PORT RISK CLASSIFICATION

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Introduction

Canada is a model for nations striving to achieve high standards of living and prosperity. It is vital that Canada take steps to demonstrate its continued commitment to economic progress in the marine sector, without compromising its respect for the environment and future generations. This is especially crucial in the current era of burgeoning maritime trade and the discovery and exploitation of new offshore oil and gas fields on the east coast.

In 2010, the authors designed and successfully tested a port risk assessment procedure for port risk management.[1] The procedure was applied to 21 ports on the east coast; five ports in each of the provinces of Quebec, New Brunswick, Nova Scotia and Newfoundland and one in Maine. These 21 ports were classified according to the level of risk pertaining to bringing a stricken oil tanker with hull damage into a place of refuge in the port. As prime examples at opposite ends of the risk spectrum, two ports are assessed for risk, one is a 'Very High Risk' port (the port of Miramichi) and the other a 'Low Risk' port (the port of Saint John). The findings of the port risk classification and the financial resources needed to upgrade the refuge suitability of the ports are presented in this paper. This risk classification has general applicability and can be extended to include all 369 Canadian ports or any port in the world.

The risk based classification of ports presented in this paper facilitates and enhances the decision-making process when a request for refuge is received from a ship in need of assistance and standardizes, streamlines and harmonizes the Canadian approach of dealing with the issue of places of refuge.

This risk assessment procedure to determine the risk category of a port can be adapted to computer models for automatically generating the risk category and the risk mitigation measures needed.

Port of Miramichi, New Brunswick

The port of Miramichi in New Brunswick is located in the city of Miramichi, at the mouth of the Miramichi River where it enters Miramichi Bay. Miramichi is the largest city in northern New Brunswick with a population of 20,000. The economy of the Miramichi area is primarily focused on forestry, mining and fishing, with the service sector being the largest employer. Miramichi is located within a 90 minute drive of two international airports (Fredericton International Airport and Greater Moncton International Airport) which have scheduled domestic and international flights. In addition, the Miramichi Airport Commission operates the Miramichi Airport on the former site of the Canadian Forces Base (CFB) Chatham.

The meander length of Miramichi River is 250 kilometres and is comprised of two important branches – the Southwest Miramichi River and the Northwest Miramichi River, each having their respective tributaries. The estuarine portion of Miramichi River is significant despite its relatively small size because it is a highly productive ecosystem. The Miramichi River and its tributaries support one of the largest populations of Atlantic salmon in North America. The river still maintains a reasonably healthy, self-sustaining run of Atlantic salmon as well as lesser runs of fish such as American shad, smelt, herring, and sea-run brook trout. Currently about half the sport catch of Atlantic salmon in North America is landed on the Miramichi River and its tributaries. Miramichi is therefore best known as a haven for outdoor sport enthusiasts, especially anglers.

The port officially commenced operation in 1985. The port of Miramachi is close to all the major forest products producers in Miramichi and the primary focus of the port is to provide logistics support to the forestry sector of New Brunswick. Railway lines

connect to the port with an 8 railcar enclosed capacity at the port. The port also has an enclosed space for loading/unloading up to 4 trucks simultaneously. There are no tugs permanently stationed at the port. The Miramichi Port Committee Inc. administers the port of Miramichi, which has hospital, police and government services.

The site where the port is located contains 21,625 square metres (5.34 acres) of property, with a berthage length of 313 metres and a water depth alongside the berth of 6.4 metres at low tide. Two unheated storage sheds are located on the property, containing 10,300 square metres and 2,325 square metres respectively, of enclosed storage area. There is an open storage area of 9,000 square metres. The oil company Ultramar Ltd. has a refined petroleum product tank farm located in Miramichi, 64 nautical miles up the Miramichi River, from which it distributes the refined products to five other oil companies in New Brunswick. This tank farm is supplied from the Diamond Shamrock (Ultramar) refinery in St. Romuald, Quebec by rail as well as by ship. Ultramar has a marine terminal in the port of Miramichi at which tankers berth for discharging the petroleum products from the Ultramar St. Romuald (Quebec) refinery into the reservoirs of the tank farm. Around 38 ship calls are made per annum at the terminal, carrying 380,000 tonnes of refined petroleum products, which account for 60 percent of the traffic handled at the port. The water depth at this oil terminal is 7.0 metres.

The approach channel has a width of 100 metres and a water depth of 6.5 metres, with a navigation draught restricted to 6.0 metres or less. Ships can anchor anywhere off the port limits and the anchorage area has a water depth varying from 6.4 metres to 7.6 metres. Pilotage is compulsory with the Miramichi River Pilot boarding off the Escouminac Breakwater at the mouth of Miramichi Bay. The Centennial Bridge spanning the Miramichi River between Miramichi East (former town of Chatham) and Miramichi West (former town of Newcastle) has an air draught for navigation of 34.7 metres.

The risk assessment for the port of Miramichi is shown in table 1, which indicates that Miramichi is a ‘Very High Risk Port’ as a place of refuge, as two of the ‘Residual Risk Factors’ are ‘Very High’.

Hence, Miramichi is unsuitable as a place of refuge. The risk factors have been determined by reference to a standard risk screening matrix and information gleaned about the port. The Decision Tree Analysis for the port of Miramichi is shown in figure 1.

Table 1: Risk Assessment for bringing a Striken Tanker with hull damage into the Port of Miramichi
CONSEQUENCE: 1) SEVERE, 2) SERIOUS, 3) MODERATE, 4) LOW
LIKELIHOOD: A) FREQUENT, B) PROBABLE, C) POSSIBLE, D) UNLIKELY
RISK FACTOR: i) Very High ii) High iii) Medium iv) Low

Critical Activity	Hazards	Conse-Quence	Likeli-hood	Initial Risk Factor	Risk Mitigation Measures	Residual Risk Factor
Towing Vessel to the Port	a) Tugs not available for towing. b) Inadequate Depth of Water in the Port	Severe Severe	Frequent Probable	Very High. Very High	2 Tugs can be summoned from Belledune (8 hours notice). Deep Draught Vessels to remain at anchorage in Miramichi Bay	**Very High.** **Medium**
Berthing Vessel in the Port	Inadequate Depth of Water at Berth	Severe	Probable	Very High	Use of experienced Harbour Pilots	**Medium**
Cargo Unload-ing	Pumping Equipment Not Available	Serious	Probable	High	Pumping Equipment will have to be brought-in from Saint John or Halifax	**High**
Damage Repair	No Repair Facilities in the Local Area	Severe	Frequent	Very High	No Local Repair Contractors with adequate skills and equipment	**Very High**
Fire-Fighting	Inadequate Fire-Fighting Equipment in the Port	Severe	Probable	Very High	Land Based Fire-Fighting Resources are available. No Water Based Fire-Fighting Resources	**High**
Oil Spill Response	Inadequate Oil Spill Response Equipment and Facilities	Serious	Probable	High	Oil Spill Response Equipment and Trained Personnel will have to be brought-in from Saint John or Halifax	**High**

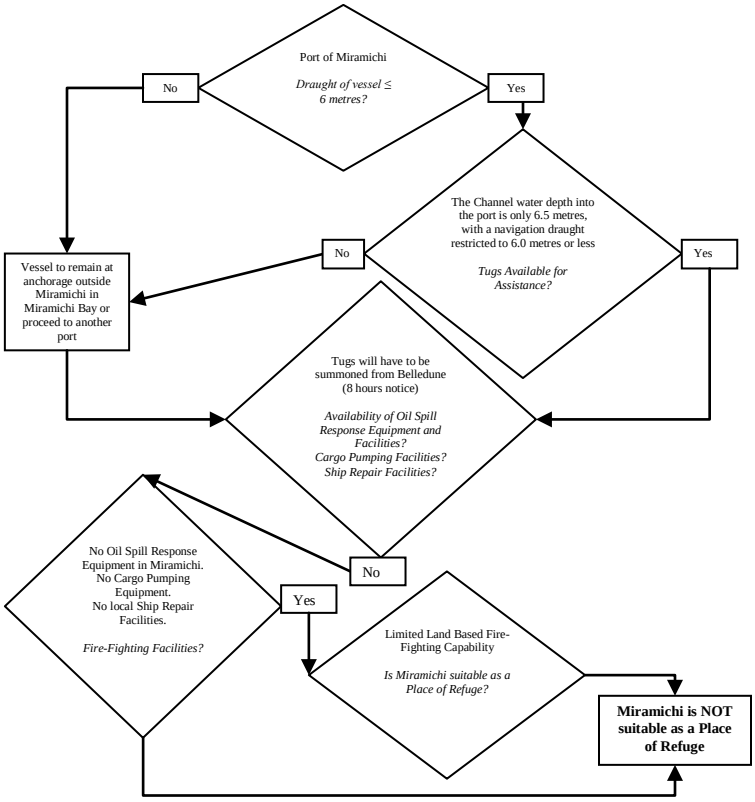

Figure 1: Decision Tree Analysis for place of refuge decision-making, in the Port of Miramichi

Port of Saint John, New Brunswick

The port city of Saint John is the oldest incorporated city in Canada and is situated along the north shore of the Bay of Fundy at the mouth

of the Saint John River. The city of Saint John became the leading industrial centre of the province of New Brunswick during the nineteenth century, fostering a shipbuilding trade that lasted until 2002. Saint John Airport is in the eastern part of the city, 15 kilometres from the city centre and is a significant transportation hub of the province. The population of Saint John is 70,000 and the metropolitan area of Greater Saint John has a population of 125,000 residents.

The port of Saint John handles more than 27 million metric tonnes of cargo annually from around the world and is the largest seaport in New Brunswick, providing a marine gateway to global markets and recognized for its strategic importance to the trade and economy of Canada. The port is vital to New Brunswick's petroleum, potash, forestry and aquaculture industries and to its import and export trade. The cruise ship activity in Saint John has been on the upswing and is a major contributor to the tourism industry. The port is well served by ship repair facilities and vessel support services. The port has five tractor tugs, each of 5,000 horsepower and 70 tonnes bollard pull. Oil cargoes account for 75 percent of the port's annual tonnage.

The Saint John Port Authority administers the port. Its mandate is to oversee the operation of the port of Saint John, provide infrastructure to support maritime trade and promote the port in the best interests of Canada's domestic and international waterborne trade.

The port operates a regular roll-on/roll-off ferry service for vehicles and passengers between Saint John and Digby, Nova Scotia. The Canadian Coast Guard operates a base in the main harbour, which includes facilities for maintaining aids to navigation and is one of the three Marine Communications and Traffic Services (MCTS) centres in the Maritimes. The port has a Naval Reserve Division on the Saint John River (opposite Navy Island) which trains naval reservists and operates an inshore multi-task Canadian Coast Guard patrol vessel. The port of Saint John has 27 berthing facilities with a total docking front of 3,865 metres and water depths at the berths ranging from 9.1 metres to 13 metres.

The port's ship servicing infrastructure consists of:

- A modern container terminal for containerized and break bulk cargo, served by two 45,000 tonne container cranes and a variety of mobile container handling equipment. A rail vehicle ramp is also available for rolling stock.
- A Forest Products Terminal for a variety of forest products and general cargo, including roll-on/roll-off cargo.
- A General and Bulk Cargo Terminal.
- A Potash Terminal for storing and loading bulk potash and rock salt.
- A Cruise Ship Terminal dedicated to cruise ships.
- A Terminal used for general cargo and paved to container terminal standards.
- A Terminal for general and bulk cargoes and occasionally for vessels under repair.
- Two Petroleum Terminals – one at Canaport (east of the harbour) operated by Irving Oil, with a water depth of 39 metres at low tide, for receiving crude oil through a monobuoy from large tankers moored offshore; and one at Courtney Bay in East Saint John for exporting refined petroleum products. Both terminals are connected by pipeline to the Irving Oil Refinery. The Courtney Bay Terminal also receives and stores caustic soda, which is shipped out in bulk by truck.
- At the Canaport Terminal, a Liquefied Natural Gas (LNG) receiving and regasification plant with an LNG ship terminal, began operations in March 2009, as Canaport LNG. The plant has three 160,000 cubic metre full containment LNG storage tanks with a throughput capacity of 600,000 cubic metres of gas per hour and a 350 metre long off-loading ship jetty with mooring facilities for LNG carriers of up to 200,000 cubic metres capacity.

The risk assessment for the port of Saint John is shown in table 2, which indicates that Saint John is a 'Low Risk Port' as a place of refuge, as all the 'Residual Risk Factors' are 'Low'. The port is therefore suitable as a place of refuge. The risk factors have been determined by reference to a standard risk screening matrix and

information gleaned about the port. The Decision Tree Analysis for the port of Saint John is shown in figure 2.

Table 2: Risk Assessment for bringing a Striken Tanker with hull damage into the Port of Saint John
CONSEQUENCE: 1) SEVERE, 2) SERIOUS, 3) MODERATE, 4) LOW
LIKELIHOOD: A) FREQUENT, B) PROBABLE, C) POSSIBLE, D) UNLIKELY
RISK FACTOR: i) Very High ii) High iii) Medium iv) Low

Critical Activity	Hazards	Conse-quence	Likeli-Hood	Initial Risk Factor	Risk Mitigation Measures	Residual Risk Factor
Towing Vessel to the Port	a) Tugs not available for towing.	Serious	Possible	Medium	Emergency Tug Assistance has Top Priority.	**Low**
	b) Inadequate Depth of Water in the Port	Severe	Possible	High	Deep Draught Vessels to remain at anchorage outside port	**Low**
Berthing Vessel in the Port	Inadequate Depth of Water at Berth	Severe	Possible	High	Use of experienced Harbour Pilots	**Low**
Cargo Unload-ing	Pumping Equipment Not Available	Serious	Possible	Medium	Irving Terminal and Local Contractors can supply the equipment for pumping	**Low**
Damage Repair	No Repair Facilities in the Local Area	Severe	Unlikely	Medium	Local Repair Contractors are easily available and accessible	**Low**
Fire-Fighting	Inadequate Fire-Fighting Equipment in the Port	Severe	Possible	High	Land Based Fire-Fighting Resources can be summoned. Tugs also have Fire-Fighting capability	**Low**
Oil Spill Response	Inadequate Oil Spill Response Equipment and Facilities	Serious	Unlikely	Medium	Saint John has an Oil Spill Response Equipment Storage Facility, with Trained Personnel	**Low**

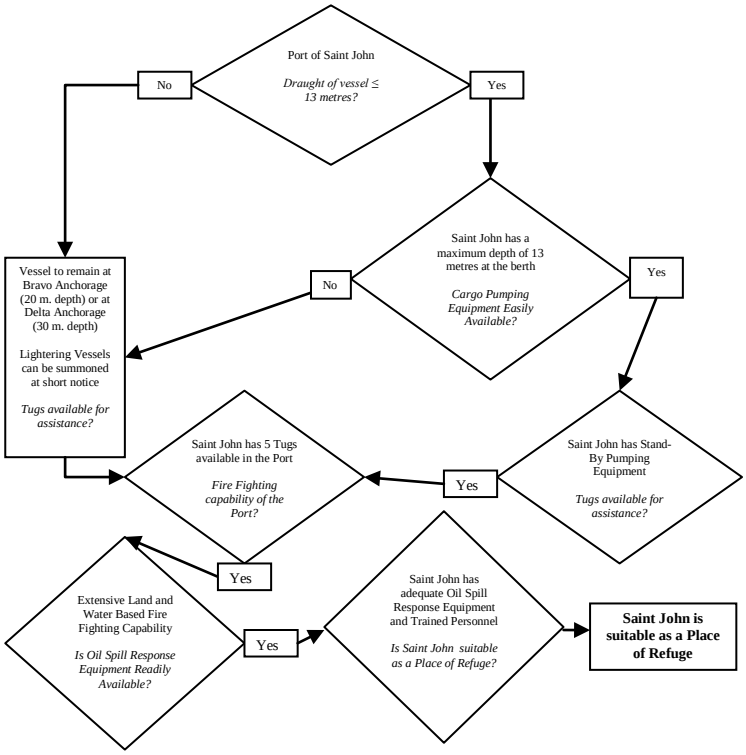

Figure 2: Decision Tree Analysis for Place of Refuge Decision-Making, in the Port of Saint John

Port Risk Classification and Financial Investments

Twenty-one eastern ports were studied and assessed for risk in this research. The risk assessments resulted in the risk classification of the ports into four categories:

1) Very High Risk Ports
2) High Risk Ports
3) Medium Risk Ports, and
4) Low Risk Ports

Table 3 presents the port risk classification in the order of their risk categories, from the 'Very High Risk Ports' to the 'Low Risk Ports'.

Having identified the risk categories of the twenty-one ports sampled in this research, a study was undertaken of the monetary investments required to upgrade the 'Very High Risk', 'High Risk' and 'Medium Risk' ports to the 'Low Risk' category. The extent of investment is based on the type of additional infrastructure, equipment and personnel needed for the upgrades. The financial information was obtained from interviews of port management personnel and data garnered on the existing resources, infrastructure and facilities of the ports studied. Although subjective, the figures give a reasonable estimate of the investments needed, if all the ports were to be fully prepared to act as places of refuge. This may not be currently feasible for several or most of the ports in the 'Very High Risk', 'High Risk' and 'Medium Risk' categories. Undoubtedly, there would have to be a growth of maritime traffic to bring-in the additional revenues to fund the upgrading projects. However, it is useful to be aware of the extent of the financial investments needed for the upgrades, as shown in table 3, so that financial planning is facilitated in preparation for the imminent maritime trade growth in Canada's waterways.

The assessments of resources needed for the upgrades were done individually for each port in the study. The resources needed are based on the 'Hazards' and their 'Residual Risk Factors'. Hence, the greater the number of port 'Residual Risk Factors' in the 'Very High', 'High' and 'Medium' risk categories, the higher the upgrading investments would have to be. In other words, the upgrading investment needed for a port in the 'Very High Risk', 'High Risk' or 'Medium Risk' classes to bring it to the 'Low Risk' class is not necessarily in direct proportion to the class of risk exposure of the port.

The 'Financial Investments' table can also be used as a guide to selectively upgrade ports on the basis of availability of financial resources and predicted growth of maritime traffic. For example, if only the seven 'Medium Risk' ports were considered for upgrading, the average investment per port would be $Can. 21.4 million.

Table 3: Port Risk Classification and Upgrading Investments - Ports Assessed for Risk Arranged on the basis of Risk Categories AND Investments Needed for Upgrading the 'Very High Risk', 'High Risk' and 'Medium Risk' Ports to the 'Low Risk' Class

Serial Number	Port	Province	Risk Category of the Port	Investment needed for upgrading to the 'Low Risk' category ($ Can. Millions)
1	**Belledune**	New Brunswick	Very High	**20**
2	**Dalhousie**	New Brunswick	Very High	**35**
3	**Miramichi**	New Brunswick	Very High	**70**
4	**Yarmouth**	Nova Scotia	Very High	**30**
5	**Shelburne**	Nova Scotia	Very High	**75**
6	**Lewisporte**	Newfoundland	Very High	**60**
7	**Gaspe**	Quebec	High	**30**
8	**Whiffen Head**	Newfoundland	High	**20**
9	**Come-By-Chance**	Newfoundland	High	**20**
10	**Eastport**	Maine, U.S.A.	Medium	**10**
11	**Bayside**	New Brunswick	Medium	**35**
12	**Rimouski**	Quebec	Medium	**25**
13	**Sept Iles**	Quebec	Medium	**10**
14	**Point Tupper**	Nova Scotia	Medium	**10**
15	**Sydney**	Nova Scotia	Medium	**35**
16	**Corner-brook**	Newfoundland	Medium	**25**
17	**Montreal**	**Quebec**	**Low**	**0**
18	**Quebec**	**Quebec**	**Low**	**0**
19	**Saint John**	**New Brunswick**	**Low**	**0**
20	**Halifax**	**Nova Scotia**	**Low**	**0**
21	**St. John's**	**Newfoundland**	**Low**	**0**

Thus, an added benefit of the risk assessment procedure designed, tested and implemented in this research is that it provides a tool to determine the financial outlays needed to prepare for the impending challenges of growing maritime trade so that enhanced maritime activity does not compromise the overwhelming public desire to preserve and protect the marine environment.

Distribution of Ports based on Risk

The findings of the risk classification are shown in table 4, where it can be seen that of the twenty-one ports studied:

- Six Ports (29 percent) are in the 'Very High Risk' Category
- Three Ports (14 percent) are in the 'High Risk' Category
- Seven Ports (33 percent) are in the 'Medium Risk' Category, and
- Five Ports (24 percent) are in the 'Low Risk' Category,

Table 4: Number of Ports According to Risk Categories

Risk Category of the Port	Number of Ports in Each Category	Percentage of Ports in Each Category
Very High Risk	6	**29**
High Risk	3	**14**
Medium Risk	7	**33**
Low Risk	5	**24**
TOTAL	**21**	**100**

Based on the sample of ports assessed, approximately one-quarter of Canadian ports are 'Low Risk Ports'. Given Canada's large number of ports (369) and extensive coastline, it is reasonable to focus the place of refuge response efforts in low risk ports as they are geographically well spread out along the Canadian coasts and equipped with the infrastructure and resources to adequately and appropriately deal with ships in need of assistance, as demonstrated in the risk assessments.

Jointly, the 'Low Risk' ports and 'Medium Risk' ports account for well over half the number of ports in the sample and adequately cover the requirements of safety and environmental conservation as maritime mercantile activity in Canada continues to grow, to meet

global trade demands. Focusing the upgrading efforts on 'Medium Risk' ports to provide them with the resources needed to fall in the 'Low Risk' category may therefore be a cost-effective and viable strategy worth considering.

At the same time, it is important to observe that more than a quarter of the ports studied fall into the 'Very High Risk' category. It is therefore necessary to be vigilant and prudent in the decision-making process of assessing a refuge request. The right decision can be made only when all the factors developed and analyzed in this study, along with factors relevant to any unique circumstance, are known and considered before the request is granted or denied.

The categorization of ports on the basis of degree of risk exposure as demonstrated in this study enables a logical and rational approach to decision-making, when a request for refuge is made by a ship in need of assistance. The innovative procedure developed and demonstrated for the twenty-one ports considered in this study is a novel approach and can be applied to any port in Canada or elsewhere in the world. Its application will ensure uniformity, standardization and harmonization in assessing the suitability of any port as a place of refuge, besides permitting expeditious decision-making.

It is foreseeable that the risk assessment procedure developed in this study can be incorporated into a computer model for generating the risk category of a port based on the details of the port and the services it provides. By entering the details of the port into the model, the programme would automatically generate the risk category and the 'Risk Mitigation Measures' to be implemented. This inexpensive technique for use by the shipping and ports community as a decision-making tool avoids the pitfalls of guesswork when speed, accuracy and confidence are vital to save lives, prevent damage to the environment and protect commercial, industrial and recreational activities.

This research focuses attention on the entire decision-making process and highlights the vital elements to be taken into consideration to

protect the environment, while allowing commercial operations to progress unhindered.

Conclusions

A viable policy on places of refuge for ships in need of assistance is a significant component of Canada's oceans management regime and one that will enhance and strengthen the regime, given the realities and consequences of Canada's rapidly growing seaborne trade and the exploitation of new offshore oil and gas fields on the east coast.

The continued growth and expansion of maritime trade can only be assured by proactive measures to nurture Canada's water resources so that they remain healthy and available to all Canadians, well into the future. A cohesive and robust structure for conflict resolution will help assure the continued progress and development of all ocean-based industries and minimize threats to Canada's oceans and marine environment.

Using a novel risk assessment procedure, twenty-one Canadian ports have been classified into four risk categories: Very High Risk Ports, High Risk Ports, Medium Risk Ports and Low Risk Ports. The Low Risk Ports and their anchorages would be the best places of refuge as they would be well equipped to handle the potential consequences of granting refuge to a ship in need of assistance. The Low Risk Ports are geographically well distributed along the Canadian coasts. The Medium Risk Ports would be the next best suited, while the High Risk Ports and the Very High Risk Ports should not be considered, unless the situation is so severe that the damaged ship cannot go anywhere else. In such cases, the risk assessment will reveal the shortcomings of the port, which need to be addressed rapidly to make the response action effective, timely, safe and environmentally conscious. Such a procedure has not been developed so far in Canada or in the rest of the world. This risk assessment procedure can be applied to any port in Canada or elsewhere in the world. Its application will ensure uniformity, standardization and harmonization

in assessing the suitability of a port as a place of refuge for ships in need of assistance.

An ancillary benefit of this port risk classification is the indication provided of the financial investments needed to upgrade the risk category of the Very High Risk, High Risk and Medium Risk ports to the Low Risk level. As a tool to support decision-making, this risk assessment approach guides the investments needed to upgrade the risk category of ports, as their traffic volumes and revenues increase with growing maritime trade.

The port risk classification strategy developed in this study considered the issue of universal applicability both in Canada and the rest of the world. The risk assessment procedure is therefore designed to be easily adaptable to computer models which can be programmed to display the risk category of ports and the risk mitigation measures necessary to improve the refuge suitability, based on inputs of the port's characteristics, infrastructure, resources and equipment. Such computer models would be useful and highly pragmatic tools for expedited decision-making when responding to requests for refuge from ships in distress and would enhance the critical safety and environmental conservation aspects of commercial maritime activity both in Canada and globally, besides indicating the scope of resources needed for upgrading the refuge suitability of ports.

[1] This paper builds on the earlier theoretical papers on this subject presented at the 2010 and 2011 CTRF Conferences, to prove the strategy by practical implementation.