature of the water below the pool of LNG. Because of its higher density, this cold layer of water is unstable and rapidly mixes with the warm lower layers of water underneath the LNG pool. This phenomenon may cause much lower water temperatures within several meters under the pool compared with the ambient water temperature. Much deeper waters may not be impacted as the currents will mix the warm waters from surrounding areas with the cold water. Therefore, the impacted area is limited to several meters immediately underneath the released pool of LNG.

Alternately, and in areas where small diameter upwelling i.e. vertical water movements are common, low temperature columns of water may be established with limited mixing leading to impacts to much greater depths than might otherwise be expected.

Further, LNG released underwater will rise to the surface and may well “boil” upwards as it transforms from the liquid to gaseous state. This could lead to more rapid dispersion giving either a larger or smaller flammable cloud depending upon a number of other factors. In addition, as the natural gas moves through the water a small portion will dissolve in the water with the potential to reach levels lethal to marine organisms. As there are no LD50 (Lethal Dose 50%) estimates available it is difficult to asses the impacts and dangers identified by Patin (1999).

**FIGURE 2-3. Maximum Hazard Zone on the Canadian Side of the Border Relative to the LNG Vessel Transit**



### 2.6.4 Impact on Land of LNG

The primary zone of impact on the surface as a result of an uncontrolled release of LNG is a few hundred metres (the maximum size of a pool). The distance between the transit path of the LNG vessels and the shorelines on the Canadian side is larger than the zone of impact if the vessel is on its normal path. Therefore, no impact on Canadian land is expected as a result of an uncontrolled release of LNG so long as that release is in the transit path. If the release is attributable to something associated with the vessel moving out of the transit path then the LNG could/would have an impact on the intertidal zone and the land itself.

In interpreting the above analysis, we concur with FERC (2004) who comment that the "estimated "worst case" scenarios should not be misconstrued as defining an exclusionary zone. Rather, the "worst case" scenarios provide guidance in developing the operating restrictions for LNG vessel movements within each shipping channel, as well as in establishing potential impact areas for emergency response and evacuation planning.

# 3.0 TRANSPORTATION AND NAVIGATIONAL ISSUES

## 3.1 ROUTE ANALYSIS, APPROACH CHARACTERISTICS AND NAVIGABILITY SURVEY

### 3.1.1 Introduction

The purpose of this section is to identify the conditions for marine navigation in the Quoddy Region in the event that a liquefied natural gas (LNG) terminal is established at Mill Cove. Note that even though siting at Mill Cove (the Downeast LNG Project) was used as a basis for this analysis, the results apply generally to all three LNG projects because all are located within the Quoddy Region and tankers navigating to any of the LNG terminal sites will need to navigate through the same area. In general terms, this area features very high tides with a tidal range of approximately six metres. These tides alter the coast and water depths and generate very strong ocean currents.

In order to provide a complete overview of the situation, certain basic hypotheses were put forward. The most important premise made involves the type of vessel used in this study. The types of vessels that will be chartered to supply the LNG terminal are unknown; however, based on consultations with stakeholders, we assumed that these vessels will have the standard features of a vessel with a capacity of 145,000 cubic metres.

It is important to note that the analysis relies on the use of the usual navigation systems that are currently used in the Passamaquoddy Bay region. Note also that the use of more high-performance navigation systems would have an impact on the findings reported herein. The same is true of the analysis of the propulsion system and the manoeuvrability of the sample vessel.

### 3.1.2 Environmental Factors

There are numerous environmental factors involved in navigating the Passamaquoddy Bay area. Firstly, highly intense currents are affected by the local configuration of the islands and vary in accordance with the tidal cycles. The wind varies seasonally and is influenced by local effects. Visibility is often reduced. Ice spray and waves have a lesser impact on the type of vessel at issue.

#### *3.1.2.1 Currents*

Major tidal currents affect the passage that will be used by the LNG tankers to travel to Quoddy Bay. These currents are periodically reversed, following the cycle of the tides. Given that they are affected by the topographical configuration of the islands, they generate major local phenomena that are more cyclical than consistent.

Vessels sailing to the proposed LNG terminal will transit the Head Harbour Passage, in which currents are southwest during flood tide (flood current) and northeast (ebb current) at ebb tide, see Figures 3-1 and 3-2. These currents turn briskly south of Indian Island, surging in the Western Passages at flood tide and are reversed during ebb tide. This occurrence creates an eddy known as Old Sow that is reputedly the largest eddy in the world. It reaches its maximum intensity approximately three hours before high tide and currents of up to 6 knots have been recorded outside of Deer Point. Consequently, this is a critical area in which vessels are required to change course by approximately 90 degrees.

Among the passages the vessels sail, Head Harbour Passage records currents of three knots, although currents of up to five knots have been known. The Western Passage features currents of the same intensity.

Currents are a very important factor that needs to be considered carefully because they are not constant and vary continually. For this reason it is absolutely necessary that mariners have sound knowledge of the local area to ensure the safe passage of a large vessel.

#### *3.1.2.2 Winds*

In the Bay of Fundy, dominant winds blow west to northwest during the cool season, and west to southwest during the warm season. From mid-November to March, the winds blow at an average of 20 knots and, during this period, gale force winds (more than 34 knots) occur 10 to 15% of the time and storm force winds 2% of the time. The configuration of the Bay and the shores are such that a number of local effects are produced. Winds measuring up to 70 knots have been recorded in Eastport, near the location at which a vessel sailing to Passamaquoddy Bay needs to undertake a major manoeuvre. Thus, there is a possibility of encountering significant winds that could hamper the vessels' manoeuvres during their passage in these critical areas.

### *3.1.2.3 Waves*

Given the size of the vessels and the fact that they are transiting protected waters during passage through and in the Bay, waves have a relatively low to negligible impact on the risk level associated with the vessels' passage.

### *3.1.2.4 Visibility*

Visibility is often reduced to less than 0.5 nautical miles in any season. Given that the coastal waters are relatively cold during the summer, warm moist air from the coast flowing over the water produces advection fog. During the month of July, visibility that is reduced to less than 0.5 miles can be expected 20 to 30% of the time. During the winter, this percentage is less than 10% and is often caused by snow.

**FIGURE 3-1 Current at Flood Tide.**
**Adapted from the Canadian Hydrographic Service**

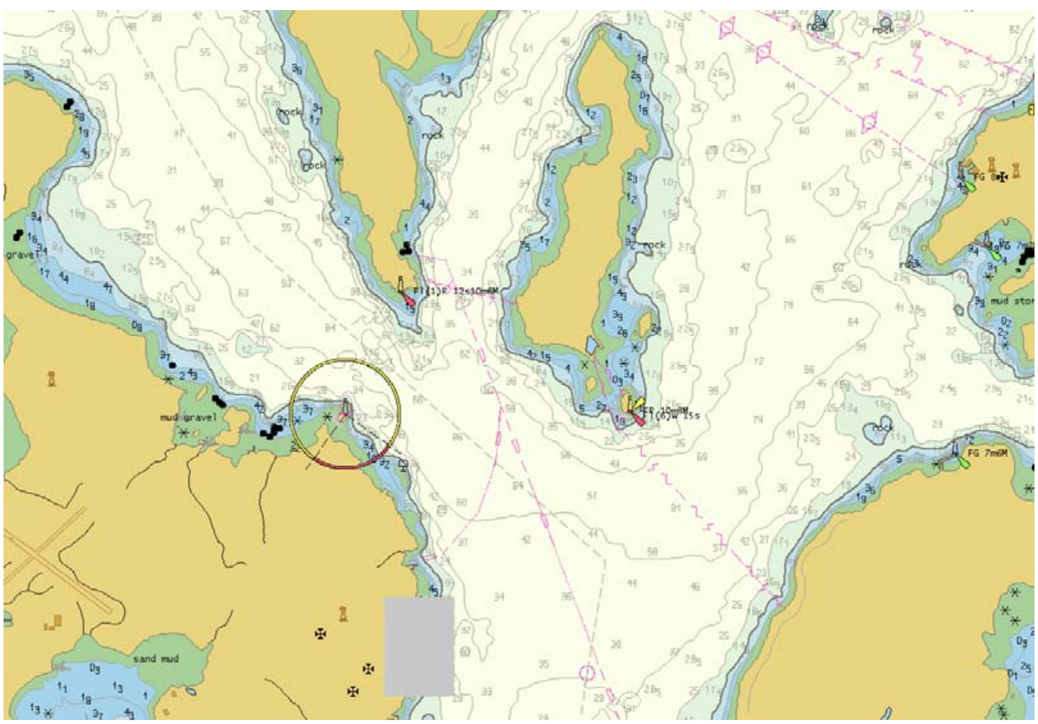
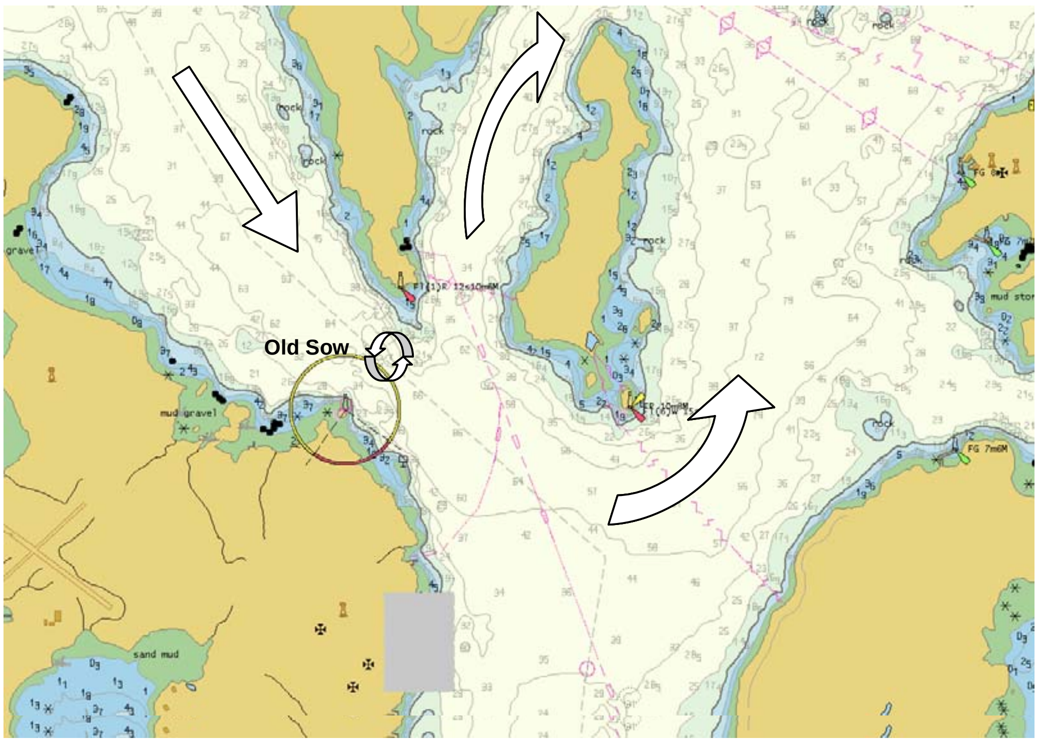


**FIGURE 3-2 Current at EBB Tide**
**Adapted from the Canadian Hydrographic Service**




### *3.1.2.5 Ice Spray*

Ice spray may create problems for certain types of vessels that have low stability or that are ill-equipped. In the case at issue, ice spray will have very little, if any, impact on the risk level attributed to the passage of an LNG tanker in the Passamaquoddy Bay area.

### 3.1.3 Ship Specification and Manoeuvrability

It is important to note that, because we do not have specific information about the vessel, other than its likely volume capacity of 145,000 $m^3$, we analyzed two types of vessels with this capacity. The ships are built under the International Maritime Organization's construction criteria for vessels carrying natural gas in a liquefied state and they are SOLAS compliant vessels. It is important to note that these construction criteria are the minimum criteria that must be met. The governments of Canada and United States have agreed to be signatories to that convention and that there would be no additional criteria applied. The first ship is a conventional sphere-type model built by

Kawasaki and the second is a membrane-type model built by Samsung, see Figure 3-3. These two types of vessels have similar features and provide equivalent manoeuvring performance. Because of the trend in new construction toward the membrane-type vessel, we used that type of model in our trial simulations.

**FIGURE 3-3 Sphere-type and Membrane-type LNG Tankers**

The only difference that may have an impact on the manoeuvrability features of these vessels (membrane or conventional) is the windage of each, which differs depending on the foredeck. Nevertheless, this difference in configuration will have a negligible impact on the manoeuvrability of one type of vessel as compared to the other.

LNG tankers are sophisticated vessels, given their cargo. These vessels are built in accordance with construction criteria approved by the International Maritime Organization and supervised by classification societies. Vessels navigating Canadian waters will have to comply with the requirements set out by Transport Canada with respect to certification, safety inspections and other regulatory points of concern.

Given their cargo, these vessels are maintained in a seaworthy condition that exceeds the normal requirements for ships and it is unlikely that one of these vessels would fail to meet Canadian standards, so those ships are normally within the Canadian regulation, authorized to enter in Canadian waters.

#### *3.1.3.1 Specifications*

The specifications of the sample vessel used in this study are as follows:

| | |
|---|---|
| Length over all (LOA) | 283 m |
| Length between perpendiculars | 270 m |
| Beam | 43.3 m |
| Depth | 26 m |

| | |
|---|---|
| Draft | 11.4 m |
| Tanks | 145 100 $m^3$ |
| Speed | 20 Km |
| Engine | Steam turbine |
| Spec. Engine | 44500 HP x 90 RPM |
| LNG Storage | GTT Mark III Membrane system |

The equipment on board this type of vessel must meet the requirements and standards set out by the International Maritime Organization. More specifically, this equipment includes an electronic chart display information system (ECDIS), interfaced with a differential global positioning system (DGPS), an automatic identification system (AIS) with a minimum of two radars not integrated to the ECDIS, and all of the radio and communications equipment required.

We worked on the premise that the vessel was equipped with the standard manoeuvring equipment. The vessel has a right-hand (runs clockwise) fixed-pitch propeller at 90 RPM, a normal rudder angled at a maximum of 35 degrees and an adjustable-pitch 2,719 HP bow thruster.

The actual vessel may be equipped with manoeuvring features that exceed the ones presented here, but given the information available, we conducted our study on the premise of a standard vessel.

#### *3.1.3.2 Manoeuvrability*

In order to estimate the manoeuvrability of this type of vessel, with only cursory information, a simulation was carried out using the sample vessel described above. This simulation enabled us to test manoeuvres on a navigation simulator. The sample vessel used in the simulation is one with a single propeller and conventional rudder, angled at a maximum of 35 degrees.

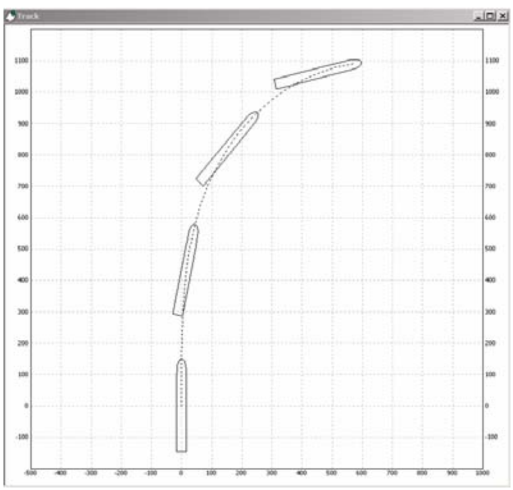
A 90-degree course change at manoeuvring speed (80% of its strength 14 knots) was simulated by applying the rudder at its maximum of 35 degrees.

In simulating a manoeuvre without wind or current, the vessel covers a distance of 1,091 metres on its initial course (advance) and 570 metres on the new course (transfer) before reaching its heading 90 degrees to the right, for a turning radius of 1,091 metres, see Figure 3-4.

When a current of three knots is included in the simulation, the vessel covered a distance of 1,344 metres on its initial course (advance) and 565 metres on the new course (transfer) before reaching its heading 90 degrees to the right, for a turning radius of 1,344 metres, see Figure 3-5.

Note that these findings will be very useful for estimating the risk level associated with the passage of the vessel in areas in which course changes are necessary.

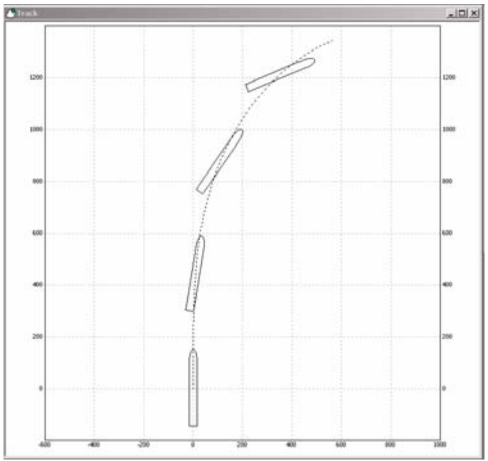
**FIGURE 3-4. Course Change with Rudder at Right 35 Degrees Simulation of a Manoeuvre Without Wind or Current**



performance

| | Speed kn | heading deg | turn rate deg/min | drift deg | Advance m | Transfer m |
|---|---|---|---|---|---|---|
| 0 | 14.08 | 0.00 | 0.00 | 0.000 | 0 | 0.0 |
| 10 | 14.08 | 0.23 | 3.58 | 0.381 | 72 | -0.1 |
| 20 | 14.07 | 1.22 | 8.09 | 1.052 | 145 | -0.2 |
| 30 | 14.05 | 2.89 | 11.79 | 1.752 | 217 | 0.5 |
| 40 | 14.02 | 5.14 | 15.19 | 2.429 | 289 | 2.8 |
| 50 | 13.97 | 7.95 | 18.43 | 3.056 | 361 | 7.5 |
| 60 | 13.90 | 11.29 | 21.65 | 3.648 | 432 | 15.2 |
| 70 | 13.82 | 15.16 | 24.74 | 4.206 | 503 | 26.6 |
| 80 | 13.70 | 19.52 | 27.55 | 4.719 | 572 | 42.2 |
| 90 | 13.57 | 24.32 | 29.99 | 5.178 | 639 | 62.6 |
| 100 | 13.42 | 29.50 | 31.99 | 5.573 | 704 | 87.9 |
| 110 | 13.25 | 34.97 | 33.52 | 5.899 | 765 | 118.4 |
| 120 | 13.08 | 40.65 | 34.63 | 6.162 | 823 | 153.9 |
| 130 | 12.89 | 46.49 | 35.38 | 6.369 | 876 | 194.3 |
| 140 | 12.71 | 52.43 | 35.83 | 6.531 | 924 | 239.1 |
| 150 | 12.54 | 58.41 | 35.95 | 6.660 | 967 | 287.9 |
| 160 | 12.36 | 64.40 | 35.88 | 6.759 | 1004 | 340.1 |
| 170 | 12.20 | 70.37 | 35.72 | 6.834 | 1035 | 395.1 |
| 180 | 12.05 | 76.31 | 35.50 | 6.891 | 1060 | 452.2 |
| 190 | 11.90 | 82.20 | 35.26 | 6.934 | 1079 | 510.8 |
| 200 | 11.77 | 88.06 | 35.00 | 6.967 | 1091 | 570.4 |

## FIGURE 3-5. Course Change with Rudder at Right 35 Degrees Simulation of a Manoeuvre with Current at 3 Knots and No Wind



performance

| | Speed kn | heading deg | turn rate deg/min | drift deg | Advance m | Transfer m |
|---|---|---|---|---|---|---|
| 0 | 14.08 | 0.00 | 0.00 | 0.000 | 0 | 0.0 |
| 10 | 14.20 | 0.19 | 3.03 | 0.385 | 73 | -0.1 |
| 20 | 14.31 | 1.03 | 6.86 | 1.041 | 146 | -0.3 |
| 30 | 14.41 | 2.45 | 10.08 | 1.731 | 220 | 0.0 |
| 40 | 14.50 | 4.38 | 13.04 | 2.407 | 294 | 1.3 |
| 50 | 14.57 | 6.80 | 15.90 | 3.041 | 369 | 4.2 |
| 60 | 14.61 | 9.69 | 18.77 | 3.640 | 444 | 9.2 |
| 70 | 14.63 | 13.05 | 21.55 | 4.202 | 519 | 16.8 |
| 80 | 14.61 | 16.86 | 24.12 | 4.718 | 593 | 27.6 |
| 90 | 14.56 | 21.08 | 26.43 | 5.178 | 667 | 42.1 |
| 100 | 14.48 | 25.66 | 28.39 | 5.576 | 739 | 60.4 |
| 110 | 14.36 | 30.53 | 29.97 | 5.905 | 810 | 83.0 |
| 120 | 14.20 | 35.63 | 31.20 | 6.171 | 878 | 109.9 |
| 130 | 14.01 | 40.91 | 32.11 | 6.382 | 944 | 141.0 |
| 140 | 13.80 | 46.31 | 32.64 | 6.549 | 1006 | 176.3 |
| 150 | 13.57 | 51.78 | 32.92 | 6.678 | 1064 | 215.5 |
| 160 | 13.31 | 57.28 | 33.04 | 6.774 | 1119 | 258.3 |
| 170 | 13.04 | 62.79 | 33.07 | 6.845 | 1169 | 304.2 |
| 180 | 12.76 | 68.30 | 33.04 | 6.898 | 1214 | 352.8 |
| 190 | 12.46 | 73.80 | 32.97 | 6.938 | 1254 | 403.7 |
| 200 | 12.16 | 79.29 | 32.88 | 6.968 | 1289 | 456.3 |
| 210 | 11.84 | 84.76 | 32.77 | 6.991 | 1319 | 510.3 |
| 220 | 11.52 | 90.21 | 32.65 | 7.009 | 1344 | 565.1 |

### 3.1.4 Underkeel Clearance

Underkeel clearance is, very simply, the height of the water column above the ocean floor from which the draft of the vessel is deducted. In short, it is the space between the vessel and the ocean floor. It is good practice to hold a reserve or to underestimate the height of the water column, in order to maintain a manoeuvring margin. It is also important to identify all variables in estimating underkeel clearance. The reliability of the underkeel clearance calculation rests on the accuracy of the single variable that has been the least well estimated.

The following variables can be found in the water column:

Base water level (bathymetry); and
Tide level.

To calculate the draft of a vessel, we use:

Maximum draft of the vessel; and
Vessel sinkage (squat).

#### *3.1.4.1 Bathymetry and Tide Effect*

The presence of tides is the main factor considered in assessing the risk of the underkeel clearance of a vessel. The tides in Passamaquoddy Bay are very strong. Navigators may use these to maximize the load on the vessel. Normally, the pilot or captain of the vessel makes a calculation to adjust the speed of the vessel as it crosses a shallower area at high tide. The use of this technique is prevalent and enables large vessels to access areas in which water depths are relatively low. This navigation technique is not a problem for persons with sound knowledge of local waters; however, some risk is involved where the passage of the vessel needs to be synchronized with high tide. Consequently, the vessel cannot arrive late or early. Atmospheric conditions may also affect the expected tide range and cycle. For the case at hand, the variations in water levels are presented in Table 3-1.

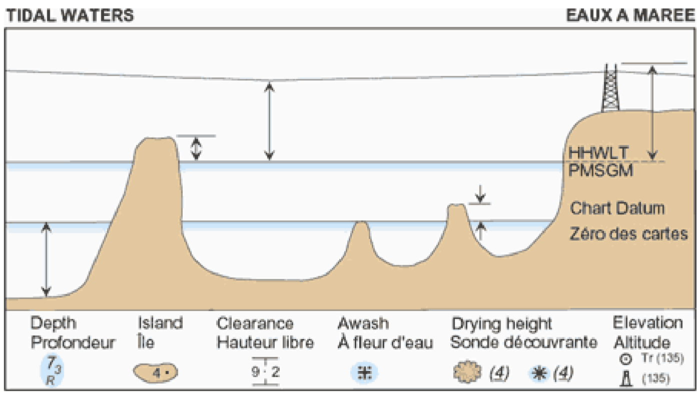
**TABLE 3-1 Variations in Water Levels for Manoeuvrability Simulation**

| Type of tide | High | Low | Range |
|---|---|---|---|
| **Maximum tide** | 7.5 m | 0.1 m | 7.4 m |
| **Average tide** | 6.5 m | 1 m | 5.5 m |

Low tide may, at times, be lower than the level of mean tide. Level 0 corresponds with higher high water and large tide (HHWLT). In the worst case scenario, the water level to be considered is 0 m, which leads to the depth indicated on the chart.

In bathymetry, this data may often be skewed in areas that contain sandbanks or a variation in the ocean floor topography, see Figure 3-6. In the area identified for the vessels' passage, variations of this type are minimal to non-existent.

**FIGURE 3-6. Ocean Floor Topography that May Skew Bathymetry Data**




## 3.2 DRAFT AND SQUAT EFFECT

The sample vessel selected has a maximum loaded draft of 11.4 metres. In estimating the squat effect, we considered the fact that the vessel is sailing on a natural waterway rather than a dredged channel, and we considered the data available about the vessel. Given these factors, the most appropriate equation to calculate the squat effect is that of Eryuzlu, N Ed.:

$$\delta = 0.298 * \left(\frac{h^2}{T}\right) * F_{nh}^{2.289} * \left(\frac{h}{T}\right)^{-2.972} * K_b$$

For this case and given that the vessel will operate within the 20-metre contour line, except in manoeuvres, the squat effect will be approximately 0.3 m. Therefore, the vessel's maximum draft will be (11.4 +0.3) 11.7 m.

It is reasonable to assume that, throughout its transit and up to the point of berthing manoeuvres, the vessel's underkeel clearance will be a minimum of 8.3 m. This clearance is the basis for the assumption that during normal transit, the vessel will have ample underkeel clearance.

The depths indicated on the chart are based on the average of the lowest low tides. If the tidal effects and draft are applied to these depths, the vessel will transit through with a minimum underkeel clearance of 8.3 metres. Given this clearance, a vessel similar to the sample vessel is unlikely to find itself in a high-risk situation with respect to underkeel clearance, regardless of the roll or pitch applied.

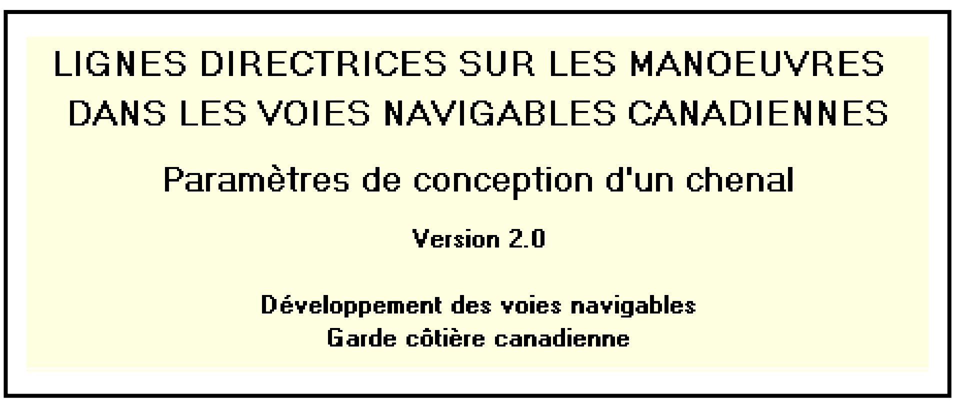
Thus, it can be affirmed that, for a typical vessel with a maximum draft of 11.4 metres, transiting from offshore to its destination at the proposed LNG terminal at Mill Cove, provides a sufficient and safe underkeel clearance throughout transit.

### 3.2.1 Channel Configuration

The Canadian Coast Guard has developed a software application for designing a safe channel. This software is known as the National Manoeuvring Guidelines, see Figure 3-7.

The software was used to verify the adequacy of the channel the LNG tankers will transit to access the proposed terminal in Passamaquoddy Bay. The data used for the calculations were taken from nautical charts and other official publications, and data on the sample vessel selected.

**FIGURE 3-7 National Manoeuvring Guidelines Software**



#### *3.2.1.1 Channel Width*

Along the route to the proposed LNG terminal, the narrowest area is located at Head Harbour Passage near the Green Shoal Light Buoy UH2 and measures approximately 450 metres. Another narrow area, measuring approximately 550 metres can be found at the southern entrance to the Western Passage.

Based on the results obtained by the software, the minimum channel width required to ensure good manoeuvrability under normal transit conditions for the sample vessel is 240.31 m. The narrowest width noted was 450 metres. The natural channel is, therefore, sufficiently wide for a vessel sailing on a set course.

#### *3.2.1.2 Channel Depth*

As we noted in Section 3.1.4 Underkeel Clearance, the depths encountered during transit are much greater than 20 m. The software's results show that a safe depth for the passage of the sample vessel in the channel is 15. 87 m. The depth of the channel is, at all times, 4.13 metres greater than the minimum depth required for safety.

#### *3.2.1.3 Width in Elbows*

During transit, one significant elbow involves a course change of 102 degrees. This elbow is at the junction of Head Harbour Passage and Western Passage, which is also where Old Sow is located. The software was used to determine whether the elbow would enable the vessel's passage.

It is important to mention that the analysis of the passage in the elbow of Head Harbour Passage and the Western Passage cannot be made by referring only to the results from the software of guidelines in waterways, because it is not about a channel as the software understands it. However, even for the relatively open water conditions in this case, the Coast Guard advises that the guidelines provide sufficiently accurate results to give a good indication of the width of waterway required to navigate the elbow safely. The analysis was based on three scenarios. The first one represents the results from the software, the second represents the results from the simulation illustrating the turning radius of the model vessel and the third relates to the plan of transit.

Circle of gyration resulting from the software

In the case of the passage of a vessel similar to the model of an LNG tanker, the software indicates that for a gyration with an advance of 1091 metres (at 14 knots), the width of waterway required to navigate the elbow would be approximately 420 metres in the absence of strong winds or currents. The required waterway width in the elbow would be reduced for slower speeds, for example the required width at 12 knots would be 347 metres and at 10 knots it would be approximately 285 metres.

Circle of gyration resulting from the simulation

In that case, the simulation under calm conditions without induction current, indicates a gyration with an advance of 1091 metres. This gyration allows the vessel to pass in the elbow with a margin of operation of 400 metres of Cherry Island with starboard and Clark Ledge with port. By applying a current of 3 knots, the operation allows for room of about the length of vessel for Island starboard and Clark Ledge to port.

Circle of gyration of passage plan

In order to stay in the centre of the channel and apply in a clarify way the transit plan, the circle of gyration has to be 570 metres. A vessel of this type, operating at a speed of 14 knots, cannot make a 102 degree bend with a beam of gyration of this scale, because according to the simulation, its beam of gyration would be 1091 metres. The vessel cannot thus apply the transit plan in an adequate way.

Note that the results obtained from the scenarios show that the passage is practicable for this type of vessel. Nevertheless, it should be noted that at the junction of Head Harbour Passage and Western Passage, the channel does not provide for the safe passage of the sample vessel at manoeuvring speed.

### 3.2.2 Transit

To plan the passage of a sample vessel to Passamaquoddy Bay, a passage plan was prepared that takes into account the aids to navigation available and the local bathymetric and topographic configurations.

#### *3.2.2.1 Navigational Aids*

Lighthouses and buoys are some of the aids to navigation available. There are no alignment or Racon systems. The aid system appears to be sufficient for commercial traffic with average-sized coastal trade vessel; however, for the safe operation and passage of larger vessels, the aid to navigation system needs to be reassessed. A traffic management system—VTS from the Bay of Fundy—also exists. When a vessel is inbound to the Bay of Fundy, it will sail through Sector 1 (channel 14: frequency 156.7 MHz), then Sector 2 (channel 12: frequency 156.6 MHz) then back into Sector 1 (channel 14: frequency 156.7 MHz) when it crosses a line between Grand Manan Island and Pt. Lepreau (approximately). Thus, information about traffic in the area is available at all times. The electronic DGPS navigation system used by the Canadian Coast Guard is in service for the Passamaquoddy Bay area, based from the Partridge Island station.

Parallel index is a radar operator's technique that is easily applied in the Passamaquoddy Bay area because the configuration of the islands, the shores, and the natural landmarks must allow for the use of high-quality radar instruments.

#### *3.2.2.2 Passage Plan*

The passage plan presented below is applicable to a normal vessel with sound manoeuvring capacity. Because they are variable, this example of passage plan does not include local weather and currents as these effects must be applied during the passage. The following plan is for a vessel inward bound (toward land) proceeding in good visibility with a suitable speed for confined waters. This plan could be modified for a vessel outward bound:

- Arriving vessels pass the Head Harbour point to the south to enter into Head Harbour Passage. The starting point of the passage through the confined area begins at Waypoint 1. (See Tables 3-2 and 3-3 for waypoints and route segments and Figures 3-8 and 3-9 for the passage plan map and chart, respectively.) From this point, the vessel maintains a course of 222 degrees over 2.33 miles. Throughout this course, the helmsman can maintain visual contact with the Cherry Island light, and the navigator can use radar, keeping the head line on the southeast point of Cherry Island. To maintain passage along the 222 degrees leg of the course use a parallel index line 1.7 cables (0.17 NM) from Campobello Island. The first change of course is to be made as the vessel is abeam the Wilson Beach light and just prior to reporting to Fundy Traffic at call-in point 4P. The new course will be 206 degrees. Throughout this course, the helmsman can maintain visual contact with the southeast shore of Treat Island. The navigator can use the radar, keeping the head line on the southeast point of Cherry Island. To maintain passage along the 206 degrees leg of the course use a parallel index line 2.75 cables (0.275 NM) from the Wilson Beach light.

- A hard turn is then required to move from the Head Harbour passage to the Western Passage. This turn can be made with the use of the beam of the Cherry Island light. Ideally, constant relative bearing is maintained abeam the vessel with a distance of 0.35 miles, up to a heading of 308 degrees. This is a precise manoeuvre that requires sound knowledge of the vessel's manoeuvring capacity and local conditions, such as currents and winds.
- After the turn, steering to 308 degrees is possible, while the helmsman maintains visual contact with Kendall Head. To maintain passage along the 308 degrees leg of the course use a parallel index line 2.5 cables (0.25 NM) from the Dog Island on port and another parallel index line 1.9 cables (0.19 NM) from the Deer Island. Then, a change of course at the Redoubt Hill point, where there appear to be small ranges for the border (see CHS chart 4114), brings the vessel to 330 degrees. To maintain passage along the 330 degrees leg of the course use a parallel index line 3 cables (0.3 NM) from the Kendall Head. The course can be maintained abeam of the Frost Ledge buoy. Then, the vessel may begin its approach to the terminal.

### TABLE 3-2 Waypoints for the Passage Plan

| Waypoint | Latitude | Longitude | Name |
|---|---|---|---|
| # 1 | 44° 57.83 ' N | 066° 54.59 ' W | Head Harbour Pas. |
| # 2 | 44° 56.10 ' N | 066° 56.79 ' W | Wilson Beach |
| # 3 | 44° 54.98 ' N | 066° 57.56 ' W | Cherry Island |
| # 4 | 44° 54.86 ' N | 066° 58.32 ' W | Old Sow |
| # 5 | 44° 55.68 ' N | 066° 59.80 ' W | Dear Island |
| # 6 | 44° 58.19 ' N | 067° 01.83 ' W | Frost Head |

### TABLE 3-3 Route Segments for the Passage Plan

| Route Segments | Course | Distance | Distance | Parallel Index | Heading |
|---|---|---|---|---|---|
| WPT #1 to WPT #2 | 222° | 2.33 nm (?) | 2.33 nm | South coast x 0.17 nm (320 m) | Cherry Island |
| WPT #2 to WPT #3 | 206° | 1.25 nm | 3.57 nm | Wilson light x 0.275 nm (510 m) | Treat Island |
| WPT #3 to WPT #4 | Variable | 0.55 | 4.12 mn (?) | Abeam Cherry light x 0.35 nm (650 m) | |
| WPT #4 to WPT #5 | 308° | 1.35 nm | 5.46 mn | Dog Island light x 0.25 nm (460 m) | Kendall Head |
| WPT #5 to WPT #6 | 330° | 2.88 nm | 8.35 nm | Kendall Head x 0.3 nm (550 m) | |
| WPT #6 to WPT #7 | | 5.76 nm | 14.11nm | | |

The transit time from the point of entry into Head Harbour Passage to the terminal depends on the manoeuvring capacity of the vessel and the speeds required in confined waters. A larger vessel should expect a minimum of two hours.

#### *3.2.2.3 Transit Specifications*

Planning the passage does not pose any difficulties, except for the section from Head Harbour Passage to Western Passage. A problem arises when shifting from one passage to the other. This change of passage involves a course change of approximately 100 degrees and must be made in an area in which strong tidal currents occur, so it's another constraint of the ship transit in the Old Sow. The Old Sow is a phenomenon, which is known as the strongest whirlpool in the world with currents ranging from three to five knots.

## FIGURE 3-8 Map Excerpt Illustrating the Passage Plan Adapted from the Canadian Hydrographic Service

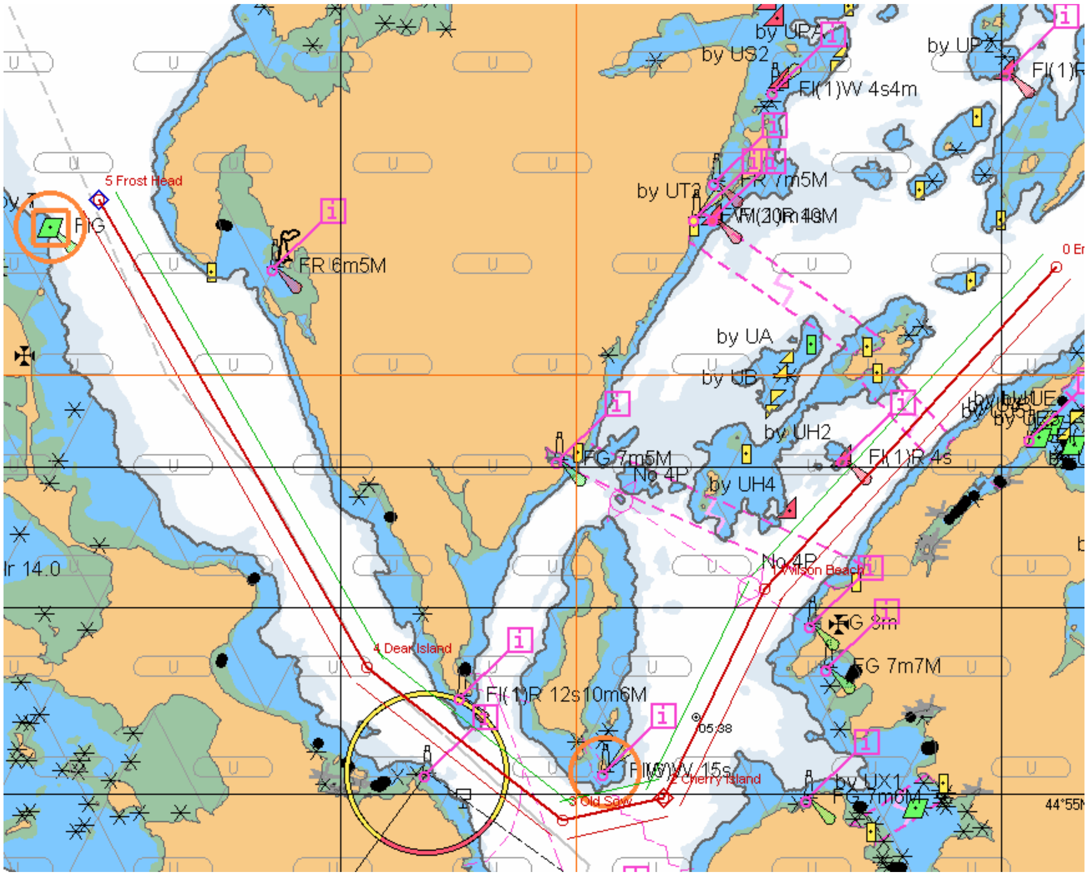
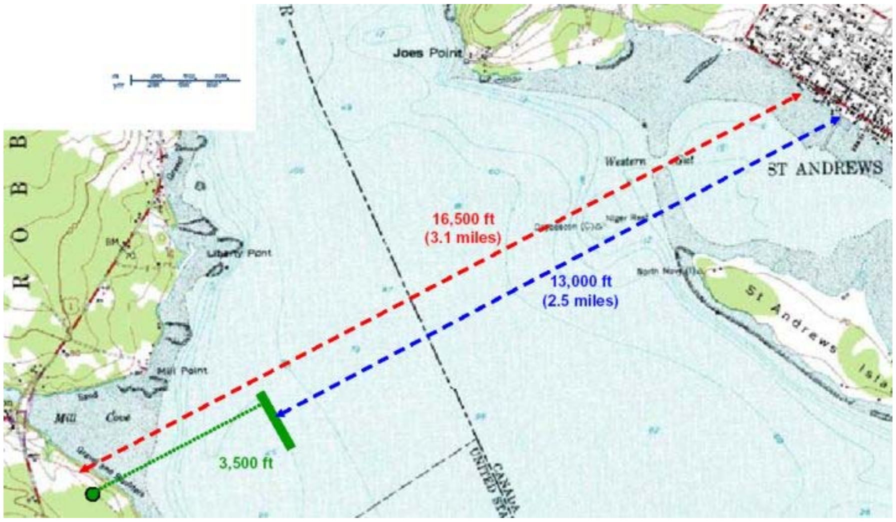


**FIGURE 3-9 Chart Illustrating the Passage Plan Trip Adapted from the Canadian Hydrographic Service**




### *3.2.2.4 Berthing and Time Windows for the Transit*

The terminal berthing area is well-sheltered from waves; only northwest winds could present a problem. The other problem arises from the strong currents that are produced at the mouth of St-Croix River. These currents vary with the tide and affect berthing manoeuvres directly.

Given that it is easier to berth a vessel facing the current, it is likely that the vessels will berth facing north, therefore, port side in ebb currents and facing south in flood currents.

The transit analysis points up one critical area, which is the change of course from Head Harbour Passage to Western Passage. This is a critical area for three reasons:

1. Change of course of 100 degrees;
2. Intense and cyclical current; and
3. Narrow passage.

Given the sample vessel's manoeuvring capacity, and specifically, its turning radius, it is obvious that it cannot proceed through this passage safely at a normal speed (80% of maximum power). The vessel should proceed at a low speed, using its bow thruster or enlisting tugboat services. That said, in proceeding slowly, the vessel becomes vulnerable to the current and, given the currents present in this area (Old Sow), it would not be a good seaman practice to venture into this elbow.

The only safe way to proceed is to plan the passage such that the change of course occurs during the stand of tide, the period in which there are no tidal currents and, where necessary, enlist the assistance of tugboat services to help facilitate the manoeuvre.

It is important to add that a vessel passing the elbow at the stand of tide must cover a distance of approximately 10 miles to reach the terminal. This means that upon its arrival at the terminal, the stand of tide will have passed, and the vessel will be affected by tidal currents throughout its berthing manoeuvre. Consequently, high-powered tugboats would be needed to assist vessels at the point of berthing.

By and large, it is possible to transit safely, but it is absolutely necessary to plan the passage in accordance with the tidal cycle. In so doing, time windows for safe passage are established based on the tidal cycle and the vessel can adjust its speed in open water before arriving in confined waters to synchronize its passage with the tidal cycle. The same is true for vessels outbound that will need to adjust their departure time to coincide with the tidal cycle.

### 3.2.3 Anchorage and Emergency Alternative

Evidently, Passamaquoddy Bay and surrounding areas offer a number of sheltered areas for vessels. In addition to the DGPS coverage, which enables accurate electronic positioning, the definition of the shores provides a multitude of radar reference markers, which offers the possibility of positioning the vessel easily while allowing for the appropriate watch in bad weather or other circumstances.

Depth is an asset that enables the safe use of well-sheltered sites near the shore. In the Passamaquoddy Bay area, the depths are sufficient to allow a vessel with a draft of 11.4 metres to find a sheltered area easily. Some reefs and shoals could present a danger; however, they are easily identifiable by their proximity to the islands on radar or marked out by aids to navigation.

Should a problem arise at the proposed terminal, it would be possible for a vessel to anchor safely in Passamaquoddy Bay in a sheltered area, where the currents are weaker. In case of difficulties, it would also be possible for a vessel sailing Head

Harbour Passage to anchor in the Friar Roads area, rather than advance toward the elbow leading to the Western Passage. One of the most critical situations for a vessel outward bound is encountering problems as it enters the southern part of the Western Passage. In this case, the vessel does not have easy access to a safe zone. Nevertheless, these events can be prevented by fabricating emergency scenarios with which pilots could experiment on the simulator.

### 3.2.4 Measures for Mitigating Risk

Despite the existing difficulties, transit from the proposed terminal is possible with a vessel similar to the sample vessel by using measures to mitigate the level of risk as follows:

- **Measures for mitigating risk –** Design vessels specifically for this transit, increase the manoeuvring capacity of the sample vessel and use tugboat services.
- **Strategic measures for mitigating risk –** Ensure that the passage of the vessel coincides with the tidal cycle, avoid passage in winds that exceed a certain speed and avoid passage in reduced visibility or at night.
- **Human factor considerations –** Provide training specific to the area with simulator for pilot navigation, hire crews who have experience in this field and resource management training in the gateway adapted to the area.

Evidently, the passage to the proposed terminal is difficult and the transit of a vessel transporting hazardous goods creates a considerable risk. The application of measures to mitigate risk in a risk-management approach could reduce the level of risk considerably.

### 3.2.5 Conclusion

The findings of the navigation and route analysis study are based on a number of basic premises, including the type of vessel, its manoeuvring capacity, the equipment on board available, etc. It is important to stress that where the premises made are found to be erroneous, the results would be biased. Often, two vessels of the same size will have completely different manoeuvring capacities. It was assumed that the vessel was equipped with dual controllable-pitch propeller with kort nozzles, oversized rudders, or an Azipod propulsion system, the findings of this study would likely have been different.

It appears that Passamaquoddy Bay is highly susceptible to environmental conditions. Given the impressive tides, a topography that generates strong tidal currents (cyclical), powerful winter winds, and visibility that is often mediocre, this area is obviously difficult to navigate.

Bathymetry indicates that the water depth is suitable for the type of vessel that is expected to transit in this area and does not pose any problems. Other features of this area include topography of the shore and the islands which provide good reference points for radar navigation and the DGPS coverage available in the area enables the use of a Differential Global Positioning System. We note that aid to navigation systems does not have any range marks (alignments) or racons, which means that the channel has a minimal number of markers. This is definitely not appropriate for the passage of vessels similar to the sample vessel used herein.

The sample vessel has the manoeuvrability features normally found in a vessel of this size. It was noted that the vessel’s turning radius at manoeuvring speed present some problems in the elbow that connects Head Harbour Passage and Western Passage. Use of the marker software “National Manoeuvring Guidelines” supported our concerns by clearly showing that the waterway at it narrowest point near the elbow is barely wide enough to support safe passage of this type of vessel in an autonomous way at normal manoeuvrability speed in light currents and mild winds.

Given these findings, the transit of an LNG tanker similar to the sample vessel involves a considerable level of risk. Nevertheless, it is possible to adopt an approach that will allow for risk management and for the application of a number of measures to mitigate risk. The risk-mitigation measures give rise to additional costs in the implementation and operation of the transportation system. In addition to these additional costs, the mitigation measures also generate considerable operational limitations.

As in the transportation industry, zero risk does not exist. The object is to manage the risk appropriately so that it is reduced to an acceptable level; however, the notion of acceptable risk has yet to be defined. We also note that the perception of risk is different from one stakeholder to another. Consequently, it is extremely difficult to arrive at a compromise to accommodate all of the parties involved.

In any case, with the information available at the time of this study, it is important to note that the passage of an LNG tanker similar to the sample vessel in Passamaquoddy Bay involves a very high level of risk. Risk-mitigation measures should be proposed and carefully analyzed before considering the passage of this type of vessel in this area.

### 3.3 REVIEW OF COMMERCIAL SHIP MOVEMENTS

The information pertaining to vessel traffic presented in this section only refers to the study zone and comes from two main sources. The first source is the Canadian Coast Guard's Marine Communications & Traffic Services (MCTS). In Eastern Canadian waters, it is mandatory for vessels of 500 gross tonnage or more, or carrying dangerous goods, to report to the vessel traffic services. In that sense, all vessels entering or leaving Passamaquoddy Bay, even if they have a US origin or destination have to (should) report to the MCTS and are thus (normally) captured by the MCTS. More precisely, Passamaquoddy Bay is within Bay of Fundy Vessel Traffic Service (VTS) zone and all the following vessels are required to report to the MCTS:

- every ship ≥ 20 metres in length;
- every ship towing or pushing any vessel or object (except fishing gear) where the combined length ≥ 45 metres; or,
- the length of the towed/pushed object is ≥ 20 metres

These regulations do not apply to yachts/pleasure crafts less than 30 metres or fishing vessels less than 24 metres in length but these vessels can report on a voluntary basis.

All reported passages and movements are thus recorded in a database. During the observed period – 1988 to 2005 – the trips recorded by the MCTS can be found in two distinct databases. For the years 1988 to 2002, the original database used comes from the ECAREG system. Starting in 2002, the MCTS phased-in the INNAV system which is the second generation of vessel traffic system (database) for Eastern Canada. In this context, it is more precise than its predecessor and for this reason not all of the information pertaining to more recent vessel traffic (post 2002) is available in the ECAREG system database. This review of commercial ship movements is thus separated into two distinct sections reflecting the use of the two databases which cannot realistically be merged.

Once the MCTS database on vessel traffic was obtained, all possible origins, destinations and reporting points were plotted on a geographical information system. The points located within the area illustrated in Figure 3-10 were later selected and all trips having either an origin, a destination or having a record indicating that they have passed through the area were extracted. The vessel traffic data presented in this section only refers to the study zone. Note that LNG traffic in the area will double cargo vessel traffic and not all vessel traffic, including pleasure and small fishing ships.

To complement the MCTS information, US Army Corps of Engineers' Waterborne Commerce Statistics Center (WCSC) data was compiled[1]. The WCSC publishes data on vessel entrance and clearances for all US ports and waterways between 1997 and 2003. This data was downloaded and vessel traffic having either an origin or a destination in the State of Maine was extracted. This source of data is considered to be the most comprehensive source of public data for US vessel traffic. Because the Canadian data covers part of vessel traffic to and from the US side of Passamaquoddy Bay, US and Canadian data cannot be summed. Figure 3-10 illustrates the area analysed.

Once the MCTS database on vessel traffic was obtained, all possible origins, destinations and reporting points were plotted on a geographical information system. The points located within the area illustrated in Figure 3-10 were later selected and all trips having either an origin, a destination or having a record indicating that they have passed through the area were extracted. For traffic between 2002 (phase-in) and the end of 2005, the database of selected vessel trips contains 19,963 records. The pre 2003 database contains 2,502 records. This is explained by the fact that the more recent data is more comprehensive and records more trips, notably those which are only going through the selected area even if they do not have an origin or a destination within it. In this context, it is believed that recent data is more consistent and reflects the actual traffic of the area. One should also be aware that because the INNAV system was phased-in, 2002 data is not considered to be complete but was kept for information purposes. These two databases are considered to be the most precise and comprehensive information sources for vessel traffic in the area. Bear in mind that, although this level of detailed data may seem excessive, it is necessary to ensure that all elements of TERMPOL Section 3.2 are covered.

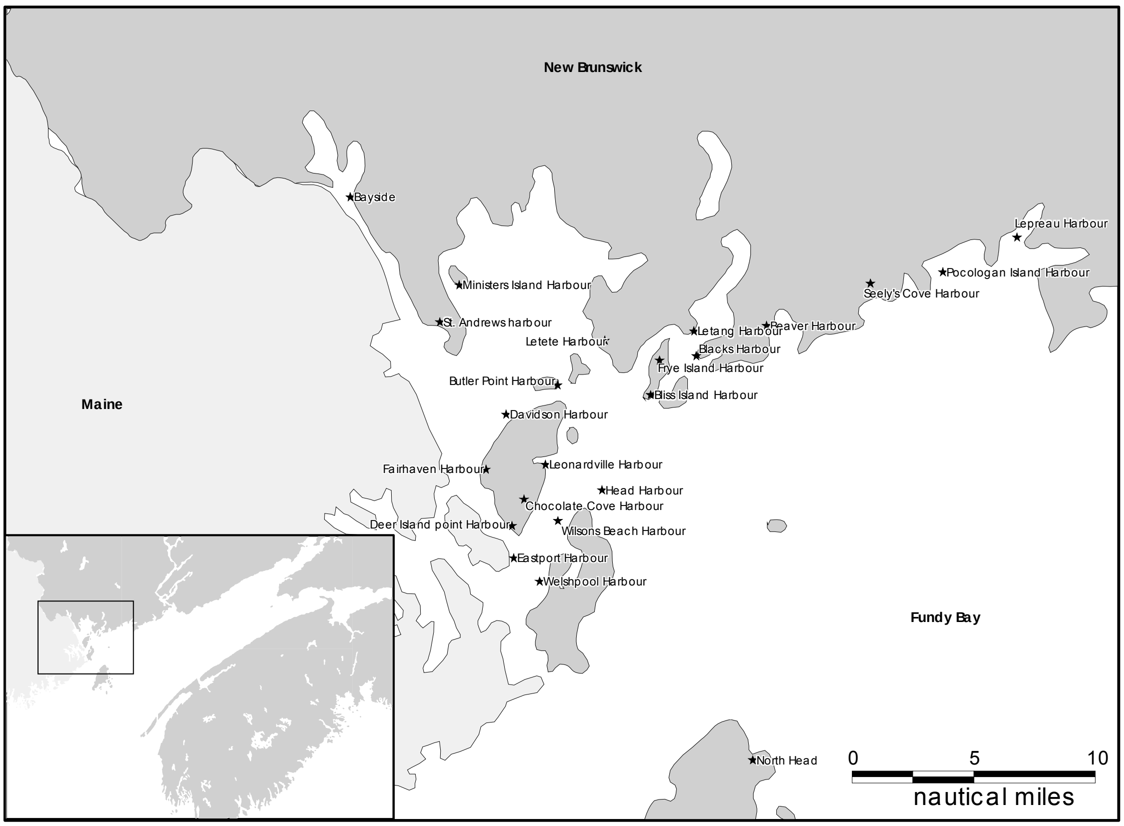
### 3.3.1 Recent Traffic

Table 3-4 presents traffic in the area according the vessel type between 2002 and 2005. Precise O-D matrixes for the main types of vessels are presented in Appendix A.

[1] http://www.iwr.usace.army.mil/ndc/data/dataclen.htm

Ferries are the type of vessel having undertaken the most number of trips in the area between 2002 and 2005. Table 3-5 presents the detailed number of trips according the precise vessel.

**FIGURE 3-10 Map Illustrating the Area Analysed in the Review of Commercial Ship Movements**




The *Grand Manan V* and the *Grand Manan* were responsible for 85% of the trips made by ferries in the area between 2002 and 2005. These ferries have 580 and 213 deadweight tonnes (DWT), respectively. The *Grand Manan V* can carry up to 65 cars and 300 passengers while the *Grand Manan* has a capacity of 25 cars and 100 passengers. They are operated by Coastal Transport Limited and sail between Grand Manan Island and Blacks Harbour on the continent. During the summer season, each vessel can offer up to 7 crossings[2].

[2] Detailed schedules can be found at the following address : http://www.coastaltransport.ca/schedule.htm

The *Deer Island Princess II* and *John E. Rigby* ferries operate on Passamaquoddy Bay between Deer Island and Letete. The *Deer Island Princess II* holds 24 cars, while the *John E. Rigby* holds 18 cars. Crossing time is approximately 20 minutes and they run year round, 16 hours per day[3].

**TABLE 3-4 Traffic in the Area According the Vessel Type Between 2002 and 2005**

| Vessel Type | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|
| Ferry | 7 | 3,026 | 3,678 | 2,581 | 9,292 |
| Fishing | 25 | 1,904 | 2,169 | 2,598 | 6,696 |
| Tug | 12 | 144 | 288 | 262 | 706 |
| Barge | 1 | 34 | 444 | 165 | 644 |
| Tanker | 24 | 133 | 202 | 213 | 572 |
| Bulk | 95 | 147 | 171 | 141 | 554 |
| General Cargo | 115 | 124 | 114 | 95 | 448 |
| Special Purpose | 10 | 82 | 159 | 102 | 353 |
| Ro-Ro | | | 230 | 4 | 234 |
| Coast Guard | 5 | 60 | 105 | 30 | 200 |
| Dredge | 1 | 28 | 69 | 42 | 140 |
| Yacht | 10 | 18 | 18 | 7 | 53 |
| Military | 9 | 3 | 14 | 3 | 29 |
| Passenger | 5 | 9 | 4 | 4 | 22 |
| Chemical tanker | | | | 8 | 8 |
| Factory Ship | 3 | | | 3 | 6 |
| Container | 1 | 3 | | 2 | 6 |
| **Total** | **323** | **5,715** | **7,665** | **6,260** | **19,963** |

*Source:* Maritime Innovation, from CCG data.

**TABLE 3-5 Ferry Trips in the Area**

| Name | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|
| *GRAND MANAN V* | 1 | 2,277 | 2,255 | 1,788 | 6,321 |
| *GRAND MANAN* | 1 | 484 | 873 | 280 | 1,638 |
| *DEER ISLAND PRINCESS 2* | 1 | 127 | 269 | 261 | 658 |
| *JOHN E RIGBY* | 1 | 123 | 277 | 251 | 652 |
| *ISLAND HOPPER* | 1 | 15 | 4 | | 20 |
| *THE CAT* | 1 | | | | 1 |
| *COREY AND TOBY* | 1 | | | | 1 |
| LADY WHITEHEAD | | | | 1 | 1 |
| **Total** | **7** | **3,026** | **3,678** | **2,581** | **9,292** |

*Source:* Maritime Innovation, from CCG data.

[3] Detailed schedules can be found at the following address : http://www.gnb.ca/0113/ferries/ferries-e.asp

The *Island Hopper* was built in 1990 and it is registered in St Andrews. Although it is reported here as being a ferry, Transport Canada's vessel registry system classifies it as "Tug – Other". It is made of steel and the 15 trips reported in 2003 were made to and from Chocolate Cove in the month of August. The trips reported in 2004 were done in May to August and were mainly made between North Head and Butler Point. *The Cat* is a high speed catamaran ferry linking Bar Harbour, Maine, and Yarmouth, Nova Scotia. In principle, the route of this vessel is outside of the area but it occasionally can enter it as was the case in July 2002 when it was reported to have sailed from the area to Yarmouth.

Finally, the *Corey and Toby* reported one trip to and from Eastport in 2002.

As indicated before, fishing vessels of 24 metres and more are required to report to the MCTS while those under this length report on a voluntary basis. Most of the trips accounted for in table 3-5 are made by regular fishing vessels between 11 m and 34 m. All trips recorded by the trawler type were made by one ship, the *Margaret Elizabeth no. 1*. v. This is also the case for the dragger *Jennifer & Boys*.

### TABLE 3-6 Fishing Vessel Trips in the Area

| Type | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|
| Fishing Vessels | 25 | 1,659 | 1,951 | 2,409 | 6,044 |
| Trawler | | 231 | 203 | 189 | 623 |
| Dragger (Scallop, Clam, etc.) | | 14 | 15 | | 29 |
| **Total** | **25** | **1,904** | **2,169** | **2,598** | **6,696** |

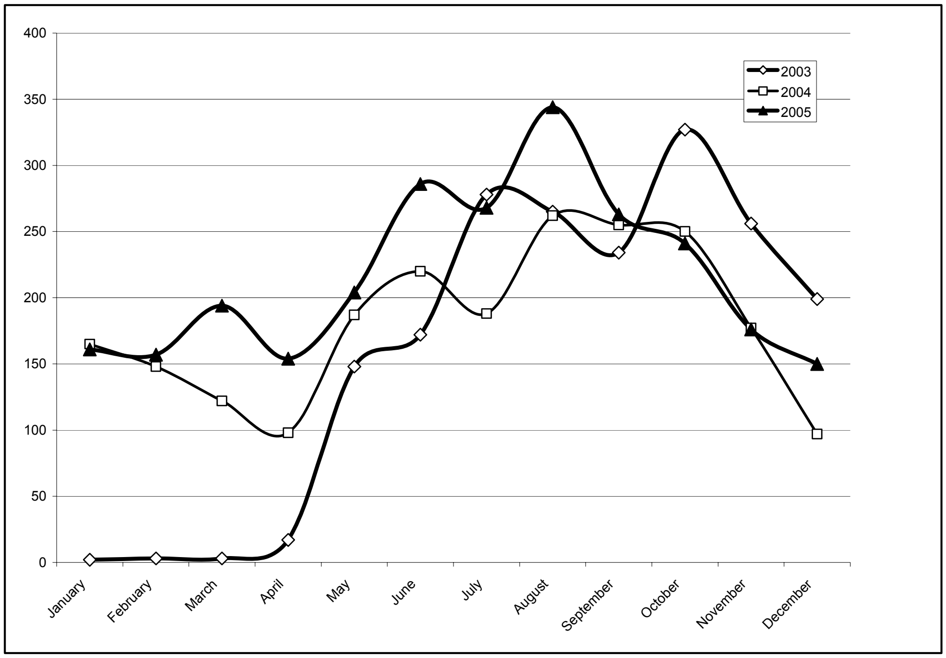
*Source:* Maritime Innovation, from CCG data.

Figure 3-11 illustrates the monthly variation of fishing vessel trips reported in the area for the years 2003-2005. Basically, fishing activities in the area are year round with a peak occurring during the months of July, August and September.

As it can be seen in Table 3-7, Blacks Harbour is definitively the principal port of call for fishing vessels accounted for in the MCTS database. Trips having "Sea" as destination are ones where the ships either declared leaving Canadian waters or went to high seas fishing grounds.

Tug and barges are most often operated together in the area, see Table 3-8. Most of these trips had the same origin as their destination and almost all these trips were reported by the *Hopper 2*, an 11 m Tug transiting in the Butler Point area and Deer Island in general.

**FIGURE 3-11 Monthly Variation of Fishing Vessel Trips Reported**




As indicated in the Table 3-9, 572 tanker trips were recorded in the area between 2002 and 2005. The table also indicates the names of each tanker and it's DWT. Most of these trips were in-transit, such as the one made by the *Eagle Birmingham* destined for Newfoundland. Only 9 trips were destined or originated from ports of the area during the period and were made by the *Arctic Wolf,* the *Troitsky Bridge* and the *Wellington Kent* and had for origin or destination Bayside, Bliss Island and North Head. In that sense, tanker traffic in the area is basically transiting traffic sailing in regular navigation routes. They are from, or bound for Saint John.

Table 3-10 indicates the bulk carriers reported transiting in the area. They are mostly in the 40 – 49,999 DWT range, mainly foreign registered and are active in international bulk, pulp and paper and wood products trades. The largest vessel to come in the area was the *Miltiadis*. This vessel was reported three times between 2003 and 2005. Two of those trips were in-transit and the other was destined for Bayside.

## TABLE 3-7 Principle Ports of Call for Fishing Vessel Trips Reported in the Area

| Destination | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|
| Blacks Harbour | 9 | 692 | 807 | 1,054 | 2,562 |
| Beaver Harbour | 3 | 109 | 187 | 209 | 508 |
| Leonardville Harbour | 1 | 170 | 82 | 223 | 476 |
| North Head | 4 | 117 | 234 | 98 | 453 |
| Eastport Harbour | | 104 | 156 | 81 | 341 |
| Bayside | 2 | 68 | 89 | 29 | 188 |
| Long Island Fishing area | 1 | 21 | 91 | 61 | 174 |
| St. Andrews | | 57 | 21 | 82 | 160 |
| Seal Cove Harbour | 1 | 55 | 3 | 87 | 146 |
| Outside of Area | | 55 | 54 | 20 | 129 |
| Letang Harbour | | 24 | 50 | 55 | 129 |
| Woods Island Harbour | | 2 | | 125 | 127 |
| Lepreau Harbour | | 21 | 51 | 46 | 118 |
| RP Within | | 31 | 26 | 54 | 111 |
| White Head Harbour | | 39 | 15 | 46 | 100 |
| Within area | | 43 | 33 | 13 | 89 |
| Upper Bay of Fundy Fishing Area | | 10 | 35 | 44 | 89 |
| Other | 4 | 286 | 235 | 271 | 796 |
| **Total :** | **25** | **1,904** | **2,169** | **2,598** | **6,696** |

## TABLE 3-8 Tug Traffic in the Area Covered

| Destination | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|
| Butler Point Harbour | | 33 | 79 | 79 | 191 |
| Saint John | 7 | 34 | 59 | 49 | 149 |
| Sea | 2 | 39 | 55 | 47 | 143 |
| Deer Island point Harbour | | | 46 | 37 | 83 |
| Chocolate Cove Harbour | | 16 | 15 | 1 | 32 |
| North Head | | 7 | 14 | 10 | 31 |
| Letete Harbour | | 3 | 8 | 6 | 17 |
| Leonardville Harbour | | 4 | 3 | 5 | 12 |
| Welshpool Harbour | | 1 | 2 | 8 | 11 |
| Letang Harbour | 1 | 2 | 1 | 6 | 10 |
| Other | 7 | 3 | 8 | 18 | |
| **Total** | **17** | **142** | **290** | **266** | **679** |

### TABLE 3-9 Tanker Traffic in the Area Covered

| Name | DWT | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|---|
| *MAERSK ROCHESTER* | 29,999 | 3 | 17 | 53 | 41 | 114 |
| *IRVING CANADA* | 37,740 | 4 | 22 | 38 | 49 | 113 |
| *MADONNA* | 38,213 | 3 | 15 | 33 | 22 | 73 |
| *URANUS* | 39,451 | 5 | 9 | 15 | 33 | 62 |
| *THALASSA DESGAGNES* | 9,748 | 5 | 21 | 31 | | 57 |
| *ROMOE MAERSK* | 34,806 | | | | 45 | 45 |
| *DELPHINA* | 39,673 | | 13 | 4 | 12 | 29 |
| *NEPTUNE* | 40,085 | | 23 | 2 | | 25 |
| *WELLINGTON KENT* | 11,500 | | 13 | 10 | | 23 |
| *VEGA* | 39,710 | | | 10 | | 10 |
| *MAERSK RADIANT* | 34,806 | | | | 8 | 8 |
| *ARCTIC WOLF* | 9,752 | 1 | | 4 | | 5 |
| *TROITSKY BRIDGE* | 47,199 | | | | 3 | 3 |
| *ROY MAERSK* | 34,999 | 2 | | | | 2 |
| *EAGLE BIRMINGHAM* | 99,343 | 1 | | | | 1 |
| *ASTRO SIRIUS* | 98,805 | | | 1 | | 1 |
| *ALGOSCOTIA* | 18,611 | | | 1 | | 1 |
| Total | | 24 | 133 | 202 | 213 | 572 |

*Source:* Maritime Innovation, from CCG data.

### TABLE 3-10. Bulk Carrier Traffic in the Area According to DWT Class

| DWT Class | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|
| < 10,000 | 2 | 1 | 1 | 1 | 5 |
| 10,000 - 14,999 | 2 | 4 | | 3 | 9 |
| 15,000 - 19,999 | 10 | 28 | 50 | 45 | 133 |
| 20,000 - 29,999 | 1 | 1 | 3 | | 5 |
| 30,000 - 39,999 | 22 | 11 | 6 | 4 | 43 |
| 40,000 - 49,999 | 54 | 99 | 111 | 88 | 352 |
| 50,000 - over | 4 | 3 | | | 7 |
| Total | 95 | 147 | 171 | 141 | 554 |

*Source:* Maritime Innovation, from CCG data.

Table 3-11 presents an overview of origin/destination pairs for bulk carriers transiting in the area in 2005. Bayside and Eastport are the main destinations of the trips reported by bulkers. For Bayside and Eastport, most of the trips were done by foreign registered vessels engaged in international trades.

General cargo vessels transiting in the area are also mainly destined to Bayside and Eastport, see Table 3-12. General cargo trips to Bayside all originate from outside the area and are made by foreign registered vessels. The same is true for Eastport. The other destinations identified in the table are often the destination following a passage in the two major ports.

**TABLE 3-11. Origin/Destination Pairs for Bulker Trips in the Area Covered (2005)**

| Origin | Destination | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | Sea | Bayside | Hantsport | Eastport Harbour | Minas Basin Anchorage | Bliss Island | Saint John | |
| Outside of Area | | 33 | 15 | 3 | 5 | 1 | | 57 |
| Bayside | 36 | | | | | | | 36 |
| Hantsport | 19 | | | | | | | 19 |
| Eastport Harbour | 17 | | | | | | 1 | 18 |
| Sea | | | 5 | | 1 | | | 6 |
| Friars Road Anchorage | | | | 3 | | | | 3 |
| Bliss Island | | 1 | | | | | | 1 |
| Saint John | | | | 1 | | | | 1 |
| Total | 72 | 34 | 20 | 7 | 6 | 1 | 1 | 141 |

*Source:* Maritime Innovation, from CCG data.

**TABLE 3-12 Destination of General Cargo Trips in the Area Covered**

| Destination | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|
| Bayside | 43 | 25 | 32 | 21 | 121 |
| Sea | 21 | 26 | 37 | 33 | 117 |
| Eastport Harbour | 21 | 31 | 17 | 20 | 89 |
| Bliss Island | 19 | 8 | 8 | 3 | 38 |
| Saint John | 4 | 8 | | 6 | 18 |
| Mulgrave | 1 | 8 | 5 | | 14 |
| Within area | 4 | 2 | 4 | | 10 |
| Pictou | 1 | 1 | 1 | 5 | 8 |
| Friars Road Anchorage | | 1 | 2 | 4 | 7 |
| RP Within | | 7 | | | 7 |
| Summerside | | 2 | 2 | 1 | 5 |
| Dalhousie | | | 4 | | 4 |
| Chedabucto Bay | | 1 | 1 | 1 | 3 |
| Liverpool | | | | 1 | 1 |
| Québec Foulon 101 | 1 | | | | 1 |
| Matane Public Wharf Section 1 | | 1 | | | 1 |
| Halifax | | 1 | | | 1 |
| Belledune | | | 1 | | 1 |
| Port Alfred Powell Wharf Section 1 | | 1 | | | 1 |
| Trois-Rivières Wharf 13 | | 1 | | | 1 |
| Total | 115 | 124 | 114 | 95 | 448 |

*Source:* Maritime Innovation, from CCG data.

Roll-on / roll-off (ro-ro) vessels carry all sorts of vehicles. The trips reported in the area were essentially made by the *Trans Gulf,* a 2,777 GT vessel registered in Canada and owned by Nada Shipping of the Bahamas. The vessel is operated between Blacks Harbour and North Head. About half of the special purpose vessel trips were made by the *Eastport Pilot Boat*. Other special purpose vessels in the area were research and survey ships. All the trips recorded by dredges were made by the *Fundy Trail.* It was mainly operated in the Deer Island area. A total of 47 yacht trips were reported in the area. The trips made by military vessels were essentially made by US and Canadian ships transiting in the Grand Manan and Blacks Harbour area. The *Nantucket Clipper* is the passenger vessel transiting most frequently in the area. This US registered vessel can carry up to 99 passengers and mostly sails between North Head and Blacks Harbour, as are the other passenger vessels reported in the area. Nonetheless, passenger vessels sailing in the area are for sightseeing and whale watching. Finally, chemical tanker trips reported in the area were in transit and had Saint John for origin or destination.

### 3.3.2 Pre 2003 Traffic

As mentioned previously, the MCTS vessel traffic database pertaining to trips prior to 2003 does not have as much precision as the INNAV database. The trips recorded between 1988 and 2002 are presented in Table 3-13.

**TABLE 3-13 Pre 2003 Traffic in the Area Covered**

| Type | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| General cargo | 68 | 110 | 204 | 106 | 116 | 91 | 78 | 78 | 97 | 91 | 89 | 76 | 66 | 77 | 26 | 1 373 |
| Bulk | 9 | 12 | 27 | 23 | 12 | 32 | 37 | 33 | 32 | 35 | 58 | 77 | 94 | 97 | 16 | 594 |
| Fishing Factory ship | | 2 | | 2 | | 10 | 25 | 25 | 28 | 62 | 51 | 26 | 5 | | | 236 |
| Container | 16 | 8 | 10 | 14 | 11 | 4 | 1 | 4 | 8 | 5 | 6 | 2 | | 2 | | 91 |
| Passenger | 3 | | | | | | 11 | 15 | 16 | 13 | 10 | 4 | 1 | 1 | | 74 |
| Unknown | 7 | 10 | 3 | 4 | 4 | 4 | 4 | 5 | 6 | | 4 | | 12 | 5 | | 68 |
| Special purpose | 3 | 7 | 1 | 2 | 1 | 4 | 1 | 2 | 1 | 2 | 4 | 11 | 3 | 4 | 2 | 48 |
| Fishing | | | | | | | 4 | | 2 | 2 | | 1 | | | | 9 |
| Tug | 3 | | | | | | | | | | | 1 | | | | 4 |
| Ferry | | | | | | | | | | | 1 | 2 | | | | 3 |
| Merchant Auto | | | | | | | | | | | | | | 2 | | 2 |
| **Total** | **109** | **149** | **245** | **151** | **144** | **145** | **161** | **162** | **190** | **210** | **223** | **200** | **181** | **188** | **44** | **2 502** |

*Source:* Maritime Innovation, from CCG data

Because fishing vessels and ferries were not reported as much in the pre 2003 database, general cargo ships and bulkers are the two types of vessels having undertaken the greatest number of trips in the area. In 2001, most of the trips reported by general cargo ships and bulkers had either Bayside or Eastport as origin or destination. Also, most of this traffic originated or was destined to the US East Coast.

Fishing factory ship trips were mostly international having Bayside as origin or destination. Containership traffic was essentially made between Eastport and other ports of the US East Coast. Finally, passenger vessels were transiting in Bayside and St. Andrews.

Table 3-14 presents the number of vessel calls to the locations of the area according to the year. One will notice that the total number of calls is somewhat higher than half of all vessel trips in the previous table. The reason explaining this is that some vessels can call to more than one location in the area before leaving. For example, the vessel will enter the area and go to Bayside. It can then make another trip to St. Andrews and then, one last trip to exit the area.

**TABLE 3-14 Vessel Calls by Location in the Area**

| Destination | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bayside | 7 | 38 | 86 | 48 | 40 | 42 | 53 | 56 | 81 | 89 | 84 | 78 | 66 | 65 | 13 | 846 |
| Eastport | 24 | 28 | 33 | 29 | 30 | 29 | 25 | 23 | 18 | 18 | 21 | 19 | 23 | 34 | 10 | 364 |
| St. Andrews | 22 | 4 | | | | | | | | | 6 | 2 | 3 | | | 37 |
| Wallace | | 5 | 2 | | 1 | 2 | | | | | | | 2 | | | 12 |
| Passamaquoddy Bay | | | | | | | | | | 1 | | | | | | 1 |
| Grand Manan | | | | | | | | | | | | | | 1 | | 1 |
| Beaver Harbour | | | | | | | | | | | | | | 1 | | 1 |
| Fundy Bay | | | | | | | | | 1 | | | | | | | 1 |
| **Total** | **53** | **75** | **121** | **77** | **71** | **73** | **78** | **79** | **100** | **108** | **111** | **99** | **94** | **101** | **23** | **1 263** |

*Source:* Maritime Innovation, from CCG data

### 3.3.3 Vessel Traffic Reported in US Ports

As mentioned before, the vessel traffic presented in this section cannot be added to the Canadian data because the latter includes vessel trips to and from the US side of Passamaquoddy Bay. WCSC data for the State of Maine indicate that only two locations within the area covered have received commercial vessel traffic recently. These locations are Eastport and the Lubec Channel. Table 3-15 presents detailed vessel traffic by vessel type for these two locations.

## TABLE 3-15 Vessel Traffic in US Locations of the Area Covered

| Location / vessel type | 1997 | | 1998 | | 1999 | | 2000 | | 2001 | | 2002 | | 2003 | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | IN | OUT | IN | OUT | IN | OUT | IN | OUT | IN | OUT | IN | OUT | IN | OUT | |
| Eastport | | | | | | | | | | | | | | | |
| Other General Cargo | 150 | 146 | 478 | 475 | 561 | 537 | 671 | 678 | 237 | 233 | 26 | 26 | 103 | 104 | 4 425 |
| Unspecified | 653 | 648 | 255 | 248 | | | | | | | | | | | 1 804 |
| Other Bulk Carrier | 11 | 9 | 7 | 6 | | | 5 | 5 | 328 | 328 | | | 132 | 131 | 962 |
| Tugboat | | | | | 2 | 1 | | | | | 192 | 192 | | | 387 |
| General Cargo-Single Deck NEI | 19 | 18 | 18 | 18 | | | 26 | 27 | 26 | 27 | 23 | 23 | 23 | 23 | 271 |
| General Cargo-Multi Deck NEI | 4 | 4 | 6 | 6 | | | 6 | 6 | 9 | 9 | 7 | 7 | 12 | 12 | 88 |
| Other Nei | | | | | 1 | 1 | | | 15 | 15 | | | | | 32 |
| General Cargo / Container | | | 12 | 12 | | | | | | | | | | | 24 |
| Other Passenger | | | | | | | | | 6 | 5 | | | 2 | 2 | 15 |
| Fish Catching | | | | | | | | | | | | | 5 | 4 | 9 |
| Other Ro-Ro Cargo | | | | | | | | | 3 | 3 | | | | | 6 |
| Other Dry Cargo Barge | | 1 | | | | | | | | | | | | | 1 |
| Lubec Channel | | | | | | | | | | | | | | | |
| Other Bulk Carrier | | | | | | | | | 4 | 3 | | | | | 7 |
| Other Passenger | | | | | | | | | 1 | 2 | | | | | 3 |
| Total | 837 | 826 | 776 | 765 | 564 | 539 | 708 | 716 | 629 | 625 | 248 | 248 | 277 | 276 | 8 034 |

*Source:* Maritime Innovation, from USACE WCSC data

“Other General Cargo” vessels reported in Eastport in 2002 were practically all made by Canadian vessels. The trips reported were transits linking Eastport to either Campobello or Blacks Harbour. After verification in Transport Canada’s Vessel Registration Query System[4], the vessels reported in the “Other General Cargo” category are fishing vessels and barges. This verification also reveals that vessels in the “Unspecified” and “Other Bulk Carrier” categories are also fishing vessels and barges. The trips reported by these types of vessels also had for origin or destination Campobello, Bayside, St. Andrews and Blacks Harbour. Single and multi deck general cargo vessels calling at Eastport are mostly foreign registered and are transiting in the area. Precisely, Mulgrave (NS), Saint John, and Portland (ME) are typical origins and destinations for the trips reported by these vessels.

Table 3-16 presents the main origins of vessels transits destined to Eastport. As it can be noticed, most of the trips originated in the Passamaquoddy area. This confirms that Eastport vessel traffic is dominated by fishing vessel traffic. The presence of international origins reflects cargo vessel traffic. Destinations of trips undertaken from Eastport present the same profile.

[4] http://www.tc.gc.ca/ShipRegistry/menu.asp?lang=e

**TABLE 3-16 Vessel Traffic to/from Bayside and Eastport by Type (Canadian Data)**

| Port /Vessel | Inbound | Outbound |
|---|---|---|
| Bayside | | |
| Bulk | 36 | 36 |
| General Cargo | 27 | 27 |
| Factory Ship | 1 | 1 |
| Container | 1 | 1 |
| Eastport Harbour | | |
| General Cargo | 23 | 23 |
| Bulk | 18 | 18 |
| Ro-Ro | 2 | 2 |
| Total | 108 | 108 |

First, it can be said that there are presently no commercial vessels transiting in the area of the size of the proposed LNG carriers. For example, the biggest ship that came into Bayside in 2005 was 223 meters long. In general, vessels coming in Passamaquoddy Bay are less than 200 meters long while the proposed LNG carriers will be 283 meters. It can also be mentioned that tankers rarely come in the area. The commodities carried are thus rarely dangerous.

Given that it is expected that the proposed LNG carriers will make approximately 1 call per week, this means that the annual traffic of cargo vessels will nearly double what it is at the present time. Although LNG carriers are often considered more secure than other vessels, the fact that they are bigger would tend to indicate that the “potential” risk of accidents implicating cargo vessels will be greater if the number of vessel trips in the area doubles.

## 3.4 General Observations

Commercial vessel traffic in the area covered by this analysis can be divided into three types. First, large cargo vessels call at ports such as Bayside, St. Andrews, Blacks Harbour and Eastport. These vessels are general cargo ships (including reefers) and bulkers active in international trades. There are also numerous tankers transiting in the area to supply isolated populations on islands of the area. Bayside and Eastport are nonetheless considered to be the only two cargo ports of the area. The Bayside Marine Terminal is a two berth facility that is currently experiencing a period of growth. The terminal's main source of traffic is in the areas of gypsum and potatoes.

From 1996 to 2003, tonnages loaded at Bayside have grown from 145,000 tonnes to 1.6 million tonnes. According to the port's website, this growth is expected to continue[5]. The port of Eastport has two terminals. The Breakwater Terminal has berthing for a vessel up to 213 meters and is used by used by the aquaculture industry, commercial fishermen, recreational boaters and fishermen but also by cruise vessels calling at Eastport. The Estes Head Cargo Terminal can accommodate a ship of 275 meters.

In practice, it is compulsory for commercial cargo vessels navigating in the Bay of Fundy to follow the traffic separation scheme which is found in the appropriate nautical charts that cover the area where they sail. This traffic separations scheme is included in a routing system and is described in Notice to Mariners 10 (Routeing of ships) published annually by the Canadian Coast Guard. Monthly editions of the Notices to Mariners must nonetheless be consulted for eventual additions and amendments. Instruments by which they are made compulsory fall under Rule 10 of the Collision Regulations, including the Canadian Modifications.

The second type of traffic is done by ferries and liner services. This is notably the case for supply and ferry services to Grand Manan Island.

The third type of traffic can be characterised by the fact that it is less prone to follow designated navigation routes. This is the case for fishing vessels, tour boats and pleasure crafts (sails and yachts). For example, Tourism New Brunswick advertises about 10 whale watching operators in the area. Most of the trips undertaken by these vessels are not necessarily reported in the MCTS database. Because most touring operators, fishermen and pleasure boaters are aware of the inherent dangers of navigation and of the area, this traffic cannot be defined as being erratic but it certainly is less predicable.

[5] http://home.houston.rr.com/nugent/bayside.html

Concerning the risks associated with the supplementary traffic generated by the passage of LNG carriers, the fact that incidents implicating this type of vessel are very limited makes any quantification of risks very theoretical. It is nonetheless possible to compare the supplementary traffic of LNG to the existing traffic. In this context, Table 3-16 presents commercial vessel traffic in 2005 according to the two ports generating cargo vessel traffic.

## 3.5 ELEMENTS OF PASSAMAQUODDY BAY, LNG TERMINAL RISK ANALYSIS

### 3.5.1 Basic Elements to Consider in the Risk Analysis

This section provides some elements to consider in the risk evaluation. The effect they can have on the whole situation is not defined for all those points, but they all play a role in this aspect of the project and may serve as a starting point for legislative modifications in order to improve the security or the safety of the whole project. Doing so, legislators should consider similar projects in Canadian waters in a way to ensure an operational coherence. Table 3-17 indicates positive (+) aspects for the protection of the Canadian assets and potential problems or negative influences (-) on the required protection.

The Canadian maritime legislation is presently in a revision process and chances are that the ratification of conventions like HNS Convention will require major changes in the various rules under the revised *Canada Shipping Act*. [Ratification of the HNS Convention will require changes to the *Marine Liability Act*.]Present laws and rules seem to provide adequate protection and sufficient right for action against vessels that might cause damages in Canadian waters unless this conclusion is denied by jurisprudence. The weak link is probably on the mandatory pilotage zone and on the security, safety zone around these large vessels. Signing the HNS Convention would provide a better protection in terms of liabilities and give access to helping fund.

**TABLE 3-17 Positive (+) Aspects for the Protection of Canadian Assets and Potential Problems or Negative Influences (-)**

| Positive(+) Negative (-) | Aspect |
|---|---|
| + | Deep water close to shore; |
| + | Liabilities well defined; |
| - | No compulsory pilotage; |
| - | Sharp long turn (90++) in order to enter the bay; |
| - | Ferries in the ship's path; |
| - | Vessel transit on the border; |
| - | HNS Convention not in force; |
| + | US rules ask for a safety and security zone in such case of Hazardous cargo; |
| - | Canada does not have such zone requirements; |
| - | Terminal in close proximity to a Canadian town; and |
| - | Major fishing industry on the path and in the vicinity of the LNG terminal. |

A report prepared by Sandia National Laboratories, provides guidance on an approach to risk analysis and safety implications arising from a Large Liquefied Natural Gas (LNG) Spill Over Water (Hightower, M. *et al.*, 2004); a subject of great interest to the proposed LNG facilities. In general terms, following the guidance set out in the Sandia report, some of the elements that need to be considered when assessing the potential risks arising from marine transport of the LNG for the Passamaquoddy Bay LNG project are likely to come from one or more of the following aspects of this project:

- the nature of the cargo itself;
- the type and size of the vessels used to carry it;
- the geomorphological structures of the transit zone;

- the natural effects of the tide, currents, wind and season;
- the actual traffic around and in the bay; and
- the response capacity in case of an accident.

The main concern, for the public, is a large release of LNG and either a fire or the development of a large vapour cloud potentially resulting in asphyxiation from lack of oxygen or the subsequent ignition of the vapour cloud after it has spread, potentially kilometres, downwind (Hightower, M. *et al.*, 2004). A schematic approach of such an event is proposed in the Sandia report and can be very useful for the risk evaluation.

The approach suggested by Sandia demonstrates that safety zones surrounding LNG tankers can vary upon the physical and human environment within which the ships transit. For example, Figure 3-12, from the Sandia report, illustrates the potential sequences of events following a breach of an LNG cargo tank. This quite simple approach allows the analyst to build up the various scenarios in order to identify the consequent risks associated with each stage of an event. This figure is very useful for understanding the mechanics of the options existing in the chains of events.

Tables in the Sandia report (e.g., Table 12 on page 47 and Table 16 on page 54) illustrate the range of potential impacts for an accidental spill (Table 12) or an intentional one (Table 16). Despite the fact that these tables do not cover all the possibilities of eventual events, they provide a good starting base for risk assessment, and risk management including the development of potential mitigation measures.

In general terms, a risk assessment needs to answer the following questions:

- what can go wrong (e.g., collision with another vessel);
- how likely is something to go wrong; and
- if something goes wrong, what are the consequences?

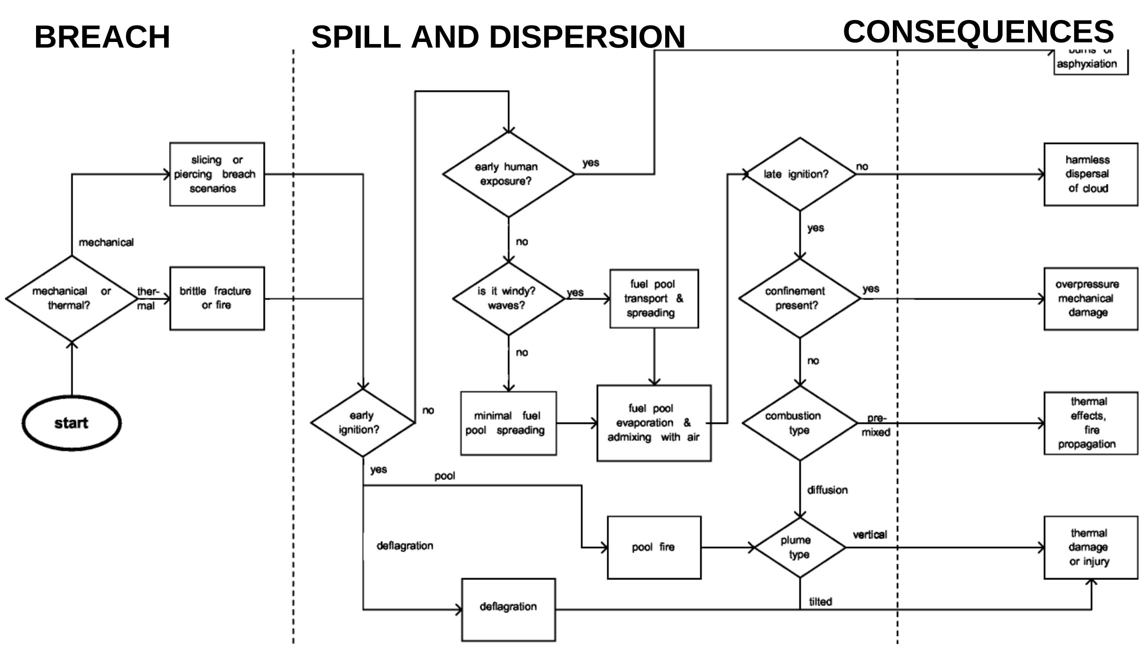
Several risk factors associated with what could go wrong and, in any event, would factor into an evaluation of the likelihood of an event, have already been discussed in previous sections and include:

- navigation in narrow passages, especially turns in elbows, fog, tidal currents, whirlpools, and river currents. (Ice not a concern for LNG);
- entering the bay without a pilot;
- potential hazards from incidents with local marine traffic:
    - Local ferries;

- Commercial;
- Fishing;
- Leisure;
- Tourism including whale watching inside and outside the bay.

All of these factors affect the chance of an LNG tanker running aground or into another vessel. Such an event has the potential to result in the release of LNG, above the waterline or below the waterline. In either event, there is potential for pooling of LNG on the water surface and subsequently for either ignition of the vapour at or near the point of release or following dispersion downwind. The size of the vapour cloud depends on many factors, including for example, the size of the LNG release, the rate of evaporation, the presence of one or more ignition sources and other factors. The Canvey Island Report (HSE 1978 and HSE 1981) provides a good description of how one might go about evaluating the potential for and consequences of an LNG release from a terminal.

**FIGURE 3-12. Potential Sequences of Events Following a Breach of an LNG Cargo tank.[6]**




6 Reproduced from the Sandia National Laboratories report entitled *"Guidance on Risk Analysis of a Large Liquefied Natural Gas (LNG) Spill Over Water"* written by Hightower, M. et al., 2004.

According to a 2003 review carried out by the University of Houston Law Center, the experience of the LNG industry has shown that maritime incidents with severe LNG releases are very rare and that, up to 2003, there has never been a spill from a ship into the water from either a collision or grounding. The University of Houston report goes on to say that LNG ships are well designed and well maintained, which reduces the chances and severity of incidents. Nevertheless, they also indicate that potential hazards could come from ignition of LNG pool fires or a vapour cloud that might results from a release of LNG. Table 3-18, reproduced from the University of Houston report, provides a list of historical LNG incidents from 1944 to 1973.

**TABLE 3-18. Historical LNG incidents. Reproduced from the University of Houston Law Centre, Institute for Energy, Law and Enterprise Report LNG Safety and Security" Dated October 2003**

| Incident Date | Ship / Facility Name | Location | Ship Status | Injuries / Fatalities | Ship / Property Damage | LNG Spill / Release | Comment |
|---|---|---|---|---|---|---|---|
| I944 | East Ohio Gas LNG Tank | Cleveland | NA | 128 deaths | NA | NA | Tank failure and no earthen berm. Vapour cloud formed and filled the surrounding streets and storm sewer system. Natural gas in the vapourizing LNG pool ignited. |
| 1965 | | Canvey Island, UK | A transfer operation | 1 person seriously burned | | Yes | |
| 1965 | Jules Vernet | | Loading | No | Yes | Yes | Overfilling. Tank cover and deck |
| 1965 | Methane Princess | | Disconnecting after discharge | No | Yes | Yes | Valve leakage. Deck fractures. |
| 1971 | LNG ship Esso Brega, La Spezia LNG Import Terminal | Italy | Unloading LNG into the storage tank | NA | NA | Yes | First documented LNG Rollover incident.<br>Tank developed a sudden increase in pressure. LNG vapour discharged from the tank safety valves and vents. Tank roof slightly damaged. No ignition |

**TABLE 3-18. Historical LNG incidents. Reproduced from the University of Houston Law Centre, Institute for Energy, Law and Enterprise Report LNG Safety and Security" Dated October 2003 (Cont'd)**

| Incident Date | Ship / Facility Name | Location | Ship Status | Injuries / Fatalities | Ship / Property Damage | LNG Spill / Release | Comment |
|---|---|---|---|---|---|---|---|
| 1973 | Texas Eastern Transmission LNG Tank | Staten Island | NA | 40 killed | No | No | Industrial incident unrelated to the presence of LNG.<br>During the repairs, vapours associated with the cleaning process apparently ignited the mylar liner.<br>Fire caused temperature in the tank to rise, generating enough pressure to dislodge a 6-inch thick concrete roof, which then fell on the workers in the tank. |
| 1973 | | Canvey Island, UK | NA | No | Yes | Yes | Glass breakage. Small amount of LNG spilled upon a puddle of rainwater, and the resulting flameless vapour |

**NOTE**: Much of the material in this table is taken from Lloyd's Register's Risk Assessment Review of the Marine Transportation of Liquefied Natural Gas, STD Report #3000-1-2, September 1992; West, H.H. and M.S. Mannan, Texas A&M University: *LNG Safety Practice & Regulation: From 1944 East Ohio Tragedy to Today's Safety Record,* AIChE meeting, April 2001 and CH-IV International: *Safety History of International LNG Operations,* November 2002.

The effects of Security and Safety zones are not addressed by Sandia but are important mitigating considerations and should be addressed in a formal risk assessment.

In response to a proposed expansion of the Canvey Island industrial complex in London England, the UK Health and Safety Executive conducted a comprehensive investigation of potential hazards to people living in the area from possible accidents associated with the loading and unloading, storage and processing of a variety of hazardous materials, including the British Gas Corporation Methane Terminal (HSE 1978). The methane terminal is located on Canvey Island and is primarily used for the receiving and storing of LNG which, at the time, was brought to the terminal in specially designed ships and stored in a combination of above ground tanks and below ground frozen pits. The facility also had three storage tanks for liquefied butane. The LNG is vaporized from storage and fed into the national gas distribution system. The major hazards associated with LNG were identified as:

- LNG release to the estuary after ship collision;
- LNG release during ship to shore transfer operations; and
- LNG release from storage tanks or inground pits.

Subsequently, three years later, the UK HSE carried out a follow-up review of the potential hazards in the Canvey Island/Thurrrock area (HSE 1981) to look at improvements since 1978 and to identify any follow-on actions. By 1981, the British gas terminal was importing about 50 shipments of LNG per year. The report discusses two main routes to a major LNG spill, namely:

- an escalating small spill; and
- a collision or fire/explosion involving a ship at the jetty.

Such issues would also need to be addressed in a risk assessment of the proposed LNG activities on *Passamaquoddy Bay*.

Transport Canada has developed a process for conducting a technical review of a LNG carrier ship and transport route for proposed terminals to be located in Canada (Transport Canada, 2001). In particular, the approach considers a dedicated design ship, its berth at a proposed marine terminal or transhipment cargo handling between vessels, or off-loading from ship to shore or vice-versa. Of importance here is the need for the proponent's submission to demonstrate that the operator's or owner's safety management system is in accordance with recognized safe management procedures., that arrangements for ongoing operational audits of the safety and management system are provided, that major accident hazard in the context of the proposed operation have been identified; and that the potential risks from these accidents have been evaluated and measures taken to reduce those risks to an acceptable level using the best available technology.

The potential for an a LNG incident to occur and for the incident to lead to a release of LNG with offsite consequences depends on a number of factors, including for example, environmental factors such as fogging, navigational hazards, design of vessels and terminals and associated safety systems and human factors. In addition to incidents that are initiated by environmental factors, inadequate design or human error, there is also the possibility of terrorist activities that lead to a release of LNG and subsequently, to fire or vapour cloud. Thus, the physical security of LNG operations also needs to be considered carefully.

The consequences of a large release of release of LNG, arising from an accident or from a terrorist action, depends on the volume and location of the release, release rate, proximity of population centres, wind direction and wind speed, and other factors. However, as noted several places in this report, a quantitative risk analysis that considers the risk triplet of what could happen, how likely is something to happen and if something happens, what the consequences are, requires detailed information about the proposed project activities, safety aspects incorporated into the design, human factors training of operators and emergency response personnel, amongst other considerations. Such an analysis should be carried out and independently peer reviewed before approvals for any of the proposals are accepted.

## 3.6 ANALYSIS OF THE RISK ASSOCIATED WITH TRANSIT IN PASSAMAQUODDY BAY

### 3.6.1 Elements Considered

In order to determine the risk associated with the passage of a vessel in a given sector, one needs a good knowledge of all the elements that may have an impact on the trip. These elements include both the ones that apply to the vessel and the ones that apply to the local conditions.

Elements that apply directly to the vessel include physical parameters such as its dimensions, its manoeuvrability, the type of cargo carried, its draft, etc. In the case of LNG transport through Passamaquoddy Bay, only one type of vessel is used and, consequently, the risk elements pertaining to the vessel remain constant and will have no impact on the fluctuation of the level of risk during the transit.

The elements that apply to the level of risk linked to local conditions are grouped into three categories:

- geographic factors such as the width of the channel, depth of the channel and topography;
- environmental factors such as currents, winds and fog; and
- navigational aids such as buoys, ranges and tugs.

Because navigational aids are currently non-existent, we assume that they will eventually be deployed proportionally to the level of risk. This implies that their ability to reduce the risk associated with potential hazards will be proportional to their level of deployment and that this input can be treated as a constant ratio all along the transit. For example, suppose that the level of service along the beaconage plan has to reduce the risk by 10%. The number of aids to navigation will have to be higher in the locations where risks are higher in order to potential risks by 10%. In this manner, the navigation aids are deployed according to the level of risk. This input is thus a constant relative to the risk and will not have an impact on the risk level fluctuation during the transit.

Based on the foregoing argument, geographic and environmental elements will have a greater impact on risk during transit and knowledge of local conditions are necessary to evaluate the risk associated with transit in specific locations.

### 3.6.2 Evaluation Method

The method applied to evaluate the difficulties that represent specific parts of the transit is based on the analysis of the trip, segment by segment. For each segment, a level of risk pertaining to geographic and environmental elements is applied. The levels of risks are the following: 1 for small, 2 for medium and 3 for high. Geographic elements include the width of channel and the sinuosity of reference marks, while environmental elements include the current, the wind and visibility.

It is important to note that the effect of multiple risks from the same category is cumulative. Therefore, the risk level of a category is calculated by adding together the levels for each element in the category. We have thus added the levels of risk for the environmental and geographic categories.

Because the risks of the geographic category apply to all the risks of the environmental category, the sums of the levels of risk of each category are compounding and were therefore were multiplied together to give an overall risk for each location (see Table 3-19 and Figure 3-13). In order facilitate the comparison between each segment of the transit, the risk levels are presented by way of a weighted average relative to the maximal risk. This was done for each segment and each time the ship alters its course. One also has to bear in mind that these are levels of risks related to the transit of the LNG ship and not values emanating from a comprehensive calculation of risk for the area that can be applied to other sectors, e.g. fishing boats.

### 3.6.3 Conclusions

Based on the above it is possible to conclude that the most critical point of the transit is close to the Old Sow turn where the risk factor is approximately double the average risk for the whole transit. The risk factor is also high in the compression of the channel at Deer Island Point and during the change in course upstream of that point (see Table 3-20 and Figure 3-13.

A Proof of Concept Simulation Study was conducted for the Downeast LNG Project. Based on the preliminary results of the navigation modelling for passage from the Pilot Boarding Site to proposed terminal at Mill Cove, the following conclusions (among others) were drawn:

- "The waterway itself is more than adequate to navigate LNGC's of 165,000 $m^3$ cargo capacity with the dimensions simulated 300m x 46m from Passamaquoddy Bay Pilot Boarding area to the planned DELNG Terminal site at Mill Cove, Robbinston, Maine; and
- Current aids to navigation need to be upgraded to provide the pilots with additional visual cues to quickly locate potential hazards and precisely identify intended navigation tracks, and improve situational awareness for all members of the pilotage team.

While the study concludes that "*The waterway itself is more than adequate to navigate LNGC's...*", it also, paradoxically, concludes in 7.1.3 that "*the pilots were steadfast about avoiding transits of the north end of Friar Roads and the Western passage during the flood tides...*". In addition, paragraph 7.1.5 states that "*Tugs need to be tethered at the earliest opportunity after the pilot has boarded.*" If this is necessary to provide steering and speed retarding forces, then the reason is because the vessel is entering a very confined passage. Note that it's not an easy task to tie up a tug in bad weather and the need for four tugs of 5000 HP implies that a significant amount of power is required to provide adequate steering and speed retarding forces.

Paragraph 7.2.3 recommends berthing the ship with the bow into the tidal current, however, it is equally important that there is no current at the Old sow when the vessel passes there. This means that the time windows to bring the ship to berth at the terminal are very restricted. Therefore, if the waterway is more than adequate for these vessels to navigate, then it should be a lot easier than implied in the Proof of Concept Simulation Study to bring a ship to berth at the terminal.

**TABLE 3-19 Level of risk for LNG Ships Associated with the Occurrence of Conventional Hazards While in Transit in Passamaquoddy Bay**

| Segment | Current | Wind | Visibility | Channel | Sinuosity | Marks | Result |
|---|---|---|---|---|---|---|---|
| **Head Harbour Pass.** | 2 | 2 | 2 | 2 | 1 | 1 | 30% |
| **Alternative course** | 3 | 2 | 2 | 1 | 2 | 1 | 35% |
| **Indian Island.** | 2 | 2 | 2 | 1 | 1 | 2 | 30% |
| **Cherry Island turn** | 3 | 3 | 2 | 3 | 3 | 2 | 79% |
| **Deer Island Point Pass** | 3 | 3 | 2 | 3 | 1 | 1 | 49% |
| **Alternative course** | 2 | 2 | 3 | 2 | 2 | 2 | 52% |
| **Western Passage** | 2 | 1 | 2 | 1 | 1 | 1 | 19% |
| **Mooring** | 3 | 3 | 3 | 1 | 1 | 1 | 33% |

**FIGURE 3-13 LNG Passage Plan (see Tables 3-20 and 3-21)**

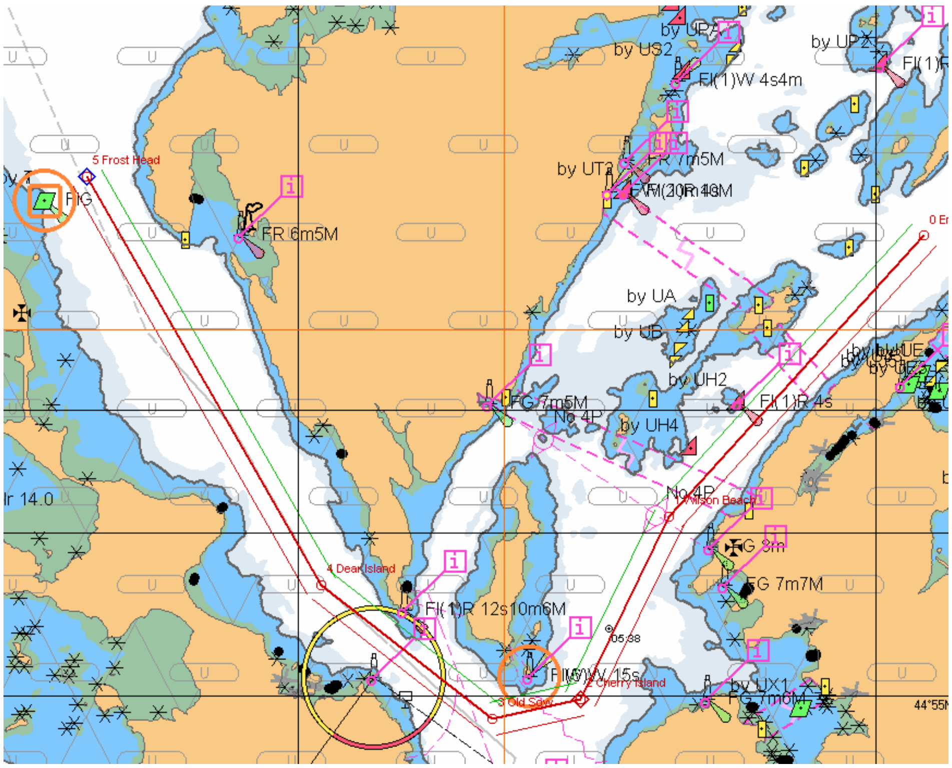



**TABLE 3-20 Waypoints for the Passage Plan (see Figure 3-13)**

| Waypoint | Latitude | Longitude | Name |
|---|---|---|---|
| # 1 | 44° 57.83 ' N | 066° 54.59 ' W | Head Harbour Passage |
| # 2 | 44° 56.10 ' N | 066° 56.79 ' W | Wilson Beach |
| # 3 | 44° 54.98 ' N | 066° 57.56 ' W | Cherry Island |
| # 4 | 44° 54.86 ' N | 066° 58.32 ' W | Old Sow |
| # 5 | 44° 55.68 ' N | 066° 59.80 ' W | Dear Island |
| # 6 | 44° 58.19 ' N | 067° 01.83 ' W | Frost Head |

**TABLE 3-21 Route Segments for the Passage Plan (see Figure 3-13)**

| Route Segments | Course | Distance | Distance | Parallel Index | Heading |
|---|---|---|---|---|---|
| WPT #1 to WPT #2 | 222° | 2.33 nm | 2.33 nm | South coast x 0.17 nm (320 m) | Cherry Island |
| WPT #2 to WPT #3 | 206° | 1.25 nm | 3.57 nm | Wilson light x 0.275 nm (510 m) | Treat Island |
| WPT #3 to WPT #4 | Variable | 0.55 | 4.12 mn | Abeam Cherry light x 0.35 nm (650 m) | |
| WPT #4 to WPT #5 | 308° | 1.35 nm | 5.46 mn | Dog Island light x 0.25 nm (460 m) | Kendall Head |
| WPT #5 to WPT #6 | 330° | 2.88 nm | 8.35 nm | Kendall Head x 0.3 nm (550 m) | |
| WPT #6 to WPT #7 | | 5.76 nm | 14.11nm | | |

### 3.6.4 Overview of Laws and Rules Pertaining to the Operational Aspects and Liabilities in Case of Accident

In order to determine how the national legislation provides protection to the Canadian citizen in this particular project, the first step was to verify how the concerned cargo is described and considered in Canadian laws and rules, and from an international point of view. Then, knowing what we are looking for, the second step consisted in analysing relevant information pertaining to the subject.

This survey is based on an operational approach and should be completed by a legal verification to obtain court interpretation. Jurisprudence might allow analysing these elements in another point of view, thus affecting the first conclusions.

The International Maritime Dangerous Goods (IMDG) Code was developed as a uniform international code for the transport of dangerous goods by sea covering such matters as packing, container traffic and stowage, with particular reference to the segregation of incompatible substances. Despite the fact that it only covers the packaged expedition of dangerous goods; the IMDG Code can be useful as a reference in terms of product identification. In the IMDG Code, LNG is described in the following manner:

- Reference **IMDG code**, LNG is identified by UN 1972
- Class 2.1, flammable gas.
- Proper Shipping Name: NATURAL GAS, REFRIGERATED LIQUID

According **to MARPOL, Annex II, Appendix II** and the **index of dangerous chemical carried in bulk**, LNG is not considered as a Noxious or Hazardous liquid.

Despite this exclusion, this cargo is included in **the Hazardous and Noxious Substances Convention**, which has been signed by the Canadian Government but not yet ratified in April 2006. This convention sets the rules of a compensation fund for liabilities coming from accidents implying Hazardous and Noxious chemicals. Based on the same principles that rule various international pollution funds, it determines the participation requirement and the limit of liabilities. The Convention defines damage as including loss of life or personal injury; loss of or damage to property outside the ship; loss or damage by contamination of the environment; the costs of preventative measures and further loss or damage caused by them. It also introduces strict liability for the ship owner and a system of compulsory insurance and insurance certificates.

The IGC code, directly related to this product carried in bulk, does not cover the operation itself of these vessels nor the possible liability related to a spill. It is strictly a construction and equipment related convention. In this context, the IGC code was not analysed in this section of the report.

### 3.6.5 Canadian Laws and Rules

#### *3.6.5.1 Dangerous Goods, Operational Aspects*

Various laws and rules govern this aspect. In order to cover a maximum of legislation, the major Canadian regulations related to maritime pollution, operation or accident, were verified. In this case, the cargo does not require the application of all the Canadian legislation concerning this kind of commodity:

***Transportation of Dangerous Goods Act***

According to article 3. (4).(c), this *Act* does not apply.

**Transportation of Dangerous Good Regulation**

We found articles that never excluded LNG from the application, these being:

Art. 1.30,

Art. 1.32,

Art. 2.1,

Art. 11.3

***Canada Shipping Act*, Regulations:**

**Air Pollution Regulations**

According to art. 3, this regulation applies for a transit in Canadian waters.

**Dangerous Goods Shipping Regulation**

Art. 4.(1) interpretation deny application of this regulation

**Dangerous Chemical and Noxious liquid substances regulation**

Despite the fact that it is carried under liquid state, the LNG is not covered by this regulation.

***Canada Shipping Act*:**

According to the **Non Canadian Safety Order, SI/97-96**, part V of the ***Canada Shipping Act****,* the *Canada Shipping Act* applies and allows power of regulation to the Minister in counsel ( Art. 338, 339)

***Canada Shipping Act* of 2001:**

Gives some power to the Minister over foreign vessels when they do not comply with International Conventions (Part 11, Art.227). The Minister can detain vessels in case of damage caused by them (Part 12, Art. 259).

**Pilotage, Atlantic region**

At present time, this part of Canadian waters (Passamaquoddy Bay) is not included in the mandatory pilotage zones. Revisions of the rules are needed for application. This zone will probably require the application of similar rules as the ones on the Seaway. US pilots are required when the vessel is bound to a US port.

See: Great Lakes pilotage, Art. 6

*Pilotage Act*, Art. 20. (2)

**Missing legislation, uncovered elements**

The Canadian laws and rules do not cover some restrictive operational conditions specifically designed for this type of cargo such as the US edited particularly for LNG vessels calling at the port of Boston.

For example, when a LNG vessel is transiting in the port, this zone, is considered as a safety and security zone. All navigable waters two miles ahead and one mile astern, and 500 yards on each side of any of those vessel types. This zone is a no mans land, and access is only permitted when granted by the Captain of the Port of Boston.

Such zone applied on a vessel transiting within Passamaquoddy Bay would imply some major impacts on the navigation in those waters. It is important to keep in mind that the exclusion zone plays a vital role in the security and safety risk management, despite the potentials drawbacks created by this space, its surveillance and management.

The following information is based on a possible scenario where the exclusion zone would be the same as the existing one applied in the port of Boston. We considered a standard application of the exclusion zone wherever which side of the border the vessel is sailing, this for the sake of an easier implementation of this zone from an operational point of view. From those various exclusion zones, accordingly to the ship' situation (underway, at anchor or moored), we can identify some perturbations in the regular traffic, especially in potential chokepoints along the intended transit line.

The application, surveillance and management of the exclusion zone are also expected to raise various administrative and legislative challenges. Who will be in charge of the application of this exclusion, which will patrol the restricted zone, which will intercept and prosecute the vessel or peoples entering without permission such zones?

The particularity of the region touched by this application of exclusion zone also raise its own legal questions regarding the authority of both country due to the fact that the transit is almost following the border. These matters could be resolved by applying a model of cooperation based on the ones in place for the St-Lawrence Seaway.

The US regulations ask for three different exclusion zones for the port of Boston:

1. Vessel underway, where the zone is from 2 miles ahead the vessel, to 1 mile behind and 500 yards on both sides
2. Vessel anchored, in identified zones, where the exclusion zone asks for neither vessels nor swimmers within a 500 yards radius around such vessel.
3. Moored vessels, where the radius of the exclusion zones is 400 yards radius

In order to define the potential chokepoints generated by such exclusion zone, we applied those values on a standard vessel expected to call the Passamaquoddy Bay terminal (length of 270 meters and width of 43 meters). The exclusion zone underway, being the most important in terms of dimension,

The resulting zone for a vessel underway would be 3,15 nautical miles long (5833,25 meters) and 0,5164 nautical mile wide (956,28 meters). By moving such exclusion zone over the map, we can identify the possible chokepoints through the vessel transit courses.

Such length ask for a traffic interruption well before the actual passage of the vessel itself, the narrow passages not allowing sufficient spaces to actually keep other vessels outside the exclusion zone at any moment during the transit. From the moment the LNG tanker, on an inbound transit, reach a position 2 miles away from East Quoddy Head until it is abeam Frost Cove, the whole Western Passage is virtually closed to ships traffic.

This is mainly caused by a combination of reasons linked to the shape of the exclusion zone, the narrow passages on the path of the vessel and the large sweep of the exclusion zone during the turning manoeuvres. Total distance for this is around 27,5 nautical miles, at 20 knots it means a traffic stop of about 1h 22, but practically we should expect something not less than 2 hrs of traffic perturbation.

This zone implementation raises some needs in terms of support vessels to patrol the waters surrounding the LNG transit and a traffic system able to provide vital information on the traffic around. If the commercial and fishing vessels can be reached by VHF, the various yachts, sailboats and other small watercrafts represents a bigger challenge in terms of information transmission and traffic management. This is why the assisting tugs could not be efficient support vessel, strictly in term of exclusion zone control. Lack of radio communication capacity asks for direct contact with such boats and this, again, well before the actual passage of the LNG tanker.

Such requirements generate a major challenge of cooperation and legislative alignment between the two countries in order to simplify the exclusion zone application and control, the actual scenario based on a standard application on both sides of the border.

See: US rules on the safety zone, for the LNG terminal in Boston.

Re: Title 33CFR, Part 165, §165.110

## 3.7 LIABILITY FOR MARINE CASUALTIES

### 3.7.1 General

#### *3.7.1.1 Canadian Process*

Damages caused by a vessel resulting in personal injury, death or property damage, may be recovered in an action against the vessel "in rem" by virtue of the *Federal Courts Act*, R.S.C. 1985, c. F-7. Such an action would be pursued under Canadian Maritime Law, a term defined in Section 2 of the *Federal Courts Act*. The Maritime jurisdiction of the Federal Courts for such an action is found in subsection 22(1), paragraph 22(2)(d), paragraphs 22(3)(a) and (c), and subsection 43(3) of that *Act*.

In order to enforce such right in rem the offending vessel would be arrested pursuant to the arrest procedures under the Federal Courts Rules and security would be obtained for the claim. Security is provided by those interested in having the vessel released and, in most circumstances, is the owner of the vessel and/or its insurers. The process of the Federal Court for arresting a vessel can be exercised within Canada only (including its territorial sea) and cannot be exercised in a foreign jurisdiction. Therefore the location of the vessel after the incident causing the damage is important from this aspect.

It is also possible to exercise rights in rem against a "sister ship". This right is contained in subsection 43(8) of the *Federal Court Act* and essentially means that a cause of action for damages caused by Ship A, which ship is not within Canadian jurisdiction, can be brought also against any or all sister ships which are physically found to be in Canada. A sister ship in essence means a ship which is in the same beneficial ownership as the subject ship at the time the suit was brought.

A party suffering damage caused by a vessel may alternatively seek to recover such damage by an action in person. Essentially this is a suit against the actual companies or individuals who own or are in possession or control of the wrongdoing ship at the time of an incident.

Although provincial superior courts have jurisdiction in marine matters, because of limitations which they have geographically and the inability to proceed in rem in such provincial superior courts (except for BC), most if not all claims for damages caused by a marine incident would be brought in the Federal Court of Canada.
As discussed below as well, the Federal Court of Canada has exclusive jurisdiction to deal with the constitution and distribution of a limitation fund.

#### *3.7.1.2 Limitation of Liability*

One rule which sets shipping apart from other areas of commerce is that a ship owner and certain other entities involved with the management and operation of a ship are entitled to limit their liability for loss of life, personal injury or property damage caused by the ship. The various claims for which liability may be limited and the monetary level of liability are now dealt with in the *Marine Liability Act*, 2001, c. 6. Essentially, liability is limited to a maximum amount based on the tonnage of the vessel involved in the incident.

The *Marine Liability Act* introduced into Canadian law, with some modification, the Convention on Limitation of Liability for Maritime Claims, 1976 (LLMC 1976), as amended by a protocol of 1996. The limits of liability are divided into claims dealing with loss of life or personal injury and secondly any "other claims" (usually comprising property damage). Reference to the *Marine Liability Act* and the Convention for the actual numbers should be made but as an example, a vessel of 70,000 tonnes would have a limit of liability of approximately $100,000,000.00 CDN for claims relating to loss of life and personal injury and an additional amount of approximately $48,000,000.00 CDN for "other claims".

The unit of account used in the Convention is actually the SDR and the equivalent amount in Canadian dollars fluctuates on a daily basis. We have used $2.00 per SDR for calculation purposes.

It should be noted that the limitation for “other claims” can include claims for the costs incurred in the raising, removal, destruction or rendering harmless of a ship or its cargo which is sunk, wrecked, stranded or abandoned.

The second tier limitations apply as well to claims in respect of the raising, removal of destruction or the rendering harmless of a ship or its cargo that is sunk, wrecked, stranded or abandoned and the costs for those matters.

### 3.7.2 Pollution (Including Oil Pollution)

A marine incident whether grounding or collision can result in the release of pollutants from the damaged vessel.

Canada is a party (contracting state) to Conventions dealing with liability for oil pollution.

These Conventions impose strict liability on the registered vessel owner in exchange for a limitation regime which in the case of the tankers carrying persistent oil as cargo (a Convention Ship) provides a maximum liability of approximately $400,000,000.00.

In the case of all ships including tankers carrying persistent oil, Canada also has a fund known as the Ship Source Oil Pollution Fund (SSOPF) which adds another level of liability.

The SSOPF is unique in that it applies to “top up” the other amounts provided for in the Conventions but acts as a source of first resort for oil pollution for non-convention ship spills, such as bunker spills. These spills would be the type emanating from an LNG carrier.

Although liability is strict it is subject to the ship owner being able to escape liability if the cause of the spill is as a result of (i) acts of war, (ii) acts of third parties with intention to cause damage (terrorist activity) and (iii) natural disasters.

The *Marine Liability Act* Part 6 deals with liability for oil pollution and like the Conventions imposes strict liability for:

- oil pollution damage
- costs and expenses incurred by
  - the Minister of Fisheries and Oceans
  - any person in Canada
  - any other person in a state that is party to the Civil Liability Convention for measures taken to prevent, repair, remedy or minimize oil pollution damage in anticipation of a discharge of oil.

This, in the case of an incident occurring which threatens to discharge oil, allows the Minister of Fisheries and Oceans or others to take measures to prevent or minimize damages and recover the costs from the offending vessel. Such costs must be shown to be reasonable and reasonably incurred.

The defences referred to above are preserved.

Oil pollution from non-convention ships, which an LNG carrier would be, would therefore fall under the LLMC Convention limitations and the SSOPF would be available to a claimant. If the ship owner is not liable because of the defences referred to above the SSOPF is still liable. For example if an LNG tanker is attacked by terrorists (act of hostility) and pollution results or is threatened, the owner would have a defence under the *Act* against a claim but the SSOPF would be liable. (Section 84(b) *Marine Liability Act*).

The SSOPF is also a direct source of compensation for those suffering loss, damage, costs or expenses as a result of oil pollution damage, actual or anticipated.

The SSOPF is subrogated to the claimant's rights.

Canadian fishermen and others involved in mariculture have a special right to claim against the SSOPF for losses including lost income resulting from an oil spill. This normally occurs in the case of a mystery spill which affects fishing gear, traps, fishing vessels, catch or causes fish plant closures.

#### *3.7.2.1 U.S.A. Situation*

The United States is not a party to any of the international conventions governing limitation of liability for maritime casualties. In the U.S. the general limitation is governed by the "*Limitations of Vessel Owners Liability Act*" 46 U.S.C. Rather than a tonnage based limitation as in the Conventions and Canadian legislation, the amount for which limitation is allowed in the U.S. is "the amount or value of the interest of the ship owner in the vessel and her freight then pending". The time when this is calculated is the termination of the voyage on which the loss or damage occurred.

If the vessel is a total loss or is substantially damaged during the voyage in which the damage occurred, the value may be reduced to zero. Therefore, the facts of the incident are crucial in determining the potential amount allowable for claimants. Conversely if the vessel is relatively undamaged, its full market value plus freight is used to calculate the limitation amount.

Also under U.S. law the right to limit liability must be taken as an action by the ship owner rather than a defence. There are special rules requiring the owner to initiate limitation proceedings in the appropriate U.S. federal court within six months of another action being started. If these limitation proceedings are taken, an order to stay the other proceedings would be granted by the U.S. court. In order to start limitation proceedings, the ship owner has to surrender the ship to the court or alternatively establish a fund in the amount of her value as calculated above.

As might be imagined, complex issues are involved in determining whether to arrest a vessel in one jurisdiction where a limitation amount may be lower than in another jurisdiction which has higher limitation amounts. Complex inter-jurisdictional questions arise particularly where one jurisdiction allows the arrest of sister ships.

***Canadian Environmental Protection Act (CEPA)***

Under this *Act*, any person who suffered loss or damage as a result of a contravention of any provision of that Act or Regulations could bring an action in any court to recover from the person who engaged in the prohibited conduct to recover the loss or damages proved to have been incurred plus compensation for costs.

This action, however, is proscribed with respect to a claim that may be made under the *Marine Liability Act* for damage caused by a ship. It is again beyond this discussion to attempt to determine if there are offences under *CEPA* or its Regulations which might be not caught by the MLA in respect to damage caused by a ship.

### 3.7.3 Canadian Liability Regulations

This part identifies the various Canadian legislations regulating possible actions for damages:

***Federal Courts Act*:**

Jurisdiction on maritime matter: Art. 22,

*In Rem, In person,* Art. 43, with the exceptions

This *Act* confirms the jurisdiction of the federal court over maritime liabilities matter, giving a good range of subjects covered by this act. Indicates certain limits of applications in case of *in rem* claims involving vessels.

***Marine Liability Act*:**

This is the main document in order to identify the limits of what is covered or not for claiming under the Canadian jurisdiction.

PART 1, PERSONAL INJURIES AND FATALITIES

Articles 4 to 14

This part of the *Act* defines the personal injuries and fatalities, with the various rights, time limitations and exclusions.

PART 3, LIMITATION OF LIABILITY FOR MARITIME CLAIMS

Articles 24 to 34

Part 3 determines the liability limits for maritime related claims. It also identifies which articles of the International convention on maritime liability apply under Canadian jurisdiction.

SCHEDULE 1 (Section 24) PART 1

Text of Articles 1 to 15 of the Convention on Limitation of Liability for Maritime Claims, 1976, as amended by the Protocol of 1996 to amend the Convention on Limitation of Liability for Maritime Claims, 1976

For information purpose, the titles of each of the articles are the following:

| | |
|---|---|
| Article 1 | Persons entitled to limit liability |
| Article 2 | Claims subject to limitation |
| Article 3 | Claims excepted from limitation |
| Article 4 | Conduct barring limitation |
| Article 5 | Counterclaims |
| Article 6 | The general limits (of liability) |
| Article 7 | The limit for passenger claims |
| Article 8 | Unit of account |
| Article 9 | Aggregation of claims |
| Article 10 | Limitation of liability without constitution of a limitation fund |
| Article 11 | Constitution of the fund |
| Article 12 | Distribution of the fund |
| Article 13 | Bar to other actions |
| Article 14 | Governing law |
| Article 15 | Scope of application |

SCHEDULE 1 (Section 24) PART 2

Text of Article 18 of the Convention on Limitation of Liability for Maritime Claims, 1976, as amended by the Protocol of 1996 to amend the Convention on Limitation of Liability for Maritime Claims, 1976, and of Articles 8 and 9 of that Protocol.

The article 18 of the convention fixes the possible reservations for a signing state.

Articles 8 and 9 of the protocol are also included in this schedule. The article 8 covers some amendments to the limits while article 9 concerns the application of the protocol.

***Canadian Environmental Protection Act*:**

This *Act* should apply, mainly because of the following articles that tend to enclose LNG in the various definitions

INTERPRETATION, Art. 3.(1), which is giving the various definitions such as air pollution or release.

CONTROLLING TOXIC SUBSTANCES, Art. 64, giving the definition of toxic substances.

LIABILITY, Art. 205, about the liability of the substance's owner.

# 4.0 MARINE ENVIRONMENTAL ISSUES

## 4.1 APPROACH USED TO ASSESS THE EFFECTS ON THE MARINE ENVIRONMENT

A key aspect of this study was to assess the potential risks to the marine environment, associated with an accidental event within the study area. This includes the potential risks to marine flora and fauna and associated ecosystems such as coastal wetlands and shore area habitats. Risks may be environmental (affecting the ecosystem as a whole or in part) and/or socio-economic (affecting commercial fishing, recreation and/or tourism) in nature.

This section provides a description of the marine, estuarine and freshwater environments that may be at risk due to a significant release of LNG during transport and from the offloading facility. As indicated in Section 2.5.4, the impact zone from a release of LNG from the docking and on land facility is considered to be less than or equal to that from a vessel docked at the terminal which was considered in Scenario 2. The primary boundaries considered in describing the existing environment is based on the identified LNG hazard zones established for the risk assessment (see Section 2.2.4). The project boundaries have been extended in some instances recognizing that some VECs may be located outside the hazard zone, but may utilize areas within the zone for foraging and as travel routes. Examples include raptors and migratory birds.

### 4.1.1 Marine and Freshwater Biological Environments

Resources including: spawning areas, rearing and nursery areas, food supply, and migrational areas were identified for risk assessment purposes. The description for the marine and freshwater environments included invertebrates (lobster, clams, scallops, quahog etc.), finfish, marine mammals, marine birds, algae, zooplankton, sedimentology and water quality. The potential for risks to marine/freshwater resources that were assessed included:

- potential risks from air emissions ;
- potential risks to fish and marine mammal activity from vessel traffic and release of hazardous materials;
- potential risks to species at risk;
- potential risks of disturbance and mortality to whales due to movements and direct impact by vessels, tankers, tugs and any other ancillary vessels;

- potential risks of combustion of LNG and contaminant impacts on marine/freshwater species and habitat;
- although not explosive in open air, when confined LNG can explode (or equivalent) causing a shock wave that could be dramatic if occurring over or near a fishing bed, although the probability is considered to be extremely low;
- potential risks of underwater release of LNG on marine habitat and resources;
- potential risks to recreational and commercial issues including: tourism in general, existing shipping, fisheries, ferries, whale watching, recreational fishing, pleasure boating and aquaculture;
- potential risk of fish habitat impacts and movements due to the presence of terminal structures and vessel transport activities; and
- Potential risk of fisheries impacts due to noise and lighting.

### 4.1.2 Water Quality

Water quality was described using existing information in available Data Reports and potential risks that may result from the Project were identified. Appropriate operating procedures and protocols as well as emergency response measures are key elements to providing protection for non-land based and land based activities which can impact on water quality and also lead to airborne contaminants.

### 4.1.3 Fish and Fish Habitat

A wide range of aquatic resources and habitat occurs in the area of the shipping lane including potential terminal locations. This also includes species at risk. Typically, contaminants can be present in sediments and the water column in areas that are significantly developed, thereby impacting the quality of habitat in an area. Also, wharf locations are typically impacted with contaminants as a result of accidental spillage and/or leakage. Strong tidal driven currents in the area are likely to transport contaminants into deeper waters. Potential terminal locations were characterized based on available information concerning presence/utilization of the area.

Habitat parameters that were described included habitat types, substrate characteristics, depth, water temperature, salinity and any identifiable fish and cetacean passage constraints. This information was compiled and presented in a map format. Available information describing presence and quality of critical/sensitive habitat, with emphasis on spawning and nursery areas, is provided.

### 4.1.4 Coastal Wetlands

Coastal wetlands represent an important habitat type both within the province and nationally. Potential issues/concerns associated with wetlands include, but may not be limited to, loss of wetland function; and noise/physical disturbance of wildlife. Information on wetlands compiled in the New Brunswick Department of Natural Resources and Environment (NBDNRE) database was reviewed for the area.

### 4.1.5 Physical Oceanography

Physical oceanography includes a description of the tides and currents, stratification and mixing fronts and waves and turbulence, based on available information. This information will assist with the assessment of contaminate movements and potential resources at risk.

## 4.2 MARINE ENVIRONMENT

The aquatic environment in the study area, in the context of project considerations, is primarily marine with respect to the shipping route and the southerly port facilities, and estuarine for the northern most ports located along the St. Croix River. The aquatic environments are described for the area of Grand Manan, Head Harbour Passage, Passamaquoddy Bay and the St. Croix River (see Figures A2, A3, and A4 in Appendix A for species at risk and other Environmental Components), near St. Andrews, NB.

Freshwater flows into the Passamaquoddy Bay via a number of freshwater streams and the St. Croix River. The St. Croix River is part of the Bay of Fundy system and therefore experiences tidal fluctuations. The tidal fluctuations extend upriver to a point several hundred metres upstream of the proposed Red Beach port. This site location will experience a high and low tide, which influences water levels along this shoreline by as much as 7 to 8 metres. During low tide, the shoreline is exposed for approximately 50 to 100 m depending on the slope of the shoreline. The water levels during tidal fluctuations are affected by the time of year and stage of tide, with the highest tides experienced in the spring. In the area of Grand Manan the tidal range at North Head is 7.1 m and 5.3 m for large tides and average tides, respectively (ACER 1999).

The area of the watershed for the St. Croix River is in the order of 4000 square kilometres, and consists of over 30 watercourses. Flow is regulated, ranging from a minimum daily flow of 21.9 $m^3$/s to a maximum daily flow of 311 $m^3$/s, and mean daily flow of 38.2 $m^3/s$. An estuarine environment is prominent as a result of the freshwater discharge that occurs into Passamaquuoddy Bay. The St. Croix waterway represents an international boundary with Canada and the United States. Under the US/Canada Boundary Waters Treaty of 1908, certain aspects of St. Croix water resource management fall under international purview -- notably for levels and flows and, to a lesser extent, quality, through an International Joint Commission (IJC) established by the federal governments. Under matching legislation, Maine and New Brunswick established the St. Croix International Waterway Commission in the 1980s to create and help to implement a cooperative state-provincial management plan for the international St. Croix corridor. Twice in the last thirty years, the IJC has studied international water level management on the St. Croix in response to concerns by lake residents. Most recently (1995-1997) federal agencies carried out computer modeling for the IJC to examine the interactions of the St. Croix's seven controlled basins. The study showed residents how the various demands on the system are balanced and increased local appreciation of the diverse uses made of the St. Croix water resources.

### 4.2.1 Bathymetry

Water depths decrease gradually into the Bay from the south to the north. The average depth in the Bay is about 24 m, with maximum depths of approximately 75 m at Western and Letete passages (St. Croix Estuary Project, 1977). The depth in the centre line of the channel from Head Harbour Passage to Eastport ranges from about 30 m to 110 m (USEPA, Undated). Depths in the Bay of Fundy are in excess of 110 m.

### 4.2.2 Hydrography

The hydrography of the study area is dominated by tidal influence. Hydrographic characteristics are described in terms of tides, waves, currents, and circulation.

#### *4.2.2.1 Tides*

The lunar semi-diurnal tide is the principal tidal constituent in the study area. The mean tidal range for Passamaquoddy Bay is 6 m, with a maximum of 8.0 m (St. Croix Estuary Project, 1977). Tide levels for Eastport and North Head Grand Manan are provided in Table 4-1.

#### *4.2.2.2 Waves*

Waves in the Bay of Fundy are comprised of two components: the North Atlantic swell which propagates into the Bay of Fundy from the open Atlantic, and locally wind-generated waves in the Bay itself. These two types are superimposed on each other (Neu, 1972).

In the outer Bay of Fundy, the most frequently occurring waves have a 4-6 second period. It is reported that nearly one-third of all waves come from outside the Bay in the form of swells, with periods of up to 15 seconds (Neu and Vandall, 1976). Passamaquoddy Bay is of sufficient length that significant waves can be generated within the Bay. Based on personal experience in the area and physical characteristics, long fetches from the southerly to the northerly directions are expected to generate waves in the 1-1.5 m range.

**TABLE 4-1 Tidal Information**

| LOCATION | Height Above Chart Datum* | | | | |
|---|---|---|---|---|---|
| | Large Tides (m) | | Average Tides (m) | | Mean Water Level (m) |
| | Higher H.W. | Lower L.W. | Higher H.W. | Lower L.W. | |
| **Eastport (1930 to 1949, USEPA, Undated)** | 8 | 3.5 | | | |
| **Eastport (1983 to 2001) Lat 44° 54.2' Long 44° 54.2'** | | | 5.87 | 0.0 | 2.96 |

*Chart Datum = Lowest Normal Tides.

Changes in sea level caused by variations in atmospheric pressure and winds are known as storm surges. In the Bay of Fundy these tend to be obscured by the large purely tidal variations. However, surges of up to 1 m on top of high tide occur periodically (Trites and Garrett, 1983).

#### *4.2.2.3 Currents*

In the Bay of Fundy the horizontal water movements are predominantly tidal in character, running strongly during flood and ebb in the two directions, which are usually opposite (Fisheries and Oceans Canada, 1990). Maximum current velocities typically occur at mid-tides, and there is a period of approximately an hour at both high and low tide when tidal currents are low or absent (slack water). Almost everywhere in the Bay of Fundy, the current is as strong down to a depth of approximately 55 m as it is on the surface. At most locations the tidal stream turns in direction on the surface and below at practically the same time (Fisheries and Oceans Canada, 1990).

Winds have an important role in moving surface waters. The effects depend upon the strength, direction and fetch (Forgeron, 1959). Wind-generated currents in the area are random in their occurrence, strength, and direction. Strong winds have the effect of advancing or retarding the current direction, altering the current velocity accordingly (Hunter and Associates, 1982).

The behaviour of the tidal stream in the Bay of Fundy is very regular and constant at any fixed point, but a marked difference may occur over short distances. Hunter and Associates (1982) reported a mean velocity of 0.7 m/sec for unrestricted tidal currents at the mouth of the Bay of Fundy.

Current velocities in the Passamaquoddy Bay area are usually less than 0.3 m/sec (Hunter and Associates, 1982; Dr. Fred Page, Fisheries and Oceans Canada, St. Andrews Biological Station personal communication, 1997 from ACER 1999). Currents in Passamaquoddy Bay peak at approximately 1 m/sec (Dr. Fred Page, Fisheries and Oceans Canada, St. Andrews Biological Station, personal communication, 1997).

#### *4.2.2.4 Circulation and Residual Currents*

Circulation and residual currents in the Bay of Fundy are induced by wind and tidal energy, but the pattern is determined by geostrophic forces and the physiographic deflection of water masses (Hunter and Associates, 1982). The seasonal patterns of surface currents for the Bay have been summarized by Bumpus and Lauzier (1965). The Bay of Fundy exhibits a counter-clockwise pattern of residual currents (residual after subtraction of diurnal and semi-diurnal tidal components). A greater flood tide occurs on the south side of the Bay, with a greater ebb tide on the northern side, and a counter-clockwise residual current gyre in the central area of the Bay. The inflow reaches a minimum during the winter months and a maximum during the summer and autumn. The outflow from the Bay also exhibits seasonal variation, being minimal during the winter and maximal during the spring and summer. The bottom circulation in the Bay of Fundy has been described by Lauzier (1967). The pattern is similar to that of the surface; although with velocities are approximately orders of magnitude lower.

Figures A6 and A7 (Appendix A) show the current circulation for the fall and spring periods (Hunter and Associates, 1982). As indicated from the figures, circulation occurs throughout the Passamaquoddy Bay, with currents moving through Western Passage and the north end of Campobello Island as well as Head Harbour Passage and Letite Passage. Studies carried out for the Passamaquoddy tidal power project shows more detailed information on currents as indicated on Figures A8 and A9. In 1957-58, extensive measurements (Bumpus, D.F., 1959) were taken over the entire Passamaquoddy and Cobscook Bay region. Measurements were again taken in 1973-75 in those areas through which oil tankers would pass, and/or berth.

In the 1957-58 studies current were monitored for periods of either 13 or 25 hours at 60 stations in the area. During the second study by Canada's Atlantic Oceanography Laboratory, EG&G, Inc., and Hydrocon, Inc., moored meters continuously monitored the currents for periods of 8 to 30 days in February/March/August 1973, June/July 1974, and September/October 1975. These meters were placed in locations within the channel approach to Eastport, and also in the proposed tanker berthing areas.

It shows that the principal inflow of water during flood to Passamaquoddy Bay is through Letite Passage, north of Deer Island, and Western Passage between Moose Island (Eastport) and the southern end of Deer Island. Maximum current speeds occur approximately three hours after low water slack. Speeds of up to two knots are attained in Western Passage. In Head Harbour Passage, the flood currents between Deer Island and Campobello Island run two to four knots maximum, depending on lunar time. A portion of this flow is diverted into Western Passage, and the remainder continues through Friar Roads around Moose Island into Cobscook Bay. Additional flow into Friar Roads is through the Lebec Narrows where currents of four knots are reached. Within Passamaquoddy Bay, tidal currents are generally weak, averaging less than 0.5 knots.

Moored meter channel current measurements by EG&G, Inc. and Atlantic Oceanographic Laboratories indicated that the currents in Head Harbour Passage and off Broad Cove are consistent in direction and speed. They are essentially parallel to the centre line of the channel during both ebb and food tides. However, observation indicated that the water entering Head Harbour Passage from the east is forced by the bathymetry to swing sharply to the southwest causing the highest velocity currents to occur along the western side of the channel during flood tide and along the eastern side during ebb tide. (Bumpus, *et. al*., 1959)

The maximum speed of the currents varies with time in the lunar cycle. The maximum peaks observed during the high or spring tides were four knots at the narrowest part of the channel; three knots opposite Western Passage. Maximum currents at the entrance to Head Harbour Passage were 2.5 knots. During neap tides, the peak currents were two or three knots lower than during spring tides.

The distance a water particle or a floating object will travel between high water slack and low water slack, or vice versa, is defined as tidal excursion. According to calculations made by Forgeron (1959) and by Louches *et al.*, (1973) based on intertidal volumes and flood current knowledge of the Head Harbour Passage, this ranges from 8 to 16 kms.

Residual currents are those that are not caused by tidal flow. In a tidal area, residual currents indicate the net flow of water. These currents are the result of river runoff, wind, unequal heating and cooling of surface waters, and the effect of the Coriolis force (earth's rotation) on tidal motions in confined waterways. In the Quoddy Region, residual or net circulation patterns have been determined largely from the drift bottle recovery work of Bumpus (1959), Chevrier (1959) and Graham (1970).

The chief features of the net surface circulation in Passamaquoddy Bay are: (1) outflow through Western Passage; (2) flow from St. Croix estuary into Passamaquoddy Bay; (3) counter clockwise surface circulation in the bay; and (4) both flow and outflow through Letite Passage. (see Figures A6 to A9 in Appendix A)

Within Cobscook Bay, the residual surface flow is towards Friar Roads. From there, outflow is through both Lubec Narrows and the eastern side of Head Harbour Passage. Inflow is along the western side of the Passage and the eastern shore of Deer Island, extending to Western Passage. Outflow from Western Passage carries this water toward Campobello and adds to the net outflow along the western shore of the island.

Outflow from Head Harbour Passage varies according to the season, winds, and fresh water runoff. It may move north easterly above the Wolves before turning south; directly southwest along the east coast of Campobello and Maine, past Grand Manan Island. The magnitude of the residual drift will vary considerably depending upon wind speed and direction. Hachey (1952) indicates that water moved inward on the mainland side along Grand Manan Island.

The Quoddy region's waters at Grand Manan Island join either the large, counter clockwise gyre which dominates surface circulation in the Gulf of Maine, or the smaller counter clockwise gyre in the Bay of Fundy. In the first instance, the waters are transported south towards Cape Cod; in the latter instance, they move across the entrance to the Bay of Fundy towards Nova Scotia. In the Bay of Fundy, net surface circulation is both inflow along the coast of Nova Scotia and outflow along the western side of the Bay.

The counter clockwise gyres in the Gulf of Maine and the Bay of Fundy are attributed due to the combined effect of the Coriolis force on tidal flood and ebb currents and freshwater discharges along the coastline. In the northern hemisphere the effect of the Coriolis force is to deflect the currents to the right of their initial direction. Thus, flood currents are intensified along the coastline to the right of their entry, and ebb currents to the left. The residual flow is then a counter clockwise gyre. The net effect of this along the Maine coast is the deflection of the river discharges southward where they contribute to and maintain the counter clockwise gyre in the Gulf of Maine. Surface drift speeds in the south easterly flow of the Gulf average about 2 kms per day and research suggests that the surface waters generally move along the coast while bottom waters move shoreward (Graham, 1970).

### 4.2.3 Ice Conditions

Strong tidal action and vertical mixing in the Bay of Fundy prevent significant ice formation in the study area. Ice formation may occur in the more protected areas during the colder days of January and February, and is of short duration.

### 4.2.4 Temperature and Salinity

Information on temperature and salinity patterns, representative of the outer Quoddy Region was presented by Trites and Garrett (1983). Mean monthly variations in temperature and salinity, surface and bottom, for the outer Quoddy Region (station between Campobello Island and The Wolves) are shown in Figure A10, Appendix A. The temperature curves are approximately sinusoidal, with an annual mean surface range of 13$^{o}$C and a bottom range of 11$^{o}$C. Temperatures in the region usually reach a maximum in late August or early September and a minimum in late February or early March.

The surface and bottom salinities of the outer Quoddy Region are typically 31 - 33$^{o}/_{oo}$ varying by 1.4$^{o}/_{oo}$ and 0.9$^{o}/_{oo}$, respectively, annually (see Figure A10, Appendix A). Salinities in this region generally reach a maximum in October and a minimum in April or May. Information reported by USEPA, (undated) is presented in Table 4-2, for samples collected for Head Harbour passage, at a location midway between Cherry Island Light and Bold Head.

**TABLE 4-2 Temperature and Salinity Data for Head Harbour Passage for Surface Water. Samples Collected Within One Half Hour of: Low water Slack**

| PARAMETER | SAMPLE DATE (1975) | | |
|---|---|---|---|
| | SEPTEMBER 16 | OCTOBER 16 | NOVEMBER 20 |
| TEMPERATURE (Celsius) | 11.0 | 9.9 | 9 |
| SALINITY | 31.92 | 32.27 | 31.8 |

### 4.2.5 Water Quality

A range of parameters have been monitored for water quality purposes in the Head Harbour Passage as part of previous studies. Results are provided in Table 4-3.

**TABLE 4-3 Other Parameter Data for Head Harbour Passage For Surface Water Samples. Collected within One Half Hour of Low Water Slack**

| PARAMETER | SAMPLE DATE (1975) | | |
|---|---|---|---|
| | SEPTEMBER 16 | OCTOBER 16 | NOVEMBER 20 |
| pH | 7.29 | 7.76 | |
| Oxygen (ppm) | 8.3 | 8.7 | |
| Chloride (mg/m$^3$) | 0.46 | 0.18 | |
| Oil and Grease (mg/L) | 0.16 | 0.11 | |
| BOD (mg/L) | | | 2.42 |
| Total Coliforms (count/100ml) | 3 | 3 | 43 |
| Fecal Coliforms (count/100ml) | | | 3 |

### 4.2.6 Sedimentology

The distribution, characteristics, and contaminant burden of sediment in the study area is described in the sections below.

#### *4.2.6.1 Sediment Distribution and Physical Characteristics*

Based on grain size distribution results for samples collected at Deep Cove and Broad Cove, sediments were generally classified as gravel and sand with no observable silt material (USEPA, Undated). The intertidal zone sediments in Deep Cove were primarily coarse gravels and Broad Cove consisted of primarily fine sandy silt, with one sample consisting of all rock. In the subtidal regions, the sediments were finer, consisting of fine sandy silt, with very little organic matter.

Shoreline features and sediment distribution in Long Island Bay have been described by MacKay *et al.* (1979) based on diver observations. The shore types from Swallow Tail to Castalia vary among mixed substrates (Pettes Cove, Castalia), predominantly rock (Net Point, area from The Dock to Castalia), and predominantly sand (most of Flagg Cove shoreline). Subtidally, the Bay has been described as predominantly mud.

**Underlying Sediments**

Based on geotechnical investigations in the general area, soil underlying the surficial sediments can be generally described as a loose to very dense gravel and sand with some cobbles and occasional boulders.

#### *4.2.6.2 Sediment Contaminant Burden*

Sediment contaminant burden data for petroleum hydrocarbons indicated concentrations of 36-82 ppm, with concentrations for Broad Cove being attributed to natural oils and concentrations of 35 to 64 ppm being attributed to natural oils and part weathered oil fraction. The weathered oil fraction was indicated to be due to a spill from a motor boat (USEPA, Undated). Additional investigations would be required to confirm conditions. During an open house presentation in Eastport Main on July 11, 2006, Mr. Dean Girdis of the Downeast LNG proposal indicated that the near shore bottom sediments for the proposed terminal site were impacted with mercury and therefore, the terminal was extended further off shore to avoid dredging.

### 4.2.7 Biological Resources

The marine biological resources of the study area have been inventoried by MacKay *et al*. (1979) and the principal coastal resources and their distribution have been identified by various sources including the St. Croix Estuary Project *et al*. (1997), Hunter and Associates, 1982, the Department of Fisheries and Oceans and ACCDC. The distribution of the principal resources in the study area is shown in Figure A5 in Appendix A, and are discussed in the following sections.

#### *4.2.7.1 Algae*

There are at least 40 species of green, red and brown algae reported to occur in the salt marshes, subtidal and intertidal regions of the estuary area (Linkletter *et al*, 1977 and Marine Research Associates Ltd., 1978 in St. Croix Estuary Project, 1997). Algae common to the study area include phytoplankton, rockweed (*Fucus* sp. and *Ascophyllum nodosum*) and *Lithothamnion*. Locations for rockweed are shown in Figure A5 in Appendix A. *Ascophyllum nodosum* is ranked fourth on the Gulf of Main habitat Panels ranked species list for priority habitats.

#### *4.2.7.2 Invertebrates*

Invertebrates common to the study area include sponges (crumb-of-bread, orange encrusting, phakellia-like), anemones, comb jellies, encrusting and erect bryozoans, Atlantic brachiopods, limpets and chitons, gastropods (periwinkles, whelks, moonsnails), bivalves (clams, blue mussel, scallops), annelid worms, ribbon worms, arthropods (sand shrimp, mysids, American lobster, common barnacles, gammarid amphipods, rock and hermit crabs), krill, and echinoderms (sea urchin, starfish).

Principal invertebrate resources identified by the St. Croix Estuary Project (1997) for the St. Croix estuary include:

- the sea scallop;
- the softshell clam;
- the American lobster (*Homarus americanus*) throughout the Bay; and
- the green sea urchin.

The locations identified for the above noted resources are provided in Figures A5 and A11, in Appendix A. Several individuals with the DFO were contacted to obtain current information related to fisheries resources in the study area including catches and location of the fisheries resources. Information on commercial fisheries landings (2004) for the fishing districts within the study area was provided (Mary Mills of DFO: May, 2006). It was indicated that there were no maps or coordinates for the recorded landings. Other DFO information sources that were reviewed included Tracy Kerluke (July, 2006) and Rob Stephenson (August 2, 2006). This information request was forwarded to Julie Porter who then forwarded it to Heath Stone. Mr. Stone provided references for landing statistics and provided some additional contact names to gather more information. However, mapping was not available that showed the location of the various resources in the study area and it was indicated that this would require significant effort. The above individuals were provided with information provided in a study completed by Yellow Wood Associates Inc. (June 2006) that showed mapped areas for fisheries resources, and advised that the mapped information was not available. It should be noted that the Yellow Wood study was not verified as part of this study and a request to Yellow Wood has been made to obtain permission to reference the material presented in their study.

Scallops spawn between late August and early October, with fertilization occurring in the open water. It is believed that scallops found in the estuary area originate from places elsewhere in Passamaquoddy Bay. Soft shell clams are found primarily in the intertidal mud flats but can also be found in subtidal waters. Clams spawn when the water temperature reaches 10 to 15 degrees celsius. Larvae disperse among plankton for about two weeks and then settle to the bottom. Lobster Larvae are hatched between July and September, with the larvae swimming/floating in the upper water column for three to ten weeks. Green sea urchins are most commonly abundant in the shallow, subtidal zone on rock, gravel or shell bottoms (Chenoweth, 1994). Green sea urchins generally spawn from February to April.

It is reported that the bathymetric variation and current patterns in Head Harbour Passage have resulted in unique "pockets" containing an abundance of highly diverse marine organisms (MacKay, 1976). The sites are located at:

- Spruce Island;
- Sandy Island;
- Bean's Island;

- Vicinity of Parker Island;
- Haddock Ledge; and
- The "Hub", Simpsons Island.

#### *4.2.7.3 Finfish*

As many as 106 fish species are reported to occur in the Estuary area (St. Croix Estuary Project, 1997). Finfish common to the Passamaquoddy Bay include Atlantic herring (*Clupea harengus*), harbour pollack (*Pollachius virens*), flounder (*Pseudopleuronectes sp*.), sculpin (*Myoxocephalus sp*.), sea raven (*Hemitripterus americanus*), and rock gunnel (*Pholis sp.*).

Principal finfish resources include:

- herring (*Clupea harengus*); and
- groundfish (mackerel, cod, flounder, and halibut being primary resources).

The locations for these species are shown in Figure A5 in Appendix A. Several individuals with the DFO were contacted to obtain current information related to fisheries resources in the study area including catches and location of the fisheries resources. Information on commercial fisheries landings (2004) for the fishing districts within the study area was provided (Mary Mills of DFO: May, 2006). It was indicated that there were no maps or coordinates for the recorded landings. Other DFO information sources that were reviewed included Tracy Kerluke (July, 2006) and Rob Stephenson (August 2, 2006). This information request was forwarded to Julie Porter who then forwarded it to Heath Stone. Mr. Stone provided references for landing statistics and provided some additional contact names to gather more information. However, mapping was not available that showed the location of the various resources in the study area and it was indicated that this would require significant effort. The above individuals were provided with information provided in a study completed by Yellow Wood Associates Inc. (June 2006) that showed mapped areas for fisheries resources, and advised that the mapped information was not available. It should be noted that the Yellow Wood study was not verified as part of this study and a request to Yellow Wood has been made to obtain permission to reference the material presented in their study.

#### *4.2.7.4 Marine Mammals*

Information on marine mammals which occur in Long Island Bay was developed through a review of the ACCDC database, the St. Croix Estuary Project (1997), Hunter and Associates, 1982, and through discussions with Merry Mills of the DFO and Chuck Shom, a local biologist in St. Andrews personal communications, 2006). Principal marine mammal resources that occur within the St. Croix Estuary/Passamaquoddy Bay, Chamcook Harbour and Bocabec Bay for the study area include:

- otter which may occur periodically throughout the area;
- harbour porpoise (*Phocoena phocoena*) which may occur regularly throughout the area;
- dolphins which occur regularly throughout the area;
- harbour seal (*Phoca vitulina*) which occur regularly throughout the area;
- minke whale (*Balaenoptera acutorostrata*) which occasionally occur in Passamaquoddy Bay ; and
- finback whale (*Balaenoptera physalus*) which occasionally occur in Passamaquoddy Bay.

The Passamaquoddy Bay area is considered to be unique as it appears to be the center of the Harbour Porpoise (personal communication: Dr. David Gaskin, August 1977, in USEPA, undated). The Right Whale (*Eubalaena gracialis*) has also been observed between Grand Manan and the West Isles, and a Right Whale sanctuary is located immediately northeast of Grand Manan (see Figures A1 and A2 in Appendix A).

#### *4.2.7.5 Marine Birds*

Seabirds commonly occurring in the study area include double-crested cormorant, common eider, herring gull, and various ducks, geese, gulls, sandpipers and terns (MacKay *et al*., 1979). Passamaquoddy Bay is utilized by various migratory birds, with northern hemisphere breeders arriving in early March and mid June, moving south in the fall, from mid July to early December (Christie, 1983 in Thomas, 1983). Stephen Gullage with the Maritime Breeding Bird Atlas, John Chardine a biologist with the Canadian Wildlife Services (CWS) (waiting for a response at the time of report preparation), Doug Bliss director at CWS-Atlantic, Peter Hicklin of the CWS, Brain Dalzell of CWS (regarding migratory bird information for the Grand Manan area with no response at the time of report preparation), David Christie (for information on migratory birds in the study area with no response at the time of report preparation), . Peter

Hicklin provided reference to a report titled "Two Hundred Years of Ecosystem and Food Web Changes in the Quoddy Region, Outer Bay of Fundy" by Heike Lotze and Inka Milewski (2002; 189 pp).

The following information is based on Heike *et al.* 2002. A range of bird species have been identified for the study are, however, exact numbers, types and locations for migrating bird species are not provided in the study. The report identifies seabirds, shorebirds, waterfowl and raptors. The majority of data for bird counts was reported to be qualitative not quantitative, therefore only estimates of relative abundance are available and not defined figures or numbers of absolute bird density (Lotze and Milewski 2002).

Approximately 300 different species of birds, the majority being migratory to some degree, are reported to inhabit the Canadian portion of the Quoddy Region during their migration, which suggests this region is of global importance (Lotze and Milewski 2002). Figure B1 in Appendix B shows the spatial distribution of shorebirds, seabirds, waterfowl and raptors counted throughout the year from 1967 to 1996. Some migrating seabirds of the Bay of Fundy that were noted included: Northern gannets, Atlantic puffins, Common Murres, Razorbills, Common and Artic terns, Black-legged kittiwakes, and the endangered Roseate tern.

It is also indicated that the Quoddy Region is used as a wintering ground for many seabirds (i.e. dovekie's, shearwaters, and Wilson's storm-petrel), and waterfowl (i.e. endangered Harlequin duck). Other migrating seabirds, shorebirds and waterfowl birds use the area as staging grounds during migration southward and migration northward (Lotze and Milewski 2002). Such shorebirds include the Red-necked phalarope and Semi-palmated sandpiper. Almost 75% of the shorebirds in the study area are Semi-palmated sandpipers with the other 25% being Least sandpipers, Semi-palmated plovers, short-billed dowitchers and others (Lotze and Milewski 2002).

There were estimates of 100,000 to 1 million birds traveling through the Bay of Fundy in a 1998 study (Lotze and Milewski 2002). Migratory seabirds noted were the Artic tern, Common tern and Bonaparte's gull, and Greater and Sooty shearwaters. Moderate numbers of seabirds, 1000-10000 birds, have been documented in Passamaquoddy Bay and in the St. Croix Estuary (Lotze and Milewski 2002). Waterfowl birds noted in the study included Scoters, Common eiders, and American Black Duck. The latest Common eider colonies estimated for Passamaquoddy Bay areas including Deer Island/Campobello are 3375 pairs with the Wolves containing an estimated 1342 pairs

(Lotze and Milewski 2002). It was also noted that the study area is important to raptors such as the bald eagle, osprey and Peregrine falcon.

The Wolves is identified as an important wintering ground for the endangered Harlequin duck with approximately 50 birds and White Head Island also accounts for 25 birds (Lotze and Milewski 2002). Grand Manan was identified as being renowned for its seabird populations. Seabirds commonly occurring in Long Island Bay include double-crested cormorant, common eider, herring gull, and various sandpipers and terns (MacKay *et al*., 1979). The colonies of Common eiders in 2002 on Grand Manan were estimated at 2763-5237 pairs (Lotze and Milewski 2002).

Principal marine bird resources identified by The St. Croix Estuary Project *et al*. (1995) in Long Island Bay include:

- the common eider (*Somateria mollissima dresseri*) adjacent to Castalia Marsh;
- the herring gull (*Larus argentatus smithsonianus*) on Long Island; and
- the great blue heron (*Ardea herodias herodias*) on Long Island.

### 4.2.8 Habitat Characteristics

The marine ecosystem in the Quoddy Region consists of islands, salt marshes, subtidal ledges and finger bays. In 1992, the Habitat Panel of the Gulf of Maine Council on the Marine Environment generated a ranked list of 161 important species, inclusive of all categories of flora and fauna in the region, with a focus on coastal species that rely on the Gulf. This list is used as a means of identifying regionally significant habitats. It is assumed that "protecting habitats for top-ranked species will tend to protect habitats for lower-ranked species in the same area." (U.S. Fish and Wildlife Service, Gulf of Maine Project and Gulf of Maine Council on the Marine Environment, 1994).

#### *4.2.8.1 Ecological Zones*

Several distinct ecological zones in the Estuary Area contribute to a highly diverse biological setting. These are: subtidal waters; intertidal zone; islands; salt water marshes; freshwater wetlands; rivers, streams and lakes; and upland forests. Following are brief descriptions of each of these zones based primarily on information presented in the St. Croix Estuary Project, (1997), with the freshwater zones being discussed in Section 4.3.

#### 4.2.8.1.1 Subtidal Waters

The subtidal zone within the Estuary Area includes the permanently submerged waters of the St. Croix Estuary, Chamcook Harbour and Bocabec Bay. Similar conditions occur near Deer Island, Campobello Island, The Wolves and Grand Manan. Life inhabiting a subtidal zone may live on the bottom, in the water column, or at the water surface. Groundfish such as a flounder and cod are adapted to life on or near the bottom of the sea, while fish such as herring move through the water column and along the surface.

#### 4.2.8.1.2 Intertidal Zone

The intertidal zone is perhaps the most noticeable zone within the Estuary Area, exposed as it is twice daily with the retreat of the tide. This zone includes rocky intertidal areas, sand and tidal flats, coarse sedimentary shores (beaches) and salt marshes. The intertidal zone is considered to be critical to estuarine/marine food webs. Similar conditions occur near Deer Island, Campobello Island, The Wolves and Grand Manan.

#### 4.2.8.1.3 Rocky Intertidal

The rocky intertidal zone covers the greatest extent of the shores of the Estuary Area. Similar conditions occur near Deer Island, Campobello Island, The Wolves and Grand Manan. Rockweeds (*Ascophyllum nodosum* and *Fucus vesiculosis*) are common and abundant, as are associated fauna such as periwinkles, barnacles, limpets, mussels, and amphipods. Tidal pools may form within the rocky intertidal zone. These have physical, chemical and biotic structures making them unique from their surroundings rocky shores. They are inhabited by species tolerant of wide fluctuations in temperature, salinity and oxygen availability (Thomas, 1983b in Thomas {ed,} 1983).

#### 4.2.8.1.4 Sand and Tidal Flats

There are over 9,300 acres of intertidal mud and sand flats in the inner Quoddy Region (Trigom, 1973). Sand and mud flats (primarily the latter) are found within relatively sheltered locations in the Estuary Area. Prominent mud flats occur in Oak Bay, in the upper St. Croix Estuary, and in Chamcook Harbour. While the physical stresses of intertidal mudflats restrict species diversity (Berrill and Berrill, 1981), resident fauna is often abundant and highly productive. Mudflats support diverse primary food types (e.g. benthic microalgae and phytoplankton) which in turn support rich animal communities. Worms, shrimp, soft-shell clam and others thrive on these foods; fish migrate over tidal flats with the incoming tides to feed; and shorebirds, wading birds and waterfowl all depend on the flats and surrounding shallow subtidal areas for habitat and food (Horsley and Witten Inc., no date). Mudflats - particularly those in the upper Bay of Fundy - also serve as feeding and gathering grounds for much of the North American shorebird population during annual migrations (Maine Coastal Program, 1991).

#### 4.2.8.1.5 Beaches

Beaches in the Estuary Area as well as Deer Island, Campobello Island, The Wolves and Grand Manan consist primarily of cobble and gravel-sized rock and typically contain macroalgae and diatoms (yellow-green algae), barnacles, limpets, periwinkles and mussels. In places, such as on St. Croix Island, sand dominates and supports wedge shells, soft-shell clams and crabs (Steele, 1983 in Thomas {ed.} 1983).

#### 4.2.8.1.6 Salt Marshes

There are over 278 acres of salt marsh in the inner Quoddy Region (Trigom, 1973). Similar conditions occur for a number of areas for Deer Island, Campobello Island, and Grand Manan. Salt marshes are low-lying coastal wetlands characterized by low-growing plants such as Spartina *grasses* (saltmarsh cordgrass and saltmeadow cordgrass) in the lower intertidal zone and Juncus and Scirpus *species* (rushes and reeds) in the upper intertidal zone. Wide ranging salinity, tidal inundation and extremes of temperature in salt marshes restrict biotic presence to those plant and animal species well adapted to such conditions (Berrill and Berrill, 1981).

The biomass of a salt marsh is usually high and is especially productive in grasses. With regular tidal inundation, nutrients, from decaying vegetation and animals are removed from the salt marshes, thereby enriching the estuary. Animals of the salt marsh include grazing snails, foraging crustaceans, fiddler crabs, a variety of insects, fish, nesting birds and migrant birds (Berrill and Berrill, 1981).

Salt marshes are important habitats, serving as nurseries for some juvenile fish; migrant fish moving up or down an estuary may also rest and feed in salt marshes. Other fish move in with the tide, foraging on the smaller fish and the invertebrates.

Several species of small fish, including mummichog, ninespine stickleback, pipefish and silversides are common in and around boreal salt marshes, except in winter (Berrill and Berrill, 1981).

Salt marshes also slow and contain runoff of water from the land, thereby protecting shores from erosion and improving water quality by holding pollutants. Salt marshes are uncommon in the Estuary Area due to its relatively steep shoreline, but are found in the following locations: at the outlet of the Bocabec River; Sam Orr Pond in Birch Cove; on the St. Andrews peninsula (Katy's Cove and O'Neil Farm); at Pagan Cove in Oak Bay; and in the upper St. Croix Estuary.

#### 4.2.8.1.7 Islands

Ten islands and a number of ledges that remain exposed at high tide are found within the Estuary Area. Listed below are major islands in the estuary area and the water bodies in which they are found.

- Spoon (Oak Bay);
- McVicar (Oak Bay);
- Rickets (Waweig Estuary);
- St. Croix (St. Croix Estuary);
- Little Dochet (St. Croix Estuary);
- Navy (St Andrews Harbour);
- Ministers (Chamcook Harbour);
- Hospital (Passamaquoddy Bay);
- Hardwood (Passamaquoddy Bay); and
- Dicks (Passamaquoddy Bay).

Islands are ecologically significant for several reasons: increase in intertidal habitat for coastal species such as rockweed and shorebirds; relative isolation provides some species with sanctuary from predators and/or human disturbance; and serve as nesting and migratory stopover sites for birds. In addition, seals use some islands and rock ledges as "haul-out" areas.

Hardwood Island has had the largest colony of great blue herons in the Bay of Fundy (47 nests in 1981), and is an important stopover for migratory birds in the spring and fall. Dicks Island has harboured up to 400 pairs of eider duck (New Brunswick Department of Natural Resources & Energy, Fredericton, NB, 1994). Islands in the area provide nesting sites for osprey and bald eagle.

## 4.3 FRESHWATER AND WETLAND ENVIRONMENTS

The freshwater environment is discussed in a general context for aquatic resources and habitat.

### 4.3.1 Rivers, Streams and Lakes

Rivers, streams and lakes provide habitat for fish that migrate between fresh and salt water (e.g. Atlantic salmon, brook trout, American shad, American eel, alewife, smelt), and for birds that use both fresh and salt water (e.g. common loon, common merganser, belted kingfisher, great blue heron, bald eagle osprey). The riparian zone along streams provide protection and enhancement of water resources; adds detrital nutrients to freshwater food webs; minimizing situation and erosion; removing excess nutrients and sediments, and helping to prevent contaminants from washing into waterways. Important local freshwater bodies include the St. Croix River, Dennis Stream, Waweig River, the lakes within the Chamcook watershed, Wheaton Lake and the Bocabec River. A number of watercourses are also associated with Deer Island, Campobello Island, The Wolves and Grand Manan, but with flows typically being much less significant.

### 4.3.2 Freshwater Wetlands

There are over 30 freshwater wetland areas greater than 10 hectares (24.7 acres) in the lower St. Croix River watershed and the Chamcook and Bocabec watersheds. Extensive wetlands occur in and adjacent to the Moosehorn National Wildlife Refuge south of Calais (Trifts, J. St Croix Estuary Project, 1994). Many birds that occur in the Estuary Area use wetlands for feeding, nesting and breeding.

Freshwater wetlands (e.g. marshes, bogs, fens and forested swamps) are highly productive ecosystems. Wetlands help modulate freshwater flows, recharge aquifers and regulate nutrients cycling. In addition, habitat or winter refuges for various reptiles, amphibians, birds and mammals are provided. Forested swamps, for example, are especially important for hole-nesting wood ducks and mergansers (Christie, 1983 in Thomas {ed.} 1982). Mammals that use wetlands include fox, coyote, moose, deer, raccoon, mink, black bear and beaver.

### 4.4 ENVIRONMENTALLY SIGNIFICANT AREAS

Environmentally Significant Areas (ESAs) in the study area were identified from the NBDELG ESA database (Jane Tims, NBDOE, personal communication, 2006), the coastal resources mapping project (the St. Croix Estuary Project, 1997), the ACCDC database and ACER 1999. ESAs specifically associated with the marine environment are discussed below. Available information concerning identified and/or designated environmentally sensitive or significant areas (ESAs) was reviewed. Information sources included ACCDC and the New Brunswick Department of Environment and Local Government ESA Database.

A number of ESAs have been identified within the study area. Details for ESAs are provided in Table 4-4 for the identified ESAs. ESAs are identified on Figures A1, A3 and A5, in Appendix A.

## TABLE 4-4 Environmental Significant Areas (ESAs) in the Study Area

| ESA | Location | Ownership | Description |
|---|---|---|---|
| *Indian Island | Indian Island | Multiple | significant for birds. |
| *Liberty Point | Campobello Island | Roosevelt-Campobello International Park | significant for wetland plants. |
| *St. Croix River Estuary | St. Croix River | N/A | significant for Birds and fish. |
| *Chamcook Lake | Saint Andrews | Multiple | significant for fish, bird and plants |
| *Dennis Stream | | Multiple | significant for fish |
| *Abrahams Plain Bog | | Public | significant for wetland |
| *Big Pond | | Private | significant for wetland |
| *Lower Duck Pond Bog | Campobello Island | Public | significant for wetland and plant |
| *Upper Duck Pond Bog | Campobello Island | Public | significant for wetland and bird |
| **Deer Island Archipelago | | Multiple | significant for bird, fish and mammal |
| ***Sam Orr Pond | | Private | significant for wetland invert |
| ***Twin Lakes | | Private | significant for amphibians and reptile |
| ***Waweig River | | NA | significant for fish, bird and plant |
| ***Clear Lake | | Multiple | significant for fish |
| ***Digdeguash River & Harbour | | NA | significant for bird, geology and fish |
| ***Lake Utopia/The Canal | | Multiple | significant for bird, fish and plant |
| ***Magaguadavic River | | NA | significant for mammal fish bird |

**TABLE 4-4 Environmental Significant Areas (ESAs) in the Study Area (Cont'd)**

| ESA | Location | Ownership | Description |
|---|---|---|---|
| ***New River (beach) & Barnaby Headland | | Multiple | significant for fish geology |
| ***Pocologan River | | NA | significant for fish and geology |
| ***Seeleys Cove/Orange Brook Bog | | Private | significant for invert |
| ***Hansom Stream - Meadow Brook Bog | | Public | significant for wetland |
| ***Hardwood Hill Bog | | Crown | significant for wetland |
| ***Castalia Marsh | Grand Manan | Public | significant for bird wetland |
| ***Laborie Marsh | Grand Manan | Multiple | significant for wetland |
| ***Right Whale Sanctuary | North East of Grand Manan | N/A | Significant for Right Whales |

It should be noted that movements of the Right Whale extend beyond the boundaries identified for the Right Whale Sanctuary. Food sources for the Right Whale are reported to occur near Campobello and the West Isles, and therefore, it is likely that the Right Whale would feed in these areas. Right Whales are frequently observed in the area bound by Grand Manan, Campobello Island, The Wolves and East Head. Finback and Humpback Whales are frequently observed in the same area. Key food sources for whales traditionally include krill and plankton, however observations in 2005 (personal communication, Chuck Schom, May 2006) for the Quoddy Region indicate that Finback Whales may be feeding primarily on larval fish with Humpback Whales feeding on bate fish. In previous years the Finback and Humpback Whales seemed to be feeding on a combination of Krill and larger fish. The extent of the food sources is unknown and the effect of vessel traffic on the behaviour of krill and larval fish is not known. Further study is recommended to assess the extent of habitat utilized by krill and larval fish and the potential effect of vessel traffic on life stages.

Krill is a very common food source for Right Whales but further investigations would be required to establish the extent of habitat in this area (personal communication: Chuck Schom, March 2006). See section 4.6 for additional details.

## 4.5 CONTAMINANT SOURCES

Although the potential cumulative affects of hazardous materials was not assessed for this study, sources have been identified to recognize that the health of the ecosystem may be suppressed under existing conditions. Therefore, this may result in potential effects at the outer boundary of an LNG spill, reflecting the near shore area, being more significant as the cumulative effects may be more prominent near shore. The potential sources of contamination in the study area have been identified from various reports historically conducted in the area (Hunter and Associates, 1982 and St. Croix Estuary Project, 1997 being key documents). The potential sources of contamination to the study area are described below.

### 4.5.1 Fish Processing Plants

Historically, a fish processing plant for tuna operated in the bay and fish processing wastes were discharged to the bay.

### 4.5.2 Bayside Marine Terminal

The terminal has been used for the operations involving frozen meat, fish, potatoes, pulpwood and finished lumber, as well as cruise ships. Wastes commonly associated with operations at these facilities include liquids from wash down of vessels and the wharves, bilge water discharge, spillage of maintenance products (e.g., solvents, paints, anti-fouling agents, oils and lubricants) and fuels (e.g., diesel), sewage, and fish wastes.

### 4.5.3 Wastewater Discharge

There are 17 wastewater treatment plants, for industrial operations and municipal systems that discharge approximately 117,318 cubic metres of wastewater per day to the lower St. Croix River, St. Croix Estuary and Passamaquoddy Bay. Discharges from Deer Island, Campobello Island and the Wolves would be less significant in comparison, with discharges from Grand Manan being comparatively similar.

### 4.5.4 Domestic Sewage

Discharges from cottage development would be similar for the study area. The current operating status of domestic sewage systems located around Long Island Bay is unknown.

### 4.5.5 Storm Drains

Ditches along roads leading to the shore area around the Bay and islands convey non-point surface drainage.

### 4.5.6 Aquaculture Sites and Hatcheries

There are five salmon grow-out sites in the Chamcook-Bocabec area, salmon hatcheries (located on the west side of Oak Bay, on the upper Waweig River, and on the Chamcook Stream), and land based sea urchin culture sites in Chamcook, the St. Andrews Biological Station and the Huntsman Marine Centre (providing technical and research support to the aquaculture industry).

Aquaculture sites occur at the southern end of Long Island Bay. Two approved Atlantic salmon cage sites are located between Castalia Marsh and the north end of Long Island (Mr. Irfan Yuksel, NB Fisheries and Aquaculture, Fredericton, NB, personal communication, 1997, from ACER 1999). Several other approved finfish aquaculture sites are located further to the south.

## 4.6 WHALES IN THE QUODDY REGION

Whales are the largest predators on earth and, for centuries, have been the primary source of oils for lubrication and light, not to mention baleen. A number of societies still prize their flesh as food and Canada, in the Bay of Fundy, provides a summer/fall feeding ground sanctuary for one of the most endangered species of whale, the North Atlantic Right Whale. The Quoddy Region stretches shoreward from the sanctuary covering about 900 sq kilometres, being bounded by the mainland of Maine and New Brunswick.

In the early 1990's the Right Whale population shifted from a slowly increasing one to a slowly decreasing population (Caswell *et al.*, 1999; Fujiwara and Caswell, 2001). The trend according to Greene *et al.*, (2003) could be reversed by preventing one or two female deaths per year.

The situation is further complicated by Climate and Oceanographic changes that may reduce the biomass of *Calanus finmarchicus*, which is the Copepod that Right Whales feed upon. When Copepod biomass reductions occur, as they have in the past, they correlate with reduced Right Whale reproductive success (Greene *et al*. 2003). Failing to account for climate driven oceanic impacts may lead to underestimating the conservation efforts required to ensure recovery of the North Atlantic Right Whale population (Greene and Pershing, 2004). Thus, habitats of marginal significance to Right Whales now could become significant if they continue to provide conditions suitable for Copepod growth and Right Whale survival.

### 4.6.1 Species Status

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) classifies The North Atlantic Right Whale (*Eubalaena glacialis*) as endangered. The Finback Whale (*Balaenoptera physalus*) is of classified as a Species of Special Concern, while the Minke Whale (*Balaenoptera acutorostrata*) is under review. The Atlantic Humpback Whale (*Globicephala melas*) is currently classified as Not At Risk. The Harbour Porpoise (*Phocoena phocoena*) is considered a Species of Special Concern.

The *American Endangered Species Act* lists the North Atlantic Right Whale (*Eubalaena glacialis*), as well as the Finback (*Balaenoptera physalus*), and Atlantic Humpback (*Globicephala melas*) Whales as endangered. The Minke Whale (*Balaenoptera acutorostrata*) is unlisted and the Harbour Porpoise (*Phocoena phocoena*) is not listed.

### 4.6.2 The Quoddy Habitat

The inner Quoddy Region, located in the South West Corner of the Bay of Fundy (shown later on Figure 4-5) offers a unique habitat. Here the Minke, Finback and Humpback Whales are found, as well as the Harbour Porpoise and occasionally the North Atlantic Right Whale. The Finback and Minke Whales are occasionally in water as shallow as 30 metres, whereas the Humpback and Right Whales tend to stay in deeper water, i.e. from 50 metres or so to the deepest water in the area, approximately 125 metres. Even the 125 metre depth is relatively shallow water for Finback Whales, as most Finback studies report feeding activity at depths in the range of 300 metres or more Goldbogen, *et al*., (2006).

### 4.6.3 Issues Considered

There are a number of issues relevant to both the passage of LNG Tankers through the area and the construction and operation of LNG Terminals. Consideration will focus on Right and Finback Whales and to a lesser extent the Harbour Porpoise and Minke Whale since all four species are listed by COSEWIC. The issues considered here include:

- **Classification of Habitat:** Is habitat for the Right, Finback and Minke Whales and the Harbour Porpoise found in the Quoddy Region?
- **Importance of Habitat:** Is the Quoddy Region Habitat critical to assisting one or more of the four species recover?
- **Risk of Physical Injury:** Does the passage of large ships in general and LNG Tankers in particular represent a physical danger to one or more of the four species?
- **Noise Levels:** Will underwater noise levels in narrow passages impact on one or more of the four species? What will the noise level be from a tanker operating on its own and/or if accompanied by tugs?
- **Food Sources:** Are the food sources in the Quoddy Region local, that is from nursery areas, or does the food come in from elsewhere?
- **Impacts on Food Sources:** If local nursery areas exist, what impacts on them from either the Tankers or the Terminals are likely?
- **Toxicants Impact:** Are any of the regular releases and/or potential accidental releases likely to have a direct impact on any of the four species?
- **Drift Patterns:** Where will accidental or regular releases from the Tankers and Terminals distribute; i.e., either on the surface and/or in the water column?
  - How long will it take for those releases that are at toxic levels to disperse to the point where they are sufficiently dilute to have no impact?
  - What is the probability of such releases either caused by an accident occurring on the Tanker or Terminal or because the ship's hull has been breached?
- **Impacts on Lower Trophic Levels:** How long would a species take to recover from a catastrophic decline caused by a release from a Tanker or Terminal.

### 4.6.4 Historical Perspective

#### *4.6.4.1 Whaling through to 1987*

The industrial, tourist, regulatory and scientific communities were slow to recognize the significance of the Fundy as Whale Habitat. It wasn't until the 1970's that the summer gathering of Right Whales in the Bay of Fundy was recognized. This was probably fortunate for the Right Whales as it meant that a small, relic, population remained hidden in the fogs of the Fundy and were thus missed by the Whalers, although they were not unknown to locals.

The traditions, among the Quoddys constituent peoples, are a little different than elsewhere. There is no history of whaling which surprises visitors and leads them to ask why? Nevertheless, whales have been part of the life in the Quoddy Region since people first arrived and the First Nations' traditions include the Whale Ceremony, in which tribal members call, feed and make offerings to the whales (Graettinger, 2006). They normally do this from Split Rock, near Eastport and the site proposed by Quoddy Bay for its LNG Terminal.

As described in Section 3.1, the marine conditions are such that tidal volume is large, the passages among the islands are narrow and the currents are strong, so they did not really encourage people to chase whales. There always seems to be a knot or two of current, even miles from shore and even at slack tide (Schom, personal observation). Furthermore, the whales move around the most at change of tide and/or the hour or so after. This is also when it would have been easiest to move a boat, i.e., when the whales travel the most and often at speeds in the range of 6 knots or occasionally more. Add to this the fact that the weather seems most unpredictable, visibility and wind conditions often change in association with the arrival of "Slack Water" and with little or no warning, and the fog tends to thicken and winds often increase at or about the change of tide. It is not unusual to sit in the fog off Head Harbour Light and hear the whales blowing within 100 metres of the boat while not being able to see them.

In addition, a significant herring trap, weir, fishery, developed. To this day, Weir Fishermen still comment that there was a whale around my Weir all summer and it caught well (Schom, personal observation). The whales helped the fishermen in that they chased fish into the Weirs, not big fish to eat and extract oil from, and thus whaling never developed in the area because where the fishermen went in a boat was dictated by the tide.

Those that grew up and/or worked in the area in the 1970's, or earlier, tell of seeing all four whale species (the Right, Humpback, Minke and Finback Whales) regularly and from the shore. The Head Harbour Light House keeper's son, tells of spending hours watching all four species of whale from the Light House (MacAleenan, personal communication). Another chap, who spent his summers in Head Harbour Passage collecting data for his Ph. D. research project, tells of watching whales, including Right Whales, during slack periods in Head Harbour Passage (Wells, personal communication). One Whale Watch Operator commented that when he was a child helping his dad as a fisherman, whales were not really of much interest because they were always around (Guptil, personal communication).

There is much anecdotal information that places all four species of whales in Head Harbour Passage and the Quoddy Region thereby identifying it as habitat used by all four species. Unfortunately, there is little published scientific evidence to corroborate this. Gaskin (1982) does report Finback and Humpback Whales off Head Harbour and elsewhere in the Quoddy Region, as he does in great detail for Harbour Porpoise dating back to 1974, but not Right Whales or Minke Whales.

#### *4.6.4.2 The Present, 1987 through 2005*

Brown (2002) prepared a report based on corrected, summarized and analysed data from the University of Rhode Island Right Whale Consortium database. A grid composed of 3 by 3 nautical mile cells was developed with a Sightings Per Unit Effort (SPUE) inserted in each cell; following the procedures of Kenney, *et al*. (1995). Grids were developed for Right, Finback, Humpback and Minke Whales. The Right Whale Consortium database includes sighting information on more then just Right Whales (see Figures 4-1, 4-2, 4-3 and 4-4).

Mossman (2006), as part of her Honours Thesis, took some 3,000 whale GPS data points and analysed them, under the direction of Dr. Chris Taggart, Dalhousie University, to produce the Whale Species distribution chart presented in Figure (4-5).

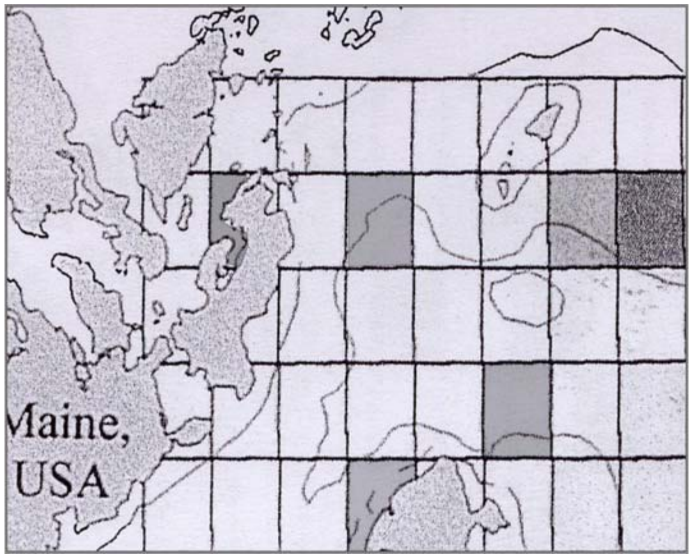
Figure 4-6 is a combination of the Brown and Mossman data, coupled with some local observations (Schom, personal communication). Since Mossman (2006) was unable to calculate a SPUE, the Brown (2002) data was converted to presence or absence data so that it could be combined with the Mossman (2006) data. Note that the whale identity associated with each blow in Mossman's (2006) data was ignored for the purposes of the Figure 4-6 but not for the discussion. In addition, because the Brown

(2002) grid did not cover the complete area of interest, additional cells were added where needed. As illustrated, when all species are combined, most of the Quoddy Region is used by Whales.

#### *4.6.4.3 Right Whales*

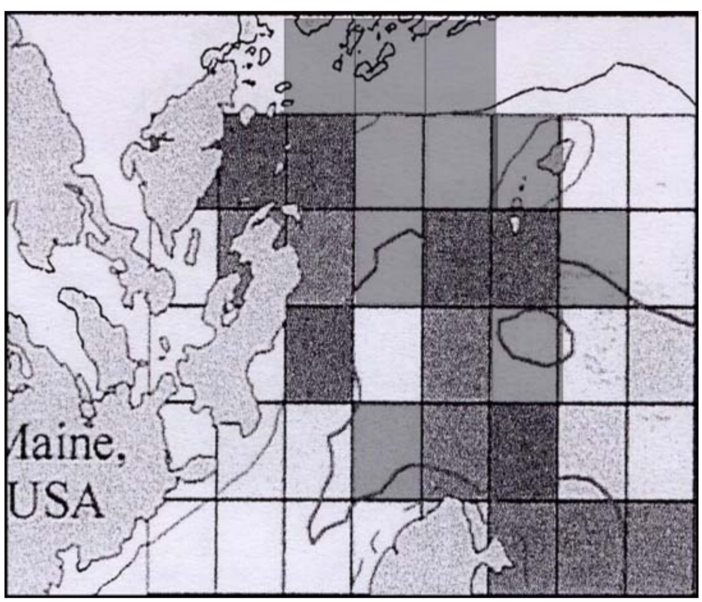
No Right Whales were spotted within 10 miles of the Head Harbour Light on the transit lines run between 1987 and 2000, however, six Right Whales were observed within that 10 mile radius in 2003 and 2004 (see Figure 4-1). These observations included a mother calf pair, one pair observed only twice in 2003, once off Georgia in the birthing grounds and once off Grand Manan Island in the Grand Manan Channel (Figure 4-7). Because Right Whales are difficult to spot, six may actually be an underestimation. One whale observed for a full half day off Wilson's Beach in Head Harbour Passage in 2004, was not seen coming in or leaving the area and it would have had to have travelled through a number of boats both coming and going. Thus, there are probably a number of Right Whales spending time in the Quoddy Region without actually being observed. Note that there are sufficient observations to state that Right Whales do use the Quoddy Region; however, there is insufficient data to say whether or not the Quoddy Region should be classified as critical Right Whale habitat.

## FIGURE 4-1 Right Whale Distribution in the Quoddy Region



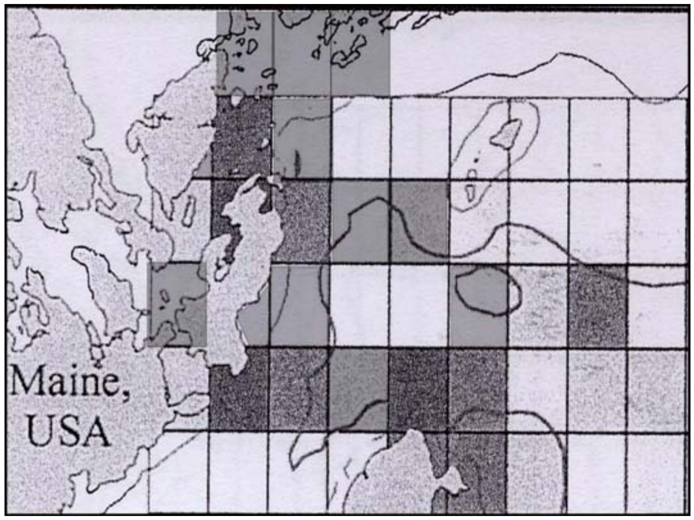

Note: The rough textured cells are where Brown (2001) reported Right Whales in the 1987 through 2000 analysis. The smooth textured cells are where Schom (2005) observed Right Whales in 2003 and 2004.

## FIGURE 4-2.Finback Whale Distribution in the Quoddy Region



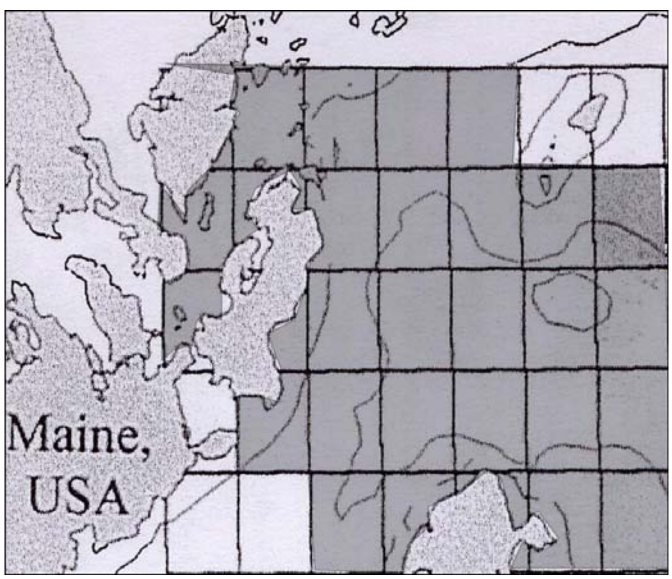

Note: The rough textured cells are where Brown (2001) reported Fin Whale in the 1987 through 2000 analysis. The smooth textured cells are those in which Mossman (2006) reported Fin Whales were observed.

## FIGURE 4-3 Minke Whale Distribution in the Quoddy Region



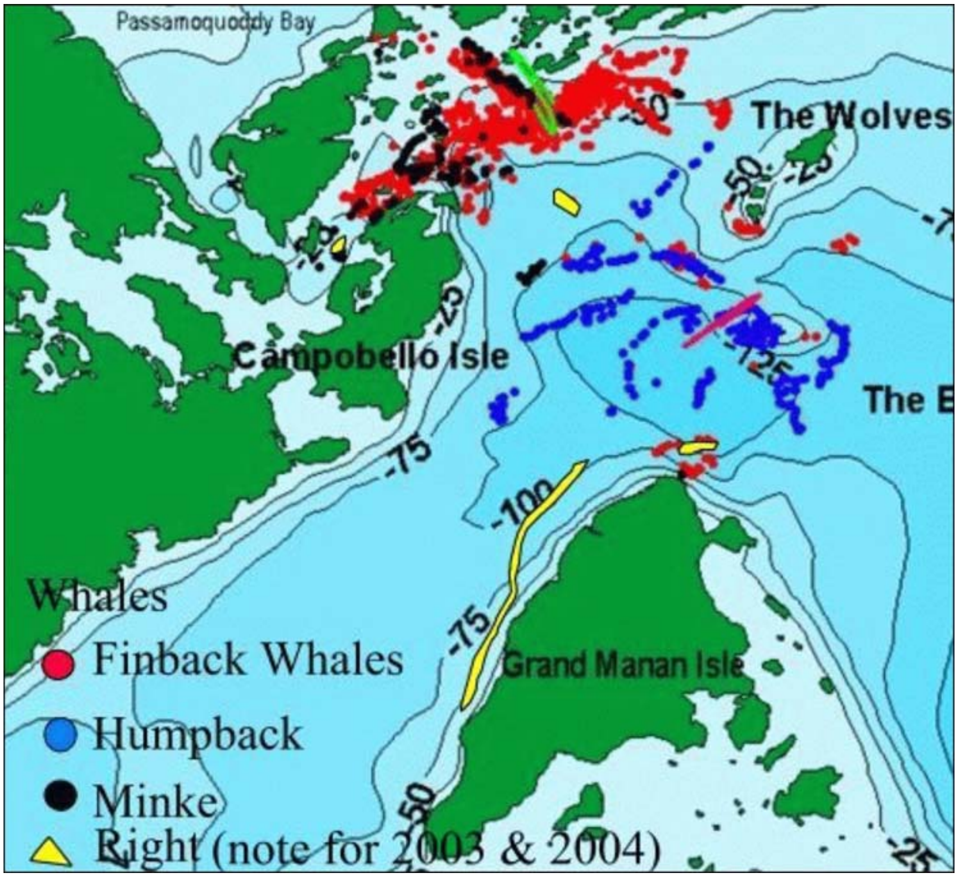

Note: The rough textured cells are where Brown (2001) reported Minke Whale were observed in the 1987 through 2000 analysis. The smooth textured cells are those in which Mossman (2006) and/or Schom (2005) reported Minke Whales were observed.

## FIGURE 4-4 Harbour Porpoise Distribution in the Quoddy Region



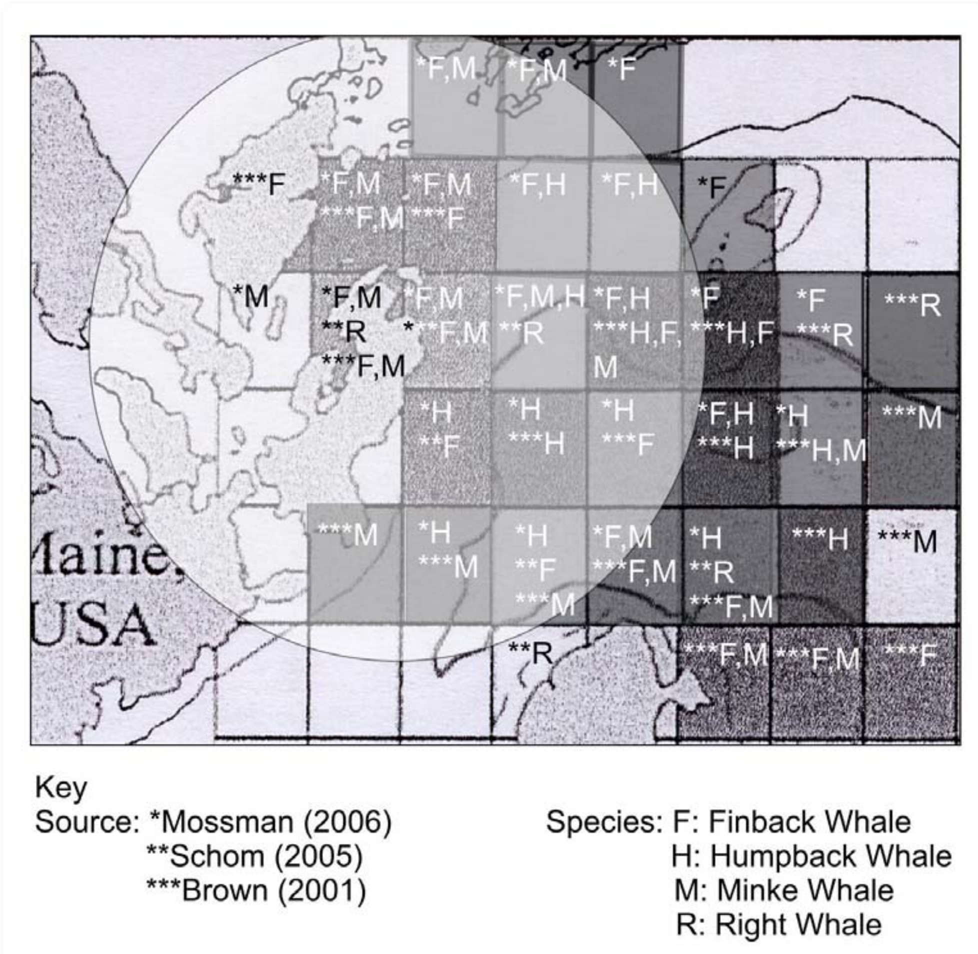

Note: The writer has observed Harbour Porpoise in all the shaded areas and even in Passamaquoddy Bay itself. If shading had been applied as an indication of numbers then Head Harbour Passage would be very dark. There are a lot of Harbour Porpoise in that area.

## FIGURE 4-5 Whale Distribution in the Inner Quoddy Region, an Area of About 200 sq kilometres




Note: Each dot represents GPS locations recording the position a whale blew. The majority of the data was recorded in 2004 and 2005, July and August. This is not a comprehensive coverage of the area, but only a record of where the whales were when the boat was with them. Further it should be noted that the Right Whale data is superimposed on this figure and is from 2003 and 2004. The Right Whale tracks are not continuous GPS recordings, but made by connecting the dots attributable to several points recorded while with the whale(s).

## FIGURE 4-6 Whale Distribution in the Quoddy Region




Note: The light circle has a 10 nm radius centred on the Head Harbour Light. Each square within the grid is 3 nm on a side (Brown, 2001). The figure itself is composite of data presented by Mossman (2006), Schom (2005) and Brown (2001). The shading of the grid squares reflects the number of sources contributing to the data. The lettering in the grid identifies the source of the data. Mossman (2006) data set based on 3,000 GPS positioned Whale Blow collected, a few in 2002 and 2003, the majority in 2004 and 2005, Schom (2005) Whale sightings in 2003 and 2004, Brown (2001) summarized and corrected University of Rhode Island Whale sighting data 1987 through 2000.

**FIGURE 4-7 Right Whale Cow and Calf Close to the Grand Manan Island Shore in 2003**

Note: They had started out near mid/ship channel in the Grand Manan Channel and moved in toward the Shore. Their track can be seen in Figure sc 5. Both the Finback Whale and Humpback Whales and of course the Minke Whales, have often been photographed this close or closer to shore. This cow and calf continued to move along and closer to the shore. The following year we followed a pair of big Humpback Whales along a similar track. This not an area the author often goes in. The calf is visible, nearing the end of its dive, to the left of the mother and in a little toward shore. This was only the second time this mother and calf were seen in 2003. They had previously been seen on the calving grounds.

### *4.6.4.4 Finback Whales*

Finback Whales are found in almost all of the Quoddy Region (Figure 4-2) and they are present in significant numbers year after year. Graettinger (2006) maintains that the First Nations peoples feel that between 2,362 and 2,814 Finback Whales use the Quoddy Region, although this number is probably very high for any one year. Furthermore, there is usually at least one mother calf pair in the area for several weeks to several months in any year.

Some Finback Whales are in the Quoddy Region year after year and they tend to utilize the same region every time they visit. One whale was first photographed off Blacks Harbour and the Ferry Track in 1998. It was back in the same area, day after day in 2005, and had been there in the intervening years and has been observed (Schom, personal communication) feeding on the Ferry Track near the buoy. During this latter single observation the whale moved off the Ferry Track by 1 km or so until a ferry destined for Grand Manan had based, at which point it returned to where it had been earlier, i.e. on the Ferry Track. New whales are seen in the area every year, although the neither the same behaviour nor similar reactions to other ships moving through the area has been observed either from the returning whales or the new whales. This begs the question as to how Finback and other whale species react to vessels and how this reaction is likely to affect the risk of injury, since avoidance of the ferry provides no information regarding how they will react to other vessels (or even if this is typical behaviour) and how whales new to the area will react. Here again, there is insufficient data to say whether or not the Quoddy Region should be classified as critical Finback Whale habitat.

#### *4.6.4.5 Minke Whales*

Minke Whales are in the area (Figure 4-3) and tend to concentrate more shoreward than do Finback Whales. Normally, they can be found in Head Harbour Passage at almost any time of tide, however, with the beginning of slack water they often move out of the passage heading, via a number of different routes, in the direction of the Wolves or towards the mainland on the other side. In the last 4 years only one dead Minke whale has been found in the area, although the cause of death was unknown.

The size of the majority of the Minke Whales suggests that they are mature individuals (some approaching 10 metres which is very large for a Minke Whale) and there are also usually one or two small individuals in the range of 3 metres. Minke Whales seem unaffected by the passage of bulk carriers and they have been known to spend time near vessels, even circling and rolling when the boat is sitting or giving the appearance of riding the pressure wave that a 35 to 50 ft boat moving in the range of 15 to 20 knots would produce (Schom, personal communication). Note that there is no clear evidence to show how Minke Whales might react to vessels the size of an LNG tanker or when confronted with a vessel in the narrowest part of the channel or close to a bulk carrier.

Minke Whales do use the Quoddy Region, although whether it is critical habitat or not is undetermined. Nevertheless, Trett (2003) has indicated that even when food availability drops in the Saguenay some whales do not leave the area suggesting that it may be critical to some individuals.

#### *4.6.4.6 Harbour Porpoise*

The Harbour Porpoise can be found through out the Quoddy Region (Figure 4-4) and the largest number of them is usually found in Head Harbour Passage. They often participate in what might be called multiple species, feeding frenzies which include Harbour Porpoise, Minke Whales, the occasional Finback Whale and sea birds, including Gannets, gulls and other birds. Gaskin (1982) describes the Harbour Porpoise as a mix with a number of mother calf pairs present. There is little information that can be used to determine how ships passing through the head Harbour Passage channel will impact on Harbour Porpoise feeding, although observations based on numbers may suggest that it is critical habitat for the Harbour Porpoise.

### 4.6.5 Habitat Use

Figure (4-6) covers the entire area in question and illustrates that one or other of the marine mammals discussed above have been observed using almost all of the Quoddy Region at one time or another. In general, they remain in one approximately 3 by 3 nautical mile area during much of either a rising tide or a falling tide. Near the change of tide and/or after, the Finback, Minke and the Humpback Whales move around a bit travelling at up to 6 knots. The same whale often seems to follow a set route each time, although not all whales and/or a particular whale follow the same route every time (Schom, personal communication). Given one time of tide over another, there are areas in the Quoddy Region in which whales are more likely to be, such as the Aisland Wake near Grand Manan Island known as the Long Eddy (Johnston, et al, 2005), as well as Campobello Island and Head Harbour Passage (Mossman, 2006; Schom, personal communication). Nevertheless, there is limited ability to predict habitat usage beyond saying that there will likely be a number of whales in the 200 sq miles of the inner Quoddy Region and that they are most likely to be found in certain areas at certain times of the tide and season.

### 4.6.6 Physical Injury

Clapman (2001) points out that between 1971 and 2001 a total of 49 North Atlantic Right Whales are classified as having died of which 17 (34.7%) were directly attributed to ship strikes. The actual rate of ship collisions with Right Whales may be much higher than this data indicate because only a portion of those classified as dead have been examined. In the 16 month period ending July 2005, there were 8 recorded Right Whale deaths including six adult females (three were carrying calves) three of which were confirmed as due to ship strikes. Based on Krause *et al.*, (2005) there is a high probability that a fourth whale was killed by a ship and some reasonable likely hood that two whales that died offshore were also victims of ships strikes, making it likely that 6 of the 8 deaths (75%) were attributable to ship strikes. Note that, one of the ship strike deaths occurred in the Bay of Fundy.

The rate of Right Whale deaths seems to be increasing, i.e., between 1971 and 2001 the rate was approximately 0.14 per month and in the 16 months ending July 2005 it was 0.5 per month. Laist *et al.* (2001) points out that ship strikes are likely to be fatal if the vessel concerned is 80 metres or more in length and/or if the vessel's speed exceeds 13 knots. Ward-Geiger *et al.*, (2005) indicate that the majority of ships (59%) travelling through areas designated as critical Right Whale habitat travel at speeds equal to or greater then 14 knots. This may be related to a view expressed by the Saint John Harbour Master who, according to Brown (2002), had the following two concerns relative to the Bay of Fundy traffic lanes:

1) That reducing speed was not conducive to safe navigation of the area; and
2) That the associated changes in hydrodynamic properties around a vessel travelling through the water would increase the risk to right whales.

One study done on Finback Whales, attributes the major and ever increasing proportion of Finback Whale deaths to ship strikes (Panigada *et al.,* 2006). That study also provided evidence that only a proportion of the Finback Whales killed by ships are identified, as is true for Right Whales. At least one Finback Whale was killed by a ship strike in the Bay of Fundy in 2004.

### 4.6.7 Noise

Ships make noise and the Harbour Porpoise uses sonar to feed. How a ship's noise will propagate and disperse in the narrow passages in the Quoddy Region, and in turn how they may affect the Harbour Porpoise, is unknown.

### 4.6.8 Food Sources

In a 1982 study conducted by Gaskin, what the whales were feeding on could not be verified, i.e., specifically on fish rather then euphausiids (Krill), Finback Whales have been observed lung feeding on the side in the presence of larval fish mixed with bate fish with no Krill evident (Schom, personal communication).

Generally, Harbour porpoise and Minke Whales will feed in the same area and Finback Whales will only rarely join them. Humpbacks sometimes feed in the same area as Finback Whales but rarely where Minke Whales are found. Thus, there is some overlap among the species in terms of feeding location, but each appears to have their own specific optimum which differs from each other and are generally unknown to us. Head Harbour Passage is extremely productive (see Section 4.2.8) and the planktonic sources of food move at the mercy of the tide. This creates an intellectual conundrum as the net flow in the Western Passage and Head Harbour Passage is out (see Section 3).

How do species that depend on net current to move from place to place end up in the inter island areas? Is there a counter current system that carries them in at one depth and out at another? Are there nursery areas, i.e., do mature adults of a species swim/move to these areas and leave their eggs and/or remain until the young emerge/hatch? The source of the young plankton has implications for whales and the ecological well being of the inter island area, not to mention the rest of the Quoddy Region, so the question then is where are the plankton coming from, local nursery areas, on currents from elsewhere or some combination of the two?

### 4.6.9 Information Gaps

Based on the preceding discussion of whales in the Quoddy Region, it is evident that there is a lack of information regarding the potential impacts that the LNG terminals and the associated tanker traffic may have on the local marine environment. More specifically, scientific data regarding the following is necessary:

- to determine whether or not the Quoddy Region is critical habitat to one or more whale species;
- whether the ships moving through the Quoddy Region represent a danger and the probability of one injuring a whale;
- whether or not there are nursery areas in the Quoody Region in general and/or the inter island area, Western Passage and Passamaquoddy Bay itself, and where the majority of the food species hatch, or if they hatch elsewhere if they arrive on a favourable current.

- the conditions under which the toxic by-products from underwater releases of LNG reported by Patin (1999) are produced and whether those conditions exist in the Quoddy Region;
- the fate and effect of a release including will it be carried on the surface and/or underwater, how will currents move them about and/or how long it will take to dilute them to a non toxic state; and
- the long term impact of a toxic release on the various trophic levels in the area.

#### 4.6.10 Status of Knowledge/Risk

Whales congregate in the Quoddy Region July through October. This concentration includes a number of calves, probably still nursing. Where the whales concentrate, week to week, is normally not possible to predict accurately. The whales can and do move from area to area, travelling at up to 6 knots or faster in areas where the current is normally greater then 1 knot. This broad ranging movement most often occurs following slack water and please note, that in the authors experience, where the whales are the current rarely, if ever, drops below 1 knot (GPS recorded). It should be noted that slack water is probably a misnomer in the Quoddy Region as there always seems to be a current of one form or another.

While Finback Whales are often seen alone that does not mean there is only one within a multi-square mile area. It means the opposite. Where there is one there is likely up to 6 or more others within five to ten miles of it. They come together. They move apart. There is often a mother and a calf somewhere within the area.

The same is, to some extent, true for the Humpback Whales in the area, although they seem to move about a bit more and even less predictably. That may be in part because they generally seem to be small/young. Rarely, do we see a big Humpback Whale in close. The Minke Whales can be anywhere from close to shore on out to deeper water. They range in size from small to near or over what some literature suggests is their maximum size.

#### 4.6.11 Evaluation of Scenario Impacts on Marine Mammals

This section addresses the potential impacts on marine mammals associated with the three scenarios described in Section 2 of this report. Note that no assessment is included here addressing the likelihood of scenario related impacts on terrestrial mammals.

#### *4.6.11.1 Scenario 1: Conventional Marine Hazards*

Among the conventional hazards likely to impact marine mammals are releases of oil and collision with marine mammals.

The 1999 EPA Report entitled "*Wildlife and Oil Spills*" identifies three main negative impacts associated with oils. They include surface adhesion leading to among, other things, heat loss; ingestion leading to illness and interference with feeding; and inhalation leading to irritation and damage of the respiratory system.

Species of pinnipeds and Cetaceans in the Quoddy Region have blubber and, unlike the fur seals, do not depend on fur for insulation at any stage of their life cycle. For this reason heat loss due to surface adhesion is not a factor. Nevertheless, as the oil weathers it becomes increasingly sticky and, under some circumstances, the flippers may become stuck to the side of the animal. This would interfere with their ability to swim and manoeuvre thus reducing their ability to feed and avoid predators.

In general, ingestion of oil is unlikely as none of the species normally groom, however, the young may ingest oil when they nurse as the teats may be contaminated. Assuming that the oil drifts inshore, pinnipeds are more likely to come into contact with oils over a longer period than Cetaceans because they also come ashore.

Both Pinnipeds and Cetaceans may ingest oils while feeding if their food was contaminated. Cetaceans, in particular, would do so if they fed on the surface, i.e. were to skim or lung feed in an area where the surface was contaminated.

Both Pinnipeds and Cetaceans breath near the surface of the water; thus, would likely inhale hydrocarbons with each breath taken. If the concentration is sufficiently high the hydrocarbon vapours will cause lung and respiratory tract mucosa injury.

The likely hood that some or all of the oil spill effects will occur depends on the volume of oil released, i.e., if it is a fairly large release it will have a negative impact. The location of a release is also important. For example, if the release is in the approaches to Head Harbour Passage the area is fairly large and the marine mammals tend to move around a fair bit, thus, the likelihood that there would be long term exposure is low. Alternatively, if the release were to occur in Head Harbour Passage or Western Passage then longer term exposure would be more likely as the marine mammals tend to stay within a particular area.

There is little or no evidence of collisions having a major impact on the smaller marine mammals. Nevertheless, ship strikes are one of the most common anthropomorphic causes of death among the Great Whales and over the last six years, one dead whale has been observed in the Quoddy Region every other year with one third of the events was attributable to a ship strike. While it is not possible to assign a numeric risk to a collision event, it is probably safe to say that the greater the number of ships the greater the potential risk of a collision occurring.

A Dead Right Whale calf was spotted in the Quoddy Region July 24th, 2006. According to an article in the Right Whale News by the Georgia Environmental Policy Institute (2006) it was hit by a ship, although whether it was before or after it died is not known. If it was hit before it died, how long it might have lived awaits the full Necropsy Report that should be available sometime in November or December 2006. Both the data and report are the property of the New England Aquarium. While it is not possible to say with certainty where the whale was struck, it is reasonable to assume that, unless it swam injured (bleeding to death) for a long period of time, it was struck in the Quoddy Region, i.e. the region of interest.

In 2004 a dead Finback Whale was spotted in the region. Initially it was moved about a bit as its stomach was distended and thus served as a sail. Once its stomach was deflated it continued to drift remaining within a few miles of the Wolves for more then a week before it was towed ashore on Grand Manan Island.

There could be difference between the likelihood of a ship/whale collision in the approaches to Head Harbour Passage and in Head Harbour Passage itself. The risk of Collisions in the approaches will depend, somewhat, on the route taken and attention paid to where whales are as the ship approaches the area. As Head Harbour Passage is narrow, thus the ship has little ability to manoeuvre, the opportunity to avoid whales by choosing an alternate route is not possible and the dangers of collision may be higher. Here the relative threat to the whale is related to the speed the vessel is traveling, generally the slower the speed the lower the risk, although this may be offset by decreased manoeuvrability. As there are unresolved questions about how ship noise will propagate and reflect within Head Harbour Passage and the impacts that this will have on the Marine Mammals, ship noise may alter (increase or decrease) the probability of a ship strike in the passage.

#### *4.6.11.2 Scenario 2: Release of LNG from the Vessel*

If the LNG release is above water and ignites near the vessel, i.e. a pool fire occurs, one would anticipate that marine mammals would stay clear of the area. In general, one might expect any scenario that includes fire to have little impact on the marine mammals as they are likely to remain underwater and away from the affected area, although there is no documented evidence to substantiate or refute this claim.

If the LNG plume spreads across the water surface without ignition, the marine mammals will have no way of knowing that there is a toxic layer over the surface of the water. Thus, when they surface to breath, the Cetaceans in particular, will expel their breath and take in a lung full of whatever concentration of pollutant is present. Whales expel almost all the air in their lungs with each breath, which is much higher percentage of air than terrestrial mammals expel when they breathe. As they normally breathe when their oxygen deficit is significant they are highly likely to be asphyxiated if the LNG has displaced much of the air. Unfortunately, there is no data to indicate at what concentration the LNG will become lethal and, as such, the danger zone may or may not coincide with those presented in Chapter 2. Further, because the air release when exhaling is so strong, i.e. as much as 3,000 litres in less then a second, it may reach a height of seven metres. Thus, the blow will create local turbulence which is likely to increase the mixing of air with the LNG creating conditions which may be ideal for ignition. Because of this, a whale that surfaces within an LNG plume of sufficient concentration has a high probability of dieing and creating a point where ignition is possible. In the case of pinnipeds there is also a high potential for asphyxiation, although again there is no specific data to put limits around the concentration necessary to cause death.

Should a release occur in Head Harbour Passage between July and November, the probability of Pinnipeds and Cetaceans dying is very high as there is rarely a time when some are not present. Should the release occur in the approaches to Head Harbour Passage the probability of death is much less likely unless it occurs near where the whales are feeding. Porpoises and/or seals are also feeding in the area at that time.

For under water releases of LNG, the impact on marine mammals should be no different from that of an above water release once it reaches the surface. Generally, an underwater release should have no direct immediate impact on the marine mammals beyond that described for above water releases. Its long term effects will depend on the impacts it has on organisms that the marine mammals feed on (see Scenario 3 below for a discussion on this).

Temperature decreases and methane concentrations in the water column should not affect the marine mammals; however, again there is no specific data to put limits around potential effects.

#### *4.6.11.3 Scenario 3: Release from Docking and Land Based Facilities*

The direct impact on marine mammals due to releases from docking and land based facilities is likely to be minimal as they are normally not found near the proposed LNG sites. Secondary effects may be significant if a large portion of the pinniped or Cetacean's annual food supply is damaged. This could come about by killing the feed directly, damaging areas that the feed needs to survive, and/or damaging areas the feed may need to reproduce.

The probability of this occurring is not known as there are no estimates of the concentrations needed to affect organisms or the life expectancy of the toxic concentrations, let alone whether or not there are nursery areas present that could be affected. All that appears to be known is that toxic concentrations can occur if releases are underwater.

# 5.0 NON-MARINE ENVIRONMENTS

## 5.1 OTHER ENVIRONMENTAL ISSUES

This section identifies other potential risks, specifically to the non-marine environment that were considered based on the following:

- vessel transport requirements including support vessels (tugs);
- the potential fire hazard zone;
- a vapour cloud associated with LNG; and
- other hazardous materials including petroleum hydrocarbons.

As shown on Figure 2.3, the fire hazard and vapour cloud zone from an LNG release extends onto shoreline as well as inland areas. Therefore, environmental issues associated with these areas have been identified for risk assessment purposes.

The approach used to identify other potential environmental issues for risk assessment purposes was based on perceived public concerns related to social, cultural, economic, or aesthetic values. The initial step in this process involved identification of Valued Environmental Components (VEC) that may be at risk through a review of applicable regulations and discussions with resource managers and government regulatory agencies and experience on similar projects. Issues and concerns identified through issues scoping and potential risks to the receiving environmental were identified by examining the pathways (or linkages) through which project activities may affect the environment. For example, the fire hazard zone provides a pathway/link between a release of LNG and any VECs that are located within the defined boundary associated with this pathway.

Where linkages between VECs and the Project activities were identified, and there are potential risks to the VEC, these components become the focus of the risk assessment. In this instance, a release of LNG during transport or off loading operations represent the activities of primary concern.

This process focuses attention on those VECs where the risk of significant adverse effects may occur. The discussion of pathways describes why there is or is not a linkage with project activities, and a potential risk to the VEC. VECs that were assessed not to be at risk were not considered any further in the analysis.

The nature of the currents that occur in Passamaquoddy Bay are likely to distribute any contaminants accidentally released, during tanker transport or at the terminal location, throughout the Bay, and given the tidal nature of the study area, contaminants may be transported into other tributaries of Passamaquoddy Bay during flood tides as well as into the Bay of Fundy. Specific considerations were also given to the geographic ranges of particular identified VECs, as applicable and transport mechanisms (consideration of ocean currents for example). Issues were identified primarily based on regulatory considerations.

The pathways that provide a linkage between the Project and other environmental components in the study area are identified in the following sections. It is recognized that standard practices are applied in US jurisdictions that are similar to Canadian practices for a number of activities that mitigate concerns related to identified pathways that are expected to be included as components of the proposed Project (e.g., WHMIS - Workplace Hazardous Materials Information System) and are indicated in the following sections where applicable. Where standard practices address potential effects/concerns, the pathway is no longer considered a concern and no further risk analysis is required for the ECC. Where there are linkages between project activities and environmental components that may be at risk, these components are considered as VECs and provide a focus for the risk assessment (Section 7.0).

In some instances there was no data indicating the presence or absence of VECs, and these represent information gaps requiring further study. Therefore, a discussion is provided for these VECs in the context of further recommended investigations. In addition, although information may have indicated that a VEC bordered the study area radius, this VEC was carried forward in the assessment to provide closure, recognizing that the study area may contain habitat that may be used by a particular VEC.

### 5.1.1 Atmospheric Environment

The relationship between project activities, pathways, and potential risks associated with the atmospheric environment are summarized in Table 5-1.

**TABLE 5-1 Potential Risks for Atmospheric Environment**

| Project Activities | Pathways | Potential Impacts |
|---|---|---|
| Maintenance equipment Operation and Marine Traffic | Release of emissions, including equipment exhaust | Reduction in air quality (human health and safety) |
| Accidental release of Contaminants | Release of emissions, including methane | Reduction in air quality (human health and safety); depletion of ozone layer increase in greenhouse gases |

An accidental release of LNG and chemical contaminants during vessel operations including the LNG tanker and supporting tug boats represent emissions of potential concern and risk to receptors. Incorporation of regulatory requirements and measures outlined in WHMIS will help to mitigate concerns related to human health and safety during construction and operation activities. The release of constituents including particulates and carbon dioxide ("green-house gases") during equipment operation can trap radiant solar energy reflected from the earth's surface, when present in the upper atmosphere. Potential risks are discussed further in Section 7.0.

The release of ozone depleting substances, including nitrogen oxides from diesel power generators, tug boats and other possible sources, may contribute to ozone depletion. The amounts of these substances produced by the proposed project will be insignificant relative to global emissions of ozone depleting substances. Therefore, the release of emissions potentially resulting in ozone depletion is no longer considered a pathway of concern.

LNG vessels are natural gas fired, thus making them among the lowest emissions transport vessels on the ocean, although they do use diesel for back-up and may lire on No. 2 or No. 6 fuel while approaching, offloading and leaving the terminal. Therefore, the contribution to emissions is considered negligible and tanker emissions are not considered further. However, two to three tugboats are required to assist during transport to and from the terminal location. Detailed calculations for emissions associated with tug boat operations were beyond the scope of this assessment. Emissions are dependent on a number of factors including engine size, speed, loading mode (full load or partial load), hours of operation, and idle time. However, an estimate has been made based on estimates for tug boats associated with a proposed LNG terminal to be located in Saint John, NB. It is expected that the tugs associated with the Passamaquoddy operations will be similar in size. Based on 50 tanker trips per year and an operating time of 30 hours for a round trip for each tanker, the resulting emissions are summarized in Table 5-2.

Given that air emissions are a potential issue, the general air quality for the study area is provided.

**TABLE 5-2 Air Emissions During Tug Boat Operations**

| SOURCE | AIR EMISSIONS (Tonnes per year) | | | | Green House Gas Emissions (Tonnes per Year) |
|---|---|---|---|---|---|
| | PM | $SO_2$ | $NO_X$ | CO | $CO_2$ |
| TANKER | NIL | NIL | NIL | NIL | NIL |
| 3 TUG BOATS | 70 | 547 | 537 | 570 | 183,030 |
| TOTAL | 70 | 547 | 537 | 570 | 183,030 |

## General Air Quality for Study Area

Air emissions for carbon monoxide, nitrogen dioxide, and Total Suspended Particulate (TSP) are governed by the New Brunswick *Clean Environment Act*, Air Quality Regulation. The national air quality objective for ozone is recognized as a guideline for ambient air quality by the New Brunswick Department of the Environment (NBDOE). Air quality is discussed in the following sections in terms of annual concentrations, and is based on information available for monitoring stations that are expected to be representative of the study area, or the only location where the specific parameter is measured.

## Carbon Monoxide

The average annual mean concentration of carbon monoxide for the five-year period from 1991 to 1996 at the Customs Building monitoring station in Saint John, NB, is 0.45

ppm. Concentrations have ranged from a high of 0.57 ppm in 1992 and 1995 to a low of 0.46 ppm in 1991. The value recorded in 1996 was 0.5 ppm.

**Nitrogen Dioxide**

The average annual mean concentration of nitrogen dioxide for the five-year period 1991 to 1996 at the Forest Hills monitoring station in Saint John, NB, is 5.4 ppb. Concentrations have ranged from a high of 6.9 ppb in 1995 to a low of 2 ppb in 1991. The value recorded in 1996 was 5.8 ppb.

**Total Suspended Particulate**

The average annual mean concentration of TSP for the period from 1991 to 1996 at the Forest Hills monitoring station in Saint John, NB, is 34.8$\mu g/m^3$. Concentrations have ranged from a high of 53.2$\mu g/m^3$ in 1978 to a low of 15.8$\mu g/m^3$ in 1995. The value recorded in 1996 was 18.16$\mu g/m^3$.

**Ozone**

The average mean concentration of ozone for the 11-year period of record at the monitoring station in Point Lepreau, NB, was 27.76 ppb. Concentrations have ranged from a high of 40.4 ppb in 1988 to a low of 18.3 ppb in 1986. The value recorded in 1996 was 31.2 ppb.

### 5.1.2 Terrestrial Environment

As indicated the fire hazard and vapour cloud zones from an LNG release extend inland by as much as several kilometres. Pathways for potential risks associated with the terrestrial environment include:

- release of LNG; and
- other chemical contaminants (petroleum hydrocarbons).

The relationship between project activities, pathways, and types of potential risks on terrestrial resources are identified in Table 5-3.

**TABLE 5-3 Possible Risks for Terrestrial Pathways**

| Project Activities | Pathways | Potential Risks |
|---|---|---|
| Accidental events during Vessel Traffic and Terminal Operations | Release of LNG<br>Release of chemical contaminants | Human health<br>Direct mortality and Degradation of habitat for Species at Risk and other ECCs<br>Ground & Surface water and Soil contamination<br>Behavioural changes in wildlife<br>Disruption of sensitive migratory periods and normal movement of terrestrial species |

### 5.1.3 Accidental Release of Chemical Contaminants and LNG

Risks to the terrestrial environment resulting from an accidental release of LNG include human health issues, and mortality of wildlife. Effects on the terrestrial environment resulting from an accidental release of petroleum hydrocarbon and other hazardous materials include ground and surface water and soil contamination, wildlife mortality, and health concerns. An accidental release of LNG and chemical contaminants is considered a potential pathway linking project operation to terrestrial environmental risks of concern. Therefore, further analysis is provided in Section 7.0.

### 5.1.4 Habitat Alteration/Destruction

The areas being considered for each option for the proposed construction are considered to provide potential habitat for migratory bird species, some of which are considered to be species of concern. Nesting and breeding areas for avian species are susceptible to damage caused by operations that could impact on the nesting locations for breeding bird species. There is also habitat for other Species at Risk including Plants, Mammals, Avian Species, herpatiles, and invertebrates. Habitat alteration is a pathway linking risks from project operation to VECs. Therefore, a description of the existing environment for these ECCS is provided in the following sections, and further analysis is provided in Section 7.0.

## 5.2 HYDROGEOLOGY

Groundwater originates from percolation of precipitation in the form of rain or snowmelt. Groundwater flows from areas of high groundwater head (recharge area) and migrates to areas of low elevation (discharge area). Private wells are used for domestic, commercial, and industrial activities in the study area. The most common problem with water quality in the area is related to salt water intrusion. Salt water intrusion is fairly common for coastal areas, where salt water from the sea extends inland as a wedge beneath the fresh groundwater in shallow zones. Therefore, it is common for wells in the area to be constructed as shallow dug wells. Groundwater yields for dug wells are in the order of three to six gallons per minute (Mr. Allen Short, Well Driller, personal communication, 1997).

Bedrock wells constructed in the area provide suitable water for domestic use at a depth of about 65 m. Water quality at a depth of about 25 to 30 m is of lower quality, with mineral concentrations being problematical. Groundwater yields for the bedrock wells are typically in the range of three to ten gallons per minute (Mr. Allen Short, Well Driller, personal communication, 1997).

## 5.3 TERRESTRIAL BIOLOGICAL SPECIES

### 5.3.1 Species of Special Status

Available information on the known occurrence of floral and faunal species of special status in the study area was compiled and reviewed to determine presence relative to the study area. Plant and animal species of special status in New Brunswick include those listed by the COSEWIC, those protected under the New Brunswick *Endangered Species Act*, and others designated as rare by species/resource experts. Information sources included published and unpublished listings of occurrences of rare species, as well as consultations with provincial government agencies and researchers, the New Brunswick Museum, and the Atlantic Canada Conservation Data Centre (ACCDC).

COSEWIC was formed and given the mandate of identifying species of special status in Canada. COSEWIC is comprised of Federal, Provincial and Territorial wildlife officials, as well as representatives of various wildlife organizations. Based on the most reliable sources and information available, COSEWIC prepares species status reports and assigns species status to sensitive species of birds, mammals, plants, fish, amphibians, and reptiles.

COSEWIC utilizes a five-level classification system as follows:

- extinct - no longer exists on the planet;
- extirpated - no longer existing in the wild of Canada, but found elsewhere;
- endangered - threatened with imminent extinction or extirpation;
- threatened - likely to become endangered unless situation changes; and
- special concern - at risk because of characteristics that make it particularly sensitive to human activities or natural events.

ACCDC uses an S-Rank system to classify species of special status. The five (5) most common ranks at the sub national (S) or provincial level, based on the ACCDC ranking system, are as follows

S 1- Extremely Rare throughout its range in the province (typically 5 or fewer occurrences or very few remaining individuals). May be especially vulnerable to extirpation.

S 2- Rare throughout its range in the province (6 to 20 occurrences or few remaining individuals). May be vulnerable to extirpation due to its rarity or other factors.

S 3- Uncommon throughout its range in the province, or found only in a restricted range, even if abundant in some locations. (21 to 100 occurrences).

S 4- Usually widespread, fairly common throughout its range in the province, and apparently secure with many occurrences, but the element is of long-term concern (e.g. watch list). (100+ occurrences).

S 5- Demonstrably widespread, abundant and secure throughout its range in the province, and essentially in eradicable under present conditions.

### 5.3.2 Plant Species of Special Status

Plant species of special status that may be at risk include those listed by COSEWIC as endangered, threatened or vulnerable, those protected under the New Brunswick *Endangered Species Act,* those designated as rare in New Brunswick (Hinds, 1983) and ACCDC. Several Floral species of special status have been identified by ACCDC to occur or potentially occur in the area of the proposed development. Floral species of special status are listed in Table 5-4 and identified on Figures A1 and A2 in Appendix A.

Figure A1 shows the point reference locations for the identified VEC, and Figure A2 shows the estimated boundary/footprint for the flora species.

Many plant species identified occur within shoreline areas as well as inland. Table 5-3 provides a list of three species that occur within the study area.

### TABLE 5-4 Flora Species of Special Status

| COMMON NAME | SCIENTIFIC NAME | RANKING/DESCRIPTION | POTENTIAL TO OCCUR AT SITE |
|---|---|---|---|
| *Small Eyebright | *Euphrasia randii* | S2 | YES |
| *Open-Field Sedge | *Carex conoidea* | S2 | YES |
| *Salt-Marsh Sedge | *Carex recta* | S2 | YES |
| ***Loesel's Twayblade | *Liparis loeselii* | S3 | YES |
| *Sea-Side Dock | *Rumex maritimus* | S2S3 | YES |
| *Dotted Smartweed | *Polygonum punctatum var. confertiflorum* | S2 | YES |
| *Carey's Smartweed | *Polygonum careyi* | S2 | YES |
| *Seabeach Dock | *Rumex pallidus* | S2? | YES |
| *Round-Leaved Liverleaf | *Hepatica nobilis var. obtusa* | S2 | YES |
| *Miss Jones Hawthorn | *Crataegus jonesiae* | S1 | YES |
| *A Hawthorn | *Crataegus submollis* | S2 | YES |
| *Swamp Rose | *Rosa palustris* | S2 | YES |
| *Cloudberry | *Rubus chamaemorus* | S3 | YES |
| *Nova Scotia False-Foxglove | *Agalinis neoscotica* | S1S2 | YES |
| *Mudwort | *Limosella australis* | S2 | YES |
| *Neckweed | *Veronica peregrina ssp. xalapensis* | S2? | YES |
| *American Basswood | *Tilia americana* | S3S4 | YES |
| *Marsh Valerian | *Valeriana uliginosa* | S2 | YES |

**TABLE 5-4 Flora Species of Special Status (Cont'd)**

| COMMON NAME | SCIENTIFIC NAME | RANKING/DESCRIPTION | POTENTIAL TO OCCUR AT SITE |
|---|---|---|---|
| *Northeastern Sedge | *Carex cryptolepis* | S3 | YES |
| *Merritt Fernald's Sedge | *Carex merritt-fernaldii* | S1 | YES |
| *Beaked Sedge | *Carex rostrata* | S1S2 | YES |
| *Slender Sedge | *Carex tenera* | S3 | YES |
| *Wiegand's Sedge | *Carex wiegandii* | S3 | YES |
| *Estuarine Sedge | *Carex vacillans* | S1 | YES |
| *Twig Rush | *Cladium mariscoides* | S2 | YES |
| *Slender Spike-Rush | *Eleocharis tenuis* | S3 | YES |
| *Brown Beakrush | *Rhynchospora fusca* | S2 | YES |
| *Gaspe Peninsula Arrow-Grass | *Triglochin gaspensis* | S2 | YES |
| *Spotted Coralroot | *Corallorhiza maculata var. occidentalis* | S2S3 | YES |
| *Hooker Orchis | *Platanthera hookeri* | S3 | YES |
| *Nodding Ladies'-Tresses | *Spiranthes cernua* | S2 | YES |
| *Purple Lovegrass | *Eragrostis pectinacea* | S2? | YES |
| *Blunt Manna-Grass | *Glyceria obtusa* | S1 | YES |
| *Creeping Alkali Grass | *Puccinellia phryganodes* | S2 | YES |
| *Small Bur-Reed | *Sparganium natans* | S2S3 | YES |
| *Tuckerman's Quillwort | *Isoetes tuckermanii* | S2S3 | YES |
| *Acadian Quillwort | *Isoetes acadiensis* | S1S2 | YES |
| *Cutleaf Grape-Fern | *Botrychium dissectum* | S3 | YES |
| *Appalachian Polypody | *Polypodium appalachianum* | S3S4 | YES |
| *Gay-Wing Milkwort | *Polygala paucifolia* | S2 | YES |

## TABLE 5-4 Flora Species of Special Status (Cont'd)

| COMMON NAME | SCIENTIFIC NAME | RANKING/DESCRIPTION | POTENTIAL TO OCCUR AT SITE |
|---|---|---|---|
| *One-Flowered Broomrape | *Orobanche uniflora* | S2 | YES |
| *Purple Bladderwort | *Utricularia purpurea* | S2S3 | YES |
| *American Pennyroyal | *Hedeoma pulegioides* | S2 | YES |
| *Slender Water-Milfoil | *Myriophyllum tenellum* | S3 | YES |
| *Herb-Robert | *Geranium robertianum* | S2? | YES |
| *Bicknell Northern Crane's-Bill | *Geranium bicknellii* | S3 | YES |
| *Marsh Felwort | *Lomatogonium rotatum* | S1 | YES |
| *Bur Oak | *Quercus macrocarpa* | S2 | YES |
| *Roseroot Stonecrop | *Rhodiola rosea* | S3 | YES |
| *American Sea-Blite | *Suaeda calceoliformis* | S2 | YES |
| *Knotted Pearlwort | *Sagina nodosa* | S2 | YES |
| *Rock Whitlow-Grass | *Draba arabisans* | S1 | YES |
| *Small-Flower Bitter-Cress | *Cardamine parviflora var. arenicola* | S1 | YES |
| *a New Belgium American-Aster | *Symphyotrichum novi-belgii var. crenifolium* | S2? | YES<br>YES |
| *Kalm's Hawkweed | *Hieracium kalmii var. kalmii* | S1 | YES |
| *Smoother Sweet-Cicely | *Osmorhiza longistylis* | S2? | YES |
| *a liverwort | *Cephaloziella divaricata, Reboulia hemisphaerica, Scapania paludicola* | S1 | YES |
| **a Moss | *Calliergonella cuspidata* | S1S2 | |

**TABLE 5-4 Flora Species of Special Status (Cont'd)**

| COMMON NAME | SCIENTIFIC NAME | RANKING/DESCRIPTION | POTENTIAL TO OCCUR AT SITE |
|---|---|---|---|
| **Frankton's Saltbush | *Atriplex franktonii* | S2 | |
| **Larger Canadian St. John's Wort | *Hypericum majus* | S3 | |
| **Roundleaf Sundew | *Drosera rotundifolia var. comosa* | S1 | |
| **Fountain Miner's-Lettuce | *Montia fontana* | SH | |
| **Tall Cinquefoil | *Potentilla arguta* | S3 | |
| **Bog Willow | *Salix pedicellaris* | S3 | |
| **Northern Comandra | *Geocaulon lividum* | S3 | |
| ** Sand Violet | *Viola adunca* | S3 | |
| **Mackenzie Sedge | *Carex mackenziei* | S3 | |
| **Bog Sedge | *Carex magellanica ssp. magellanica* | S2 | |
| **Creeping Alkali Grass | *Puccinellia phryganodes* | S2 | |
| ***Pussy-Toes | *Antennaria howellii ssp. petaloidea* | S1 | |
| ***Beach Wormwood | *Artemisia campestris ssp. caudata* | S3 | |
| ***Seabeach Groundsel | *Senecio pseudoarnica* | S1 | |
| ***Boreal American-Aster | *Symphyotrichum boreale* | S2 | |
| ***Swamp Birch | *Betula pumila* | S3 | |
| ***American Winter-Cress | *Barbarea orthoceras* | S1S2 | |
| ***Water Awlwort | *Subularia aquatica var. americana* | S1 | |
| ***Cardinal Flower | *Lobelia cardinalis* | S3 | |
| ***Prickly Hornwort | *Ceratophyllum echinatum* | S1S2 | |

**TABLE 5-4 Flora Species of Special Status (Cont'd)**

| COMMON NAME | SCIENTIFIC NAME | RANKING/DESCRIPTION | POTENTIAL TO OCCUR AT SITE |
|---|---|---|---|
| ***Giant-Seed Goosefoot | *Chenopodium simplex* | S1 | |
| ***Disguised St. John's-Wort | *Hypericum dissimulatum* | S1 | |
| ***Pale Dogwood | *Cornus obliqua* | S2 | |
| ***Water Pigmy-Weed | *Crassula aquatica* | S2 | |
| ***Small Water-Wort | *Elatine minima* | S2 | |
| ***Dwarf Blueberry | *Vaccinium caespitosum* | S3 | |
| ***Seaside Spurge | *Chamaesyce polygonifolia* | S1 | |
| ***Twining Bartonia | *Bartonia paniculata ssp. iodandra* | S2 | |
| ***Closed Gentian | *Gentiana rubricaulis* | S1 | |
| ***Bicknell Northern Crane's-Bill | *Geranium bicknellii* | S3 | |
| ***Common Water-Milfoil | *Myriophyllum sibiricum* | S2 | |
| ***American Germander | *Teucrium canadense* | S2 | |
| ***Hidden-Fruited Bladderwort | *Utricularia geminiscapa* | S2 | |
| ***Humped Bladderwort | *Utricularia gibba* | S1 | |
| ***Lesser Bladderwort | *Utricularia minor* | S2 | |
| ***Purple-Leaf Willow-Herb | *Epilobium coloratum* | S2? | |
| ***Hornemann Willow-Herb | *Epilobium hornemannii* | S2 | |
| ***Downy Willow-Herb | *Epilobium strictum* | S2 | |
| ***Eastern Jointweed | *Polygonella articulata* | S2SE | |

## TABLE 5-4 Flora Species of Special Status (Cont'd)

| COMMON NAME | SCIENTIFIC NAME | RANKING/DESCRIPTION | POTENTIAL TO OCCUR AT SITE |
|---|---|---|---|
| ***Water Smartweed | *Polygonum amphibium var. emersum* | S2 | |
| ***Narrow-Leaved Collomia | *Collomia linearis* | S2SE | |
| ***Collomia linearis | *Polemonium vanbruntiae* | SX | |
| ***American Shore-Grass | *Littorella uniflora* | S2 | |
| ***Whorled Loosestrife | *Lysimachia quadrifolia* | S1 | |
| ***American Wintergreen | *Pyrola americana* | S3S4 | |
| ***Purple Clematis | *Clematis occidentalis* | S3 | |
| ***Eastern White Water-Crowfoot | *Ranunculus longirostris* | S1? | |
| ***Cursed Crowfoot | *Ranunculus sceleratus* | S1 | |
| ***Veined Meadowrue | *Thalictrum venulosum* | S3 | |
| ***Oblong-Leaf Serviceberry | *Amelanchier canadensis* | S3 | |
| ***Bog Bedstraw | *Galium labradoricum* | S2 | |
| ***Purslane Speedwell | *Veronica peregrina* | S2? | |
| ***False Nettle | *Boehmeria cylindrica* | S2 | |
| ***New England Violet | *Viola novae-angliae* | S2 | |
| ***Arrow-Leaved Violet | *Viola sagittata var. ovata* | S1 | |
| ***Skunk Cabbage | *Symplocarpus foetidus* | S2 | |
| ***Long Sedge | *Carex folliculata* | S3 | |
| ***Cloud Sedge | *Carex haydenii* | S2 | |

**TABLE 5-4 Flora Species of Special Status (Cont'd)**

| COMMON NAME | SCIENTIFIC NAME | RANKING/DESCRIPTION | POTENTIAL TO OCCUR AT SITE |
|---|---|---|---|
| ***Hop Sedge | *Carex lupulina* | S2 | |
| ***Michaux Sedge | *Carex michauxiana* | S3 | |
| ***Swan Sedge | *Carex swanii* | SX | |
| ***Sparse-Flowered Sedge | *Carex tenuiflora* | S2 | |
| ***Toothed Sedge | *Cyperus dentatus* | S3 | |
| ***Small Spikerush | *Eleocharis parvula* | S2 | |
| ***Robbins Spikerush | *Eleocharis robbinsii* | S2 | |
| ***Clinton Bulrush | *Trichophorum clintonii* | S3 | |
| ***Stalked Bulrush | *Scirpus pedicellatus* | S2S3 | |
| ***Red Bulrush | *Blysmus rufus* | S2 | |
| ***Gaspe Peninsula Arrow-Grass | *Triglochin gaspensis* | S2 | |
| ***Greene's Rush | *Juncus greenei* | S1 | |
| ***Bayonet Rush | *Juncus militaris* | S3 | |
| ***Thread-Like Naiad | *Najas gracillima* | S1 | |
| ***Swamp-Pink | *Arethusa bulbosa* | S3 | |
| ***White Adder's-Mouth | *Malaxis brachypoda* | S1 | |
| ***Large Purple-Fringe Orchis | *Platanthera grandiflora* | S3 | |
| ***Nodding Ladies'-Tresses | *Spiranthes cernua* | S2 | |
| ***Yellow Nodding Ladies'-Tresses | *Spiranthes ochroleuca* | S1 | |
| ***Pickering's Reed Bent-Grass | *Calamagrostis pickeringii* | S2 | |
| *** Cypress Witchgrass | *Dichanthelium dichotomum* | S1 | |

**TABLE 5-4 Flora Species of Special Status (Cont'd)**

| COMMON NAME | SCIENTIFIC NAME | RANKING/DESCRIPTION | POTENTIAL TO OCCUR AT SITE |
|---|---|---|---|
| ***Slim-Leaf Witchgrass | *Dichanthelium linearifolium* | S1S2 | |
| ***Indian Wild Rice | *Zizania palustris* | S3 | |
| ***Algae-Like Pondweed | *Potamogeton confervoides* | S2 | |
| ***Oakes Pondweed | *Potamogeton oakesianus* | S2 | |
| ***Tuckerman's Quillwort | *Isoetes tuckermanii* | S2S3 | |
| ***Least Grape-Fern | *Botrychium simplex* | S2 | |
| ***Adder's Tongue | *Ophioglossum pusillum* | S2 | |
| ***Jacob's Ladder | *Polemonium vanbruntiae* | SX, NPROT-Threatened | |

Notes: * Located within zone 1

** Located within zones 1 and 2

*** Located in all three zones

### 5.3.3 Mammal Species of Special Status

Information on mammal species of special status that was considered, included those listed by COSEWIC as endangered, threatened or vulnerable, those protected under the New Brunswick *Endangered Species Act,* those designated as rare on a Provincial basis in New Brunswick (Dilworth, 1984; Anonymous, 1993a) and ACCDC.

Based on the information review several mammal species of special status occur in the study area that may be at risk. Table 5-5 provides a list of the species that occur in the study area. Mammal species of special status are identified on Figures A1 and A2 in Appendix A, in an area opposite to the proposed terminal locations in Saint Andrews (brown bat and hoary bat) and also in St. Stephen. Figure A1 shows the point reference locations for the identified VEC, and Figure A2 shows the estimated boundary/footprint for the mammal (vertebrate fauna) species.

**TABLE 5-5 Mammal Species of Special Status**

| COMMON NAME | SCIENTIFIC NAME | RANKING/DESCRIPTION | POTENTIAL TO OCCUR AT SITE |
|---|---|---|---|
| *Big Brown Bat | *Eptesicus fuscus* | S2 Rare | YES |
| *Eastern Red Bat | *Lasiurus borealis* | S2 Rare | NO |
| *Hoary Bat | *Lasiurus cinereus* | S2 Rare | YES |

### 5.3.4 Avian Species of Special Status and Raptors

Information on avian species of special status that was considered included those listed by ACCDC and by COSEWIC as endangered, threatened or vulnerable, those protected under the New Brunswick *Endangered Species Act*, and those designated as rare on a provincial basis in New Brunswick (Dilworth, 1984; Anonymous, 1993a).

A list of the species identified by ACCDC as occurring or potentially occurring within the study area that may be at risk is provided in Table 5-6: Avian species of special status are identified on Figures A1 and A2 in Appendix A. Figure A1 shows the point reference locations for the identified VEC, and Figure A2 shows the estimated boundary/footprint for the avian species.

## TABLE 5-6 Avian Species of Special Status

| COMMON NAME | SCIENTIFIC NAME | STATUS | RANKING |
|---|---|---|---|
| *Black-crowned Night-heron | *Nycticorax nycticorax* | | S2B |
| ***Gadwall | *Anas strepera* | | S2B |
| *American Wigeon | *Anas americana* | | S3B |
| *Bufflehead | *Bucephala albeola* | | S3N |
| *Bald Eagle | *Haliaeetus leucocephalus* | NPROT - Reg. Endangered | S4B,S2N |
| ***Horned Lark | *Eremophila alpestris* | | S3B |
| **Northern Rough-winged Swallow | *Stelgidopteryx serripennis* | | S2B |
| *Nelson's Sharp-tailed Sparrow | *Ammodramus nelsoni* | | S3B |
| **Harlequin Duck | *Histrionicus histrionicus* | NPROT-Special Concern, SPROT-Reg. Endangered | S1B,S1N |
| ***Piping Plover | *Charadrius melodus* | NPROT/SPROT-Reg. Endangered | |
| *Northern Garnet | *Morus bassanus* | | SHB,S5M,S5N |
| *Green Heron | *Butorides virescens* | | S2B |
| *Black-crowned Night-heron | *Nycticorax nycticorax* | | S2B |
| *Brant | *Branta bernicla* | | S1N,S2S3M |
| *American Wigeon | *Anas americana* | | S3B |
| *King Eider | *Somateria spectabilis* | | S1N |
| *Red-breasted Merganser | *Mergus serrator* | | S3B,S4S5M,S4N |
| *Red-shouldered Hawk | *Buteo lineatus* | NPROT-Special Concern | S2B |
| *Whimbrel | *Numenius phaeopus* | | S3M |
| *Hudsonian Godwit | *Limosa haemastica* | | S3M |
| *Red-necked Phalarope | *Phalaropus lobatus* | | S3M |
| *Black-legged Kittiwake | *Rissa tridactyla* | | S1B, S3N |
| *Arctic Tern | *Sterna paradisaea* | | S2B |

**TABLE 5-6 Avian Species of Special Status (Cont'd)**

| COMMON NAME | SCIENTIFIC NAME | STATUS | RANKING |
|---|---|---|---|
| *Razorbill | *Alca torda* | | S1B, S3N |
| *Black Guillemot | *Cepphus grylle* | | S3 |
| *Snowy Owl | *Nyctea scandiaca* | | S3N |
| *Whip-Poor-Will | *Caprimulgus vociferus* | | S3B |
| *Purple Martin | *Progne subis* | | S3B |
| *House Wren | *Troglodytes aedon* | | S1B |
| *Eastern Bluebird | *Sialia sialis* | | S3B |
| *Wood Thrush | *Hylocichla mustelina* | | S3B |
| *Northern Mockingbird | *Mimus polyglottos* | | S3B |
| *Brown Thrasher | *Toxostoma rufum* | | S2B |
| *Pine Warbler | *Dendroica pinus* | | S2S3B |
| *Northern Cardinal | *Cardinalis cardinalis* | | S2B |
| *Indigo Bunting | *Passerina cyanea* | | S3B |
| *Eastern Meadowlark | *Sturnella magna* | | S2B |
| *Pine Grosbeak | *Pinicola enucleator* | | S3 |
| *Red Crossbill | *Loxia curvirostra* | | S2S3 |
| *White-winged Crossbill | *Loxia leucoptera* | | S3S4 |
| **Leach's Storm-Petrel | *Oceanodroma leucorhoa* | | S2B |
| **Purple Sandpiper | *Calidris maritima* | | S3M,S4N |
| **Black-headed Gull | *Larus ridibundus* | | S2M, S1N |
| **Atlantic Puffin | *Fratercula arctica* | | S1S2B |
| **Eastern Bluebird | *Sialia sialis* | NAR | S3B |
| **Red Crossbill | *Loxia curvirostra* | | S2S3 |
| **White-winged Crossbill | *Loxia leucoptera* | | S3S4 |
| **Red-necked Grebe (Migratory) | *Podiceps grisegena* | | S3M, S2N |
| ***Greater Scaup | *Aythya marila* | | S2B, S1N |
| ***American Golden-Plover | *Pluvialis dominica* | | S3M |
| ***Solitary Sandpiper | *Tringa solitaria* | | S2B, S3M |

**TABLE 5-6 Avian Species of Special Status (Cont'd)**

| COMMON NAME | SCIENTIFIC NAME | STATUS | RANKING |
|---|---|---|---|
| ***Willet | *Catoptrophorus semipalmatus* | | S2S3B |
| ***Upland Sandpiper | *Bartramia longicauda* | | S1B |
| ***Red Knot | *Calidris canutus* | | S2S3M |
| ***Pectoral Sandpiper | *Calidris melanotos* | | S3M |
| ***Purple Sandpiper | *Calidris maritima* | | S3M,S4N |
| ***Laughing Gull | *Larus atricilla* | | S1B |
| ***Roseate Tern | *Sterna dougallii* | NPROT-Reg. Endangered | S1B |
| ***Common Tern | *Sterna hirundo* | NAR | S3B |
| ***Common Murre | *Uria aalge* | | S1B, S3N |
| ***Long-eared Owl | *Asio otus* | | S2S3 |
| ***Boreal Owl | *Aegolius funereus* | NAR | S1?B |
| ***Willow Flycatcher | *Empidonax traillii* | | S1S2B |
| ***Vesper Sparrow | *Pooecetes gramineus* | | S2B |
| ***Eastern Meadowlark | *Sturnella magna* | | S2B |
| ***Short-eared Owl | *Asio flammeus* | | S3B |
| ***American Peregrine Falcon | *Falco peregrinus anatum* | NPROT - Threatened SPROT- Reg. Endangered, | S1B |
| ***Barrow's Goldeneye (Quoddy Region) | *Bucephala islandica* | NPROT-Special Concern | |

Notes: * Located within zone 1

** Located within zones 1 and 2

*** Located in all three zones

The bufflehead is a small diving duck that is a migratory species that inhabits coastal regions. This species frequents shallow, sheltered waters of coves, river mouths, and lagoons, and are seldom found along exposed shores of the Bay of Fundy at any season (Hinterland Who's Who, 2004

(http://www.hww.ca/hww2p.asp?id=31&cid=7).

The harlequin duck has been identified to over-winter along the coast of the Bay of Fundy, specifically near Point Lepreau and near Grand Manan Island and is likely to occur in other areas along the coast. This species is listed as a species of special concern by COSEWIC, November 2003, and is also designated as endangered under the New Brunswick *Endangered Species Act*. The piping plover was also identified in the EIA and is listed as endangered by COSEWIC, *Species at Risk Act* (SARA) and under the New Brunswick *Endangered Species Act*. This species inhabits sandy beaches above the high water mark and forages for marine invertebrates along sandy beaches within the intertidal zone.

Suitable habitat conditions for nesting purposes occur and attributes associated with nearby rivers, coves, estuaries and wetland areas within the Passamaquoddy Bay area provide foraging opportunities to support these species. Field reconnaissance would need to be conducted to assess existing site conditions and to validate existing data as to the presence/absence of avian species of special status. Field investigations should be conducted by a qualified individual, at an appropriate time to further confirm site conditions.

There are raptors species of concern present in the study area. Bald Eagles nests typically occur in the range of approximately 1 to 2 km beyond the shoreline. Bald Eagles are listed to be regionally endangered in New Brunswick by NBDNRE. In addition to bald eagles, peregrine falcons have also been observed in the study area. This species is listed as endangered in New Brunswick by NBDNRE and as threatened under the SARA. These species may utilize a large area during foraging/feeding activities.

### 5.3.5 Herpetile Species of Special Status

Information on herpetile species of special status that were considered included those listed by COSEWIC as endangered, threatened or vulnerable, those protected under the New Brunswick *Endangered Species Act,* and those designated as rare on a Provincial basis in New Brunswick. Herpetile species of special status are identified on Figures A1 and A3 in Appendix A. Figure A1 shows the point reference locations for the identified VEC, and Figure A2 shows the estimated boundary/footprint for the herpetile species.

There are approximately 25 species of amphibians and reptiles known to occur in New Brunswick, but the cool climate of the Bay of Fundy excludes most of these species

(NBDNRE, 1982). The closest siting for an amphibian of special status is the Dusky Salamander north of St. Patrick.

In general, the Wood Turtle (Clemmys insculpta) has been reported to be present in watershed areas within the study area, approximately 200 m upstream of the proposed Red Beach Terminal location. The Wood Turtle may occur at other locations along the St. Croix River and other tributaries with similar habitat characteristics ACCDC has rated the Wood Turtle as uncommon (S3) throughout its range within the Province, and COSEWIC (2003) has identified the Wood Turtle as a species of special concern. Other herpetile species of special status, such as the Leatherback Turtle (*Dermochelys coriacea*) have been identified to occur in the Bay of Fundy. This species occurs in the Bay of Fundy year round, however, it is not known if the area contains limiting or critical habitat. Field investigations would be required to assess the presence/absence of this species including habitat.

### 5.3.6 Invertebrate Species of Special Status

Available information sources included the database at the ACCDC. There are numerous invertebrate species of special status in the study area that may be at risk including odonates, and butterflies in association with rivers, wetlands, estuaries and streams (see Table 5-7). Figure A1 shows the point reference locations for the identified VECs, and Figure A3 shows the estimated boundary/footprint for the invertebrate species. Rankings include the following for:

**Odonates**

S 1 - Extremely Rare throughout its range in the province (typically 5 or fewer occurrences or very few remaining individuals). May be especially vulnerable to extirpation.

S 2 - Rare throughout its range in the province (6 to 20 occurrences or few remaining individuals). May be vulnerable to extirpation due to its rarity or other factors.

S 3 - Uncommon throughout its range in the province, or found only in a restricted range, even if abundant in some locations. (21 to 100 occurrences).

**Butterflies**

S 1 - Extremely Rare throughout its range in the province (typically 5 or fewer occurrences or very few remaining individuals). May be especially vulnerable to extirpation.

S 2 - Rare throughout its range in the province (6 to 20 occurrences or few remaining individuals). May be vulnerable to extirpation due to its rarity or other factors.

S 3 - Uncommon throughout its range in the province, or found only in a restricted range, even if abundant in some locations. (21 to 100 occurrences).

### TABLE 5-7 Fauna Invertebrates (Butterfly and Dragonfly) Species of Special Status

| COMMON NAME | SCIENTIFIC NAME | STATUS | RANKING |
|---|---|---|---|
| *American Copper | *Lycaena phlaeas americana* | | S3 |
| *Monarch | *Danaus plexippus* | NPROT-Special Status | S2B |
| *Beaverpond Clubtail | *Gomphus borealis* | | S3 |
| *Harpoon Clubtail | *Gomphus descriptus* | | S1 |
| *Brook Snaketail | *Ophiogomphus aspersus* | | S3 |
| *Maine Snaketail | *Ophiogomphus mainensis* | | S3 |
| *Rusty Snaketail | *Ophiogomphus rupinsulensis* | | S2 |
| *Green-Striped Darner | *Aeshna verticalis* | | S2 |
| *Forcipate Emerald | *Somatochlora forcipata* | | S2 |
| *Delicate Emerald | *Somatochlora franklini* | | S2 |
| *Kennedy's Emerald | *Somatochlora kennedyi* | | S3 |
| *Brush-Tipped Emerald | *Somatochlora walshii* | | S3 |
| *Twelve-Spotted Skimmer | *Libellula pulchella* | | S2 |
| *Saffron-Winged Meadowhawk | *Sympetrum costiferum* | | S3 |
| *Band-Winged Meadowhawk | *Sympetrum semicinctum* | | S3 |
| *Yellow-Legged Meadowhawk | *Sympetrum vicinum* | | S3 |
| *Emerald Spreadwing | *Lestes dryas* | | S3 |
| *Spotted Spreadwing | *Lestes congener* | | S3 |
| *Slender Spreadwing | *Lestes rectangularis* | | S2 |
| *Lyre-Tipped Spreadwing | *Lestes unguiculatus* | | S1 |

## TABLE 5-7 Fauna Invertebrates (Butterfly and Dragonfly) Species of Special Status (Cont'd)

| COMMON NAME | SCIENTIFIC NAME | STATUS | RANKING |
|---|---|---|---|
| *Tule Bluet | *Enallagma carunculatum* | | S1 |
| *Azure Bluet | *Enallagma aspersum* | | S1 |
| *Stream Bluet | *Enallagma exsulans* | | S3 |
| *Fragile Forktail | *Ischnura posita* | | S1 |
| *Aurora Damsel | *Chromagrion conditum* | | S3 |
| ***Common Least Skipper | *Ancyloxypha numitor* | | S3 |
| ***Two-spotted Skipper | *Euphyes bimacula* | | S2 |
| ***Bog Elfin | *Callophrys lanoraieensis* | | S3 |
| ***Crowberry Blue | *Lycaeides idas empetri* | | S3 |
| ***Compton Tortoiseshell | *Nymphalis vaualbum j-album* | | S3 |
| ***Milbert's Tortoiseshell | *Nymphalis milberti* | | S3 |
| ***Jutta Arctic | *Oeneis jutta ascerta* | | S3 |
| ***Black-Shouldered Spinyleg | *Dromogomphus spinosus* | | S1 |
| ***Dusky Clubtail | *Gomphus spicatus* | | S3 |
| ***Ocellated Darner | *Boyeria grafiana* | | S3 |
| ***Prince Baskettail | *Epitheca princeps* | | S2 |
| ***Lake Emerald | *Somatochlora cingulata* | | S3 |
| ***Calico Pennant | *Celithemis elisa* | | S2 |
| ***Twelve-Spotted Skimmer | *Libellula pulchella* | | S2 |
| ***White Corporal | *Ladona exusta* | | S1 |
| ***Saffron-Winged Meadowhawk | *Sympetrum costiferum* | | S3 |
| ***Band-Winged Meadowhawk | *Sympetrum semicinctum* | | S3 |
| ***Yellow-Legged Meadowhawk | *Sympetrum vicinum* | | S3 |
| ***Superb Jewelwing | *Calopteryx amata* | | S3 |
| ***Sweetflag Spreadwing | *Lestes forcipatus* | | S2 |
| ***Swamp Spreadwing | *Lestes vigilax* | | S2 |
| ***Little Bluet | *Enallagma minusculum* | | S1 |
| ***Familiar Bluet | *Enallagma civile* | | S3 |
| ***Vesper Bluet | *Enallagma vesperum* | | S1 |

Notes: * Located within zone 1

** Located within zones 1 and 2

*** Located in all three zones

### 5.3.7 Sensitive and Critical Habitat

Available information sources included the database at the NBDNRE, ACCDC and COSEWIC status reports. Sensitive/critical habitats such as potential deer wintering areas may occur near shoreline areas. Avian, mammal, herpitiles, and invertebrate species of special status that may be at risk have been identified within the study area based on information from the ACCDC database. Species at risk have been identified in association with ESAs in some instances. Mammal species of special status are identified on Figures A1 and A2 in Appendix A. Figure A1 shows the point reference locations for the identified VECs, and Figures A2 and A3 show the estimated boundary/footprint for the VEC species. Field surveys for these VECs were not part of the study scope. Potential habitat for these species may be further assessed during field surveys as recommended in Section 7.0.

### 5.3.8 Environmentally Sensitive or Significant Areas (ESAs) and Other Critical Habitat Features

Available information concerning identified and/or designated environmentally sensitive or significant areas (ESAs) was reviewed to identify areas potentially at risk. Information sources included ACCDC and the New Brunswick Department of Environment and Local Government ESA Database.

A number of ESAs have been identified within the study area and direct marine based ESAs were discussed in Section 4.4. Other areas that are considered to be transitional between the marine environment and inland areas, as well as inland areas are provided in Table 5-8. In most instances, the ESAs identified in this section relate to birds, including migratory birds, shorebirds, and inland birds as well as plants, fish, and other species at risk. Some sites identified in Section 4.4 are repeated here recognizing that plants and birds represent a component of this section for example. ESAs are identified on Figures A1 and A5, in Appendix A.

## TABLE 5-8 ESA's in the Study Area

| ESA | Location | Ownership | Description |
|---|---|---|---|
| *Indian Island | Indian Island | Multiple | significant for birds. |
| *Liberty Point | Campobello Island | Roosevelt-Campobello International Park | significant for wetland plants. |
| *St. Croix River Estuary | St. Croix River | N/A | significant for birds and fish. |
| *Chamcook Lake | Saint Andrews | Multiple | significant for fish, bird and plants |
| *Dennis Stream | | Multiple | significant for fish |
| *St. Andrews Headland | | Multiple | significant for bird geology |
| *Robert M. Stewart Nature Preserve | | Private | significant for bird aesthetic |
| *Basket Heath, | Campobello Island | Public | significant for plant |
| *Friar's Head | Campobello Island | Public | significant for geology and plant |
| *Head Harbour Passage/Quoddy River Region | | NA | significant for bird and mammal |
| *Lower Duck Pond Bog | Campobello Island | Public | significant for wetland and plant |
| *Seven Days Work Cliff | | Multiple | significant for bird |
| *Upper Duck Pond Bog | Campobello Island | Public | significant for wetland and bird |
| *White Horse Island | | Crown | significant for bird |
| *White Island | | Private | significant for bird |
| *Dark Harbour Lagoon | Grand Manan | Multiple | significant for aesthetic geology |
| **Beaver Harbour Shoreline | | Multiple | significant for geology fossil |
| **Blacks Harbour Redbeds | | Multiple | significant for geology |
| **Deer Island Archipelago | | Multiple | significant for bird, fish and mammal |
| **Frye Island Group | | Private | significant for bird |
| **Letang Estuary | | NA | significant for bird geology |
| **Letete Or Green's Point | | Multiple | significant for plant, bird and geology |
| **Letete Passage | | | significant for bird |

## TABLE 5-8 ESA's in the Study Area (Cont'd)

| ESA | Location | Ownership | Description |
|---|---|---|---|
| **Mohawk Island | | Private | significant for bird |
| **Pendleton Island | | Private | significant for forest |
| **The Wolves (south, Flat, East, Spruce I) | | NA | significant for bird and plant |
| ***Highway 1, Exit 14 To St. Andrews | | Multiple | significant for geology |
| ***Limeburners Lake | | Multiple | significant for bird and plant |
| ***Ministers Island | | Multiple | significant for bird |
| ***Sam Orr Pond | | Private | significant for wetland invert |
| ***St. Croix Mountain | | Multiple | significant for bird |
| ***Twin Lakes | | Private | significant for amphibians and reptile |
| ***Waweig River | | NA | significant for fish, bird and plant |
| ***Bethel Polygonella Site | | Multiple | significant for plant |
| ***Bocabec Roadcuts | | Multiple | significant for geology |
| ***Dicks Island | | Private | significant for bird |
| ***Digdeguash River & Harbour | | NA | significant for bird, geology and fish |
| ***Hardwood Island | | Private | significant for bird |
| ***Lake Utopia/The Canal | | Multiple | significant for bird, fish and plant |
| ***Maces Bay & Ledges | | NA | significant for bird geology |
| ***Magaguadavic River | | NA | significant for mammal fish bird |
| ***Seeleys Cove/Orange Brook Bog | | Private | significant for invert |
| ***The Brothers/Salkeld Islands | | Crown | significant for bird |
| ***Dipper Harbour Roadcuts | | Multiple | significant for geology |
| ***North Head | Grand Manan | Multiple | significant for geology, plant and aesthetic |

**TABLE 5-8 ESA's in the Study Area (Cont'd)**

| ESA | Location | Ownership | Description |
|---|---|---|---|
| ***Bill's Islet | | NA | significant for plant |
| ***Castalia Marsh | Grand Manan | Public | significant for bird wetland |
| ***Dwelleys Pond | Grand Manan | Private | significant for plant |
| ***Grand Harbour | Grand Manan | NA | significant for plant and bird |
| ***Grand Manan Bird Sanctuary (great Pond) | | Crown | significant for bird and plant |
| ***Grand Manan Island Archipelago | | NA | significant for bird geology mammal |
| ***Ingalls Head Bog | | Private | significant for plant |
| ***Long Island | Grand Manan | Private | significant for bird |
| ***Machias Seal I. Migratory Bird Sanctuary | | Public | significant for bird |
| ***Nantucket Island | | Private | significant for bird |
| ***Ox-head | Grand Manan | Multiple | significant for plant |
| ***Ross Island | | Private | significant for plant |
| ***Southern Head, | Grand Manan | Multiple | significant for geology, plant and bird |
| ***Three Islands (Kent, Sheep, Hay) | | Multiple | significant for bird plant |
| ***Wood Island & Outer Wood Island | | Multiple | significant for bird and plant |
| ***Gull Cove | | Multiple | significant for plant |
| ***Right Whale Sanctuary | North East of Grand Manan | N/A | Significant for Right Whales |

Notes: * Located within zone 1

** Located within zones 1 and 2

*** Located in all three zones

It should be noted that movements of the Right Whale (see Figures A1 and A3 in Appendix A) extend beyond the boundaries identified for the Right Whale Sanctuary. Whales are discussed in more detail elsewhere in the document.

# 6.0 SOCIO-ECONOMIC ISSUES

## 6.1 PATHWAYS FOR SOCIO-ECONOMIC RISKS

Pathways for potential risks for tanker transport and terminal operations associated with the socio-economic environment considered for this study include release of chemical contaminants and LNG. The potential effect on land use values was not included in the scope of work. The relationship between project activities, pathways, and risks to the socio-economic environment for the above, are summarized in Table 6-1.

**TABLE 6-1 Possible Socio-Economic Risk Considerations**

| Project Activities | Pathways | Potential Impacts |
|---|---|---|
| Vessel Traffic and Terminal Operation and Accidental events | Operational activity | Potential loss of life<br>Recreational use<br>Commercial fisheries operations<br>Disturbance of heritage resources |
| | Release of chemical contaminants and LNG | Recreational use<br>Commercial fisheries operations<br>Groundwater contamination (see terrestrial environment)<br>Surface water contamination (see aquatic and marine resources)<br>Potential loss of life<br>Disturbance of heritage resources |

### 6.1.1 Operational Activities

Noise from vessel traffic and lighting requirements during evening operations may possibly interfere with enjoyment of property. Noise and lighting may also interfere with the movement of fish such as herring, and thereby interfere with this activity.

The release of LNG and contaminants may impact on recreational users and commercial fisheries resources and activities.

Specific pathways for potential risks associated with archaeological/heritage and paleontological resources include:

- Damage/disturbance from fire hazard associated with a release of LNG;
- Damage from contact with liquid LNG (considered very unlikely);
- Surface disturbance during remedial activity; and
- Sub-surface disturbance during remedial activity.

Resources may be destructed or disturbed by fire as a result of a fire associated with a release of LNG. The extent of impacts would be reduced with proper emergency response resources and planning.

Although a release of LNG and pooling is considered unlikely, it is recognized that significant damage can occur if liquid LNG comes in contact with materials.

Surface/subsurface disturbances would also be associated with a vessel accidentally running aground in an area that contains this resource. A disturbance may also result within the marine environment should a vessel sink in an area containing this resource.

Surface/subsurface and marine based disturbances are considered to represent a risk to this resource during operations.

In recognition of the above noted potential risks to socio-economic resources, a description of the socio-economic components that are potentially at risk is provided in the following sections and further analysis is provided in Section 7.0. Potential risks to groundwater and surface water users were discussed elsewhere and are identified in Section 7.0.

## 6.2 SOCIO-ECONOMIC SETTING

This section includes a description of the socio-economic environment with respect to information on the local economy for commercial fisheries operations, general land use, marine transportation and harbour uses, emergency services, and heritage/archaeological and paleontological resources.

### 6.2.1 Local Economy

The local economy is based primarily on commercial fisheries and tourism. Commercial fisheries operations include inshore and offshore fisheries. The principal tourism activities in the area include whale watching, sight-seeing, birdwatching and water sports/adventure activities, including kayaking and outback camping. There are a number of attractions in the area including parks and historical sites.

### 6.2.2 Current Land Use

There are several communities located adjacent to the estuary area including the city of Calais, towns of St. Andrews, St. Stephen and Robinston, and six rural communities (St. Croix Estuary Project, 1997). About 15,000 individuals live year-round in these communities with over 9,000 individuals residing in the St. Stephen-Calais areas. The total year round population within the St. Croix River watershed is estimated between 20,500 to 23,000 individuals (Environment Canada, 1897, St. Croix International Waterway Commission, 1993). For Deer Island the population was reported at approximately. 1000 people (2005 July), (http://www.angelfire.com/biz2/ditourism/trivia.html) and 851 people in 2001 (http://en.wikipedia.org/wiki/Deer_Island,_New_Brunswick). For Campobello Island a Population of 1,195 was reported in 2001(http://en.wikipedia.org/wiki/Campobello_Island,_New_Brunswick).

### 6.2.3 Marine Water-Based Uses of Long Island Bay

The water-based uses of Long Island Bay are described below as they relate to historical harbour development, terminal/port facilities, commercial fisheries, aquaculture sites, and other significant uses.

#### *6.2.3.1 Historical Harbour Development*

An overview of historical site development for the Quoddy Region has been reported by St. Croix Estuary Project (1997). Major timber harvesting began in the late 1700’s with numerous mills dotting the St. Croix shoreline. In the mid 1800’s, more lumber was shipped from the St. Croix than any other port in North America. Shipbuilding for trans-oceanic vessels and smaller fishing vessels peaked between 1838 and 1848. Hatcheries and grow out sites were constructed in the late 1900’s.

#### *6.2.3.2 Terminal/Port Facilities*

Current facilities include the Bayside Marine Terminal, initially constructed in 1966, with a major expansion undertaken in 1989. The harbour facilities in St. Andrews were constructed in the early 1800's.

#### *6.2.3.3 Commercial Fisheries*

The study area falls within Fisheries and Oceans Canada (DFO) statistical districts 49-53. There are currently over 2,000 commercial and recreational licenses in the area which land various shellfish and fish species (Table 6-2). Of these, clam, lobster and scallop constitute the major shellfish component landed whereas herring and groundfish make-up the dominant fish species collected. The commercial fishing seasons for species fished in Long Island Bay are shown in Table 6-3.

Commercial landing statistics for 2004 were obtained from DFO (Ms. Mary Mills, Commercial Data Division, Fisheries and Oceans Canada, St. Andrews, NB, personal communication, 2006). All commercial sea fisheries and freshwater fisheries landing are given in Appendix A, (these estimates are specific to the Passamaquoddy Bay area and do not include recreational or aquaculture estimates). Most landings occur in boats smaller than 65 feet, and consist of catches from several categories which include groundfish, pelagic and estuarine species, and molluscs and crustaceans (Table A-8 in Appendix A). The landed value of catch of each category for each district is given in Table A-9. Mollusc and crustaceans comprise the highest landed value, and is primarily attributed to lobster catch. In Charlotte County as many as 2,000 individuals may be employed at marine grow sites, hatcheries and support businesses (Charlotte County Economic Forum, 1996). Locations are identified in Figure A-11, in Appendix A.

## TABLE 6-2 Number of Commercial and Recreational Licenses

| SPECIES | COMMERCIAL | RECREATIONAL |
|---|---|---|
| Clam | 461 | No licence required |
| Groundfish | 194 | No licence required |
| Herring – includes weirs and vessel based | 321 | Not available |
| Bait | 12 | Not available |
| Lobster – vessel based | 282 | Not available |
| Lobster – pounds | 36 | Not available |
| Lobster – grey zone | 17 | Not available |
| Scallop | 179 | 366 |
| Crab | 11 | Not available |
| Mackerel | 71 | No licence required |
| Marine Worm | 10 | |
| Sea Cucumber | 2 | Not available |
| Flounder | 19 | No licence required |
| Sea Urchin | 30 | Not available |
| Tuna | 1 | Not available |
| Shark | | 8 |
| Shrimp | 4 | Not available |
| Swordfish | 7 | Not available |
| Gaspereau | 8 | |
| Shad | 3 | |
| Eel | 5 | |

Source: Mary Mills DFO, February 2007.

## TABLE 6-3 Commercial Fishing Seasons for Species Fished in Long Island Bay

| FISHERY | SEASON |
|---|---|
| Lobster | April to June and mid November to mid January |
| Herring | Typically June to October |
| Scallop | Year round |
| Sea Urchin | Insufficient data |
| Rockweed | Insufficient data |
| Clams | Insufficient data |

6.2.3.3.1 Lobster

Commercial lobster fishing may occur in various locations around the Bay (see Figures A5 and A11 in Appendix A). Annual landings in the estuary are estimated at 88 tonnes (St. Croix Estuary Project, 1997). Locations are identified in Figure A11, in Appendix A.

6.2.3.3.2 Herring

Commercial herring fishing may occur in various locations around the Bay (see Figure A5 in Appendix A). There are over 23 sites located in the Bay area. Herring weir licenses provide for an exclusion zone in the area such that no other herring fishing gear may be placed within 1,000 feet (304 m) of a weir. Landings and value of herring are presented in Table 6-4.

**TABLE 6-4 Aggregate Statistics for Selected Herring Weirs in Long Island Bay**

| LANDINGS/VALUE | YEAR | |
|---|---|---|
| | 1960 – 1992 average | 1994 |
| **Landings (tonnes, live weight)** | 1789 | 23,600 |
| **Value ($'000)** | | |

Although twine may be placed on weirs in early May, the principal fishing period in the area is June - October (Mr. Burton Small, Weir Fisherman, Woodwards Cove, Grand Manan, NB, personal communication, 1997).

6.2.3.3.3 Scallops

Commercial scallop fishing may occur in various locations around the Bay throughout the year. In southwestern NB, the total harvest represented a value of $7,232,000 (438 tonnes) in 1994 (Smith, 1944, in St. Croix Estuary Project, 1997). Locations are identified in Figure A11, in Appendix A.

6.2.3.3.4 Sea Urchins

As with scallop, sea urchins may also be harvested from various locations around the Bay. In south west NB, urchin landings were reported at 1,446 tonnes (Smith, 1944, in St. Croix Estuary Project, 1997). Harvesting locations are not known.

6.2.3.3.5 Rockweed Harvesting

Rockweed harvest areas occur in various locations in the Bay. Locations are identified in Figure A11, in Appendix A. There was no data related to harvesting.

6.2.3.3.6 Clams

Clam harvest areas occur at “approved”, “conditionally approved” and “restricted” locations in the Bay. The present economic value of local clam digging is unknown. Locations are identified in Figures A5 and A11, in Appendix A.

#### *6.2.3.4 Aquaculture Sites*

There are five approved salmon grow-out sites in the Chamcook-Bocabec area as indicated on Figure A11 in Appendix A.

#### *6.2.3.5 Other Significant Uses Including Tourism*

Other significant activities in the study area include recreational fishing, water sports/adventure activities, camping, golfing, bird watching, and whale watching. These are described below:

- **Recreational Fishing and Boating –** Recreational fishing effort is directed at a variety of species. Fishing from various wharves around the Bay occurs periodically for species such as pollack, mackerel, and striped bass. It is our understanding that recreational diving for scallops is a year-round activity, but locations are not known. Additional information should be collected to establish areas of use and time. Canoeing is very popular for the St. Croix River.

- **Water Sports/Adventure Activities –** Water jet skiing is a common activity in St. Andrews during summer months. Swimming also occurs at various locations. Sea kayaking, diving and windsurfing are also common activities in the Bay, along the coast and in the grand Manan area. A kayak/canoe rental business operates out of St. Andrews during the tourist season. Whale watching activities operate out of St. Andrews as well. Individuals are transported to several areas throughout the Bay of Fundy, towards Grand Manan.
- **Lobster Holding Area –** Lobster cars (floating pens of wooden construction, having free water exchange through them) may be located in this area, given that a lobster fishery exists. This should be confirmed. Lobster cars are used as holding facilities for lobster packed in crates, awaiting sale. Lobster pounds, for holding captures lobster are also located in the Bay.
- **Other Activities –** Other leisure and recreational activities in the area includes golfing, birdwatching and recreational camping (including parks). Airports are located within the study area as well for small aircraft.

### 6.2.4 Emergency Services

Policing in the study area is provided by the Royal Canadian Mounted Police. Fire protection is provided by volunteer fire departments located in St. Andrews, St. Stephen, Campobello Island and Grand Manan. Ambulance service is provided under contract and access to the hospitals in these areas is considered to be good. A hospital is located in St. Stepehn that services Deer Island and Campobello Island. Both Deer Island and Campobello Island have a Health Center.

### 6.2.5 Archaeological/Heritage and Paleontological Resources

Archaeological Services New Brunswick (ASNB) report that there are over 200 sites of cultural, historical, archaeological, or architectural significance in the study area. Locations are identified on Figure A12 in Appendix A.

## 6.3 EMERGENCY PREPAREDNESS AND RESPONSE

Marine disasters are not, unfortunately, particularly isolated incidents and as long as humans are involved in the manufacture, transport, use, disposal and storage of petroleum and chemical products, accidents will continue to occur. But even though the consequences of such catastrophes are often disastrous, in both human and environmental terms, they serve to highlight the need for national response planning to minimize the impacts that result from such emergencies.

The proposed transport of LNG through Passamaquoddy Bay has the potential to result in an environmental emergency situation. Therefore it is important for Canada to thoroughly review its preparedness capacity and its ability to respond in the unlikely event of such an incident. This section describes the preparedness and response capability in Atlantic Canada which could be utilized in any of the three risk scenarios described in Section 2 of this report.

In response to the many high profile accidents involving oil and chemical pollution in both marine and terrestrial environments, Canada has developed national prevention, preparedness and response mechanisms to effectively manage environmental emergencies. These mechanisms would come into play in the case of an LNG accident in Passamaquoddy Bay.

It is worth emphasizing that the physical response to environmental emergencies is almost exclusively carried out by the private sector. The Canadian governments at all levels act mainly as monitoring agencies to ensure that the environment is being adequately protected and that the responsible party is managing the cleanup in an effective and environmentally acceptable manner. Government agencies are, however, mandated to intervene, within the limits of the law, and take over the command and control of a response effort when circumstances warrant, as for example would be the case if a polluter was unwilling or unable to mount an effective response. In those cases the government would always attempt to recover any costs associated with its required intervention.

The government organizations for response to all types of emergencies, including LNG incidents, will be summarized in this section and the specifics of environmental planning and emergency response for an LNG accident will be presented in more detail. The legislative framework will be described where appropriate and operational / resource information on response organizations will be detailed where possible.

### 6.3.1 General Emergency Preparedness in Canada

Canada has developed a federal policy for providing a response to all types of emergencies, including natural ones such as earthquakes and tornadoes and human-caused events such as hazardous material spills, transportation accidents, or even war.

The purpose of emergency preparedness planning is to ensure that there is in place a mechanism to adequately deal with the consequences of such events. Within the federal government, emergency preparedness is based on the efforts of federal departments and agencies coordinated by Public Safety and Emergency Preparedness Canada (PSEPC), a federal government department created in 2003.

The Canadian emergency response system is premised upon the following:

- responsibility for initial action lies with the individual;
- if the incident is beyond the capacity of the responsible individual, the municipal services respond. Each mayor or community leader in each local government unit across the country is responsible for ensuring that emergency plans exist and are routinely exercised within the community;
- if the municipality cannot manage to respond effectively to an emergency, the province or territory is expected to come to the assistance of the local authorities;
- if the response capacity of the province or territory is exceeded, then the federal government will intervene and provide assistance. The federal government would normally only intervene when requested to or when the emergency clearly lies within federal jurisdiction (e.g. an LNG accident in Passamaquoddy Bay). When the federal government does intervene a lead Minister is usually designated to co-ordinate the federal efforts. That lead Minister will be head of the Department whose normal responsibilities closely relate to the circumstances of the incident. (e.g. Environment Canada for an environmental emergency on federal land, or the Canadian Coast Guard for spills originating from a ship).

The federal response effort is normally conducted under the overall direction of the responsible provincial government or, in the event of a primarily federal or national emergency, in close collaboration with provincial responders. Public Safety and Emergency Preparedness Canada monitors emergency situations in Canada and ensures that there is a federal lead but rarely assumes the lead role in emergency response.

### 6.3.2 Legislation

There are two federal statutes which set out the general responsibilities of the Government of Canada for emergency preparedness and response. They are the *Emergencies Act* and the *Emergency Preparedness Act*.

#### *6.3.2.1 The Emergencies Act*

The *Act* became law in 1988 and defines four categories of emergencies where the federal government, under extraordinarily adverse conditions, may be required to act:

1. public welfare emergencies – natural or human-made disasters, including environmental emergencies which are beyond the capacity of a province to handle;
2. public order emergencies – threats to Canada's internal security, acts of terrorism;
3. international emergencies – external threats to the sovereignty, security or territorial integrity of Canada, and
4. war.

#### *6.3.2.2 The Emergency Preparedness Act*

The *Act* became law in 1988 and defines the federal government requirements for emergency preparedness and response. For example, the Act:

- requires each federal Minister responsible for a federal department, agency or Crown Corporation to plan and prepare for emergencies related to his/her normal area of responsibility and to be prepared to assist other Ministers and other levels of government in times of emergency.
- directs the Minister Responsible for Emergency Preparedness, who is currently the Minister of Public Safety, to work with other federal Ministers to co-ordinate emergency preparedness among federal departments and between federal, provincial and territorial governments.
- designates Public Safety and Emergency Preparedness Canada (PSEPC) to be the central federal organization responsible for ensuring that co-ordination of federal efforts is carried out and for ensuring that there are no gaps or overlaps in the federal approach to emergency preparedness and response.

### 6.3.3 Public Safety and Emergency Preparedness Canada

The mandate of the PSEPC is to lead the national effort to protect Canadians from a range of risks such as natural disasters, crime and terrorism. To do this, PSEPC coordinates and supports the efforts of federal organizations in ensuring national security and the safety of Canadians. PSEPC also works with other levels of government, first responders, community groups, the private sector and other nations.

As Canada's lead department for public safety, PSEPC works with six agencies and three review bodies, which are managed in a single portfolio and report to the same minister. The result is better integration among federal organizations dealing with national security, emergency management, law enforcement, corrections, crime prevention and borders.

PSEPC incorporates an all-hazards and multi-disciplinary approach and its major emergency management efforts are directed towards coordinating federal emergency preparedness and response activities. It also fosters preparedness among other levels of government as well by:

- providing financial assistance to certain emergency preparedness projects;
- delivering and sponsoring training programs at the Canadian Emergency Management College;
- sponsoring research into various aspects of emergency preparedness and response;
- promoting public awareness; and
- consulting with international agencies on emergency preparedness issues of mutual concern.

### 6.3.4 Other Resources

The federal government owns very few physical resources that can be used in an emergency situation. The ones that do exist include approximately 200 emergency hospitals and other medical supplies strategically located across the country; transportation resources of a number of federal departments including the Department of National Defence; limited engineering and maintenance resources from Public Works and Government Services Canada; the financial resources of the federal government and the resources of the Canadian Forces. The Canadian Coast Guard is required to maintain a 50% capacity with respect to oil spill response equipment.

### 6.3.5 Provincial Emergency Management Organizations

In addition to the federal PSEPC, each province has established a provincial Emergency Management Office or Emergency Measures Organization (EMO) to provide a reasonable level of readiness during disasters. These provincial EMOs are established under the legislative authorities in each province. In Nova Scotia, for example, the EMO draws its legislative mandate from the *Emergencies Management*

*Act*, Nova Scotia's emergency management and emergency powers legislation. It establishes the rules for managing emergencies in Nova Scotia and requires municipal governments to have emergency plans.

As with the Nova Scotia Emergency Management Office, the New Brunswick Emergency Measures Organization (NB EMO) co-ordinates preparedness for emergencies. The NB EMO works at both provincial and municipal levels to ensure that New Brunswick communities are protected by emergency plans. NB EMO district co-ordinators, as well as headquarters staff, provide assistance to municipalities and local service districts with contingency planning for major emergencies. NB EMO also co-ordinates provincial response operations during emergencies and administers disaster financial assistance programs.

Like the federal PSEPC, the provincial EMOs play mainly a coordinating role, assisting other provincial departments in the preparation, review and implementation of their own contingency plans, conducting training sessions and liaising with federal authorities in emergency situations. As with the federal system, each provincial department is responsible for evaluating the potential for emergencies which could fall within its area of responsibility, and for determining its own capability for responding. Each department is also responsible for the preparation of departmental disaster plans, which then form part of the overall provincial emergency contingency plan.

Provincial plans incorporate the concept of a “lead department” that takes primary responsibility for provincial response to emergencies. For example, in Nova Scotia the Department of the Environment and Labour is the lead department for an environmental emergency. Provincial plans usually specify the municipality as the first line of response and stipulate those conditions where provincial resources will be mobilized.

### 6.3.6 Environmental Emergency Preparedness & Response – International Influences

#### *6.3.6.1 The International Impetus*

Major shipping accidents serve to focus national and often international attention on the problems and severe consequences of the resulting pollution. They have also provided the impetus for the development and implementation of spill prevention and response regimes around the world. The international focus on oil spill preparedness and response was precipitated by five serious oil pollution incidents:

- the Torrey Canyon – a grounded tanker off the coast of the United Kingdom;
- the Arrow – a grounded tanker off the coast of Nova Scotia, Canada;
- the Amoco Cadiz – a grounded VLCC off the coast of France;
- the Exxon Valdez – a grounded VLCC off the coast of Alaska; and
- the Nestucca – a grounded oil barge off the coast of British Columbia, Canada.

After the Torrey Canyon incident, the International Maritime Organization (IMO), which is the United Nations agency responsible for shipping, was considerably strengthened and three important international conventions were drafted:

1. the International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution (INTERVENTION 1969), entered into force in 1975;
2. the International Convention on Civil Liability for Oil Pollution Damage (CLC 1969), entered into force in 1975; and
3. the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND 1971), entered into force in 1978.

An important global concern for oil pollution from ships was addressed in a later convention, the International Convention for the Prevention of Pollution from Ships (MARPOL 1973/1978), entered into force in 1983. Recently, the IMO concluded the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC 1990) which entered into force in 1995.

Most national oil spill response regimes around the world, including Canada, have been developed as a direct result of these international conventions. As with most UN conventions these set the ground rules and then, in order to ratify the Convention, each signing country instituted domestic legislation which incorporated the international standards.

#### *6.3.6.2 International Convention for the Prevention of Pollution from Ships (MARPOL 1973/1978)*

The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 and updated by amendments through the years.

MARPOL was adopted on 2 November 1973 at IMO and covered pollution by oil, chemicals, harmful substances in packaged form, sewage and garbage. The Protocol of 1978 relating to the 1973 International Convention for the Prevention of Pollution from Ships (1978 MARPOL Protocol) was adopted at a Conference on Tanker Safety and Pollution Prevention in February 1978 held in response to a spate of tanker accidents in 1976-1977.

As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument is referred to as the International Convention for the Prevention of Marine Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78), and it entered into force on 2 October 1983 (Annexes I and II).

The Convention includes regulations aimed at preventing and minimizing pollution from ships, both accidental pollution and that from routine operations, and currently includes six technical Annexes.

#### *6.3.6.3 The OPRC Convention*

The OPRC is the most recently developed IMO Convention. Many nations, including Canada, have developed national oil spill response regimes which incorporate this international standard.

The OPRC recognizes the “polluter pays” principle as a general principle of international environmental law and stresses the importance of a tiered approach and mutual assistance arrangements to ensure an adequate response regime is in place. The Convention includes detailed specifications related to:

- oil pollution emergency plans;
- oil pollution reporting procedures;
- required actions upon receipt of an oil pollution report;
- national and regional systems for preparedness and response;
- international co-operation in pollution response, research and development;
- technical co-operation; and
- the promotion of bilateral and multilateral co-operation in preparedness and response.

With respect to national and regional systems for preparedness and response, the OPRC calls for the establishment of systems which should include, at a minimum:

1. a competent national authority with responsibility for oil pollution preparedness and response;
2. a national contingency plan for preparedness and response;
3. the development, in co-operation with the oil and shipping industries, a minimum level of pre-positioned oil spill combating equipment, commensurate with the risks involved;
4. the development, in co-operation with the oil and shipping industries, a program of exercises for oil spill response organizations, and training;
5. development, in co-operation with the oil and shipping industries, detailed plans and communications for an oil pollution incident; and
6. development, in co-operation with the oil and shipping industries, a mechanism to co-ordinate the response to any oil spill with the capabilities to organize the necessary resources.

The OPRC Convention provides an international requirement for national oil spill pollution preparedness, response and co-operation which effectively links government and industry capabilities.

### 6.3.7 The International Oil Pollution Compensation Funds (IOPC Funds)

The International Oil Pollution Compensation Funds (IOPC Funds) are part of an international regime of liability and compensation for oil pollution damage caused by oil spills from tankers. Under the regime the owner of a tanker is liable to pay compensation up to a certain limit for oil pollution damage following an escape of persistent oil from his ship. If that amount does not cover all the admissible claims, further compensation is available from the 1992 Fund if the damage occurs in a State which is a Member of that Fund. Additional compensation may also be available from the Supplementary Fund if the State is a Member of that Fund as well.

The IOPC Funds are financed by levies on certain types of oil carried by sea. The levies are paid by entities which receive oil after sea transport and, normally, not by States. Anyone who has suffered pollution damage in a Member State may make a claim against the IOPC Funds for compensation.

### 6.3.8 Environmental Emergency Response – Players in Atlantic Canada

In Atlantic Canada, the key groups which would respond to an LNG loss at sea or during the docking process are the Canadian Coast Guard, the Habitat Management Division of the Department of Fisheries and Oceans, Environment Canada, the Regional Environmental Emergency Team (REET), the Regional Response Organizations (ROs) - an industry led initiative, and the polluter (ship owner).

#### *6.3.8.1 Canadian Coast Guard*

The Canadian Coast Guard responds to all ship source spills either as the primary responder or as a monitor. Its role is to ensure the rapid and environmentally friendly clean-up of substances that are harmful to the environment, as well as to provide advice and response capabilities to other government departments. In addition to environmental response and prevention, the Coast Guard provides service in contingency planning and advice to industry. Contingency planning officers are continually working with industry and environmental groups, response organizations, and other governments, including that of the United States, to develop, update, test and exercise contingency plans to be ready in the event of a spill.

The Canadian Coast Guard follows its Marine Spills Contingency Plan when responding to environmental emergencies involving petroleum products or hazardous chemicals. The contingency plan defines the Canadian Coast Guard (CCG) as lead federal agency for all spills originating from a ship and spilling in waters of Canadian interest, not controlled by Ports Canada or Harbour Commission. It also designates Environment Canada as the resource agency advising the CCG on environmental matters as the Regional Environmental Emergency Response Team (REET).

In the case of an LNG loss in Passamaquoddy Bay, the CCG would defer to the response processes identified in the Joint Canada-United States Marine Pollution Contingency Plan as the accident would fall in contiguous waters of Canada and the USA. The Coast Guard would immediately contact Transport Canada for their experience and knowledge regarding the vessel itself and then deploy to the area. The first activities of the response team would be for the Coast Guard, the ship owner and the REET to complete a risk assessment. The appropriate experts would need to be contacted in order for an immediate hazard assessment to be completed, involving modeling, determination of the concentration impact zone, and identification of potential impacts to humans and the ecosystems.

### *6.3.8.2 The Canada - United States Joint Marine Pollution Contingency Plan*

Canada has entered an agreement with the United States (Canada - United States Joint Marine Pollution Contingency Plan) to develop and implement appropriate spill preparedness and response measures to deal with incidents which may have international consequences affecting both nations. In the case of an LNG loss in the Passamaquoddy region of the Bay of Fundy, this plan would be followed as these waters are considered international and both the US and Canada would be involved in the response.

The purpose of the Joint Plan is to provide an effective response to pollution incidents through the coordination of federal, state, provincial, regional and local plans of both countries. The plan, as with most, relies on the tiered approach, with local authorities having the first responsibility for response and other agencies assisting as necessary.

Five areas fall within the jurisdiction of the plan: the Great Lakes; the Atlantic Coast; the Pacific Coast; the Beaufort Sea in the North, and the Dixon Entrance off the Pacific Coast. The Plan requires that both countries respond effectively to any pollution incident which might affect the resources of the other; it identifies notification and alerting procedures; it specifies the funding arrangements for response operations, and identifies agency responsibilities in both countries.

As with most contingency plans, the Joint Plan specifies the required response and planning elements, designates a Joint Response Team, its responsibilities and authorities, and identifies training and exercises which must be conducted to test the effectiveness of the plan in a simulated emergency. The Plan is tested every two years through exercises led by the Canadian and U.S. Coast Guards. Implementation of the plan is the joint responsibility of the Canadian Coast Guard and the U.S. Coast Guard.

### *6.3.8.3 The Habitat Management Division of DFO*

One of the sensitive resources at risk in the study area is the North Atlantic Right Whale which is an endangered species. An important measure that the Canadian government has undertaken to protect the whale population from ship collisions was to change the shipping lanes through the Bay of Fundy. In 2003, the Maritime Safety Committee of International Maritime Organization (IMO) approved and adopted the Government of Canada's proposed changes to the shipping lanes in the Bay of Fundy to protect the endangered North Atlantic right whale population from ship strikes.

A Working Group on Ship Strikes co-chaired by Transport Canada and the Canadian Whale Institute, and including representatives from the shipping, fishing and whale watching communities, determined that this approach would be the most effective in reducing strikes and maintaining safe commercial marine operations.

The new shipping lanes are based on considerable scientific whale research and were reviewed by several marine industry stakeholders and experts to ensure safety would be maintained. The new lanes help to protect the right whale by organizing the ship traffic flow in and around an area where the right whale densities are the greatest. The new lanes became effective on July 1, 2003 following the necessary amendments to the navigational charts and vessel traffic control procedures, as well as the completion of distribution and notification procedures.

Many vessels in the Bay of Fundy have also implemented the presence of whale watchers aboard their ships, which contributes to the reduction of collisions with whales. This could be considered on LNG vessels as they enter the Bay of Fundy in order to further reduce the risk of striking a whale or other marine mammal.

In the case of an LNG vessel colliding with a marine mammal, but without a loss of LNG product, the response would be undertaken by the Department of Fisheries and Oceans (DFO) to deal with the injured or dead mammal. If the mammal was not killed DFO would monitor its activities and record the collision but likely would not be able to aid the mammal in any way. If the mammal is killed DFO would assess whether it was a hazard to navigation and identify the most appropriate disposal plan. There is an internal DFO Marine Mammal Contingency Plan that would provide the basic procedures to follow in this case.

### 6.3.9 Environment Canada

#### *6.3.9.1 Background*

In 1973, following the spill of oil from the tanker “Arrow” in Chedabucto Bay, Nova Scotia, the federal government issued a Cabinet Directive that specified Environment Canada’s responsibilities in dealing with environmental emergencies. The Directive required Environment Canada to develop an environmental emergency program; to coordinate the federal government’s response in the event of an environmental emergency; to develop and maintain the capability to provide technical advice in emergency situations; to prepare for and be able to respond to environmental emergencies, and to develop, assess and test new response tools. This mandate was supported in a Federal Policy for Emergencies approved in May 1995. The overall responsibility within Environment Canada for coordinating the delivery of the environmental emergencies program was assigned to the Environmental Protection Service.

The mandate of the Environmental Emergencies program is further defined as the provision of national and international leadership, and scientific and technical services to respond to natural hazards and severe meteorological events, and to prevent and respond to oil and chemical spill emergencies leading to environmental damages. The objectives of the program are to reduce the frequency and severity of accidental releases of deleterious substances to the environment through effective prevention, preparedness and response strategies at the regional and national level.

The Environmental Emergencies program is set up to provide a strong, coordinated framework for all phases of emergency management through the development and application of a number of tools related to planning, training and exercises, response mechanisms and incident prevention protocols. The program personnel also provide communication management within the department in crisis situations and participate in international forums to shape and influence environmental emergency related conventions and agreements.

The Environmental Emergencies Section (EES) in the Atlantic Region consists of a multi-disciplinary team of people that delivers the departmental responsibilities for environmental emergencies in the four Atlantic Provinces. In most cases, the EES acts as an environmental advisor to another federal agency (in the case of an LNG incident, the Canadian Coast Guard), the province, a municipality or industry in planning for and responding to pollution emergencies.

In discharging its responsibilities, the EES undertakes a number of activities related to emergency prevention and response. One of the most important elements of the EES's response capability is the maintenance of a 24-hour emergency reporting system to receive and communicate reports on spills and other environmental emergency situations.

The EES maintains an up-to-date listing of regional environmental emergency services, both government and private, and can access any of them to report an incident, to request assistance or advice, or to coordinate response activities.

There are some incidents where a spill has the potential to affect shorelines, and, in these circumstances, the EES will assist in establishing priorities for shoreline protection and cleanup. In order to establish such priorities, the EES has developed a Shoreline Cleanup and Assessment Technique (SCAT) that allows the use of standardized terminology. SCAT teams undertake comprehensive surveys of shoreline conditions. They collect information related to the types and characteristics of product stranded on the shoreline, the geomorphologic features of the shoreline, and the environmental resources at risk, either from existing information sources or from field evaluations conducted at the time of a spill.

#### *6.3.9.2 Legislative and Policy Elements*

Historically, the management of environmental emergencies in Canada had mainly been reactive, relying on local and then regional personnel to handle emergency incidents, including the environmental aspects of such incidents. As experience with environmental emergencies grew both nationally and internationally, it became clear that it was both ineffective and costly to deal with emergencies after they occur. The federal government realized the need to develop a more practical framework and one in which more elements than simply response was included.

The necessary factors for an effectively managed environmental emergency program include: prevention, preparedness, response and recovery. Prevention provides the ability to anticipate, prevent or reduce the probability of the accidental release of a substance; preparedness to establish the ability to respond to such events, response to undertake timely actions to stop the release and mitigate its effects, and recovery to restore the environment, which includes mitigation measures and compensation for environmental damages. This philosophy, with particular emphasis on pollution prevention, is the key to Environment Canada’s current policy for dealing with environmental emergencies.

Environment Canada draws its major legislative mandate for addressing environmental emergencies from two federal Acts, the *Canada Fisheries Act* and the *Canadian Environmental Protection Act*. The *Canada Fisheries Act* prohibits the deposit of deleterious substances into waters frequented by fish or in any place where such a substance could enter waters frequented by fish. It also applies to some aspects of emergency prevention and response. The *Canadian Environmental Protection Act* (CEPA) controls the management of toxic substances, including their storage, handling, transport and disposal.

The EES also participates in international marine spill exercises with the United States, and is a signatory to the Joint Marine Pollution Contingency Plan with the United States Environmental Protection Agency.

The EES maintains an inventory of materials, equipment and resources in the region to ensure it is always prepared to effectively respond to an environmental emergency. For example, it can provide quick and ready access to a number of computerized data bases containing information that may be crucial in developing adequate responses to emergency situations.

#### *6.3.9.3 Sensitivity Mapping*

One of the more important functions Environment Canada has undertaken in conjunction with the oil industry is the development of a computer-based national sensitivity mapping system to meet the needs of the individuals and organizations who respond to oil and chemical spill emergencies in this country.

Environmental sensitivity maps are useful tools employed by agencies and organizations responding to petroleum spills. They consolidate data from many sources and allow an accurate identification of resources at risk during and immediately after a spill. They provide first responders with the information they need to determine protection priorities and to select appropriate cleanup and spill treatment options.

The mapping project covers the coastlines of the country and incorporates data from existing sources, including geomorphological information from previous coastal studies, aerial photographs and aerial videos. Data on biological and human use and resources available for logistical support in a cleanup effort have been incorporated into the system, as have shoreline protection, treatment and cleanup strategies.

All the information is available in a user-friendly, readily accessible format. The computerized maps will assist experts during the critical period of first response, and provide invaluable data on which to base environmental protection and cleanup decisions. Digitized maps are available for the entire Bay of Fundy coastline.

### 6.3.10 The Regional Environmental Emergency Team

In an environmental emergency situation like an LNG loss from a tanker in Passamaquoddy Bay in the Bay of Fundy, comprehensive environmental information must be made available in a timely fashion. In Atlantic Canada, the Regional Environmental Emergency Teams (REET) would be a key player in providing this required information.

The REET includes members from federal and provincial government agencies, and industry associations, all of whom have specific expertise and/or responsibilities in planning for and responding to environmental emergencies. The core team meets at least once every year and members share technical, scientific and legislative information on prevention and response technologies and contingency planning. They also revisit roles and responsibilities of team members and update and/or revise them as necessary.

The REET maintains a significant amount of expertise and knowledge on environmentally sensitive resources, which can be used in emergency situations to assist with decisions on protection and cleanup. The REET also provides training on spill response and contingency planning, and conducts tests and trials of response equipment and techniques to ensure everything works as it should.

In an emergency situation, the REET is mobilized and acts mainly to provide advice to the Incident Commander (IC), the person in charge of the emergency response activities. In the case of an LNG loss at sea, the Department of Fisheries and Oceans, Canadian Coast Guard would provide the IC in the form of the Coast Guard's On-scene Commander (OSC). The types of events in which the REET is most likely to be involved are larger spills of oil and other hazardous materials which local authorities and organizations are unable to manage with their own resources; chemical fires and explosions, or spills that could cross international borders.

When a REET is activated to respond to an environmental emergency offshore, it draws on the expertise and experience of its members to provide advice on such matters as the direction in which an offshore spill might move; the methods to track it; the techniques that might be effective in removing the spill, and whether or not chemicals, mainly dispersants, should or could be used. The REET also assists in the decisions relating to shoreline protection and cleanup priorities; the probable impacts of a spill on wildlife and sensitive shoreline areas, and the appropriate ways to deal with the wastes generated during a spill cleanup. The REET also provides information on weather patterns, wind and wave conditions and predicted storm events to assist in the planning and implementation of response activities.

#### *6.3.10.1 The REET Contingency Plan*

The REET has developed and routinely updates a Contingency Plan to ensure it is ready to respond in a timely fashion in an emergency situation. The Atlantic Region REET Contingency Plan would form the basis for the Environment Canada response procedures in the case of an LNG loss in Passamaquoddy Bay.

The Plan indicates how a response effort will be initiated and carried out during an emergency situation. It identifies those organizations currently participating in REET, the resources available within each organization, points of contact in each organization and the alerting mechanism.

#### *6.3.10.2 Major REET Roles and Activities*

The following is a partial listing of the major activities that the REET undertakes in an emergency situation. It basically functions as an environmental, scientific and technical advisor to the Incident Commander. In a response mode the REET is responsible for:

- reporting and alerting appropriate members of the team;
- exchanging information and deploying observers to monitor cleanup activities;
- assisting in securing air, water and soil monitoring equipment;
- providing gas plume dispersion information, spill trajectories, weather/ice forecasts and current/oceanographic factors;
- advising on environmental monitoring needs;
- identifying resources at risk;
- providing shoreline cleanup assessment teams;
- photographing and video taping containment and cleanup operations;
- recommending appropriate containment and cleanup techniques, equipment and priorities based on shoreline assessments;
- identifying temporary and permanent sites for disposal of cleanup debris;

- responding to specific requests for technical support from the Incident Commander;
- advising on dispersant use; and
- co-ordinating input from all agencies.

During an emergency the Atlantic REET functions as an advisory body to the Incident Commander and the Regional Environmental Emergency Co-ordinator from Environment Canada usually acts as the Chairman and lead spokesperson for the REET.

### 6.3.11 Regional Response Organizations

The Canadian Public Review Panel on Tanker Safety and Marine Spills Response Capability (the Brander-Smith report); a Government of Canada internal review, and several independent studies highlighted significant gaps and inefficiencies in Canada's capability to respond to a major marine disaster. One of the most important recommendations of the Public Review Panel was the establishment of a response capability of 10,000 tonnes in each region of the country funded and managed by the private sector. The Canadian Petroleum Products Institute (CPPI) represents most of Canada's oil refining, transportation and marketing industries and endorsed the Public Review Panel's recommendations, as did the Government of Canada.

The Government of Canada responded by amending the *Canada Shipping Act* (CSA) to improve the domestic spill response arrangements and also to allow the country to ratify the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC).

The federal government then set out to develop the required policy framework and the necessary legislation to ensure that an adequate emergency response capability was established in all areas of the country. The approach was based on the "polluter pays" principle and fundamental to its success was the requirement that all potential polluters participate and contribute equitably to spill response capabilities.

Following extensive public consultations, the federal government amended the *Canada Shipping Act* (Bill C-121) and developed four regulations and two standards to facilitate the implementation of a national spill response capability. The main components of the spill response regime in Canada secured by the legislative amendments are:

1. adequate response equipment and trained personnel available to respond to any spill in Canada within specified time frames;
2. mandatory Oil Pollution Emergency Plans (OPEPs) for all vessels operating in Canadian waters and all oil handling facilities;
3. spill response capabilities funded and operated by the private sector, and
4. regional and national contingency plans developed by government to oversee private sector response capability and response efforts and to take over operational control only if required.

#### *6.3.11.1 The Regulations*

The Oil Pollution Prevention Regulations (OPPR) and the Pollutant Discharge Reporting Regulations (PDRR) require ships to have on board a declaration that names the ship's insurer and identifies the person(s) responsible for implementing the shipboard oil pollution emergency plan. These individuals need to be accessible to the Canadian Coast Guard on a 24 hour basis while the ship is in Canadian waters to enable the Coast Guard to call upon this person in the event of an oil spill incident in order to expedite the response. The regulations also require oil handling facilities and ships to report spills.

Regulations for Response Organizations and Oil Handling Facilities and the Publication of Standards Regulations stipulate the requirements for the Response Organizations (ROs) and oil handling facilities. Basically, the ROs must provide the operational management and the equipment resources to respond to a marine oil spill of up to 10,000 tonnes anywhere in Canadian waters except the Arctic, which remains the responsibility of the Canadian Coast Guard. They also stipulate that all designated oil handling facilities (those loading or unloading oil to or from a ship) must have oil pollution emergency plans in place. These facilities must enter into an arrangement with an RO to provide emergency spill response capability when necessary and pay a fee for this contingency service. Vessels also have to negotiate similar arrangements with an RO.

#### *6.3.11.2 The Standards*

The standards developed to complement the regulations were a Standard for Response Organization Response Plans and a Standard for Oil Handling Facility Oil Pollution

Emergency Plans. The standards provide the basis on which contingency plans for ROs and Oil Handling facilities are to be assessed.

The standards also specify the geographic areas within the country where marine activity dictates a higher response priority (Primary Areas of Response) and designates ports within these areas where response capability must be established. Several Enhanced Response Areas are also specified which do not have a designated port but which still warrant a higher response priority. The standards include a requirement for logistical arrangements to be in place to deliver response equipment in a tiered manner (depending on the severity of the spill) with specified time frames.

#### *6.3.11.3 The Industry Regime*

The oil industry response to the Brander Smith report and the resulting legislative initiatives was the development of the Marine Environment Protection Plan and a national marine oil spill response organization. Five independent regional response corporations were established as well as a National Response Association to co-ordinate inter-regional support, to ensure consistency of standards and equipment, and to provide a national response focus. The response organizations are privately funded and managed and are open to any party wishing to become a full member. They are also available to government agencies and other third parties on an “if available’ basis for a charge out fee.

Five ROs were established to provide spill response capability for all Canadian waters south of 60°N latitude. The three ROs listed below could be expected to be notified and/or involved in the response to an LNG accident in Passamaquoddy Bay:

1. the Eastern Canada Response Corporation (ECRC) – The ECRC, operating out of Dartmouth, Nova Scotia, and St. John’s, Newfoundland, serves the Atlantic provinces south of the 60th parallel of latitude, except for those areas serviced by Alert and Point Tupper Marine Services Company.
2. Atlantic Emergency Response Team (“Alert”) Inc. – operating out of Saint John, New Brunswick, provides response coverage in the primary area associated with the designated Port of Saint John, New Brunswick.
3. Point Tupper Marine Services Co – The Point Tupper RO, operating out of Port Hawksbury, Nova Scotia, provides all marine-related ancillary service to the Statia Terminal and marine vessels utilizing the facility.

A Canadian Marine Response Corporation (CMRMC) was established in Ottawa to provide management and coordination on a national level. The ECRC would be the primary RO involved in a LNG loss in Passamaquoddy Bay.

#### 6.3.11.4 Response Plans

Every RO, by law, must have a response plan prepared and approved by the government before it is certified to operate and provide marine oil spill response services. The plan must include the following elements;

- the rated capacity – the size of spill which the RO is capable of responding to;
- the geographic area where the RO is capable of responding within the required response times (10,000 tonne);
- notification procedures and a list of contacts;
- response activities, strategies and tactics (how the RO would respond to various spill scenarios);
- response times in Primary Areas of Response;
- response management capabilities;
- special environmental needs and responses in the geographic area where the RO will operate;
- communications and co-ordination plans;
- equipment listings and locations;
- training and exercises; and
- plan review and update procedures.

#### 6.3.11.5 Equipment and Resources

Each RO maintains an inventory of specialized spill response equipment. Table 6-5 summarizes the equipment stored at approximately 14 different locations across Canada.

**TABLE 6-5 Inventory of Equipment Stored at ROs in Canada**

| EQUIPMENT | QUANTITY | COST ($K) |
|---|---|---|
| Skimming units: | | |
| For sheltered waters | 12 | 18,000 |
| For unsheltered waters | 12 | 9,300 |
| Booms: | | |
| Protection | 55,000 m | 5,500 |
| Containment | 24,000 m | 2,400 |
| shoreline cleanup | 5,000 m | 500 |
| Deployment Boats | 33 | 4,950 |
| Recovered Product Storage: | | |
| Barges | 18 (average1000 t) | 9,300 |
| storage units | 700t | 700 |
| Shoreline Treatment Equipment. | Miscellaneous | 2,000 |

The ROs are not equipped to respond to a shipboard fire. If there was a fire or the possibility of a fire, fire fighting vessels would have to be leased from a private company (Atlantic Towing) in Saint John and/or Halifax. The ship owner or Incident Commander would have to make this decision, depending on the severity of the incident.

#### *6.3.11.6 Ship Owner*

If there was a grounding of the LNG vessel (again without loss of LNG product) the ship owner would act as the responsible party to determine the most appropriate action to bring the vessel to safety (e.g. using tug boats). If there was a loss of bilge water or fuel oil the ship owner would likely act as the responsible party and contact the Coast Guard. In this case, depending on the severity of the loss, the REET and ROs might be deployed.

### 6.3.12 Summary

The marine transport and distribution of LNG in the Passamaquoddy Bay region of the Bay of Fundy presents the potential for emergencies whose impacts on the environment could range from minor to significant. In order to minimize such risks the government of Canada and appropriate industry groups have developed contingency plans designed to ensure an effective response to these situations. This portion of the study has reviewed both the general preparedness of Canada to respond to an LNG or tanker fuel loss, as well as the specifics of the environmental emergency response systems in place in Canada.

Response to an LNG loss in Passamaquoddy Bay would be led by the Canadian Coast Guard, following the Joint US-Canada Marine Pollution Contingency Plan. The Regional Environmental Emergency Teams (REET) would be deployed to offer its expertise with respect to the LNG or fuel loss and the appropriate Regional Response Organization(s) could also be enlisted to respond to the accident.

The following documents were reviewed in the preparation of this section, Emergency Preparedness and Response, of the report:

- Directions in Marine Chemical Emergency Response - An Industry Perspective, David M. Finlayson, MIACC Proceedings 1995;
- Canada's Oil Spill Response Regime: Implementation, Suzanne Shireff, MIACC Proceedings 1995;
- REET Regional Environmental Emergency Team - Contingency Plan - Atlantic Region, 1996;
- The Role of Environment Canada in Emergency Response, Environment Canada, ISBN 0-660-16613-5, Catalogue Number En 40-229/2-1996E, September 1996;
- The Role of Industry in Emergency Response, Environment Canada, ISBN 0-660-17717-8, Catalogue Number En40-229/6-1996E, September 1996;
- Provisional Plan for a Marine Oil Spill Response Organization, MEPP Task Force, May 1993;
- Emergency Response Assistance Planning, Transport Canada, TP 9285, Transport Canada, Ottawa;

- Improving Canada's Marine Spill Response Capability, Canadian Coast Guard, September 1992;
- Response Organizations and Oil Handling Facilities Regulations, SOR/95-405, January 1996;
- Response Organization Standards, Canadian Coast Guard, TP 12401, 1995;
- A Canadian Marine Chemical Emergency Response Capability, Jacques Savard, MIACC Proceedings 1995;
- Directions in Chemical Marine Emergency Response - An Industry Perspective, David M. Finlayson, MIACC Proceedings 1995;
- A Summary of Federal Emergency Preparedness in Canada. Emergency Preparedness Canada. October 1995;
- Canadian Oil Spill Response Capability - An Investigation of the Proposed Fee Regime, Oil Spill Response Organization Fee Structure Investigation Panel (Edgar Gold, Chair), Department of Fisheries and Oceans, August, 1996; and
- The National Oil and Hazardous Substances Pollution Contingency Plan (NCP), US Coast Guard, 40 CFR citation: 300.920 OMB control No. :2050-0401, 1996.

# 7.0 POTENTIAL RISKS AND POLICY CONSIDERATIONS

This section consists of an assessment of potential risks to environmental receptors resulting from the proposed project, and identification of information gaps that require further investigation. The study area identified for the risk assessment generally considered the marine environment of the Passamaquoddy Bay and 300 m inland, as well as the general area between Passamaquoddy Bay and Grand Manan. Consideration was also given to operational activities at the proposed terminal locations recognizing that activities may impact on the receiving waters and shoreline areas on the Canadian side of the border and the presence of the structures may impact on fish habitat and movements.

The interactions (effects) resulting from the Project on the existing environment were assessed and monitoring is recommended to evaluate compliance with existing regulations and the effects of the activities on the environment if/as appropriate. Contingency plans are identified for implementation if negative adverse impacts are identified for a given phase of the Project. Policies may be established based on the monitoring and contingency plans recommended.

This section assesses the risks associated with project activities on the environment for VECs, as well as the effect of the environment on the Project.

## 7.1 APPROACH

Section 2.2 outlines the approach to the risk assessment with threats to the existing environment arising from scenarios that first involve a collision, grounding, explosion or other event that could result in uncontrolled release of bulk cargo into the sea. The assessment considers the following:

- What can go wrong?
- How likely is something to go wrong?
- What are the consequences of something going wrong?

Potential hazards or things that “can go wrong”, associated with a large release of LNG is presented in Section 2.2.1. With respect to “how likely is something to go wrong’ the probability of occurrence is considered small, especially with Canadian and US regulations in-place and enforced as discussed in Section 2.2.2. As indicated in Section 2.2.3 with respect to “what are the consequences of something going wrong”, the actual risks arising from a large uncontrolled release of LNG depend not only on the particular characteristics of the release but also on the local environment where the release occurs. For example the consequences will likely be quite different if a major release were to occur near population centres, in the area of a sensitive ecosystem, rather than an open area remote from people or sensitive environments. For this undertaking, a representative example would be an incident that occurs between Campobello Island and Deer Island. The population and environmental receptors would be more extensive for this area, than an area located between Campobello Island and Grand Manan and therefore, the risks to environmental receptors is greater and the consequences would be more significant.

The assessment considers the things that can go wrong as presented in Section 2.2.1 for several scenarios.

**SCENARIO 1: Conventional marine hazards.** Release of Oil Fuels and Bilge content, etc., for example. This assessment focuses on the risk posed by oil fuels or petroleum hydrocarbons to the receiving environment. An assessment of risks associated with a loss of bilge water was outside the scope of the assessment.

**SCENARIO 2: Release of LNG from the LNG vessel.** This has two aspects a) formation of pool of uncontrolled release of LNG with ignition and b) uncontrolled release of LNG resulting in a large vapour cloud both attributable to a release either above water or below water. Consequences are related to the hazard zones (see Section 2.2.4) identified for a release of LNG and hazardous materials into the receiving environment and associated risks to receptors.

**SCENARIO 3: Release of LNG from the docking and on land facilities.** The impact zone from these releases would be less than or equal to that from a vessel docked at the terminal which was considered in Scenario 2.

The risks to the aquatic, wetland and terrestrial environments/receptors are identified based on the environmental descriptions provided in Sections 4.0 and 5.0. The socio-economic environment/receptor(s) is described in Section 6.0.

## 7.2 POTENTIAL EFFECTS ON AIR QUALITY

The potential effects on air quality and the related project interactions associated with vessel traffic activities including berthing operations at terminal locations are summarized in Table 7-1.

### TABLE 7-1 Potential Impacts on Air Quality During Operations

| VALUED ENVIRONMENTAL COMPONENTS | PROJECT INTERACTION | POTENTIAL IMPACTS |
|---|---|---|
| Air Quality | ➢ Tug boat emissions<br>➢ Tanker emissions (nil)<br>➢ Equipment operation (nil)<br>➢ Accidental release of contaminants | ➢ Reduction in air quality to unacceptable levels<br>➢ Greenhouse gases |

Table 7-2 presents the types of emissions and the components of those emissions that could result from the project activities.

### TABLE 7-2 Operational Emissions Sources and Descriptions

| ACTIVITY | TYPE OF EMISSION | COMPONENTS |
|---|---|---|
| Marine Vessels (tug boats and tankers) | ➢ Diesel engine exhaust<br>➢ Lubricants<br>➢ Hydrocarbon vapours<br>➢ Fumes/Odour | ➢ Suspended particulates<br>➢ Sulphur dioxide<br>➢ Nitrogen oxides<br>➢ Carbon monoxide<br>➢ Fuel vapours<br>➢ PAHs<br>➢ Carbon dioxide<br>➢ Liquid hydrocarbons<br>➢ Hydrogen<br>➢ Aldehydes<br>➢ Water<br>➢ Nitrogen |
| Accidental Release of Contaminants | ➢ Solvents<br>➢ Hydrocarbon vapours<br>➢ Odour<br>➢ Fuel spills | ➢ Hydrocarbon solvents<br>➢ Fuel vapours |

### 7.2.1 Marine Vessel Traffic

Detailed calculations for emissions associated with tug boat operations was beyond the scope of this assessment, as indicated in Section 5.1. Emissions are dependent on a number of factors including engine size, speed, loading mode (full load or partial load), hours of operation, and idle time. However, an estimate has been made based on estimates for tug boats associated with a proposed LNG terminal to be located in Saint John, NB. It is expected that the tugs associated with the Passamaquoddy operations will be similar in size. Based on 50 tanker trips per year and an operating time of 30 hours for a round trip for each tanker, the resulting emissions are summarized in Table 5-2.

The National Ambient Air Quality Objectives and the New Brunswick Maximum Permissible Ground Level concentrations for specified contaminants of interest are presented in Table 7-3 for reference and comparison with measured data. The provincial requirements for the Saint John Airshed, the closest area with monitoring data, have been identified for assessment purposes. It should be noted that the guidelines are more stringent than those for other areas of the province with respect to $SO_2$. However, the more stringent provincial guidelines are similar to the most stringent National Ambient Air Quality Objectives for the maximum desirable concentrations.

The maximum permissible concentrations, above which immediate action should be taken to protect air quality, are also provided in Table 7-3 for comparison. The Canada Wide Standard for $PM_{25}$ (i.e., Particular Matter < 25 $\mu$m) of 30 $\mu g/m^3$ is based on a 24-hour averaging period, to be achieved on the $98^{th}$ percentile measurement annually, averaged over three consecutive years. This latter standard does not come into effect until the year 2010.

## TABLE 7-3 Canadian and New Brunswick Ambient Air Quality Objective

| Contaminant | Averaging Period | New Brunswick – Maximum Permissible Ground Level Concentration in Saint John County[1 2] (μg/m³) | National Ambient Air Quality Objectives – Maximum Desirable / Acceptable Levels (μg/m³) | Other Ambient Air Quality Standards or Objectives (μg/m³) |
|---|---|---|---|---|
| **Sulphur dioxide ($SO_2$)** | 1-hour | 450 | 450 / 900 | --- |
| | 24-hour | 150 | 150 / 300 | --- |
| | Annual | 30 | 30 / 50 | --- |
| **Nitrogen Oxides ($NO_1$) as $NO_2$** | 1-hour | 400 | -- / 400 | --- |
| | 24-hour | 200 | -- / -- | --- |
| | Annual | 100 | 50 / 100 | --- |
| **Carbon Monoxide** | 1-hour | 35 000 | 15 000 / 35 000 | --- |
| | 8-hour | 15 000 | 5 000 / | |
| **Total Suspended Particular Matter (PM)** | 24-hour | 120 | -- / 120 | --- |
| | Annual | 70 | 50 / 70 | |
| **Respirable Particulate Matter ($PM_{25}$)** | 24-hour | --- | -- / -- | 30 [4] |
| **Ground Level Ozone ($O_3$)** | 1-hour | --- | 100 (51 ppb)/ 151 (82 ppb) | |
| | 8-hour | --- | -- / -- | --- |
| | 24-hour | --- | 30 (15 ppb) / 50 (25 ppb) | 130 (55 ppb) [4] |
| | Annual | --- | -- / 30 (15 ppb) | |

Source: 1) GNB (1997), Schedule H
2) GNB (1997) Schedule C
3) Government of Canada (1999), National Ambient Air Quality Objectives
4) CCME (2003). Canada Wide Standards for Respirable Particulate Matter and Ozone, effective by 2010.

The Province has adopted the federal National Ambient Air Quality Objective for a 1-hour period of 82 ppb (151 μg/m³) for ground level ozone and is also maintaining statistics to verify compliance with the new Canada Wide Standard for ozone (55 μg/m³ / 130 μg/m³, based on an 8-hour averaging period) to be achieved by 2010. Ground

Level ozone is formed by the reaction of other air contaminants such as nitrogen oxides $NO_x$ and volatile organic compounds (VOCs), in the presence of strong sunlight on hot days. The major contributions to ground level ozone in Atlantic Canada are associated with the long range transport of vehicle exhaust and industrial emissions resulting from heavily populated areas of the Northeastern USA and Central Canada.

There are no federal or provincial standards for total or specific VOCs such as benzene, butadiene, or methane.

A detailed analysis to determine estimates of emissions of particulate matter $SO_2$, $NO_x$, CO and ozone in consideration of general air quality was not within the scope of this assessment and is considered to be an information gap. It is recommended that a more detailed analysis be carried out in consideration of the above noted guidelines. It should also be noted that risks to other environmental receptors was not within the scope of the assessment, and that an assessment of human health issues would provide an indication of potential risks.

**Policy Considerations**

It is also recommended that a policy be considered that requires monitoring to be carried out at the outset of the project and if vessel transit requirements are increased, to confirm that air quality standards are being met.

#### *7.2.1.1 Accidental Release of Contaminants*

Contaminants may be released to the surrounding airshed as a result of accidental spillage of solvents, fuels, and epoxies being stored on-site. The primary air quality concern resulting from the accidental release of contaminants is impact of solvent vapour, hydrocarbon vapour, and fuel vapour on air quality. Risks would be primarily associated with any material that reached the shoreline. Should an accidental release occur, spillage is expected to be limited and wave action and mixing is expected to disperse the material and effects should dissipate quickly. Standard operating procedures for marine vessel operations and emergency response plans should also provide for environmental protection. Therefore, air quality concerns associated with accidental releases are considered to represent a low potential risk to human health and other VECs for the study area.

### Policy Considerations

Operating procedures including emergency response plans should be reviewed by Environment Canada, the Canadian Coast Guard, Transport Canada, the Emergency Measures Organization and local emergency responders, in consideration of planning and responding to accidental releases and clean-up measures. CCME guidelines for contaminants of concern should be identified as a requirement for remedial measures, and protocols for a remedial monitoring plan should be established.

## 7.3 Scenario 1-Potential Risks to Environment From an Accidental Release Of Contaminants and Other Issues

Hazardous chemicals associated with operations primarily include petroleum, oil, and lubricant (POL), solvents, and possibly epoxy resins. Discharge may occur into receiving waters and contaminants may be transported to shore line areas. The potential risks to the environment resulting from an accidental release will depend on the quantity released, characteristics of the contaminants, weather conditions, tidal exchange and currents, local hydrogeologic characteristics, and groundwater use of the area. Accidental releases of hazardous materials may potentially cause some parameters in the surface water and groundwater to exceed federal and provincial guidelines.

Risks would be primarily associated with any material that reached the shoreline. Should an accidental release occur near the shoreline, spillage is expected to be limited and wave action and mixing should cause dispersion the material and effects would be expected to dissipate over several weeks, with clean up efforts implemented. Standard operating procedures for marine vessel operations and emergency response plans should reduce risks to the environment.

### 7.3.1 Potential Risks to Groundwater Resources

The potential risks to groundwater resources resulting from operation activities are summarized in Table 7-4. There are no groundwater protection areas for municipal water supplies located within or near the proposed works. However, private wells are located within 300 m of shoreline areas, most being domestic wells that are likely to be shallow due to salt water intrusion issues.

### TABLE 7-4 Potential Risks to Groundwater Resources for Operations

| VALUED ENVIRONMENTAL COMPONENTS | PROJECT INTERACTION | POTENTIAL RISK |
|---|---|---|
| Groundwater Resources | ➢ Accidental Release of Contaminants | ➢ Low risk to groundwater quality for spill along transit route. Medium to low risk to groundwater quality for near or onshore incidents |

### 7.3.2 Groundwater Risks Related to Accidental release of Contaminants

Risks would be primarily associated with any contaminants that reached the shoreline and remained at high concentrations for an extended period time. Recognizing that groundwater discharge occurs near shoreline areas and with proper implementation of appropriate emergency response plans, accidental releases are considered to represent a low potential risk to groundwater quality.

**Policy Considerations**

Prevention (use of pilots, tugs, improved navigation systems, etc), in addition to proper planning to minimize the risk and possible impacts of discharges and spills should be considered. Operating procedures including emergency response plans should be reviewed by Environment Canada, the Canadian Coast Guard, Transport Canada, the Emergency Measures Organization and local emergency responders, in consideration of planning and responding to accidental releases and clean-up measures. CCME guidelines for contaminants of concern should be identified as a requirement for remedial measures, and protocols for a remedial monitoring plan should be established.

### 7.3.3 Potential Risks to Terrestrial Resources

The potential risks to terrestrial resources located near shoreline areas are summarized in Table 7-5.

Potential risks to wildlife resources during operations include:

- alteration/displacement of habitat;

- noise/physical disturbance of wildlife; and
- potential mortality resulting from accidental release of contaminants or from equipment/human contact.

Potential risks to wildlife resources are assessed for each of the above concerns.

### *7.3.3.1 Risk of Habitat Alteration/Destruction*

Habitat within the study area that may be affected can be characterized as a mixture of open wetland areas (discussed in a separate section) and forested shoreline areas. The potential risks to wildlife habitat consider critical habitat and species of special status.

**TABLE 7-5 Potential Risks to Terrestrial Resources**

| VALUED ENVIRONMENTAL COMPONENTS | PROJECT INTERACTION | POTENTIAL RISKS |
|---|---|---|
| ➢ Species of special status – endangered, threatened or rare<br>- Birds<br>- Herpetiles<br>- Odonates<br>- Plants<br>➢ Sensitive/Critical wildlife habitat<br>Environmentally Significant/Sensitive Areas | ➢ Accidental Release of Contaminants<br><br>➢ Vessel traffic (see noise)<br>➢ Noise and light | ➢ Mortality<br>➢ Alteration/displacement of habitat (may be sensitive/critical to a specific species impacted)<br><br>➢ Disruption of Sensitive Migratory Periods and Normal Movements<br>➢ Noise/physical disturbance of wildlife<br>➢ Mortality<br>➢ Behavioural Changes |

### 7.3.4 Accidental Release of Contaminants

Accidental releases of hazardous materials may potentially cause direct mortality and loss or degradation of habitat, and contamination of surface waters used by various VECs.

**Mammal Species of Special Status**

For vertebrate fauna, three species of bats (Big Brown, Eastern Red and Hoary) were identified from the ACCDC database for the study area (see Figure A1 in Appendix A), in an area opposite to the proposed terminal locations in Saint Andrews (brown bat and hoary bat) and also in St. Stephen. They are classified as S 2, rare throughout its range in the province (6 to 20 occurrences or few remaining individuals) and may be vulnerable to extirpation due to its rarity or other factors. Given the location of these receptors and that there should be limited contact with a spill (primarily an airborne species), in addition to mixing and effective implementation of remedial action plans, the risk of impacts is considered low.

**Avian Species of Special Status**

As indicated previously, there is information indicating that a number of avian species of special status are known to occur in the area (see Figure A1 for the location of vertebrate fauna and Figure A2, in Appendix A). Species were identified under all 5 ACCDC rankings as well as COSEWIC and SARA. There are also raptor species of concern identified within the study area.

The *Migratory Birds Convention Act* states that no person may disturb, destroy, or take/have in their possession a migratory bird (alive or dead), or its nest or eggs, except under authority of a permit. Migratory birds are known to utilize various areas/habitats in and around the study area. Due to the relative proximity of anthropogenic sources within the study areas, the species of migratory birds most likely to use the habitats within the study area(s) would be those species that have some degree of tolerance of human activities. However, portions of the study area(s) with the least exposure to anthropogenic sources would be most likely to provide habitat, if available, for the more sensitive species. The risk of mortality is considered to be high for water birds and shorebirds that come into direct contact with a spill, but the number of mortalities is expected to be low given that only small quantities are expected to be spilled and concentrations dissipated relatively quickly with wind and wave action as well as effective implementation of remedial action plans.

**Herpatile Species of Special Status**

A Wood Turtle (*Clemmys insculpta*) siting is reported by ACCDC approximately 200 m upstream of the proposed Red Beach site. It is likely that the Wood Turtle occurs in other areas of the St. Croix River and other tributaries in the study area with similar habitat conditions. ACCDC has rated the Wood Turtle as uncommon (S3) throughout its range within the Province, and COSEWIC (Nov. 2003) has identified the Wood Turtle as a species of special concern. The risk of mortality is considered to be high for wood turtles that come into direct contact with a spill, but the number of mortalities is expected to be low given that only small quantities are expected to be spilled and concentrations are expected to dissipate relatively quickly with wind and wave action as well as effective implementation of remedial action plans.

**Odonate Species of Special Status**

A variety of Odonate species of special status have been identified for the Study area through ACCDC in association with rivers, wetlands, estuaries and streams, with the following rankings;

- S 1 - Extremely Rare throughout its range in the province (typically 5 or fewer occurrences or very few remaining individuals). May be especially vulnerable to extirpation.
- S 2 - Rare throughout its range in the province (6 to 20 occurrences or few remaining individuals). May be vulnerable to extirpation due to its rarity or other factors.
- S 3 - Uncommon throughout its range in the province, or found only in a restricted range, even if abundant in some locations. (21 to 100 occurrences).

The risk of mortality is considered to be high for odonata that come into direct contact with a spill, but the number of mortalities is expected to be low there should be limited contact with a spill (primarily an airborne species) and only small quantities are expected to be spilled and concentrations are expected to dissipate relatively quickly with wind and wave action as well as effective implementation of remedial action plans.

## Butterflies of Special Status

There are numerous species of butterflies of special status identified in the study area through ACCDC in association with rivers, wetlands, estuaries and streams. Figure A1, Appendix A, shows the point reference locations for vertebrate fauna, and Figure A2, Appendix A, shows the estimated boundary/footprint for the invertebrate species. Note that specific species cannot be identified because all invertebrate fauna have the same symbol. Rankings include the following for:

- S 1 - Extremely Rare throughout its range in the province (typically 5 or fewer occurrences or very few remaining individuals). May be especially vulnerable to extirpation;
- S 2 - Rare throughout its range in the province (6 to 20 occurrences or few remaining individuals). May be vulnerable to extirpation due to its rarity or other factors; and
- S 3 - Uncommon throughout its range in the province, or found only in a restricted range, even if abundant in some locations. (21 to 100 occurrences).

The risk of mortality is considered to be high for butterflies that come into direct contact with a spill, but the number of mortalities is expected to be low given that there should be limited contact with a spill (primarily an airborne species) and only small quantities are expected to be spilled and concentrations are expected to dissipate relatively quickly with wind and wave action as well as effective implementation of remedial action plans.

## Flora Species of Special Status

As indicated in Section 5.4.1 a variety of plant species of special status have been reported in the study area in association with shoreline areas and wetland areas (Figures A1 and A2 in Appendix A), including ESAs. However, additional investigations (based on seasonal timing and species specific requirements) are recommended to assess the presence of plant species of special status along shoreline areas, and locations marked. The risk of mortality is considered to be high for plants that come into direct contact with a spill, but loss of the resource is expected to be low given that only small quantities are expected to be spilled and concentrations are expected to dissipate relatively quickly with wind and wave action as well as effective implementation of remedial action plans.

**Environmentally Sensitive or Significant Areas (ESAs) and Other Critical Habitat Features**

A number of ESAs occur in the study area (see Figure A4 in Appendix A), with the most notable being the St. Croix Estuary due primarily to the presence of very important bird species and associated habitat. The risk of mortality or loss of these resources is considered to be high for VECs that come into direct contact with a spill, but the number of mortalities or loss of resources is expected to be low given that there should be limited contact with a spill (primarily an airborne species) and only small quantities are expected to be spilled and concentrations are expected to dissipate relatively quickly with wind and wave action as well as effective implementation of remedial action plans.

**Policy Considerations**

Prevention (use of pilots, tugs, improved navigation systems, etc), in addition to proper planning to minimize the risk and possible impacts of discharges and spills should be considered. Operating procedures including emergency response plans should be reviewed by Environment Canada, the Canadian Coast Guard, Transport Canada, the Emergency Measures Organization and local emergency responders, in consideration of planning and responding to accidental releases and clean-up measures. CCME guidelines for contaminants of concern should be identified as a requirement for remedial measures, and protocols for a remedial monitoring plan should be established.

### 7.3.5 Noise and Light

**Mammal Species of Special Status**

As indicated previously, several species of bats (Big Brown, Eastern Red and Hoary) were identified from the ACCDC database for the study area (see Figure A10 in Appendix A), in an area opposite to the proposed terminal locations and along the proposed LNG shipping lane. Given that vessel movements will be along the centreline of the channel and off shore, the risk of impacts is considered low in consideration of noise and light.

**Avian Species of Special Status**

As indicated previously, there is information indicating that a number of avian species of special status are known to occur in the area (see Figure A1 for locations of vertebrate fauna in Appendix A). Species were identified under all 5 ACCDC rankings as well as COSEWIC and SARA. There are also raptor species of concern identified within the study area. There has been speculation that noise associated with construction activities may disrupt the breeding activities and territorial defence of some songbirds under some circumstances. However, little information is available to substantiate this (United States Department of Transportation, 1982).

The *Migratory Birds Convention Act* states that no person may disturb, destroy, or take/have in their possession a migratory bird (alive or dead), or its nest or eggs, except under authority of a permit. Migratory birds are known to utilize various areas/habitats in and around the study area. Due to the relative proximity of anthropogenic sources within the study areas, the species of migratory birds most likely to use the habitats within the study area(s) would be those species that have some degree of tolerance of human activities. However, portions of the study area(s) with the least exposure to anthropogenic sources would be most likely to provide habitat, if available, for the more sensitive species. Therefore, the risk of disturbance or interference with activity is considered to be low in consideration of noise and light. It is expected that receptors will acclimatize to the increase in vessel traffic. However, the extent of use by migratory birds in the area is not detailed and this is considered an information gap.

**Herpatile Species of Special Status**

As indicated previously a Wood Turtle (*Clemmys insculpta*) siting is reported by ACCDC approximately 200 m upstream of the proposed Red Beach site. It is likely that the Wood Turtle occurs in other areas of the St. Croix River and other tributaries in the study area with similar habitat conditions. Field investigations would be required to further assess the presence/absence of this species including habitat. This is considered to represent an information gap.

ACCDC has rated the Wood Turtle as uncommon (S3) throughout its range within the Province, and COSEWIC (Nov. 2003) has identified the Wood Turtle as a species of special concern. Given that vessel movements will be along the centreline of the channel and off shore, the risk of impacts is considered low in consideration of noise and light.

**Odonate Species of Special Status**

As indicated previously a variety of Odonate species of special status have been identified for the Study area through ACCDC in association with rivers, wetlands, estuaries and streams.

Given that vessel movements will be along the centreline of the channel and off shore, the risk of impacts is considered low in consideration of noise and light.

**Butterflies of Special Status**

As indicated previously, there are numerous species of butterflies of special status identified in the study area through ACCDC in association with rivers, wetlands, estuaries and streams. Figure A1, Appendix A, shows the point reference locations for vertebrate fauna, and Figure A2, Appendix A, shows the estimated boundary/footprint for the invertebrate species.

Given that vessel movements will be along the centreline of the channel and off shore, the risk of impacts is considered low in consideration of noise and light.

**Environmentally Sensitive or Significant Areas (ESAs) and Other Critical Habitat Features**

As indicated previously, a number of ESAs occur in the study area (see Figure A4 in Appendix A), with the most notable being the St. Croix Estuary due primarily to the presence of very important bird species and associated habitat. As indicated for avian species of special status, given that vessel movements will be along the centreline of the channel and off shore, the risk of impacts is considered low in consideration of noise and light for the other species at risk. It is expected that receptors will acclimatize to the increase in vessel traffic.

**Policy Considerations**

No additional policy considerations have been identified in consideration of light and noise.

### 7.3.6 Potential Effects on Marine and Freshwater Aquatic Resources

The Federal *Fisheries Act* is the primary statute providing for the protection of fish and fish habitat in Canada, and defines fish habitat as:

> "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes" (R.S.C., 1985; *Fisheries Act*).

The location for aquatic species, based on the available information, is shown in Figures A5 and A11. Potential risks to aquatic resources and related project interactions resulting from operations are summarized in Table 7-6.

## TABLE 7-6 Potential Risks to Aquatic Resources During Operations

| VALUED ENVIRONMENTAL COMPONENTS | PROJECT INTERACTION | POTENTIAL IMPACTS |
|---|---|---|
| <u>Fisheries Resources</u><br>➢ Atlantic Salmon<br>➢ Brown trout<br>➢ Brook trout<br>➢ Striped bass<br>➢ Small Mouth Bass<br>➢ Chain pickerel<br>➢ American shad<br>➢ American eel<br>➢ Shortnose sturgeon<br>➢ Green sea urchin<br>➢ American lobster<br>➢ Atlantic herring<br>➢ Clams<br>➢ Sea scallop<br>➢ Groundfish<br>➢ Rockweed<br>➢ Periwinkle | ➢ Accidental release of Contaminants<br>➢ Noise and Lighting<br>➢ Physical Presence of Terminal<br>➢ Vessel Traffic | ➢ Alteration/displacement of aquatic habitat<br>➢ Mortality<br>➢ Interference with fish behaviour<br>➢ Whale Collisions |
| <u>Marine Mammals</u><br>➢ Right whale<br>➢ Minke whale<br>➢ Finback whale<br>➢ Harbour porpoise | | |

The St. Croix River, estuary, Passamaquoddy Bay and Bay of Fundy Coastal areas contain both critical habitat for VEC species, and required habitat for various life stages of VEC species. Terminal construction activities in and adjacent to the marine environment have the potential to significantly impact habitat.

The quality of the water in the study area may be subject to adverse local and/or short-term effects and represents a potential risk to receptors due to an accidental release of contaminants. The behaviour of aquatic species may be affected by noise and light from operations.

### 7.3.7 Potential Risks Due to Accidental Release of Chemical Contaminants

Potential impacts on aquatic resources resulting from an accidental release of chemical contaminants can include mortality of aquatic biota and degradation of aquatic habitat. The significance of the impact will be a function of the concentration of the contaminant and duration of exposure. The risk of mortality or loss of these resources is considered to be high for VECs that come into direct contact with a spill, but the number of mortalities or loss of resources is expected to be low given that there should be limited contact with a spill and only small quantities are expected to be spilled and concentrations are expected to dissipate relatively quickly with wind and wave action as well as effective implementation of remedial action plans.

#### Policy Considerations

Prevention (use of pilots, tugs, improved navigation systems, etc), in addition to proper planning to minimize the risk and possible impacts of discharges and spills should be considered. Operating procedures including emergency response plans should be reviewed by Environment Canada, the Canadian Coast Guard, Transport Canada, the Emergency Measures Organization and local emergency responders, in consideration of planning and responding to accidental releases and clean-up measures. CCME guidelines for contaminants of concern should be identified as a requirement for remedial measures, and protocols for a remedial monitoring plan should be established.

### 7.3.8 Potential Risks to Interference with Fish Passage

Vessel traffic and the presence of the proposed terminals can represent a barrier to movement of VEC fish species during sensitive migratory periods (for example, salmonid spawning) due to physical presence and noise. The least biologically sensitive period is July to September for the most common VEC species (i.e. Atlantic salmon, trout etc.) utilizing the study area. The width of the river is such that it is likely that sufficient room and water depth exists to allow for fish passage during equipment operations. The risk to interference is considered to be low for fish species as risk.

A discussion concerning commercial fisheries operations is discussed elsewhere in Section 7.3.12.

**Policy Considerations**

Should movement of fish species at risk be identified as a concern, policies concerning vessel activity during sensitive migratory periods may include a reduction in the number of tanker trips in to the area.

### 7.3.9 Potential Risks Associated With Local Current Regime

The construction of the proposed terminal may result in changes in the nearshore currents and wave patterns in the vicinity of a terminal. The areal extent and magnitude of the potential impact of a terminal on the tidal current patterns have not been quantified. However, the effects on the rates and patterns of water movement are anticipated to be localized in nature. Concerns with potential changes in the local current regime include the potential effect of the currents on movement of fish species and alteration of habitat due to movement of substrate materials. Monitoring of currents and current modelling is necessary to determine if there are any risks to fisheries resources and habitat. This is considered an information gap. In addition, following terminal construction, monitoring would be required to provide verification of the post-construction current regime and would provide data to determine if any action is required in consideration of fish behaviour and habitat. In addition, an assessment of fish habitat is also required in order to assess any potential change in conditions following construction, in consideration of potential changes in currents.

**Policy Considerations**

*Fisheries Act* is considered adequate.

### 7.3.10 Potential Risks to Aquatic Resources from Vessel Traffic/Movement

The physical presence as well as noise and vibrations generated as a result of vessel traffic may be disruptive to several species at risk and other socially important species identified in the area, as well as important food sources for these species including:

- Right Whales and the Right Whale Sanctuary;
- Fin Back Whale;
- Minke Whale;
- Harbour Porpoise;
- Atlantic Salmon; and
- Krill (food source for whales).

Whales are frequently observed in the area bound by Grand Manan, Campobello Island, The Wolves and East Head. Key food sources for whales traditionally include krill and plankton, however observations in 2005 (personal communication, Chuck Schom, May 2006 for the Quoddy Region indicate that Finback Whales may be feeding primarily on larval fish with Humpback Whales feeding on bate fish. In previous years the Finback and Humpback Whales seemed to be feeding on a combination of Krill and larger fish. The extent of the food sources is unknown and the effect of vessel traffic on the behaviour of krill is not known. Further study is recommended to assess the extent of habitat utilized by krill and the potential effect of vessel traffic on life stages.

As indicated, whales are frequently observed in the area bound by Grand Manan, Campobello Island, The Wolves and East Head, and therefore, the shipping lanes passes through the area frequented by whales. In this instance there is potential for collision with a whale that would result in a direct fatality.

There are several information gaps that prohibit the assessment of risks to whales and require further assessment as follows:

- Information on extent of habitat for krill and effect of marine traffic on life processes in consideration of whale species of special status.
- Effect of an LNG release on krill and krill habitat as well as other fish species and aquatic resources.
- Assessment in the use of larval fish as a food source for whale species of special status including extent of habitat and effect of marine traffic and an LNG spill below the water surface on life processes.
- Probability of impact and whale fatality for anticipated ship traffic.

Porpoise appear demonstrate an adaptive ability with respect to vessel traffic/movements and risks are considered to be low.

The risk to the movement of Salmon through the study area is expected to be low given the open water available to provide for avoidance responses, and the depth of water should provide for acceptable passage during vessel traffic movements. It is also noted that salmon move intermittently through a watercourse during migration, and therefore, would be able to move through areas during the intermittent non-traffic periods.

Prevention (use of pilots, tugs, improved navigation systems, etc), in addition to proper planning to minimize the risk and possible impacts of discharges and spills should be considered. Operating procedures including emergency response plans should be reviewed by Environment Canada, the Canadian Coast Guard, Transport Canada, the Emergency Measures Organization and local emergency responders, in consideration of planning and responding to accidental releases and clean-up measures. CCME guidelines for contaminants of concern should be identified as a requirement for remedial measures, and protocols for a remedial monitoring plan should be established.

### 7.3.11 Potential Risks to Wetland Resources

There are over 30 freshwater wetland areas greater than 10 hectares (24.7 acres) in the lower St. Croix River watershed. There are no wetlands located in the immediate vicinity of the proposed terminal locations. However, coastal marshes/wetlands occur in the St. Croix Estuary and Passamaquoddy Bay area. Potential issues and risks were discussed in Sections 7.3.3.1 and 7.3.3.1

### 7.3.12 Potential Risks to Socio-Economic Environment

The potential risks to the socio-economic environment due to an accidental release of hazardous materials are summarized in Table 7-7.

**TABLE 7-7 Potential Risks to Socio-Economic Resources During Operations Associated With an Accidental Release of Contaminants and Other Activities**

| VALUED ENVIRONMENTAL COMPONENTS | PROJECT INTERACTION | POTENTIAL RISKS |
|---|---|---|
| ➢ Commercial Fisheries | ➢ Accidental release of contaminants<br>➢ Vessel Traffic | ➢ Human health<br>➢ Risks to fisheries resources<br>➢ Risks to surface and groundwater (see Section 7.3.1)<br>➢ Risk of Interference with Commercial Fisheries activities (physical, noise and light) |
| ➢ Recreational Activities including Tourism | ➢ Accidental release of contaminants<br>➢ Vessel Traffic | ➢ Risk of Interference with recreational activities |
| ➢ Archaeological/Heritage and Paleontological Resources | ➢ Accidental release of contaminants | ➢ Risk of Loss/disturbance to Archaeological/heritage and Paleontological resources |

### *7.3.12.1 Accidental Release of Contaminants*

As previously indicated, hazardous chemicals associated with operations primarily include petroleum, oil, and lubricant (POL), solvents, and possibly epoxy resins. Discharge may occur into receiving waters and be transported to shore line areas. The potential risks to the environment resulting from an accidental release will depend on the quantity released, characteristics of the contaminants, local hydrogeologic characteristics, and groundwater use of the area, usage of area by individuals for recreational activities, and presence of fisheries resources. Risks to surface water and groundwater are discussed in Section 7.3.1.

Risks to human health and commercial fisheries is expected to be low recognizing that for an accidental release along the transit route or even near the shoreline, spillage is expected to be limited and wave action and mixing is expected to disperse the material and effects would be expected to dissipate over several weeks, with clean up efforts implemented. It is expected that appropriate protocols will be included in the emergency response plan to ensure that contaminated areas are clearly marked with signs indicating hazardous area, and monitored to ensure that individuals do not use an area and become exposed to risk.

There is also a risk of disruption to commercial and recreational activities due to the presence of vessels and equipment requirements involved in a clean up. It is recognized that a spill will is likely to be small, and on this basis, it is expected that requirements for emergency response equipment would be limited and the duration of the activity would be limited, thereby minimizing disturbances.

In general, standard operating procedures for marine vessel operations and emergency response plans should also reduce associated risks to the environment.

**Policy Considerations**

Prevention (use of pilots, tugs, improved navigation systems, etc), in addition to proper planning to minimize the risk and possible impacts of discharges and spills should be considered. Operating procedures including emergency response plans should be reviewed by Environment Canada, the Canadian Coast Guard, Transport Canada, the Emergency Measures Organization and local emergency responders, in consideration of planning and responding to accidental releases and clean-up measures. CCME guidelines for contaminants of concern should be identified as a requirement for remedial measures, and protocols for a remedial monitoring plan should be established.

#### *7.3.12.2 Vessel Traffic*

The St. Croix is used frequently by recreational boaters and some recreational diving and fishing occurs as well as beach related activities. The Grand Manan ferry operates daily, with a ferry terminal located at Blacks Harbour. It is expected that the risk to recreational and commercial fisheries activities will be low given the open water available along the transport route. Lobster fishing activities would represent the activity with the greatest potential to be disrupted.

**Policy Considerations**

Reduced tanker traffic during periods of greatest activity could be considered if it is determined to be necessary based on input from fishermen after start-up. Prevention (use of pilots, tugs, improved navigation systems, etc), in addition to proper planning to minimize the risk and possible impacts of tanker traffic.

#### *7.3.12.3 Potential Risks to Archaeological/Heritage and Paleontological Resources*

There are several archaeological sites that are located within along the waterway. Potential risks would be associated with disturbances resulting from an accidental release of contaminants including direct contact of contaminants with the resources and disturbances associated with remedial activities. Discharge may occur into receiving waters and be transported to shore line areas. The potential risks to the environment resulting from an accidental release will depend on the quantity released, characteristics of the contaminants, and nature of the remedial activities.

**Policy Considerations**

A professional archaeologist should be retained to provide recommendations for the protection of heritage resources for any affected areas that may require remedial work, in discussion with Archaeological Services NB.

## 7.4 SCENARIOS 2 AND 3-POTENTIAL RISKS TO RECEIVING ENVIRONMENT FOR A RELEASE OF LNG

The hazard zones for a release of LNG, for which the identification of risks to receptors is based upon, are defined as follows:

- Fire hazard zone; For this assessment, the risk of mortality and property damage in consideration of a large fire is considered to be high within 500 m of the release. The risk of mortality and property damage is medium for a distance of 500 to 1600 from a release, and low beyond a distance of 1600 m.
- Fire ball hazard zone; For this assessment, the risk of mortality and property damage in consideration of a large fire is considered to be high in the immediate area of the release (less than 500 m). The risk of mortality and property damage is medium within a distance of 500 to 1600 m, and low for a distance greater than 1600m.
- Vapour cloud hazard zone; For this assessment, the risk of mortality and health effects in consideration of a vapour cloud is considered to be high within a distance of 1600 m of a release. The risk of mortality and property damage is

medium for a distance of 1600 to 6000 from a release, and low beyond a distance of 6000 m.

- Cold gas hazard zone is much smaller than the fire hazard zone and is limited to the close vicinity of the spill area. For this assessment, the risk of mortality and property damage in consideration of cold gas is considered to be high within a distance of 200 m of a release. The risk of mortality and property damage is considered to be conservatively set at medium for a distance of 500 m to 1600 m from a release, and low beyond a distance of 1600 m.
- Liquid LNG on land; the primary zone of impact on the surface as a result of uncontrolled release of LNG is a few hundred metres (The maximum size of a pool). For this assessment, the risk of mortality and property damage in consideration of LNG on land is considered to be high within a distance of 200 m of a release near the shoreline. The risk of mortality and property damage is medium for a distance of 200 to 400 m from a release near the shoreline, and low beyond a distance of 400 m.
- For surface water, the temperature effects are limited to several meters immediately underneath the released pool of LNG. A 310 m radius LNG pool, from the spill location, has been applied for the assessment based on maximum pool radius estimates with reference to pool fires. For this assessment, the risk of mortality in consideration of temperature effects is considered to be high for organisms that come into direct contact with the LNG pool. The risk of mortality or health effects is medium to a depth of 3 m, and low beyond a depth of 3m.

The hazard zones are presented on the figures contained in Appendix C for the various VECs considered in the assessment. Several specific assumptions are reiterated here that have been applied for the assessment as noted in Section 2.0, including the following;

- It is assumed that there is very limited wind and wave action. It is generally expected that under conditions of high winds and wave action that the LNG will disperse more readily, resulting in diminished effects.
- For the LNG liquid on land aspect, although this can not occur based on the transit path approach, it is assumed that this will occur in combination with the fire hazard and vapour cloud aspects but risks will be noted separately for differentiation purposes.
- With respect to thermal effects for surface water it is assumed that there are no opportunities for upwelling i.e. vertical water movements whereby low

temperature columns of water may be established with limited mixing leading to impacts to much greater depths than might otherwise be expected.

- For surface water, the depth to which potential lethal levels for marine organisms is a potential concern is unknown (a small portion will dissolve in the water). In addition the toxicity levels may exist for anywhere from a few minutes to several hours depending on a number of unknown and untested factors. Therefore, toxic affects has been excluded from the assessment due to lack of information, and has been identified as an information gap requiring further investigation.
- The analysis of a release source at the terminal location (Scenario 3) has not been conducted based on the assumption that the impact zone from these releases would be less than or equal to that from a vessel docked at the terminal, which is realized as part of the transit path analysis.
  - The potential for asphyxiation due to reduced oxygen levels in water is not known and represents an information gap that requires further assessment.
  - There is an ignition source at the point of the spill.

It should also be noted that an assessment of several specific spill locations was not considered feasible for this study. For this assessment, the spill and dispersion of LNG and other hazardous materials was assumed to be uniform, and risks are determined based on the footprint represented by the boundary zones as identified in Figure 2.3 over the entire length of the transit route. This represents a conservative approach to identification of potential risks to receptors as explained in the following discussion. Not withstanding the discussion provided in Section 2.0 concerning wind and wave dispersion effects, a spill would actually be better represented by an ellipsoidal dispersion of LNG. The resulting footprint would be significantly reduced in comparison with the footprint represented by the entire transit route, with a significant reduction of potential risks.

It is also important to note that the consequences of a release of LNG or other hazardous material will be more significant during specific periods. These include, but may not be limited to the following:

- During tourist season, the number of individuals in an area is typically much greater and therefore, the risk is increased with respect to mortalities;
- During the height of the fishing season, the number of individuals will be increased, but more importantly there may be landings placed in storage or holding that would represent a greater risk in the event of a spill,

- During the breeding season and the migratory period for migratory birds, the number of birds in an area is expected to be more significant and therefore, the risk is increased with respect to mortalities;
- The presence and movement of marine life including whales, salmon and other fisheries resources are more critical during certain periods of the year and therefore, the risk is increased with respect to mortality.

An assessment of risk that includes these factors is beyond the scope of this project. For conservative purposes, it is assumed that these receptors may be present at any given time.

It should also be noted that the assessment does not consider other potential contributory effects that may occur as a result of LNG hazards. For example, the fire hazard issue may trigger other incidents such as a fuel tank explosion that would further contribute to risks to receptors. In addition, that assessment does not consider any potential long term contributory effects that may occur due to exposure of material to LNG. For example, LNG can cause embrittlement and cracking of metal materials, such as petroleum storage tanks, that may result in failure after the initial LNG hazard event that could lead to an incident and additional risks to receptors.

The establishment of policies may consider operating procedures including emergency response plans that should be reviewed by Environment Canada, the Canadian Coast Guard, Transport Canada, the Emergency Measures Organization and local emergency responders, in consideration of planning and responding to accidental releases and clean-up measures. CCME guidelines for contaminants of concern should be identified as a requirement for remedial measures, and protocols for a remedial monitoring plan should be established. Policies may also include consideration of sensitive periods, with limitations such as reduced vessel traffic or increased requirements such as additional tugs or visibility factors being imposed to reduce the likelihood of an accidental event during peak periods of activity.

The potential risks associated with an accidental release of LNG, is discussed in the following sections for the following VECs in recognition of potential risks to health, mortality and to habitat:

- Human health;
- Mammals
- Avians;
- Herpetiles

- Faunal invertebrates;
- Flora
- Aquatic Resources;
- Wetland Resources; and
- Socio-economic Environment.

Ecologically Sensitive Areas (ESAs) are inherently included as species at risk and/or sensitive critical habitat are typically associated with the ESA.

### 7.4.1 Potential Risks to Human Health

Potential risks to human health associated with hazards for Scenarios 1 and 2 are identified in Table 7-8.

## TABLE 7-8 Potential Risks to Human Health Associated With Hazards for Scenarios 1 and 2

| HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) | | |
|---|---|---|---|
| | HIGH | MEDIUM | LOW |
| **FIRE HAZARD ZONE** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **FIREBALL HAZARD ZONE** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **VAPOUR CLOUD** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **COLD GAS HAZARD** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **LIQUID LNG ON LAND** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **SURFACE WATER** | NOT APPLICABLE | NOT APPLICABLE<br>Related to aquatic organisms | NOT APPLICABLE<br>Related to aquatic organisms |

### 7.4.2 Potential Risks to Terrestrial Mammal Species at Risk

Three species of bats (Big Brown, Eastern Red and Hoary) were identified from the ACCDC database for the study area (see Figures C1 and C2 in Appendix C), with sitings reported near St. Andrews for the big brown bat and hoary bat in an area opposite to the proposed terminal location for the Calais LNG site. They are classified as S 2, rare throughout its range in the province (6 to 20 occurrences or few remaining individuals) and may be vulnerable to extirpation due to its rarity or other factors. It is likely that these species occur in other areas of the study area with similar habitat conditions. Field investigations would be required to further assess the presence/absence of this species including habitat to fully determine the risks to these species. This is considered to represent an information gap.

Potential risks to mammal species at risk associated with hazards for Scenarios 1 and 2, based on siting boundaries identified in Figure C2 in Appendix C, are identified in Table 7-9.

**TABLE 7-9 Potential Risks to Bat Species At Risk Associated With Hazards for Scenarios 1 and 2**

| HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) | | |
|---|---|---|---|
| | HIGH | MEDIUM | LOW |
| **FIRE HAZARD ZONE** | YES<br>2 but likely greater | YES<br>Number of receptors 2 is same compared with high risk area | YES<br>Number of receptors 3 is greater compared with medium risk area |
| **FIREBALL HAZARD ZONE** | YES<br>2 but likely greater | YES<br>Number of receptors 2 is same compared with high risk area | YES<br>Number of receptors 3 is greater compared with medium risk area |
| **VAPOUR CLOUD** | YES<br>2 but likely greater | YES<br>Number of receptors 2 is same compared with high risk area | YES<br>Number of receptors 3 is greater compared with medium risk area |
| **COLD GAS HAZARD** | YES<br>2 but likely greater | YES<br>Number of receptors 2 is same compared with high risk area | YES<br>Number of receptors 3 is greater compared with medium risk area |

**TABLE 7-9 Potential Risks to Bat Species At Risk Associated With Hazards for Scenarios 1 and 2 (Cont'd)**

| HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) | HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) |
|---|---|---|---|
| | HIGH | | HIGH |
| **LIQUID LNG ON LAND** | YES<br>2 but likely greater | YES<br>Number of receptors 2 is same compared with high risk area | YES<br>Number of receptors 3 is greater compared with medium risk area |
| **SURFACE WATER** | NOT APPLICABLE | NOT APPLICABLE<br>Related to aquatic organisms | NOT APPLICABLE<br>Related to aquatic organisms |

### 7.4.3 Potential Risks to Avian Species of Special Status and Migratory Birds

As indicated previously, there is information indicating that a large number of avian species of special status are known to occur in the area (see Table 5-5 in Section 5.0 and Figures C1, C2, C5 and C9 in Appendix C). Species were identified under all 5 ACCDC rankings as well as COSEWIC and SARA. There are also raptor species of concern identified within the study area.

The information available for the study area is reported to be outdated by various authors, and is considered to be outdated according to the Canadian Wildlife Service. The number of various species identified is the primary unknown. Field investigations would be required to further assess the presence/absence of avian species, including numbers, as well as habitat to fully determine the risks to these species. This is considered to represent an information gap.

Potential risks to avian species at risk and migratory birds associated with hazards for Scenarios 1 and 2, based on siting boundaries identified in Figure C2, as well as Figures C5 (ESAs and other raptor locations) and C9 (migratory and other avian species) in Appendix C, are identified in Table 7-10.

### 7.4.4 Potential Risks to Herpetile Species at Risk

A Wood Turtle (*Clemmys insculpta*) siting is reported by ACCDC approximately 200 m upstream of the proposed Red Beach site. It is likely that the Wood Turtle occurs in other areas of the St. Croix River and other tributaries in the study area with similar habitat conditions. Field investigations would be required to further assess the presence/absence of this species including habitat, and to fully determine the significance of risks. This is considered to represent an information gap.

ACCDC has rated the Wood Turtle as uncommon (S3) throughout its range within the Province, and COSEWIC (Nov. 2003) has identified the Wood Turtle as a species of special concern. Potential risks to herpetile species at risk associated with hazards for Scenarios 1 and 2, based on siting boundaries identified in Figure C2 in Appendix C, are identified in Table 7-11.

**TABLE 7-10 Potential Risks to Avian Species At Risk And Migratory Birds Associated With Hazards for Scenarios 1 and 2**

| HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) | | |
|---|---|---|---|
| | HIGH | MEDIUM | LOW |
| **FIRE HAZARD ZONE** | YES<br>Migratory bird numbers much greater | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **FIREBALL HAZARD ZONE** | YES<br>Migratory bird numbers much greater | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **VAPOUR CLOUD** | YES<br>Migratory bird numbers much greater | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **COLD GAS HAZARD** | YES<br>Migratory bird numbers much greater | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **LIQUID LNG ON LAND** | YES<br>Migratory bird numbers much greater | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **SURFACE WATER** | NOT APPLICABLE | NOT APPLICABLE<br>Related to aquatic organisms | NOT APPLICABLE<br>Related to aquatic organisms |

## TABLE 7-11 Potential Risks to Herpetile Species At Risk Associated With Hazards for Scenarios 1 and 2

| HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) | | |
|---|---|---|---|
| | HIGH | MEDIUM | LOW |
| **FIRE HAZARD ZONE** | YES<br>1 but numbers highly likely to be greater | YES<br>Number of receptors likely greater compared with high risk area | YES<br>Number of receptors likely greater compared with medium risk area |
| **FIREBALL HAZARD ZONE** | YES<br>1 but numbers highly likely to be greater | YES<br>Number of receptors likely greater compared with high risk area | YES<br>Number of receptors likely greater compared with medium risk area |
| **VAPOUR CLOUD** | YES<br>1 but numbers highly likely to be greater | YES<br>Number of receptors likely greater compared with high risk area | YES<br>Number of receptors likely greater compared with medium risk area |
| **COLD GAS HAZARD** | YES<br>1 but numbers highly likely to be greater | YES<br>Number of receptors likely greater compared with high risk area | YES<br>Number of receptors likely greater compared with medium risk area |
| **LIQUID LNG ON LAND** | YES<br>1 but numbers highly likely to be greater | YES<br>Number of receptors likely greater compared with high risk area | YES<br>Number of receptors likely greater compared with medium risk area |
| **SURFACE WATER** | NOT APPLICABLE | NOT APPLICABLE<br>Related to aquatic organisms | NOT APPLICABLE<br>Related to aquatic organisms |

### 7.4.5 Potential Risks to Invertebrate Species of Special Status

There are numerous invertebrate species of special status in the study area that may be at risk including odonates, and butterflies in association with rivers, wetlands, estuaries and streams (see Table 5-6). Figure C1 in Appendix C shows the point reference locations for the identified VECs, and Figure C3 in Appendix C shows the estimated boundary/footprint for the invertebrate species. Rankings include the following for:

Odonates

- S 1 - Extremely Rare throughout its range in the province (typically 5 or fewer occurrences or very few remaining individuals). May be especially vulnerable to extirpation.
- S 2 - Rare throughout its range in the province (6 to 20 occurrences or few remaining individuals). May be vulnerable to extirpation due to its rarity or other factors.
- S 3 - Uncommon throughout its range in the province, or found only in a restricted range, even if abundant in some locations. (21 to 100 occurrences).

Butterflies

- S 1 - Extremely Rare throughout its range in the province (typically 5 or fewer occurrences or very few remaining individuals). May be especially vulnerable to extirpation.
- S 2 – Rare throughout its range in the province (6 to 20 occurrences or few remaining individuals). May be vulnerable to extirpation due to its rarity or other factors.
- S 3 - Uncommon throughout its range in the province, or found only in a restricted range, even if abundant in some locations. (21 to 100 occurrences).

It is likely that these species occur in other areas of the study area with similar habitat conditions. Field investigations would be required to further assess the presence/absence of this species including habitat to fully determine the significance of risks to these species. This is considered to represent an information gap.

Potential risks to invertebrate species at risk, based on siting boundaries in Figure C2 in Appendix C, associated with hazards for Scenarios 1 and 2 are identified in Table 7-12.

## TABLE 7-12 Potential Risks to Invertebrate Species At Risk Associated With Hazards for Scenarios 1 and 2

| HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) | | |
|---|---|---|---|
| | HIGH | MEDIUM | LOW |
| **FIRE HAZARD ZONE** | YES<br>>10 and numbers highly likely to be greater | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **FIREBALL HAZARD ZONE** | YES<br>>10 and numbers highly likely to be greater | YES<br>Number of receptors likely greater compared with high risk area | YES<br>Number of receptors likely greater compared with medium risk area |
| **VAPOUR CLOUD** | YES<br>>10 and numbers highly likely to be greater | YES<br>Number of receptors likely greater compared with high risk area | YES<br>Number of receptors likely greater compared with medium risk area |
| **COLD GAS HAZARD** | YES<br>>10 and numbers highly likely to be greater | YES<br>Number of receptors likely greater compared with high risk area | YES<br>Number of receptors likely greater compared with medium risk area |
| **LIQUID LNG ON LAND** | YES<br>>10 and numbers highly likely to be greater | YES<br>Number of receptors likely greater compared with high risk area | YES<br>Number of receptors likely greater compared with medium risk area |
| **SURFACE WATER** | NOT APPLICABLE | NOT APPLICABLE<br>Related to aquatic organisms | NOT APPLICABLE<br>Related to aquatic organisms |

### 7.4.6 Potential Risks to Flora Species of Special Status

As indicated in Section 5.4.1 a variety of plant species of special status have been reported in the study area in association with shoreline areas and wetland areas (Figures C1 and C2 in Appendix C), including ESAs. Field investigations would be required to further assess the presence/absence of flora species in order to fully determine the significance of risks. This is considered to represent an information gap.

Field investigations would be required to further assess the presence/absence of this species including habitat to fully determine the significance of risks to these species. This is considered to represent an information gap.

Potential risks to invertebrate species at risk, based on siting boundaries in Figure C2 in Appendix C, associated with hazards for Scenarios 1 and 2 are identified in Table 7-13.

### 7.4.7 Potential Risks to Aquatic Resources

Although a number of marine species occur in the area that are considered important socially, the discussion in this section is limited to species at risk, with a discussion of other resources related to commercial and recreational fisheries activities provided in Section 7.5. Marine and shorebirds, including species at risk were considered in Section 7.4.3. Several species of whales and Atlantic salmon have been identified to occur in the study area, with a Right Whale sanctuary being located near Grand Manan (see Figures C1 and C3 in Appendix C). Sitings of whales are identified also identified on Figures C1 and C3 in Appendix C, with Figure C3 representing the boundaries for sitings.

#### *7.4.7.1 Releases of Toxic Materials*

Industrial activity generates materials that may be detrimental to the well being of species downstream from where a release occurs. Potential sources of releases include the LNG Terminal and the LNG Tankers traversing the Quoddy Region. Modelling the distribution of releases from the Terminal should be possible with some certainty because of their fixed nature. Tanker releases depend on where the release occurs and on whether the material floats on the surface or disperses in the water column.

Patin (1999) reports on both laboratory and field observations that show underwater releases of LNG in sea water leads to the production of materials that have high toxicity to fish species. Among the incidences cited are accidents in Russia that include underwater releases and large fish kills. (There is no information on the impact of these chemicals on plankton.) Similar releases in the inter island area could have the potential to cause devastating effects on Head Harbour Passage productivity, assuming conditions in the Quoddy Region provide an environment suitable for the production of Patin's (1999) toxicants. Note that there is no information on direct toxicity to marine mammals of any releases, regular or accidental, from either LNG Tankers or Terminals.

The two releases with the greatest potential for toxic impact may be the release of diesel fuel and/or the underwater release of LNG followed by the creation of the toxic by products described by Patin (1999). Information regarding to where materials will move, how long it will take them to break down and/or become dilute enough to have no impact, could releases in Head Harbour Passage remain toxic and form a plume that would move out of the passage, and if so how would it mix in the water column and/or to what depth would the plum extend, and could a plum form then settle in the basin off the entrance to head Harbour Passage is lacking. Nevertheless, a model developed by Dr. Page at the St. Andrews Biological Station could be used to potentially provide answers to these questions. Note that the impact of releases in the Quoddy Region on the lower trophic levels and how long the impacts would last, i.e., days, weeks, months, etc., are also unknown.

The food sources that represent a critical aspect associated with whales also occur in the study area, and therefore have been considered to be essentially as important as the whales for the purpose of this assessment. Given that sitings of whales has occurred throughout the study area, it is reasonable to assume that their food sources also occur in the same areas.

Key food sources for whales traditionally include krill and plankton, however observations in 2005 (personal communication, Chuck Schom, May 2006) for the Quoddy Region indicate that Finback Whales may be feeding primarily on larval fish with Humpback Whales feeding on bate fish. In previous years the Finback and Humpback Whales seemed to be feeding on a combination of Krill and larger fish. The extent of the food sources is unknown and further study is recommended to assess the extent of habitat utilized by krill and larval fish in order to fully assess potential risks. Krill is a very common food source for Right Whales but further investigations are required to establish the extent of habitat in this area (personal communication: Chuck Schom, March 2006). See section 4.6 for additional details. This is considered to represent an information gap.

**TABLE 7-13 Potential Risks to Flora Species at Risk Associated With Hazards for Scenarios 1 and 2**

| HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) | | |
|---|---|---|---|
| | HIGH | MEDIUM | LOW |
| **FIRE HAZARD ZONE** | NO | YES Number >6 of receptors greater compared with high risk area | YES Number > 26 of receptors within 6000 m greater compared with medium risk area |
| **FIREBALL HAZARD ZONE** | NO | YES Number >6 of receptors greater compared with high risk area | YES Number > 26 of receptors within 6000 m greater compared with medium risk area |
| **VAPOUR CLOUD** | NO | YES Number >6 of receptors greater compared with high risk area | YES Number > 26 of receptors within 6000 m greater compared with medium risk area |
| **COLD GAS HAZARD** | NO | YES Number >6 of receptors greater compared with high risk area | YES Number > 26 of receptors within 6000 m greater compared with medium risk area |
| **LIQUID LNG ON LAND** | YES >20 and numbers highly likely to be greater | YES Number > 20 of receptors likely greater compared with high risk area | YES Number 20 of receptors likely greater compared with medium risk area |
| **SURFACE WATER** | NOT APPLICABLE | NOT APPLICABLE Related to aquatic organisms | NOT APPLICABLE Related to aquatic organisms |

Potential risks to whale and salmon species at risk as well as the food supply for whales, based on siting boundaries in Figure C3 in Appendix C, associated with hazards for Scenarios 1 and 2 are identified in Table 7-14.

## TABLE 7-14 Potential Risks to Whale and Salmon Species At Risk and Food Supplies for Whales Associated With Hazards for Scenarios 1 and 2

| HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) | | |
|---|---|---|---|
| | HIGH | MEDIUM | LOW |
| **FIRE HAZARD ZONE** | YES | YES<br>Number of receptors similar compared with high risk area | YES<br>Number of receptors similar compared with medium risk area |
| **FIREBALL HAZARD ZONE** | YES | YES<br>Number of receptors similar compared with high risk area | YES<br>Number of receptors similar compared with medium risk area |
| **VAPOUR CLOUD** | YES | YES<br>Number of receptors similar compared with high risk area | YES<br>Number of receptors similar compared with medium risk area |
| **COLD GAS HAZARD** | YES | YES<br>Number of receptors similar compared with high risk area | YES<br>Number of receptors similar compared with medium risk area |
| **LIQUID LNG ON LAND** | YES | YES<br>Number of receptors similar compared with high risk area | YES<br>Number of receptors similar compared with medium risk area |
| **SURFACE WATER** | YES | YES<br>Number of receptors similar compared with high risk area | YES<br>Number of receptors similar compared with medium risk area |

#### *7.4.7.2 Vessel Traffic Noise Issues and Exclusion Zone Considerations*

Noise, particularly in the oceans, is created by numerous sources such as commercial and military ships, oil exploration, and military and scientific tests. The National Marine Fisheries Service, which enforces the *Marine Mammal Protection Act* of 1972 announced in 1994 that scientists, often in an effort to protect marine life through their research "...contribute to the harassment of these denizens of the deep" (Schulhof, 1994). In agreement with this declaration, the Acoustical Society of America announced in that same year that human-created noise was posing an ever greater threat to the health of marine mammals. To support their position they cited the increasing tendency of whales to become caught in nets in Newfoundland after blasting occurred in an effort to enlarge a channel for tanker travel. Entanglement in the nets suggested that the whales' ability to echolocate had been impaired. Dr. Darlene Ketten, a hearing specialist from Harvard University confirmed this suspicion after finding the ear bones of two whales killed in the blast shattered and the ear canals filled with blood and pus. The National Marine Fisheries Service, partly in response to Ketten's discovery, recommended that a 120 decibel cap be placed on underwater noise in order to minimize the potential injurious effect on whales and other aquatic life. It was also indicated that many researchers were outraged by this demand, asserting that dolphin calls have been recorded at levels of 130 decibels and that a decibel cap would undermine their ability to perform experiments. The cap was not enacted, but the debate over noise in the ocean and other waterways was far from over and to date remains unresolved.

Tom Norris' studies of "The Effects of Boat Noise on the Acoustic Behaviour of Humpback Whales" exemplifies this obstacle of uncertainty. Dr. Norris studied the songs of Megaptera novaegliae as they were introduced to boat noise and discovered that "...boat noise level might affect humpback whale song structure at the most basic level by altering the rhythm or increasing the tempo of songs..." (Norris,1994). Dr. Norris noted that the significance of these effects, especially on the behaviour of the whales, remains uncertain. Similarly, disagreements among scientists also engender a level of uncertainty. In the 1994 report "Low Frequency Sound and Marine Mammals," a committee appointed by the Ocean Studies Board of the National Academy of Sciences National Research Council scientists could not come to consensus (Holing, 1994). "While it acknowledged that the effects of loud, low frequency sound `could conceivably range between potential hearing damage and gradual deafness for the entire species - and eventual extinction - and practically no discernible impact' the report concluded that a dearth of scientific evidence makes it virtually impossible to predict what those effects will be" (Holing, 1994). While that particular committee made that conclusion, other scientists such as Sylvia Earle, former chief scientist at the National Oceanic and Atmospheric Association, are of a different opinion. Dr. Earle asserted that "each sound by itself is probably not a matter of much concern, but taken all together, it's creating a totally different environment than existed fifty years ago. The high level of noise is bound to have a hard, sweeping impact on life in the sea" (Holing, 1994).

Pattock, in the article, "Cacophony of human-made noise pounds oceans," echoes the uncertainty by posing the question "...how much noise is too much?" Pattock discusses the intensity of noise in the oceans, noting that supertankers, "....the largest human-made source of ocean noise... are so loud they can be heard under water a full day before they appear on the horizon." While the levels of sound are easily measured, the problem again lies in determining the effects of this noise on marine life because "...so little is known about these creatures that scientists cannot say for sure how they are affected by the noise of humans, particularly the cumulative effect of low frequency sound." This knowledge was evident to Peter Schiefele, a researcher at the National Undersea Research Center at the University of Connecticut, as recently as May 1997. Scheifele, in determining whether noise levels in the St. Lawrence and Saguenay Rivers in Quebec are damaging the hearing and capacity of survival for beluga whales indicated that the extent of damage continues to remain unclear. (Chang, 1997).

In March of 1997 a forty foot sperm whale became trapped in the inshore waters of Firth of Forth near Edinburgh, Scotland (Quinn, 1997). Scientists attributed this to traffic noise from the rail and road bridges that traverse the waterway. Although they could not confirm their suspicions, the scientists believed that the clamorous noise made the sperm whale reluctant to return to open waters which eventually caused it to become stranded in the shallows between the bridges. This incident, like many others of its kind provides anecdotal rather than definitive evidence and as such is often dismissed by researchers, policy makers and those responsible for generating the noise.

A study of Personal Water Craft noise versus outboard motor noise on a heavily used lake showed that the actual noise level (in terms of decibels) is much higher than most other types of watercraft (Wagner, 1994). The loudness decreased with distance from the watercraft, such that the sound level was within background levels at distances of 100 metres or more. Therefore, a setback of 100 metres from as aquaculture site may be considered to address potential noise issues.

From this review it is evident that noise is a potential concern for marine life, and is has been indicated that a noise level of 120 decibels may be sufficient to avoid potential adverse impacts on whales and other marine life. It is apparent that the effects on various marine life is not understood and the noise level of 120 decibels has been established in an effort to address concerns based on science at the time. For this study, there is an interest in identifying possible setbacks from the whale sanctuary, but based on a short review of the literature there is no specific reference to setbacks. Alternatively, the distance from a potential receptor such as a whale sanctuary could be established based on an upper noise level reading of 120 decibels. However, it should also be noted that the noise generated from tanker traffic and associated tug boats will be episodic, and potential adverse effects would be minimized compared with chronic noise emissions. It should be further noted that the life span for species raised or contained in aquaculture sites is relatively short term in nature and therefore concerns for long term effects are not as critical.

### 7.4.8 Potential Risks to Wetland Resources

There are over 278 acres of salt marsh in the inner Quoddy Region (Trigom, 1973). Similar conditions occur for a number of areas for Deer Island, Campobello Island, and Grand Manan.

There are over 30 freshwater wetland areas greater than 10 hectares (24.7 acres) in the lower St. Croix River watershed and the Chamcook and Bocabec watersheds. Extensive wetlands occur in and adjacent to the Moosehorn National Wildlife Refuge south of Calais (Trifts, J. St Croix Estuary Project, 1994). Many birds that occur in the Estuary Area use wetlands for feeding, nesting and breeding. A variety of fish also use these areas and plant lives including species at risk occur in wetlands.

Potential risks to wetlands, based on sitings in Figure C5 in Appendix C, associated with hazards for Scenarios 1 and 2 are identified in Table 7-15.

### 7.4.9 Potential Risks to Sensitive and Critical Habitat

Sensitive/critical habitats such as potential deer wintering areas may occur near shoreline areas. Avian, mammal, herpitiles, and invertebrate species of special status that may be at risk have been identified within the study area. Species at risk have been identified in association with ESAs in some instances. Mammal species of special status are identified on Figures C1 and C2 in Appendix C. Figure C1 shows the point reference locations for the identified VECs, and Figures D2 and D3 show the estimated boundary/footprint for the VEC species identified. As indicated elsewhere in this report, field investigations would be required to further assess the presence/absence of a number of the VEC species identified in order to fully determine the significance of risks. This is considered to represent an information gap.

**TABLE 7-15 Potential Risks to Wetlands Associated With Hazards for Scenarios 1 and 2**

| HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) | | |
|---|---|---|---|
| | HIGH | MEDIUM | LOW |
| **FIRE HAZARD ZONE** | YES | YES<br>Extent of receptors similar compared with high risk area | YES<br>Extent of receptors similar compared with high risk area |
| **FIREBALL HAZARD ZONE** | YES | YES<br>Extent of receptors similar compared with high risk area | YES<br>Extent of receptors similar compared with high risk area |
| **VAPOUR CLOUD** | YES | YES<br>Extent of receptors similar compared with high risk area | YES<br>Extent of receptors similar compared with high risk area |
| **COLD GAS HAZARD** | YES | YES<br>Extent of receptors similar compared with high risk area | YES<br>Extent of receptors similar compared with high risk area |
| **LIQUID LNG ON LAND** | YES | YES<br>Extent of receptors similar compared with high risk area | YES<br>Extent of receptors similar compared with high risk area |
| **SURFACE WATER** | YES | YES<br>Extent of receptors similar compared with high risk area | YES<br>Extent of receptors similar compared with high risk area |

Fisheries resources habitat is also considered to represent sensitive/critical habitat. Several individuals with the DFO were contacted to obtain current information related to fisheries resources in the study area including catches and location of the fisheries resources. Information on commercial fisheries landings (2004) for the fishing districts within the study area was provided (Mary Mills of DFO: May, 2006). It was indicated that there were no maps or coordinates for the recorded landings. Other DFO information sources that were reviewed included Tracy Kerluke (July, 2006) and Rob Stephenson (August 2, 2006). This information request was forwarded to Julie Porter who then forwarded it to Heath Stone. Mr. Stone provided references for landing statistics and provided some additional contact names to gather more information. However, mapping was not available that showed the location of the various resources in the study area and it was indicated that this would require significant effort. The above individuals were provided with information provided in a study completed by Yellow Wood Associates Inc. (June 2006) that showed mapped areas for fisheries resources, and advised that the mapped information was not available. It should be noted that the Yellow Wood study was not verified as part of this study and a request to Yellow Wood has been made to obtain permission to reference the material presented in their study. This is considered to represent an information gap. The locations for fisheries resources based on the information reviewed is shown in Figures D5 and D6, in Appendix C. However, mapping prepared by Yellow Wood Associates Inc. indicates sensitive/critical habitat to essentially be present throughout the study area, with particular reference to commercial fisheries resources.

Potential risks to wetlands, based on sitings in Figure C5 in Appendix C, associated with hazards for Scenarios 1 and 2 are identified in Table 7-16.

### 7.4.10 Potential Risks to Environmentally Sensitive or Significant Areas (ESAs) and Other Critical Habitat Features

A number of ESAs have been identified within the study area and direct marine based ESAs were discussed in Section 4.4. Other areas that are considered to be transitional between the marine environment and inland areas, as well as inland areas are provided in Table 5-7. In most instances, the ESAs identified in this section relate to birds, including migratory birds, shorebirds, and inland birds but also includes plants, fish, and other species at risk. ESAs are identified on Figures C1, C2, C3, C4, C5, A1 and A5, in Appendix A.

**TABLE 7-16. Potential Risks to Sensitive/Critical Habitat Associated With Hazards for Scenarios 1 and 2**

| HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) | | |
|---|---|---|---|
| | HIGH | MEDIUM | LOW |
| **FIRE HAZARD ZONE** | YES<br>Extensive | YES<br>Extent of receptors greater compared with high risk area | YES<br>Extent of receptors greater compared with medium risk area |
| **FIREBALL HAZARD ZONE** | YES<br>Extensive | YES<br>Extent of receptors greater compared with high risk area | YES<br>Extent of receptors greater compared with medium risk area |
| **VAPOUR CLOUD** | YES<br>Extensive | YES<br>Extent of receptors greater compared with high risk area | YES<br>Extent of receptors greater compared with medium risk area |
| **COLD GAS HAZARD** | YES<br>Extensive | YES<br>Extent of receptors greater compared with high risk area | YES<br>Extent of receptors greater compared with medium risk area |
| **LIQUID LNG ON LAND** | YES<br>Extensive | YES<br>Extent of receptors greater compared with high risk area | YES<br>Extent of receptors greater compared with medium risk area |
| **SURFACE WATER** | YES<br>Extensive | YES<br>Extent of receptors greater compared with high risk area | YES<br>Extent of receptors greater compared with medium risk area |

## 7.5 POTENTIAL RISKS TO SOCIO-ECONOMIC ENVIRONMENT.

Potential risks to human receptors were presented in Section 7.4.1. Potential risks are assessed in this section for the following:

- Recreational and commercial fisheries;
- Recreation and tourism; and
- Heritage resources.

### 7.5.1 Recreational and Commercial Fisheries

Recreational activities occur throughout the study area. Commercial fisheries activities include the areas actively fished including areas containing habitat. Commercial fisheries also include the location for salmon grow out sites, herring weirs, and holding facilities such as lobster pounds.

The locations for fisheries resources are shown in Figure C5 and C6, in Appendix C. Several individuals with the DFO were contacted to obtain current information related to fisheries resources in the study area including catches and location of the fisheries resources. Information on commercial fisheries landings (2004) for the fishing districts within the study area was provided (Mary Mills of DFO: May, 2006). It was indicated that there were no maps or coordinates for the recorded landings. Other DFO information sources that were reviewed included Tracy Kerluke (July, 2006) and Rob Stephenson (August 2, 2006). This information request was forwarded to Julie Porter who then forwarded it to Heath Stone. Mr. Stone provided references for landing statistics and provided some additional contact names to gather more information. However, mapping was not available that showed the location of the various resources in the study area and it was indicated that this would require significant effort. The above individuals were provided with information provided in a study completed by Yellow Wood Associates Inc. (June 2006) that showed mapped areas for fisheries resources, and advised that the mapped information was not available. It should be noted that the Yellow Wood study was not verified as part of this study and a request to Yellow Wood has been made to obtain permission to reference the material presented in their study. However, mapping prepared by Yellow Wood Associates Inc. indicates sensitive/critical habitat to essentially be present throughout the study area, with particular reference to commercial fisheries resources. This is considered to represent an information gap.

The locations for fisheries resources based on the information reviewed is shown in Figure C5 and C6, in Appendix C. However, mapping prepared by Yellow Wood Associates Inc. indicates sensitive/critical habitat to essentially be present throughout the study area, with particular reference to commercial fisheries resources.

With respect to a fire hazard, clam beds are considered to be the most susceptible given that the fire may burn for up to an hour and the beds are more susceptible to exposure. The potential risks to fisheries receptors would be expected to be lower during high tides as there is greater opportunity for an avoidance response should the water temperature increase with respect to a fire hazard.

Potential risks to commercial fisheries facilities (salmon aquaculture sites, herring weirs, lobster pounds), based on Figure C6 in Appendix C, associated with hazards for Scenarios 1 and 2 are identified in Table 7-17.

**TABLE 7-17 Potential Risks to Commercial Fisheries Areas Associated With Hazards for Scenarios 1 and 2**

| HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) | | |
|---|---|---|---|
| | HIGH | MEDIUM | LOW |
| **FIRE HAZARD ZONE** | NO | YES<br>Number >10 of receptors compared with high risk area | YES<br>Number >50 of receptors compared with medium risk area |
| **FIREBALL HAZARD ZONE** | NO | YES<br>Number >10 of receptors compared with high risk area | YES<br>Number >50 of receptors compared with medium risk area |
| **VAPOUR CLOUD** | Not applicable | Not applicable | Not applicable |
| **COLD GAS HAZARD** | NO | YES<br>Number >10 of receptors compared with high risk area | YES<br>Number >50 of receptors compared with medium risk area |
| **LIQUID LNG ON LAND** | NO | YES<br>Number >10 of receptors compared with high risk area | YES<br>Number >50 of receptors compared with medium risk area |
| **SURFACE WATER** | NO | YES<br>Number >10 of receptors compared with high risk area | YES<br>Number >50 of receptors compared with medium risk area |

#### *7.5.1.1 Vessel Traffic Noise Issues and Exclusion Zone Considerations*

Boats including recreational watercraft and ships may interact with the aquatic environment by a variety of mechanisms, including emissions and exhaust, propeller contact, turbulence from the propulsion system, waves produced by movement, noise, and movement itself. In turn, each of these impacting mechanisms may have multiple effects on the aquatic ecosystem. Sediment resuspension, water pollution, disturbance of fish and wildlife, destruction of aquatic plants, and shoreline erosion are the major areas of concern.

Water clarity is important as it may affect the ability of fish to find food, the depth to which aquatic plants can grow, dissolved oxygen content, and water temperature. Propellers may disturb the lake or river bottom directly, or indirectly through the wash or turbulence they produce, especially in shallow water. This may affect water clarity by increasing the amount of sediment particles in the water or may cause nutrients that are stored in the sediments, such as phosphorus to become available for algal growth. Waves created by watercraft may contribute to shoreline erosion, which can also cloud the water.

Boats have been shown to affect water clarity and can be a source of nutrients and algal growth in aquatic ecosystems. Shallow areas are the most susceptible to impacts. Depth of impact varies depending upon many factors including boat size, engine size, speed and substrate type. Few impacts have been noted at depths greater than 3m. Based on this, no-wake zones in shallow areas could help to reduce impacts on water clarity.

Dissolved oxygen and pH levels may be affected and influence fish and limit shoreline erosion. In some jurisdictions, boats are restricted from operating at speeds greater than no-wake within 30m from fixed structures such as boat docks and swimming platforms. Many lake communities have established no-wake ordinances at 30m from shore or more.

There have been numerous studies on the effects of outboard motor exhaust and related pollution from fuel leakage (Warner, 1991). In general, studies have shown minimal toxic effects of aquatic organisms because 1) the amount of pollution is small compared to the volume of a lake; and 2) most hydrocarbons are volatile and quickly disperse.

The following is obtained from http://interact.uoregon.edu/medialit/wfae/readings/radle.html:

Most researchers agree that noise can effect an animal's physiology and behaviour, and if it becomes a chronic stress, noise can be injurious to an animal's energy budget, reproductive success and long-term survival. Determining the effect of noise on wildlife is complicated however because responses vary between species and between individuals of a single population. These variable responses are due to the characteristics of the noise and its duration, the life history characteristics of the species, habitat type, season, activity at the time of exposure, sex and age of the individual, level of previous exposure, and whether other physical stresses such as drought are occurring around the time of exposure (Busnel, 1978).

The U.S. Fish and Wildlife Service in cooperation with Ecological Services, field offices, refuges, hatcheries, research centers conducted a survey in January of 1987 that focused on the perceived effects of aircraft noise and sonic booms on fish and wildlife. It was indicated that death of fish occurred for a hatchery in response to intense sonic booms. Specifics on species type was not provided in the excerpt.

Noise, particularly in the oceans, is created by numerous sources such as commercial and military ships, oil exploration, and military and scientific tests. The National Marine Fisheries Service, which enforces the *Marine Mammal Protection Act* of 1972 announced in 1994 that scientists, often in an effort to protect marine life through their research "...contribute to the harassment of these denizens of the deep" (Schulhof, 1994). In agreement with this declaration, the Acoustical Society of America announced in that same year that human-created noise was posing an ever greater threat to the health of marine mammals. To support their position they cited the increasing tendency of whales to become caught in nets in Newfoundland after blasting occurred in an effort to enlarge a channel for tanker travel. Entanglement in the nets suggested that the whales' ability to echolocate had been impaired. Dr. Darlene Ketten, a hearing specialist from Harvard University confirmed this suspicion after finding the ear bones of two whales killed in the blast shattered and the ear canals filled with blood and pus. The National Marine Fisheries Service, partly in response to Ketten's discovery, recommended that a 120 decibel cap be placed on underwater noise in order to minimize the potential injurious effect on whales and other aquatic life. It was also indicated that many researchers were outraged by this demand, asserting that dolphin calls have been recorded at levels of 130 decibels and that a decibel cap would undermine their ability to perform experiments. The cap was not enacted, but the debate over noise in the ocean and other waterways was far from over and to date remains unresolved.

Tom Norris' studies of "The Effects of Boat Noise on the Acoustic Behaviour of Humpback Whales" exemplifies this obstacle of uncertainty. Dr. Norris studied the songs of Megaptera novaegliae as they were introduced to boat noise and discovered that "...boat noise level might affect humpback whale song structure at the most basic level by altering the rhythm or increasing the tempo of songs..." (Norris, 1994). Dr. Norris noted that the significance of these effects, especially on the behaviour of the whales, remains uncertain. Similarly, disagreements among scientists also engender a level of uncertainty. In the 1994 report "Low Frequency Sound and Marine Mammals," a committee appointed by the Ocean Studies Board of the National Academy of Sciences National Research Council scientists could not come to consensus (Holing, 1994). "While it acknowledged that the effects of loud, low frequency sound `could conceivably range between potential hearing damage and gradual deafness for the entire species - and eventual extinction - and practically no discernible impact' the report concluded that a dearth of scientific evidence makes it virtually impossible to predict what those effects will be" (Holing, 1994). While that particular committee made that conclusion, other scientists such as Sylvia Earle, former chief scientist at the National Oceanic and Atmospheric Association, are of a different opinion. Dr. Earle asserted that "each sound by itself is probably not a matter of much concern, but taken all together, it's creating a totally different environment than existed fifty years ago. The high level of noise is bound to have a hard, sweeping impact on life in the sea" (Holing, 1994).

Pattock, in the article, "Cacophony of human-made noise pounds oceans," echoes the uncertainty by posing the question "...how much noise is too much?" Pattock discusses the intensity of noise in the oceans, noting that supertankers, "....the largest human-made source of ocean noise... are so loud they can be heard under water a full day before they appear on the horizon." While the levels of sound are easily measured, the problem again lies in determining the effects of this noise on marine life because "...so little is known about these creatures that scientists cannot say for sure how they are affected by the noise of humans, particularly the cumulative effect of low frequency sound." This knowledge was evident to Peter Schiefele, a researcher at the National Undersea Research Center at the University of Connecticut, as recently as May 1997. Scheifele, in determining whether noise levels in the St. Lawrence and Saugenay Rivers in Quebec are damaging the hearing and capacity of survival for beluga whales indicated that the extent of damage continues to remain unclear. (Chang, 1997).

In March of 1997 a forty foot sperm whale became trapped in the inshore waters of Firth of Forth near Edinburgh, Scotland (Quinn, 1997). Scientists attributed this to traffic noise from the rail and road bridges that traverse the waterway. Although they could not confirm their suspicions, the scientists believed that the clamorous noise made the sperm whale reluctant to return to open waters which eventually caused it to become stranded in the shallows between the bridges. This incident, like many others of its kind provides anecdotal rather than definitive evidence and as such is often dismissed by researchers, policy makers and those responsible for generating the noise.

A study of Personal Water Craft noise versus outboard motor noise on a heavily used lake showed that the actual noise level (in terms of decibels) is much higher than most other types of watercraft (Wagner, 1994). The loudness decreased with distance from the watercraft, such that the sound level was within background levels at distances of 100 metres or more. Therefore, a setback of 100 metres from as aquaculture site may be considered to address potential noise issues.

From this review it is evident that noise is a potential concern for marine life, and is has been indicated that a noise level of 120 decibels may be sufficient to avoid potential adverse impacts on whales and other marine life. It is apparent that the effects on various marine lives is not understood and the noise level of 120 decibels has been established in an effort to address concerns based on science at the time. For this study, there is an interest in identifying setbacks from aquaculture sites, but based on a short review of the literature there is no specific reference to setbacks. Alternatively, the distance from a potential receptor such as an aquaculture site could be established based on an upper noise level reading of 120 decibels. However, it should also be noted that the noise generated from tanker traffic and associated tug boats will be episodic, and potential adverse effects would be minimized compared with chronic noise emissions. It should be further noted that the life span for species raised or contained in aquaculture sites is relatively short term in nature and therefore concerns for long term effects are not as critical.

### 7.5.2 Recreation and Tourism

Recreation and tourism activities are primarily associated with the following:

- whale watching;
- bird watching;
- water sports/adventure activities;

- camping;
- golfing;

Potential risks to recreation and tourism activities, based on Figure C6 in Appendix C, associated with hazards for Scenarios 1 and 2 are identified in Table 7-18.

The significance of risks will be greater during the tourist season.

### 7.5.3 Potential Risks to Heritage Resources

Potential risks to recreation and tourism activities, based on Figure C7 in Appendix C, associated with hazards for Scenarios 1 and 2 are identified in Table 7-19.

## 7.6 ASSESSMENT OF RISKS FOR CUMULATIVE EFFECTS

The full impact of a project on the environment may not be reflected by the individual interactions of project components or activities with VECs. In many cases, individual projects and/or project components produce environmental effects that are insignificant. However, when combined with the effects of other project components, these small effects can become cumulatively important, including consideration of future additional inputs. Air quality and potential risk is an example whereby a cumulative assessment of inputs would normally provide for an improved assessment of potential risks.

## TABLE 7-18 Potential Risks to Recreation and Tourism Associated With Hazards for Scenarios 1 and 2

| HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) | | |
|---|---|---|---|
| | HIGH | MEDIUM | LOW |
| **FIRE HAZARD ZONE** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **FIREBALL HAZARD ZONE** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **VAPOUR CLOUD** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **COLD GAS HAZARD** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **LIQUID LNG ON LAND** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **SURFACE WATER** | Not applicable | Not applicable | Not applicable |

## TABLE 7-19 Potential Risks to Heritage Resources Associated With Hazards for Scenarios 1 and 2

| HAZARD ZONE | RISKS IDENTIFIED (AND COMMENTS) | | |
|---|---|---|---|
| | HIGH | MEDIUM | LOW |
| **FIRE HAZARD ZONE** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **FIREBALL HAZARD ZONE** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **VAPOUR CLOUD** | Not applicable | Not applicable | Not applicable |
| **COLD GAS HAZARD** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **LIQUID LNG ON LAND** | YES | YES<br>Number of receptors greater compared with high risk area | YES<br>Number of receptors greater compared with medium risk area |
| **SURFACE WATER** | Not applicable | Not applicable | Not applicable |

# 8.0 REFERENCES

ABS Consulting 2004. *Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers.* Prepared for the Federal Energy Regulatory Commission under Contract No. FERC04C40196. 131-04 GEMS 1288209. 13 May.

ACER Environmental Services Ltd. 1998. *Environmental Screening Proposed Ferry Wharf, North Head, Grand Manan Island, NB*. Completed by senior Team members that included dredging and ocean disposal and required an assessment of the marine environment over a large area as well as an environmental protection plan that included consideration of emergency measures for releases of hazardous materials.

Anderson, P.G., B.R. Taylor, and G.C. Balch 1996. *Quantifying the Effects of Sediment Release on Fish and Their Habitats*. Can. Manuscript. Rep. Fish. Aquat. Sci. 2346: 110 p. + 3 Append.

Anderson, W. A., H. W. Borns Jr., et al. 1989. Neotectonic activity in coastal Maine, Neotectonics in Maine, Augusta, Maine Geological Survey Bulletin 40, and Anderson, W. A., J. T. Kelley, et al. (1989) Neotectonic activity in coastal Maine: United States of America, Earthquakes at North-Atlantic Passive Margins: Neotectonics and Postglacial Rebound, Kluwer Academic Publishers, will provide information on earthquake and localization of subsidence in eastern coastal Maine, which is occurring at rates of up to at least 5 mm/yr.

Appleby, J.P. and D.J. Scarratt 1989. *Physical Effects of Suspended Solids on Marine and Estuarine Fish and Shellfish with Special Reference to Ocean Dumping: A Literature Review.* Can. Tech. Rep. Fish. Aquat. Sci. 168:v + 33 p.

Bailey, L.W. 1871. *On the Physiography and Geology of the Island of Grand Manan.* Canadian Naturalist, New Series, 6, pp. 43-54.

Bartlett, Bruce 2005. *Maine LNG Proposal filed with Commission*, Telegraph Journal.

Beanlands and Duinker 1983. *An Ecological Framework for Environmental Impact Assessment in Canada.* Institute for Resource and Env. Studies. Dalhousie University, 132 pp.

Berrill, D.G. and D. Berrill 1981. *A Sierra Club Naturalists' Guide: The North Atlantic Coast – Cape Cod to Newfoundland.* Sierra Club Books, San Francisco, CA, 464 p.

Bishai, H. M. 1961. *The Effects of Pressure on the Survival and Distribution of Larval and Young Fish.* Zoology Dept., Faculty of Science, Cairo Univ., Egypt. p. 292-311.

Black & Veatch 2006. *Liquefied Natural Gas (LNG) Import Terminals, Gas, Oils & Chemicals.*

Bliss, D.G. and M.R. Larson 1989. *Extreme Water Level Estimates at 9 Locations in Atlantic Canada.* Proc. Canadian Coastal Conference 1989, Kingston, ON.

Bond et al. 1992. Wetland Evaluation Guide. *Final Report of the Wetlands are not Wastelands Project.* North American Wetlands Conservation Council (Canada). Issues Paper, No. 1992-1. 121 p.

BP 2002. *Global LNG (1999-2002).* British Petroleum. Online: http://www.bplng.com/index.asp.

Brown, M.W. (2002). *Assessing Strategies to Reduce the Potential for Collisions between Right Whales and Ships in Canadian Waters.* Submitted to: Habitat Stewardship Program for Species at Risk - Atlantic Region Canadian Wildlife Service, Environment Canada; World Wildlife Fund Canada/Canadian Wildlife Service Endangered Species Recovery Fund; and World Wildlife Fund US Species Program.. In turn based in part on: Owen, J., Smith, H.D. and Ballinger, R.C. (2001), Fundy Risk Assessment Project (FRAP), Department of Earth Sciences, Cardiff University, Submitted to the World Wildlife Fund US.

Bumpus, D.F. 1959. *Source of Water in the Bay of Fundy Contributed by Surface Circulation.* Report of the International Passamaquoddy Fisheries Board to the International Joint Commission.

Bumpus, D.F., and L. Lauzier 1965. *Circulation on the Continental Shelf Off Eastern North America Between Newfoundland and Florida.* Serial Atlas of the Marine Environment - Folio 7, American Geographical Society.

California Energy Commission 2003. *Liquefied Natural Gas in California: History, Risks and Siting.* Staff White Paper 700-03-005. July.

Campbell, A. 1990. *Aggregations of Berried Lobsters (Homarus americanus) in Shallow Waters Off Grand Manan, Eastern Canada.* Can. J. Fish. Aquat. Sci. 47: 520-523.

Canadian Coast Guard 1994. *Eastport Ship Terminal System, Accessibility and Ship Safety, Preliminary Analysis and Assessment, Ship Safety ~ Nautical Division.*

Canadian Environmental Assessment Agency 1994. *Responsible Authorities Guide.*

Canadian Hydrographic Service 2006. *Notice to Mariners 1 to 46. Annual Edition April 2006.* Fisheries and Oceans Canada, Catalogue No. Fs151-4/2006E, Ottawa.

Available on Internet at:
http://www.notmar.com/go.php?doc=eng/services/2006_annual_e/table_of_contents_e

*Canada Shipping Act*, Collision Regulations, CRC, Vol. XV, c. 1416.

Available on Internet at:

http://www.tc.gc.ca/acts-regulations/GENERAL/C/csa/regulations/010/csa014/csa14.html

Caswell, H., M. Fujiwara, M. and Brault, S. 1999. *Declining Survival Probability Threatens the North Atlantic Right Whale.* Proceedings of the National Academy of Science USA, 96, 3308–3313.

Chang B. D., Stephenson RL, Wildish DJ, Watson-Wright WM. 1995. *Protecting Regionally Significant Marine Habitats in the Gulf of Maine: a Canadian Perspective.* Pages 121-146 in: Improving interactions between coastal science and policy. Proceedings of the Gulf of Maine Symposium, Kennebunkport ME, 1-3 November 1994. National Academy Press, Washington DC.

Chevrier, J.R. 1959. *Drift Bottle Experiments in the Quoddy Region.* Report of the International Passamaquoddy Fisheries Board to the International Joint Commission.

Christie, D. 1983 Birds. *In Thomas, M.L.H. {ed.}, 1983 Marine and Coastal Systems of the Quoddy Region, New Brunswick, Department of Fisheries and Oceans, Ottawa, ON*, pp. 215-229.

Clapman, P.J. 2002. *Are Ship-Strike Mortalities Affecting the Recovery of the Endangered Whale Populations off North America? P 13-15.* Proceedings of the Workshop: Collisions Between Cetaceans and Vessels: Can we Find Solutions? ECS Newsletter No. 40 - Special Issue.

Coastal Oceanography Division, Atlantic Oceanographic Laboratory, Coastal Oceanography Division 1973. *Atlantic Oceanographic Laboratory.* Some physical environmental factors relevant to spilled oil in the vicinity of Eastport, Maine, U.S.A.

Contant, C.K. and L.L. Wiggins 1991. *Defining and analyzing cumulative environmental impacts*. Environmental Impact Assess. Rev. 1991; 11:297-309.

Cooper, R.A., and J.R. Uzmann 1980. *Ecology of Juvenile and Adult Homarus*. pp. 97-142 in J.S. Cobb and B.F. Phillips, eds. The biology and management of lobsters, Vol. II. Academic Press, New York.

COSEWIC, 2003. Annual report.

Department of External Affairs, 1976. Eastport, No. 133.

DFO Stock Status Reports.

Dickert. T.G., and A.E. Tuttle 1985. *Cumulative Impact Assessment in Environmental Planning: A coastal wetland watershed example.* Environmental Impact Assessment Review 5:37-64.

Dilworth, 1984; Anonymous, 1993a. Land Mammals of New Brunswick. Unipress Ltd. 228p.

DNV Piblado RM, J Baik, G J Hughes, et al. 2004. *Consequences of LNG Marine Incidents, CCPS Conference Summary Orlando June 29-July 1.*

Donnelly, J.P. 1976. *A Sanitary Survey of Grand Manan, Campobello and Deer Islands.* Environmental Protection Service, Environment Canada. Surveillance Report EPS-5-AR-76-14.

Dr. Fred Page, Fisheries and Oceans Canada, St. Andrews Biological Station, personal communication, 1997 in ACER, 1997.

Environment Canada 1995. *Users Guide to the Application Form for Ocean Disposal.* Marine Environment Division, Environmental Protection Service. Report EPS 1/MA/1.

Environment Canada 1988. *New Brunswick Hydrometric Network Evaluation.* Background Report No. 2, delineation of physiographic - climatic zones.

Environment Canada 1996. *Air Quality Regulation Under the Clean Environment Act.* Regulation 83-208.

Environmental Protection Agency (EPA) 1999. *Wildlife and Oil Spills.* In Understanding Oil Spills and Oil Spill Response. United States Environmental Protection Agency, Office of Emergency and Remedial Response. pp49, EPA 540-K-99-007, Oswer 9200.5-104A, PB2000-963401.

Federal Register: August 9, 2000 (Volume 65, Number 154).

Fenety 1997. *In St. Croix Estuary Project, St. Croix Estuary Area, A Profile*, March 1977.

Federal Energy Regulation Commission (FERC) 2003. *Final Environmental Impact Statement.* Hackberry LNG Project, produced by the FERC Office of Energy Projects, Washington, DC 20426, August 2003.

Fisheries and Oceans Canada 1991. *Hydrographic Chart L/C 4340.* Bay of Fundy - Grand Manan. Corrected through notices to mariners, Edition 09 February 28, 1997.

Fisheries and Oceans Canada 1981. *Atlas of Tidal Currents - Bay of Fundy and Gulf of Maine.* 36 p.

Fisheries and Oceans Canada 1990. *Sailing Directions.* Nova Scotia (Atlantic Coast) and Bay of Fundy.

Fisheries Research Board of Canada 1974. *Summary of Physical, Biological, Socio-Economic and Other Factors Relevant to Potential Oil Spills in the Passamaquoddy Region of the Bay of Fundy,* Technical Report No. 428.

Forgeron, F.D. 1959. *Temperature and salinity in the Quoddy Region.* International Passamaquoddy Fisheries Board Report to the International Joint Commission. Append. I, Oceanography, Chapter 1.

Fujiwara, M. and H. Caswell 2001. *Demography of the Endangered North Atlantic Right Whale.* Nature,414, 537–541.

Fundy North 2006. *Fisherman's Association.*

Gaskin, D.E. 1982. *The Ecology of Whales and Dolphins.* Heinemann, London and Exeter, pp 1 - 428.

Gaskin, David 1977. Personal communication: August 1977, in USEPA, undated.

Georgia Environmental Policy Institute 2006. *Right Whale in Bay of Fundy Hit by Ship, in Right Whale News, Georga Environmental Policy Institute*. pp.13.

Goldbogen, J.A., Calambokidis, J., Shadwick, R.E., Oleson, E.M., McDonald, M.A., and Hildebrand J.A. 2006. *Kinematics of Foraging Dives and Lunge-feeding in Fin Whales.* The Journal of Experimental Biology 209: 1231-1244.

Graettinger, D. 2006. *Tribal group links fates of LNG, whales. Bangor Daily News* (See Appendix sc).

Graham, J.J. 1970. *Coastal currents of the Western Gulf of Maine*. International Commission for the Northwest Atlantic Fisheries.

Gray, William O., Jennifer Waters, Alan Blume, and Alexander C. Landsburg 2002. Channel Design and Vessel Manoeuvrability – Next Step. *When Ships Get Too Big for Their Ditches.*

Greenberg, D.A., J.A. Shore, F.H. Page, and M. Dowd 2005. *A Finite Element Circulation Model for Embayments with Drying Intertidal Areas with Application to the Quoddy Region of the Bay of Fundy.* Ocean Modelling 10(1-2):211-231

Greene, C.H. and A.J. Pershing 2004. *Climate and the Conservation Biology of North Atlantic Right Whales: Being a Right Whale at the Wrong Time?* Frontiers in Ecology and the Environment, 2.

Greene, C.H., Pershing, A.J., Robert D. Kenney, R.D. and Jack W. Jossi, J.W. 2003. *Impact of Climate Variability on the Recovery of Endangered North Atlantic Right Whales*. Oceanography, 16: 4.

Guptil, J. 2005. *Whale Watch Operator and Commercial Fisherman.*

Hachey in Pittston 1952.

Harvey J. and friends of the Bay of Fundy 1994. *Turning the Tide: A Citizen's Action Guide to the Bay of Fundy.* Conservation Council of New Brunswick, Fredericton, NB 88 p.

Hightower, M., J. Covan et al. 2004. Paper on: *Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water.* December.

Hinds, H.R. 1983. *The Coastal Forest of the Passamaquoddy Bay Area.* In Thomas, M.L.H. {ed.} 1983, Maine and Coastal Systems of the Quoddy Region, New Brunswick. Department of Fisheries and Oceans, Ottawa, ON, pp. 269-276.

Hinterland Who's Who 2004 (http://www.hww.ca/hww2p.asp?id=31&cid=7).

Horsley & Witten, Inc. no date.

HSE UK Health and Safety Executive 1978. *CANVEY, an Investigation of Potential Hazards in the Canvey Island / Thurrock area.*

HSE 1981. *CANVEY, a Second Report, a Review of Potential Hazards in the Canvey Island / Thurrock Area Three Years After the Publication of the Canvey Report.*

Hunter and Associates 1982. *Coastal zone management study - Bay of Fundy, New Brunswick*. Prepared for Minerals Resources Branch, New Brunswick Department of Natural Resources.

Johnson, D.W., and D.J. Wildish 1981. *Avoidance of Dredge Spoil by Herring (C. harengus harengus).* Bull. Env. Contam. Toxicol. 26: 307-314.

Johnston D.W., L. H. Thorne L.H. and Read, A.J. 2005. *Fin Whales Balaenoptera physalus and Minke Whales 562.* Balaenoptera acutorostrata \exploit a tidally driven island wake ecosystem in the Bay of Fundy. Mar Ecol Prog Ser. 305: 287–295.

Kelly 1993 in St Croix Estuary, 1997.

Kenney, R.D., Winn, H.E., and Macaulay, M.C. 1995. *Cetaceans in the Great South Channel, 1979-1989: Right Whale (Eubalaena glacialis).* Continental Shelf Research 15: 385-414.

Kindrasky, G.A. and M. Debellefeuille 1967. *Bacteriological survey Grand Manan, NB. 48 (Long Island Bay), 1966*. Division of Public Health Engineering, Department of National Health and Welfare. Manuscript Report No. 67-12.

Kobriger, N.P., T.V. Dupuis, W.A. Kreutzberger, F. Stearns, G. Guntenspergen, and J.R. Keough 1983. *Guidelines for the Management of Highway Runoff of Wetlands.* National Cooperative Highway Research Program Report 264.

Kraus, S.D., Brown, M.W., Caswell, H., Clark, C.W., Fujiwara, M., Hamilton, P.K., Kenney, R.D., Knowlton, A.R., Landry, S.,.Mayo, C.A., McLellan, W.A.,.Moore, M.J., Nowacek, D.P., Pabst, D.A., Andrew J. Read, A.J., and Rolland, R.M. 2005. *North Atlantic Right Whales in Crisis*. SC. 309: 561 - 562.

Laist, D.W., Knowlton, A.R., Mead, J.G., Collett, A.S., and Podesta, M. 2001. *Collisions Between Ships and Whales*. Marine Mammals Science 17: 35 - 75.

Lauzier, L.M. 1967. *Bottom Residual Drift on the Continental Shelf Area of the Canadian Atlantic Coast.* J. Fish. Res. Board Can. 24: 1845-1859.

Lawton, P. and D.A. Robichaud. In Preparation. *Summer Distribution of Berried Lobsters (Homarus americanus) Off Grand Manan Island, and Potential Conflict with Salmon Aquaculture.* Draft Manuscript.

Linkletter, L.E., E.I. Lord, and M.J. Dadswell 1977 and Marine Research Associates Ltd. *A Checklist of Marine Fauna and Flora of the Bay of Fundy.* The Huntsman Marine Laboratory, St. Andrews, NB. 68p.

Loring, D.H. 1979. *Baseline Levels of Transition and Heavy Metals in the Bottom Sediments of the Bay of Fundy.* Proc. NS Inst. Sci. (1979) Vol. 29:335-346.

Louches in Pittston 1973.

MacAleenan, J, 2005. *Fisherman, Manager, Builder.*

MacKay, A, 2005. *LNG Tankers (Provisional Title), St. Croix Estuary Project Report.* The report provides a list of and specifications for all LNG tankers in use and/or being built as of 2005.

MacKay, A. 1996. Cited.

MacKay, A.A. 2006. *Regulating Protection of the Quoddy Region* - Using a precautionary approach to the development of the Quoddy Region, Charlotte County, New Brunswick, Canada, VOLUME 2 SHIPPING. St. Croix Estuary Project Inc, St. Stephen, N.B.

MacKay, A.A., Jennifer Cameron, Mark Bader 2003. *The St. Croix Estuary 1604-2004.* The Environmental Health of the St. Croix Estuary after 400 years. St. Croix Estuary Project Inc, St. Stephen, N.B. The report includes a detailed study of the water column, biota, contaminants, nutrients, etc. The study area included two of the three proposed LNG Terminal sites.

MacKay, A.A., R.K. Bosien, and P. Leslie 1979. *Bay of Fundy Resource Inventory.* Vol. 4, the Grand Manan Archipelago. Marine Research Associates Ltd. Final report to the New Brunswick Department of Fisheries.

MacKenzie, C., J.R. Moring and L. Shanks 1985. *Species Profiles: Life Histories and Environmental Requirements of Coastal Fisheries and Invertebrates (North America) -- American Lobster.* U.S. Fish and Wildlife. Serv. Biol. Rep. 82 (11.33). U.S. Army Corp of Engineers, TR EL-82-4, 19 pp.

Maine Coastal Program 1991. The Estuary Book. Maine State Planning Office, Augusta, ME, 48 p.

McLeod, M.J., S.C. Johnson, and A.A. Ruitenberg 1994. *Geological Map of Southwestern New Brunswick*. New Brunswick Department of Natural Resources and Energy, Mineral Resources, Map NR-5.

Messieh, S.N., D.J. Wildish, and R.H.J. Peterson 1981. *Possible Impact of Sediment from Dredging and Spoil Disposal on the Miramichi Bay Fishery.* Can. Tech. Rep. Fish. Aquat. Sci. No. 1008.

M-I. Buzeta, J. Davies, M. Janowicz, D.R. Duggan, D. Campbell and R. Singh 2002. *Integrated Marine Planning in the Coastal Zone of Southwest New Brunswick,* Report from the First Focus Meeting, Pennefield, NB, Oceans and Habitat Branch Maritimes Region, Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth, NS B2Y 4A2, 2003, Canadian Manuscript Report of Fisheries and Aquatic Sciences 2682.

M-I. Buzets, R. Singh and S. Young-Lai 2003. *Identification of Significant Marine and Coastal Areas in the Bay of Fundy, Oceans and Coastal Management Division, Fisheries and Oceans Canada, St. Andrews's Biological Station, St. Andrews, NB.* Canadian Manuscript Report of Fisheries and Aquatic Sciences 2635.

Mills, Mary, Commercial Data Division, Fisheries and Oceans Canada, St. Andrews, NB, personal communication 2006.

Moore, Alan (Sr.) and Robert Kopka 2006. *Quoddy Bay LNG Meeting, Campobello Island*. Comments and Responses of US Officials.

Morris, Chris (Canadian Press) 2006. *LNG Developer Says US Won't Back Down from Sending Tankers Through Canadian Waters Off Southern NB.*

Morrison, Gerald 2005. E-mail to Capt. Bob Peacock, Capt. James Matthews and Lt. Dan McLean, dated August 29, 2005, 9:29 am. Vessel Traffic Information.

Mossman, J. 2006. *The Assessment of Local Tide in the Displacement of Whales in the Southern Bay of Fundy.* In partial completion of the Honours Bachelor of Science Degree, Dalhousie University, NS.

NEG/ECP 2001. *Climate Change Action Plan 2001.* Committee on the Environment and the Northeast International Committee on Energy, August 2001.

Neu, H.A. 1972. *A Preliminary Assessment of the Hydrodynamics in the Area of the Planned Lorneville Superport*. Lorneville Environmental Impact Study Vol. 2, Depart. of Environment, Canada. Pp. 210-234.

Neu, H.J.A., and P.E. Vandall, Jr. 1976. *Review of the Environmental Forces for the Design of the Tiner Point Oil Terminal.* Bed. Inst. Oceanogr. Rep. Ser./BI-R-76-7: 19p.

New Brunswick Department of Natural Resources 1994. Data from New Brunswick N*atural Areas Inventory.*

New Brunswick Department of the Environment 1992. *Guideline for the Assessment and Remediation of Contaminated Sites.*

New Brunswick Department of the Environment 1997. *Guideline for the Application and Removal of Protective Coatings.*

New Brunswick Department of Transportation 1995. *Environmental protection plan.*

Newcombe, C. P. 1994. *Suspended Sediment in Aquatic Ecosystems: Ill Effects as a Function of Concentration and Duration of Exposure.* Habitat Protection Branch. British Columbia Ministry of Environment, Lands and Parks. Victoria, British Columbia, Canada 298 pg.

OTA (Office of Technology Assessment (US Congress)) 1977. *Transportation of Liquefied Natural Gas, NTIS order #PB-273486.* Online: http://www.princeton.edu/cgi-bin/byteserv.prl/-ota/disk3/1977/7712/771203.PDF.

Owen House 2005. E-mail, dated November 9, 2005, 3:47 pm. Background.

Owen House 2005. E-mail, dated November 9, 2005, 7:51 pm. Overlapping Jurisdiction.

Page, F.H., B.D. Chang and D.A. Greenberg 2004. *Fish Health and Oceanography Project of the Aquaculture Collaborative Research and Development Program: Final Project Report.* Can. Tech. Rep. Fish. Aquat. .Sci. 2543: vi + 47 p.

Page, Fred, Fisheries and Oceans Canada, St. Andrews Biological Station, personal communication, 1997 in ACER, 1997.

Panigada, S., and Podestá, M. Greco, S., and Rosso, M., 2006. *Update on Ship Strikes Events in Italian Waters Between 2002 and 2005*. J. CETACEAN RES. MANAGE. (In Press).

Parks Canada, Tourism New Brunswick 1985. *Recommended Resource Management Guidelines for the Proposed National Marine Park in the West Isles, New Brunswick, West Isles Feasibility Study, A Study to Assess the Feasibility of Establishing a National Marine Park in the West Isles Area of the Bay of Fundy, New Brunswick, Task Report.*

Parks Canada, Tourism New Brunswick 1984. *Analysis and Summary of Public Comments from Open Houses and Public Meeting, June 1984, West Isles Feasibility Study, A Study to Assess the Feasibility of Establishing a National Marine Park in the West Isles Area of the Bay of Fundy, New Brunswick, Task Report.*

Parks Canada, Tourism New Brunswick 1985. *Historical / Archaeology Concerns and Opportunities in Western Charlotte County, New Brunswick, West Isles Feasibility Study, A Study to Assess the Feasibility of Establishing a National Marine Park in the West Isles Area of the Bay of Fundy, New Brunswick, Task Report.*

Parks Canada, Tourism New Brunswick 1985. *West Isles Feasibility Study, A Study to assess the Feasibility of Establishing a National Marine Park in the West Isles Area of the Bay of Fundy, New Brunswick, Phase 1 Report.*

Patin, S. (Translator: Elena Cascio, Ph.D.) 1999. *Environmental Impact of the Offshore Oil and Gas Industry.* Ecomonitor.

Patin, Stanislay (Translated by Elena Cascio) 1999. *Environmental Impact of the Offshore Oil and Gas Industry*. Ecomonitor Pub, pp 448.

Peterson, E.B., Y. -H. Chan, N.M. Peterson, G.A. Constable, R.B. Caton, C.S. Davis, R.R. Wallace, and G.A. Yarranton 1987. *Cumulative Effects Assessments in Canada: An agenda for Action and Research.* Canadian Environmental Assessment Research Council, Canada: Minister of Supply and Services.

Peterson, R.H. 1987. *Influence of Water pH on Frequency of Collection of Certain Invertebrates During Lake and Stream Surveys in New Brunswick and Nova Scotia.* Canada. Dept. of Fisheries and Oceans. Biological Station (St. Andrews, N.B.). 7 p.

Pitblado, R. M., J. Baik, G. J. Hughes, C. Ferro, and S. J. Shaw 2004. *Consequences of LNG Marine Incidents*. Proceedings of the CCPS Conference, 29 June to 1 July, 2004, Orlando, Florida.

Quoddy Bay LNG Undated. *LNG & the Environment, Website – www.quoddylng.com*

Quoddy Bay LNG Undated. *Safety & Security, Website – www.quoddylng.com.*

Quoddy LNG 2005. *Preliminary Navigations/Waterways Analysis and LNG Safety Review for LNG Receiving Terminal at Point Pleasant, Maine*. TRC Customer Focused Solutions. A consultants report prepared for the proponents of one of the Terminals.

Quoddy Region Bibliography: *All Studies with Sampling Sites in the Region are Included in this Bibliography*. General studies of resident species are not included unless at least part of the work addresses the species distribution or ecology within the region.

R.S.C., 1985. *Fisheries Act.*

Rampton, V.N. 1984. *Surficial geology, New Brunswick.* Geological Survey of Canada, Map 1594A. Geologic Survey of Canada.

Rampton, V.N., R. C. Gauthier, J. Thibault, and A.A. Seaman 1984. *Quaternay Geology of New Brunswick.* Geological Survey of Canada, Memoir 416, 77 p.

Robichaud, D.A. and P. Lawton. (In Preparation). *Summer Habitat use by Lobsters Off Grand Manan, NB.* Draft Manuscript.

Robinson S. M. C., Martin J.D., Page F.H., Losier R. 1996. *Temperature and Salinity Characteristics of Passamaquoddy Bay and Approaches Between 1990 and 1995.* Can. Tech. Rep. Fish. Aquat. Sci 2139:59.

Robinson, Dr. Shawn and Art MacIntyre 1993. *Sea Urchin Population Survey of Campobello Island, Deer Island and Grand Manan.* Department of Fisheries and Oceans Biological Station. Sponsored by: Campobello Fisherman's Association, The Canada-New Brunswick Cooperation Agreement on Fisheries & Aquaculture Development.

Save Passamaquoddy Bay 2005. *Liquified Natural Gas Proposals for Passamaquoddy Bay* (Non-technical opposition articles).

Scarratt, D.J. 1979. *Department of Fisheries and Oceans Biological Station, St. Andrews, NB, Evaluation of Recent Data Relative to Potential Oil Spills in the Passamaquoddy Area*. Fisheries and Marine Services, Technical Report No. 901.

Scattergood, L.W. and S.N. Tibbo 1959. *The Herring Fishery of the Northwest Atlantic.* Bull. Fish. Res. Board Can. 121, 42 pp.

Scherman, W.S. and Booye, S. I. 2005. *Request to Initiate Pre-Filing Process, Quoddy Bay L.L.C., Quoddy Bay LNG Import and Regasification Terminal Project (FERC PF06-1).* Skadden, Arps, Slate, Meagher & Flora LLP. The documents filled by one of the proponents initiating the Federal Energy Regulator Commission (FERC) pre-filing review of Quoddy Bay's proposed Quoddy Bay LNG import and regasification terminal project.

Schom. (Personal observation) Author of the section *Whales of the Quoddy.*

Scott, Andy (Hon.) 2005. Letter to Greg Thomson, MP, Minister of Veterans Affairs regarding the construction of Liquid Natural Gas (LNG) terminals in Passamaquoddy Bay.

Sherk, J.A., J.M. O'Conner, and D.A. Neumann 1974. *Effects of Suspended and Deposited Sediments on Estuarine Environments.* In: L.E. Cronin (ed.) Estuarine Research, Volume II, Geology and Engineering. Academic Press Inc., NY: 541-558.

Short, Allen, Well Driller, personal communication 1997.

Shuldiner, P.W., D.F. Cope, and R.B. Newton 1979a. *Ecological Effects of Highway Fills on Wetlands*. Research Report. National Cooperative Highway Research Program Report 218a.

Shuldiner, P.W., D.F. Cope, and R.B. Newton 1979b. *Ecological Effects of Highway Fills on Wetlands. User's Manual.* National Cooperative Highway Research Program Report 218b.

Small, Burton, Weir Fisherman, Woodwards Cove, Grand Manan, NB, personal communication, 1997.

Smith, 1944, in St. Croix Estuary Project 1997.

St. Croix Estuary Project 1997. St. Croix Estuary Area, A Profile.

Steel, J. 1996 and 1995. Cited (Marine Educator).

Stickney, A.P. 1969. *Factors Influencing the Attraction of Atlantic Herring, Clupea harengus, to Artificial Lights.* Fishery Bulletin 68(1): 73-85.

Stickney, A.P. 1972. *The Locomotor Activity of Juvenile Herring (Clupea harengus harengus L.) in Response to Changes in Illumination.* Ecology 53(3): 438-445.

TERMPOL Review Process 2001. *Transport Canada, Marine Safety.* TP743E. January.

Termpol Review Process 2001. TP743E.

The Evening Times-Globe 1973. *Saint John, NB, Barnes Expresses Concern Over Pittston Proposal, NB Fishing*, Tourism Threat Cited.

The Geographer, Office of the Geographer, Bureau of Intelligence and Research 1992. *Limits in the Seas, No. 112, United States Responses to Excessive National Maritime Claims.*

The St. Croix Estuary Project, Eastern Charlotte Waterways Inc., West Isles Clean Environment Association Inc., and Fisheries and Oceans Canada 1995. *Charlotte County - Passamaquoddy Bay coastal resources mapping project.* Chart 5 - Grand Manan, Map 44 and 46.

Thomas, M.L.H. [ed.} 1983a. *Marine and coastal systems of the Quoddy Region, New Brunswick.* Canadian Special Publication of Fisheries and Aquatic Sciences 64.

Thomas, M.L.H. 1983b. *Tide Pool Systems*. In Thomas, N.L.H. {ed.} 1983 Marine and Coastal Systems of the Quoddy Region, New Brunswick. Department of Fisheries and Oceans, Ottawa, ON, pp. 95-106.

Thomas, M.L.H. 1989. *Introducing the Sea.* Huntsman Marine Science Centre, St. Andrews, NB, 112 p.

Thompson, Greg 2006. Letter to His Worship John Craig Council & Citizens, Town of St. Andrews. Issues facing the Community is the proposed Liquefied Natural Gas (LNG) Terminals on the US side of Passamaquoddy Bay.

Tims, Jane, NBDOE, personal communication 2006.

TRC Customer-Focused Solutions, LNG Serviced Undated.

TRC Customer-Focused Solutions, Pipeline Services Undated.

Trifts, J. 1994. *St. Croix Estuary Project, based on information from Canadian Wildlife Service's Wetland Atlas.*

Trigom 1973. Research Institute of the Gulf of Maine. *Literature Review of the Marine Environmental Data for Eastport, Maine.* Vol. I and II.

Trites, R.W. and J.R. Garrett 1983. *Physical Oceanography of the Quoddy Region.* pp 9-34 in Thomas, M.L.H. (ed.), 1983. Marine and coastal systems of the Quoddy Region, New Brunswick. Canadian Special Publication of Fisheries and Aquatic Sciences 64.

Tscherter, U. 2003. Personal Communication, Director, Ocean Research and Education Society.

U.S. Environmental Protection Agency Undated. *Volume III, Supplemental to Appendices Environmental Impact Statement, Proposed Issuance of Federal Permits to The Pittston Company of New York for the Construction of a 250,000 Barrel/Day Oil Refinery and Marine Terminal – Eastport, Maine.*

U.S. Federal Energy Regulatory Commission 2004. *Notice of Availability of Staff's Responses to Comments on the Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers.* Docket No. AD04-6-000. 18 June.

U.S. Fish and Wildlife Service, Gulf of Maine Project and Gulf of Maine Council on the Marine Environment, 1994.

University of Houston Law Centre 2003. *LNG Safety and Security.* Institute for Energy Law & Enterprise. October.

US Department of Homeland Security, United State Coast Guard 2005. *The Coast Guard Journal of safety at Sea PROCEEDINGS of the Marine Safety & Security Council, Fall 2005*. Liquefied Natural Gas, Ensuring its safe and secure marine transportation.

US Environmental Protection Agency. *Volume II, Final Environmental Impact Statement, Proposed Issuance of Federal Permits to The Pittston Company of New York for the Construction of a 250,000 Barrel/Day oil Refinery and Marine Terminal-Eastport, Maine.*

Ward-Geiger, L.I.; Silber, G.K.; Baumstark, R.D.; Pulfer, T.L, 2005. *Characterization of Ship Traffic in Right Whale Critical Habitat*. Coastal Management 33:.263-278.

Wells, P., 2005. Scientist, Environment Canada.

Wildish, D.J., A.J. Wilson, and H. Akagi 1977. *Avoidance by Herring of Suspended Sediment from Dredge Soil Dumping*. International Council for the Exploration of the Sea Paper C.M. 1977/E:11.

Wright, D. G. 1982. *A Discussion Paper on the Effects of Explosives on Fish and Marine Mammals in the Water of the Northwest Territories.* Can. Tech. Rep. Fish. Aquat. Sci. No. 1052.

Wright, D.G. 1995. *Guidelines for the use of Explosives in Canadian Fisheries Waters.* Can. Tech. Rep. Fish. Aquat. Sci. vi + 25p.

Wright, D.G. In Preparation. *The Effects of the use of Explosives on Fish and Marine Mammals, Including Models to Predict their Impact and Mitigation Strategies to Reduce the Effect on Fish and Marine Mammals.* Draft Manuscript.

Yellow Wood Associates. *Socio-Economic Analysis of the impact of LNG Terminal(s) on the Three Nations (Provisional Title) describes the socio-economic impact of the LNG Terminals on Canadians, Americans and Native people.*

# APPENDIX A
# DETAILED TABLES AND FIGURES

**TABLE A1. Origin-destination data for ferries in 2005. Source: Maritime Innovation, from CCG data.**

| Origin / Destination | Blacks Harbour | North Head | Butler Point Harbour | Deer Island point Harbour | Eastport Harbour (Maine) | Leonardville Harbour | Letang Harbour | Letete Harbour | Wilsons Beach Harbour | St. Andrews | Saint John | Welshpool Harbour | Fundy Bay | Frye Island Harbour | Bliss Island Harbour | Sea | Selected area | Bayside | Seely's Cove Harbour | Head harbour | Upper Bay of Fundy Fishing Area | Chocolate Cove Harbour | Westport Harbour | Liverpool | Friars Road Anchorage | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **North Head** | 944 | 1 | 4 | | | | 5 | 2 | | | | | | | | | | | | | | | | | | 956 |
| **Blacks Harbour** | 52 | 460 | | | | 17 | 5 | | 3 | | | | 5 | 1 | 3 | | | | | 1 | 1 | | | | | 548 |
| **Butler Point Harbour** | | 6 | 70 | | | | | 1 | | | | | | | | | | | | | | | | | | 77 |
| **Deer Island point Harbour** | | | | 64 | 4 | 1 | | 2 | | | | 1 | | | | | | | | | | | | | | 72 |
| **Eastport Harbour (Maine)** | | | | 2 | 55 | | | | | | 4 | | | | | | | | | | | | | | | 61 |
| **Leonardville Harbour** | | | | 1 | | 6 | 15 | 11 | 1 | | | | | 3 | | | | | 1 | | | | | | | 38 |
| **Letang Harbour** | | 3 | 3 | | | 17 | 1 | | 1 | | | | | | | | | | | | | | | | | 25 |
| **Letete Harbour** | | 2 | | 1 | | 11 | 1 | | 7 | | | | | | | | | | | | | | | | | 22 |
| **Saint John** | | 2 | | | 4 | | | | | 1 | 1 | | | | | 2 | | | | | | | | | | 10 |
| **Welshpool Harbour** | | | | 1 | | | | | | 1 | | 6 | | | | | | | | | | | 1 | | | 9 |
| **Wilsons Beach Harbour** | | | | | | | | 7 | | | | | | | | | | | | | | | | 1 | | 8 |
| **Beaver Harbour** | | 1 | | | | 5 | | 1 | | | | | | | | | | | | | | | | | | 7 |
| **St. Andrews** | | | | | | | | | | 6 | | | | | | | | | | | | | | | | 6 |
| **Sea** | | | | | 1 | | | | | 1 | 2 | | | | | | 1 | | | | | | | | | 5 |
| **Frye Island Harbour** | | | | | | 3 | 1 | | | | | | | | | | | | | | | | | | | 4 |
| **White Head Harbour** | 3 | | | | | | | | | | | | | | | | | | | | | | | | | 3 |
| **Friars Road Anchorage** | | | | | | | | | | | 1 | | | | | | | | | | | | | | 1 | 2 |
| **Chocolate Cove Harbour** | | | | | | | | | 1 | | | | | | | | | | | | | 1 | | | | 2 |
| **Seely's Cove Harbour** | | | | | | 2 | | | | | | | | | | | | | | | | | | | | 2 |
| **Upper Bay of Fundy Fishing Area** | 2 | | | | | | | | | | | | | | | | | | | | | | | | | 2 |
| **Head harbour** | 1 | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| **Bayside** | | | | | | | | | | | | | | | | | | 1 | | | | | | | | 1 |
| **Bliss Island Harbour** | | | | | | 1 | | | | | | | | | | | | | | | | | | | | 1 |
| **Total** | **1002** | **475** | **77** | **69** | **64** | **63** | **28** | **24** | **13** | **9** | **8** | **7** | **5** | **4** | **3** | **2** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | 1862 |

**TABLE A2. Origin-destination data for fishing boats in 2005. Source: Maritime Innovation, from CCG data.**

| Origin / Destination | Blacks Harbour | Butler Point Harbour | Leonardville Harbour | North Head | Beaver Harbour | Sea | Saint John | Eastport Harbour (Maine) | Dipper Harbour | Letang Harbour | Ingalls Head Harbour | Bayside | Upper Bay of Fundy Fishing Area | Bliss Island Harbour | Digby | Letete Harbour | Fairhaven Harbour | Lepreau Harbour | Ministers Island Harbour | Westport Harbour | Yarmouth | Pictou | Davidson Harbour | Woods Island Harbour | Deer Island point Harbour | Frye Island Harbour | Seal Cove Harbour | Fundy Bay | Long Island Fishing area | Whiffen Head | Cap Aux Meules | Head harbour | Friars Road Anchorage | Selected area | Corner Brook | Pocologan Island Harbour | Port Hawkesbury | Chedabucto Bay | Minas Basin Anchorage | Fishing South | Tiverton Harbour | Chocolate Cove Harbour | Dartmouth | Meteghan | Wilsons Beach Harbour | Fishing West | Halifax | Maritime Voluntary R.P. 3 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Blacks Harbour | 98 | | 218 | 91 | 160 | 2 | 18 | 35 | 39 | 29 | 12 | | 26 | 20 | 7 | 3 | 4 | 1 | 6 | 9 | 5 | | 1 | 3 | | 3 | 2 | | | | | 1 | 1 | | | | 1 | | | | | | | | | | | | 795 |
| Butler Point Harbour | 2 | 498 | | | 1 | | | | | | | 1 | | | | 2 | | | | | | | | | | | | 1 | | | | | | 1 | | | | | | | | | | | | | | | 506 |
| Saint John | 120 | | | 5 | 2 | 85 | 18 | | | | | | | | | | | 1 | | | 1 | | | | | | | | | 1 | | | | | | | | | 1 | | | | | | | | | | 234 |
| Leonardville Harbour | 137 | 2 | 3 | | 4 | | | 27 | | | 1 | 2 | | 1 | 3 | | 13 | | 2 | | | | 1 | | 2 | | 1 | | | | | | | | | | | | | 1 | | | | | | | | | 200 |
| North Head | 3 | | | 120 | | | 4 | | | | 16 | 2 | | | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | 1 | | 1 | 150 |
| Beaver Harbour | 75 | | | 1 | 8 | | | | 3 | 23 | | | | | 2 | 2 | | 2 | 6 | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 124 |
| Eastport Harbour (Maine) | 58 | | | | | 30 | | | 1 | | | 16 | | | | | | 3 | | | 1 | 3 | | | | | | | | | 1 | | | | 1 | 1 | | | | | | | | | | | | | 115 |
| Bayside | | 1 | 2 | 2 | | 58 | | 15 | | | | 3 | | | 1 | | | 1 | | | | 1 | | | | | | | 1 | | | | | | | | | 1 | | | 1 | | 1 | | | | | | 88 |
| St. Andrews | 55 | | | | 3 | | | | 3 | 2 | | 4 | | | 6 | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | 79 |
| Sea | 13 | 1 | | | 1 | | 45 | 3 | | | | | | | | | | | | | | | | | 1 | | | 1 | | | | | 1 | | | | | | | | | | | | | | | | 66 |
| Seal Cove Harbour | 61 | | | | 1 | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 63 |
| Letang Harbour | 31 | | | | 24 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 56 |
| Long Island Fishing area | 52 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | 53 |
| Dipper Harbour | 39 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 39 |
| Lepreau Harbour | 1 | 1 | | | 3 | | 1 | 4 | 16 | | 1 | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | 29 |
| Bliss Island Harbour | 21 | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | 23 |
| Fairhaven Harbour | 19 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 19 |
| Letete Harbour | 5 | 1 | | | | | | | | | | | | | | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 16 |

| Origin / Destination | Blacks Harbour | Butler Point Harbour | Leonardville Harbour | North Head | Beaver Harbour | Sea | Saint John | Eastport Harbour (Maine) | Dipper Harbour | Letang Harbour | Ingalls Head Harbour | Bayside | Upper Bay of Fundy Fishing Area | Bliss Island Harbour | Digby | Letete Harbour | Fairhaven Harbour | Lepreau Harbour | Ministers Island Harbour | Westport Harbour | Yarmouth | Pictou | Davidson Harbour | Woods Island Harbour | Deer Island point Harbour | Frye Island Harbour | Seal Cove Harbour | Fundy Bay | Long Island Fishing area | Whiffen Head | Cap Aux Meules | Head harbour | Friars Road Anchorage | Selected area | Corner Brook | Pocologan Island Harbour | Port Hawkesbury | Chedabucto Bay | Minas Basin Anchorage | Fishing South | Tiverton Harbour | Chocolate Cove Harbour | Dartmouth | Meteghan | Wilsons Beach Harbour | Fishing West | Halifax | Maritime Voluntary R.P. 3 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ministers Island Harbour | 13 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 13 |
| White Head Harbour | 9 | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | 1 | | | | 12 |
| Digby | 10 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 11 |
| Ingalls Head Harbour | 7 | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 9 |
| Woods Island Harbour | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 |
| Wilsons Beach Harbour | 3 | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 4 |
| Davidson Harbour | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 |
| Meteghan Harbour | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 |
| Head harbour | 1 | | | | | | | | | | | | | 1 | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 |
| Pocologan Island Harbour | 2 | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 |
| Frye Island Harbour | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 |
| Deer Island point Harbour | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | 2 |
| Seely's Cove Harbour | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 |
| Sandy Cove Harbour | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| Halifax | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| Alma Harbour | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |

| Origin / Destination | Blacks Harbour | Butler Point Harbour | Leonardville Harbour | North Head | Beaver Harbour | Sea | Saint John | Eastport Harbour (Maine) | Dipper Harbour | Letang Harbour | Ingalls Head Harbour | Bayside | Upper Bay of Fundy Fishing Area | Bliss Island Harbour | Digby | Letete Harbour | Fairhaven Harbour | Lepreau Harbour | Ministers Island Harbour | Westport Harbour | Yarmouth | Pictou | Davidson Harbour | Woods Island Harbour | Deer Island point Harbour | Frye Island Harbour | Seal Cove Harbour | Fundy Bay | Long Island Fishing area | Whiffen Head | Cap Aux Meules | Head harbour | Friars Road Anchorage | Selected area | Corner Brook | Pocologan Island Harbour | Port Hawkesbury | Chedabucto Bay | Minas Basin Anchorage | Fishing South | Tiverton Harbour | Chocolate Cove Harbour | Dartmouth | Meteghan | Wilsons Beach Harbour | Fishing West | Halifax | Maritime Voluntary R.P. 3 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Freeport Harbour | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| Mid Bay Fishing area | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| Total | **856** | **505** | **223** | **220** | **209** | **176** | **87** | **85** | **62** | **54** | **30** | **29** | **26** | **22** | **20** | **17** | **17** | **16** | **14** | **10** | **8** | **4** | **4** | **3** | **3** | **3** | **3** | **2** | **2** | **2** | **2** | **2** | **2** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **2733** |

**TABLE A3. Origin-destination data for tugs in 2005. Source: Maritime Innovation, from CCG data.**

| Origin / Destination | Blacks Harbour | Saint John | St. Andrews | Hantsport | Sea | North Head | Lepreau Harbour | Fundy Bay | Selected area | Minas Basin Anchorage | Head harbour | Eastport Harbour (Maine) | Pocologan Island Harbour | Halifax | Friars Road Anchorage | Bayside | Ministers Island Harbour | Seely's Cove Harbour | Bliss Island Harbour | Dartmouth | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Woods Island Harbour** | 103 | | | | | | | | | | | | | | | | | | 1 | | 104 |
| **Blacks Harbour** | | 67 | 12 | | | | | 6 | | | | | 2 | | | | | | | | 87 |
| **Beaver Harbour** | | 4 | 35 | | | | | 1 | | | | | | | | | | | | | 40 |
| **Sea** | | | | 20 | | 1 | | | | 5 | 1 | 3 | | | | | 1 | | | | 31 |
| **Hantsport** | | 1 | | | 15 | | | | | | | | | | | | | | | | 16 |
| **Leonardville Harbour** | | 6 | | | | | | | 3 | | | | | | | | | 1 | | | 10 |
| **Dipper Harbour** | | | | | | | 10 | | | | | | | | | | | | | | 10 |
| **Saint John** | | 1 | | | 4 | 3 | | | | | | | | | | | | | | | 8 |
| **North Head** | | | | | | 7 | | | 1 | | | | | | | | | | | | 8 |
| **White Head Harbour** | 7 | | | | | | | | | | | | | | | | | | | | 7 |
| **Bayside** | | | 3 | | | | | | | | | | | | 1 | | | | | | 4 |
| **Long Island Fishing area** | | | | | | | | | | | 2 | | | | | | | | | | 2 |
| **Strait of Canso Beaver Wharf** | | | | | | | | | | | | | | 1 | | | | | | 1 | 2 |
| **Pocologan Island Harbour** | | | | | | | | | 1 | | | | | | | | | | | | 1 |
| **Bliss Island Harbour** | | 1 | | | | | | | | | | | | | | | | | | | 1 |
| **Upper Bay of Fundy Fishing Area** | 1 | | | | | | | | | | | | | | | | | | | | 1 |
| **Friars Road Anchorage** | | | | | | | | | | | | | | | | 1 | | | | | 1 |
| **Total** | **111** | **80** | **50** | **20** | **19** | **11** | **10** | **7** | **5** | **5** | **3** | **3** | **2** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | 333 |

**TABLE A4. Origin-destination data for general cargo ships in 2005. Source: Maritime Innovation, from CCG data.**

| Origin / Destination | North Head | Blacks Harbour | Bayside | Long Island Fishing area | Saint John | Bliss Island Harbour | Head harbour | Selected area | Eastport Harbour (Maine) | Ingalls Head Harbour | Hantsport | Welshpool Harbour | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Blacks Harbour** | 104 | | | 6 | | | | | | | | | **110** |
| **Upper Bay of Fundy Fishing Area** | | 14 | | | 1 | | | | | | | | **15** |
| **Woods Island Harbour** | | 12 | | | | | | | | | | | **12** |
| **Westport Harbour** | | 8 | | | | | | 1 | | | 1 | | **10** |
| **Sea** | | | 6 | | | 1 | | | | | | | **7** |
| **Saint John** | 1 | 1 | | | 2 | 1 | | 1 | | | | | **6** |
| **Meteghan Harbour** | 1 | | | | | 1 | 3 | | | | | | **5** |
| **Yarmouth** | | 2 | | | | 1 | | | | 1 | | | **4** |
| **Lunenburg** | | | | | 1 | | | | | | | 1 | **2** |
| **Liverpool** | | | 1 | | | | | | 1 | | | | **2** |
| **Friars Road Anchorage** | | | | | | | | | 1 | | | | **1** |
| **Bayside** | | | 1 | | | | | | | | | | **1** |
| **Fishing West** | | | 1 | | | | | | | | | | **1** |
| **Bliss Island Harbour** | | | 1 | | | | | | | | | | **1** |
| **Total** | **106** | **37** | **10** | **6** | **4** | **4** | **3** | **2** | **2** | **1** | **1** | **1** | **177** |

**TABLE A5. Origin-destination data for bulk carriers in 2005. Source: Maritime Innovation, from CCG data.**

| Origin/Destination | Bayside | Eastport Harbour (Maine) | North Head | Long Island Fishing area | Bliss Island Harbour | Friars Road Anchorage | Blacks Harbour | Wilsons Beach Harbour | Total |
|---|---|---|---|---|---|---|---|---|---|
| **Sea** | 45 | 25 | 1 | 1 | 8 | 5 | | | **85** |
| **Blacks Harbour** | | | 30 | 14 | | | | | **44** |
| **Bayside** | 7 | | | | 1 | | | | **8** |
| **Bliss Island Harbour** | 6 | 1 | | | | | | | **7** |
| **Friars Road Anchorage** | 1 | 5 | | | | | | | **6** |
| **Woods Island Harbour** | | | | | | | 5 | | **5** |
| **Eastport Harbour (Maine)** | 1 | 2 | | | | 1 | | | **4** |
| **Saint John** | | | 2 | | | | | 1 | **3** |
| **Mulgrave** | | 1 | | | | | | | **1** |
| **Summerside** | | 1 | | | | | | | **1** |
| **Total** | **60** | **35** | **33** | **14** | **9** | **6** | **5** | **1** | **164** |

**TABLE A6. Origin-destination data for tankers in 2005. Source: Maritime Innovation, from CCG data.**

| Origin / Destination | Saint John | North Head | Lepreau Harbour | St. Andrews | Pocologan Island Harbour | Blacks Harbour | Seely's Cove Harbour | Sea | Eastport Harbour (Maine) | Long Island Fishing area | Butler Point Harbour | Letang Harbour | Bayside | Selected area | Royal Kennebecasis Yacht Club | Letete Harbour | Leonardville Harbour | Shelburne | Beaver Harbour | Whiffen Head | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sea** | 98 | | | 1 | | | | | | | 1 | | | | | | | | 1 | 1 | **102** |
| **Saint John** | 0 | 1 | 1 | 2 | 3 | 1 | 2 | | 3 | 1 | | | 2 | 1 | 1 | | | | | | **18** |
| **Ingalls Head Harbour** | 0 | 17 | | | | | | | | | | | | | | | | | | | **17** |
| **Seal Cove Harbour** | 0 | 1 | 13 | | | | 1 | | | | | | | | | | | | | | **15** |
| **White Head Harbour** | 1 | 9 | | | | | | | | | 1 | | | | | 1 | 1 | 1 | | | **14** |
| **Dipper Harbour** | 0 | | 7 | 4 | | | | | | | | | | | | | | | | | **11** |
| **Digby** | 1 | 2 | | 6 | 1 | | | | | | | | | | | | | | | | **10** |
| **Woods Island Harbour** | 0 | 2 | | | | 3 | | | | | | 1 | | | | | | | | | **6** |
| **Blacks Harbour** | 0 | 4 | | | | | | | | 2 | | | | | | | | | | | **6** |
| **Long Island Fishing area** | 3 | | | | | | | | | | | | | | | | | | | | **3** |
| **Hantsport** | 0 | | | | | | | 3 | | | | | | | | | | | | | **3** |
| **Mid Bay Fishing area** | 1 | 1 | | | | | | | | | | | | | | | | | | | **2** |
| **Sandy Cove Harbour** | 0 | | | | | | | | | | | 1 | | | | | | | | | **1** |
| **Total** | **104** | **37** | **21** | **13** | **4** | **4** | **3** | **3** | **3** | **3** | **2** | **2** | **2** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **208** |

**TABLE A7. Origin-destination data for Ro-ro in 2005. Source: Maritime Innovation, from CCG data.**

| Origin / Destination | North Head | Blacks Harbour | Total |
|---|---|---|---|
| **Blacks Harbour** | 228 | | **228** |
| **Upper Bay of Fundy Fishing Area** | | 1 | **1** |
| **Total** | **228** | **1** | **229** |

Fisheries and Oceans Canada / Pêches et Océans Canada

# Landed Qty by District/ Species/ Vessel Length (Table 30 Dist)

## ** NON CONFIDENTIAL **

User: walkere
Date: 04-May-2006
01:51 PM

Prompts: Sector : SCOTIA FUNDY
From Date : 2004-01-01
To Date : 2004-12-31
Disrticts : 48 To : 81
Category : ALL
Species : ALL

Aquaculture not included
(All quantities are in Metric Tonnes)

| District | Species Code | Species Desc | Non Vessel | < 45 FT | 45-64 FT | Total < 65 FT | 65-99 FT | > 100 FT | Total 65 FT + | Grand Total | EA Licences * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 49 | 100 | COD | 0 | 33 | 0 | 33 | 0 | 0 | 0 | 33 | 0 |
| | 110 | HADDOCK | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 3 | 0 |
| | 120 | REDFISH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 130 | HALIBUT | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| | 140 | AMERICAN PLAICE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 142 | GREYSOLE/WITCH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 149 | FLOUNDER, UNSPECIFIED | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 161 | DOGFISH | 0 | 259 | 0 | 259 | 0 | 0 | 0 | 259 | 0 |
| | 170 | POLLOCK | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |
| | 171 | WHITE HAKE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 172 | SILVER HAKE | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |
| | 176 | LUMPFISH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 177 | MONKFISH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | GROUNDFISH | | 0 | 302 | 0 | 302 | 0 | 0 | 0 | 302 | 0 |
| | 200 | HERRING | 0 | 60 | 0 | 60 | 0 | 0 | 0 | 60 | 0 |
| | 350 | ALEWIVES/GASPEREAU | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 355 | SHAD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 379 | SHARK, UNSPECIFIED | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| TOTAL | PELAGIC AND ESTUARIAL | | 1 | 61 | 0 | 61 | 0 | 0 | 0 | 61 | 0 |
| | 612 | SCALLOP, SEA | 0 | 322 | 201 | 523 | 0 | 0 | 0 | 523 | 0 |
| | 650 | SEA URCHINS | 0 | 81 | 1 | 82 | 0 | 0 | 0 | 82 | 0 |
| | 700 | LOBSTER | 0 | 261 | 22 | 283 | 0 | 0 | 0 | 283 | 0 |
| TOTAL | MOLLUSC AND CRUSTACEAN | | 0 | 664 | 223 | 888 | 0 | 0 | 0 | 888 | 0 |
| TOTAL FOR DISTRICT | 49 | | 1 | 1,026 | 223 | 1,250 | 0 | 0 | 0 | 1,250 | 0 |



* This report reflects the vessel length of the fishing vessel. EA Licences total includes any landing for an enterprise allocation licence, regardless of vessel length; includes TVRP.

Canada

Fisheries and Oceans Canada / Pêches et Océans Canada

# Landed Qty by District/ Species/ Vessel Length (Table 30 Dist)
## ** NON CONFIDENTIAL **

User: walkere
Date: 04-May-2006
01:51 PM

Prompts: Sector : SCOTIA FUNDY
From Date : 2004-01-01
To Date : 2004-12-31
Disrticts : 48 To : 81
Category : ALL
Species : ALL

Aquaculture not included
(All quantities are in Metric Tonnes)

| District | Species Code | Species Desc | Non Vessel | < 45 FT | 45-64 FT | Total < 65 FT | 65-99 FT | > 100 FT | Total 65 FT + | Grand Total | EA Licences * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 100 | COD | 0 | 70 | 0 | 70 | 0 | 0 | 0 | 70 | 0 |
| | 110 | HADDOCK | 0 | 11 | 0 | 11 | 0 | 0 | 0 | 11 | 0 |
| | 130 | HALIBUT | 0 | 5 | 0 | 5 | 0 | 0 | 0 | 5 | 0 |
| | 142 | GREYSOLE/WITCH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 143 | WINTER FLOUNDER | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| | 161 | DOGFISH | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 3 | 0 |
| | 170 | POLLOCK | 0 | 48 | 0 | 48 | 0 | 0 | 0 | 48 | 0 |
| | 171 | WHITE HAKE | 0 | 30 | 0 | 30 | 0 | 0 | 0 | 30 | 0 |
| | 172 | SILVER HAKE | 0 | 15 | 0 | 15 | 0 | 0 | 0 | 15 | 0 |
| | 176 | LUMPFISH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 177 | MONKFISH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | GROUNDFISH | | 0 | 183 | 0 | 183 | 0 | 0 | 0 | 183 | 0 |
| | 200 | HERRING | 0 | 194 | 5,846 | 6,041 | 237 | 0 | 237 | 6,277 | 0 |
| | 350 | ALEWIVES/GASPEREAU | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 375 | SHARK, MAKO | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| | 379 | SHARK, UNSPECIFIED | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | PELAGIC AND ESTUARIAL | | 1 | 195 | 5,846 | 6,041 | 237 | 0 | 237 | 6,278 | 0 |
| | 601 | CLAMS, SOFT SHELL | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 |
| | 612 | SCALLOP, SEA | 0 | 538 | 162 | 700 | 0 | 0 | 0 | 700 | 0 |
| | 614 | PERIWINKLES | 67 | 0 | 0 | 0 | 0 | 0 | 0 | 67 | 0 |
| | 650 | SEA URCHINS | 0 | 396 | 5 | 401 | 0 | 0 | 0 | 401 | 0 |
| | 700 | LOBSTER | 1 | 971 | 78 | 1,049 | 0 | 0 | 0 | 1,050 | 0 |
| | 703 | CRAB, JONAH | 0 | 291 | 25 | 316 | 0 | 0 | 0 | 316 | 0 |
| | 704 | CRAB, ROCK | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 3 | 0 |
| | 705 | CRAB, SNOW | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 3 | 0 |
| TOTAL | MOLLUSC AND CRUSTACEAN | | 79 | 2,201 | 271 | 2,471 | 0 | 0 | 0 | 2,550 | 0 |
| | 999 | ITEMS, UNSPECIFIED | 3,959 | 0 | 0 | 0 | 0 | 0 | 0 | 3,959 | 0 |



* This report reflects the vessel length of the fishing vessel. EA Licences total includes any landing for an enterprise allocation licence, regardless of vessel length; includes TVRP.

Canada

Fisheries and Oceans Canada / Pêches et Océans Canada

# Landed Qty by District/ Species/ Vessel Length (Table 30 Dist)
## ** NON CONFIDENTIAL **

User: walkere
Date: 04-May-2006
01:51 PM

Prompts: Sector : SCOTIA FUNDY
From Date : 2004-01-01
To Date : 2004-12-31
Disrticts : 48 To : 81
Category : ALL
Species : ALL

Aquaculture not included
(All quantities are in Metric Tonnes)

| District | Species Code | Species Desc | Non Vessel | < 45 FT | 45-64 FT | Total < 65 FT | 65-99 FT | > 100 FT | Total 65 FT + | Grand Total | EA Licences * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL | OTHER SPECIES | | 3,959 | 0 | 0 | 0 | 0 | 0 | 0 | 3,959 | 0 |
| TOTAL FOR DISTRICT | 50 | | 4,038 | 2,578 | 6,117 | 8,695 | 237 | 0 | 237 | 12,970 | 0 |



* This report reflects the vessel length of the fishing vessel. EA Licences total includes any landing for an enterprise allocation licence, regardless of vessel length; includes TVRP.

Canada

Fisheries and Oceans Canada / Pêches et Océans Canada

# Landed Qty by District/ Species/ Vessel Length (Table 30 Dist)
## ** NON CONFIDENTIAL **

User: walkere
Date: 04-May-2006
01:51 PM

Prompts: Sector : SCOTIA FUNDY
From Date : 2004-01-01
To Date : 2004-12-31
Disrticts : 48 To : 81
Category : ALL
Species : ALL

Aquaculture not included
(All quantities are in Metric Tonnes)

| District | Species Code | Species Desc | Non Vessel | < 45 FT | 45-64 FT | Total < 65 FT | 65-99 FT | > 100 FT | Total 65 FT + | Grand Total | EA Licences * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 100 | COD | 0 | 41 | 0 | 41 | 0 | 0 | 0 | 41 | 0 |
| | 110 | HADDOCK | 0 | 23 | 0 | 23 | 0 | 0 | 0 | 23 | 0 |
| | 130 | HALIBUT | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 3 | 0 |
| | 142 | GREYSOLE/WITCH | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| | 143 | WINTER FLOUNDER | 0 | 17 | 0 | 17 | 0 | 0 | 0 | 17 | 0 |
| | 149 | FLOUNDER, UNSPECIFIED | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 161 | DOGFISH | 0 | 6 | 0 | 6 | 0 | 0 | 0 | 6 | 0 |
| | 170 | POLLOCK | 0 | 27 | 0 | 27 | 0 | 0 | 0 | 27 | 0 |
| | 171 | WHITE HAKE | 0 | 6 | 0 | 6 | 0 | 0 | 0 | 6 | 0 |
| | 172 | SILVER HAKE | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 3 | 0 |
| | 173 | CUSK | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | GROUNDFISH | | 0 | 126 | 0 | 126 | 0 | 0 | 0 | 126 | 0 |
| | 200 | HERRING | 0 | 0 | 115 | 115 | 1,616 | 0 | 1,616 | 1,731 | 0 |
| | 379 | SHARK, UNSPECIFIED | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| TOTAL | PELAGIC AND ESTUARIAL | | 0 | 1 | 115 | 116 | 1,616 | 0 | 1,616 | 1,732 | 0 |
| | 601 | CLAMS, SOFT SHELL | 103 | 0 | 0 | 0 | 0 | 0 | 0 | 103 | 0 |
| | 612 | SCALLOP, SEA | 0 | 361 | 43 | 404 | 0 | 0 | 0 | 404 | 0 |
| | 619 | SEA CUCUMBER | 0 | 566 | 639 | 1,205 | 0 | 0 | 0 | 1,205 | 0 |
| | 650 | SEA URCHINS | 0 | 228 | 0 | 228 | 0 | 0 | 0 | 228 | 0 |
| | 700 | LOBSTER | 0 | 318 | 0 | 318 | 0 | 0 | 0 | 318 | 0 |
| | 704 | CRAB, ROCK | 0 | 66 | 0 | 66 | 0 | 0 | 0 | 66 | 0 |
| TOTAL | MOLLUSC AND CRUSTACEAN | | 103 | 1,539 | 682 | 2,221 | 0 | 0 | 0 | 2,324 | 0 |
| | 999 | ITEMS, UNSPECIFIED | 1,819 | 0 | 0 | 0 | 0 | 0 | 0 | 1,819 | 0 |
| TOTAL | OTHER SPECIES | | 1,819 | 0 | 0 | 0 | 0 | 0 | 0 | 1,819 | 0 |
| TOTAL FOR DISTRICT | 51 | | 1,922 | 1,665 | 797 | 2,463 | 1,616 | 0 | 1,616 | 6,001 | 0 |



* This report reflects the vessel length of the fishing vessel. EA Licences total includes any landing for an enterprise allocation licence, regardless of vessel length; includes TVRP.

Canada

Fisheries and Oceans Canada / Pêches et Océans Canada

# Landed Qty by District/ Species/ Vessel Length (Table 30 Dist)
## ** NON CONFIDENTIAL **

User: walkere
Date: 04-May-2006
01:51 PM

Prompts: Sector : SCOTIA FUNDY
From Date : 2004-01-01
To Date : 2004-12-31
Disrticts : 48 To : 81
Category : ALL
Species : ALL

Aquaculture not included
(All quantities are in Metric Tonnes)

| District | Species Code | Species Desc | Non Vessel | < 45 FT | 45-64 FT | Total < 65 FT | 65-99 FT | > 100 FT | Total 65 FT + | Grand Total | EA Licences * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 52 | 110 | HADDOCK | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| | 143 | WINTER FLOUNDER | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |
| TOTAL | GROUNDFISH | | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 3 | 0 |
| | 350 | ALEWIVES/GASPEREAU | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| TOTAL | PELAGIC AND ESTUARIAL | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 601 | CLAMS, SOFT SHELL | 204 | 0 | 0 | 0 | 0 | 0 | 0 | 204 | 0 |
| | 612 | SCALLOP, SEA | 0 | 34 | 0 | 34 | 0 | 0 | 0 | 34 | 0 |
| | 650 | SEA URCHINS | 0 | 46 | 38 | 85 | 0 | 0 | 0 | 85 | 0 |
| | 700 | LOBSTER | 0 | 78 | 0 | 78 | 0 | 0 | 0 | 78 | 0 |
| | 704 | CRAB, ROCK | 0 | 6 | 0 | 6 | 0 | 0 | 0 | 6 | 0 |
| TOTAL | MOLLUSC AND CRUSTACEAN | | 204 | 165 | 38 | 203 | 0 | 0 | 0 | 407 | 0 |
| | 999 | ITEMS, UNSPECIFIED | 3,853 | 0 | 0 | 0 | 0 | 0 | 0 | 3,853 | 0 |
| TOTAL | OTHER SPECIES | | 3,853 | 0 | 0 | 0 | 0 | 0 | 0 | 3,853 | 0 |
| TOTAL FOR DISTRICT | 52 | | 4,058 | 168 | 38 | 207 | 0 | 0 | 0 | 4,265 | 0 |



* This report reflects the vessel length of the fishing vessel. EA Licences total includes any landing for an enterprise allocation licence, regardless of vessel length; includes TVRP.

Canada

Fisheries and Oceans Canada / Pêches et Océans Canada

# Landed Qty by District/ Species/ Vessel Length (Table 30 Dist)
## ** NON CONFIDENTIAL **

User: walkere
Date: 04-May-2006
01:51 PM

Prompts: Sector : SCOTIA FUNDY
From Date : 2004-01-01
To Date : 2004-12-31
Disrticts : 48 To : 81
Category : ALL
Species : ALL

Aquaculture not included
(All quantities are in Metric Tonnes)

| District | Species Code | Species Desc | Non Vessel | < 45 FT | 45-64 FT | Total < 65 FT | 65-99 FT | > 100 FT | Total 65 FT + | Grand Total | EA Licences * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 | 200 | HERRING | 0 | 0 | 18,016 | 18,016 | 2,486 | 10,508 | 12,994 | 31,010 | 0 |
| TOTAL | | PELAGIC AND ESTUARIAL | 0 | 0 | 18,016 | 18,016 | 2,486 | 10,508 | 12,994 | 31,010 | 0 |
| | 601 | CLAMS, SOFT SHELL | 170 | 0 | 0 | 0 | 0 | 0 | 0 | 170 | 0 |
| | 612 | SCALLOP, SEA | 0 | 76 | 0 | 76 | 0 | 0 | 0 | 76 | 0 |
| | 650 | SEA URCHINS | 0 | 328 | 1 | 328 | 0 | 0 | 0 | 328 | 0 |
| | 700 | LOBSTER | 0 | 197 | 7 | 203 | 0 | 0 | 0 | 203 | 0 |
| | 704 | CRAB, ROCK | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |
| TOTAL | | MOLLUSC AND CRUSTACEAN | 170 | 602 | 7 | 609 | 0 | 0 | 0 | 779 | 0 |
| | 999 | ITEMS, UNSPECIFIED | 2,457 | 0 | 0 | 0 | 0 | 0 | 0 | 2,457 | 0 |
| TOTAL | | OTHER SPECIES | 2,457 | 0 | 0 | 0 | 0 | 0 | 0 | 2,457 | 0 |
| TOTAL FOR DISTRICT | | 53 | 2,627 | 602 | 18,024 | 18,626 | 2,486 | 10,508 | 12,994 | 34,246 | 0 |



* This report reflects the vessel length of the fishing vessel. EA Licences total includes any landing for an enterprise allocation licence, regardless of vessel length; includes TVRP.

Canada

Fisheries and Oceans Canada / Pêches et Océans Canada

# Landed Value by District/ Species/ Vessel Length (Table 31 Dist)
## ** NON CONFIDENTIAL **

User: walkere
Date: 04-May-2006
01:57 PM

Prompts: Sector : SCOTIA FUNDY
From Date : 2004-01-01
To Date : 2004-12-31
Districts : 48 To : 81
Category : ALL
Species : ALL

Aquaculture not included
(Values in Thousands of Dollars)

| District | Species Code | Species Desc | Non Vessel | < 45 FT | 45-64 FT | Total < 65 FT | 65-99 FT | > 100 FT | Total 65 FT + | Grand Total | EA Licences * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 49 | 100 | COD | 0 | 59 | 0 | 59 | 0 | 0 | 0 | 59 | 0 |
| | 110 | HADDOCK | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 3 | 0 |
| | 120 | REDFISH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 130 | HALIBUT | 0 | 7 | 0 | 7 | 0 | 0 | 0 | 7 | 0 |
| | 140 | AMERICAN PLAICE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 142 | GREYSOLE/WITCH | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| | 149 | FLOUNDER, UNSPECIFIED | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 161 | DOGFISH | 0 | 86 | 0 | 86 | 0 | 0 | 0 | 86 | 0 |
| | 170 | POLLOCK | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| | 171 | WHITE HAKE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 172 | SILVER HAKE | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |
| | 176 | LUMPFISH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 177 | MONKFISH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | GROUNDFISH | | 0 | 159 | 0 | 159 | 0 | 0 | 0 | 159 | 0 |
| | 200 | HERRING | 0 | 10 | 0 | 10 | 0 | 0 | 0 | 10 | 0 |
| | 350 | ALEWIVES/GASPEREAU | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 355 | SHAD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 379 | SHARK, UNSPECIFIED | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| TOTAL | PELAGIC AND ESTUARIAL | | 0 | 11 | 0 | 11 | 0 | 0 | 0 | 11 | 0 |
| | 612 | SCALLOP, SEA | 0 | 517 | 328 | 846 | 0 | 0 | 0 | 846 | 0 |
| | 650 | SEA URCHINS | 0 | 241 | 2 | 243 | 0 | 0 | 0 | 243 | 0 |
| | 700 | LOBSTER | 0 | 3,445 | 282 | 3,727 | 0 | 0 | 0 | 3,727 | 0 |
| TOTAL | MOLLUSC AND CRUSTACEAN | | 0 | 4,203 | 612 | 4,815 | 0 | 0 | 0 | 4,815 | 0 |
| TOTAL FOR DISTRICT | 49 | | 0 | 4,372 | 612 | 4,984 | 0 | 0 | 0 | 4,985 | 0 |

X:\Reports Harvest\Standard\Table 31 District Value by Vessel LOA.imr

* This report reflects the vessel length of the fishing vessel. EA Licences total includes any landing for an enterprise allocation licence, regardless of vessel length; includes TVRP.



Canada

Fisheries and Oceans Canada / Pêches et Océans Canada

# Landed Value by District/ Species/ Vessel Length (Table 31 Dist)
## ** NON CONFIDENTIAL **

User: walkere
Date: 04-May-2006
01:57 PM

Prompts: Sector : SCOTIA FUNDY
From Date : 2004-01-01
To Date : 2004-12-31
Districts : 48 To : 81
Category : ALL
Species : ALL

Aquaculture not included
(Values in Thousands of Dollars)

| District | Species Code | Species Desc | Non Vessel | < 45 FT | 45-64 FT | Total < 65 FT | 65-99 FT | > 100 FT | Total 65 FT + | Grand Total | EA Licences * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 100 | COD | 0 | 128 | 0 | 128 | 0 | 0 | 0 | 128 | 0 |
| | 110 | HADDOCK | 0 | 11 | 0 | 11 | 0 | 0 | 0 | 11 | 0 |
| | 130 | HALIBUT | 0 | 41 | 0 | 41 | 0 | 0 | 0 | 41 | 0 |
| | 142 | GREYSOLE/WITCH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 143 | WINTER FLOUNDER | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |
| | 161 | DOGFISH | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| | 170 | POLLOCK | 0 | 17 | 0 | 17 | 0 | 0 | 0 | 17 | 0 |
| | 171 | WHITE HAKE | 0 | 16 | 0 | 16 | 0 | 0 | 0 | 16 | 0 |
| | 172 | SILVER HAKE | 0 | 11 | 0 | 11 | 0 | 0 | 0 | 11 | 0 |
| | 176 | LUMPFISH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 177 | MONKFISH | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | GROUNDFISH | | 0 | 228 | 0 | 228 | 0 | 0 | 0 | 228 | 0 |
| | 200 | HERRING | 0 | 37 | 1,061 | 1,098 | 44 | 0 | 44 | 1,142 | 0 |
| | 350 | ALEWIVES/GASPEREAU | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 375 | SHARK, MAKO | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| | 379 | SHARK, UNSPECIFIED | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | PELAGIC AND ESTUARIAL | | 0 | 38 | 1,061 | 1,099 | 44 | 0 | 44 | 1,143 | 0 |
| | 601 | CLAMS, SOFT SHELL | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 0 |
| | 612 | SCALLOP, SEA | 0 | 878 | 270 | 1,148 | 0 | 0 | 0 | 1,148 | 0 |
| | 614 | PERIWINKLES | 129 | 0 | 0 | 0 | 0 | 0 | 0 | 129 | 0 |
| | 650 | SEA URCHINS | 0 | 1,177 | 15 | 1,193 | 0 | 0 | 0 | 1,193 | 0 |
| | 700 | LOBSTER | 14 | 12,475 | 950 | 13,425 | 0 | 0 | 0 | 13,439 | 0 |
| | 703 | CRAB, JONAH | 0 | 386 | 33 | 419 | 0 | 0 | 0 | 419 | 0 |
| | 704 | CRAB, ROCK | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |
| | 705 | CRAB, SNOW | 0 | 17 | 0 | 17 | 0 | 0 | 0 | 17 | 0 |
| TOTAL | MOLLUSC AND CRUSTACEAN | | 169 | 14,935 | 1,269 | 16,204 | 0 | 0 | 0 | 16,373 | 0 |
| | 999 | ITEMS, UNSPECIFIED | 730 | 0 | 0 | 0 | 0 | 0 | 0 | 730 | 0 |



* This report reflects the vessel length of the fishing vessel. EA Licences total includes any landing for an enterprise allocation licence, regardless of vessel length; includes TVRP.

Canada

Fisheries and Oceans Canada / Pêches et Océans Canada

# Landed Value by District/ Species/ Vessel Length (Table 31 Dist)
## ** NON CONFIDENTIAL **

User: walkere
Date: 04-May-2006
01:57 PM

Prompts: Sector : SCOTIA FUNDY
From Date : 2004-01-01
To Date : 2004-12-31
Districts : 48 To : 81
Category : ALL
Species : ALL

Aquaculture not included
(Values in Thousands of Dollars)

| District | Species Code | Species Desc | Non Vessel | < 45 FT | 45-64 FT | Total < 65 FT | 65-99 FT | > 100 FT | Total 65 FT + | Grand Total | EA Licences * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL | OTHER SPECIES | | 730 | 0 | 0 | 0 | 0 | 0 | 0 | 730 | 0 |
| TOTAL FOR DISTRICT | 50 | | 899 | 15,201 | 2,330 | 17,531 | 44 | 0 | 44 | 18,474 | 0 |



* This report reflects the vessel length of the fishing vessel. EA Licences total includes any landing for an enterprise allocation licence, regardless of vessel length; includes TVRP.

Canada

Fisheries and Oceans Canada / Pêches et Océans Canada

# Landed Value by District/ Species/ Vessel Length (Table 31 Dist)
## ** NON CONFIDENTIAL **

User: walkere
Date: 04-May-2006
01:57 PM

Prompts: Sector : SCOTIA FUNDY
From Date : 2004-01-01
To Date : 2004-12-31
Districts : 48 To : 81
Category : ALL
Species : ALL

Aquaculture not included
(Values in Thousands of Dollars)

| District | Species Code | Species Desc | Non Vessel | < 45 FT | 45-64 FT | Total < 65 FT | 65-99 FT | > 100 FT | Total 65 FT + | Grand Total | EA Licences * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 100 | COD | 0 | 73 | 0 | 73 | 0 | 0 | 0 | 73 | 0 |
| | 110 | HADDOCK | 0 | 26 | 0 | 26 | 0 | 0 | 0 | 26 | 0 |
| | 130 | HALIBUT | 0 | 25 | 0 | 25 | 0 | 0 | 0 | 25 | 0 |
| | 142 | GREYSOLE/WITCH | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| | 143 | WINTER FLOUNDER | 0 | 27 | 0 | 27 | 0 | 0 | 0 | 27 | 0 |
| | 149 | FLOUNDER, UNSPECIFIED | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 161 | DOGFISH | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |
| | 170 | POLLOCK | 0 | 9 | 0 | 9 | 0 | 0 | 0 | 9 | 0 |
| | 171 | WHITE HAKE | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 3 | 0 |
| | 172 | SILVER HAKE | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |
| | 173 | CUSK | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | GROUNDFISH | | 0 | 168 | 0 | 168 | 0 | 0 | 0 | 168 | 0 |
| | 200 | HERRING | 0 | 0 | 22 | 22 | 307 | 0 | 307 | 329 | 0 |
| | 379 | SHARK, UNSPECIFIED | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| TOTAL | PELAGIC AND ESTUARIAL | | 0 | 1 | 22 | 23 | 307 | 0 | 307 | 330 | 0 |
| | 601 | CLAMS, SOFT SHELL | 255 | 0 | 0 | 0 | 0 | 0 | 0 | 255 | 0 |
| | 612 | SCALLOP, SEA | 0 | 580 | 68 | 648 | 0 | 0 | 0 | 648 | 0 |
| | 619 | SEA CUCUMBER | 0 | 124 | 141 | 265 | 0 | 0 | 0 | 265 | 0 |
| | 650 | SEA URCHINS | 0 | 676 | 1 | 677 | 0 | 0 | 0 | 677 | 0 |
| | 700 | LOBSTER | 0 | 4,224 | 0 | 4,224 | 0 | 0 | 0 | 4,224 | 0 |
| | 704 | CRAB, ROCK | 0 | 48 | 0 | 48 | 0 | 0 | 0 | 48 | 0 |
| TOTAL | MOLLUSC AND CRUSTACEAN | | 255 | 5,652 | 210 | 5,861 | 0 | 0 | 0 | 6,117 | 0 |
| | 999 | ITEMS, UNSPECIFIED | 91 | 0 | 0 | 0 | 0 | 0 | 0 | 91 | 0 |
| TOTAL | OTHER SPECIES | | 91 | 0 | 0 | 0 | 0 | 0 | 0 | 91 | 0 |
| TOTAL FOR DISTRICT | 51 | | 346 | 5,821 | 232 | 6,053 | 307 | 0 | 307 | 6,706 | 0 |



* This report reflects the vessel length of the fishing vessel. EA Licences total includes any landing for an enterprise allocation licence, regardless of vessel length; includes TVRP.

Canada

Fisheries and Oceans Canada / Pêches et Océans Canada

# Landed Value by District/ Species/ Vessel Length (Table 31 Dist)
## ** NON CONFIDENTIAL **

User: walkere
Date: 04-May-2006
01:57 PM

Prompts: Sector : SCOTIA FUNDY
From Date : 2004-01-01
To Date : 2004-12-31
Districts : 48 To : 81
Category : ALL
Species : ALL

Aquaculture not included
(Values in Thousands of Dollars)

| District | Species Code | Species Desc | Non Vessel | < 45 FT | 45-64 FT | Total < 65 FT | 65-99 FT | > 100 FT | Total 65 FT + | Grand Total | EA Licences * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 52 | 110 | HADDOCK | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| | 143 | WINTER FLOUNDER | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 3 | 0 |
| TOTAL | GROUNDFISH | | 0 | 5 | 0 | 5 | 0 | 0 | 0 | 5 | 0 |
| | 350 | ALEWIVES/GASPEREAU | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | PELAGIC AND ESTUARIAL | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 601 | CLAMS, SOFT SHELL | 456 | 0 | 0 | 0 | 0 | 0 | 0 | 456 | 0 |
| | 612 | SCALLOP, SEA | 0 | 59 | 0 | 59 | 0 | 0 | 0 | 59 | 0 |
| | 650 | SEA URCHINS | 0 | 135 | 113 | 249 | 0 | 0 | 0 | 249 | 0 |
| | 700 | LOBSTER | 0 | 1,022 | 0 | 1,022 | 0 | 0 | 0 | 1,022 | 0 |
| | 704 | CRAB, ROCK | 0 | 5 | 0 | 5 | 0 | 0 | 0 | 5 | 0 |
| TOTAL | MOLLUSC AND CRUSTACEAN | | 456 | 1,221 | 113 | 1,334 | 0 | 0 | 0 | 1,790 | 0 |
| | 999 | ITEMS, UNSPECIFIED | 193 | 0 | 0 | 0 | 0 | 0 | 0 | 193 | 0 |
| TOTAL | OTHER SPECIES | | 193 | 0 | 0 | 0 | 0 | 0 | 0 | 193 | 0 |
| TOTAL FOR DISTRICT | 52 | | 648 | 1,226 | 113 | 1,339 | 0 | 0 | 0 | 1,987 | 0 |



* This report reflects the vessel length of the fishing vessel. EA Licences total includes any landing for an enterprise allocation licence, regardless of vessel length; includes TVRP.

Canada

Fisheries and Oceans Canada / Pêches et Océans Canada

# Landed Value by District/ Species/ Vessel Length (Table 31 Dist)
## ** NON CONFIDENTIAL **

User: walkere
Date: 04-May-2006
01:58 PM

Prompts: Sector : SCOTIA FUNDY
From Date : 2004-01-01
To Date : 2004-12-31
Districts : 48 To : 81
Category : ALL
Species : ALL

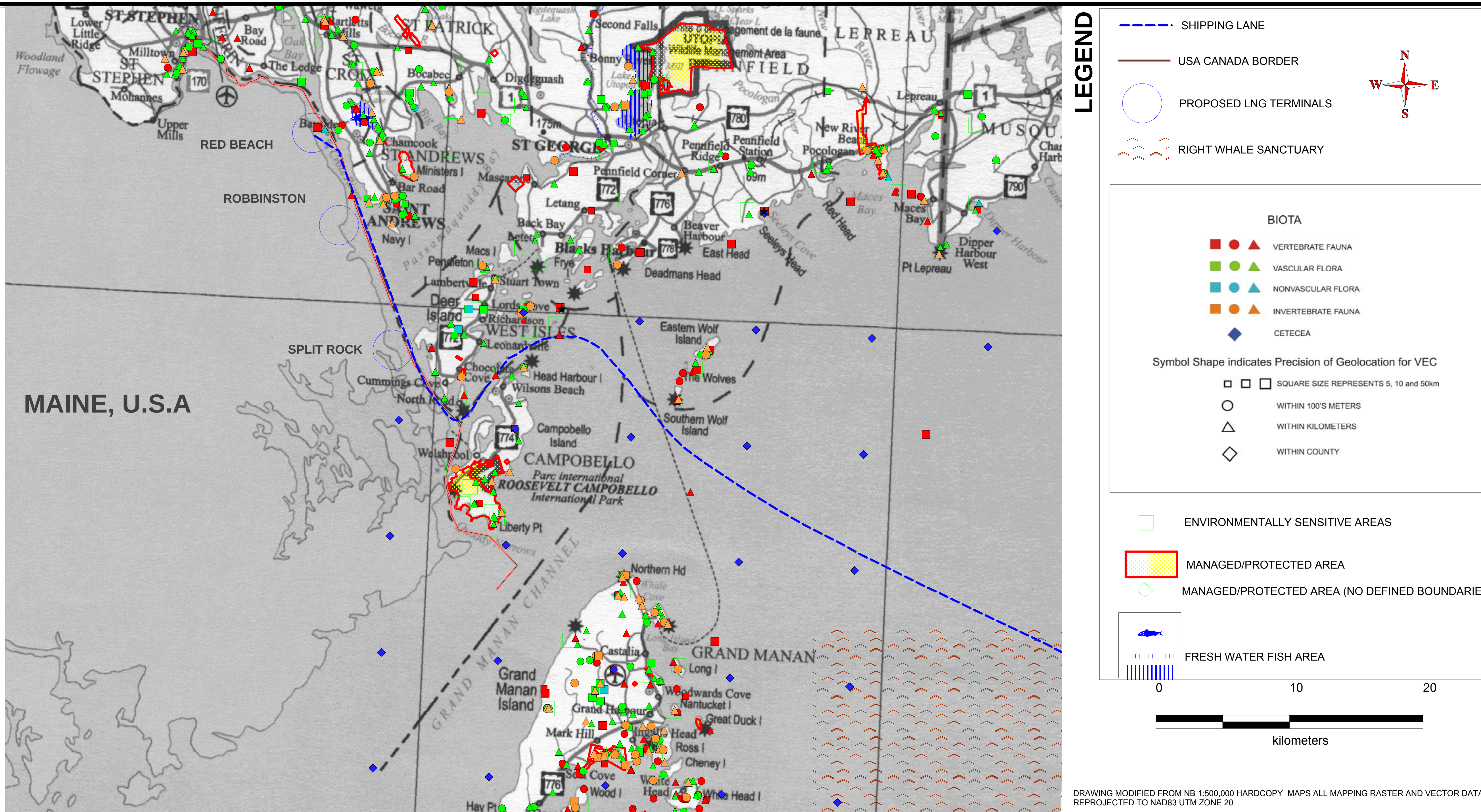
Aquaculture not included
(Values in Thousands of Dollars)

| District | Species Code | Species Desc | Non Vessel | < 45 FT | 45-64 FT | Total < 65 FT | 65-99 FT | > 100 FT | Total 65 FT + | Grand Total | EA Licences * |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 | 200 | HERRING | 0 | 0 | 3,315 | 3,315 | 470 | 1,799 | 2,269 | 5,584 | 0 |
| TOTAL | | PELAGIC AND ESTUARIAL | 0 | 0 | 3,315 | 3,315 | 470 | 1,799 | 2,269 | 5,584 | 0 |
| | 601 | CLAMS, SOFT SHELL | 389 | 0 | 0 | 0 | 0 | 0 | 0 | 389 | 0 |
| | 612 | SCALLOP, SEA | 0 | 121 | 0 | 121 | 0 | 0 | 0 | 121 | 0 |
| | 650 | SEA URCHINS | 0 | 975 | 2 | 977 | 0 | 0 | 0 | 977 | 0 |
| | 700 | LOBSTER | 0 | 2,580 | 82 | 2,663 | 0 | 0 | 0 | 2,663 | 0 |
| | 704 | CRAB, ROCK | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |
| TOTAL | | MOLLUSC AND CRUSTACEAN | 389 | 3,678 | 84 | 3,762 | 0 | 0 | 0 | 4,151 | 0 |
| | 999 | ITEMS, UNSPECIFIED | 123 | 0 | 0 | 0 | 0 | 0 | 0 | 123 | 0 |
| TOTAL | | OTHER SPECIES | 123 | 0 | 0 | 0 | 0 | 0 | 0 | 123 | 0 |
| TOTAL FOR DISTRICT | | 53 | 512 | 3,678 | 3,399 | 7,077 | 470 | 1,799 | 2,269 | 9,858 | 0 |



* This report reflects the vessel length of the fishing vessel. EA Licences total includes any landing for an enterprise allocation licence, regardless of vessel length; includes TVRP.

Canada

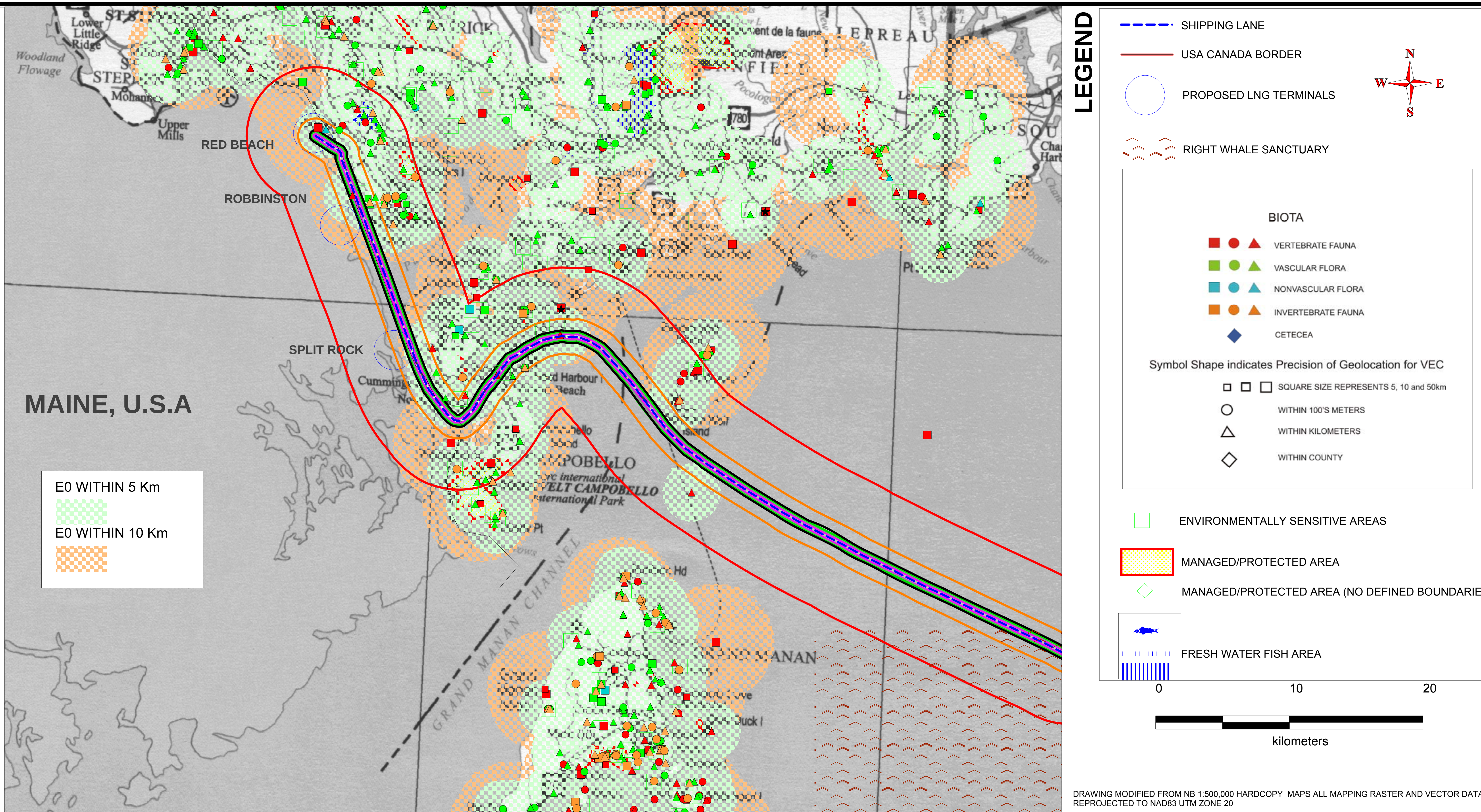



ACER Environmental Services Ltd.

# DEVELOPMENT OF LIQUIFIED NATURAL GAS TERMINALS ON PASSAMAQUODDY BAY

FILE NAME: FIG A1 SPECIES AT RISK | JOB NO: FAC 15-1 | DRAWN BY: EBL | CHECKED BY: | DATE:

**FIGURE A1**
**SPECIES AT RISK AND SENSITIVE AREAS FOR THE STUDY AREA**



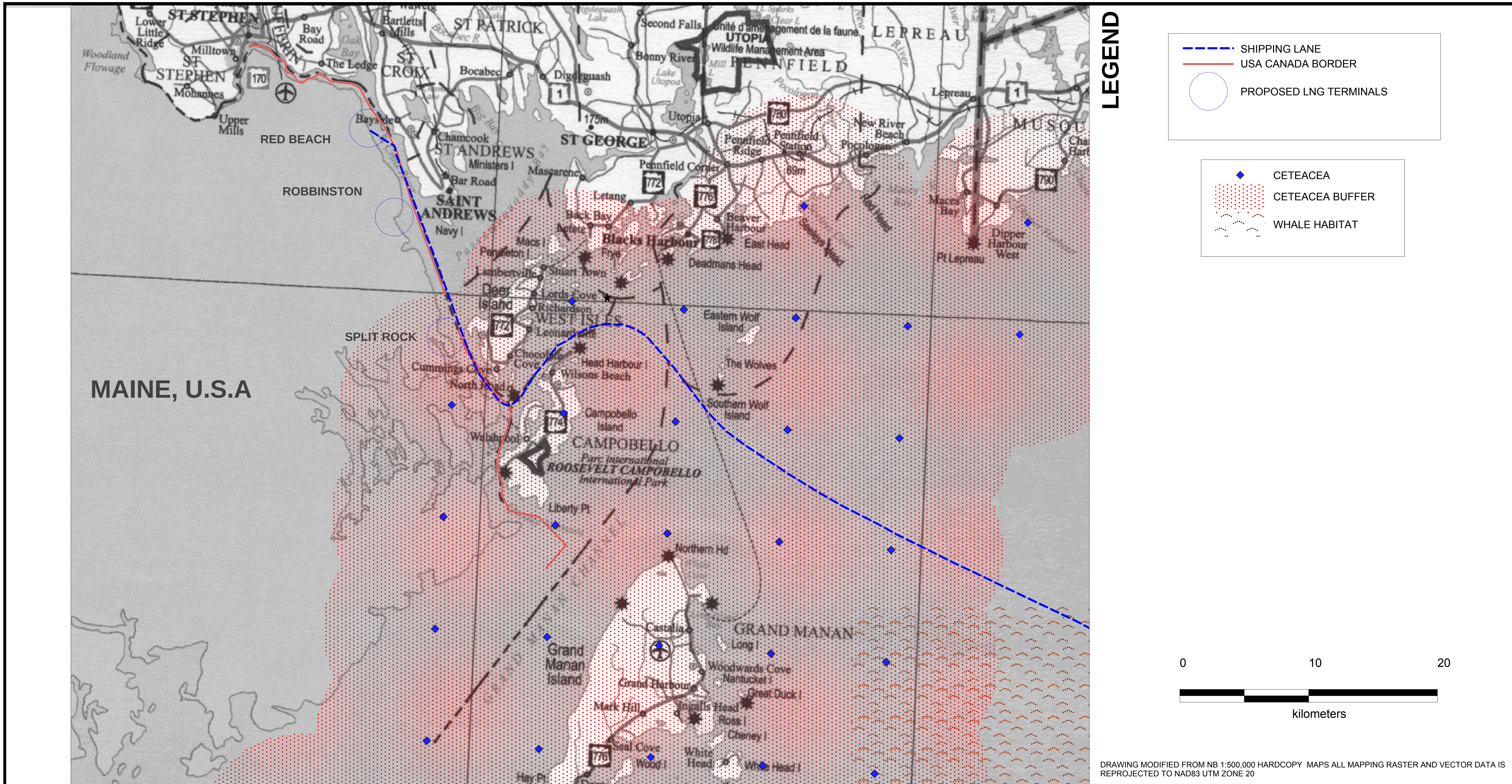

DRAWING MODIFIED FROM NB 1:500,000 HARDCOPY MAPS ALL MAPPING RASTER AND VECTOR DATA IS REPROJECTED TO NAD83 UTM ZONE 20

ACER Environmental Services Ltd.

# DEVELOPMENT OF LIQUIFIED NATURAL GAS TERMINALS ON PASSAMAQUODDY BAY

FILE NAME: FIG A2 FLORA AND FAUNA SPECIES AT RISK | JOB NO: FAC 15-1 | DRAWN BY: EBL | CHECKED BY: | DATE:

**FIGURE A2**
**VALUED ENVIRONMENTAL COMPONETS FOR FLORA AND FAUNA SPECIES AT RISK SHOWING ESTIMATED BOUNDARIES**

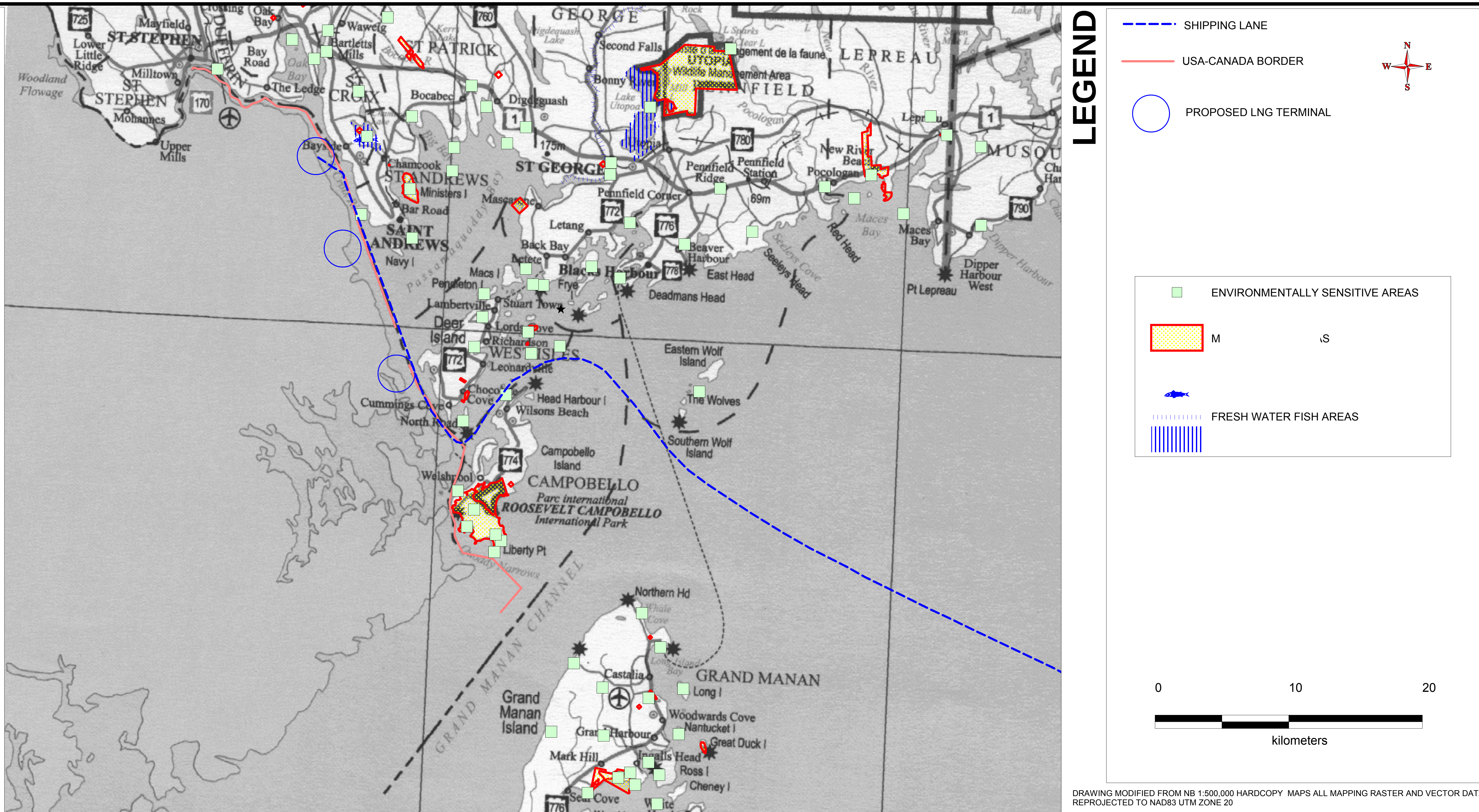



ACER Environmental Services Ltd.

**DEVELOPMENT OF LIQUIFIED NATURAL GAS TERMINALS ON PASSAMAQUODDY BAY**

FILE NAME: FIG A3 CETACEA SPECIES AT RISK JOB NO: FAC 15-1 DRAWN BY: EBL CHECKED BY: DATE:

**FIGURE A3**
**CETACEA SPECIES AT RISK**
**SHOWING ESTIMATED BOUNDARIES**

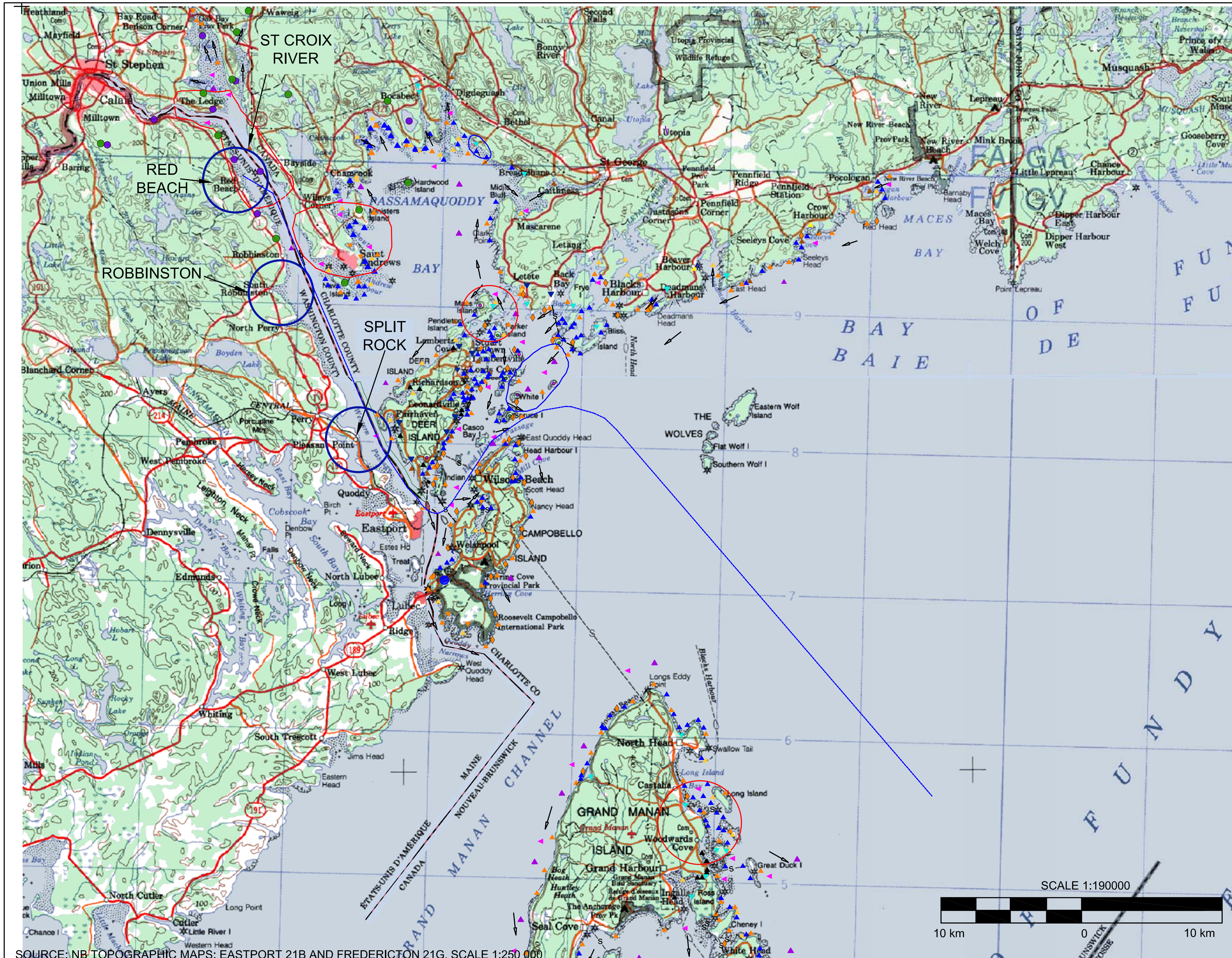



ACER Environmental Services Ltd.

# DEVELOPMENT OF LIQUIFIED NATURAL GAS TERMINALS ON PASSAMAQUODDY BAY

FILE NAME: FIG A4 ENVIRONMENTALLY SENSITIVE AREAS JOB NO: FAC 15-1 DRAWN BY: EBL CHECKED BY: DATE:

**FIGURE A4**
**SENSITIVE AND MANAGED/PROTECTED AREAS AND FRESH WATER FISH AREAS BASED ON ACCDC DATABASE**




SOURCE: NB TOPOGRAPHIC MAPS: EASTPORT 21B AND FREDERICTON 21G, SCALE 1:250 000

**LEGEND**

- Porposed LNG Terminals
- Approximate Location of Proposed LNG Shipping Lane
- Canada/USA Border

(REFERENCE: HUNTER & ASSOC. 1982 )

- Electrical Transmission Line
- Submarine power Cable
- Ground Fisheries
- Anadromous Species
- Lobster Ground
- Lobster Pound
- Clam Area
- Herring Weir
- Residual Nearshore Tidal Transport (mud)
- Residual Littoral Transport (sand/gravel/cobbles)
- Ecological Area (fauna Avian)
- Industrial-Dulse Grounds
- Costal Processes
- Salt Marsh
- Flooded Estuary
- Small Craft Harbour
- Proposed Ecological Reserve
- Water Supply Reservior
- Marine National Park Potential
- Wharf or Breakwater
- Ferry Route

(REFERENCE: ST. CROIX ESTUARY PROJECT

- Bald Eagle Nesting Habitat
- Osprey Nesting Habitat
- Salt Marsh

(REFERENCE: WEST ISLES FEASIBILITY STUDY)

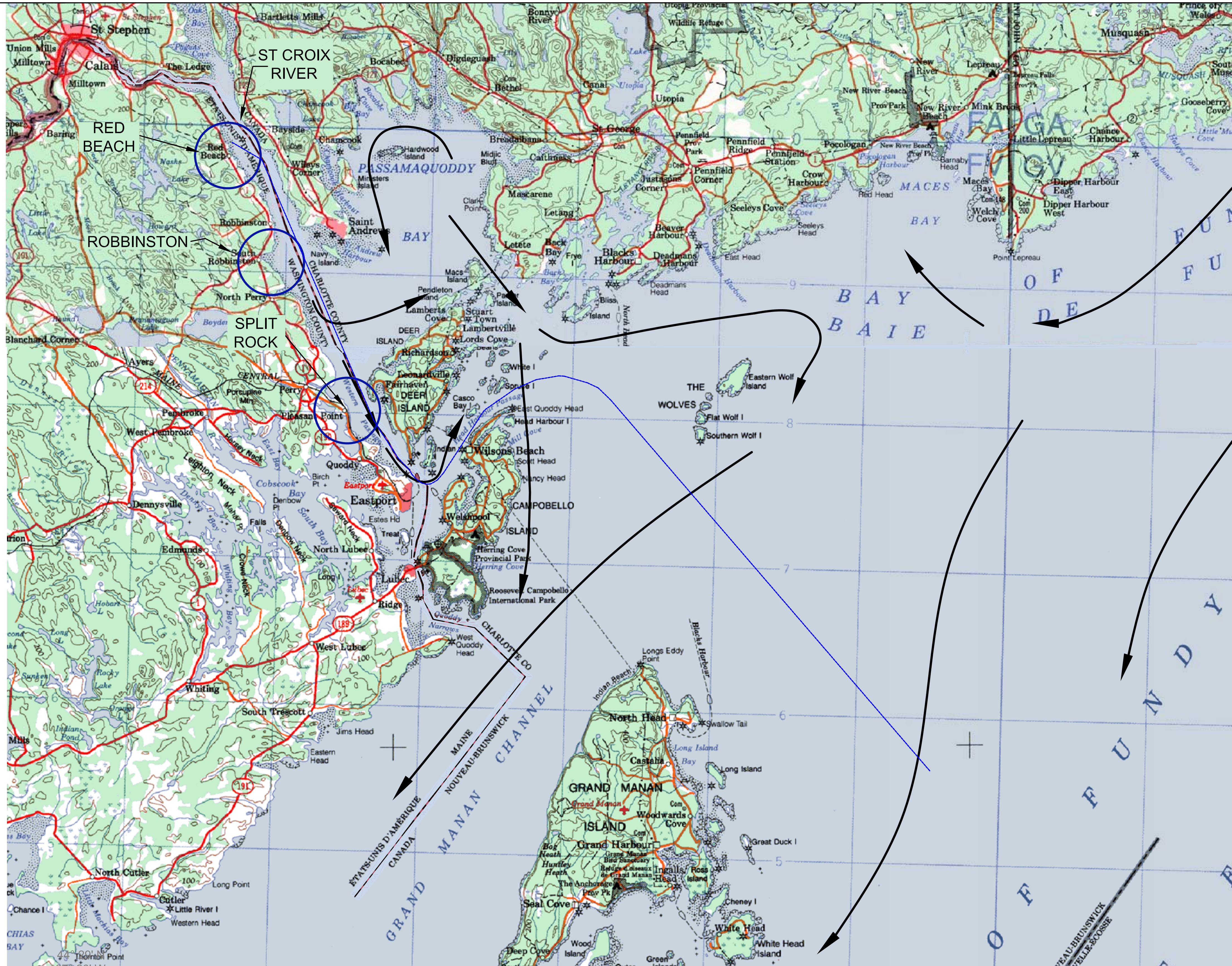
- Bald Eagle Nesting Habitat
- Osprey Nesting Habitat
- Ecological Area (Avian fauna- Cormorant, Black Guilletmot, possible Gannet sites.)

ACER Environmental Services Ltd.

DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY

FIGURE A5
OTHER VALUED ENVIRONMENTAL COMPONENTS FOR THE STUDY AREA

| FILE NAME: FIG A5 OTHER VEC'S | JOB NO: FAC 15-1 | DRAWN BY: RLJ | CHECKED BY: GP | DATE:05/08/06 |
|---|---|---|---|---|




LEGEND

PROPOSED LNG TERMINALS

APPROXIMATE LOCATION OF PROPOSED LNG SHIPPING LANE

CANADA/USA BORDER

DIRECTION OF CIRCULATION

REFERENCE: FUNDY COASTAL ZONE STUDY, MARCH 1, 1982

10000 5000 0 5000 10000

SCALE 1:30000

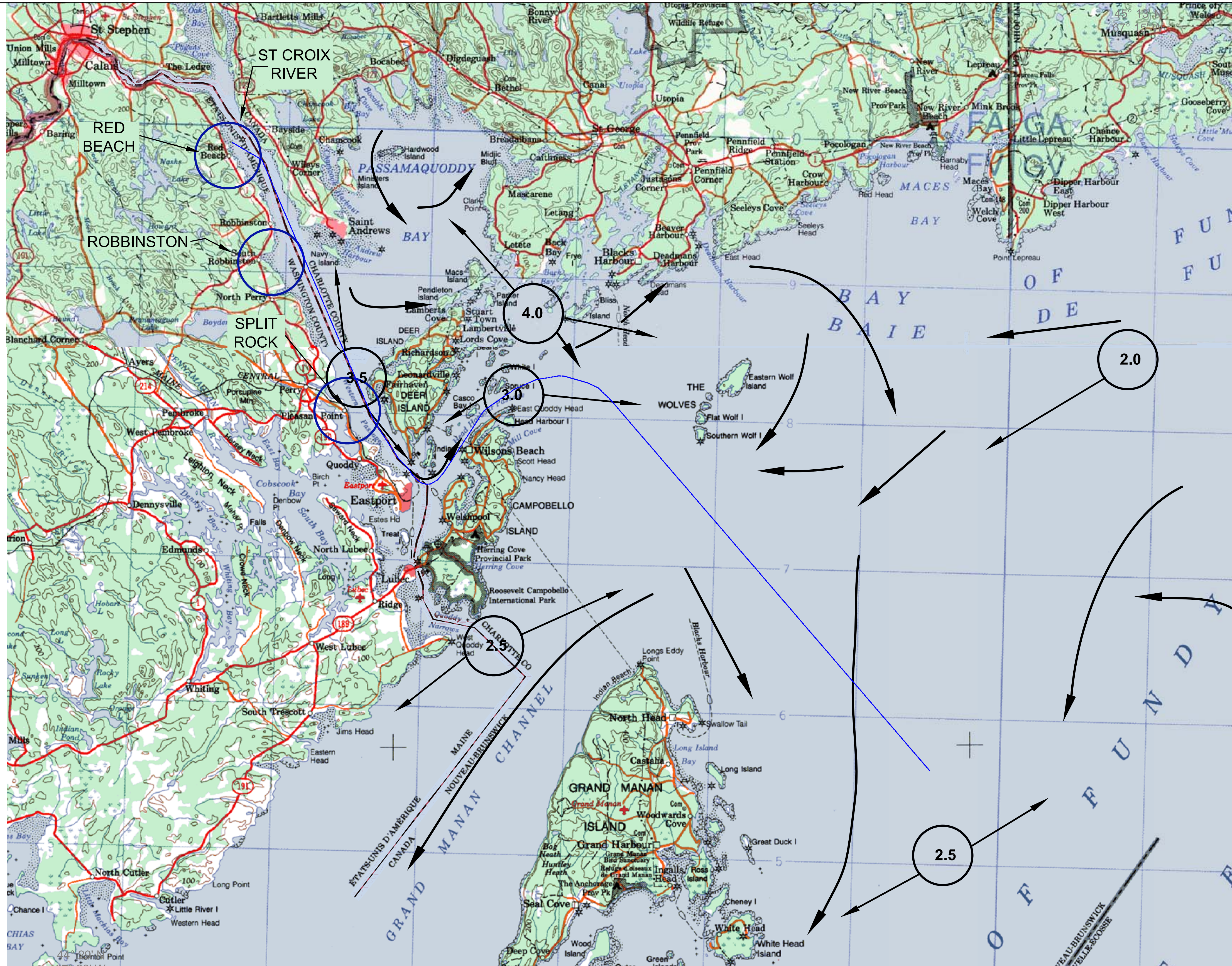
DRAWING MODIFIED FROM NB TOPOGRAPHIC MAPS; EASTPORT 21 B, SCALE 1:250 000 AND FREDERICTON 21 G, SCALE 1:250 000

ACER Environmental Services Ltd.

**DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY**

**FIGURE A6**
**SURFACE CIRCULATION TIDAL RANGE (SPRING)**

| FILE NAME: FIG A6 SURFACE CIRR.(spring) | JOB NO: FAC 15-1 | DRAWN BY: RLJ | CHECKED BY: GP | DATE:05/20/06 |
|---|---|---|---|---|




LEGEND

- PROPOSED LNG TERMINALS
- APPROXIMATE LOCATION OF PROPOSED LNG SHIPPING LANE
- CANADA/USA BORDER
- DIRECTION OF CIRCULATION
- 4.0 TIDAL SPEED IN KNOTS
- EBB-FLOOD TIDES

REFERENCE: FUNDY COASTAL ZONE STUDY, MARCH 1, 1982

10000 5000 0 5000 10000

SCALE 1:30000

DRAWING MODIFIED FROM NB TOPOGRAPHIC MAPS; EASTPORT 21 B, SCALE 1:250 000 AND FREDERICTON 21 G, SCALE 1:250 000

ACER Environmental Services Ltd.

DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY

| JOB NO: FAC 15-1 | DRAWN BY: RLJ | CHECKED BY: GP | DATE:05/20/06 |
|---|---|---|---|

**FIGURE A7**
**SURFACE CIRCULATION TIDAL RANGE (AUTUMN)**


LEGEND

PROPOSED LNG TERMINALS

APPROXIMATE LOCATION OF PROPOSED LNG SHIPPING LANE

CANADA/USA BORDER

FORRESTERS STATION NUMBERS

CANADIAN DEPARTMENT OF ENVIRONMENTAL STATION NUMBER

(2.6) NUMBERS IN PARENTHESIS IS MAXIMUM CURRENT SPEED (KNOTS)

CURRENT FLOW PATTERN

REFERENCE: CURRENT DIRECTION AND SPEED FROM U.S. ENVIRONMENTAL PROTECTION AGENCY REGION I, BOSTON, MA 02203

5000 0 5000

SCALE: 1: 160000

DRAWING MODIFIED FROM NB TOPOGRAPHIC MAPS; EASTPORT 21 B, SCALE 1:250 000 AND FREDERICTON 21 G, SCALE 1:250 000

ACER Environmental Services Ltd.

DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY

FIGURE A8
FLOOD TIDAL CURRENT PATTERNS IN QUODDY REGION AT SELECTED STATIONS

| FILE NAME: FIG A 8 FLOOD TIDAL CURRENT | JOB NO: FAC15-1 | DRAWN BY: RLJ | CHECKED BY:GP | DATE:06/12/06 |
|---|---|---|---|---|


LEGEND

PROPOSED LNG TERMINALS

APPROXIMATE LOCATION OF PROPOSED LNG SHIPPING LANE

CANADA/USA BORDER

FORRESTERS STATION NUMBERS

CANADIAN DEPARTMENT OF ENVIRONMENTAL STATION NUMBER

(2.6) NUMBERS IN PARENTHESIS IS MAXIMUM CURRENT SPEED (KNOTS)

CURRENT PATTERN DIRECTON

REFERENCE: CURRENT DIRECTION AND SPEED FROM U.S. ENVIRONMENTAL PROTECTION AGENCY REGION I, BOSTON, MA 02203

5000 0 5000

SCALE 1:160000

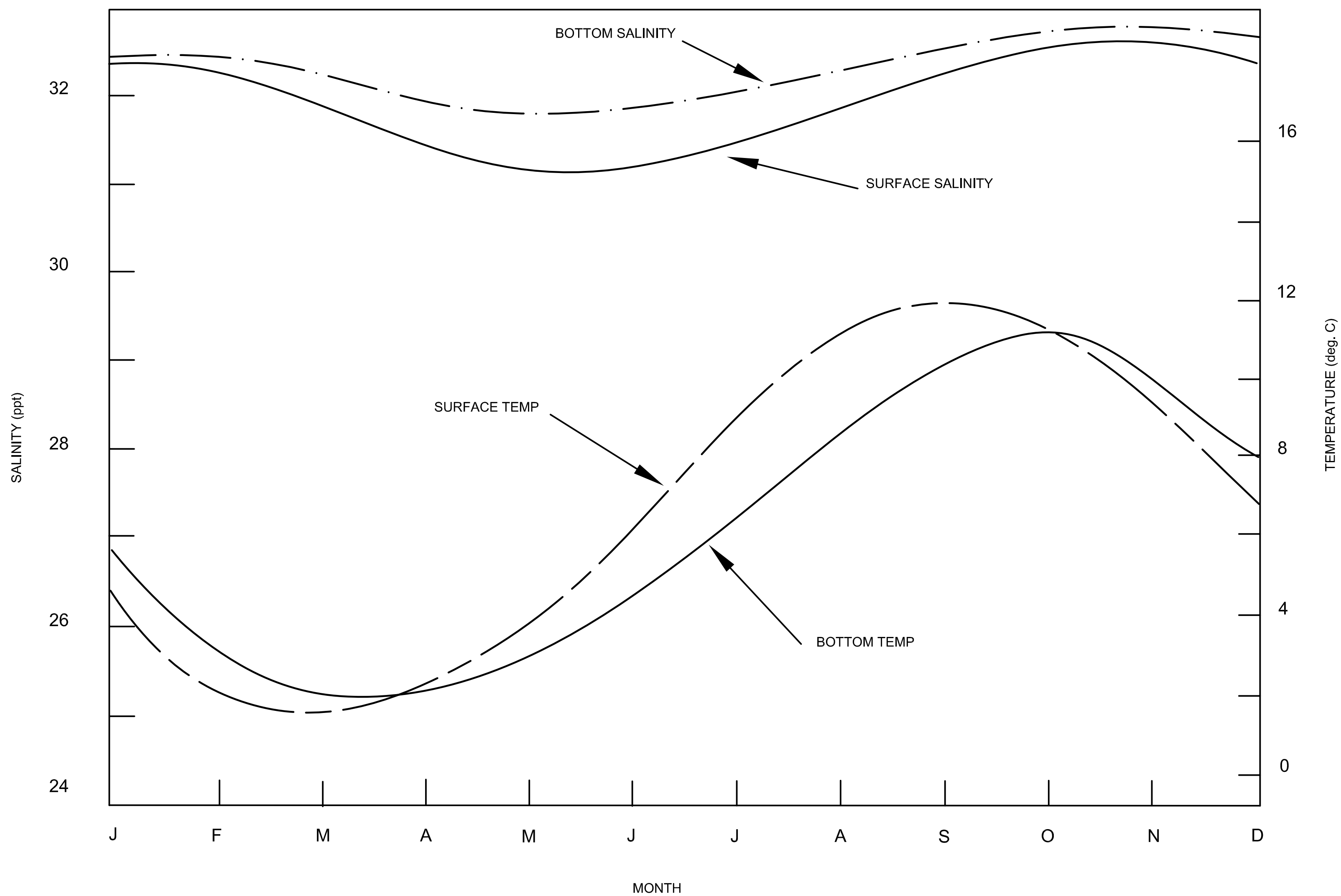
DRAWING MODIFIED FROM NB TOPOGRAPHIC MAPS; EASTPORT 21 B, SCALE 1:250 000 AND FREDERICTON 21 G, SCALE 1:250 000

ACER Environmental Services Ltd.

DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY

FIGURE A9
EBB TIDAL CURRENT PATTERNS IN QUODDY REGION AT SELECTED STATIONS

| FILE NAME: FIG A 8 FLOOD TIDAL CURRENT | JOB NO: FAC15-1 | DRAWN BY: RLJ | CHECKED BY:GP | DATE:06/12/06 |
|---|---|---|---|---|



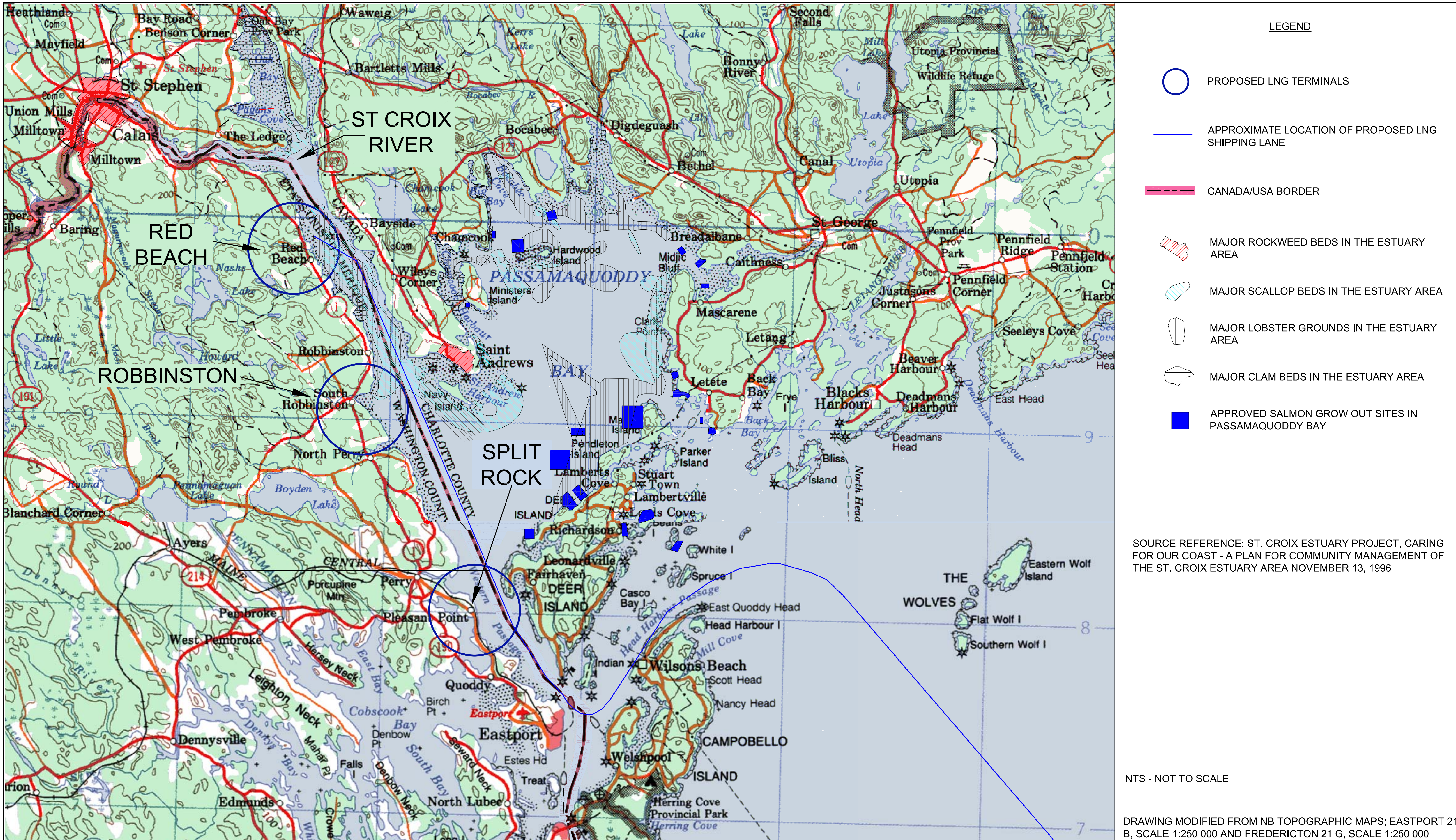

SOURCE: TRITES AND GARRETT, 1983

ACER Environmental Services Ltd.

**DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY**

| | | | | |
|---|---|---|---|---|
| FILE NAME: FIG A10 TEMPERATURE & SALINITY | JOB NO: FAC 15-1 | DRAWN BY: BPM | CHECKED BY: | DATE:06/15/06 |

**FIGURE A10**
**VARIATIONS IN MEAN MONTHLY TEMPERATURE AND SALINITY IN THE OUTER QUODDY REGION**




SOURCE REFERENCE: ST. CROIX ESTUARY PROJECT, CARING FOR OUR COAST - A PLAN FOR COMMUNITY MANAGEMENT OF THE ST. CROIX ESTUARY AREA NOVEMBER 13, 1996

NTS - NOT TO SCALE

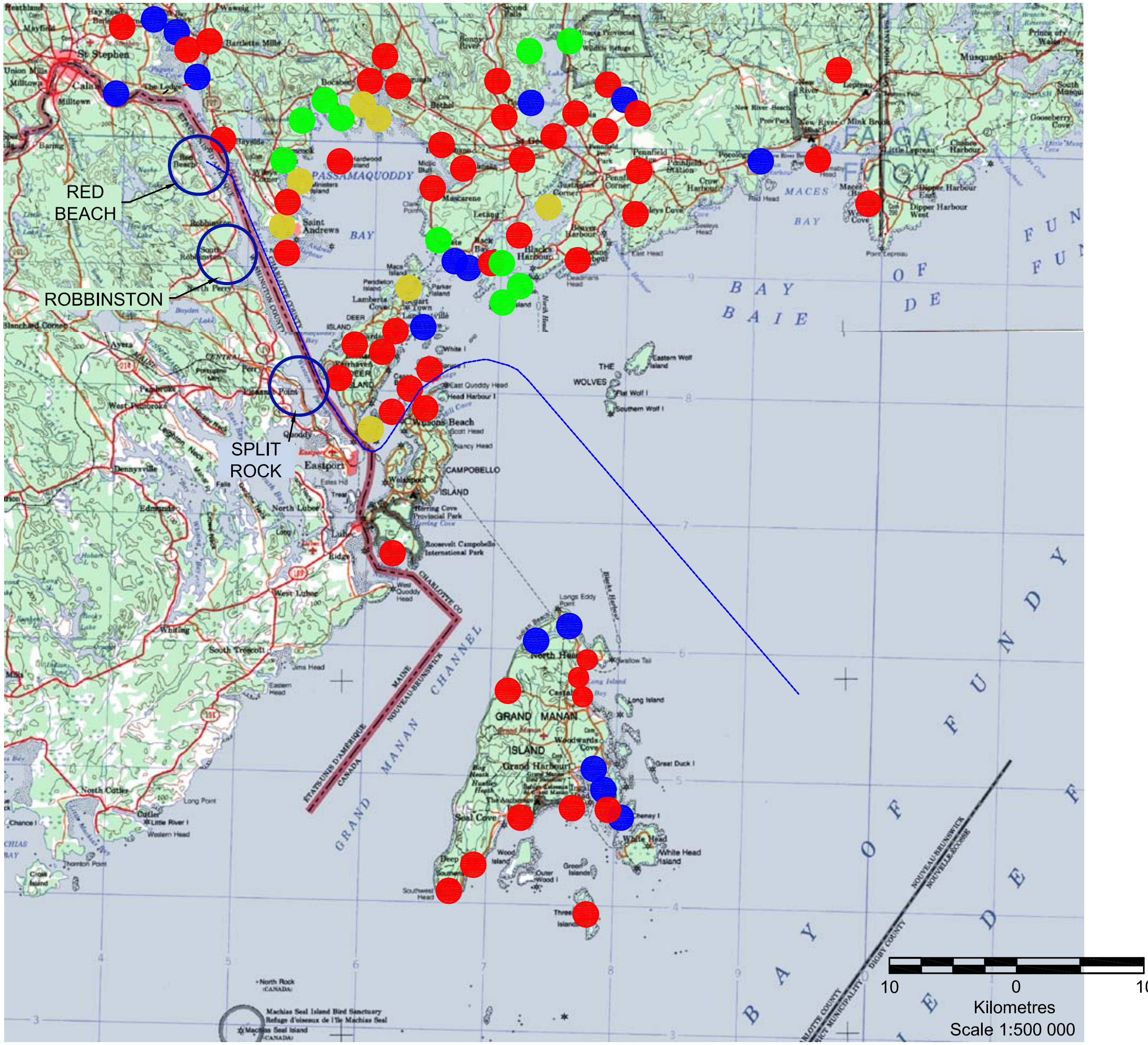
DRAWING MODIFIED FROM NB TOPOGRAPHIC MAPS; EASTPORT 21 B, SCALE 1:250 000 AND FREDERICTON 21 G, SCALE 1:250 000

ACER Environmental Services Ltd.

**DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY**

| FILE NAME: FAC 15-1 | JOB NO: FAC 15-1 | DRAWN BY: BPM | CHECKED BY: | DATE:05/10/06 |
|---|---|---|---|---|

**FIGURE A11**
**COMMERCIAL FISHERIES RESOURCES IN THE STUDY AREA**




N
W E
S

LEGEND

- Proposed Terminals
- Approximate Location of Proposed LNG Shipping Lane
- One Site Within a Few 1000 m
- Two Sites Within a Few 1000 m
- More Than Five Sites Within a Few 1000 m
- More Than Ten Sites Within a Few 1000 m

DATA PROVIDED BY THE NEW BRUNSWICK ARCHAEOLOGICAL SERVICES, HERITAGE BRANCH, DEPARTMENT OF WELLNESS, CULTURE AND SPORT

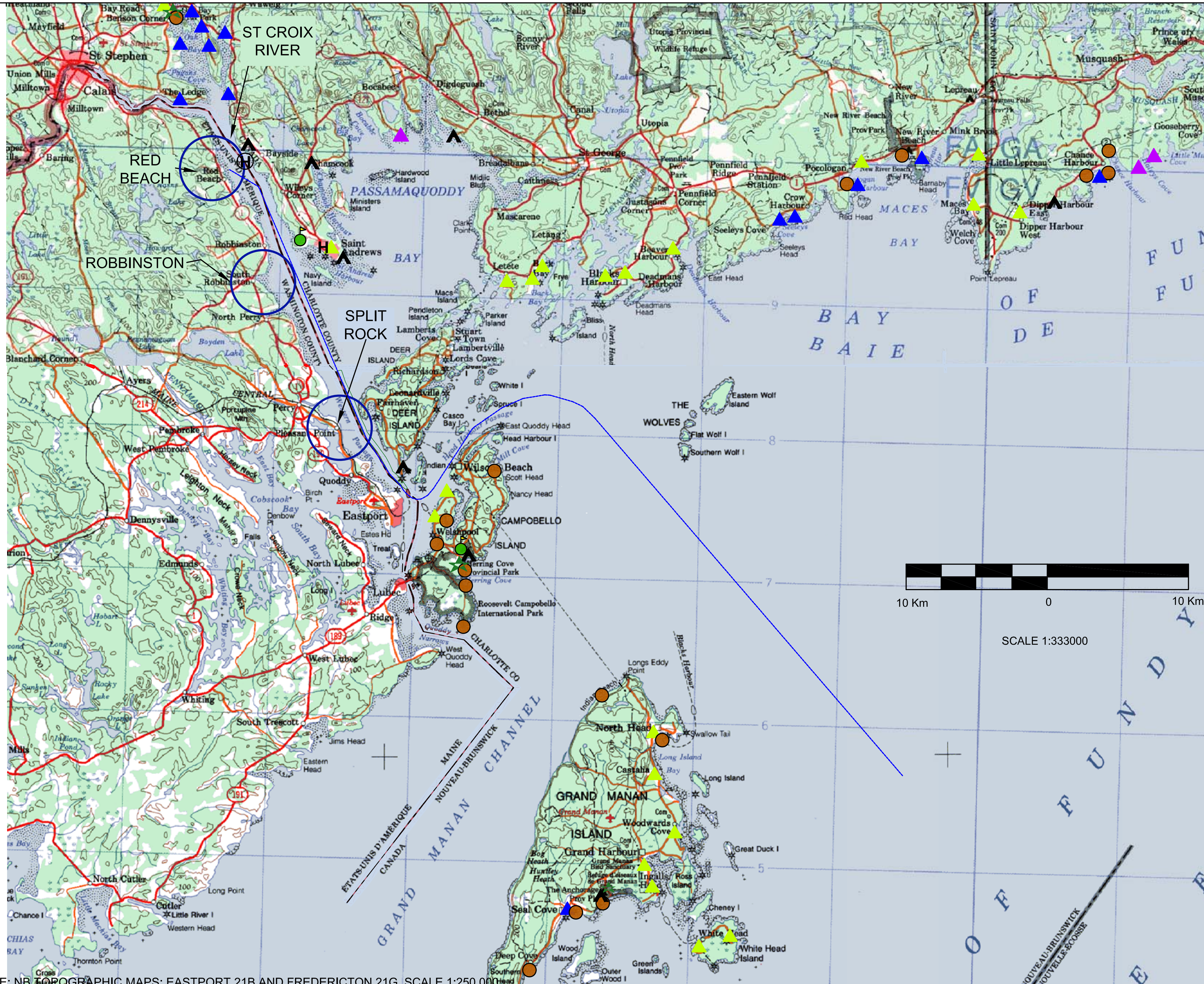
REFERENCE: ZONES MODIFIED FROM OLD SOW PUBLISHING, EASTPORT, MAINE

ACER Environmental Services Ltd.

**DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY**

**FIGURE A12**
**ARCHAEOLOGICAL DATA**

| FILE NAME: FIG A12 ARC DATA | JOB NO:FAC15-1 | DRAWN BY: RJ | CHECKED BY: | DATE:05/17/06 |
|---|---|---|---|---|




LEGEND

- Porposed LNG Terminals
- Approximate Location of Proposed LNG Shipping Lane
- Canada/USA Border

ON/NEAR SHORE ACTIVITIES

- Provincial Park
- Residentail Shore Development
- Public Beaches (recreation day use/beach)
- Campground/Trailer Park
- Golf Course
- Public Landing
- Urban and Rural Built Up Areas (Shore)
- H Historical Site

(REFERENCES: HUNTER & ASSOC. 1982,QUODDY LOOP-PARKS, RECREATION, NATURAL & HIKING AREAS 2006.
WEBSITES: WWW.FDR.NET/ENGLISHII/INTERACTIVEMP.HTML
HTTP://NEW-BRUNSWICK.NET/NEW-BRUNSWICK/MAPS/GRANDMANAN.JPG)

SOURCE: NB TOPOGRAPHIC MAPS: EASTPORT 21B AND FREDERICTON 21G, SCALE 1:250 000

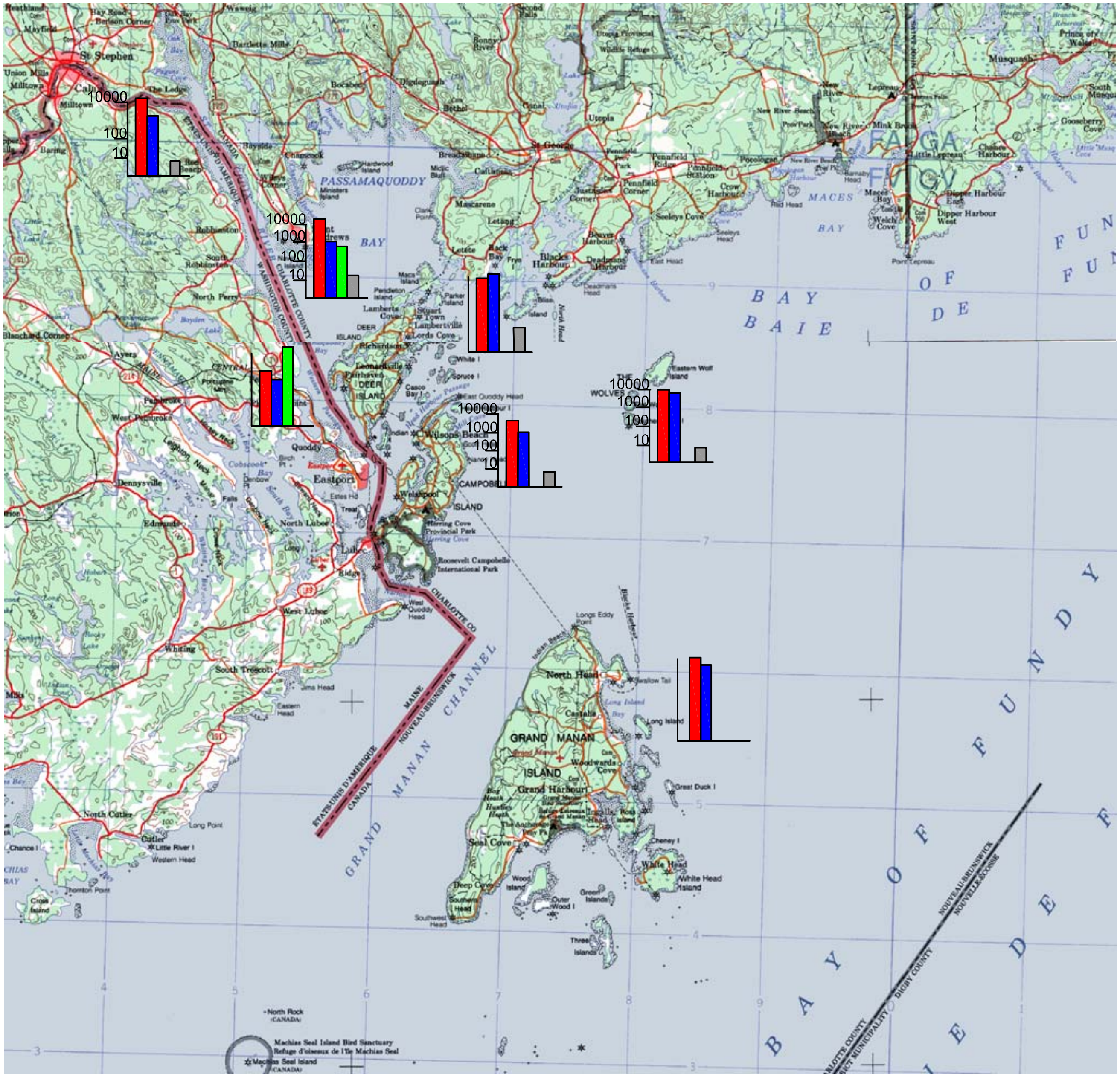
ACER Environmental Services Ltd.

DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY

| FILE NAME: FIG A15 Tour./Rec Areas | JOB NO: FAC 15-1 | DRAWN BY: RLJ | CHECKED BY: GP | DATE:07/18/06 |
|---|---|---|---|---|

**FIGURE A13**
**OTHER SOCIO-ECONOMIC LAND USE CONSIDERATIONS IN THE STUDY AREA**

# APPENDIX B
# SPATIAL DISTRIBUTION




N
W E
S

LEGEND

- Waterfowl
- Seabirds
- Shorebirds
- Raptors

(Data are on a logarithmic scale.)

- Approximate Location of Proposed LNG Shipping Lane
- Porposed LNG Terminals

REFERENCE:LOTZE AND MILEWSKI 2002

ACER Environmental Services Ltd.

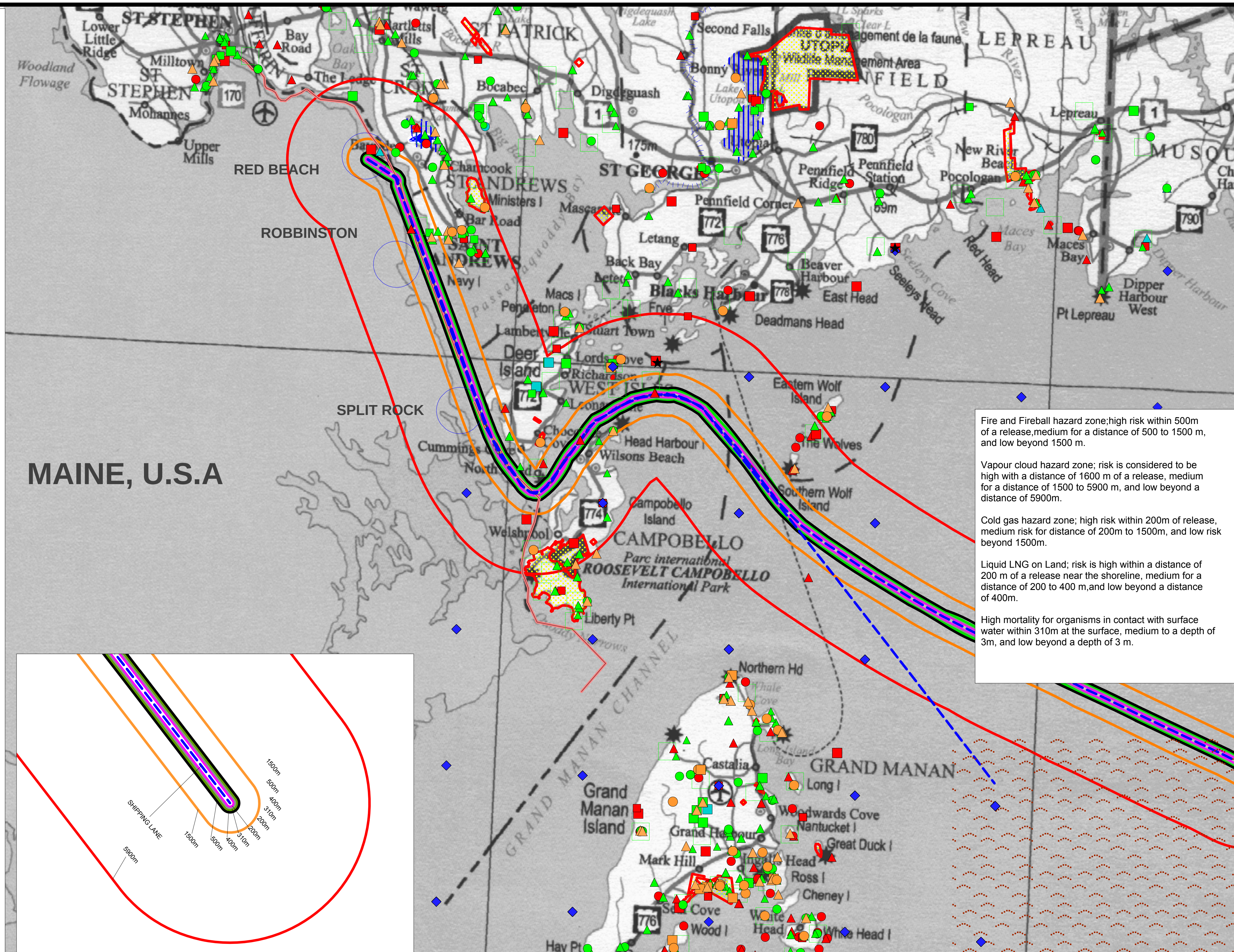
**DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY**

| FILE NAME: FIGURE B1 | JOB NO:FAC15-1 | DRAWN BY: BM | CHECKED BY: | DATE:08/31/06 |
|---|---|---|---|---|

**FIGURE B1**
**SPATIAL DISTRIBUTION OF WATERFOWL, SEABIRDS, SHOREBIRDS AND RAPTORS IN THE STUDY AREA**

# APPENDIX C

# ENVIRONMENTAL DATA FOR PROJECT




## LEGEND

- SHIPPING LANE
- USA CANADA BORDER
- PROPOSED LNG TERMINALS
- RIGHT WHALE SANCTUARY

N / W / E / S

**BIOTA**

- VERTEBRATE FAUNA
- VASCULAR FLORA
- NONVASCULAR FLORA
- INVERTEBRATE FAUNA
- CETECEA

Symbol Shape indicates Precision of Geolocation for VEC

- SQUARE SIZE REPRESENTS 5, 10 and 50km
- WITHIN 100'S METERS
- WITHIN KILOMETERS
- WITHIN COUNTY

- ENVIRONMENTALLY SENSITIVE AREAS
- MANAGED/PROTECTED AREA
- MANAGED/PROTECTED AREA (NO DEFINED BOUNDARIES)
- FRESH WATER FISH AREA

0 10 20

kilometers

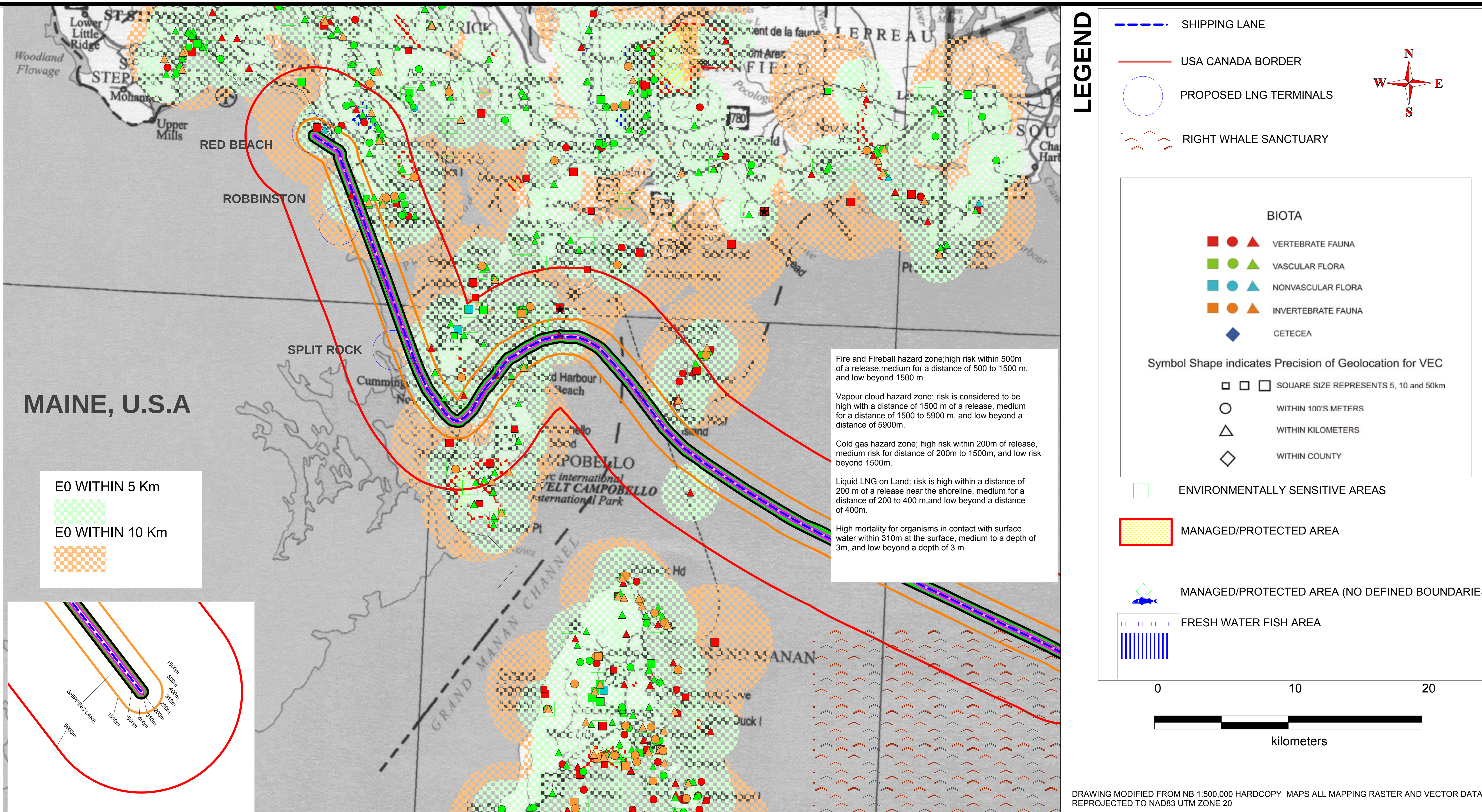
DRAWING MODIFIED FROM NB 1:500,000 HARDCOPY MAPS ALL MAPPING RASTER AND VECTOR DATA IS REPROJECTED TO NAD83 UTM ZONE 20

ACER Environmental Services Ltd.

# DEVELOPMENT OF LIQUIFIED NATURAL GAS TERMINALS ON PASSAMAQUODDY BAY

| FILE NAME: FIG D1 SPECIES AT RISK | JOB NO: FAC 15-1 | DRAWN BY: EBL | CHECKED BY: | DATE: |
|---|---|---|---|---|

**FIGURE C1**
**SPECIES AT RISK AND SENSITIVE AREAS FOR THE STUDY AREA and HAZARD ZONES**



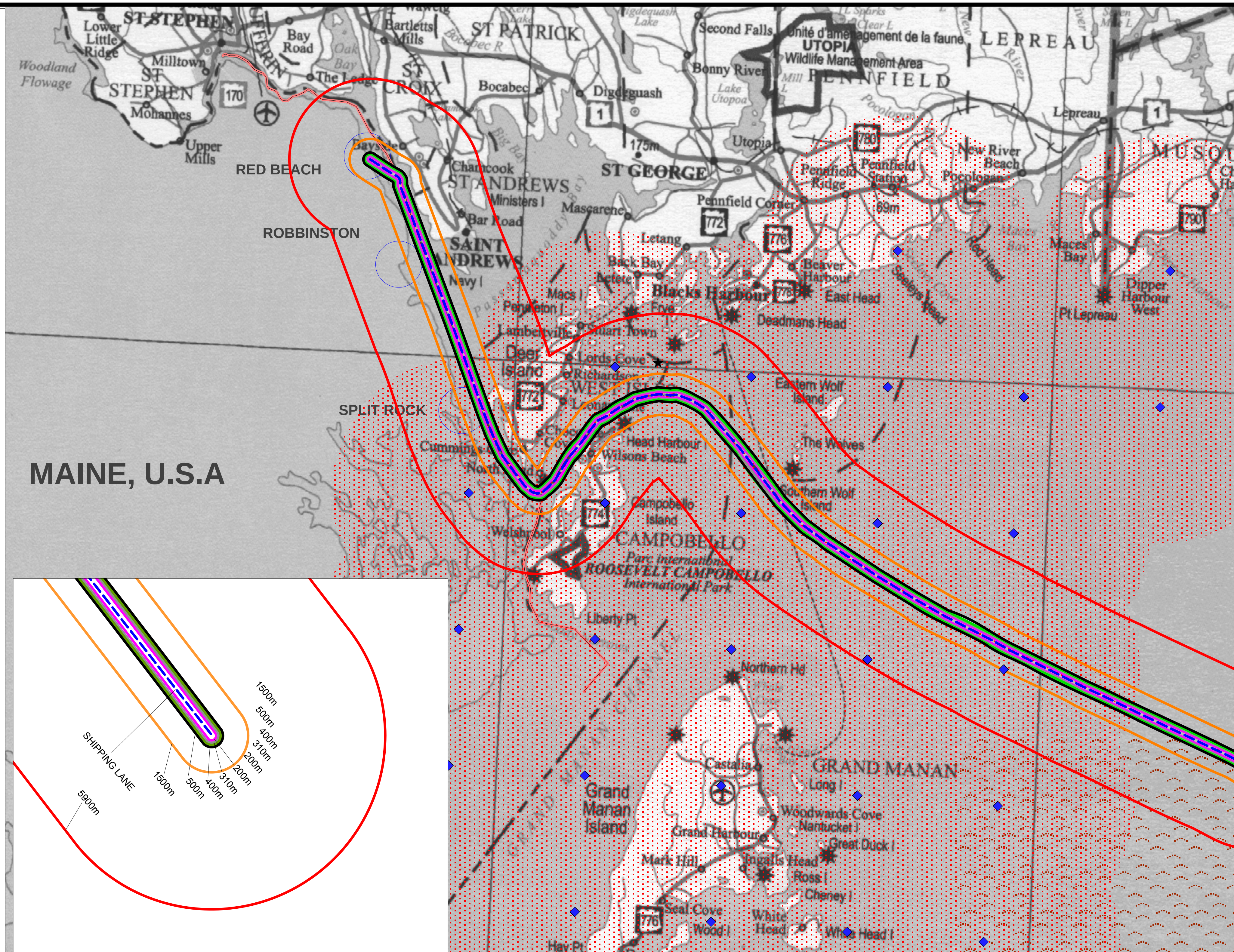

DRAWING MODIFIED FROM NB 1:500,000 HARDCOPY MAPS ALL MAPPING RASTER AND VECTOR DATA IS REPROJECTED TO NAD83 UTM ZONE 20

ACER Environmental Services Ltd.

# DEVELOPMENT OF LIQUIFIED NATURAL GAS TERMINALS ON PASSAMAQUODDY BAY

| FILE NAME: FIG D2 FLORA AND FAUNA SPECIES AT RISK | JOB NO: FAC 15-1 | DRAWN BY: EBL | CHECKED BY: | DATE: |
|---|---|---|---|---|

**FIGURE C2**
**VALUED ENVIRONMENTAL COMPONETS FOR FLORA AND FAUNA SPECIES AT RISK SHOWING ESTIMATED BOUNDARIES and HAZARD ZONES**




**LEGEND**

USA CANADA BORDER
SHIPPING LANE
PROPOSED LNG TERMINALS

CETEACEA
CETEACEA BUFFER
WHALE HABITAT

Fire and Fireball hazard zone;high risk within 500m of a release,medium for a distance of 500 to 1500 m, and low beyond 1500 m.

Vapour cloud hazard zone; risk is considered to be high with a distance of 1500 m of a release, medium for a distance of 1500 to 5900 m, and low beyond a distance of 5900m.

Cold gas hazard zone; high risk within 200m of release, medium risk for distance of 200m to 1500m, and low risk beyond 1500m.

Liquid LNG on Land; risk is high within a distance of 200 m of a release near the shoreline, medium for a distance of 200 to 400 m,and low beyond a distance of 400m.

High mortality for organisms in contact with surface water within 310m at the surface, medium to a depth of 3m, and low beyond a depth of 3 m.

0 10 20

kilometers

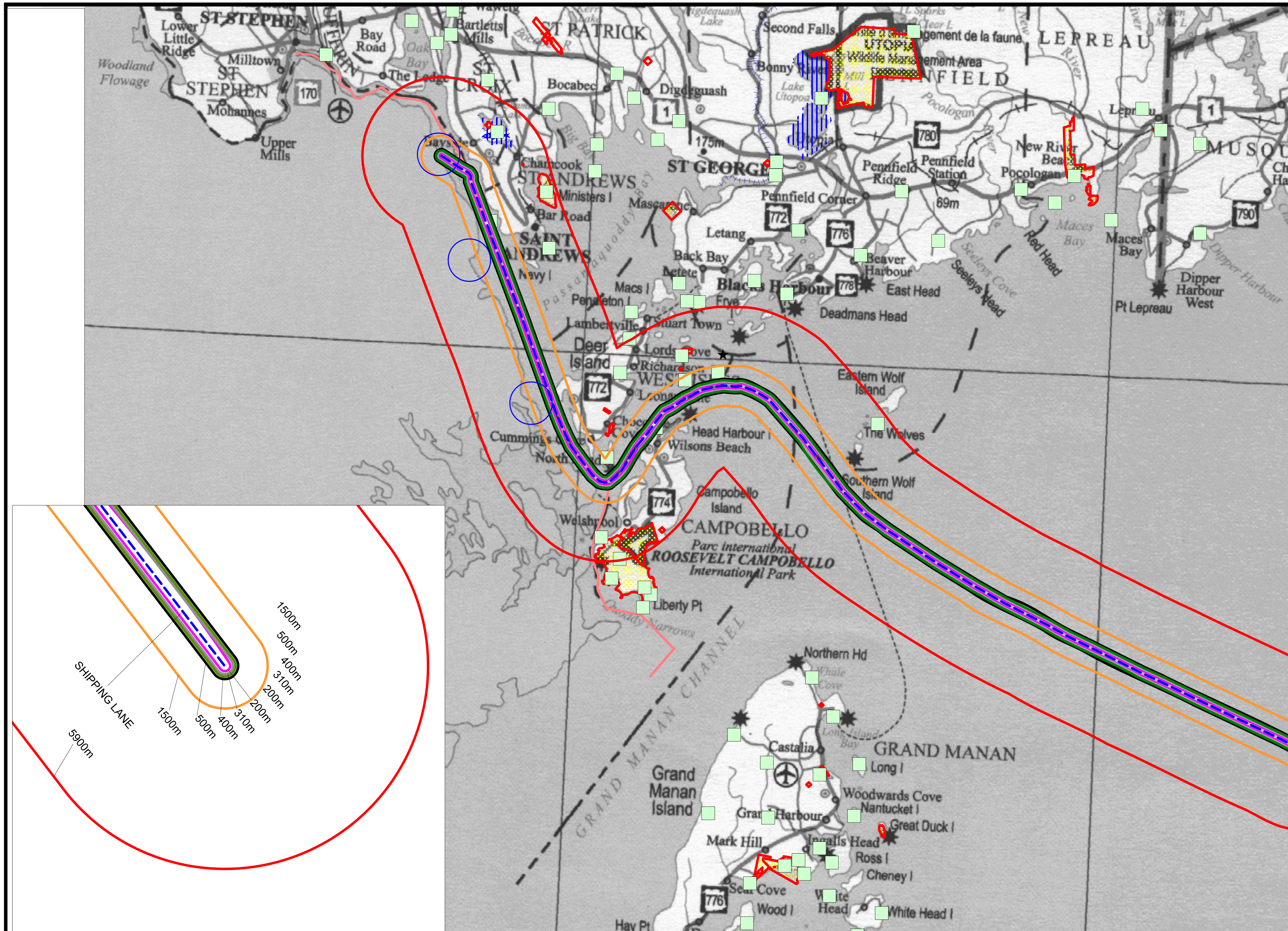
DRAWING MODIFIED FROM NB 1:500,000 HARDCOPY MAPS ALL MAPPING RASTER AND VECTOR DATA IS REPROJECTED TO NAD83 UTM ZONE 20

ACER Environmental Services Ltd.

# DEVELOPMENT OF LIQUIFIED NATURAL GAS TERMINALS ON PASSAMAQUODDY BAY

FILE NAME: FIG D3 CETACEA SPECIES AT RISK JOB NO: FAC 15-1 DRAWN BY: EBL CHECKED BY: DATE:

**FIGURE C3**
**CETACEA SPECIES AT RISK**
**SHOWING ESTIMATED BOUNDARIES**
**and HAZARD ZONES**




# LEGEND

SHIPPING LANE

USA-CANADA BORDER

PROPOSED LNG TERMINAL

N W E S

ENVIRONMENTALLY SENSITIVE AREAS

MANAGEMENT AREAS

FRESH WATER FISH AREAS

Fire and Fireball hazard zone;high risk within 500m of a release,medium for a distance of 500 to 1500 m, and low beyond 1500 m.

Vapour cloud hazard zone; risk is considered to be high with a distance of 1500 m of a release, medium for a distance of 1500 to 5900 m, and low beyond a distance of 5900m.

Cold gas hazard zone; high risk within 200m of release, medium risk for distance of 200m to 1500m, and low risk beyond 1500m.

Liquid LNG on Land; risk is high within a distance of 200 m of a release near the shoreline, medium for a distance of 200 to 400 m,and low beyond a distance of 400m.

High mortality for organisms in contact with surface water within 310m at the surface, medium to a depth of 3m, and low beyond a depth of 3 m.

0 10 20

kilometers

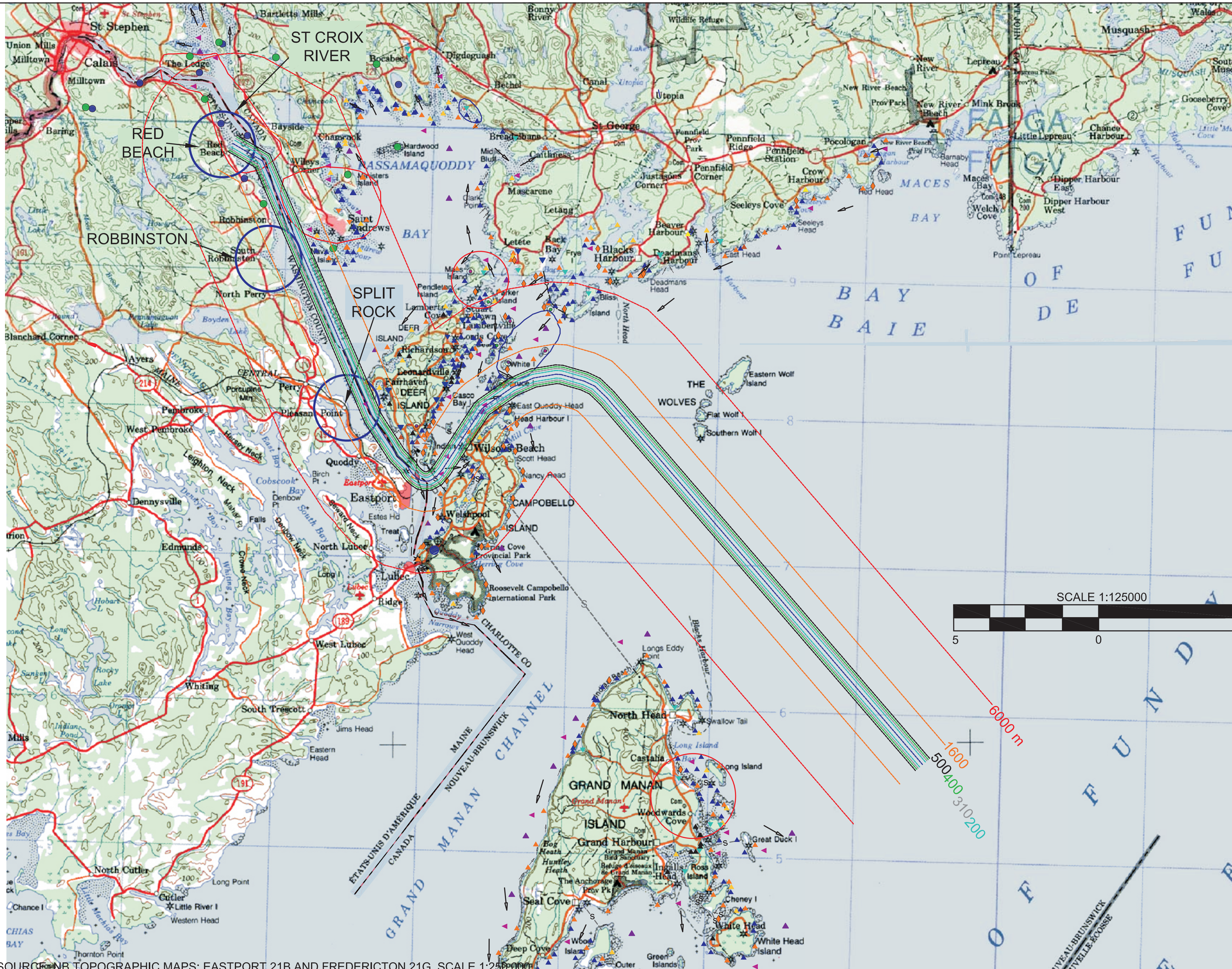
DRAWING MODIFIED FROM NB 1:500,000 HARDCOPY MAPS ALL MAPPING RASTER AND VECTOR DATA IS REPROJECTED TO NAD83 UTM ZONE 20

**ACER**
Environmental Services Ltd.

# DEVELOPMENT OF LIQUIFIED NATURAL GAS TERMINALS ON PASSAMAQUODDY BAY

FILE NAME: FIG D4 ENVIRONMENTALLY SENSITIVE AREAS JOB NO: FAC 15-1 DRAWN BY: EBL CHECKED BY: DATE:

**FIGURE C4**
**SENSITIVE AND MANAGED/PROTECTED AREAS AND FRESH WATER FISH AREAS BASED ON ACCDC DATABASE and HAZARD ZONES**




## LEGEND

- Porposed LNG Terminals
- Approximate Location of Proposed LNG Shipping Lane
- Canada/USA Border

(REFERENCE: HUNTER & ASSOC. 1982 )

- Electrical Transmission Line
- Submarine power Cable
- Ground Fisheries
- Anadromous Species
- Lobster Ground
- Lobster Pound
- Clam Area
- Herring Weir
- Residual Nearshore Tidal Transport (mud)
- Residual Littoral Transport (sand/gravel/cobbles)
- Ecological Area (fauna Avian)
- Industrial-Dulse Grounds
- Costal Processes
- Salt Marsh
- Flooded Estuary
- Small Craft Harbour
- Proposed Ecological Reserve
- Water Supply Reservior
- Marine National Park Potential
- Wharf or Breakwater
- Ferry Route

(REFERENCE: ST. CROIX ESTUARY PROJECT

- Bald Eagle Nesting Habitat
- Osprey Nesting Habitat
- Salt Marsh

(REFERENCE: WEST ISLES FEASIBILITY STUDY)

- Bald Eagle Nesting Habitat
- Osprey Nesting Habitat
- Ecological Area (Avian fauna- Cormorant, Black Guilletmot, possible Gannet sites.)

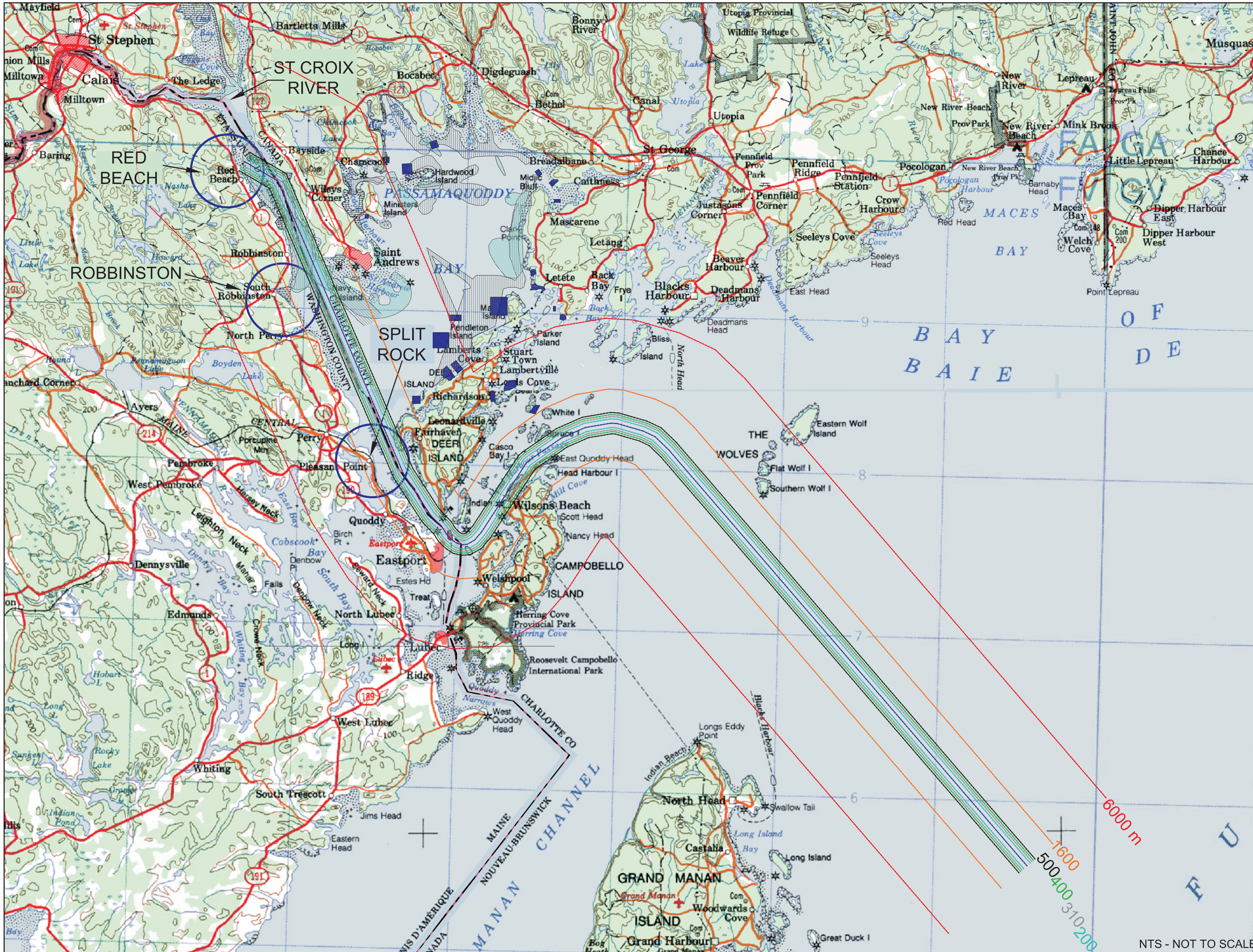
REFER TO FIGURE D4 LEGEND DESCRIBING MAXIMUM HAZARD ZONES.

ACER Environmental Services Ltd.

DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY

FIGURE C5
OTHER VALUED ENVIRONMENTAL COMPONENTS FOR THE STUDY AREA AND HAZARD ZONES

| FILE NAME: FIG A5 OTHER VEC'S | JOB NO: FAC 15-1 | DRAWN BY: RLJ | CHECKED BY: GP | DATE:05/08/06 |
|---|---|---|---|---|




LEGEND

- PROPOSED LNG TERMINALS
- APPROXIMATE LOCATION OF PROPOSED LNG SHIPPING LANE
- CANADA/USA BORDER
- MAJOR ROCKWEED BEDS IN THE ESTUARY AREA
- MAJOR SCALLOP BEDS IN THE ESTUARY AREA
- MAJOR LOBSTER GROUNDS IN THE ESTUARY AREA
- MAJOR CLAM BEDS IN THE ESTUARY AREA
- APPROVED SALMON GROW OUT SITES IN PASSAMAQUODDY BAY

SOURCE REFERENCE: ST. CROIX ESTUARY PROJECT, CARING FOR OUR COAST - A PLAN FOR COMMUNITY MANAGEMENT OF THE ST. CROIX ESTUARY AREA NOVEMBER 13, 1996

FIRE AND FIREBALL HAZARD ZONE; HIGH RISK WITHIN 500 M OF A RELEASE, MEDIUM FOR A DISTANCE OF 500 TO 1600 M, AND LOW BEYOND 1600 M.

VAPOUR CLOUD HAZARD ZONE; RISK IN CONSIDERED TO BE HIGH WITH A DISTANCE OF 1600 M OF A RELEASE, MEDIUM FOR A DISTANCE OF 1600 TO 6000 M, AND LOW BEYOND A DISTANCE OF 6000 M.

COLD GAS HAZARD ZONE; HIGH RISK WITHIN 200M OF RELEASE, MEDIUM RISK FOR DISTANCE OF 200M TO 1600M, AND LOW RISK BEYOND 1600M

LIQUID LNG ON LAND; RICK IS HIGH WITHIN A DISTANCE OF 200 M OF A RELEASE NEAR THE SHORELINE, MEDIUM FOR A DISTANCE OF 200 TO 400 M, AND LOW BEYOND A DISTANCE OF 400M.

HIGH MORTALITY FOR ORGANISMS IN CONTACT WITH SURFACE WATER WITHIN 310 m AT THE SURFACE, MEDIUM TO A DEPTH OF 3 m, AND LOW BEYOND A DEPTH OF 3 m.

REFERENCE: Zones Modified from 2005 Old Sow Publishing, Eastport, Maine

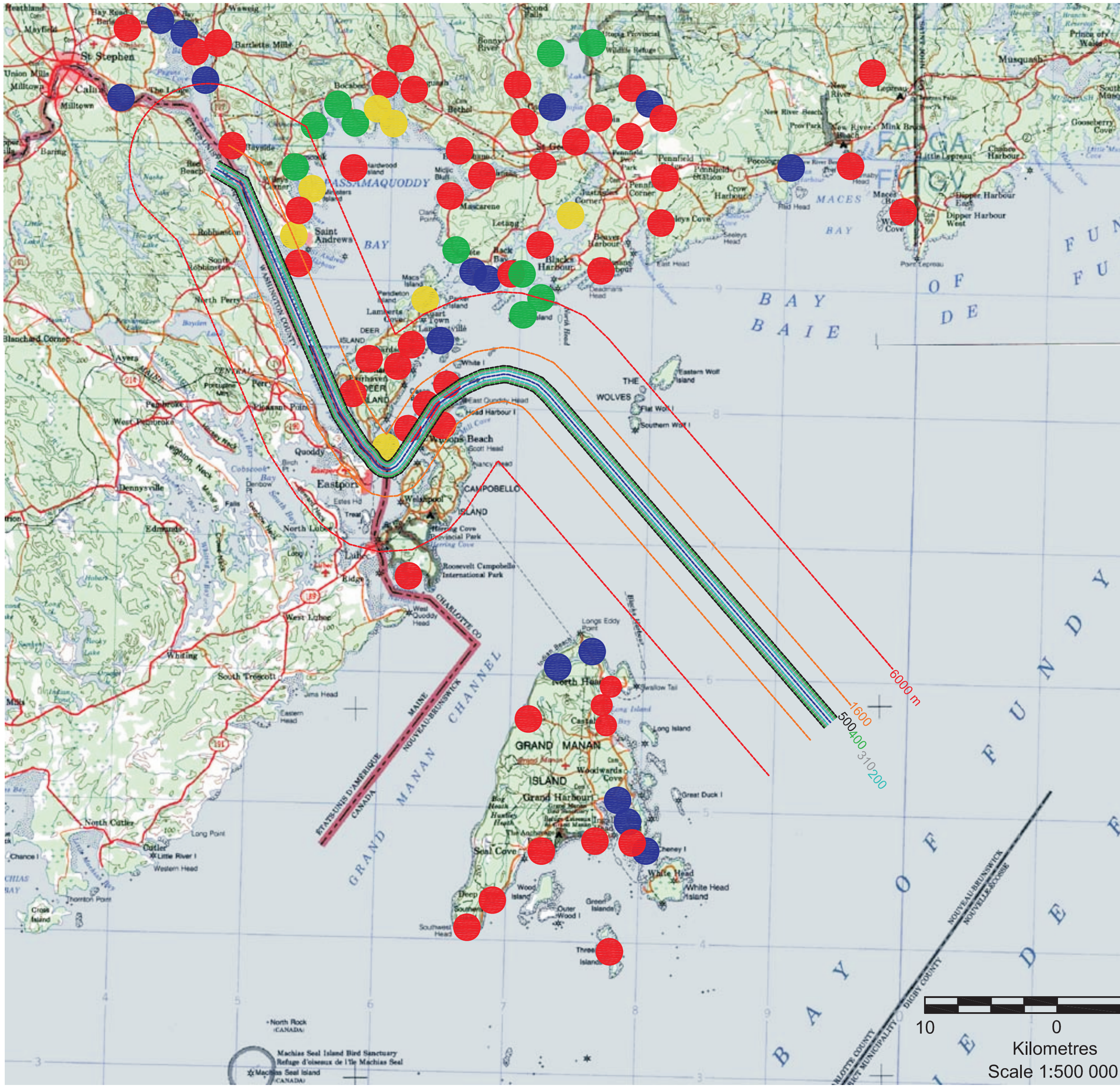
DRAWING MODIFIED FROM NB TOPOGRAPHIC MAPS; EASTPORT 21 B, SCALE 1:250 000 AND FREDERICTON 21 G, SCALE 1:250 000

ACER Environmental Services Ltd.

DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY

FIGURE C6
COMMERCIAL FISHERIES RESOURCES FOR THE STUDY AREA AND HAZARD ZONES

| FILE NAME: FAC 15-1 | JOB NO: FAC 15-1 | DRAWN BY: BPM | CHECKED BY: | DATE:05/10/06 |
|---|---|---|---|---|




N
W E
S

LEGEND

- One Site Within a Few 1000 m
- Two Sites Within a Few 1000 m
- More Than Five Sites Within a Few 1000 m
- More Than Ten Sites Within a Few 1000 m

DATA PROVIDED BY THE NEW BRUNSWICK ARCHAEOLOGICAL SERVICES, HERITAGE BRANCH, DEPARTMENT OF WELLNESS, CULTURE AND SPORT

Fire and Fireball hazard zone; high risk within 500 m of a release, medium for a distance of 500 to 1600 m, and low beyond 1600 m.

Vapour cloud hazard zone; risk in considered to be high with a distance of 1600 m of a release, medium for a distance of 1600 to 6000 m, and low beyond a distance of 6000 m.

Cold gas hazard zone; high risk within 200m of release, medium risk for distance of 200m to 1600m, and low risk beyond 1600m

Liquid LNG on Land; rick is high within a distance of 200 m of a release near the shoreline, medium for a distance of 200 to 400 m, and low beyond a distance of 400m.

High mortality for organisms in contact with surface water within 310 m at the surface, medium to a depth of 3 m, and low beyond a depth of 3 m.

10 0 10
Kilometres
Scale 1:500 000

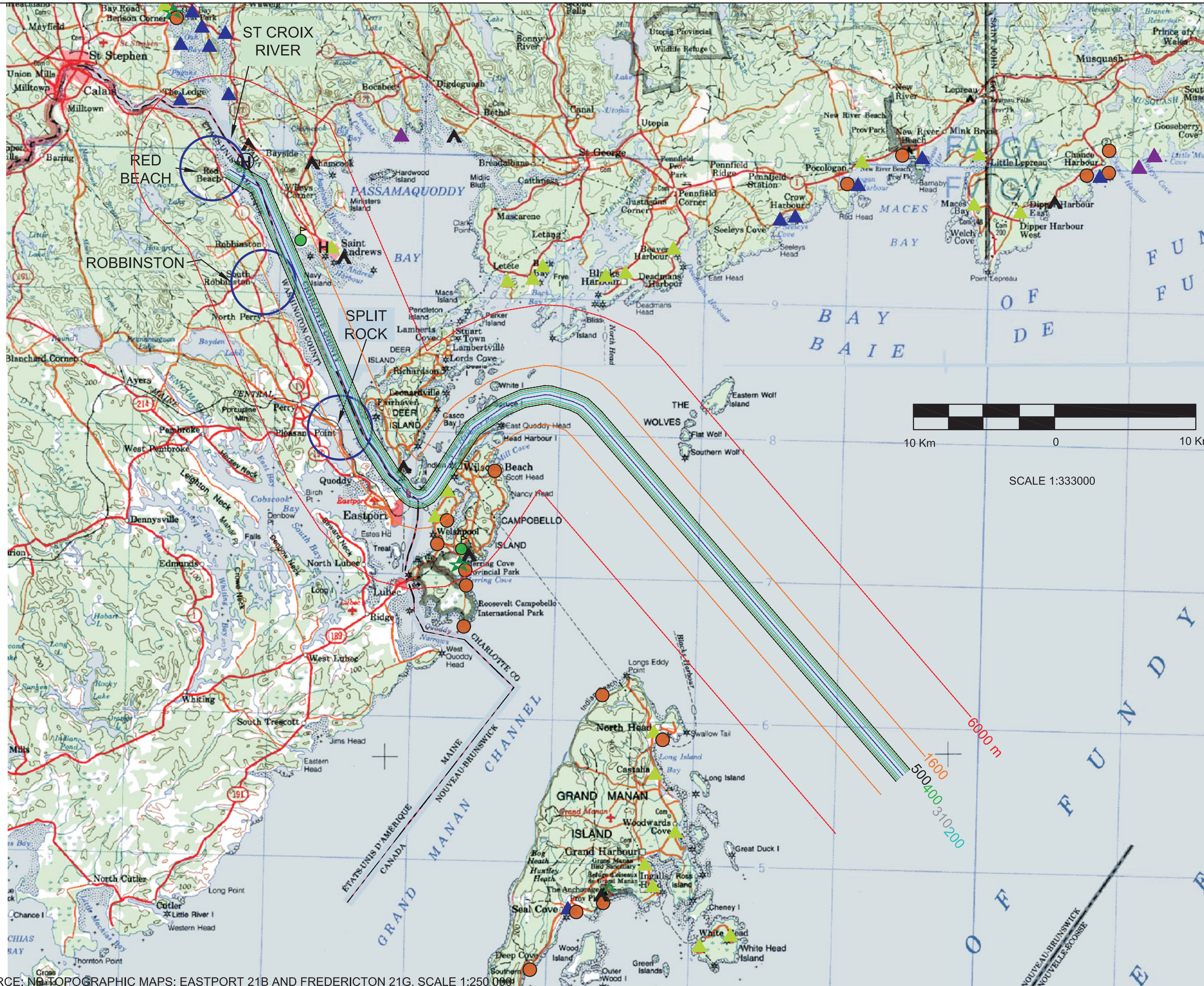
REFERENCE: ZONES MODIFIED FROM OLD SOW PUBLISHING, EASTPORT, MAINE

ACER
Environmental Services Ltd.

**DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY**

**FIGURE C7**
**ARCHAEOLOGICAL DATA FOR THE STUDY AREA AND HAZARD ZONES**

| FILE NAME: FIG A12 ARC DATA | JOB NO:FAC15-1 | DRAWN BY: RJ | CHECKED BY: | DATE:05/17/06 |
| --- | --- | --- | --- | --- |




SOURCE: NB TOPOGRAPHIC MAPS: EASTPORT 21B AND FREDERICTON 21G, SCALE 1:250 000

**LEGEND**

- Porposed LNG Terminals
- Approximate Location of Proposed LNG Shipping Lane
- Canada/USA Border

**ON/NEAR SHORE ACTIVITIES**

- Provincial Park
- Residentail Shore Development
- Public Beaches (recreation day use/beach)
- Campground/Trailer Park
- Golf Course
- Public Landing
- Urban and Rural Built Up Areas (Shore)
- H Historical Site

(REFERENCES: HUNTER & ASSOC. 1982,QUODDY LOOP-PARKS, RECREATION, NATURAL & HIKING AREAS 2006.
WEBSITES: WWW.FDR.NET/ENGLISHII/INTERACTIVEMP.HTML
HTTP://NEW-BRUNSWICK.NET/NEW-BRUNSWICK/MAPS/GRANDMANAN.JPG)

Fire and Fireball hazard zone; high risk within 500 m of a release, medium for a distance of 500 to 1600 m, and low beyond 1600 m.

Vapour cloud hazard zone; risk in considered to be high with a distance of 1600 m of a release, medium for a distance of 1600 to 6000 m, and low beyond a distance of 6000 m.

Cold gas hazard zone; high risk within 200m of release, medium risk for distance of 200m to 1600m, and low risk beyond 1600m

Liquid LNG on Land; rick is high within a distance of 200 m of a release near the shoreline, medium for a distance of 200 to 400 m, and low beyond a distance of 400m.

High mortality for organisms in contact with surface water within 310 m at the surfacec, medium to a depth of 3 m, and low beyond a depth of 3 m.

REFERENCE: Zones Modified from 2005 Old Sow Publishing, Eastport, Maine

ACER Environmental Services Ltd.

**DEVELOPMENT OF LIQUEFIED NATURAL GAS TERMINLAS ON PASSAMAQUODDY BAY**

**FIGURE C8**
**OTHER SOCIO-ECONOMIC LAND USE CONSIDERATIONS IN THE STUDY AREA AND HAZARD ZONES**

| FILE NAME: FIG A15 Tour./Rec Areas | JOB NO: FAC 15-1 | DRAWN BY: RLJ | CHECKED BY: GP | DATE:07/18/06 |
|---|---|---|---|---|