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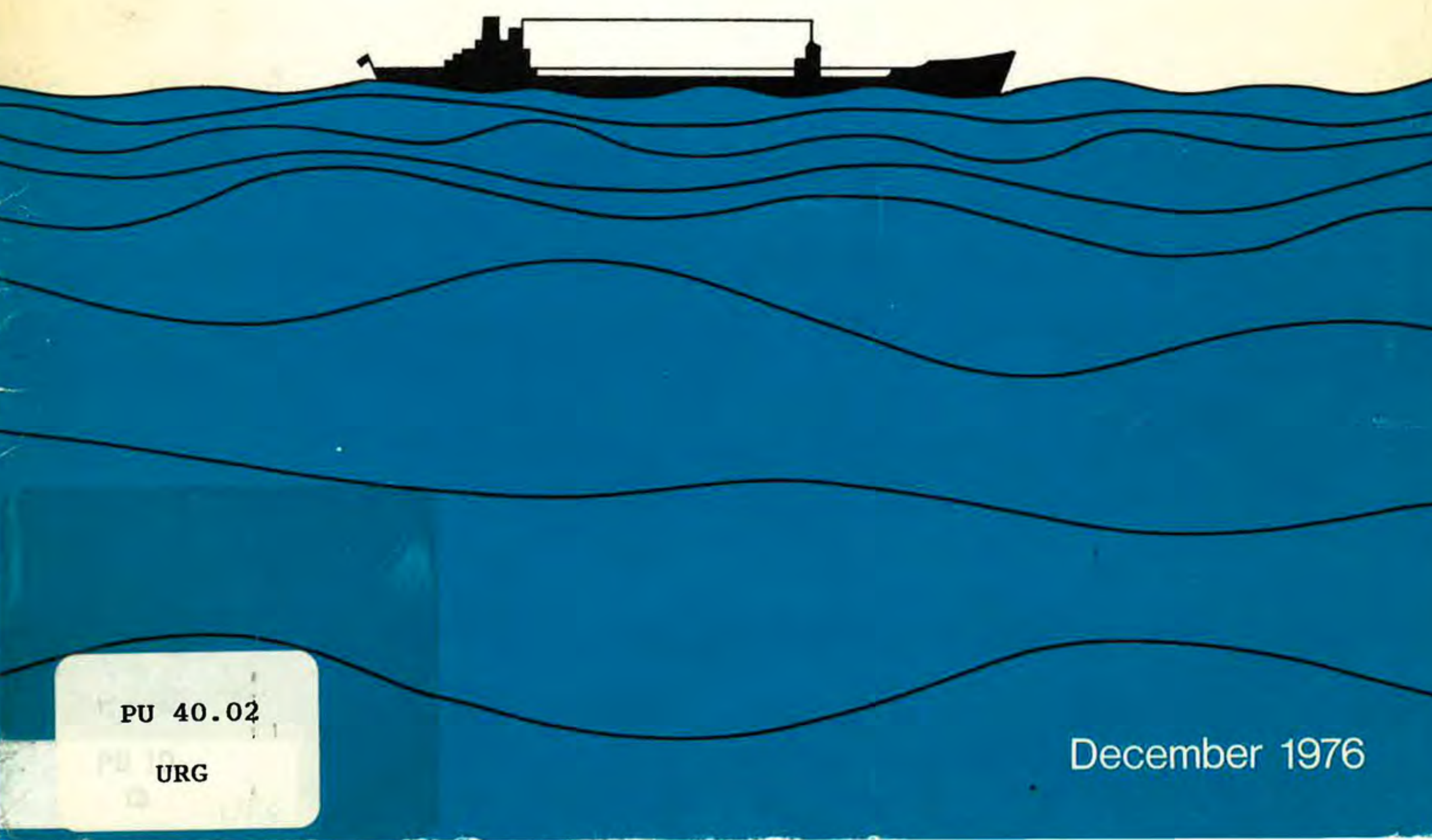
AN ENVIRONMENT RISK INDEX FOR THE SITING OF DEEP WATER OIL PORTS



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AN ENVIRONMENTAL RISK INDEX
FOR THE SITING OF
DEEP WATER OIL PORTS

A Report By

The Department of Fisheries and the Environment
Working Group on East Coast
Deep Water Oil Ports

Members

J.D. Bradford
J.F. Carreiro
S. Dee
D. Phillips
T.W. Pierce
S.L. Ross
D.J. Scarratt
H.S. Weiler
K.B. Yuen (Chairman)

Department of Fisheries and the Environment
Ottawa, Canada
December, 1976

ABSTRACT

A methodology has been developed whereby an **environmental risk index** can be calculated for deep water oil ports. Twenty-two potential sites in eastern Canada were assessed and compared with this rating system.

RÉSUMÉ

Une méthodologie a été developpée par lequel un **indice de risque environmental** peut être calculé pour les ports d'huile. Vingt-deux sites potentiels ont été assessés et comparés avec ce système d'évaluation.

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Chapter 1

INTRODUCTION

1.1 BACKGROUND

In recent years, the pollution of the sea by oil has been an issue of considerable national and international concern. Domestically, oil port issues continue to arise from time to time, but the consideration of these issues does not appear to be adequate. Deliberations cover a wide range of federal and other interests and responsibilities which are often in conflict with one another. The result is an administrative jungle with no demonstrated sense of coherence or purpose.

It is recognized that oil terminals and refineries are economic undertakings predicated upon social, economic and other needs. The optimum industrial locations, from a purely economic viewpoint, may not be compatible with the best choices from a navigational and environmental risk point of view. Thus, the choice of specific locations will involve the acceptance of varying degrees of environmental risk, which must be accounted for in the cost-benefit equation. For example, the "Sixth Annual Report of the Council on Environmental Quality" (1975) addresses the relationship of total cost of developments and environmental policies.

The Department of Fisheries and the Environment has a major responsibility to advise government on those aspects of oil ports relating to the environment and renewable resources. Environmental inputs, if they are to be useful, must be provided to decision-makers in a quantitative and comparative fashion. To date, this has not been achieved. Thus, what is urgently needed is a method by which Fisheries and Environment Canada can consolidate, evaluate and present quickly and succinctly the relevant environmental information that does exist.

1.2 OBJECTIVE

The objective of this study is to develop a numerical rating system for the assessment and comparison of certain environmental risks and costs related to alternative deepwater oil port sites in eastern Canada. Towards this objective, the study takes into consideration:

(a) Physical oceanographical, climatological, hydrographical and nautical factors affecting navigational risk and the spreading of oil released into the sea, and

(b) Components of the marine ecosystem, and commercial fisheries, that would be put at risk by a major oil spill.

The main thrust is the development of a rating scheme which will permit the systematic and concise compilation and comparison of relevant environmental and resource data.

The ratings developed can be used to compare the relative vulnerability and risks associated with various sites, and provide background information for a site selection process. The assessment of a specific proposal would require a much more detailed and comprehensive examination. It is cautioned that the rating of the various factors is still a subjective process, particularly in controversial areas or where knowledge gaps may exist. The factors considered are not necessarily exhaustive nor are the ratings definitive. The indices are designed to be augmented if new information becomes available, and individual ratings can be modified to reflect changing environmental or social trends and values. The system can also serve as a model for the assessment of a wide range of other environmental problems.

1.3 DEVELOPMENT OF INDICES

For the purposes of this study, the environmental risk is taken to be the product of the probability of an oil spill and the environmental damages and costs that would result if an oil spill were to occur. The study does not address the operational pollution problems of refineries and terminals, such as the continuous discharge of oily waste into the sea and gaseous emissions into the atmosphere.

In the absence of a published rating of navigational risk, it has been necessary to examine a number of physical oceanographical, climatological, hydrographical and nautical factors which influence navigational safety and combine these into a NAVIGATIONAL RISK INDEX. This index takes into account the entire length of the shipping lane from the open ocean to the specific port site. It is assumed that this index is a reasonable measure of the relative probability of an oil spill.

In considering the environmental damage that could result from a major oil spill, we have limited our examination to a crude oil spill of 25,000 tons. It is generally assumed that present technology is inadequate to contain spilled oil effectively in currents greater than 1.5 knots or in waves of height greater than a few feet. What is subjectively taken into account, in assessing the fate of released oil, are natural features such as bays or lagoons which may help to contain or immobilize released oil and natural forces which determine where released oil might go. The study does not provide an assessment of the effects of released oil on plankton and benthos, for example, since the state of the art does not permit an accurate prediction of these effects. Rather, as a preliminary study, it is assumed that areas of high fishery productivity reflect areas of high planktonic or benthic productivity. Furthermore, regardless of the effect of spilled oil on fish, it is clear that oil on the water surface and in the water column can seriously hamper and curtail fishing operations, through the contamination of fishing equipment and of the catch itself. Thus, the ENVIRONMENTAL VULNERABILITY INDEX is based on the total number of fishermen and the value of the fish landings that would be seriously put at risk following a major oil spill. The index also takes into account aquatic birds, the recreation capability of shoreland and oil spill cleanup costs both onshore and offshore.

An ENVIRONMENTAL RISK INDEX is finally determined as the product of the ENVIRONMENTAL VULNERABILITY INDEX and the NAVIGATIONAL RISK INDEX.

1.4 STUDY AREA

The area under study (Fig. 1.1) includes all major coastal areas of the East Coast of Canada, with the western limit being Quebec City and the northern limit being the Strait of Belle Isle. A number of existing terminals and potential sites have been chosen to provide a general yet representative coverage of the major geographical regions of the East Coast, as follows:

(a) **Nova Scotia Atlantic Coast**

- Strait of Canso, N.S.
- Halifax, N.S.
- St. Margaret's Bay, N.S.

(b) **Bay of Fundy and Passamaquoddy Bay**

- Head Harbour Passage, N.B.
- Saint John, N.B.

(c) **St. Lawrence River and Estuary**

- Quebec City, Que.
- Grande Ile, Que.
- Ile Verte, Que.
- Baie Comeau, Que.
- Sept Iles, Que.

(d) **Northeastern Gulf of St. Lawrence**

- Bay of Islands, Nfld.
- Bonne Bay, Nfld.
- Baie Johan Beetz, Que.
- Natashquan, Que.

(e) **Southern Gulf of St. Lawrence**

- Chandler, Que.
- Souris, P.E.I.
- Magdalen Islands, Que.

(f) **Newfoundland South Coast**

- Fortune Bay, Nfld.
- Placentia Bay, Nfld.

(g) **Newfoundland East Coast**

- Trinity Bay, Nfld.
- Conception Bay, Nfld.
- Bonavista Bay, Nfld.

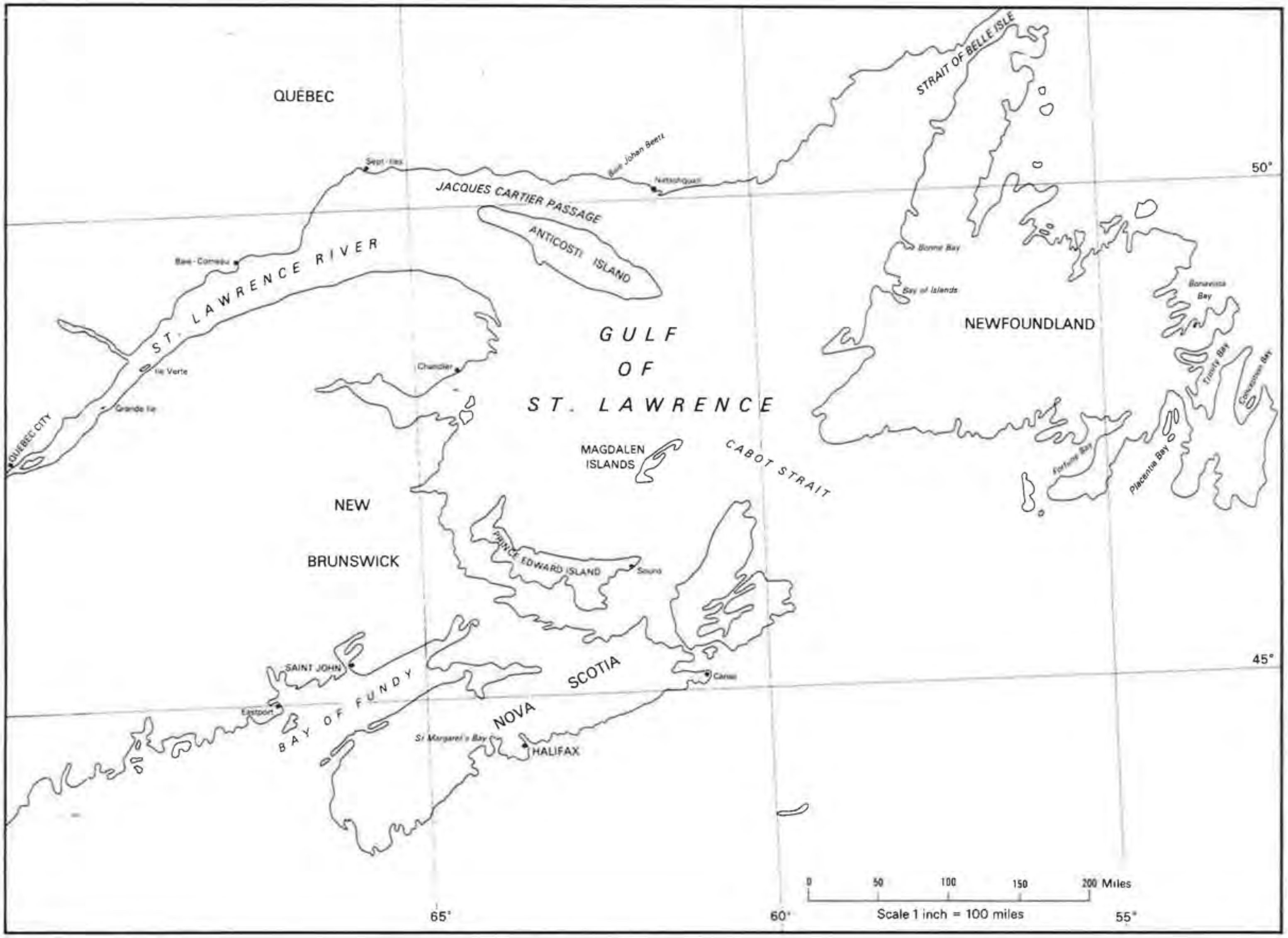

Figure 1.1 General Map of East Coast Showing Study Sites

Chapter 2

FINDINGS AND RECOMMENDATIONS

2.1 FINDINGS

1. A general assessment has been made of the marine environmental risks associated with deepwater oil port development on the East Coast of Canada. This assessment, designed as a managerial tool in the site selection process, has been restricted to the environmental damage that could result from a major oil spill of 25,000 tons, such as could occur following a tanker collision or grounding

2. A numerical rating system was developed, by which twenty-two potential port sites were rated and compared. An ENVIRONMENTAL RISK INDEX was developed, as the product of a NAVIGATIONAL RISK INDEX and an ENVIRONMENTAL VULNERABILITY INDEX. The latter two indices are based upon existing baseline data from various sources within Environment Canada, and take into account only those relevant factors for which data could be readily assembled and quantified.

3. The NAVIGATIONAL RISK INDEX is an expression of the relative probability of a major spill and takes into account various physical environmental, navigational and other potentially causative factors. It is not an absolute measure, since that requires a statistical approach, which is clearly not available for hypothetical port sites. Additionally, the relationship between the probability of a polluting incident and certain physical environmental parameters cannot yet be quantified in an exact fashion.

4. An ENVIRONMENTAL VULNERABILITY INDEX was developed, based upon a weighted combination of ratings for fisheries, aquatic birds, shoreline recreation capability, and oil spill cleanup. These indices take into account the entire approach to the terminal from the open ocean, and the potential wide spread dispersal of the oil following a spill.

5. The use of the indices should be restricted to general comparisons of these port sites only, as part of a site selection process. The consideration of a specific port proposal requires a more detailed examination of a wider range of factors than was possible here with a rating system.

6. An analysis of the indices developed during this study indicated that:

   (a) Tanker traffic should not be permitted through Head Harbour Passage, because the value of fisheries and aquatic bird resources in the region is so high that no risk can be afforded. At the same time, the high level of navigational risk associated with the passage adds even further to the unacceptable environmental risk.

   (b) Oil ports should not be sited along the St. Lawrence estuary because the value of aquatic bird resources in that region are the highest on the East Coast, and because of the associated risk to Gulf of St. Lawrence fisheries. The navigational risk along the estuary is also high.

   (c) For fisheries reasons, sites in the southern part of the Gulf of St. Lawrence should be avoided, e.g. Souris and Magdalen Islands. These two areas also possess high shoreland recreational capability.

   (d) St. Margaret's Bay should be avoided because it is an extremely highly productive marine system.

   (e) Bonavista Bay and Baie Johan Beetz are poor sites primarily because of aquatic bird populations.

(f) Conception Bay is also poor because of the generally high vulnerability of local resources and especially since better alternatives exist along the East Coast of Newfoundland.

(g) Bay of Islands should be avoided because cleanup costs for this area would be considerably higher than for any of the other sites studied.

(h) Sites such as Halifax, the Strait of Canso, Baie Comeau, and Natashquan appear to be acceptable environmental alternatives.

(i) Less desirable sites include Sept Iles, Bonne Bay, Saint John, Trinity Bay, Placentia Bay, Fortune Bay, and Chandler. However, these and those sites listed in (h) above all represent negotiable environmental alternatives, providing (1) they are all inputted into a total cost benefit equation, (2) an objective evaluation of all factors is made, and (3) once the site is selected, all reasonable precautions and procedures for navigational safety and environmental protection are incorporated into the design and operation of the terminal.

(j) A summary of the findings is presented in Table 2.1.

7. It is recognized that the study has involved only 22 potential port sites, and only sites on the East Coast. Noting this regional limitation, the Working Group also recognized that the conclusions reached in paragraph 6 above involve certain subjective value judgements, particularly as they relate to the identification of non-negotiable limits of environmental risk. To make the results of this study more useful as a tool in the comprehensive planning and management of deepwater oil ports in Canada as a whole, that is, to eliminate any inherent regional biases, comparisons should be made with a number of representative sites from other coastal regions of Canada.

2.2 RECOMMENDATIONS

The Working Group recommends:

(a) that dissemination of this report to all Services of this Department be approved;

(b) that this report be provided to the Minister of Fisheries and the Environment as a background information document on the issue of East Coast deepwater oil ports;

(c) that this report be made available to other departments and agencies involved with deepwater oil ports issues, such as the Departments of Transport, Public Works, External Affairs and Regional Economic Expansion. Deepwater oil port issues continue to exist on the East Coast from time to time, and it is felt that this report would be of use to those concerned;

(d) that other regions of Fisheries and Environment Canada be encouraged to apply the methodology developed here in the assessment of oil port proposals, particularly on the West Coast where a number of port issues also exist;

(e) that this methodology be further refined, at such time as the improvement of environmental data bases permit the rating and/or quantification of other factors, including socio-economic impacts, recreational fishing, other important or critical ecological habitats, and marine productivity. Further work should also be encouraged to expand the rating system to include the assessment of chronic sources of oil pollution at terminals, and to improve methods for the prediction of oil spill dispersion.

(f) that the Department of Transport be encouraged to develop methodologies for estimating spill probability, and to conduct and publish studies of navigational risk. If and when such studies become available, the environmental risk indices reported above should be recalculated accordingly.

Table 2.1

Summary Table

Port Site	Overall Assessment
Passamaquoddy	Unacceptable*
Magdalen Islands	Unacceptable
Ile Verte	Unacceptable
Quebec City	Unacceptable
Grande Ile	Unacceptable
Conception Bay	Poor
Souris	Unacceptable
Bonavista Bay	Poor
Baie Johan Beetz	Poor
Fortune Bay	Negotiable
Bay of Islands	Unacceptable
Chandler	Negotiable
Placentia Bay	Negotiable
St. Margaret's Bay	Unacceptable
Trinity Bay	Negotiable
Bonne Bay	Negotiable
Sept Iles	Negotiable
Saint John	Negotiable*
Natashquan	Acceptable
Baie Comeau	Acceptable
Canso	Acceptable
Halifax	Acceptable

*Passamaquoddy and Saint John ratings include U.S. fisheries.
If only Canadian fisheries are considered, the overall assessment for Saint John would be acceptable but Passamaquoddy would still be unacceptable. However, the Canadian fisheries rating for Passamaquoddy would be poor rather than unacceptable.

Chapter 3

PHYSICAL ENVIRONMENT

3.1 PHYSICAL OCEANOGRAPHY AND CLIMATOLOGY

The following is summarized from Bradford, 1974 and Phillips, personal communication, 1975.

3.1.1 General Circulation Patterns and Current Speeds

The St. Lawrence River discharge, combined with vigorous tidal streams, produces local areas of swift currents in the St. Lawrence estuary. Whereas the net transport is seaward, flood tidal streams of up to 4 knots occur in the area of Ilet Rouge near the mouth of the Saguenay River. At full ebb during spring tides these streams can reach a rate of 7 knots. A second area of strong currents (rate up to 4.5 knots) is the navigation channel south of Ile d'Orleans.

The typical summer surface circulation pattern in the Gulf of St. Lawrence (Fig. 3.1) exhibits a two-way flow in Cabot Strait and the Strait of Belle Isle, a generally counter-clockwise circulation in the Gulf proper, and a well-defined Gaspé current. Rates of 3.5 knots during falling tides are found in the Gaspé Current while 2 knots may be reached in the outflow through the Cabot Strait. Elsewhere in the Gulf, surface drifts greater than 0.2 knots are seldom encountered. The strong outflow through the Cabot Strait turns southwestward as it rounds Cape Breton Island, loses most of its velocity and drifts parallel to the south shore of Nova Scotia to the vicinity of Halifax. West of Halifax, the surface circulation is variable in direction and slow.

A counter-clockwise circulation prevails in the Bay of Fundy, with the outflow streaming southwestward along the New Brunswick - Maine Coast and the inflow moving northward along the Nova Scotia coast. This is superimposed on a tidal regime which generates tidal streams attaining rates of up to 2 knots. These streams generally run parallel to the shoreline and have equal velocities in both directions. Currents are especially high in confined waters responding to powerful tidal influences. In Head Harbour Passage, for example, tidal currents at times exceed 5 knots.

3.1.2 Fog

Canada's East Coast is noted for its fogs. The highest incidence occurs all along the Atlantic Coast from the Bay of Fundy to the Avalon Peninsula. However, the incidence falls off sharply to the north and west with the result that most of the Gulf and Estuary have less than one half the number of foggy periods than the Atlantic coastal margin.

Fog can be expected over 20 percent of the time along most of the Atlantic coast and over 23 percent of the time at Yarmouth and St. John's (Fig. 3.2). By contrast, the clearest weather appears to be in the Mont Joli area where fog normally can be expected only about 7 percent of the time. The period of foggiest weather varies throughout the study region. Along the Atlantic coastal margin and in the Estuary, summer is the peak foggy period. In July, for example, fog can be expected over 40 percent of the time at Yarmouth, and 35 percent at Saint John. Over the Gulf of St. Lawrence area, fog occurs most frequently in the late autumn, whereas at St. John's, spring is the foggiest period.

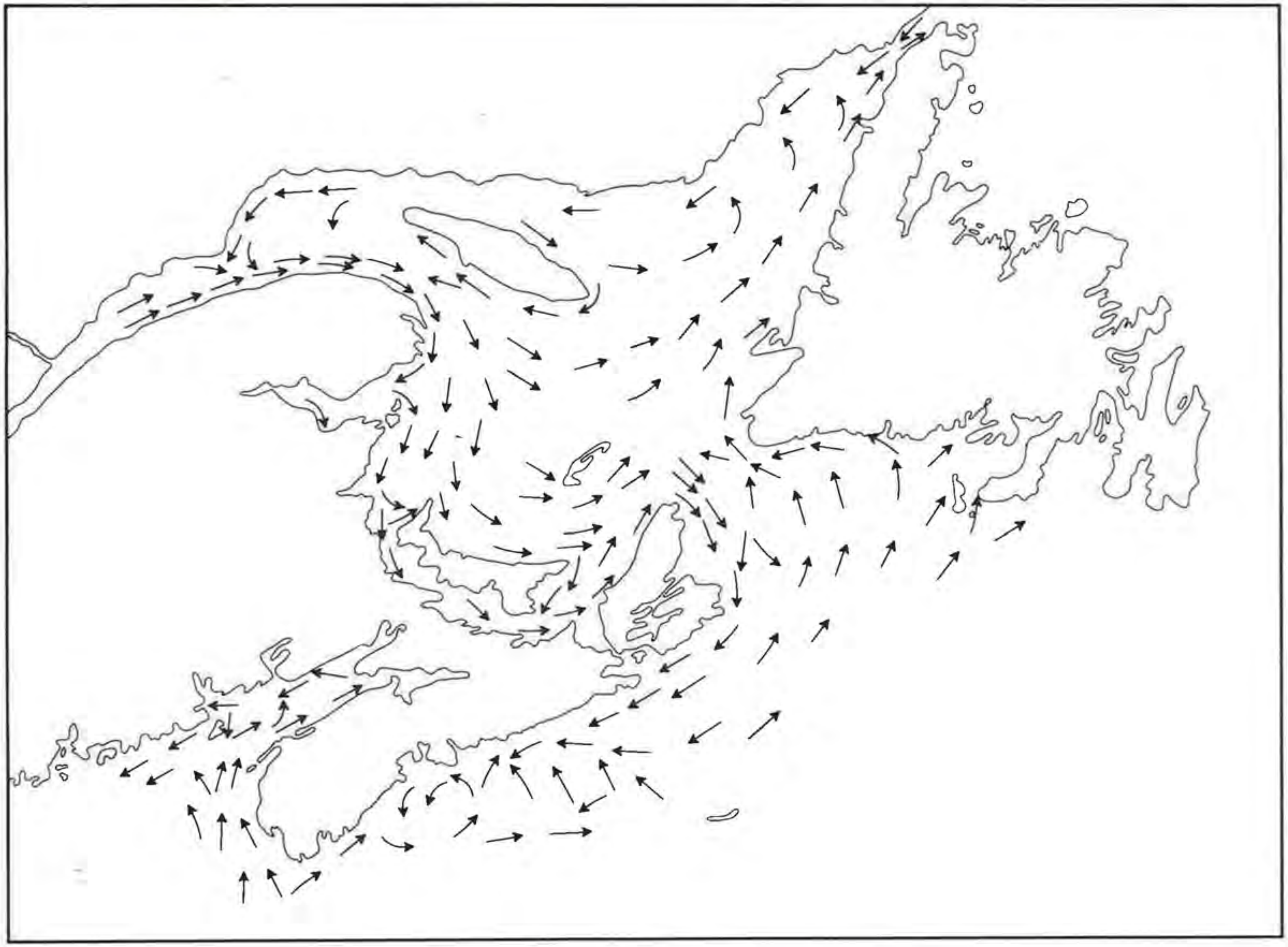

Figure 3.1 General Surface Circulation Pattern in the Summer

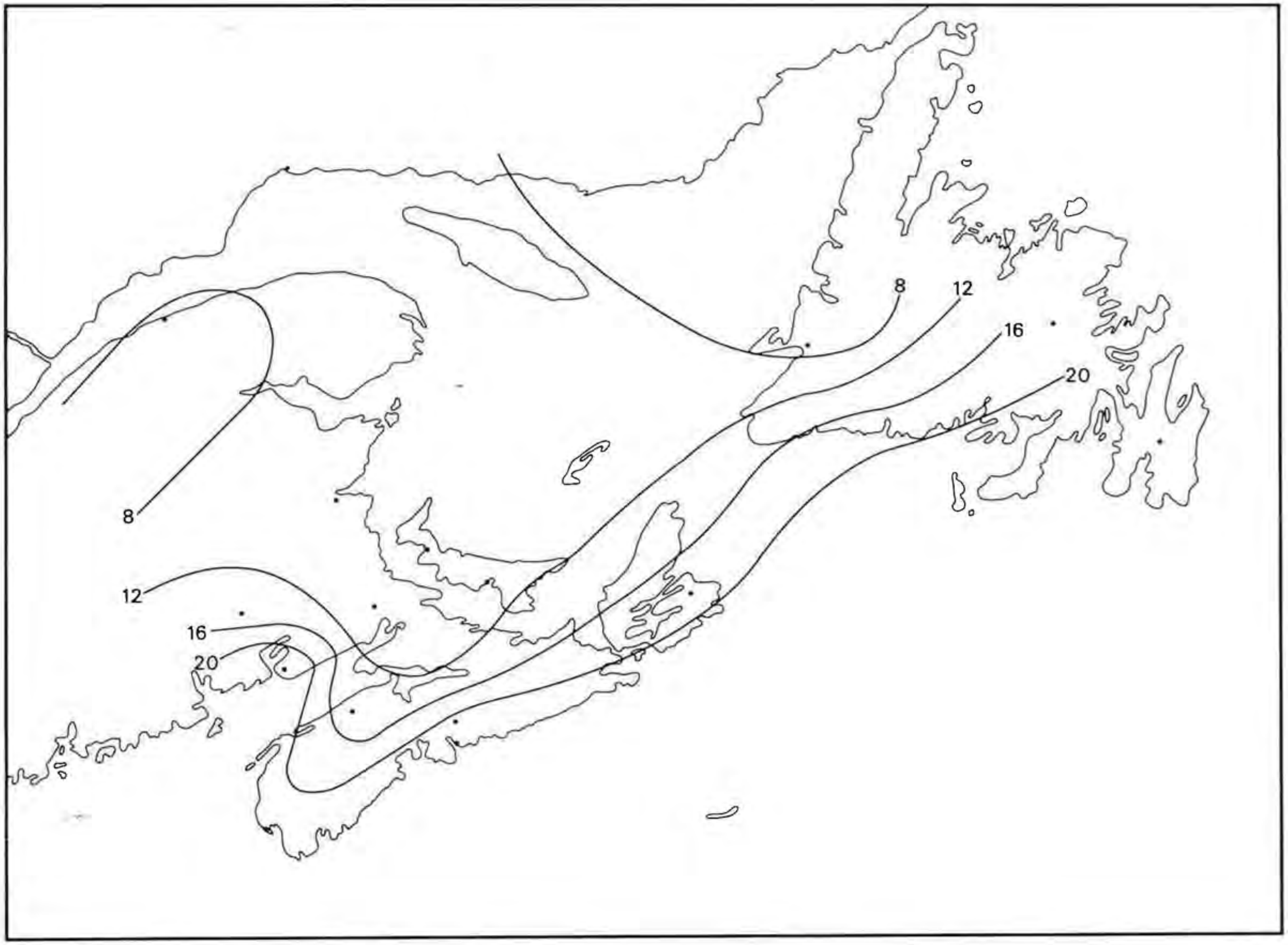

Figure 3.2 Percentage Frequency of Fog

In the Estuary region, fogs occur infrequently in mid-winter. At Mont Joli, they occur less than 5 percent of the time in February and March. Sept Iles is equally fog-free in January.

3.1.3 Ice

Ice is frequently a hazard to navigation in most parts of Canada's East Coast. In the Gulf of St. Lawrence, maximum accumulations generally occur in the central and southern portions. The normal mid-winter pattern is one of relatively light ice and open water leads in the northern Gulf, and thicker more closely packed ice in the south. Ice formed in the northern Gulf and Estuary tends to be moved southward by prevailing winds and by the southerly flowing Gaspé Current. The ice accumulates and thickens in the Magdalen Shallows area where it tends to be impounded by landforms.

The most remarkable feature of the ice season is its extreme variability. In 1969 in the Cabot Strait, for example, no ice was observed. In the previous year, the entire 96 miles between North Sydney and Port aux Basques was ice covered for a brief period early in March. However, as pointed out in the "Gulf and River St. Lawrence Sailing Directions", "the ice cover in the Gulf becomes quite extensive in normal winters, but even in the coldest years, it is never completely covered. Tidal motion, currents, and wind induced drift all combine to keep at least small areas of open water present, and in normal seasons there are useful leads that can be used in navigation".

Ice forms earliest in the Estuary, usually making its appearance between Pointe des Monts and Quebec City by mid-December. By early January, it begins to create problems especially along the south shore and Gaspé Coast where prevailing northerly and westerly winds and easterly-flowing currents tend to pack the ice. Icebreakers are usually at work in the western part of the Estuary two to three weeks before they are needed in the Gulf.

Ice growth in the Gulf of St. Lawrence, which is usually ice free at the beginning of January, proceeds rapidly through January and February and reaches its maximum extent in mid-March. Early in the season, the Bay of Chaleur, Northumberland Strait and the Strait of Belle Isle have heavier concentrations; but by the end of February the packing of ice in the southern part of the Gulf is usually apparent.

Figure 3.3 illustrates where ice creates navigational problems. It is assumed, based on observations of ships navigating in ice, that until approximately six-tenths of the water surface in any given area is covered by ice at least six inches thick, navigation can continue with very little disruption. What the figure illustrates therefore is the number of years out of ten in the Gulf area during the period 1961-1970 that at least six-tenths coverage of ice over, six inches thick was experienced. Clearly, it indicates ice congestion along the north shore of the Gaspé Peninsula and in the southern part of the Gulf. However, it does not indicate the period of disruption, which may have lasted for only a few days or could have continued for periods of weeks. This of course would be dependent upon the severity of the winter and the persistance of winds.

By early April, the Estuary is mostly ice free. By mid-April, open water extends from Port aux Basques to Quebec City and beyond, but ice persists in the Cape Breton Island area often through April and sometimes until the end of May.

Throughout much of the winter, ice spills out of the Gulf through the Cabot Strait. At the earliest, ice appears in the Strait towards the end of January. At the latest, it lingers until early June. The ice tends to drift southward through the Strait, along the Cape Breton shore, then westward around Scatari Island, occasionally reaching Chedabucto Bay and beyond.

The Bay of Fundy, the southern Nova Scotia coast as far east as Halifax and the south coast of Newfoundland from Port aux Basques to the Burin Peninsula are virtually ice free. What little ice that does form during cold snaps quickly melts or is broken up by wave action and carried out to sea. The ice which

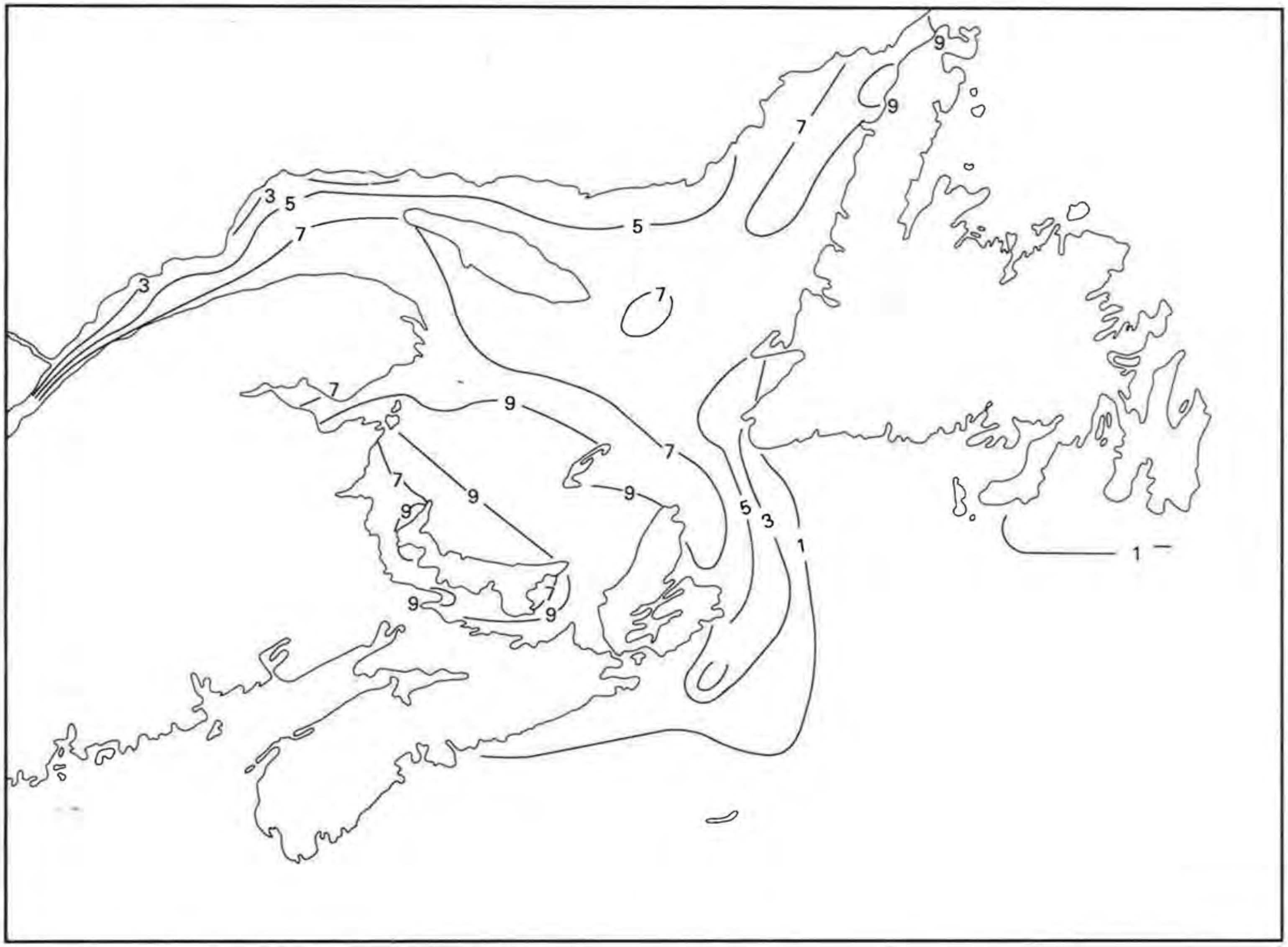

Figure 3.3 Number of Years During the Period 1961–70 that Ice Accumulation Presented a Navigational Hazard

occasionally appears east of the Burin Peninsula has its origins in the Newfoundland-Labrador coastal waters north of St. John's.

3.1.4 Tides

Bay of Fundy tides are world renowned. They have an average range (Fig. 3.4) of about 22 feet at Saint John and nearly double that value in the Minas Basin. Large tides (Fig. 3.5) have a range of nearly 30 feet at Saint John and over 50 feet in Minas Basin. At Cape Sable at the southwestern tip of Nova Scotia, the average range is 9 feet (12 feet for large tides) as compared with an average of only half that for nearly all of the south shore of Nova Scotia, Cape Breton and Newfoundland.

The smallest tides in the region occur in the southwestern part of the Gulf of St. Lawrence. There is major amphidromic point in the vicinity of the Magdalen Islands with another in Northumberland Strait. The average range is less than 3 feet and spring tides seldom exceed 6 feet. Slightly larger ranges occur in the eastern half of the Northumberland Strait, the Bay of Chaleur and in the approaches to the Strait of Belle Isle.

Tidal ranges in the St. Lawrence estuary increase (up to Quebec City) with distance from the Gulf. Average ranges at Sept Iles, Baie Comeau and Quebec City, for example, are 8, 10, and 18 feet respectively. Spring tide ranges for the same three localities are 12, 16, and 19 feet, respectively.

3.1.5 Waves

A number of wave observations have been taken at specific locations on the East Coast but detailed maps showing wave climate are not yet available. Intermittent periods of records are available for a number of automatically-recording wave stations over the June-December period and visually-obtained wave data are available from ships which have passed through the study area. Records at many recording stations do extend to one year while records taken by observers on ships (even though they are trained for the purpose) are almost certain to reflect the subjectivity of the observer. Wave heights are usually described in terms of significant wave heights which is the average height of the highest one-third of the wave spectrum. Maximum wave heights are up to 1.8 times the significant wave height.

In spite of the limited amount of wave data, sufficient records have been amassed to indicate a few basic differences between various East Coast regions. As one would expect, the distribution patterns in Fig. 3.6 resemble quite closely those of the mean wind speed (Fig. 3.7). For example, the highest percentage of rough seas (those with significant wave heights of 6 feet or greater) are found in the Cabot Strait - Magdalen Islands areas and in the open seas off Placentia Bay. Relatively calmer seas prevail along the mainland coast. Fig. 3.6 does not display wave height distributions, but rather it is an indication of the percentage of time during which significant waves over 6 feet high can be expected over the June to December period. In this manner, it provides a general indication of relative storminess. June to December are the only months for which data were available from all stations. Wave recording instruments are normally removed when ice is expected.

Like winds, wave heights have a pronounced seasonal variation. Significant wave heights higher than 6 feet seldom occur in the study area during June and July, whereas in November and December, significant waves higher than 6 feet are commonplace, especially in the southeastern part of the Gulf and in the open seas off the south coast of Nova Scotia and Newfoundland. At Bird Rocks in the southeastern Gulf, over 40 percent of the significant wave observations in November and December exceed 6 feet. The highest waves recorded also occurred during these two months. Significant waves of 23 and 26 feet have been recorded off Osborne Head and Western Head respectively, meaning that maximum waves of the order of 45 feet were probably observed. Waves estimated to be 52 feet high have been observed from ships passing through the open seas south of the Burin Peninsula in November and December.

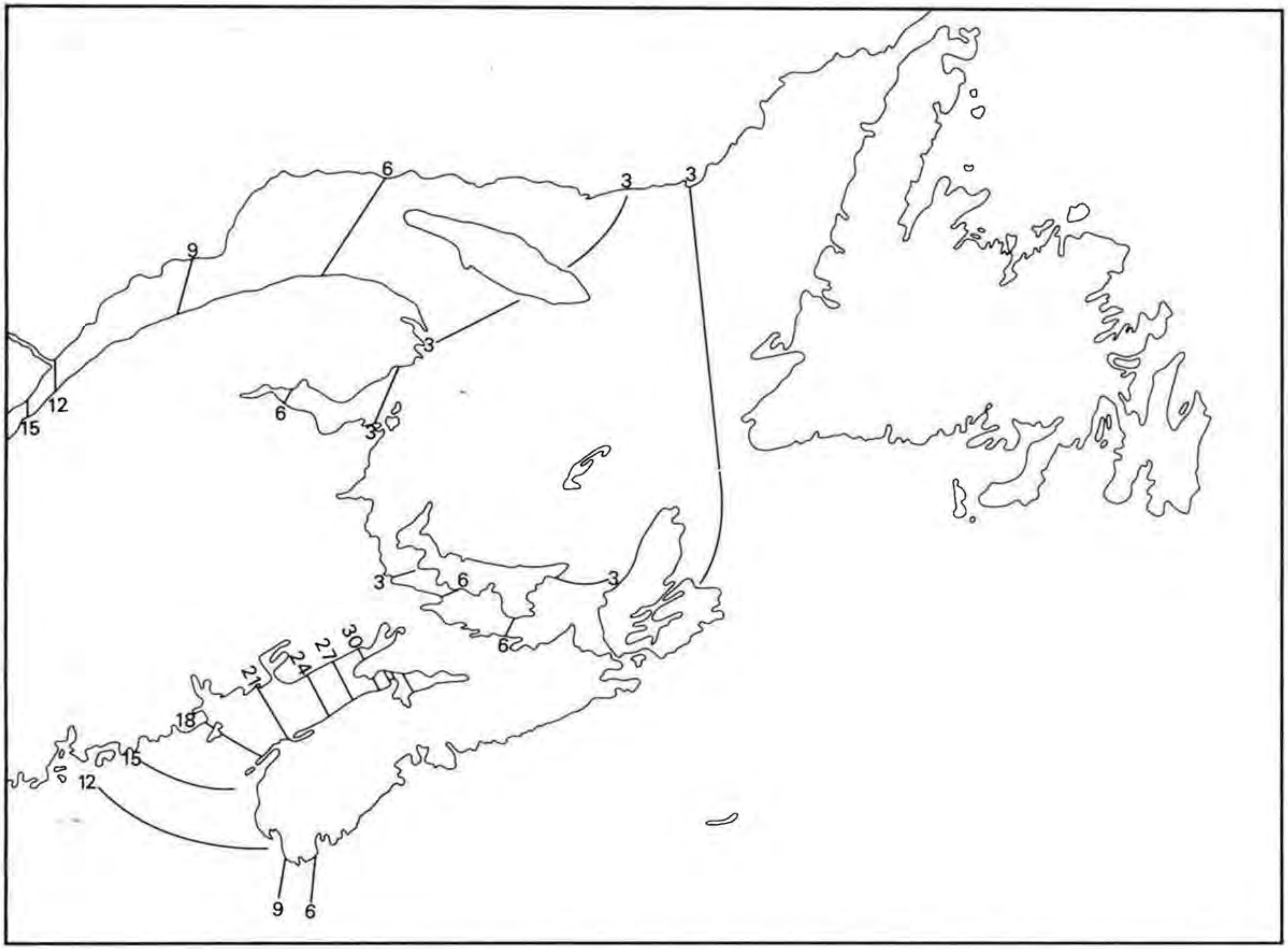

Figure 3.4 Tidal Range (in feet) for Average Tides

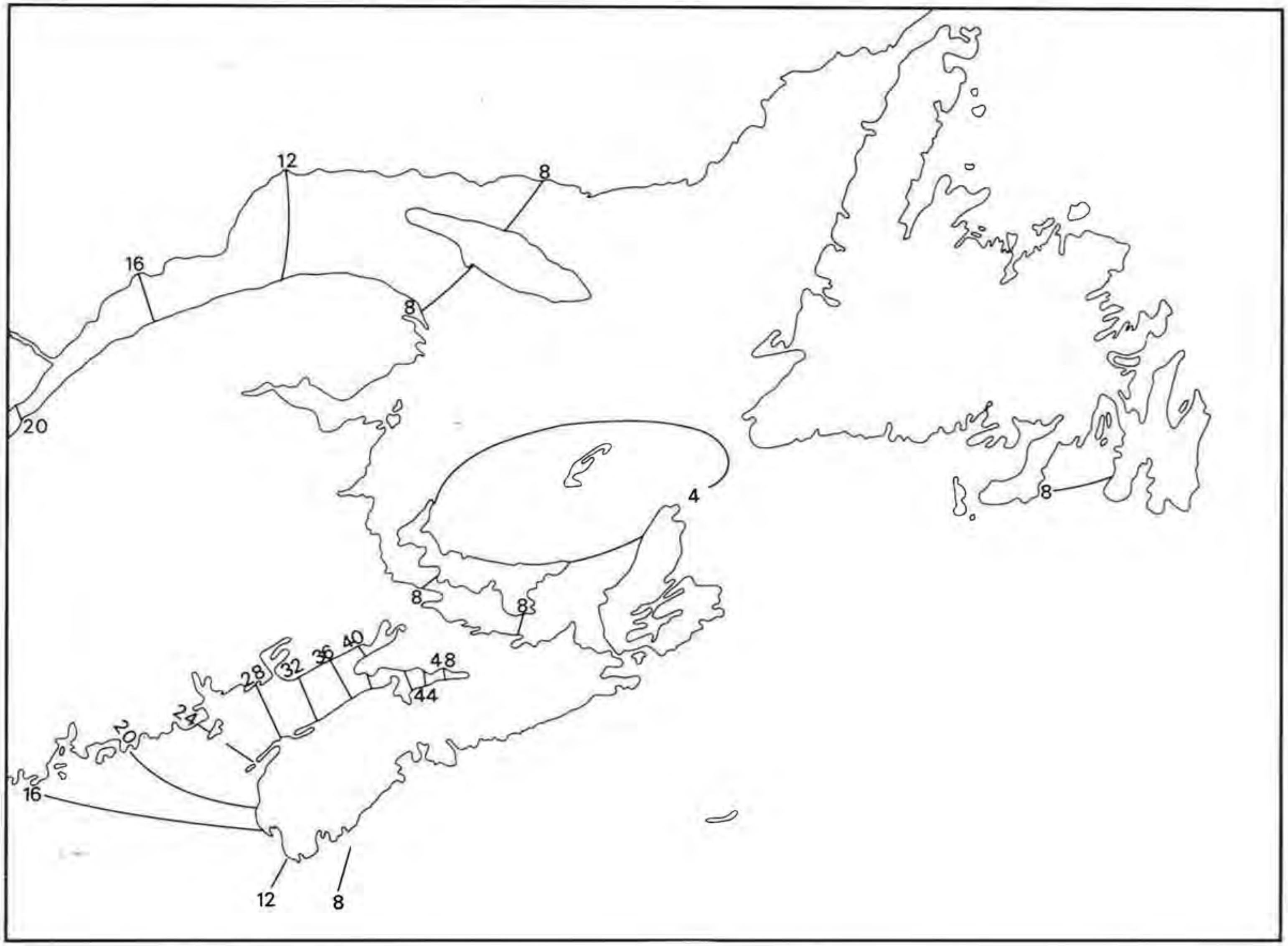

Figure 3.5 Tidal Range (in feet) for Large Tides

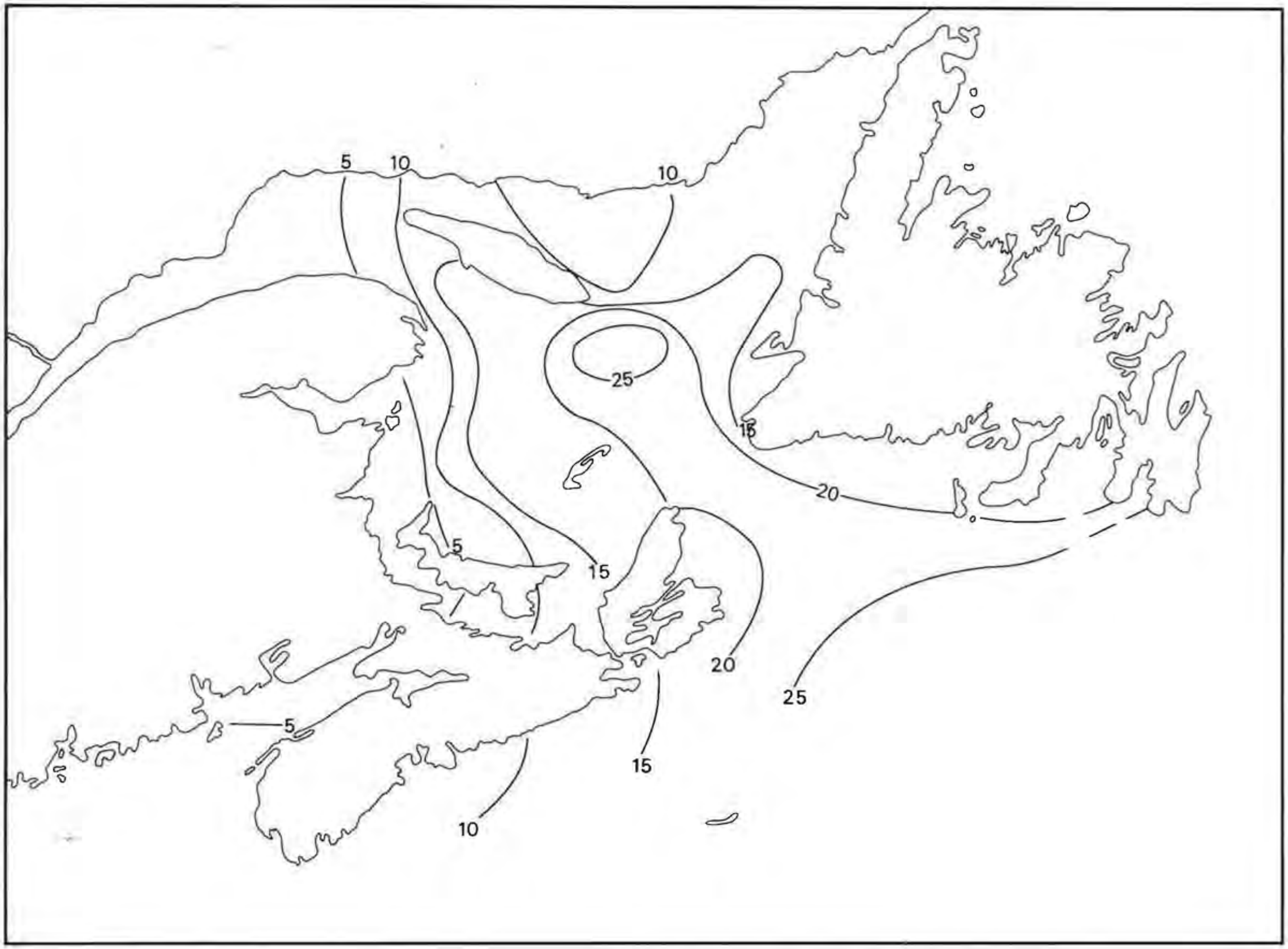

Figure 3.6 Percentage of Waves Greater than Six Feet (Average June to December)

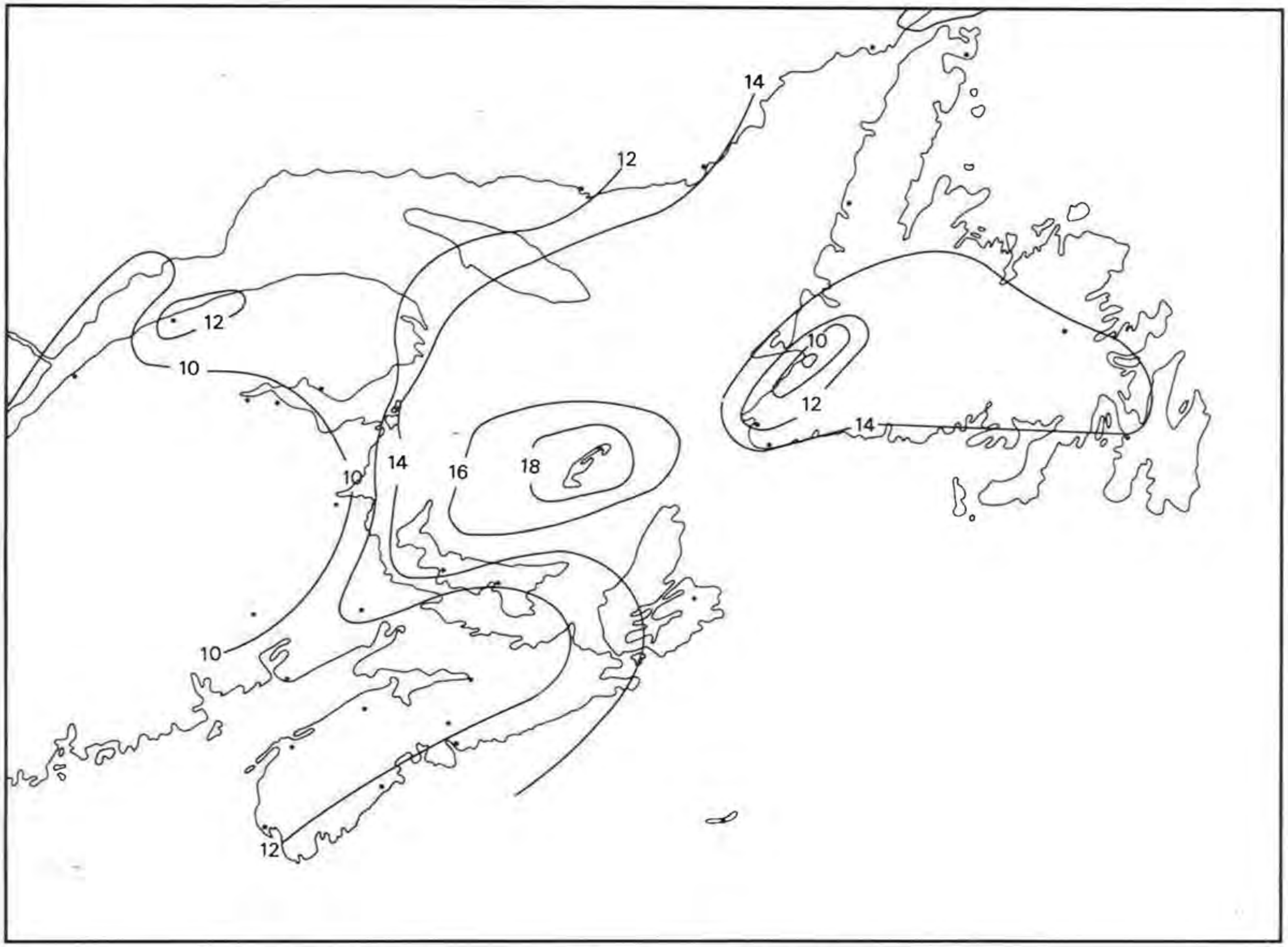

Figure 3.7 Mean Annual Wind Speeds (in Miles per Hour)

3.1.6 Winds

In the most general terms, wind velocities are lower in the western part of the study area (Fig. 3.7). The windiest section is the central Gulf in the vicinity of the Magdalen Islands. Here wind speeds **average** nearly 20 miles per hour throughout the year and about 24 miles per hour in December, the windiest month. Other areas of relatively high velocities are the Cabot Strait and Strait of Belle Isle. The Baie Comeau - Riviere du Loup area, on the other hand, has the lowest mean speeds (approximately 9 miles per hour), and even during the windiest month, mean speeds average under 12 miles per hour.

Winds over most of the East Coast show a distinct seasonal variation. At most stations, December and January are the windiest months averaging about 50% higher than in July and August, normally the months of lightest winds. Winds at Sydney and Port aux Basques adjacent to the Cabot Strait, for example, average about 16 and 19 miles per hour, respectively, during their windiest months, compared with about 10 miles per hour in midsummer.

Strong winds (that is, those with velocities over 25 miles per hour) occur most frequently in the Magdalen Islands - Cabot Strait area. Here winds can be expected to exceed 25 miles per hour over 40% of the time for most of the November to February period. Again, the high incidence of strong winds is chiefly a winter phenomenon. In the May to August period, strong winds normally occur less than 10% of the time except in the central Gulf where 10-20% is the expected figure.

Throughout the year, strong winds occur least frequently along what can most easily be described as the entire mainland coast of the study region. Along the Fundy Coast and parts of the south shore of Nova Scotia, for example, winds speeds greater than 25 miles per hour normally occur not more than 10% of the time in any month.

Wind direction is extremely variable throughout the year in the study region, because of the passage of numerous cyclonic storms ("Lows"). However, the prevailing winds tend to be from south to southwest in summer and from west to northwest in winter. Three isolated areas where east winds blow frequently are the Quebec City and Sept Iles vicinities and the Port aux Basques to Burgeo area of southwestern Newfoundland.

3.1.7 Climatological Statistics

In addition to the information presented above, further supporting data analysis was provided by the Atmospheric Environment Service (Phillips, personal communication, 1975). A summary of this climatological information is provided in Table 3.1. For this study only the most obvious location criteria were used. However, in the examination of specific port proposals, more detailed criteria, such as those used to design airport runways, could be applied to deepwater oil ports, for example, the cross-component wind speeds in the approaches to the port.

The summary provided in Table 3.1 relates to the following criteria:

(1) Frequency of occurrence of visibility equal to or less than 2 nautical miles (percentage frequency of all observations during the year for the period of record).

(2) Highest duration (hrs.) of visibility less than 5/8 mile.

(3) Frequency of wind speed equal to or greater than 25 m.p.h. (percentage frequency of all observations during the year for the period of record).

(4) Maximum duration (hrs.) of wind speed greater than 40 m.p.h.

(5) Number of years out of 10 that ice hindered navigation (Bradford, 1974).

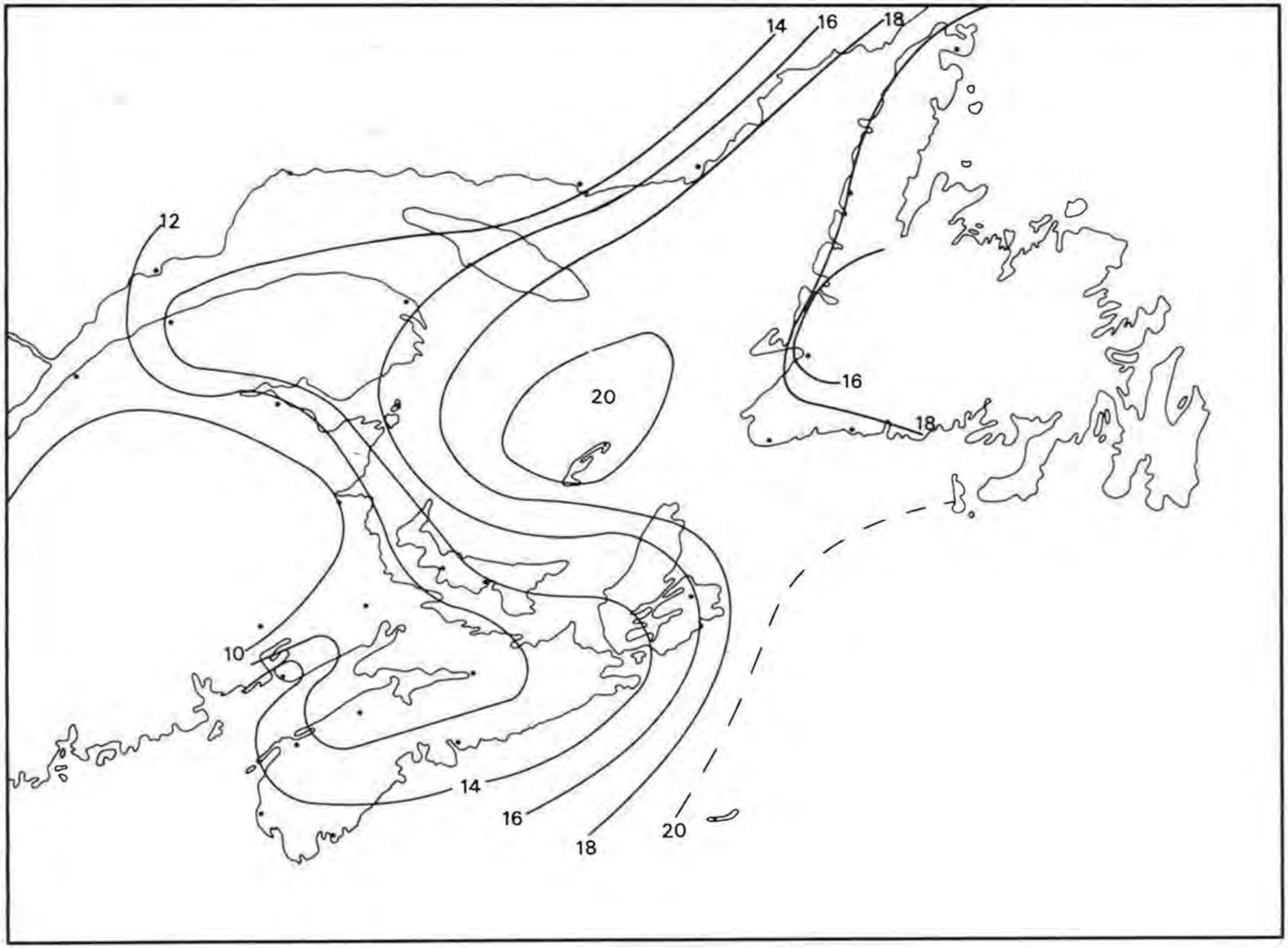

Figure 3.8 Mean Wind Speed During Windiest Month of the Year (in Miles per Hour)

(6) Combined number of weeks per year of plentiful ice (4-6/10) and congested ice (over 8/10) in immediate vicinity.

(7) Frequency of occurrence of freezing precipitation based on all hourly observations in January and February (percentage of hourly readings during December to March, for the period of record).

(8) Frequency of occurrence of observations equal to or greater than 32 m.p.h. and dry bulb temperature of 0 to 25° F. (percentage of hourly observations during December to March, for the period of record).

Table 3.1. Climatological Statistics

Site	Criteria (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Baie Comeau	9	33	2.6	9	6	12	.60	.50
Bay of Islands	8	31	2.3	10	6	6	.50	.50
Bonavista Bay	14	86	15.6	39	4	6	1.70	7.10
Bonne Bay	10	28	9.8	24	6	8	.50	4.50
Conception Bay	20	132	12.8	24	6	13	3.70	3.00
Head Harbour Psg.	17	71E	4.7E	18E	0	0	.30	.58E
Fortune Bay	22	126	14.5	40	0	0	.40	9.40
Grande Ile	10	80	0.4	1	8	14	1.40	.02
Halifax	13	52	5.8	12	0	0	.38	.80
Ile Ste. Genevieve	12	51	5.4E	12	6	6	.30	2.80
Ile Verte	10	80	0.4	1	8	13	1.00	.02
Magdalen Islands	11	56	24.7	42	8	12	.65	9.90
Natashquan	12	51	5.4E	12	6	10	.30	2.80
Placentia Bay	20	118	13.0	35	2	1	.30	5.10
Pte. au Marquereau	10	23	1.7	8	8	11	.50	5.00
Quebec City	9	30	3.0	8	6	15	2.50	.70
Saint John	17	71	4.7	18	0	0	.80	.58
St. Margaret's Bay	14	52	4.7	11	0	0	.45	.85
Sept Iles	11	51	5.4	12	6	12	1.10	1.20
Souris	9	37	4.9	11	10	13	1.70	1.10
Strait of Canso	17	55	4.7	13	2	2	.30	1.80
Trinity Bay	14	86	15.6	39	4	7	1.70	7.10

(E = estimated from nearby stations)

NOTE: For explanation of criteria used, see Section 3.1.7

3.2 HYDROGRAPHIC FEATURES

The following is summarized from Canadian Hydrographic Service, 1973.

3.2.1 St. Lawrence River - Quebec City to Saguenay River

(a) **Quebec City.** While the ship channel in Quebec Harbour is relatively wide and deep, in the North Traverse, east of Ile d'Orleans, the approach channel has a least width of 1,000 feet, and a least depth of 41 feet following dredging completed in 1974. With mean tides, the tide rises 17.6 feet at higher high water in this area.

The existing Golden Eagle Oil terminal wharf in Quebec Harbour has a least depth alongside of 54 feet with a berthing length of about 1,200 feet. In the foreseeable future it will therefore be possible for a tanker drawing 50 feet to use this terminal, and for tankers with a 55-foot draught (approximately 135,000 d.w.t.) to enter Quebec Harbour.

There is a marine traffic control system in effect along the St. Lawrence River from Sept Iles to Montreal and the navigational aids are adequate. However, there is the problem of ice during the winter months when many of the navigational buoys are lifted. It may be necessary for the appropriate authority to limit the size of tanker that is permitted to use Quebec Harbour, particularly during the winter season.

(b) **Grande Ile.** This island, about 6 cables (0.6 nautical mile) in length, is situated off the south shore of the St. Lawrence River near the summer resort of Kamouraska, about 75 miles below Quebec City. As a potential deep water oil terminal it has the great advantage of having deep water close off its NW side. The 20-fathom (120 feet) contour is less than 1 cable off the island. However, there is a least depth of 14 fathoms (84 feet) in the approaches. The ebb tidal stream sets at a rate of 2 to 3 knots close off the island and would present an obstacle to the manoeuvring and berthing of large tankers. For selection as a deep water terminal, additional aids to navigation would be required to indicate the preferred approach channel to the berth.

(c) **Ile du Gros Cacouna.** This island, nearly 1 1/2 miles long, is situated about 23 miles below Grand Ile. It is joined to the south shore of the river by swamp grasslands across which a causeway is laid. At the SW end of the island, an artificial harbour enclosed by breakwaters has been constructed; the navigable entrance between the breakwaters is about 315 feet wide with a least depth of 35 feet. For a potential deep water port, a depth of 84 feet is available about 1/2 mile off the NW side of the island.

The tidal streams off Ile du Gros Cacouna set at about the same rate as those off Grande Ile, and in general this site suffers from the same disadvantages as Grande Ile as a potential deep water oil terminal.

(d) **Ile Verte.** Ile Verte, 6 1/2 miles long, is situated off the south shore of the St. Lawrence River, 2 miles below Ile du Gros Cacouna, and nearly opposite to the mouth of the Saguenay River. The 20-fathom (120 feet) contour lies about 1/2 mile off the NW side of the island. In the vicinity of Ile Verte, between it and Ile Rouge, the strong tidal streams and tide rips would present serious problems in the manoeuvring and berthing of VLCC's. In addition, Ile Verte also suffers from the same disadvantages as Ile du Gros Cacouna and Grande Ile.

3.2.2 St. Lawrence Lower Estuary and Gulf North Shore

(a) **Sept Iles.** The harbour of Sept Iles is situated on the north shore of the St. Lawrence River about 285 miles below Quebec City. It is important as a shipping port for iron ore to steel mills on the Great Lakes, the Atlantic coast, the United Kingdom, and continental Europe. The new Iron Ore Company wharf is 875 feet long with a depth along-side of 57 feet. There are several suitable locations for a deep water oil terminal both within the harbour and outside the harbour limits, where a depth of 120 feet is available within 1/2 mile of the shore. The rate of the tidal streams in the bay and in the principle channels between the islands seldom reaches 1 knot.

Although ice would be a problem for VLCC's navigating to Sept Iles during the winter months, the port is now used on a year round basis by ore carriers up to 165,000 deadweight tons (d.w.t.). In general, light ice conditions usually prevail in the Jacques Cartier Passage, north of Anticosti. However, in years with prevalent NE winds this pattern can be altered.

Depending on the exact siting for a deep water oil terminal wharf at Sept Iles, it may be necessary to install additional navigational aids and to make changes to the traffic separation scheme presently in effect.

(b) **Baie Johan Beetz.** The settlement of Baie Johan Beetz lies at the head of Piashti Bay, situated about 140 miles east of Sept Iles on the north shore of the Gulf of St. Lawrence. In the approaches to Piashti Bay, there are depths of 22 feet. Any deep water oil terminal in this area would need to be situated in open waters well off the shore; the 20-fathom (120 feet) contour to the east of Piashti Bay is about 1 1/2 miles off-shore. However, it is considered that a single point mooring buoy would be impracticable here due to the winter ice conditions.

The ice and weather conditions in winter would make the manoeuvring and berthing of VLCC's in this area extremely hazardous at certain times.

3.2.3 Magdalen Shallows

(a) **Chandler.** The small exposed harbour of Chandler is situated about 15 miles WSW of Cap d'Espoir on the north shore of Chaleur Bay. The main industry of the town is the Gaspesia Pulp and Paper Company. There is a least depth of 20 feet in the harbour leading to one Government wharf, and a second Government wharf has a least depth of 32 feet at its outer end. A deep water oil terminal in this area would need to be situated in open waters off the shore; the 20-fathom (120 feet) contour lies 1.7 miles off the outer end of the second above-mentioned Government wharf. However, to the south of Chandler, the 20-fathom contour lies 5 to 6 cables offshore in some places.

With the expected ice and weather conditions as previously described, the manoeuvring and berthing of VLCC's in the vicinity of Chandler would be an extremely hazardous operation during certain times of the year. Tidal streams would not be a serious problem since they are fairly regular and seldom exceed 1 knot. Fogs are fairly frequent and there would be a need for better navigational aids in the area. An extension of the traffic separation scheme into the Bay of Chaleur would also be required to assist support traffic into a deep water oil terminal in this area.

(b) **Souris.** Souris Harbour is situated on the SE coast of Prince Edward Island, about 14 miles SW of East Point; the community of Souris is a fishing and farming centre. The harbour comprises Colville Bay, where depths are generally less than 50 feet. A deep water terminal in the vicinity of Souris would need to be situated well off the shore in unsheltered waters. The 20-fathom contour is closest to the coast (a distance of about 1.7 miles) at Red Point, which is 5 miles to the east of Souris.

Souris Harbour usually freezes over early in January and is clear of ice by early May. Ice and weather conditions in general would be a severe problem for a deep water terminal in this area. The approaches to such a deep water terminal would need to be marked by navigational aids.

(c) **Magdalen Islands.** These islands are situated in the Gulf of St. Lawrence about 50 miles NW of Cape St. Lawrence. The principle industry of the islands is fishing. The surrounding sea area is relatively shallow. The 20-fathom contour lies closest to Brion Island, situated 9 miles north of the main group of islands, but even there this contour lies 3 1/2 miles off Brion Island.

Fog and rain are frequent at the Magdalen Islands. During autumn, thick weather and easterly gales are prevalent. Ice is a problem from about mid-December to early April. Field ice drifts in towards the islands about mid-January and disappears in early May.

It is considered that because of weather and ice conditions, and the depth of water available, the Magdalen Islands area is most unsuitable as a deep water oil terminal.

3.2.4 Bay of Fundy and the Passamaquoddy Bay Area

(a) **Eastport, Maine.** The city of Eastport, Maine, is situated on the east side of Moose Island, just west of Campobello Island. The principal industries are fishing, with its accompanying phases of canning and smoking herring, and the manufacture of fish by-products such as fish oil, meal, pearl essence, and fertilizer.

It is possible to build a deep water oil terminal wharf off Eastport with depths alongside in the range from 80 to 90 feet. However, entrance to such a facility is via Head Harbour Passage, which is noted for its strong tidal streams, tide rips, and whirlpools. Its narrowest point is 1,800 feet wide between the coast of Campobello Island and a 27-foot shoal. Tidal streams in this passage sometimes attain a rate of nearly 5 knots. At the intersection of Head Harbour Passage with Western Passage, tide rips and whirlpools are formed at certain stages of the tide.

These strong tidal streams in the narrow entrance to Eastport would make it extremely difficult, and at times impossible, to manoeuvre and berth VLCC's in this area. In fog and reduced visibility, the difficulties of navigating such vessels would be further compounded. The area has already been considered and rejected by the New Brunswick government as too hazardous for a potential deepwater port site and is included in this study simply because of a current U.S. proposal to build a marine terminal and oil refinery at Eastport, Maine.

(b) **Saint John Area.** Saint John Harbour is situated at the mouth of the Saint John River. A deep water oil terminal buoy is already in existence close outside the harbour limits; this single point mooring is moored in a depth of about 20 fathoms. The facility, known as Canaport, which is owned and operated by the Irving Oil Company, is situated 6 cables south of Mispec Point, and is connected to a tank farm by two submarine pipelines.

The approaches to Canaport are from the open waters of the Bay of Fundy where a traffic separation scheme is in effect, from the entrance of the bay to the pilot boarding station off Saint John. The prevalence of fog in the Bay of Fundy, adverse weather conditions, and the tidal streams are navigational hazards to be encountered by VLCC's operating in and out of Canaport.

There has been a proposal to construct a deep water oil terminal wharf near Lorneville, about 6 miles SW of Saint John Harbour. The 20-fathom contour lies about 1,800 feet off the coast near Lorneville. The advantages and disadvantages in the approaches, from a navigational point of view, of a deep water terminal at Lorneville are similar to those for Canaport, which has now been in operation for several years. However, there are differences in operational constraints between a single point mooring and a wharf due to the ability of a moored ship to align itself in response to the forces of winds and currents.

3.2.5 Strait of Canso

Ice in the approaches to the Strait of Canso and off the Atlantic coast in this area is little more than an occasional inconvenience for shipping. During the colder years, ice forms in the Strait but it is seldom a problem to navigation. At Port Hawkesbury the range of the tide is 6.9 feet with spring tides. The tidal streams in the Strait of Canso and Chedabucto Bay are relatively weak.

A deep water oil terminal wharf is located at Wright Point in the Strait of Canso, about 2 1/2 miles SE of Port Hawkesbury. There is a least depth of 96 feet in the berth alongside this wharf; VLCC's of up to 350,000 d.w.t. are presently using this terminal. The deep water approach channel to this wharf has a least width of 1,700 feet. Additional deep water oil terminal facilities could be constructed in the Strait.

The approaches to the Strait of Canso through Chedabucto Bay are well marked with leading lights and buoys. A traffic separation scheme is in effect for entering and leaving Chedabucto Bay. A marine traffic regulating system is in effect for the Chedabucto Bay and Strait of Canso area. This system is operated by the Eddy Point Marine Aids Centre, which is equipped with harbour surveillance radar. The navigational aids for this deep water terminal are considered to be quite adequate. There is suitable anchorage for VLCC's in Chedabucto Bay.

3.2.6 Newfoundland South Coast

(a) **Fortune Bay.** This large bay is situated close west of the Burin Peninsula. There are many islands in the approaches and within the bay, which extends for about 65 miles. The shores are indented by many smaller bays and harbours. Fortune Bay is generally deep, and in many places there is deep water close to shore. Even near the head, about 2 miles SW of Terenceville, the 20-fathom contour lies within 600 feet of the shore.

There are many places in Fortune Bay where a deep water oil terminal wharf could be constructed. A terminal in the bay would necessitate better navigational aids in the area and probably a routing or traffic separation scheme. Navigation to and from such a terminal would be difficult at times because of fog, ice, and weather conditions.

(b) **Placentia Bay.** This bay lies east of the Burin Peninsula; it is about 50 miles wide at its entrance, and extends 60 miles in a NNE direction. Placentia Bay contains numerous islands, inlets, sounds, bays, and harbours. A deep water oil terminal wharf has been constructed at Come-by-Chance near the head of Placentia Bay. This wharf has a least depth of about 95 feet in the berth alongside. VLCC's were using this facility but the refinery is presently shut down. There are many other places in Placentia Bay where a deep water terminal could be constructed. For example, Mortier Bay, situated on the west side of Placentia Bay, has deep water close to its shores.

The currents and tidal streams in Placentia Bay are generally erratic and unpredictable. Rates of flow (horizontal water movement) from 2 to 3 knots have been encountered in the bay with the approach of SE gales and during gales; rates of 1 1/2 knots are sometimes encountered in good weather. Off the oil terminal wharf at Come-by-Chance, the flow was found to be generally weak both in summer and winter. In the approaches to the oil terminal, the general rates were 0.2 to 0.6 knot, with a maximum rate of 1 knot recorded. The direction of flow exhibited diverse patterns.

During SW winds fog is usually very dense on the east side of Placentia Bay, especially in the vicinity of Cape St. Mary's. With SW winds fog is prevalent in the bay with no clearing along the shores of the Avalon Peninsula. SW winds prevail in the bay during the summer and NW winds during the winter.

Placentia Bay has sometimes a considerable amount of ice in it early in February, but it is seldom completely filled before the middle of that month; south and SW winds are necessary to drive the ice into the bay. Heavy ice and small icebergs are occasionally carried as far north as Come-by-Chance Point. Thus, ice, fog, and weather conditions present navigational hazards for VLCC's.

3.2.7 Eastern Gulf of St. Lawrence

(a) **Bay of Islands.** This large bay divides into three arms, North, Middle and Humber Arms, about 9 miles east of its entrance. The city of Corner Brook is situated on the south side of Humber Arm. The main arms of the Bay of Islands usually freeze between December 20 and January 20, and suddenly break up between April 20 and May 10. In recent years, with icebreaker assistance, Corner Brook Harbour has been available on a year-round basis. The tidal streams and currents in the Bay of Islands are generally weak, except through the narrow channels and close to shoals and banks.

There are numerous places in the Bay of Islands where the 20-fathom contour lies close to the coast, including the Corner Brook area. In Humber Arm, strong winds, which occasionally reach 60 knots, create the greatest navigational problem. In addition, ice and fog would present navigational hazards to VLCC's operating into the Bay of Islands.

(b) **Bonne Bay.** Bonne Bay is an extensive inlet entered about 25 miles to the north of the Bay of Islands. The bay separates into two arms, South Arm and East Arm. The 20-fathom contour lies close to the shores of the bay. Easterly gales, which are not frequent, are generally accompanied by thick rainy weather.

Bonne Bay freezes over when the field ice appears about the middle of January. It is then completely closed with thick ice until about the middle of April when the field ice disappears, though, occasionally, ice on the coast blocks it until the end of June.

(c) **Natashquan.** Natashquan Harbour is a small craft harbour, situated on the north shore of the Gulf of St. Lawrence, about 42 miles east of Baie Johan Beetz. A deep water oil terminal in this area would have to be situated in open waters off the coast. The 20-fathom contour lies about 1 mile from the coast in the vicinity of Natashquan Point.

The ice and weather conditions would make the manoeuvring and berthing of VLCC's extremely hazardous at certain times, although in most years the ice conditions north of Anticosti are less severe than other parts of the Gulf of St. Lawrence.

3.2.8 Newfoundland East Coast

(a) **Trinity Bay.** This bay on the east coast of Newfoundland extends SW for about 50 miles, and contains many small harbours and anchorages. After easterly winds, a current sets up the NW side of the bay, and fog hangs more over this side than on the SE side. The bay never freezes over, but field ice has been met with in December, and has continued off the mouth until May. Icebergs come up the bay as early as the last week in May, and may remain grounded until the last week in August. With favourable winds, the bay is generally clear of ice by the end of June.

There are many places in Trinity Bay with deep water close to the shore. Smith and Random Sounds, on the west side of the bay, are possible sites but in severe winters, both of these inlets may freeze over for several months. Ice would be a problem in most of the sheltered bays and inlets in Trinity Bay.

(b) **Conception Bay.** This large bay is entered north of Cape St. Francis; it extends about 45 miles in a southerly direction. The south part of the west side and the head of the bay are indented with numerous inlets.

Conception Bay normally fills with ice between the middle of January and March 1, and clears between the middle of March and April 20. However, ice has been known to remain until May 25, and occasionally very little ice enters the bay at all.

As with Trinity Bay, there are many locations with deep water close to the shore. The 20-fathom contour lies less than 900 feet off parts of the east coast of Bell Island. At the head of Conception Bay, Holyrood Harbour is used by the Golden Eagle Company for importing crude oil and exporting refined petroleum products. The Golden Eagle wharf has a least depth of 32 feet alongside. Although there are sufficient depths to construct a deep water oil terminal in the harbour, there is a limiting depth of 84 feet in the approaches. Holyrood Harbour is normally closed to navigation due to ice for about three weeks in March.

The construction of a deep water oil terminal in Conception Bay would require an improvement in navigational aids, and probably the introduction of a traffic separation scheme.

(c) **Bonavista Bay.** This large bay lies to the north of Trinity Bay on the east coast of Newfoundland. The harbours in Bonavista Bay freeze over at intervals between January 20 and March 20, and are closed at intervals by ice about 1 foot thick from January 20 to May 15. Field ice appears about February 15 and disappears towards the end of May. Coastal vessels frequent the harbours in the bay throughout the year.

There are many places where there is deep water close to the shore. In general, ice would be more of a problem in Bonavista Bay than in Trinity or Conception Bays.

Chapter 4

THE MARINE ENVIRONMENTAL EFFECTS OF OIL POLLUTION

The literature available on the chemistry of oils, their effect on living beings, and the effects of spills and cleanup technology on individual species, communities and systems is extensive. Many references dealing with the potential ecological impact of spilled oil and refinery wastes are covered in major reviews by Nelson-Smith (1972) and Moore *et al* (1973). References in this chapter can be found in Power *et al* (1974), Loutfi (1974) and Anon. (1974a).

4.1 EFFECTS OF OIL UPON MARINE ECOSYSTEMS

The effects of oil are varied and are in principle a function of the type and quantity of oil spilled and the conditions of spillage. Five different responses can be identified:

(a) lethal toxicity,
(b) sublethal disruption of physiological or behavioural activities,
(c) mechanical interferences,
(d) incorporation into organisms, causing accumulation in food chains or tainting, and
(e) changes in biological habitats.

(a) Toxicity of oil is closely related to solubility in water which decreases with the number of carbon atoms in the molecule. Low boiling point aromatic hydrocarbons are very soluble and most toxic; low boiling point saturated hydrocarbons (paraffins) are less soluble and produce narcosis which may lead to death; low boiling point olefinic hydrocarbons occupy an intermediate position. More complex, larger molecules have higher boiling points and are less toxic but some are carcinogenic (Blumer, 1971).

Thus, refined oils containing the low boiling fractions such as gasoline, diesel fuel, and light fuel oils are extremely toxic and may have pronounced lethal, sublethal, and tainting effects. Residual oils, from which the lighter fractions have been distilled are relatively non-toxic and their effect on living organisms is principally mechanical. They may have additional mechanical effects on sediments and beaches and become incorporated in organisms and cause tainting. Crude oils occupy an intermediate position in that they contain all fractions. They may be initially very toxic but become less so in hours or days as the light fractions dissolve or volatilize.

(b) Sublethal physiological or behavioural disruption can take a number of forms such as: the inhibition of respiratory movements in clams, oysters, and barnacles; the attraction of lobsters to kerosene fractions followed by inhibition of feeding responses and stimulation of grooming (Blumer *et al.*, 1973); the tendency of some fish species and marine mammals to avoid contaminated areas; the interference with chemosensory communication between marine organisms by blocking or mimicking which could upset feeding and reproductive mechanisms in a number of important species; the inhibition of sexual maturation (e.g., in clams, mussels - Saunders *et al.*, 1972). Inhibition of phytoplankton photosynthesis (Gordon and Prouse, 1973).

Renzoni (1973) shows that spermatozoa of some marine bivalves are particularly sensitive to crude oils and light derivatives. Larval development is adversely affected at oil concentrations which are not likely to be found at sea but which may occur in estuaries or lagoons. These areas may be the sites of commercial fisheries. Similarly Wells (1972) shows increased frequency of abnormal development of lobster larvae in sea water containing less than 1 ppm crude oil. It is unlikely that abnormal larvae will have normal probability of survival (Allen, 1971).

(c) Mechanical effects are most likely to occur as a result of heavy oil stranding on beaches. These include the physical smothering of clams, barnacles, and limpets; interference with byssus attachment of mussels; detachment of limpets (e.g., *Acmaea)* due to the weight of oil on the shell; the flow of oil into the burrows of clams *(Mya arenaria)* causing the clams to emerge and become subject to increased predation (Thomas, 1973a); the detachment of algae, e.g., *Fucus seratus*, due to weight of contaminating oil (Thomas, 1973a). In addition, there are the well documented effects of oil on birds.

(d) Incorporation of hydrocarbons into organisms offers two principal concerns. The first is tainting. Species that filter large volumes of water (e.g., oysters, clams) rapidly become tainted in hydrocarbon concentrations as low as .01 ppm. Tainting is noticeable at concentrations of 5-50 ppm tissue weight, but there is some capacity for self-cleaning following exposure to non-contaminated water (Wilder, 1970). Note, however, that absence of tainting is no indication of lack of contamination (Sanders *et al.*, 1972). Farrington and Quinn (1972) show the presence of petroleum hydrocarbons similar to those found in crude and fuel oils, in clams and sediments, from parts of Narragansett Bay which are subjected to chronic contamination from urban sewer effluents. Clams from uncontaminated areas did not show this range of hydrocarbons.

Of more concern than tainting may be the incorporation of polycyclic aromatic hydrocarbons (PAH) such as 3,4-benzpyrene and 1,2,3,4-tetrahydronaphthalene which are known carcinogens. PAH carcinogens stimulate plant growth and their carcinogenic and growth stimulating properties are directly related. They occur naturally, and also in crude and residual oils. Lee *et al.* (1972) showed that mussels concentrated PAH's in the gut up to concentrations of 3 - 10 ug/animal of 3,4-benzpyrene and 10 ug/animal of 1,2,3,4-tetrahydronaphthalene, although much of this was discharged following transfer to clean water. In nature these compounds degrade slowly.

(e) Oil-induced alteration of habitats can occur either mechanically or physiologically. Mechanical effects include the incorporation of oils into sediments. With light oils this results in long-term suppression of the fauna or persistent tainting (e.g., the West Falmouth spill where some 5500 acres were still affected four years after a spill of 700 tons of diesel fuel). With heavier oils impervious "pavements" of oil-soaked gravel may develop such as now exists on parts of the shoreline of Chedabucto Bay, or the impervious layers in salt marshes (Thomas, 1973; Baker quoted by Nelson-Smith, 1972; Moore *et al.*, 1973) which prevent the penetration of marsh plant roots and shoots and lead to denudation of the marsh. Light and heavy oils can become incorporated into sediments at depths depending on turbidity, turbulence and mixing, e.g., 10 m at West Falmouth, 20 m in Chedabucto Bay. Oil incorporated into sediments degrades slowly and may remain for years.

Physiological alteration of habitats is caused by the selective elimination of oil sensitive species thus allowing less sensitive species to become dominant. For example, diesel oil spilled from "Tampico Maru" (North *et al.*, 1964, cited by Nelson-Smith, 1972) eliminated abalones and sea urchins which normally browse on kelp. Kelp plants settling shortly after the spill were thus allowed to grow unimpeded by normal browsing and produced an abnormally luxuriant canopy which persisted for more than five years. Similar events have occurred on shores from which limpets and littorina were eliminated thus allowing abnormal growth of littoral seaweeds.

4.2 EFFECTS OF OIL UPON FISHERIES

There are a number of effects which should be considered. These include:

(a) the direct biological effects on the species concerned. Some of these have been outlined earlier.

(b) the effects on a fisherman's ability to fish, either because the grounds or gear are contaminated,

(c) the effects that oil spills may have on fish processing plants, and

(d) the effect on the retail market itself.

In this latter case, it was clearly found after "Torrey Canyon" that shellfish markets in England were depressed (Cowan, 1968, p. 147) but the effect was most severe in France where retail fish sales fell 40% in the week following the arrival of oil on Brittany beaches (Cowan 1.c, p. 169). The decline in the market included species which had no likelihood of being contaminated and represented a loss of confidence in the fishing industry as a whole.

Fish processing plants that depend on raw material from a limited area are particularly vulnerable since any contamination of local beds or grounds could reduce supplies. In addition many require clean seawater for their processing routines. In the event that approval was given for construction of an oil terminal, it would be imperative to design and construct emergency water filters for those plants which did not have access to an alternate source of uncontaminated water. Plants close to the terminal would require these to be operable at immediate notice. Construction of a filter for the Booth fish plant at Petit de Grat following the wreck of the "Arrow" cost $15,000 (Anon., 1970). It is conceivable that such filters might not be effective for all types of oil, particularly the light fractions, in which case plants might have to interrupt production until the area was clean.

Damage to specific fisheries is difficult to predict insofar as much will depend on the type and volume of oil spilled and the time of spillage. The following is an indication of the problems that might be expected to arise.

(a) **Beach fisheries; shellfish and seaweeds**

These are possibly the most vulnerable of all fisheries to oil contamination. All types of spilled oil may become incorporated into beach sediments and persist for many years. Blumer and Sass (1972) show that the area affected by the West Falmouth diesel oil spill is extending as contaminated sediments are redistributed. Scarratt and Zitko (1973) show that clams from beaches "cleaned" of "Arrow" Bunker C, three years earlier, contained 48 ug/g. All the clam beds in the Chedabucto area remain closed to fishing.

Some red seaweeds are sensitive to oil concentrations as low as 1 ppm and oil on beaches would interfere significantly with typical harvesting techniques for Irish moss.

(b) **Pelagic and estuarial fisheries**

There are strong possibilities that migration routes of some fish may be affected by the presence of oil (Rice, 1973), and the gear used in these fisheries is susceptible to oiling, particularly weirs and traps for herring, salmon, eels, smelt, etc. This type of gear would require thorough cleaning or replacement if fouled. The cost of a typical Bay of Fundy herring weir was estimated at $8,000 (Anon., 1973).

Surface drift nets and gill nets for herring, mackerel, salmon, shad are perhaps slightly less vulnerable to oiling than fixed gear set on poles or stakes insofar that less protrudes through the water surface.

Seines for herring and mackerel are less vulnerable by reason of the fact that fishermen can elect not to set in areas where oil is visible on the surface. Nevertheless, in Chedabucto Bay a net "laundry" was built at a cost of $28,500 to clean seines that became oiled (Anon., 1970). Catches contaminated by oil will not receive top market price.

(c) **Inshore lobster and crab fisheries**

Except for spills of refined oil or crude oil in shallow water or spills near holding pounds, these fisheries are vulnerable principally through the danger of tainting the catch. This is likely to occur if oil from buoys and ropes contaminates the bait used when the trap is reset. Thus, floating oil in the vicinity of favoured grounds would discourage fishermen from setting gear.

Lobster have been reported killed by spills of light fuel oil and are known to be tainted by fresh Bunker C. Fresh crude oil would be toxic in shallow turbulent areas. Larval lobsters are abundant in the Gulf of St. Lawrence and breeding potential could be affected. Stored lobsters would be particularly vulnerable to spills of all types of oil either from direct toxicity or tainting. Lobsters so killed could not be salvaged by immediate cooking. An oil spill of 1000 gallons of Venezuelan crude in Eastern Passage, Halifax Harbour, January 1973, caused tainting of 1800 lbs. of lobsters in storage tanks one-half mile downstream (Cote, personal communication). Water samples from the tanks contained 180 ppb hydrocarbons. After two days the lobsters were removed to clean water in St. Margaret's Bay and checked regularly; by March 31 only 50 lbs. remained alive. These were still tainted. Mortality among other lobsters was considered to be normal. It is possible that mortality may be considerably delayed and lobsters exposed to certain types of fuels may be a total commercial loss. Spills in the vicinity of or affecting tidal lobster pounds could have serious consequences for stock in the pounds, and cause long-term contamination of the sediments forming the floor of the pound. Note that booming might be only partially successful in reducing contamination; the seawater intake to the tanks contaminated in the Halifax spill was 6 feet below low-water mark!

(d) **Groundfish, scallops, shrimp and deep-water crab fisheries**

Deep-water fisheries are perhaps the least vulnerable insofar as dilution of oil would be maximal and fishermen would have greatest freedom to set nets in clear water. Nevertheless fishermen are not likely to set close to floating oil patches and contaminated catches would likely be dumped or used only for fish meal.

(e) **Other fisheries considerations**

Certain areas, e.g., S.W. Nova Scotia, North Shore, N.B., North Shore, P.E.I., are known spawning areas for herring. Massive spills near these areas, at critical times of the year, could interfere with spawning success and larval development. Contamination of sediments in these areas (particularly the shallower beds) could cause significant interruptions in spawning over several years. Kuhnhold (1969) reports that 0.1 ppm oil in water gives a high incidence of deformed herring larvae.

Detailed study of potential oil-ports should determine whether the spawning beds of any species are located within the area considered "at risk". In addition, such detailed studies should identify areas of marine mammal concentrations (Gaskin, 1973), and sea-bird rookeries, particularly those of rare or threatened species. Areas with high potential for aquaculture should be identified and protected so that heavy industrial developments do not pre-empt development of renewable resource-based industries.

Finally considerable attention must be paid to the routing of vessels to and from potential sites. For mutual safety there should be maximum separation between tanker lanes and fishing grounds.

4.3 EFFECTS OF OIL UPON BIRDS

Sea-birds are very susceptible to oil pollution (Loutfi, 1974). The occurrence of dead and dying birds along the coast is often the first, and sometimes the only, superficial indication that there has been an oil spill. Petroleum destroys two important qualities of bird plumage: water repellency and insulation. Furthermore, oil clinging to the feathers interferes with the ability to fly. Water or oil fills the spaces in which air is usually trapped, eliminating heat insulation and reducing buoyancy. Contact poisoning by toxic sulphur compounds in the oil is an additional factor. It has been reported that a spot of oil 2 to 3 cm in diameter in the breast of a bird is sufficient to cause death (Nelson-Smith, 1970).

Autopsies of dead birds indicate that oil is frequently present in the digestive system, presumably as a result of preening (Odham, 1971). This causes a variety of secondary complications. In a series of experiments, ducks (*Anas* spp.) fed oil showed lipid pneumonia, severe intestinal irritation, changes in the liver tissue, necrosis, adrenal enlargement and nervous abnormalities indicating interference with anticholinesterase activity (Hartung and Hunt 1966). In oiled birds, metabolic activity is high in order to maintain their body temperature. Birds with adequate fat reserves survive best. Evidence summarized by Nelson-Smith (1970) indicates that mortality is highest where temperatures are low and food is not readily accessible.

Viability of bird eggs is reduced drastically by oil pollution. If the parent birds or the nest material is oiled, the hatching success of eggs is reduced, sometimes to nil (Nelson-Smith 1970). Furthermore, the ingestion of oil has been found to halve egg laying and to suppress reproductive behaviour (Hartung 1963).

Large kills of marine birds are the most obvious effect of accidental spills. A large spill in 1937 near the coast of California killed upwards of 10,000 birds (Moffitt and Orr 1938). On the Newfoundland coast, one colony of auks estimated at 250,000 was nearly destroyed by oil (Foyn, 1965). A collision off Chatham, Massachusetts, in 1952 resulted in the reduction of the wintering eiders from 500,000 to 150,000 (Burnett and Snyder 1954). It has been calculated that the annual bird mortality in the North Atlantic due to oil, totals 150 to 450 thousand (Tanis and Morzer Bruyns, 1968). Nelson-Smith (1970) estimates that chronic pollution kills as many annually as a single catastrophic spill.

Despite high mortalities from pollution, a number of bird species are in no danger of extinction. Nelson-Smith (1970, p. 258) lists the following as increasing in numbers: "gulls *(Larus* spp), cormorants *(Phalacrocorax* spp), gannets *(Sula bassana)*, petrels, including fulmars *(Fulmarus glacialis)*; Manx shearwaters *(Puffinus puffinus)*; storm-petrels *(Hydrobates pelagicus)* ".

This is not true for divers *(Gavia* spp.), which form only a small percentage of the birds affected by pollution; however, their world population is small, and their reproductive rate is low. Also in serious trouble are the sea-ducks *(Clangula hyemalis* and others), eiders *(Somateria mollissima)*, and shelducks *(Tadorna tadorna)*. According to Nelson-Smith (1970), the auks are, however, probably the most seriously affected. These birds are typical top carnivores with few natural enemies, very low reproductive rates and a long life span. It has been estimated that if a colony of guillemots (an auk species, *Uria aalge)* suffered a 50% catastrophic mortality, it would take more than half a century to recover under natural conditions (Clark, 1968). Another seriously affected member of the auk family is the puffin, *Fratercula arctice*, which has been declining in numbers. The population crash is an accelerating process because small colonies have proportionately less reproductive success than large ones (Clark, 1968). In the opinion of Nelson-Smith (1970), an effective conservation policy, including the rehabilitation of oiled individuals, is the only way to protect many species of auks from extermination in the North Atlantic.

The old methods of rehabilitation showed little success. According to a UPI press release dated May 15th, 1971, only 305 of the estimated 7,000 birds oiled in the January 18th (1971) San Fransico Bay spill survived. Of the 5,711 oiled birds collected in the wake of "Torrey Canyon", only about 150 were returned to sea, and probably less than 100 survived. In quoting these figures, Nelson-Smith (1970) points out that "...a great deal of trouble and resources were, in effect, being devoted to prolonging the suffering of over nine-tenths of the stranded birds. Most ornithologists advise that quick humane killing is at present the best treatment." Zeldin (1971) estimated that the cost per surviving bird was about $10,000.

More effective methods of rehabilitation are obviously needed, and efforts would perhaps best be confined to selected individuals and species. Most cleansing agents remove the natural feather wax as well as the pollutants, and thus cause further damage to the plumage. The chemical properties of the feather wax and petroleum are very similar (Odham, 1971). Since feather wax is essential in providing water repellency and heat insulation, birds should not be returned to sea until the wax has been replaced in some way. Since many of these birds are very difficult to keep in captivity even when healthy (Nelson-Smith, 1970), it is not feasible to keep them until they have moulted a new set of feathers.

A new cleansing agent, Larodan, which permits simultaneous cleaning and re-waxing, appears to be very promising. "Larodan has been used on a large scale in Scandinavia, for example, in Gavle, Sweden, where about seventy-five birds belonging to the family of Anatidae were successfully cleaned and returned to their natural environment within a fortnight" (Odham, 1971). Recent work at the Research Unit on the Rehabilitation of Oiled Seabirds (University of Newcastle-upon-Tyne) indicates that good results can be achieved by the use of ordinary household detergents if certain precautions are taken (Clark and Croxall, 1972). The report of the Unit should be consulted for more detail (Anon., 1972).

4.4 EFFECTS OF OIL UPON MAMMALS

As the case is with bird plumage, mammalian fur readily loses its insulation property when fouled by oil (Loutfi, 1974). There are a number of reports from inland waters on the effects of oil products on a variety of mammals, such as muskrat and beavers (Nelson-Smith, 1970), but we know of no cases of extensive marine mammal mortality attributable to oil. However, there have been reports of damage by oil to seals in the Antarctic (Lilie, 1954) and following the "Torrey Canyon" (Spooner, 1967), Santa Barbara (Smithsonian Inst., 1969) and "Arrow" incidents (Anon., 1970).

It has been observed that grey whales detect and avoid oil. Nevertheless, in the Santa Barbara spill, five whales, in addition to four porpoises, were found dead - but there was no proof that the deaths were caused by oil. Heavy mortality was observed in colonies of sea lions and sea elephants surrounded by oil. A dead bottle-nosed dolphin had its blowhole plugged with oil (Nelson-Smith, 1970). The extent of oil damage to marine mammals remains to be assessed.

Chapter 5

NATURAL RESOURCES

5.1 FISHERIES

The principal fisheries and related significant factors are summarized below for (1) each major geographical region and for (2) each site under study. The areas for which these local and regional assessments of fisheries have been made correspond to the areas utilized in Chapter 6 for rating the impact of a major spill. The local area is the area of immediate impact, where all resources are assumed to be put at risk. For regional resources, a major spill at a specific site is considered also to put at risk a fraction of the more distant regional resources, e.g. a spill in the Strait of Canso will affect the Chedabucto Bay fisheries plus a fraction of the fisheries of the Scotian Shelf. This aspect will be addressed further in Chapter 6.

Much more detailed information on the fisheries can be found in Power *et al* (1974). The fisheries statistics (1968-72 average except where noted) are summarized in the following thumbnail sketches. -

5.1.1 Outer Coast of Nova Scotia

On the outer coast of Nova Scotia from Cape North on Cape Breton Island to the Shelburne-Yarmouth boundary, an average of 379,219,000 pounds of fish worth $40,492,000 were landed annually. The most valuable species were cod, lobster, haddock, redfish and plaice. These species contributed 47% of the total value of fisheries and 57% of the weight of fish in this area.

An average of 7610 fishermen worked in this area, of whom 3000 fished full time. There are about 80 fish processing plants which employed 4600 employees, 3200 of them permanently.

In 1972 licenses were issued for 377 fixed traps, 4000 gill nets and 733,000 lobster traps.

(a) **Canso.** The area likely to be affected by an oil spill at the Strait of Canso has been taken to include Nova Scotia Sea Fisheries Districts 8, 9, 14, 15 and 16. From 1968 through 1972, an average of 103,489,000 pounds of fish worth $3,769,000 were landed annually. Over these years the most valuable species were cod, redfish, herring, lobster and plaice. Together these species accounted for 80% of the landed value and 85% of landed weight of fish in these districts.

An average of 788 fishermen were engaged in these fisheries of whom 123 worked full time. There are 8 fish processing plants which together employed 907 workers of whom 723 were permanent employees.

In 1972 licenses were issued for approximately 58 fixed traps, 1800 gill nets and 86,000 lobster traps.

(b) **Halifax.** The area of immediate impact for an oil spill in the vicinity of the port of Halifax has been taken to include fisheries statistical districts 18 (20B), 20, 21 and 22. From 1968 through 1972 an average of 42,700,000 pounds of fish valued at $3,431,000 were landed annually (marine mammals have been excluded from the above statistics). The most valuable species, in order of decreasing landed value, has been cod, haddock, lobster and swordfish (currently banned because of high mercury levels). These species together accounted for 56% of landed weight and 65% of landed value.

An average of 1,132 fishermen were engaged in these fisheries of which 268 worked full time. In 1972 licenses were issued for 58 fixed trap nets, 642 gill nets and 53,500 lobster traps. There are seven fish processing plants in the area which together employed 334 people of whom 288 were permanent employees.

(c) **St. Margaret's Bay**. The area of immediate impact for St. Margaret's Bay was taken to include fisheries statistical districts 22, 23, 25 and 26. The average annual landings for 1968-72 were 107,000,000 pounds valued at $14,337,000 (excluding marine mammals). The most important species, in decreasing order of landed value, were scallops, haddock, cod and swordfish (currently banned because of high mercury levels). These species together account for 52% of landed weight and 75% of landed value.

An average of 1,815 fishermen were engaged in the trade, of whom 847 were full-time fishermen. In 1972, licenses were issued for 162 fixed fish traps, 3,270 gill nets and 81,100 lobster traps. There are nine fish processing plants in the area which together employed 942 people of whom 759 were permanent employees.

5.1.2 Bay of Fundy

This area includes those statistical districts in the Bay of Fundy and its approaches from the Yarmouth County/Shelburne County line to the New Brunswick/Maine Border. Approximately 3,700 fishermen land $16.7 million worth of fish. The principal single species is lobster with annual landings in excess of $7 million. The next largest species is herring ($5 million) and there are significant catches of haddock ($1.3 million), cod ($.9 million), scallops ($.7 million), pollock ($.6 million), soft-shell clams ($.5 million) and seaweeds ($.5 million). The principal fishing areas are in the western part of the bay, namely off Charlotte, Digby and Yarmouth counties. One hundred and nineteen companies, processing (78), handling (41) fish plus 20 lobster pounds employ over 3,600 persons of whom nearly 1,600 are permanent employees. Over 600 permanent jobs are accounted for by the sardine canning industry in Charlotte County alone.

The total value of fish products for the Bay of Fundy was estimated at $52.7 million in 1972 of which $25.2 million are ascribed to Charlotte County.

(a) **Charlotte County Area (Passamaquoddy)**. Approximately 1000 fishermen land $4.4 million worth of fish. The principal fishery is herring ($2.4 million) and of these, 42% are caught in fixed weirs for use in the food industry and the remainder by purse seiners with a large fraction going for reduction. The lobster fishery is worth approximately $1 million annually and the soft-shell clam about $200,000. There is a small, unique seaweed fishery and some potential for mussels, winkles, sea urchins.

There are several major and many minor processing plants in the area. The high tidal range and ice-free winter conditions make the area suitable for lobster storage pounds. Up to 5.2 million pounds may be held in storage at any one time.

The area has been studied in some detail to assess the possible impact of an American oil terminal and refinery proposal for the city of Eastport (Anon. 1974).

(b) **Washington County, Maine.** Since neither fish nor oil spills recognize political boundaries, the Charlotte County area of New Brunswick cannot be logically considered without similar attention to Washington County in the State of Maine. Approximately 2000 fishermen are employed in Washington County and land approximately $4.5 million worth of fishery products. Due to the nature of their coastline, the species composition is quite dissimilar from Charlotte County. The principal landings are lobsters ($2.2 million) and clams ($1.2 million) with two species of littoral worms ($2.3 million) occupying third place. Herring, scallops and shrimp are important seasonal components, and there are other significant fisheries for groundfish, eels, smelt, crabs and a number of incidental species.

The principal inshore fisheries of the State of Maine are lobster ($20 million), shrimp ($4 million), clams ($2.7 million) and worms ($1.4 million). Of the ocean perch landings ($2.4 million), approximately half comes from the Gulf of Maine.

There are approximately 10,000 fishermen in Maine and their total marine landings are in the order of $30 million annually.

(c) **Saint John Area**. Slightly more than 200 fishermen land about $300,000 worth of fish in the Saint John area. A major item was a drift and set-net fishery for salmon; however, this has declined due to power developments on the river and overfishing on the high seas, and is now temporarily banned pending stock recovery. Other significant fisheries are lobster ($175,000) and herring ($70,000) taken in weirs and seines. There are minor fisheries for shad and alewives in the Saint John River and a small sport fishery for striped bass.

There are no large investments in processing plants.

The area has received some detailed study already for the "Lorneville" report (Anon. 1973).

5.1.3 St. Lawrence River and Estuary

The total number of fishermen amounts to somewhat less than 2,000, landing $3.3 million worth of fish. In general terms, the fisheries are of minor importance but can be of local significance. There are potential fisheries for seaweeds, sea urchins and mussels. The area could to some extent be considered underexploited.

(a) **L'ile Verte, Kamouraska** (District 3). Less than 100 fishermen operate in this district. The principal fishery is for eels (up to $100,000 annually) with minor fisheries for herring, smelt, codfish, and halibut. Fishing techniques are traditional with low capital investment, using fish traps, gill nets, long lines and hand lines.

(b) **Sept Iles** (District 19). About 100 fishermen land $40,000 worth of fish annually. The principal fishery is salmon, with smaller fisheries for cod, halibut, and other groundfish, crabs, and shrimps, with incidental catches of other species.

(c) **Grand Ile, Kamouraska** (District 2). Less than 100 fishermen operate in this district and the principal fishery is for eels ($124,000) with minor fisheries for herring and smelt. These are principally trap-net fisheries and hence are vulnerable to oil.

5.1.4 Northeastern Gulf of St. Lawrence

The fishery is characterized by heavy dependence upon the inshore fishery for herring, capelin, mackerel and salmon. Molluscs and crustaceans, primarily lobster and shrimp fisheries, are the largest source of income. Fishing is conducted usually for 8-9 months per year.

(a) **Bay of Islands** (Part of Statistical Area L). Lobster fishing is the major source of income (more than $300,000) and a herring fishery with an average landing of 11 million pounds and an average value of $178,685. The single most important Atlantic salmon river, the Humber, flows into the bay in addition to three other scheduled rivers. The average angling catch is approximately 4000 fish with an estimated recreational value of $480,000. There are seven small operations involved with limited processing and distribution of fish. A total of 280 fishermen are resident in the bay, most of whom fish for less than five months a year.

(b) **Bonne Bay** (Part of Statistical Area M). Lobster fishing is the most valuable fishery in the bay with landings of approximately $60,000 annually. One scheduled salmon river flows into the bay with an estimated recreational value of $25,000 annually. The fishery is largely conducted on a part-time basis. Bonne Bay is within the boundaries of Gros Morne National Park.

(c) **Baie Johann Beetz, Natashquan** (District 21). About 100 fishermen land about $30,000 worth of fish annually, principally salmon, cod, and halibut taken in gill nets and trap nets. These are traditional small boat type fisheries with low capital investment.

5.1.5 Southern Gulf of St. Lawrence

Nearly 12,000 fishermen land approximately $30 million worth of fish of which the principal single species is lobster worth in excess of $13 million. Other invertebrates are scallops, ($2 million) and snow crabs ($1.2 million). There are locally significant fisheries for oysters, rock crabs, clams and bar clams. Groundfish landings have varied from $4.2 million to $6.6 million with the principal species being cod, plaice, redfish and hake in that order. Landed value of the herring fishery has averaged $3.2 million and there are additional landings of mackerel and a sport fishery for tuna. The annual harp seal hunt takes place partly in this area. The fisheries are quite seasonal due to climatic conditions. Imposed seasonal fisheries (e.g. lobsters) or the migratory habits of the species concerned. There are no readily available figures for numbers of fishermen or plant workers employed, nor for the total value of fisheries products.

(a) **Chandler, P.Q.** (Quebec Maritime Fisheries Districts 10, 11, 12). About 950 fishermen land $2.3 million worth of fish. The principal fisheries are offshore fisheries for cod, redfish, and plaice worth about $1.7 million and for Queen crabs, worth about $0.2 million. The inshore lobster fishery is worth about $375,000. There are minor fisheries for herring, mackerel, salmon, and shad worth about $40,000 per year. These are prosecuted with seines or set nets and are thus relatively vulnerable to oil. There are a number of processing plants scattered along the coast.

(b) **Souris, P.E.I.** (Districts 87 and 88). Eleven hundred fishermen land $4.8 million worth of fish. The principal offshore fisheries are for groundfish (cod, redfish, plaice, hake, winter flounders) but the most important single species is lobster ($3.1 million). There is a significant fishery for scallops ($0.5 million). The Irish moss fishery ($140,000) is particularly vulnerable in this area as the harvest is exclusively of cast moss collected off the beaches. There are minor fisheries for eels, smelt, mackerel, and herring and a developing sports fishery for large bluefin tuna ($27,000 in 1972).

There are several fish processing and packing plants in the area.

(c) **Magdalen Islands, P.Q.** Approximately 1250 fishermen are based in the Magdalen Islands. The most valuable fishery is for lobsters with landings approximately $2 million annually. Other vulnerable species are herring fished with seine and trap nets ($1,000,000 annually) and minor fisheries for mackerel and eels. Less vulnerable fisheries are for groundfish ($1.3 million) principally redfish from deep water and a significant ($0.3 million) fishery for scallops. There are several fish packing and processing plants. The islands are a base for part of the spring seal fishery and there are minor domestic fisheries for clams, bait, etc. which do not appear in official statistics.

5.1.6 Southern Newfoundland

South coast bays are generally ice-free South coast bays are generally ice-free and as such, fishing is conducted on a 12-month basis. The effort is primarily offshore; however, there is also an important inshore fishery. Groundfish landings account for the majority of catch in poundage and value. Pelagic species of importance include herring, capelin, salmon and mackerel. Fisheries for shrimp, crab and scallop are expected to become of increasing importance to the south coast.

(a) **Fortune Bay** (Statistical Area I). Approximately 1000 fishermen are engaged in the fishery which has an average landed value of $5.7 million. This represents about 15.5% of the total provincial fishery, based on 1972 values and catches. There are three major fish processing plants employing approximately 550 people, in addition to a number of smaller processing plants.

(b) **Placentia Bay** (Statistical Area H). This bay accounts for approximately 15.5% of the total provincial fishery, with an average landed value of $5.7 million. In 1971 there were 1359 fishermen employed. In addition to a number of small processors, there are two major processing plants which employ approximately 450 people.

5.1.7 Eastern Newfoundland

The fishery is primarily an inshore effort starting in late April and continuing until early December, with the possibility of some fishing in January and February, weather and ice conditions permitting. Groundfish landings, primarily cod and flounder, account for the majority of catch, with pelagic species, i.e. capelin, herring, mackerel and salmon, also fished extensively. Crab and lobster are also important fisheries.

(a) **Bonavista Bay** (Newfoundland Fisheries Area C). Bonavista Bay averaged landed value of fish is $1.6 million which, expressed as a percentage of the 1972 catch, is 4.3% of the total provincial fishery. The inshore effort accounts for roughly two-thirds of the total. In 1971 there were 1213 fishermen. Four major processing plants employed approximately 560 people.

(b) **Trinity Bay** (Area D). In 1971 there were 1035 fishermen employed in the fishery, which has had an average landed value of $2.6 million. Inshore effort again accounts for about two-thirds of this value. There are five major processors employing about 650 people, in addition to a number of smaller processors. The Trinity Bay fishery is approximately 7% of the total 1972 provincial fishery.

(c) **Conception Bay** (Area E). Conception Bay has a fishery with an average landed value of $1.7 million, primarily composed of an inshore effort. This comprises roughly 4.5% of the total 1972 provincial fishery. In 1971 there were 1220 fishermen. In addition to a dozen small processors, there are three major processors that employ approximately 500 people.

5.2 AQUATIC BIRDS

The documentation on aquatic bird populations that may be affected by a major oil spill is based upon existing information from the Canadian Wildlife Service (Carreiro, personal communication, 1974). Information can also be found in the "Atlas of eastern Canadian seabirds", by Brown *et al* (1975). The areas studied were determined in concert with the development of slick drift roses (see section 6.5), wherein a methodology was developed to calculate the area of open water and the extent of shoreline contaminated by a major spill at each of the port sites under consideration. Detailed charts of aquatic birds populations affected by a spill are not provided here, in view of their size and degree of detail. However, a written summary description is provided below. Additionally, since examination of the impact upon aquatic birds must extend beyond local areas to include offshore areas in the approaches to a port, a series of seasonal charts is presented here to illustrate general seasonal distributions in offshore areas of potential impact (see Figures 5.1 to 5.4).

5.2.1 Nova Scotia Atlantic Coast, Strait of Canso

Approaches to this port are close to Sable Island and the south shore of Nova Scotia. An oil spill in this area would affect mainly birds of the open sea and birds associated with the coastal zone of Sable Island. Brown *et al* (1973) reported an estimated minimum mortality of 4,800 birds caused by the "Arrow" spill of 1970, of which 2,800 were murres. The other species which died in large numbers were Dovekies and Fulmars.

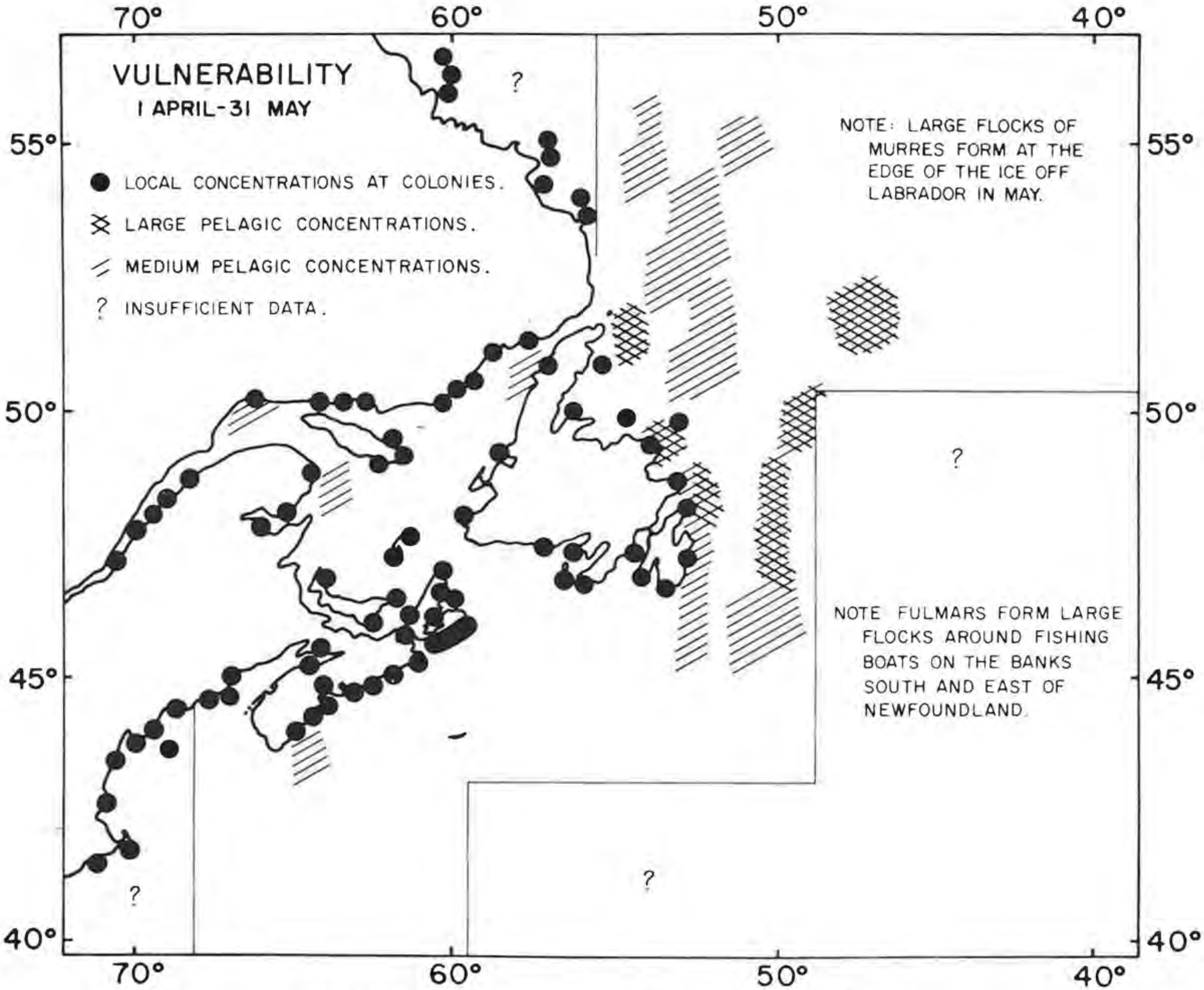

Figure 5.1 Seabird Vulnerability to Oil Spills – April 1 to May 31
(Brown *et al.*, 1975)

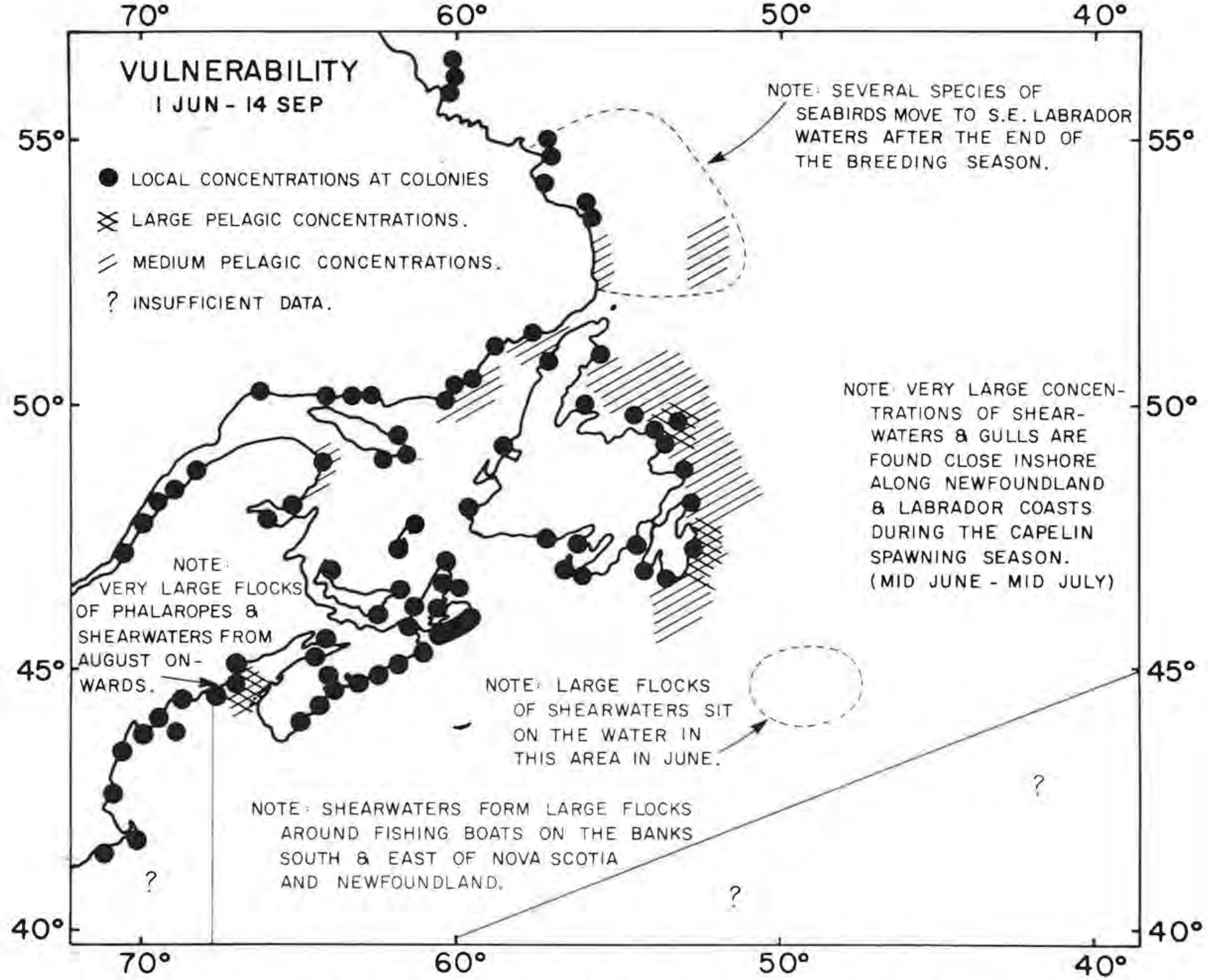

Figure 5.2 Seabird Vulnerability to Oil Spills – June 1 to Sept. 14
(Brown *et al.*, 1975)

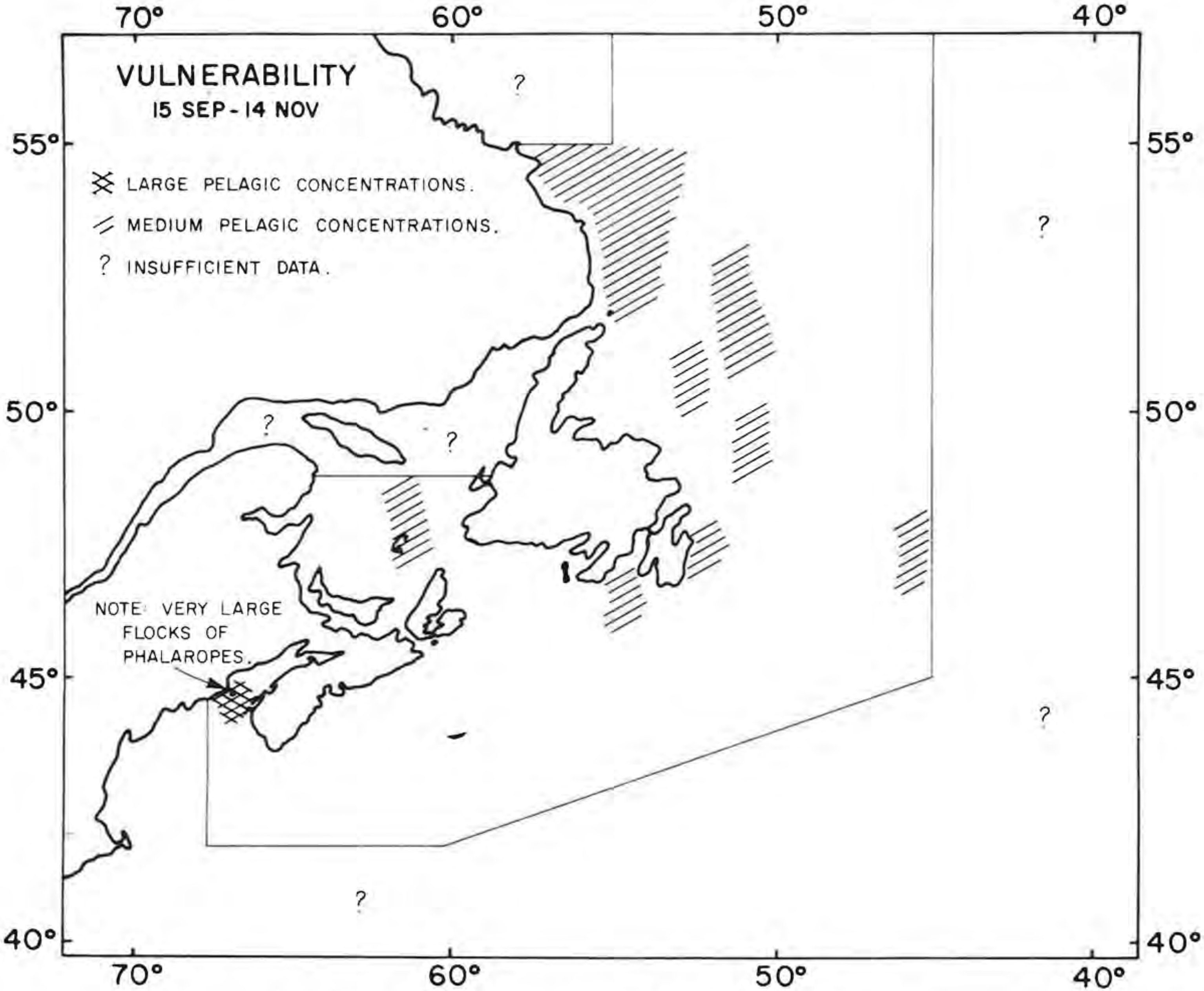

Figure 5.3 Seabird Vulnerability to Oil Spills – Sept. 15 to Nov. 14
(Brown *et al.*, 1975)

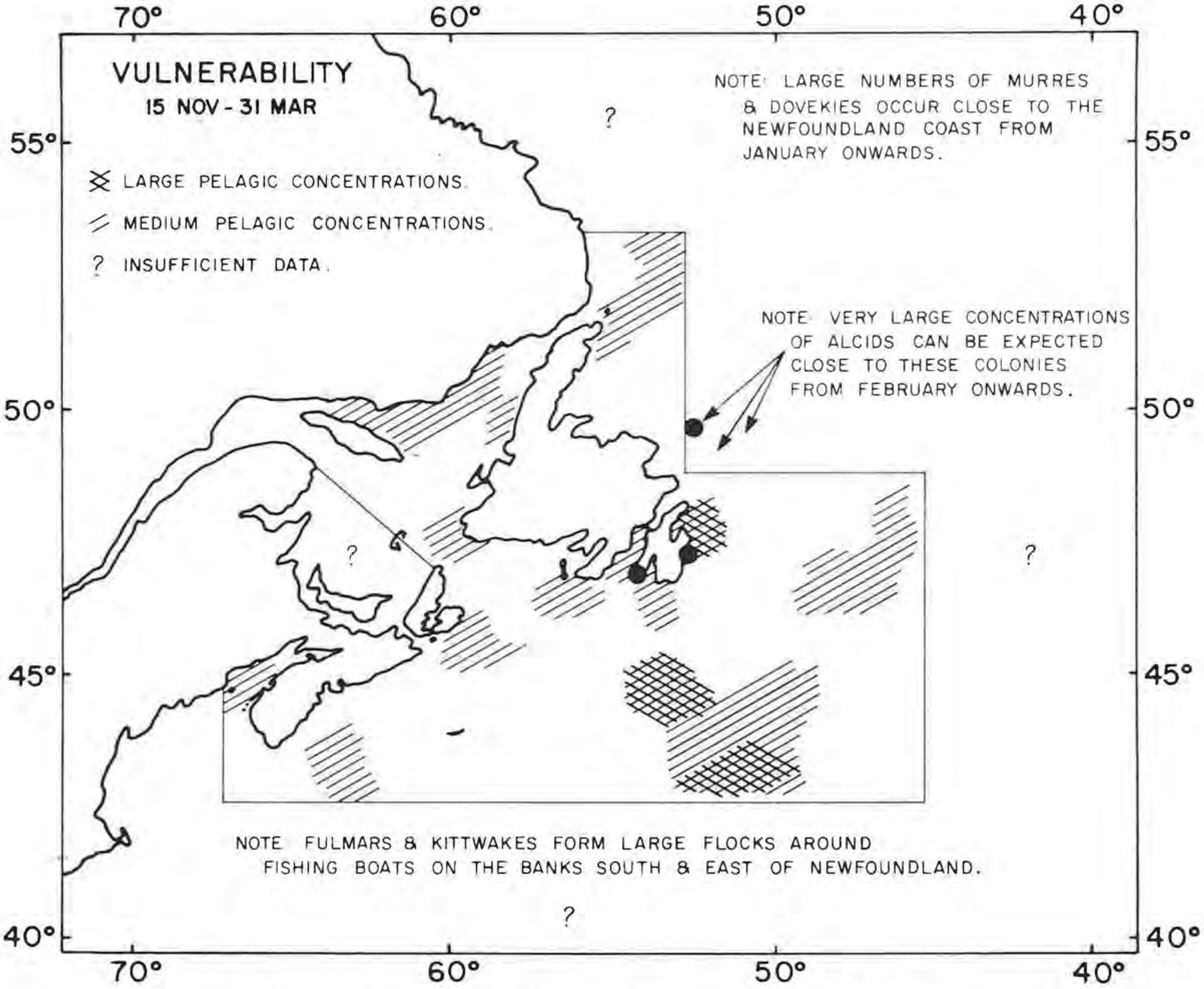

Figure 5.4 Seabird Vulnerability to Oil Spills – Nov. 15 to March 31
(Brown *et al.*, 1975)

5.2.2 Bay of Fundy and Passamaquoddy Bay

In fall or spring, tens of thousands of waterfowl of the Atlantic Flyway use the coastal waters of southern Nova Scotia and southern New Brunswick extensively. In addition, there are active colonies of eiders in the Grand Manan Archipelago. There also exists numerous fowl migration habitat such as brackish marshes in southwest Nova Scotia. It is speculated that due to the high tides in the Bay of Fundy, oil will be distributed over a larger area of shoreline than in areas with lower tidal ranges.

5.2.3 Saint Lawrence River

Numerous small islands in the estuary of the St. Lawrence support large colonies of aquatic birds during the reproduction season, such as common eider (nearly 20,000 nests); double-crested cormorant (over 2,700 nests); great blue heron (over 350 nests); black-crowned night heron (over 450 nests); black guillemot (1,300 nests); razorbill (nearly 550 nests); herring gull (nearly 15,000 nests). (Austin Reed - Aquatic Bird Colonies in the Saint Lawrence Estuary).

The mouth of the St. Lawrence River has mud flats on both shores which are used by migrating waterfowl both spring and fall. An oil spill in those seasons would not only harm the thousands of birds present there, but would also seriously damage migration habitat. Clean-up of these mud flats and their aquatic vegetation would be very difficult and likely result in additional damage to the habitat.

The National Wildlife Area at Cap Tourmente, 32 miles east of Quebec City (North Shore), contains unique migration habitat for Greater Snow Geese. In April and May, and again in September until freeze-up, over 100,000 geese, most of the world's population, stop on the mud flats of the St. Lawrence River to rest and feed.

A large oil spill in the approaches to the estuary would also seriously affect seabirds of the Gulf of St. Lawrence; in spring or fall, thousands of waterfowl of the Atlantic Flyway migrate through the coastal waters of Northumberland Strait, the Iles de la Madeleine and the northern coast of New Brunswick. Also, the presence of oil near Bonaventure Island and Perce Rock would cause heavy mortality to the breeding colonies of gannets (over 17,000 pairs); common murres (17,000 pairs); Kittiwakes (nearly 15,000 pairs); double-crested cormorants (341 pairs); razorbill (over 550 pairs).

5.2.4 Saint Lawrence Estuary and Gulf North Shore

The approaches to these harbours would be the same as for St. Lawrence River ports. Along the North Shore there are a number of migratory bird sanctuaries; one is situated in the Bay of Seven Islands on Carrousel Island. It provides breeding habitat for double-crested cormorants, common eiders, herring gulls, kittiwakes and black guillemots.

Another wildfowl area, the Watshishu Sanctuary, made up of a large number of islands with a total area of 45.0 square miles, is located east of Baie Johan Beetz. Gulls, common eiders, common and Arctic Terns and double-crested cormorants breed there. Other seabird sanctuaries stretch along the North Shore from Baie Johan Beetz eastward to the Strait of Belle Isle. These tiny islands are breeding habitat for a large variety of seabirds such as cormorants, eiders, terns, murres, quillemots, and puffins. Also, migratory waterfowl use the coastal zone during the migration periods.

5.2.5 Western Newfoundland and Eastern St. Lawrence Gulf North Shore North Shore

The approaches to these areas lead through the Gulf of St. Lawrence, and thus the remarks for that area apply. Bay of Islands has breeding colonies of greater cormorants, black guillemots, kittiwakes and common terns. Breeding colonies exist at Bonne Bay but these are not well documented. The mouth of the Natashquan River provides habitat to double crested cormorants, common eiders, common and Arctic terns, razorbilled awks, black guillemots, puffins and redthroated loons.

5.2.6 Magdalen Shallows

The Magdalen Islands with their shallow lagoons are excellent migration habitat for migratory birds but the data base on this area is very inadequate.

5.2.7 Newfoundland South Coast Fortune Bay, Placentia Bay

Brown et al (1970) reported an estimated minimum mortality of 6,000 birds was caused by oil slicks which occurred in the vicinity of Burin; the main species involved were eiders and murres. In late February and March, other populations of murres tend to be concentrated in dense flocks on the water close to their colonies at Cape St. Mary's (Tuck, 1961). These reports demonstrate that large numbers of seabirds frequent this area, and, due to their dense concentrations, are very vulnerable to oiling. However, much more needs to be known of the life habits of birds of the sea, (Nettleship, 1973).

5.2.8 Newfoundland East Coast, Trinity Bay, Conception Bay and Bonavista Bay

Trinity Bay has an amazing diversity of species such as Leach's Petrels, gannets, kittiwakes, murres and common terns. An outstanding seabird colony is Baccalieu, which harbours over 10,000 breeding pairs. Conception Bay has large colonies of Kittiwakes. Bonavista Bay is one of the largest known seabird colonies on the East Coast. Colonies at Cape Freels and Funk Island harbour up to one million breeding pairs. Funk Island provides breeding habitat for more than 80% of all common murres in eastern North America. Other important species are: gannets, kittiwakes, razorbills, puffins and Leach's Petrel. The importance of Bonavista Bay for seabirds cannot be over-emphasized.

5.3 SHORELAND RECREATION CAPABILITY

The following has been summarized from Pierce and Montpetit (1975).

Past experience has demonstrated that oil spills and subsequent cleanup operations can result in extensive contamination or damage to shoreland. Past experience has demonstrated that oil spills and subsequent cleanup operations can result in extensive contamination or damage to shorelands. Ideally an analysis should include such factors as:

- the physical features and characteristics of shorelands which affect the degree of contamination;
- the effects of beach cleaning methods;
- the socio-economic importance, regionally and locally, of shorelands;
- the market values of shorelands and associated properties and developments.

Unfortunately, existing information is inadequate to make useful assessments of these factors.

From a practical viewpoint, it was decided to restrict the shoreland aspects of this study to an examination of the capability of the shoreland to support recreation.
The Canada Land Inventory maps for "Land Capability For Recreation", (Department of Regional Economic Expansion, 1970), which are compiled by the Lands Directorate of Environment Canada, were used. These maps classify land in seven classes, according to their capability for recreation. Additionally, subclasses are used to classify the kind of recreation for which the land is suited.

A methodology for assessing the impact of a spill upon shoreland recreation capability is presented in Section 6.2.3. The area of shoreland contaminated by the spill is first determined from the slick drift roses developed in Section 6.2.4. A rating system is then applied which is based upon the amount of contaminated shoreland in the various classes and subclasses.

Chapter 6

RATING SYSTEM

6.0 INTRODUCTION

In the development of the rating system, an attempt has been made to assess, firstly, the likelihood of oil spills taking place, and secondly, the "value" or significance of the renewable resources put at risk by the spill, including the cost of cleanup. Thus, the ENVIRONMENTAL RISK INDEX is the product of two sub-indices, namely, the NAVIGATIONAL RISK INDEX and the ENVIRONMENTAL VULNERABILITY INDEX.

Wherever possible, numerical parameters have been used to compare the various sites; for example, the depth of channel, number of days of fog or ice per year, the value of fisheries landings, etc. But in other cases subjective assessments have been made as, for example, for the adequacy of anchorage areas, ease of spill containment, the significance of bird or wildlife colonies for which numerical data are not readily available or where the known physiological effects of oil on individual organisms cannot readily be extrapolated to give the impact on entire communities.

The value of this type of approach lies in the fact that each site is treated on its own merits and the ratings can be modified as new parameters are considered. The same criteria are applied to all potential sites. The working group rejected, quite early, the concept of a purely comparative, or ranking-indexing approach, since that would not have facilitated the objective assessment of additional port sites.

6.1 NAVIGATIONAL RISK INDEX

6.1.1 Calculation of Index

The Federal responsibility for navigation lies with the Department of Transport. However, expertise also exists within Environment Canada, pertaining to physical environmental factors which have obvious but not necessarily quantifiable affects upon navigational safety. These relate to physical oceanography, ice studies, meteorology, hydrography, tides, currents and so on. In the absence of published information relating to the probability of polluting incidents by oil tankers in Canadian coastal waterways, the working group exploited data sources within Environment Canada to develop a preliminary NAVIGATIONAL RISK INDEX. This assessment was necessary in order that a relative probability or frequency of environmental damage could be estimated.

Currents, visibility, ice, tides, waves and winds are physical factors which can hinder navigation. The rating here provides a measure of the relative degree of hindrance present by these physical elements. Each of these elements can be measured quantitatively, and in many cases, long historical and statistical records are available. The rating of the physical factors is similar to the approach taken in Bradford (1972) but utilizing more up-to-date statistical analyses (Bradford, 1974, and Phillips, 1975, personal communication). Each of the elements has been rated initially from 0 to 5 in order of increasing relative severity, in the following manner:

(a) **Current Speeds** (in approaches).

Speed	**Rating**
Less than 1 knot	0
1.0 – 1.9 knots	1
2.0 – 2.9 knots	2
3.0 – 3.9 knots	3
4.0 – 4.9 knots	4
Over 4.9 knots	5

(b) **Restricted Visibility.** Based upon both frequency and duration.

(i) **Frequency** - percentage of hourly readings when the visibility is reported to be equal to or less than 2 statute miles.

Percentage Frequency	**Rating**
Less than 9 percent	0
9–11 percent	1
12–14 percent	2
15–17 percent	3
18–20 percent	4
Over 20 percent	5

(ii) **Duration.** Maximum duration (in hours) of visibility less than 5/8 statute miles, for continuous hourly observations allowing for one hour dropout.

Duration	**Rating**
Less than 41 hours	0
41–60 hours	1
61–80 hours	2
81–100 hours	3
101–120 hours	4
Over 120 hours	5

(c) **Ice.** The ice rating is based upon the number of years out of 10 that ice hindered navigation and on the combined average number of weeks per year of plentiful ice cover (4-6 tenths) and congested ice cover (8 tenths) in the immediate vicinity.

Number of Years Navigation Hindered	**Rating**
0 years	0
1 – 2 years	1
3 – 4 years	2
5 – 6 years	3
7 – 8 years	4
9 – 10 years	5

Number of weeks congested and plentiful ice	Rating
Over 12	5
10–12 weeks	4
8–9 weeks	3
6–7 weeks	2
4–5 weeks	1
Less than 4 weeks	0

(d) **Tidal Range**. (for large tides).

Range	Rating
0 – 4 feet	0
5 – 8 feet	1
9 – 12 feet	2
13 – 16 feet	3
17 – 20 feet	4
Over 20 feet	5

(e) **Waves**. Percentage frequency of significant waves greater than 6 feet in height.

Percentage Frequency	Rating
0 – 5 percent	0
6 – 10 percent	1
11 – 15 percent	2
16 – 20 percent	3
21 – 25 percent	4
Over 25 percent	5

(f) **Wind Speed.** This rating is based upon an average of the percentage frequency of occurrence of wind speeds equal to or above 25 m.p.h., and on the maximum duration (hours) of wind speed greater than 40 m.p.h.

Percentage Frequency	Rating
Less than 5 percent	0
5–8 percent	1
9–12 percent	2
13–16 percent	3
17–20 percent	4
Over 20 percent	5

Duration (Hours)	Rating
Less than 8 hours	0
8–15 hours	1
16–23 hours	2
24–31 hours	3
32–39 hours	4
Over 39 hours	5

(g) **Freezing Precipitation.** Percentage frequency of occurrence of freezing precipitation (percentage of hourly readings reporting freezing precipitation).

Percentage Frequency	Rating
Less than .50 percent	0
.50 – .99 percent	1
1.00 – 1.49 percent	2
1.50 – 1.99 percent	3
2.00 – 2.49 percent	4
Over 2.50 percent	5

(h) **Icing.** Percentage frequency of occurrence of wind speed equal or above 32 m.p.h. and dry bulb temperature between 0 and 25° F. (percentage of hourly readings reporting this condition).

Percentage Frequency	Rating
Less than 1 percent	0
1 – 2 percent	1
3 – 4 percent	2
5 – 6 percent	3
7 – 8 percent	4
Over 8 percent	5

In addition to the above physical elements, the safety of navigation can also be affected by a number of other nautical factors, which are less quantitative in nature and require for their rating a more subjective approach based upon an appreciation of navigational requirements. These include:

(i) **Approaches** - This means the navigable waters connecting the port area to the open sea. The ease of accessibility is rated according to the length of channel, channel width, configuration of the channel, and the depth of water.

(j) **Anchorages and Turning Basins** - Is there a good, sheltered anchorage area for VLCC's within a reasonable distance of the port area? Is there an area for a turning basin for VLCC's adjacent to the possible terminal sites in the port area?

(k) **Shipping density** - This includes the complexity and density of existing and projected traffic patterns, including ferry traffic and pleasure craft, in the approaches and the port area. The fishing vessel activity in the approaches has also been considered.

(l) **Aids to Navigation** - The existing aids to navigation, including radio aids, have been considered. The use of radar in fixing a ship's position in the approaches and the port area is another factor. Are there sufficient radar conspicuous marks or objects for good radar fixing? Is there a need for additional aids for the navigation of VLCC's?

(m) **Charts** - The availability of adequate and accurate navigation charts and publications covering the port area and its approaches has been considered.

The study of these factors was conducted by the Canadian Hydrographic Service (1973).

In arriving at a NAVIGATIONAL RISK INDEX, each of the 22 port sites was rated as outlined above, initially in the range 0-5. However, it is clear that different factors may have different effects upon navigational risk. It is extremely difficult to determine accurately the relative importance of these factors and thus any weighting process is subjective. A number of different weightings were experimented with and yet no major differences were found over a range of different weightings which were judged to be reasonable.

The rating of the factors affecting navigational risk is shown in Table 6.1, for a specific weighting scheme. It will serve as the basis for later calculations. The total ratings were then arbitrarily divided by the lowest rating (21 for St. Margaret's Bay) to arrive conveniently at a set of small numbers for the Navigational Risk Index. These results are displayed in Table 6.2 in descending order, that is, lower values of the index indicate lower navigational risk.

Table 6.1

Rating of Navigational Risk Factors

FACTORS / **Port Sites**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**Total**
Maximum Points	10	10	15	15	1	1	8	15	15	10	100
Relative Weighting	2	2	3	3	.2	.2	1.6	3	3	2	
Baie Comeau	2	0	2	9	-	-	1	3	6	2	25
Bay of Islands	4	4	0	9	-	-	1	3	6	4	31
Bonavista Bay	2	10	8	6	1	1	5	3	3	8	47
Bonne Bay	4	4	2	9	-	1	4	6	3	6	39
Conception Bay	2	8	14	9	1	-	5	3	3	6	51
Head Harbour Passage	10	0	8	0	-	-	2	15	6	9	50
Fortune Bay	2	6	15	0	-	1	6	9	3	6	48
Grande Ile	4	0	5	12	-	-	0	12	12	4	49
Halifax	2	2	5	0	-	-	2	9	9	0	29
Baie Johan Beetz	2	2	5	9	-	-	2	6	3	6	35
Ile Verte	10	2	5	12	-	-	0	12	12	4	57
Magdalen Islands	4	6	3	12	-	1	8	6	3	4	47
Natashquan	2	2	5	9	-	-	2	6	3	6	35
Placentia Bay	4	6	12	3	-	1	5	6	3	2	42
Chandler	2	0	2	12	-	1	1	6	6	4	34
Quebec City	8	0	2	9	1	-	1	15	15	2	53
Saint John	4	0	8	0	-	-	2	3	6	2	25
St. Margaret's Bay	2	2	5	0	-	-	2	3	3	4	21
Sept Iles	2	0	3	9	-	-	2	6	9	2	33
Souris	2	2	2	15	1	-	2	3	3	4	34
Strait of Canso	2	2	6	3	-	-	2	6	6	0	27
Trinity Bay	2	8	8	6	-	1	5	3	3	8	44
									Average		**43.5**

FACTORS

- A = Tides and Currents
- B = Waves
- C = Visibility
- D = Sea Ice
- E = Freezing Precipitation
- F = Icing
- G = High Winds
- H = Approaches
- I = Shipping Density
- J = Aids to Navigation

6.1.2 Discussion of Navigational Risk Index

Table 6.2, shows that some of the St. Lawrence River Sites rate very poorly (high navigational risk) as does Head Harbour Passage. This is also true to a lesser extent for the East Coast of Newfoundland. On the other hand, there appear to be a number of good navigational alternatives along the Nova Scotian coast, at Saint John, and along the Gulf of St. Lawrence North Shore.

Table 6.2

Ranking of Navigational Risk Index

	Rating	Index
Ile Verte	57	2.71
Quebec City	53	2.52
Conception Bay	51	2.43
Head Harbour Passage	50	2.38
Grande Ile	49	2.33
Fortune Bay	48	2.29
Bonavista Bay	47	2.24
Magdalen Islands	47	2.24
Trinity Bay	44	2.09
Placentia Bay	42	2.00
Bonne Bay	39	1.86
Baie Johan Beetz	35	1.67
Natashquan	35	1.67
Chandler	34	1.62
Souris	34	1.62
Sept Iles	33	1.57
Bay of Islands	31	1.48
Halifax	29	1.38
Strait of Canso	27	1.29
Baie Comeau	25	1.19
Saint John	25	1.19
St. Margaret's Bay	21	1.00
	Average	**2.07**

It is cautioned that this is not a permanent rating. While natural characteristics such as fog, waves, currents and so on are not easily altered, the navigational risk can be reduced by such actions as the production of up-to-date nautical charts, the installation of modern aids to navigation, and real-time oceanic and meteorological monitoring systems, the dredging of channels, and the marking of shoals. However, the analysis of the probability of a major spill does not take into account the human error factor.

It is further cautioned that the NAVIGATIONAL RISK INDEX only applies to VLCC's in general. The Ministry of Transport, in its "Recommended Standards for the Prevention of Marine Pollution at Marine Terminals", for example, defined "Very Large Oil (Crude) Carrier" to mean a tanker of 80,000 tons or more. Nevertheless, the limiting depth is a risk factor in relation to the draft of VLCC's and may also be a design factor or limitation. Thus, as an aid to the planning of marine terminal, the limiting depth in the approaches to the study sites and within several miles of the shore are presented in Table 6.3. Most of the port areas have a limiting depth of greater than 120 feet, except for Quebec City (41 feet), Halifax (50 feet), Head Harbour Passage (81 feet), Grande Ile (84 feet) and Strait of Canso (90 feet). The minimum underkeel allowance should be at least 15% of the maximum draft.

Table 6.3

Limiting Depths

Port Area	Limiting Depth (See Note)
Baie Comeau	120+
Bay of Islands	120+
Bonavista Bay	120+
Bonne Bay	120+
Conception Bay	120+
Head Harbour Passage	81
Fortune Bay	120+
Grande Ile	84
Ile Ste. Genevieve	120+
Ile Verte	120+
La Poile Bay	120+
Lorneville	120+
Magdalen Is.	90
Natashquan	120+
Placentia Bay	120+
Pte au Macquereau	120+
Quebec City	41
St. Georges Bay	120+
Sept Iles	120+
Souris	120+
Strait of Canso	90
Trinity Bay	120+

Note: The limiting depths are depths in feet below chart datum available within 2 nautical miles of the shore in the various port areas, and in the approaches thereto.

6.2 ENVIRONMENTAL VULNERABILITY INDEX

An **ENVIRONMENTAL VULNERABILITY INDEX** has been designed to take into account four components, namely:

- fisheries
- aquatic birds
- shoreland recreation potential, and
- oil spill cleanup costs.

6.2.1 Fisheries

A fisheries environmental vulnerability index as it relates to fisheries and fisheries-related industries has been derived (Power *et al.*, 1974). No separate or discrete assessments have been made regarding plankton, benthos or marine mammals. These factors are assumed to be reflected to a large degree by the value of the fisheries from the area. Areas of high fishery productivity are assumed to have high planktonic or benthic productivity and no separate assessment was made in this preliminary study.

The values of individual fisheries, capital investment in fish plants or gear or numbers of plant workers are not readily available. Therefore the index is based on published total landed values of fisheries in their principal groupings and total numbers of fishermen. The index can be calculated for any port or district outside the list initially considered. This has the advantage that new criteria may be considered and points added by experts from other disciplines to obtain an overall port rating. For example, additional points could be added for plants dependent on salt water for processing fish caught elsewhere, as well as locally.

The rating of the impact of a spill upon fisheries has been considered on two scales. The first is the area of immediate impact, which includes the coastline within a 20-30 mile radius of the port, near which the oil spill is assumed to have taken place. Thumbnail sketches have already been provided in Section 4.1. Fisheries landings have been considered for the appropriate fisheries statistical district boundaries. Additionally, it is recognized that published fish landings for a given district may include fish caught in more distant waters. However, it is felt that more accurate figures would require much more data gathering but would not make significant changes to the final ratings.

The fisheries rating system assigns points as follows:

(a) one point for each 100 active fishermen (full or part time),

(b) one point for each $200,000 of groundfish landings,

(c) three points for each $200,000 of pelagic and estuarial or molluscs and crustacean landings, and

(d) five points for each $200,000 of seaweed landings.

This system gives a higher rating to vulnerable species (e.g., clams), and those species traditionally fished by vulnerable gear, such as fixed gear (fish traps, etc.), surface gear (seines, etc.), or gear which must be set in specific locations (e.g., lobster traps), and the highest rating to seaweeds which are considered to be the most vulnerable.

For the area of immediate impact, all of the local resources are assumed to be put at risk. The point rating for each port is shown in Table 6.4. In the case of the Bay of Fundy sites, the fisheries landings in Washington County, Maine and in the state of Maine are also taken into account. The reasons are (1) the western shore of Passamaquoddy Bay is in fact part of the coast of Maine and (2) the surface circulation in the Bay of Fundy is continuous with that along the Maine coast (predominantly southwestward).

In addition to the local impact, it is assumed that a major oil spill at a port site will have some affect upon the resources of the major areas, outside the immediate area of impact, e.g. the effect of a spill at Ile Verte upon Gulf of St. Lawrence resources, or of a spill at Saint John upon the remainder of the resources of the Bay of Fundy and parts of the Gulf of Maine. Up to a maximum of 10% has been allocated as a dispersion factor to reflect these additional impacts. The dispersion factors have been derived subjectively taking into account such conditions as currents, ice, winds and the coastline configuration, all of which bear upon the dispersion of spilled oil. The dispersion factor was then added to the local impact rating to form the Fisheries Environmental Vulnerability Index (Table 6.4). The high ratings indicate areas where there are large or sensitive (to oil) fisheries, while low ratings indicate areas where fisheries impact may be of minor concern (also Table 6.5).

Table 6.4

Fisheries Vulnerability Index

FACTORS / AREA	A	B	C	D	E	F	G	J	K
Canso	8	13	10	7	-	38	4%	17	55
Halifax	11	12	9	7	-	39	3%	13	52
St. Margaret's Bay	18	26	34	103	-	181	3%	9	190
TOTAL OUTER N.S.	76	92	60	234	12	474			
Saint John	2	-	2	3	-	7	8%	62	69
Passamaquoddy Bay	30	3	40	88	-	161	5%	31	192
BAY OF FUNDY/GULF OF MAINE	137	36	90	513	9	785			
Grande Ile (Dist. 3)	<1	-	2	- -	-	2+	9%RG	50	52
Ile Verte	<1	-	1	- -	-	1+	9%RG	50	51
Sept Iles	<1	-	<1	- -	-	1+	4%RG	22	23
Natashquan and									24
Baie Johan Beetz	<1	-	<1	1	-	2	4%RG	22	24
RIVER ST. LAWRENCE TOTAL	19	10	15	5	-	49			
Chandler	9	7	1	5	-	22	8%G	39	61
Souris	11	4	3	49	7	74	7%G	30	104
Magdalen Islands	12	6	6	30	-	54	6%R	27	81
SOUTH GULF OF ST. LAWRENCE	117	33	68	255	34	507			
Bay of Islands	6	<1	3	8	-	17+	4.5%	2	19+
Bonne Bay	6	<1	<1	6	-	12+	5%	3	15+
NEWFOUNDLAND WEST COAST	28	5	8	28	-	69			
Fortune Bay	9	23	13	2	-	47	1%	1	48
Placentia Bay	14	27	2	2	-	45	1.5%	2	47
NEWFOUNDLAND SOUTH COAST	39	74	51	5	-	169			
Conception Bay	14	7	1	2	-	24	7%	9	33
Trinity Bay	11	9	2	2	-	24	6.5%	9	33
Bonavista Bay	13	6	2	3	-	24	7%	9	33
NEWFOUNDLAND EAST COAST	86	44	14	15	-	159			

NOTE: G = Gulf of St. Lawrence RG = Gulf and River of St. Lawrence

FACTORS
A = Total Fishermen
D = Molluscs and Crustaceans
G = Dispersion Weighting

FACTORS
B = Groundfish
E = Sea Weeds
J = Dispersion Factor

FACTORS
C = Pelagic & Estuarial
F = Subtotal
K = Fisheries Vulnerability Index

Table 6.5

Ranking of Fisheries Vulnerability Index

Area	Rating
Passamaquoddy	192*
St. Margaret's Bay	190
Souris	104
Magdalen Islands	81
Saint John	69*
Chandler	61
Canso	55
Halifax	52
Quebec City	52
Grande Ile	52
Ile Verte	51
Baie Comeau	51
Fortune Bay	48
Placentia Bay	47
Trinity Bay	33
Conception Bay	33
Bonavista Bay	33
Baie Johan Beetz	24
Natashquan	24
Sept Iles	23
Bay of Islands	19
Bonne Bay	15
Average	**59.5**

*These ratings take into account fisheries statistics for the State of Maine. The ratings for Passamaquoddy and Saint John based upon Canadian statistics only would be 82 and 29, respectively.

6.2.2 Aquatic Birds (Pierce and Montpetit, 1975)

Basic data were reported in Section 5.2 regarding the distribution of aquatic birds within the impact areas delineated by the seven-day spill roses (see Section 6.2.4) for each of the port sites under consideration. A numerical rating is provided in Table 6.6, based upon an initial maximum rating of 100.

Table 6.6

Aquatic Birds Vulnerability Index

Port Site	Local Rating	Rating of Approaches	Overall Rating
Quebec City	100	100	100
Ile Verte	100	100	100
Grande Ile	100	100	100
Bonavista Bay	100	90	95
Magdalen Islands	100	80	90
Passamaquoddy	80	100	90
Baie Johan Beetz	100	75	87
Saint John	50	100	75
Natashquan	65	75	70
Conception Bay	40	100	70
Trinity Bay	40	100	70
Baie Comeau	85	40	62
Sept Iles	75	40	57
Bay of Islands	90	20	55
Placentia Bay	30	60	45
Chandler	50	20	35
Fortune Bay	20	50	35
Bonne Bay	50	20	35
St. Margaret's Bay	30	15	23
Canso	10	30	20
Souris	20	10	15
Halifax	5	15	10
		Average	**60.9**

6.2.3 Shoreland Recreation Capability (Carriero, 1975)

A susceptibility index was developed, based upon Canada Land Inventory maps for outdoor recreation capability. The classes and subclasses of recreation capability employed in this study are provided below:

Class	Capability
1	very high
2	high
3	moderately high
4	moderate
5	moderately low
6	low
7	very low

The following descriptive subclasses were used in the analysis, grouped according to their susceptability:

Very High

B – shoreland capable of supporting family beach activities;

E – land with vegetation possessing recreation value;

A – land providing access to water affording opportunity for angling or viewing fish;

W – land affording opportunity for viewing wetland wildlife;

J – area offering particular opportunities for gathering and collecting items of popular interest. (usually clam digging or fossils in the areas covered in this study).

High

Y – shoreland providing access to water suitable for popular forms of family boating (i.e. water-skiing);

D – shoreland with deeper inshore water suitable for swimming, boat mooring or launching;

C – land fronting on and providing direct access to waterways with significant capability for canoe tripping.

Moderately High

N – land suited to family or other recreation lodging use;

K – land suited to organized camping;

Z – areas exhibiting major, permanent, non-urban, man-made structures of recreation interest;

P – areas exhibiting cultural landscape patterns of agricultural, industrial or social interest.

Moderate

R – interesting rock formations;

U – shoreland fronting water accommodating yachting or deep water boat tripping.

Moderately Low

V – a vantage point or area which offers a superior view relative to the class of unit(s) which contains it, or a corridor or other area which provides frequent viewing opportunities;

L – interesting landform features other than rock formations;

Q – areas exhibiting variety in topography or land or water relationships, which enhances opportunities for general outdoor recreation such as hiking and nature study or for aesthetic appreciation of the area;

H – historic or pre-historic site.

The relative vulnerability of the shoreland unit's recreation capability was rated according to the following scheme:

STEP 1.

Class Rating	**"T"**
Class 1	100
Class 2	85
Class 3	70
Class 4	55
Class 5	40
Class 6	25

STEP 2. Because different types of shoreland have different vulnerabilities, the T value is modified according to the following table:

Subclass	**Rating**
if B, E, A, or W	rating is T
if Y, J, D, or C	rating is T minus 5
if N, K, P, or Z	rating is T minus 10
if R or W	rating is T minus 15
if V, L, Q, or H	rating is T minus 20

In the application of this procedure, the amount of shoreline contaminated is first determined from the slick drift roses. The final rating is then based upon the above rating scheme weighted according to the amount of contaminated shoreline in the various classes and subclasses. The results for the ratings is provided in Table 6.7. It is noted that the Canada Land Inventory maps do not extend to the north shore of the Gulf of St. Lawrence, and the ratings for Sept Iles, Baie Johann Beetz and Natashquan were based on supplementary information (Pierce, personal communication, 1976).

Table 6.7

Shoreland Recreation Capability Index

Port Site	Rating
Souris	76
Magdalen Islands	59
Bonne Bay	48
Bay of Islands	48
Baie Comeau	45
Sept Iles	45
Chandler	45
Baie Johan Beetz	45
Canso	40
Ile Verte	40
Quebec City	38
St. Margaret's Bay	35
Conception Bay	34
Halifax	31
Bonavista Bay	31
Placentia Bay	30
Fortune Bay	29
Saint John	29
Passamaquoddy	27
Grande Ile	27
Natashquan	18
Trinity Bay	12
Average	**37.8**

6.2.4 Oil Spill Cleanup

A method was devised (Pratt, 1975 and Bien, 1975) for the development of an oil spill cleanup index, based on a 1974 Environmental Emergency Branch (DOE) Study on the Feasibility of Oil Spill Cleanup. This method involves several steps: the estimation of the areal extent of the spill, the determination of the amount of contaminated shoreline, an estimate of the cost of offshore and shoreline cleanup, and finally, the calculation of an index based upon cost of cleanup, effectiveness and environmental sensitivity.

(a) Computation of Oil Spill Roses

For each port, slick drift roses were calculated for a 25,000 ton oil spill over a 24-hour period. Initially, the slick is assumed to spread under surface tension viscous forces according to

$$A = 2.5 \times 10^{-5} V^{.667} t^{.5}$$

where A is the area in square nautical miles, V is the volume in gallons and t is the time in hours after the initial spill. Additionally, the slick is subjected to the physical environmental conditions particular to the given port, including tides, currents and extreme wind speeds and persistence. To allow a realistic time interval to implement containment and cleanup operations, the slick was assumed to spread for seven days. The effective area of the slick drift rose after seven days is 2.65 (square root of 7) greater than the 24-hour rose. For each port site, roses were constructed for each ice-free month and the worst case chosen. The degree of contamination was then determined by superimposing the slick drift rose onto the appropriate hydrographic charts and the amount of contaminated shoreline measured according to a classification of sand, shingle or cliff type. Details of the slick drift roses for each of the 22 port sites considered can be found in Pratt, 1975 and Bien, 1975.

(b) Oil Spill Cleanup Index

A cleanup index was designed where the first consideration was the cost of cleanup. Secondly, this cost is then modified by an index which gives a measure of the effectiveness with which cleanup can be conducted at the specific locality of the spill. Thirdly, a sensitivity factor was applied, which reflects the required thoroughness of cleanup to meet social and ecological demands.

The cost of cleanup is the sum total of the shoreline cleanup costs and the offshore cleanup costs. The offshore costs (adapted from Little, 1969) include:

- cost of materials to clean up spill,
- cost of transporting equipment and materials to and from the spill site,
- cost of disposing of spill materials,
- cost of renting and operating offshore vessels for cleanup,
- cost of labour for cleanup.

The cost of shoreline cleanup was estimated as follows:

– sand beach	$2.17 per lineal foot,
– cobble or shingle	$3.73 per lineal foot,
– cliff	$5.08 per lineal foot.

An effectiveness index was arrived at by a panel of experts, with each member individually rating six factors followed by consensus rating. The factors included:

- rough weather
- currents
- shoreline
- ice conditions
- visibility
- logistics and availability.

It is cautioned the effectiveness has been defined in such a way that the larger the index, the greater the effectiveness of cleanup.

Sensitivity was established on the basis of a partially subjective assessment of such factors as public recreation, ecological resources, population density, existence of marinas, and the quality and quantity of recreational areas. The sensitivity factor ranges from 1 to 2, with a higher value indicating a greater need to cleanup thoroughly. This factor is multiplied against the cleanup cost since this cost is only an estimated general cost.

An oil spill cleanup index is thus developed based upon the product of the cost of cleanup multiplied by sensitivity and divided by effectiveness. The computation of this index is given in Table 6.8, ranked in the order of highest value (least receptive to cleanup or greatest cost) to lowest value of the index.

Table 6.8

Oil Spill Cleanup Index

Port Area	Seven Day Slick Drift Rose Area (square naut.miles)	Offshore Cleanup Cost ($million)	Shoreline Restoration Cost ($million)	Total Cleanup Cost ($million)	Effect-iveness Index	Sensi-tivity Index	Cleanup Index (CS/E times 1000)
Bay of Islands	245	7.31	4.82	12.13	82	1.45	215
Baie Johan Beetz	101	3.97	2.25	6.22	96	1.41	109
Conception Bay	151	5.14	3.99	9.13	92	1.05	104
Chandler	154	5.22	1.87	7.09	96	1.38	102
Souris	94	3.80	.69	4.49	80	1.79	100
Magdalen Islands	204	6.38	1.91	8.29	80	1.10	98
Bonne Bay	88	3.66	2.09	5.75	80	1.34	96
Passamaquoddy	173	5.64	1.45	7.09	98	1.29	93
Sept Iles	190	4.44	1.75	6.19	94	1.38	91
Quebec City	53	2.85	2.32	5.17	116	2.00	89
Ile Verte	176	5.73	1.19	6.92	108	1.16	75
Natashquan	66	3.16	2.25	5.41	88	1.19	73
St. Margaret's Bay	86	4.82	1.22	6.04	117	1.34	69
Fortune Bay	119	4.39	1.85	6.24	98	1.05	67
Bonavista Bay	117	4.34	.96	5.30	88	1.05	63
Placentia Bay	86	3.61	2.61	6.22	104	1.05	63
Saint John	58	2.97	1.95	4.92	109	1.37	62
Halifax	44	3.53	.91	4.44	122	1.61	59
Baie Comeau	90	4.16	.46	4.62	102	1.15	52
Grande Ile	100	3.94	1.65	5.59	112	1.04	47
Trinity Bay	73	3.32	.85	4.17	94	1.00	44
Canso	53	2.85	1.34	4.19	125	1.27	43
						Average	**80.3**

6.2.5 Environmental Vulnerability

The ENVIRONMENTAL VUNERABILITY INDEX is calculated as a weighted combination of the indices for each environmental component. The weighting process is based not upon maximum scores, but rather, upon the average ratings of the specific environmental factor over the 22 port sites considered. For a specific factor, the weighted rating for a specific port is calculated as

weighted rating = raw rating x desired average/$_{\text{raw average}}$.

For example, from Table 6.4, the average fisheries rating is 59.5, and the raw fisheries rating for Souris is 104. If the desired weighted fisheries average is 100, then the weighted fisheries rating for Souris would be

$$104 \times 100/59.5 = 174.8$$

Such a weighting process is somewhat subjective. However, over a reasonable range of weighting variations, the relative ranking of the various port sites were found to remain more or less the same. This is demonstrated in Table 6.9. Variations in rank of 3 to 4 were only found in the middle to lower ranks, but this is not significant because the actual differences in ratings are also small in this range.

Table 6.9

Environmental Vulnerability Index

Comparison of Port Rankings for Various Weighting Schemes

Weighted Average								
Fisheries Vulnerability	100	80	100	100	80	120	120	120
Aquatic Birds Vulnerability	80	80	100	80	60	100	80	100
Shoreland Recreation Capability	60	80	60	80	80	80	80	80
Oil Spill Cleanup	60	80	60	80	60	80	40	40
Port Site								
Passamaquoddy	1	1	1	1	1	1	1	1
St. Margaret's Bay	2	3	2	2	2	2	2	2
Magdalen Islands	3	2	3	3	3	3	3	3
Souris	4	4	4	4	4	4	4	4
Quebec City	5	6	5	6	6	6	5	5
Bay of Islands	6	5	7	5	5	5	8	10
Ile Verte	7	7	6	7	7	7	6	6
Baie Johan Beetz	8	8	8	8	8	8	11	9
Saint John	9	10	9	10	10	9	7	7
Grande Ile	10	12	10	11	13	11	9	8
Chandler	11	9	12	9	9	10	10	12
Conception Bay	12	11	13	12	12	12	14	14
Baie Comeau	13	14	14	13	11	13	12	11
Bonavista Bay	14	13	11	14	14	14	13	13
Sept Iles	15	15	15	15	15	15	15	15
Placentia Bay	16	17	16	17	17	16	16	16
Fortune Bay	17	18	18	18	19	18	18	18
Bonne Bay	18	16	19	16	16	17	19	20
Natashquan	19	19	17	20	20	19	20	19
Canso	20	20	21	19	18	20	17	17
Trinity Bay	21	22	20	22	22	21	22	21
Halifax	22	21	22	21	21	22	21	22

Table 6.10 presents the results from one particular weighting scheme, which will serve as a representative rating and also as a basis for further calculations and discussions. The weighted averages used were as follows:

- fisheries 100
- aquatic birds 80
- recreational capability 60
- cleanup 60

For this weighting, the individual weighted ratings for Souris would be 174.8, 19.7, 120.6 and 73.0, respectively, for a total of 388.1.

Table 6.10

Environmental Vulnerability Index

Port Site	Rating
Passamaquoddy	552*
St. Margaret's Bay	455
Magdalen Islands	419
Souris	388
Quebec City	344
Bay of Islands	337
Ile Verte	335
Baie Johan Beetz	306
Saint John	306*
Grande Ile	296
Chandler	294
Conception Bay	277
Baie Comeau	277
Bonavista Bay	276
Sept Iles	251
Placentia Bay	231
Fortune Bay	221
Bonne Bay	217
Natashquan	214
Canso	213
Trinity Bay	199
Halifax	192
Average	**300.0**

*Includes State of Maine fisheries. Based on Canadian resources only, the indices for Passamaquoddy and Saint John are 367 and 238, respectively.

6.3 ENVIRONMENTAL RISK INDEX

The ENVIRONMENTAL RISK INDEX is calculated as the product of the environmental vulnerability index and the navigational risk index. The results based upon the above (Section 6.2.5) weighted averages are presented in Table 6.11 in decreasing order, that is, the ratings with the highest values represent the port sites with greatest environmental risk.

Table 6.11

Environmental Risk Index

Port Site	Navigation Risk Index	times	Environmental Vulnerability Index	equals	Environmental Risk Index
Passamaquoddy	2.38		552		1313*
Magdalen Islands	2.24		419		940
Ile Verte	2.71		335		908
Quebec City	2.52		344		867
Grande Ile	2.33		296		689
Conception Bay	2.43		277		674
Souris	1.62		388		629
Bonavista	2.24		276		617
Baie Johan Beetz	1.67		306		510
Fortune Bay	2.29		221		507
Bay of Islands	1.48		337		498
Chandler	1.62		294		476
Placentia Bay	2.00		231		463
St. Margaret's Bay	1.00		455		455
Trinity Bay	2.09		199		415
Bonne Bay	1.86		217		404
Sept Iles	1.57		251		395
Saint John	1.19		306		363*
Natashquan	1.67		214		357
Baie Comeau	1.19		277		329
Canso	1.29		213		275
Halifax	1.38		192		265
				Average	**562**

*Includes State of Maine fisheries. The environmental risk indices with Canadian fisheries only are 873 and 284 for Passamaquoddy and Saint John, respectively.

6.4 DISCUSSION OF RESULTS

The information presented in Sections 6.1 to 6.3 above represent general assessments only. The indices are by no means comprehensive; only a limited number of potential sites have been examined and the small number of environmental factors considered is not exhaustive. Additionally, a number of assumptions and some of the numerical results are to a degree subjective. Nevertheless, the indices are more than adequate to give planners and decision makers a comparative tool for use during the preliminary stages of site selection and for rejection, as well as for identifying environmental problems to be considered later during detailed engineering and design stages.

Several points should be borne in mind in the interpretation and use of the study results, as follows:

(a) Each proposed deepwater port will have a number of expected cost and benefits, and their integrated total will form part of the basis for a decision to build or not to build. For each parameter, for example, the environmental costs, there may exist a point of non-negotiability.

Thus, there may exist sites for which the environmental risk is so great that no risk can be afforded. The discussion below will identify a **minimum** number of such sites.

(b) For those cases which are not non-negotiable, the indices will be useful only if the site selection process includes a fair consideration of the environmental alternatives. The rating system and indices developed above can be a useful tool for comparing alternatives, by providing a quantitative estimation of the environmental costs associated with each port site. From this, sites can still be assessed as acceptable, negotiable or poor alternatives.

From Table 6.10 (environmental vulnerability index), clearly unacceptable sites include Passamaquoddy, St. Margaret's Bay, Magdalen Islands and Souris, on the basis of the extremely high overall value of resources that would be put at risk. The sites of Quebec City, Bay of Islands and Ile Verte are possibly unacceptable, but any cutoff value would be extremely subjective. Nevertheless, at the very least these sites are certainly poor alternatives. An examination of Table 6.11 (environmental risk index) indicates that Passamaquoddy is again clearly unacceptable. Others that are unacceptable environmental choices include Magdalen Islands, Ile Verte and Quebec City. From this can be derived a list of sites for which the probability of an oil spill and the value of resources put at risk are both too high for any risk to be taken. These include Passamaquoddy, Magdalen Islands, Ile Verte, Quebec City, St. Margaret's Bay and Souris.

Does this mean that all the other candidate sites could be reasonable choices? Certainly not. The overall rating for a specific port may not be unacceptably high, but the port may be unacceptable because of one specific environmental factor which would exclude it from further consideration. It is thus necessary to go back to the specific indices and supporting baseline data to determine critical sites for each of fisheries, aquatic birds, shoreline recreation capability and cleanup.

An examination of the Fisheries Vulnerability Index (Table 6.5) shows two ports are clearly not acceptable. These are the Passamaquoddy region, because of the high value of fisheries both regionally and in nearby U.S. waters, and St. Margaret's Bay, which is a highly productive marine ecosystem. The sites of Souris and the Magdalen Islands have high ratings also, and are considered poor sites because of the potential impact upon the Gulf of St. Lawrence fishery. Saint John is considered negotiable because of potential ''downstream'' effects upon fisheries in the State of Maine and the Bay of Fundy.

In terms of the Aquatic Birds Vulnerability Index, (Table 6.6) sites along the St. Lawrence estuary are not acceptable, namely, Quebec City, Grande Ile and Ile Verte. A number of other sites are poor alternatives, including Bonavista Bay, Magdalen Islands, the Passamaquoddy area and Baie Johan Beetz.

From the Shoreland Recreational Capability Index, (Table 6.7) it is difficult to establish a limit of negotiability. Souris and the Magdalen Islands are at least poor and should be avoided since many alternatives exist and especially since these are also poor sites from a fisheries point of view.

From the Oil Spill Cleanup Index, one port site stands well above the others, namely Bay of Islands. The other sites seem to be spread out evenly over a broad range of values.

What can now be said of the remaining sites? Table 6.12 presents the environmental risk indices, in a different format in decreasing order vertically down the page, but with the unacceptable sites on the left and the remainder on the right. It is seen that the rating for Conception Bay is much higher than for the rest, a reflection of its medium environmental vulnerability overall coupled with a very high navigational risk. Since better alternatives exist in Newfoundland, Conception Bay is considered as a poor alternative. There remains then eleven out of the original twenty-two port sites in the negotiable range. The acceptable environmental alternatives appear to be Halifax, Canso, Baie Comeau, Saint John and Natashquan. Negotiable alternatives include Sept Iles, Bonne Bay, and Trinity Bay, Fortune Bay, Chandler and Placentia Bay could be considered negotiable.

Table 6.12

Ranking of Environmental Risk Index

Unacceptable Sites		Remaining Sites	
Passamaquoddy	1313		
Magdalen Islands	940		
Ile Verte	908		
Quebec City	867		
Grande Ile	689		
		Conception Bay	674
Souris	629		
Bonavista Bay	617		
Baie Johan Beetz	510		
		Fortune Bay	507
Bay of Islands	498		
		Chandler	476
		Placentia Bay	463
St. Margaret's Bay	455		
		Trinity Bay	415
		Bonne Bay	404
		Sept Iles	395
		Saint John	363
		Natashquan	357
		Baie Comeau	329
		Canso	275
		Halifax	265

Chapter 7

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