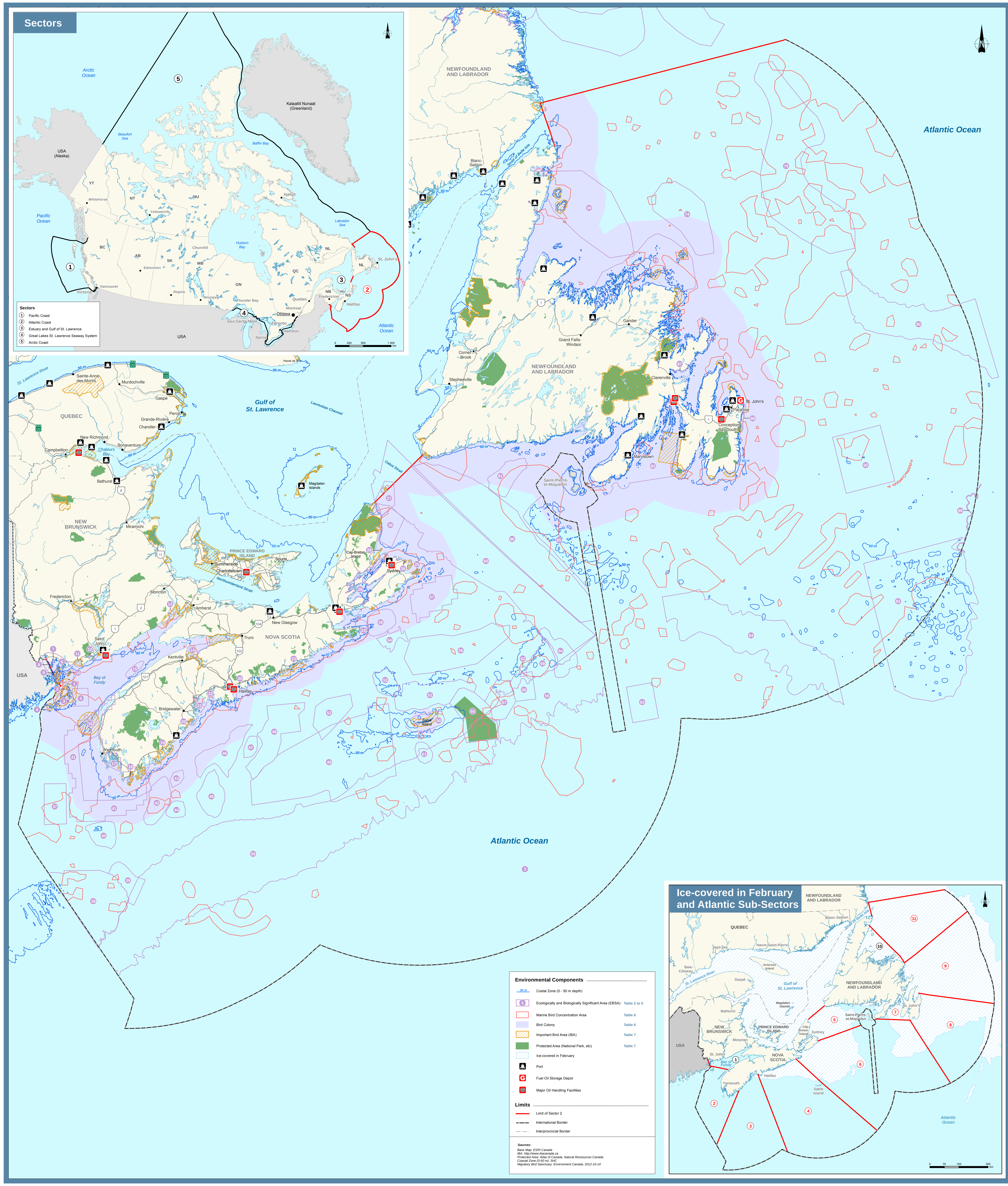


Table 1 Shoreline Types and Distribution

Shoreline Type	Length (km)	Proportion (%)
Bedrock	12,554.7	47.8
Boulder Beach	2,803.2	10.7
Man-made Solid Structure	338.7	1.3
Mixed-Sediment (Sand-Gravel) Beach	2,852.5	10.8
Mud Tidal Flat	433.8	1.6
Pebble/Cobble Beach	5,122.4	19.5
Salt Marsh	1,252.8	4.8
Sand Beach or Flat	929.3	3.5
Total Shoreline in the Pacific Sector	**26,287.3**	**100.0**

Source: Environment Canada, 2013

Table 2 Characteristics of Ecologically and Biologically Significant Areas (EBSA) in Bay of Fundy (Nova Scotia).

EBSA	Particular Characteristics
1. Long Eddy, NE Grand Manan	• Aggregation of seabirds, whales and harbour porpoise.
2. Flagg Cove, Whale Cove, Grand Manan	• Aggregation and spawning area for lobster.
3. Southwest Grand Manan	• Nesting and feeding area for eiders and other seabirds. • Significant area for seaducks, shorebirds, alcids, pelagic seabirds and phalaropes.
4. Machias Seal Island	• Important nesting area of seabirds, including Arctic tern and Atlantic puffin. • Significant area for alcids, pelagic seabirds, shorebirds, terns and waterfowl.
5. Right Whale Conservation Area	• Aggregation area for several cetacean species, including North Atlantic right whale, large pelagics (e.g. basking sharks) and seabirds.
6. Whole of Quoddy	• Feeding aggregation of marine mammals (e.g., North Atlantic right whale, harbour porpoise) in summer. • High diversity of sessile marine invertebrates. • Critical habitat for juvenile herring and red-necked phalaropes.
7 and 8. Sam Orr Pond and Tongue Shoal, Passamaquoddy Bay	• Atypically warm waters; flora and fauna are atypical to this area. • Large and diverse bird species, with a large nesting colony of great blue herons, nesting ospreys, herring gulls and common eider. • Important stopover for migratory birds. • Significant juvenile lobster population. • Large number of Anguilla rostrata. • Spawning area for many fish species, including cod.
9. Head Harbour, West Isles, Passages	• Aggregation of seabirds, invertebrates, fish, seals, porpoise and whales. • Nesting area for red-necked phalaropes, common eider, guillemots and double-crested cormorants. • Refuge for lobster, crab, juvenile fish (cod, pollock), cunner and tautog. • Haulout area for several harbour seals. • Feeding and aggregation area for harbour porpoise.
10. The Wolves	• Important wintering area for Harlequin duck and seabirds. • Spawning area for lumpfish and other finfish (e.g., herring, pollock and tautogs). • Nursery area for lobster and cod. • Aggregation of benthic species.
11. Maces Bay	• Ideal haulout area for seals. • Aggregation and nursery area for lobster and scallop. • Feeding and breeding area for sea ducks, brants, shorebirds, gulls, terns and cormorants. • Abundance of benthic invertebrates.
12. Musquash Estuary	• Presence of a salt marsh ecosystem which offer a good habitat for several species.
13. Marys Point, Chignecto Bay	• Important area for sea ducks, shorebirds and mergansers. • Spawning and nursery area for lobster. • Presence of scallop and soft-shelled clam beds.
14. Evangeline, Blomidon, Minas Basin	• Large number of migratory birds (late July). • Critical habitat as a foraging/roosting area for the world population of the Semipalmated sandpiper during its southward migration. • Aggregation of invertebrates (clams, crustaceans).
15. Modiolus reefs, Nova Scotia Shore	• Aggregation of invertebrates (clams, crustaceans).
16. Brier Island	• Feeding and wintering area for Greater and Sooty Sherwaters as well as for Wilson's Strom-Petrel. • Aggregation and feeding area of seabirds, whales (e.g., humpback, finback and minke whale, white-sided dolphin) and fishes (e.g., mackerel, squid and herring). • Spawning area for cod (January to April).

Table 3 Characteristics of Ecologically and Biologically Significant Areas (EBSA) in Atlantic Coast of Nova Scotia.

EBSA	Particular Characteristics
17. Lobster Bay	• Aggregation of lobster, multiple demersal fish species, spiny dogfish, grey seal, butterfish, Atlantic cod, skates and winter flounder. • Most productive area for lobster in the coastal zones of Nova Scotia. • Spawning area for herring. • Presence of extensive eelgrass beds and salt marshes.
18. Cape Sable Island	• Spawning and nursery area for Atlantic cod and lobster. • Nursery area for herring, alewives and sand lance. • Presence of extensive eelgrass beds and salt marshes.
19. Port Joli/Kejimkujik Seaside Adjunct	• Spawning area for herring. • Nursery area for a multitude of fish species, including herring, pollock and winter flounder. • Presence of extensive eelgrass beds and salt marshes. • Intact marine environment with several adjacent terrestrial protected areas. • Abundance of invertebrates, urchins and lobsters. • Seal haul-outs.
20. LaHave River and Islands	• Important habitat for anadromous fish: Atlantic salmon and Atlantic whitefish. • Feeding area for Bluefin tuna. • High diversity and abundance of fish species, including commercial species (e.g., lobster, scallop, snow crab). • Presence of extensive eelgrass beds and salt marshes. • Dense and diverse marine algae.
21. Mahone Bay and Islands (Wildlife Management Area)	• Spawning area for pollock and Northern shrimp. • Nursery area for juvenile pollock, sand lance and hake. • Feeding area for Bluefin tuna. • Seal aggregations around shoals. • Scattered but dense eelgrass beds and salt marshes.
22. St. Margaret's Bay	• Spawning area for Atlantic cod, mackerel, herring and yellowtail flounder. • Nursery area for pollock, silver hake and cunner. • Presence of Northern shrimp populations. • High species diversity.
23. Eastern Shore Islands (Wildlife Management Area)	• Spawning area for Atlantic cod and haddock (historic). • Nursery area for hake, herring and other species. • Aggregations of invertebrates: lobster, scallop, snow crab and rock crab. • Numerous seal haul-outs.
24. The Canso Ledges	• Historic spawning area for Atlantic cod and herring. • Abundance and diversity of marine species: overwintering mackerel, Northern shrimp, Atlantic wolffish, lobster, snow crab, winter flounder, grey and harbour seals, harbour porpoise, white-sided dolphin, Atlantic pilot whale, fin whale and minke whale. • Feeding area for marine mammals.
25. Mira Bay and Scatarie Island	• Spawning area for herring. • Lobster and scallop bottom, extensive rock crab habitat and oyster in the area. • Largest grey seal breeding colony on the Atlantic coast of Nova Scotia. • Extensive and dense eelgrass beds and salt marshes.
26. The Bird Islands	• Spawning area for Atlantic cod, capelin and herring. • Important nursery area for Atlantic cod and other demersal species. • Overwintering area for herring. • Seal haul-out area.
27. St. Paul's Island	• Significant spawning and overwintering area for Atlantic cod. • Aggregation and feeding area of cetaceans. • Aggregation of lobster, snow crab, toad crab, scallop, urchin and mackerel. • Potentially important for lifecycle stages during migrations between Atlantic Ocean and Gulf of St. Lawrence.
28. Bras d'Or Lakes	• Spawning area for cod, herring, mackerel, gaspereau, smelts, alewives and salmon. • Nursery area for four-bearded rockling, winter flounder, cod, smelt, herring, windowpane flounder and white hake. • Several rare species in Nova Scotia: oysters, windowpane flounder, Arctic remnant invertebrates and warm water invertebrates. • Distinct population of herring. • Aggregations of grey and harbour seals.
29. Port l'Hebert	• Presence of extensive eelgrass beds and salt marshes. • Potential reproduction area for lobster.
30. Cole Harbour Estuary	• Potential spawning area for Atlantic cod and Atlantic salmon. • Spawning area for herring (offshore). • Foraging area for Bluefin tuna (offshore). • Abundance of blue crabs and soft-shell clams. • Presence of extensive eelgrass beds and salt marshes.
31. Chezzetcook Inlet to Jeddore Harbour	• Spawning area for pollock, herring, witch flounder, and potentially Atlantic cod and Atlantic salmon. • Potential haddock nursery area. • Presence of extensive eelgrass beds and salt marshes. • Abundance and diversity of invertebrates.
32. Taylor Head to Sheet Harbour	• Haddock spawning in offshore area. • Potential recovery area for Atlantic salmon. • Potential haddock nursery area. • Dense and diverse marine algae.
33. St. Marys River and Watershed	• Important salmon spawning area. • Presence of extensive eelgrass beds.
34. Janvrin Islands	• Spawning area for herring.
35. Big Glace Bay	• Spawning area for Atlantic cod, herring and capelin. • Presence of extensive eelgrass beds. • Abundance and diversity of marine algae.
36. Western Sydney Bight	• Important Atlantic cod spawning area. • Spawning area for American plaice, herring and capelin. • Important nursery area for cod, snow crab, several other fishes and invertebrates. • Overwintering area for migratory populations of Atlantic cod, plaice, white hake, witch flounder, redfish and herring. • High biodiversity and highly productive area. • Important area for cetaceans.

Table 4 Characteristics of Ecologically and Biologically Significant Areas (EBSA) in Offshore of Nova Scotia.

EBSA	Particular Characteristics
37. The Rock Garden and Environs	• High concentration and diverse community of epifauna. • Unique habitat, unique bedrock outcrop, and unique and diverse benthic community (e.g., corals, anemones, benthic invertebrates). • Dense aggregations of krill.
38. Canadian Portion of Georges Bank	• Very productive ecosystem that supports active fisheries. • Highly productive with diverse communities. • Spawning, breeding and feeding area as well as a migration route for several species (e.g., cod, haddock, scallop and deep water lobster).
39. Northeast Channel	• Highly productive area where corals are found in densest aggregations in Atlantic Canada. • Aggregation of pelagic species and swordfish. • High diversity of whales (dolphins to deep diving whales).
40. Browns Bank and Edge Slope	• Aggregation of large lobsters and scallops. • Spawning area for cod and haddock. • Nursery for gadoid.
41. Southwest Nova Scotia and Frontal Area from Browns Bank	• Very productive ecosystem that supports active fisheries, such as lobster. • High lobster productivity. • Nursery for juvenile haddock and herring. • Spawning area for herring. • High fish species diversity (demersal, wolffish) as well as abundance of whales and porpoises. • Diversity of birds (Roseate Terns, Brandt, Oyster Catcher, Piping Plover). • Presence of eelgrass beds.
42. Roseway Basin	• Feeding area for migrating whale species such as the highly endangered North Atlantic right whales as well as for others (e.g., fin, blue). • High concentration of krill, Cananus sp. and juvenile redfish.
43. Roseway Bank	• Good fish habitat, including cod and other demersal species.
44. Baccaro Bank	• Presence of cod, probably a Scotian Shelf sub-population.
45. LaHave Bank	• Important spawning area for many species, including cod.
46. LaHave Basin	• Concentration of krill and overwintering Calanus sp.
47. Sambro Bank	• Presence of cod, probably a Scotian Shelf sub-population.
48. Emerald Basin and The Patch	• Primary residence and spawning area for silver hake. • Overwintering area for basking sharks and porbeagle sharks. • Residence of whales and dolphins, as well as for tuna and swordfish (summer). • Important aggregation of krill.
49. Emerald Bank and Western Bank	• Hotspot for large glass sponges, Vazella pourtalesi, which provide habitat for other species.
50. Sable Island Area	• Important area for seals (primarily grey seals). • High concentrations of juvenile fish, particularly haddock.
51. Gully Trough	• Common foraging area for seals and marine mammals.
52. The Bull Pen, the Cow Pen and the Owl	• Highly productive area with a large number of both southern and northern fish species. • Possible white hake spawning area.
53. Middle Bank	• Presence of cod, probably a Scotian Shelf sub-population.
54. Canso Bank	• Presence of cod, probably a Scotian Shelf sub-population.
55. Scotian Slope/Shelf Break	• High fish diversity, including demersal, mesopelagic and pelagic species. • Primary migratory route for large pelagic fishes (e.g., sharks, swordfish, tuna). • Migratory route for whales, leatherback turtles. • Overwintering area for a number of shelf fish species, halibut and lobster.
56. Deep Holes North of Banquereau Bank	• Area of high density of commercial sized snow crab.
57. The Noodles	• Aggregation of shrimp. • Possible snow crab retention.
58. Deep Holes of Canso Area	• Aggregation of large lobster.
59. Eastern Shoal	• Aggregation of surf clams, sand lances, scallops and quahogs.
60. Laurentien Channel and Slope	• Overwintering area for cod, Canalus sp., white hake, Dover sole, turbot, redfish and Greenland shark. • Important migration route via Cabot Strait to Gulf of St. Lawrence.
61. Logan Canyon	• Area of high finfish diversity.
62. Banquereau Bank – Sandy Area North of Haldimand Canyon	• Very important area for infaunal species (shellfish, surf clam). • Aggregation of sea urchins.
63. Laurentian Channel Cold Seep	• Large dense communities of vesicomyid, thyasind clams, gastropods and galatheid crabs.
64. Stone Fence and Laurentian's Environs	• Variety of corals, including only confirmed location of Lophelia coral on the Scotian Shelf. • Potentially important habitat for juvenile fishes. • Variety of species from dolphins to deep diving whales (e.g., sperm whale).
65. The Gully	• Very high diversity and density of cetacean species, including northern bottlenose whale, blue whale and sperm whale. • Area of high finfish diversity. • Higher diversity of deep water corals (> 12 species). • Potentially important habitat for juvenile fishes.
66. Haldimand Canyon	• Aggregation of endangered northern bottlenose whales and probably other species (e.g., blue whale and sperm whale). • Presence of gorgonian corals.
67. Shortland Canyon	• Aggregation of endangered northern bottlenose whales and probably other species (e.g., blue whale and sperm whale). • Presence of gorgonian corals. • Area of high finfish diversity.

Table 5 Characteristics of Ecologically and Biologically Significant Areas (EBSA) in Newfoundland and Labrador.

EBSA	Particular Characteristics
68. Outer Shelf Saglek Bank	• Presence of cold-water corals. • Spawning and wintering area for Atlantic cod.
69. Grey Island	• na
70. Lake Melville	• Extensive intertidal wetlands around the lake which contain a diversity of wetland plant species. • Staging and breeding area for waterfowl, including dabbling ducks, diving ducks and geese. • Species founded in the lake: whelk, brook trout, Arctic char, rainbow smelt, Atlantic salmon, Greenland cod, scallops, sea urchins and cod. • Very large aggregations of surf, black and white-winged scoters, especially during the annual feather moult. • Seals are found throughout the lake, and harbour porpoise, dolphins and long-finned pilot whale are present in the area.
71. Northern Labrador	•
72. Hamilton Inlet	• Aggregations and colonies of waterfowl, seabird and other migratory birds. • Intertidal marshes in the area contain unique flora, including temperate and arctic species.
73. Fogo Shelf	• na
74. Notre Dame Channel	• na
75. Ophan Spur	• na
76. Labrador Marginal Trough	• na
77. Labrador Slope	• na
78. Nain Area	• Very productive habitat. • High species diversity. • Nesting area for a large number of seabirds (approximately 24,000 colonial seabirds recorded). • Aggregation of fish, seals and whales.
79. Hopedale Saddle	• na
80. Outer Shelf Nain Bank	• na
81. Gilbert Bay	• na
82. Southeast Shoal and Tail of the Banks	• The only known offshore spawning site for capelin. • The single nursery area of the entire stock of yellowtail flounder. • The highest benthic biomass on the Grand Bank. • A spawning area for several demersal species (American plaice, yellowtail flounder, Atlantic cod). • Important feeding area for large aggregations of marine mammals (especially humpbacks and northern bottlenoses) and seabirds. • The highest concentration of striped wolfish, a listed-species, on the Tail of the Banks.
83. Placentia Bay Extension	• The largest spawning stock of Atlantic cod in the Northwest Atlantic Ocean. • Many cetaceans and leatherback turtles aggregate and feed from spring to fall; harbours seals, otters and some cetaceans feed in the area year round. • High pelagic and demersal diversity. • High biomass of birds and terrestrial mammals typical of river and estuarine habitats. • High concentration of meroplankton (cod, cunner, plaice, capelin and others). • Important pupping area for harbour seals and otters. • Historic summer aggregation area for migratory marine mammals; possible migratory path for leatherback turtles.
84. Southwest Shelf Edge and Slope	• Host to the northernmost population of haddock in the Northwest Atlantic Ocean. • High cold-water coral species concentration and diversity. • High number of demersal species on the banks. • Intense feeding area for a wide variety of seabird species. • Aggregation of many marine mammals and leatherback turtles, particularly in the summer. • Atlantic halibut in the region found almost exclusively in this area during spring. • Importance spawning area for redfish. • Migration route for cod.
85. St. Pierre Bank	• Highest and only concentration of Sea scallops on the Grand Banks, which spawn in this area in spring. • Feeding area for several species of cetaceans. • Potentially important spring feeding area for overwintering and migrating whales.
86. Laurentian Channel and Slope	• The sole pupping ground for black dogfish in Canada. • Cabot Strait is an important migratory corridor for marine mammals moving in and out of the Gulf of St. Lawrence; no alternate route exists. • Important juvenile/nursery area for smooth skate. • High concentration of monkfish, Pollock and white hake in spring.
87. Smith Sound	• Largest remaining known spawning area for northern cod. • High northern cod egg/larvae densities. • Important overwintering area for populations of northern cod. • Very dense aggregation of fish during the winter months.
88. Eastern Avalon	• Cetaceans, leatherback turtles, seals and seabirds aggregate to feed in the spring to fall. • Historic aggregation of many marine mammals, particularly in the summer.
89. Lilly Canyon-Carson Canyon	• Important area to the feeding and productivity of Iceland scallops. • Year round aggregation of marine mammals for feeding and overwintering.
90. Northeast Shelf and Slope	• Great proportion of spotted wolffish (listed-species) aggregated in spring. • High concentration of Greenland halibut in spring. • Aggregation of marine mammals, particularly harp seal and pilot whale.
91. Burgeo Bank	• Important spawning area for cod, with a peak in March and April.
92. Virgin Rocks	• Spawning area for demersal fish (Atlantic cod, American plaice and yellowtail flounder).

Sources: Gromack et al., 2010; Rao et al., 2009; Buzeta and Singh, 2008; Doherty and Horsman, 2007; Templeman, 2007; Buzeta et al., 2003

Table 6 Important Key Species[a]

Category	Most Numerous Species		Total Number (All Species)
	Name	Number	
Colonial Birds	Leach's Storm Petrel	9,361,986 couples	12,073,808 couples
Waterfowl	Common Eider	326,081 ind.[b]	586,840 ind.[b]
Shorebirds	Semiplamated Plover	1,166,909 ind.	2,206,413 ind.
Special-Status Species (COSEWIC)[c]	Endangered: 5 sp.	Threatened: 0	Special concern: 5 sp.

[a] *All numbers are based on spatial data information provided by CWS to GENIVAR and analysed in this project.*
[b] *Winter counts of eiders excluded from numbers.*
[c] *Only birds related to marine environment considered, including Peregrine Falcon and Short-Eared Owl.*

Table 7 Type of Marine and Coastal Protected Area

Protected Area Type	Number	Surface Area (km^2)
International Designation		
Important Bird Area	75	7,131.8
NEW BRUNSWICK		
Federal Designation		
Marine Protected Area	2	1.3
Migratory Bird Sanctuary	4	15.4
National Park of Canada	1	211.1
National Wildlife Area	1	11.0
Provincial Designation		
Protected Natural Area	3	17.8
Provincial Park	5	10.8
NEWFOUNDLAND AND LABRADOR		
Federal Designation		
Ecological Reserve	13	163.9
Marine Protected Area	1	0.3
Migratory Bird Sanctuary	4	13.5
National Park of Canada	1	404.3
Provincial Designation		
Provincial Park	8	51.4
Wildlife Reserve	1	1.4
NOVA SCOTIA		
Federal Designation		
Marine Protected Area	4	2,474.1
Migratory Bird Sanctuary	8	15.1
National Park of Canada	3	992.8
National Wildlife Area	3	6.6
Provincial Designation		
Provincial Park	1	26.6
Nature Reserve	1	3.8
Wilderness Area	6	456.5
Total	**145**	**12,009.5**

Source: Government of Canada, 2013; Environment, 2013

Table 8 Demographic and Economic Overview

Total Coastal Population (2011)	1,476,935 inhabitants
NOVA SCOTIA	
Population	824,360 inhabitants
Urban Centers	Halifax, Sydney and New Glasgow
Key Economic Sectors	Commercial fisheries, forestry and tourism
NEW BRUNSWICK	
Population	269,515 inhabitants
Urban Centers	Saint-John, Moncton and Fredericton
Key Economic Sectors	Forestry, commercial fisheries and tourism
NEWFOUNDLAND AND LABRADOR	
Population	383,060 inhabitants
Urban Centers	St-John's, Mount Pearl and Corner Brook
Key Economic Sectors	Mining and mineral processing, forestry and commercial fisheries

Sources: Statistics Canada, 2013; Canadian Encyclopedia, 2013

Risk Assessment for Marine Spills in Canadian Waters

Phase 1: Oil Spills Risk Assessment

Atlantic – Sector 2

1 : 2 250 000

0 22,5 45 90 135 km

January 2014

File: 131_17593_Map6_1_S2_Atlantic_Env_131223.mxd

WSP SL ROSS

Map 6.1

6.1.3 Human Features

The coastal zone ecosystem is exposed to a wide variety of human pressures and uses (e.g. aquaculture, habitat destruction, addition of nutrients and contaminants, maritime shipping and commercial fishing) that pose a significant threat to its ecological integrity and sustainability.

Essentially, the coastal zone of the Atlantic Coast has some localities, with the major urban centres being as Halifax and Sydney (Nova Scotia), Saint-John (New Brunswick) and St-John's and Mount Pearl (Newfoundland and Labrador) (Map 6.1). The coastal population was approximately 1,477,000 inhabitants in 2011.

The Atlantic Coast's key economic sectors are commercial fisheries, forestry, tourism and mining. The fishing industry is significant in the Atlantic sector with an average of 100 M$ of landing value in 2011. The Yarmourth harbour is the most important commercial fishery landing area in the Atlantic sector. The shellfish aquaculture industry is among the key economic Atlantic sectors. Fair quantities of shellfish and finfish are also harvested along the Newfoundland and Labrador coasts. Port activity and tourism industries are well developed in this sector.

Due to the presence of habitat and strong wildlife diversity in the coastal zone, many areas have been protected by international, federal or provincial regulations. A total of 145 protected areas are present in the Atlantic Coast sector, which occupy 12,009 km^2. They include important bird areas (IBAs), migratory bird sanctuaries, national parks of Canada, national wildlife areas, marine protected areas, ecological reserves, provincial parks, protected natural areas, wildlife reserves, nature reserves and wilderness areas (Map 6.1).

6.2 Vessel Traffic Description

The following description and tables summarize the estimated spill frequency for the Atlantic Coast sector and its sub-sectors. Tables 6.1 to 6.3 present the potential spill frequency for each of the three oil type (crude oil cargo, refined oil cargo, and oil carried as fuel), for each of the four spill size ranges, with a breakdown per sub-sector and zone (nearshore, intermediate and deep-sea). Summary maps indicate the combined frequency for all spill sizes and zone per oil type (Map 6.2).

For ease of comparison, the summary tables are presented with frequency as "return periods", or average number of years between events.

Table 6.1 Cargo Crude Return Periods.

Sub-sector	Cargo Crude Return Periods (years)											
	Nearshore Zone (0-12 nm)				Intermediate Zone (12-24 nm)				Deep-sea Zone (24-200 nm)			
	S	M	L	XL	S	M	L	XL	S	M	L	XL
1	2,380	3,555	2,650	12,442	3,060	4,571	3,407	15,997	5,356	7,999	5,962	27,995
2	2,380	3,555	2,650	12,442	3,060	4,571	3,407	15,997	5,356	7,999	5,962	27,995
3	3,011	4,497	3,352	15,741	3,872	5,782	4,310	20,238	6,775	10,119	7,542	35,416
4	748	1,117	832	3,908	961	1,436	1,070	5,025	1,682	2,512	1,873	8,793
5	3,270	4,884	3,640	17,093	4,204	6,279	4,680	21,977	7,357	10,988	8,190	38,459
6	480	717	534	2,509	617	922	687	3,226	1,080	1,613	1,202	5,645
7	1,579	2,358	1,757	8,252	2,030	3,031	2,260	10,610	3,552	5,305	3,954	18,568
8	2,653	3,963	2,954	13,870	3,411	5,095	3,798	17,833	5,970	8,916	6,646	31,207
9	-	-	-	-	-	-	-	-	-	-	-	-
10	922,849, 138,842	1,378,281, 181,387	1,027,329, 954,645	4,823,984, 134,856	1,186,520, 321,368	1,772,075, 804,641	1,320,852, 798,830	6,202,265, 316,244	2,076,410, 562,395	3,101,132, 658,122	2,311,492, 397,952	10,853,964, 303,427
11	6,936	10,358	7,721	36,254	8,917	13,318	9,927	46,613	15,605	23,306	17,372	81,572

Table 6.2 Cargo Refined Return Periods.

Sub-sector	Cargo Refined Return Periods (years)											
	Nearshore Zone (0-12 nm)				Intermediate Zone (12-24 nm)				Deep-sea Zone (24-200 nm)			
	S	M	L	XL	S	M	L	XL	S	M	L	XL
1	44	262	1,106	-	56	337	1,422	-	98	589	2,488	-
2	44	262	1,106	-	56	337	1,422	-	98	589	2,489	-
3	294	1,765	7,453	-	378	2,270	9,583	-	662	3,972	16,770	-
4	36	218	921	-	47	280	1,184	-	82	491	2,072	-
5	79	471	1,990	-	101	606	2,559	-	177	1,060	4,477	-
6	31	189	797	-	40	243	1,025	-	71	425	1,794	-
7	99	594	2,508	-	127	764	3,225	-	223	1,337	5,644	-
8	169	1,016	4,289	-	218	1,306	5,515	-	381	2,286	9,651	-
9	854	5,122	21,628	-	1,098	6,586	27,808	-	1,921	11,525	48,664	-
10	3,661	21,967	92,753	-	4,707	28,243	119,253	-	8,238	49,425	208,693	-
11	220	1,319	5,567	-	283	1,695	7,158	-	494	2,967	12,527	-

Table 6.3 Fuel Return Periods

Sub-sector	Fuel Return Periods (years)											
	Nearshore Zone (0-12 nm)				Intermediate Zone (12-24 nm)				Deep-sea Zone (24-200 nm)			
	S	M	L	XL	S	M	L	XL	S	M	L	XL
1	147,662	467,596	43,436,237	-	189,851	601,195	55,846,590	-	332,239	1,052,092	97,731,532	-
2	21,095	66,799	6,205,177	-	27,122	85,885	7,978,084	-	47,463	150,299	13,961,647	-
3	1,507	4,771	443,227	-	1,937	6,135	569,863	-	3,390	10,736	997,261	-
4	19	59	5,505	-	24	76	7,078	-	42	133	12,386	-
5	23	72	6,647	-	29	92	8,546	-	51	161	14,955	-
6	15	49	4,541	-	20	63	5,838	-	35	110	10,217	-
7	296	936	86,959	-	380	1,204	111,805	-	665	2,106	195,659	-
8	47	148	13,741	-	60	190	17,667	-	105	333	30,918	-
9	268	850	78,975	-	345	1,093	101,539	-	604	1,913	177,694	-
10	147,662	467,596	43,436,237	-	189,851	601,195	55,846,590	-	332,239	1,052,092	97,731,532	-
11	68	214	19,916	-	87	276	25,606	-	152	482	44,810	-

For crude oil cargo, Atlantic sub-sectors 4 and 6 have the highest PSFs in the country, reflecting the substantial crude oil traffic to refineries in those sub-sectors, as well as traffic transiting the area en route to locations in the St. Lawrence Seaway system. Refined product cargo also has substantial PSF values in these sub-sectors, as in Atlantic sub-sectors 1 and 2.

For spills of fuel, sub-sectors 5, 6 and 7 are amongst the highest PSFs in the country, reflecting a high level of marine traffic in the area; sub-sectors 8 and 11 also have significant PSF values in this regard.

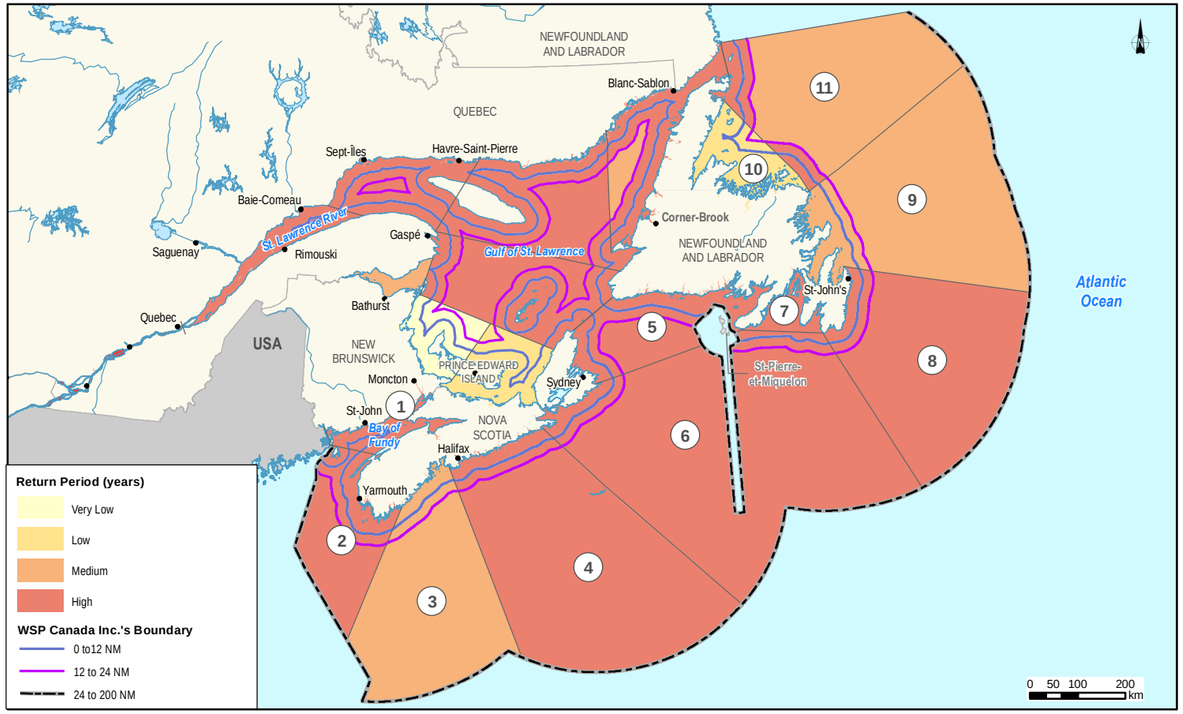
Table 6.4 Class Breakdown to Determine Environmental Risk Index (ERI) Classes.

ERI Class	Natural Breakdown			
	10-99.9 m^3	100-999.9 m^3	1,000-9,999 m^3	≥ 10,000 m^3
Crude Oil				
Very High	134.8 to 347.6	628.3 to 1,221.6	8,601.2 to 37,798.7	3,727.1 to 9,613.1
High	62.1 to 134.8	366.5 to 628.3	3,482.9 to 8,601.2	1,718.4 to 3,727.1
Medium	28.3 to 62.1	169.7 to 366.5	1,537.5 to 3,482.9	783.0 to 1,718.4
Low	10.1 to 28.3	49.3 to 169.7	449.6 to 1,537.5	278.1 to 783.0
Very Low	0.0 to 10.1	0.0 to 49.3	0.0 to 449.6	0.0 to 278.1
Refined Oil				
Very High	4,608.7 to 58,806.7	735.0 to 2,346.9	932.1 to 1,535.2	7,895,456.7 to 23,298,700.7
High	794.3 to 4,608.7	267.2 to 735.0	336.4 to 932.1	3,004,643.6 to 7,895,456.7
Medium	305.5 to 794.3	130.0 to 267.0	132.2 to 336.4	1,238,071.0 to 3,004,643.6
Low	105.4 to 305.5	49.8 to 130.0	33.3 to 132.2	0.0 to 1,238,071.0
Very Low	0.0 to 105.4	0.0 to 49.8	0.0 to 33.3	0.0 to 0.0
Fuel Oil				
Very High	4,201.6 to 12,771.6	15,242.0 to 25,008.8	939.8 to 1,583.4	0.0 to 0.0
High	1,208.2 to 4,201.6	4,839.3 to 15,242.0	398.8 to 939.8	0.0 to 0.0
Medium	468.1 to 1,208.2	2,002.4 to 4,839.3	122.0 to 398.8	0.0 to 0.0
Low	155.3 to 468.1	685.5 to 2,002.4	41.4 to 122.0	0.0 to 0.0
Very Low	0.0 to 155.3	0,0 to 685.5	0,0 to 41.4	0.0 to 0.0

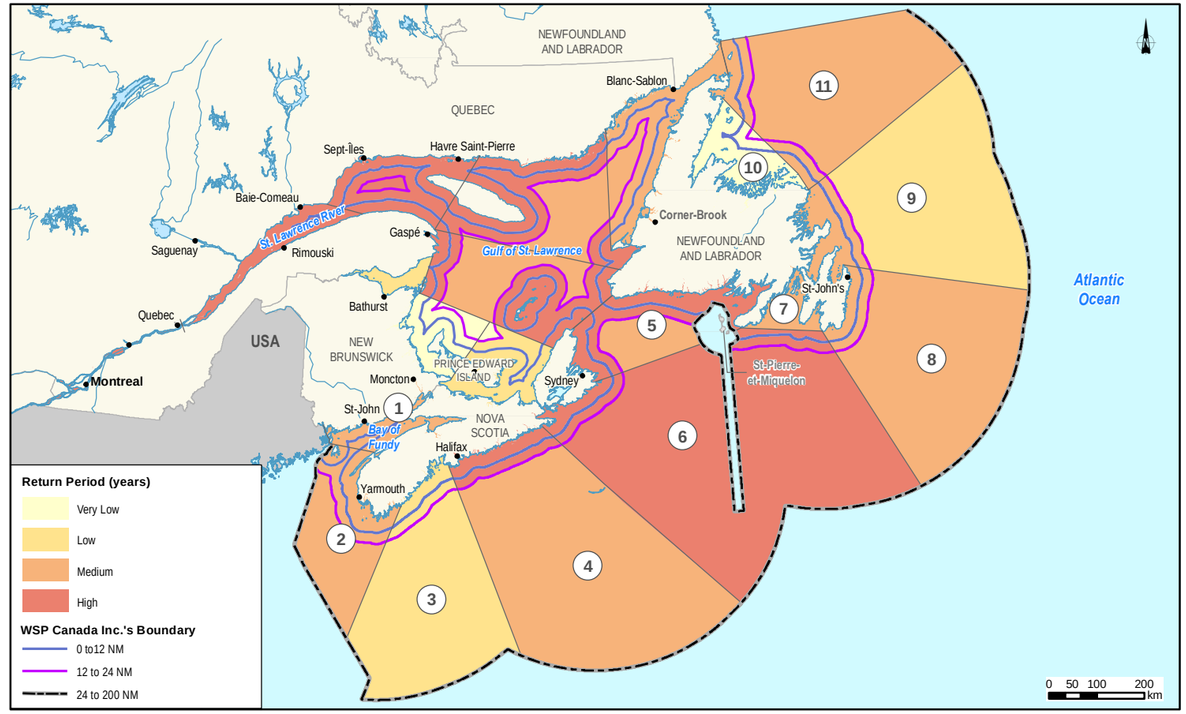
6.3 Overall Risk Results

The Environmental Risk Index (ERI) has been calculated for each oil type (crude oil, refined products and fuel), along a gradient of spill volumes (4 classes from 10 to 10,000 m^3). The following maps illustrate ERI values according to five categories or risk (from very low to very high). The definition of the categories involves a natural break calculation using ArcGIS (Table 6.4). Based on this method, class breaks are

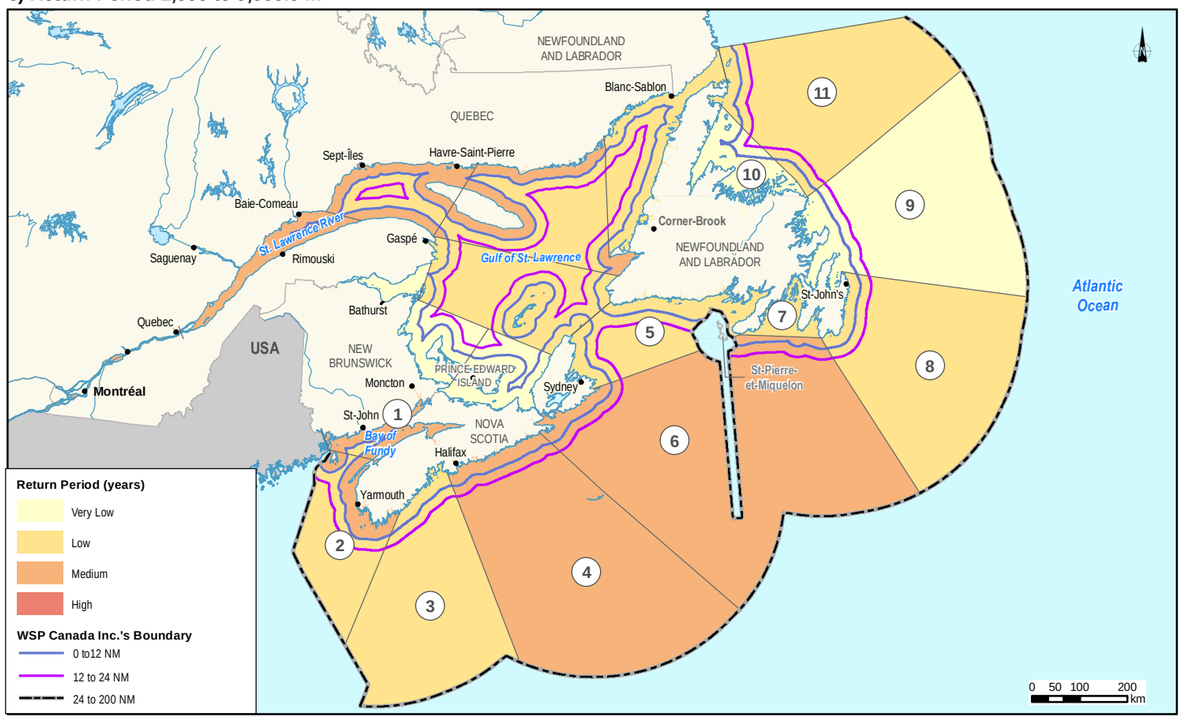
a) Return Period 10 to 99.9 m^3



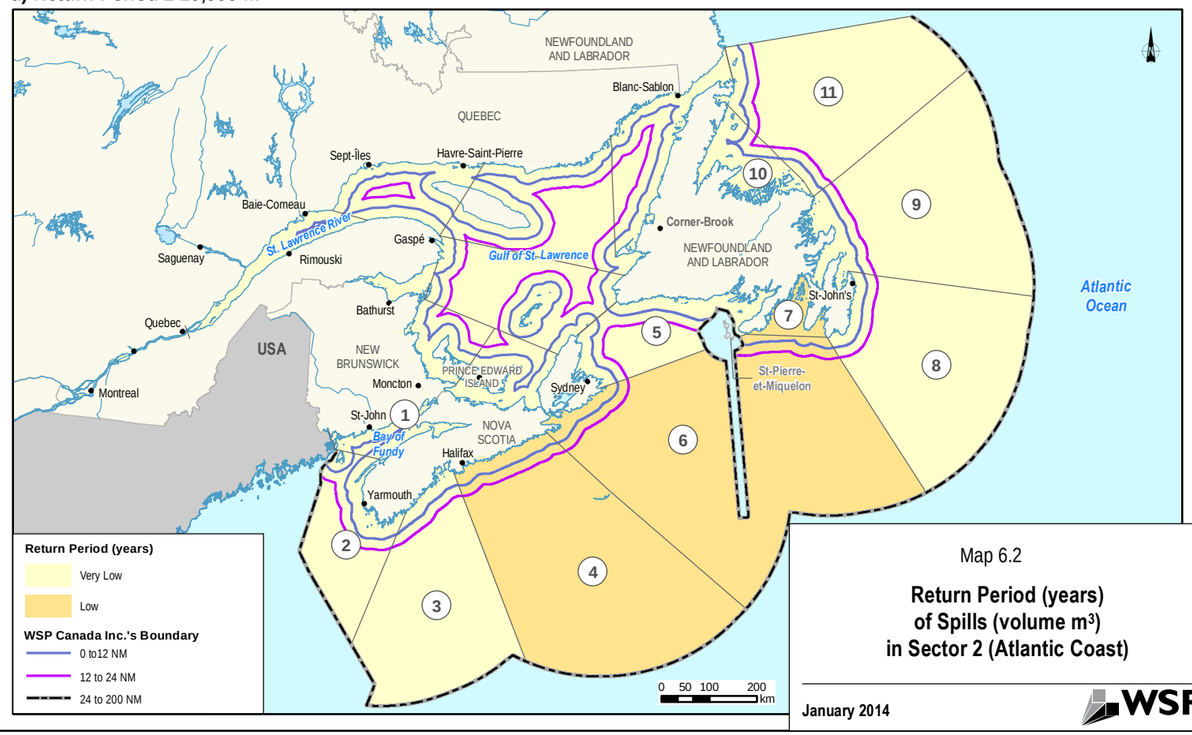
b) Return Period 100 to 999.9 m^3



c) Return Period 1,000 to 9,999.9 m^3



d) Return Period ≥ 10,000 m^3



Map 6.2

Return Period (years) of Spills (volume m^3) in Sector 2 (Atlantic Coast)

January 2014

WSP

File: 131_17593_c6.2_Cargo_Return_period_Atlantic_131223.mxd

chosen in function of the best grouping of similar values and in order to maximize the difference between classes. A detailed map was produced for each sector and the following sub-sections provide an overview of the ERI results for each map.

6.3.1 Crude Oil Environmental Risk Index (ERI)

6.3.1.1 10 to 99.9 m^3 and ≥ 10,000 m^3 Oil Spill Size

The Map 6.3 (a and d) allows for the following observations:

- The highest ERIs values are observed in the nearshore zones of sub-sectors 4 and 6 as well as in the intermediate zone of sub-sector 6, due to high spill frequency values in these zones. Moreover, these zones show very high ESI values as a result of very high and high physical sensitivity (such as vegetated emergent wetlands), also these zones have a high ice coverage area. In this case, the ESI is also influenced by BRI parameters, such as the high surface area of the coastal zone, abundance and diversity of marine species as well as large surface area sheltering a high bird concentration and numerous bird colonies.
- The nearshore zone of sub-sectors 2 and 7 as well as the intermediate zone of sub-sector 4 have a high ERI. The main cause for high ERI values is the spill frequency which is based on crude oil volume transported by vessel in this zone. In addition, these zones also have high ESI scores explained by several variables, such as sensitive shoreline types (rank 6; influencing the PSI) as well as several marine bird concentration areas and colonies (influencing the BRI).
- The nearshore zones of sub-sectors 1, 3, 5 and 8, the intermediate zones of sub-sector 2 and the deep-sea zone of sub-sector 6 all show medium ERI values. The medium ERI is explained by high frequencies combined with lower ESI values.
- The other Atlantic zones show very low ERI. The spill frequencies are very low; the crude oil volume transported throughout these zones is very low.

6.3.1.2 100 to 999 m^3 Oil Spill Size

Results for 100 m^3 spills (Map 6.3b) show that:

- The highest ERIs values are observed in the nearshore zones of sub-sectors 4 and 6. These two zones have the highest spill frequency values of their category (100 to 999.9 m^3). This influences directly their ERI score. These zones show medium ESI values as a result of high PSI such as vegetated emergent wetlands, and a high ice coverage area. The ESI values of these zones are also influenced by a large coastal zone (a BRI parameters).

- The intermediate zone of sub-sector 6 has a high ERI. The main reason for this high ERI value is the frequency (this zone has the second highest 100 to 999 m^3 spill frequency in the Atlantic sector). In addition, this zone's high ESI is because of its many protected areas and because of some vegetated emergent wetlands sites (influencing PSI and BRI).
- The nearshore zone of sub-sectors 1, 2, 7 and 8, the intermediate zone of sub-sector 4 and the deep-sea zone of sub-sector 6 all range in the medium ERI category. These zones have frequencies amongst the highest of their category both in the Atlantic sector as in Canada as a whole.
- The other Atlantic zones show very low ERI values. The spill frequencies as well as the ESI values are low or very low.

6.3.1.3 1,000 to 9,999 m^3 Oil Spill Size

The Map 6.3c allows the following observations:

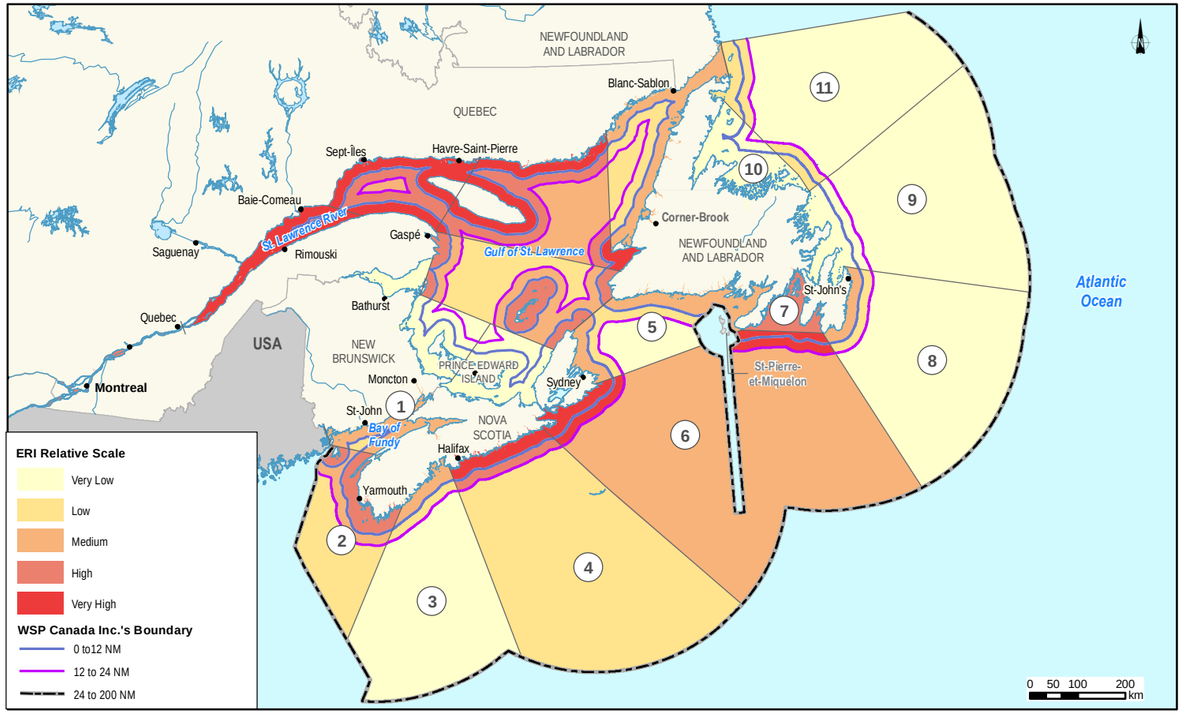
- There are no very high ERI values in this category.
- The nearshore zones of sub-sectors 4 and 6 have high ERI scores and very high in others crude oil spill size categories. This indicates that the spill frequency is lower in these zones.
- The nearshore zone of sub-sectors 2 and 7 and the intermediate zone of sub-sector 4 all range in the medium ERI values. These zones have frequencies amongst the highest in their category. The medium ERI scores are caused by moderate spill frequencies combined with medium ESI values (influenced by a high or a very high BRI or HRI).
- The other Atlantic zones have low to very low ERI values. The spill frequencies are low; crude oil volume transported throughout these zones is very low or inexistent and the ESI scores are lower than in other zones.

6.3.2 Refined Oil Environmental Risk Index (ERI)

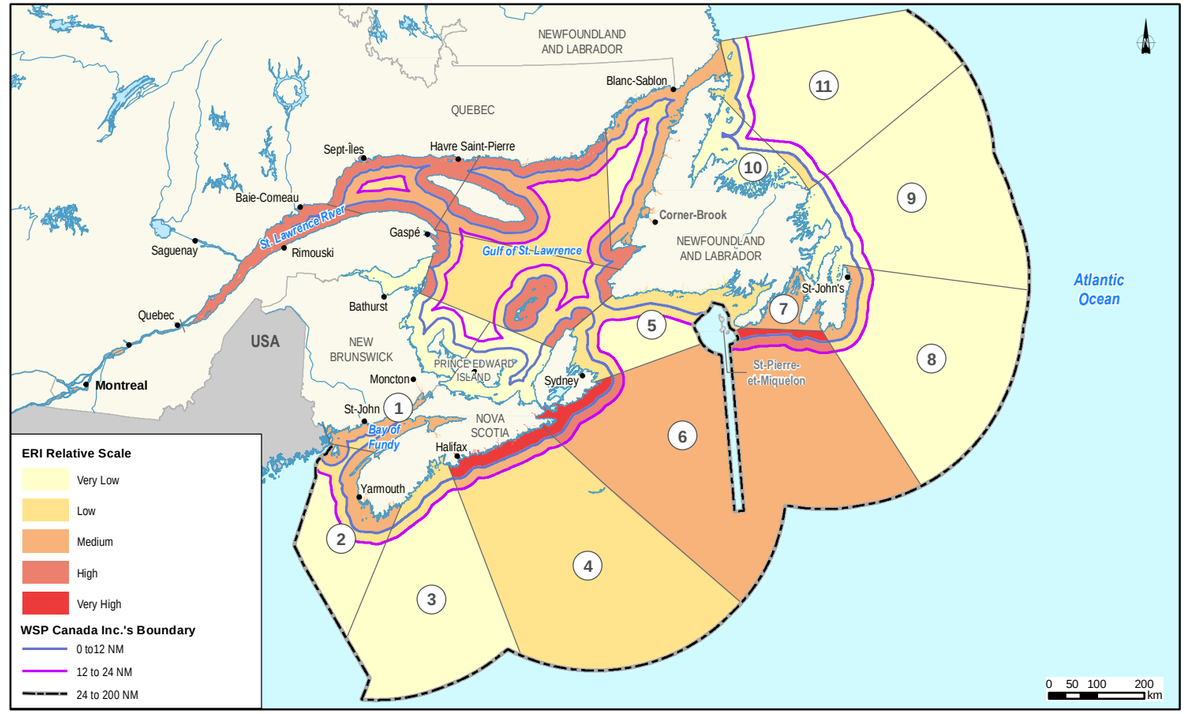
6.3.2.1 10 to 99 m^3 Oil Spill Size

Based on Map 6.4a's results, the following observations can be made:

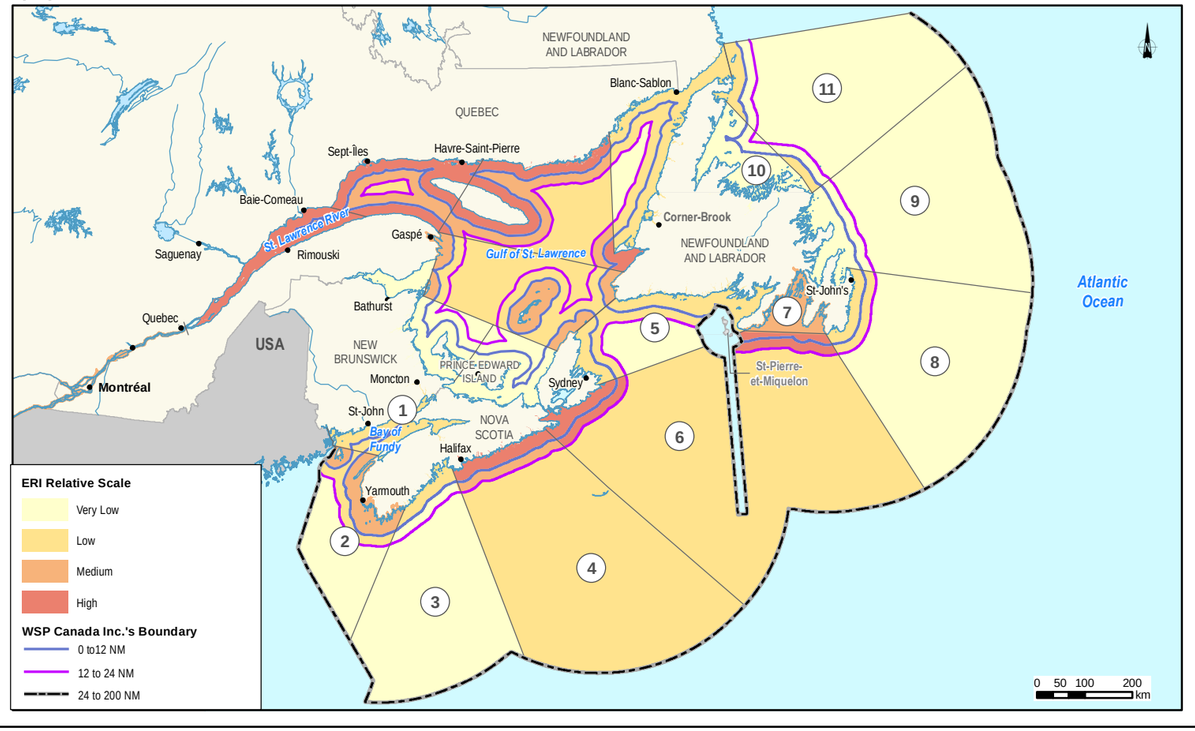
a) Spill Volume 10 to 99.9 m^3



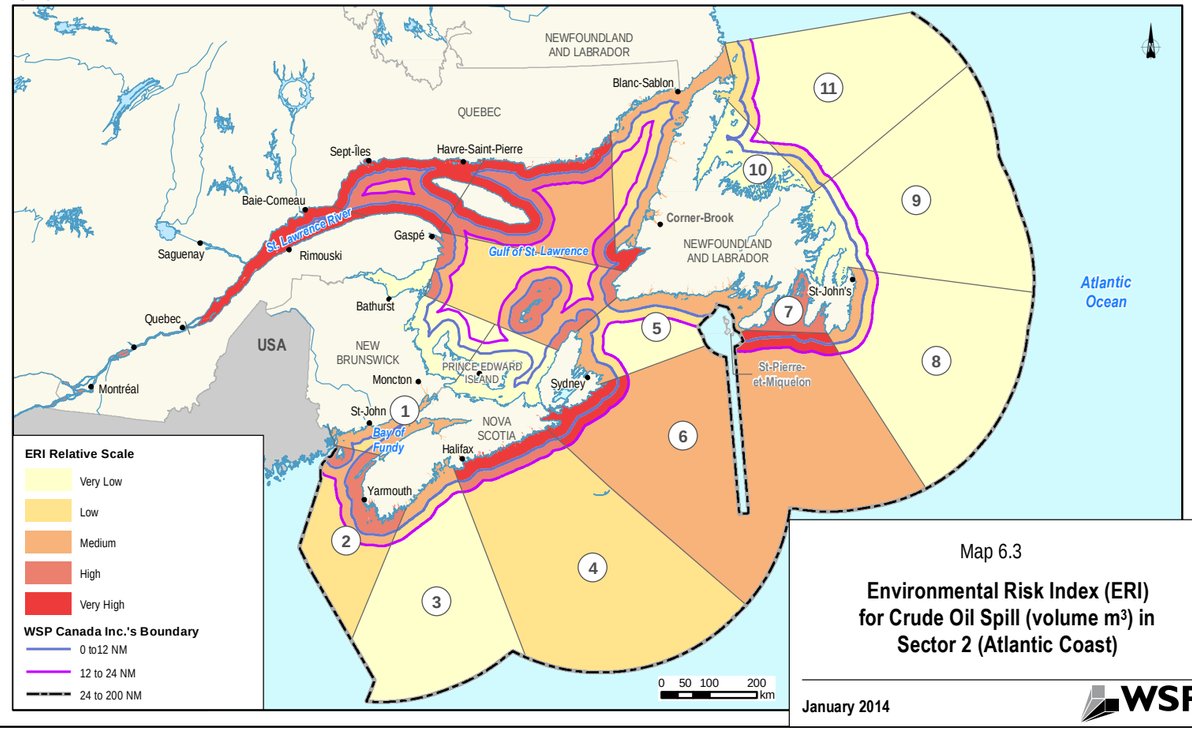
b) Spill Volume 100 to 999.9 m^3



c) Spill Volume 1,000 to 9,999.9 m^3



d) Spill Volume ≥ 10,000 m^3



Map 6.3

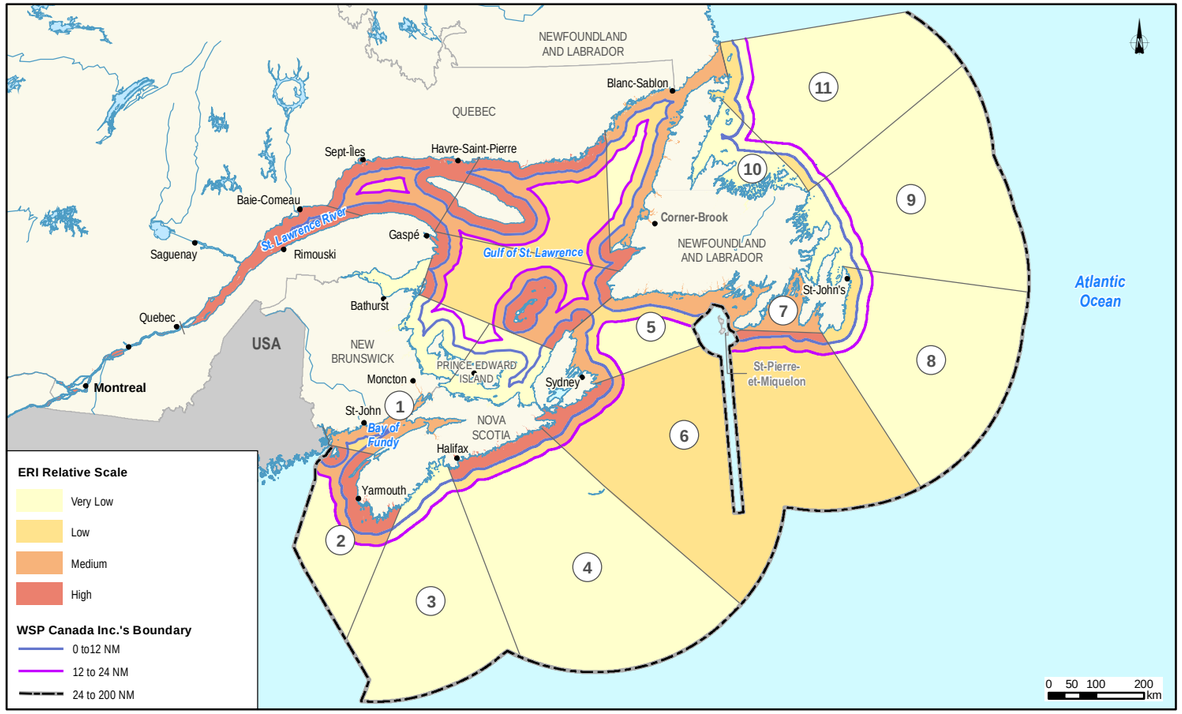
Environmental Risk Index (ERI) for Crude Oil Spill (volume m^3) in Sector 2 (Atlantic Coast)

January 2014

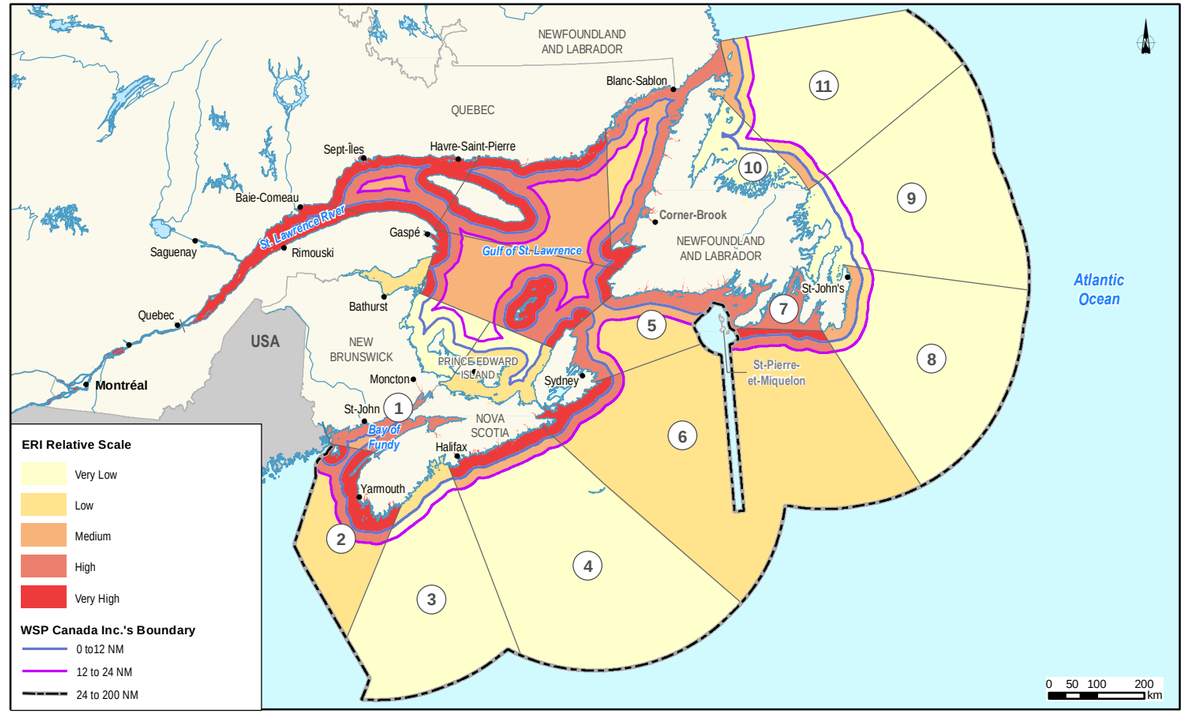
WSP

File: 131_17593_c6.3_Cargo_Crude_Atlantic_131223.mxd

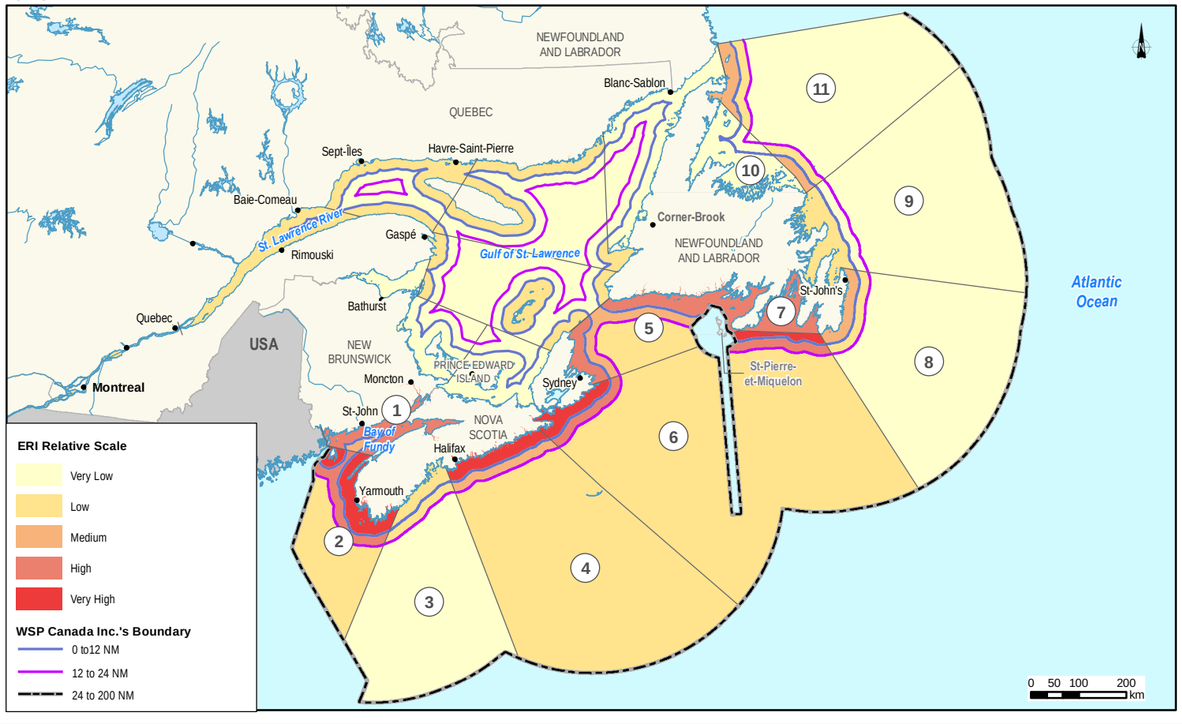
a) Spill Volume 10 to 99.9 m^3



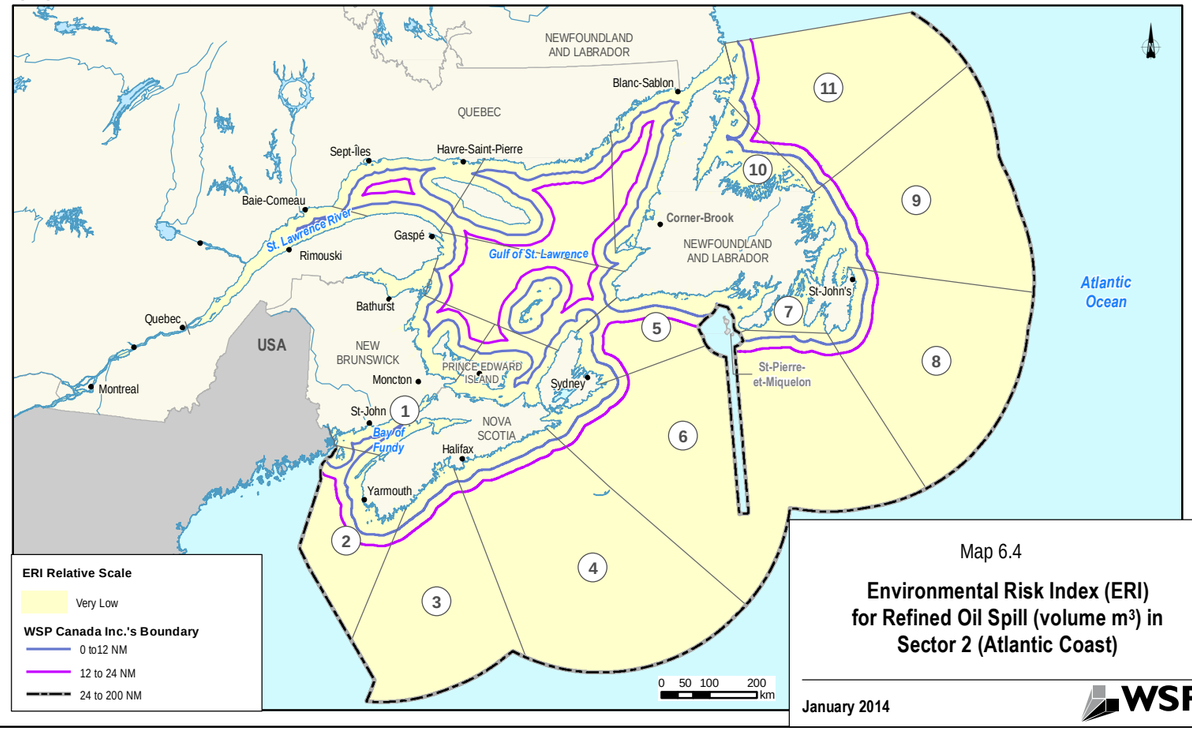
b) Spill Volume 100 to 999.9 m^3



c) Spill Volume 1,000 to 9,999.9 m^3



d) Spill Volume ≥ 10,000 m^3



Map 6.4

Environmental Risk Index (ERI) for Refined Oil Spill (volume m^3) in Sector 2 (Atlantic Coast)

January 2014

WSP

File: 131_17593_c6.4_Cargo_Refined_Atlantic_131223.mxd

- High ERI values in this category are associated with the nearshore zones of sub-sectors 2, 4 and 6 as well as the intermediate zones of sub-sectors 2 and 6. These zones have frequency values amongst the highest of their category. Due to the very high commercial fishery landings, the presence of many EBSA as well as marine bird concentration areas, these zones display a very high ESI.
- The nearshore zone of sub-sectors 1 and 7 have medium ERI scores. These zones have relatively moderate spill frequency values. In general, these zones show medium ESI values as a result of the presence of sensitive shoreline types (influencing the PSI) and many protected areas.
- The other Atlantic zones have low to very low ERI values. Despite an ESI varying from medium to very low depending on the zone, the spill frequencies are low and influence significantly the ERI values.

6.3.2.2 100 to 9,999.9 m^3 Refined Oil Spill Size

Map 6.4 (b and c) allows for the following observations:

- The highest ERI values in this category are associated with the nearshore zones of sub-sectors 2, 4 and 6 as well as the intermediate zone of sub-sectors 2 and 6. These zones have frequency values amongst the highest of their category. Due to the very high commercial fishery landings, the presence of many EBSAs as well as marine bird concentration areas, these zones have a very high ESI.
- The other Atlantic Coast zones have ERI values which vary from medium to very low. These results confirm that these zones are less in use to carry oil than other Canadian zones.

6.3.2.3 ≥ 10,000 m^3 Refined Oil Spill Size

Calculations for the 10,000 m^3 and greater spills (Map 6.4d) show that:

- The entire Atlantic coast has very low ERI values. Despite a medium ESI in all the nearshore zones, the spill frequencies calculated in those zones is almost null. As a safety precaution (principle of sustainable development), a very low ERI score was given to this scenario.

6.3.3 Fuel Environmental Risk Index

6.3.3.1 10 to 99 m^3 Oil Spill Size

Map 6.5a allows for the following observations:

- The nearshore zone in sub-sectors 4, 5 and 6 have a high ERI value. These results are due, in large part, to the very high spill frequencies calculated in these zones. Also, these zones show medium ESI values as a result of high PSI caused by vegetated emergent wetlands, and a high ice coverage area. The ESI values of these zones are also influenced by a large coastal zone (a BRI parameters).
- The other Atlantic coast zones, including nearshore, intermediate and deep-sea zones, have ERI values that vary from medium to very low. These results confirm that these zones are less in use for traffic vessel than other Canadian zones.

6.3.3.2 100 to 9,999.9 m^3 Oil Spill Size

As shown on Map 6.5 (b and c):

- There are no high or very high ERI scores in the Atlantic coast sector.
- Medium ERI scores are attributed to the nearshore zone of sub-sectors 4, 5 and 6. The main factor that influences the ERI value of these zones is the moderate spill frequencies.
- In general, very low ERI values are encountered for spills of this magnitude.

6.3.3.3 ≥ 10,000 m^3 Oil Spill Size

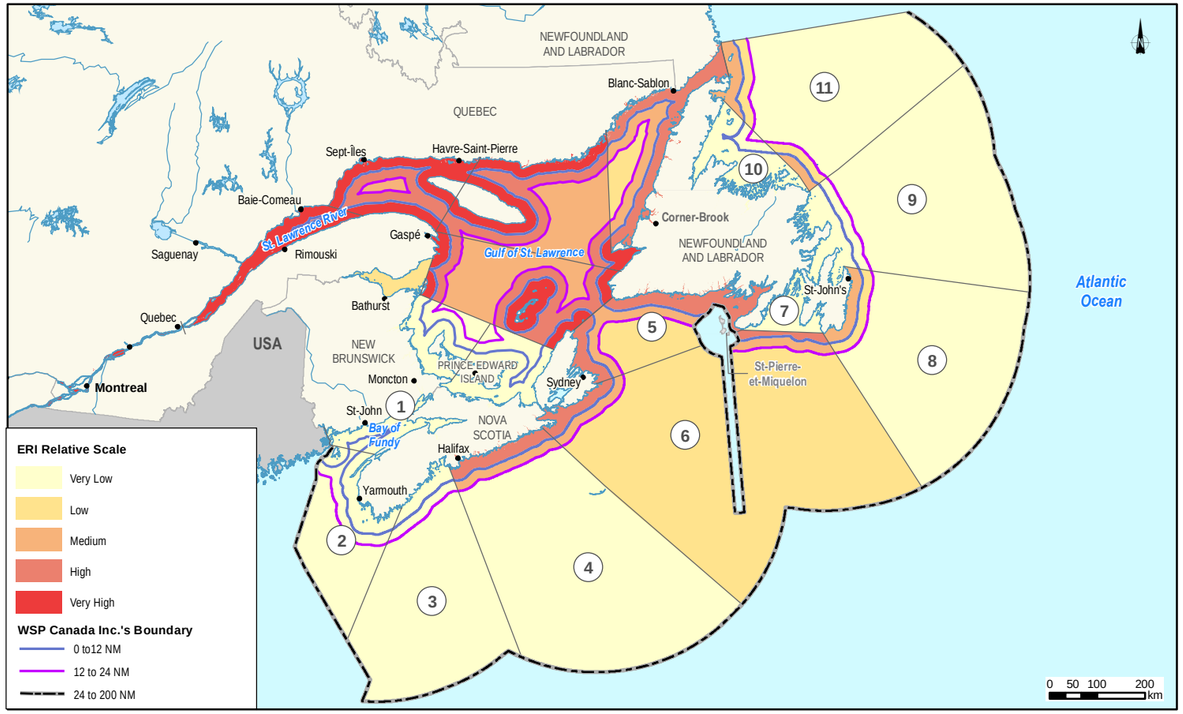
Results for 10,000 m^3 spills (Map 6.5d) show that:

- The entire Atlantic coast has very low ERI values. Despite a medium ESI in the entire nearshore zone, the spill frequencies calculated area almost null. As a safety precaution (principle of sustainable development), a very low ERI score has been given to this scenario.

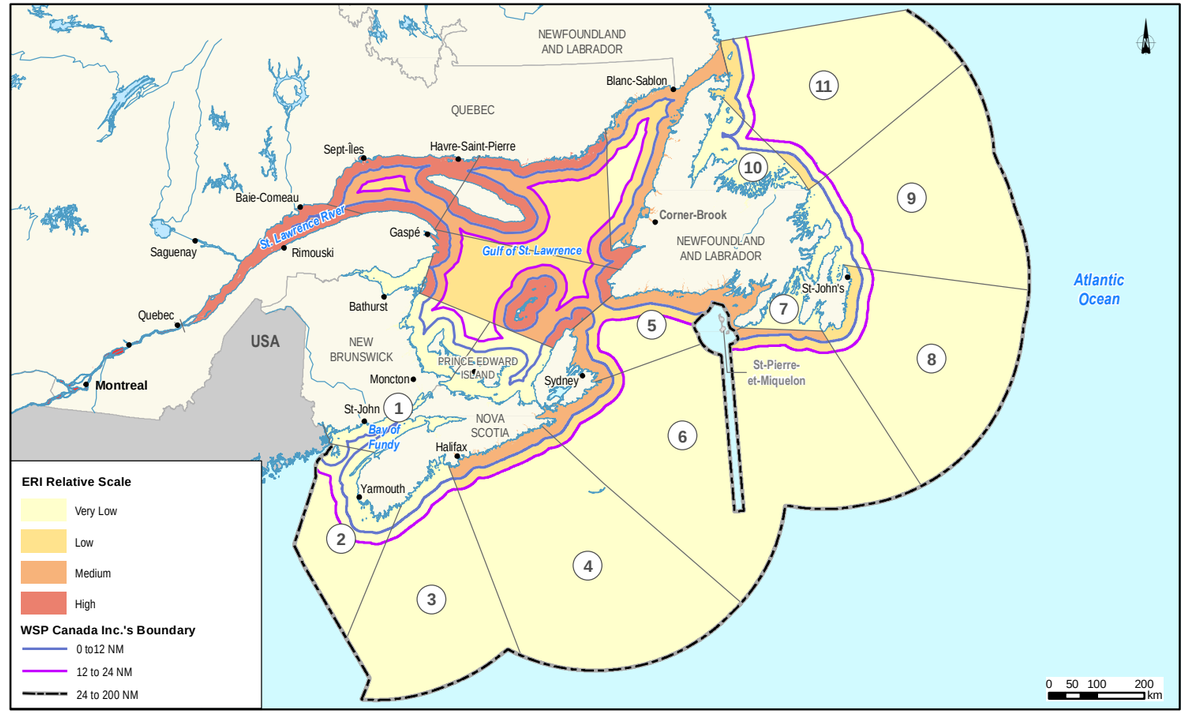
6.3.4 Environmental Sensitivity Index (ESI)

In addition to the very high and high ERI values of the zones, there are other sensitive zones in the Atlantic coast sector which may be affected by future increases in volumes (Map 6.6; Appendix 2 – Map B).

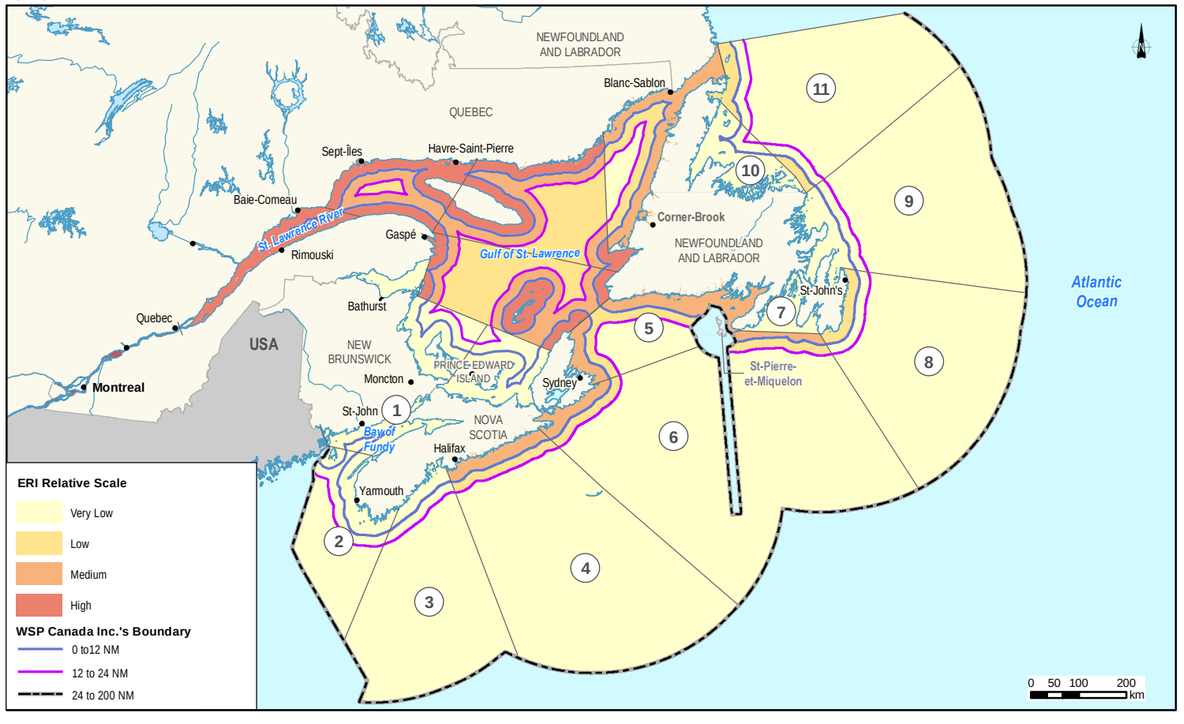
a) Spill Volume 10 to 99.9 m^3



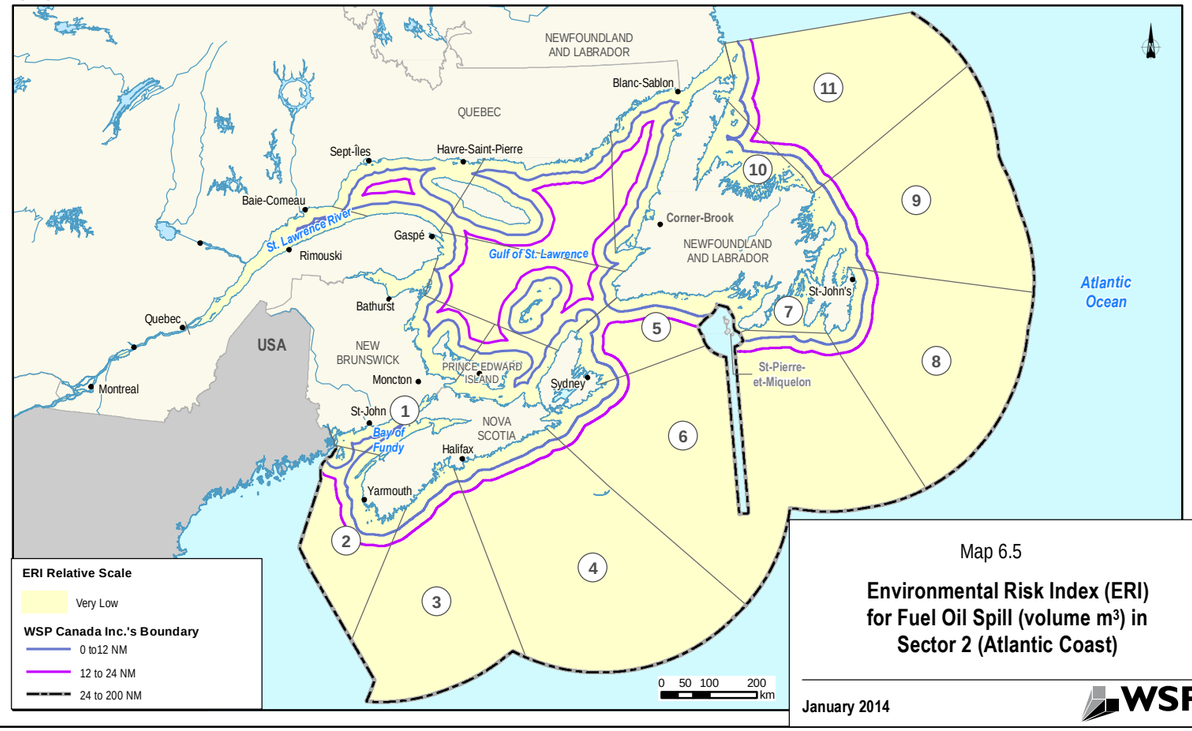
b) Spill Volume 100 to 999.9 m^3



c) Spill Volume 1,000 to 9,999.9 m^3



d) Spilled Volume ≥ 10,000 m^3



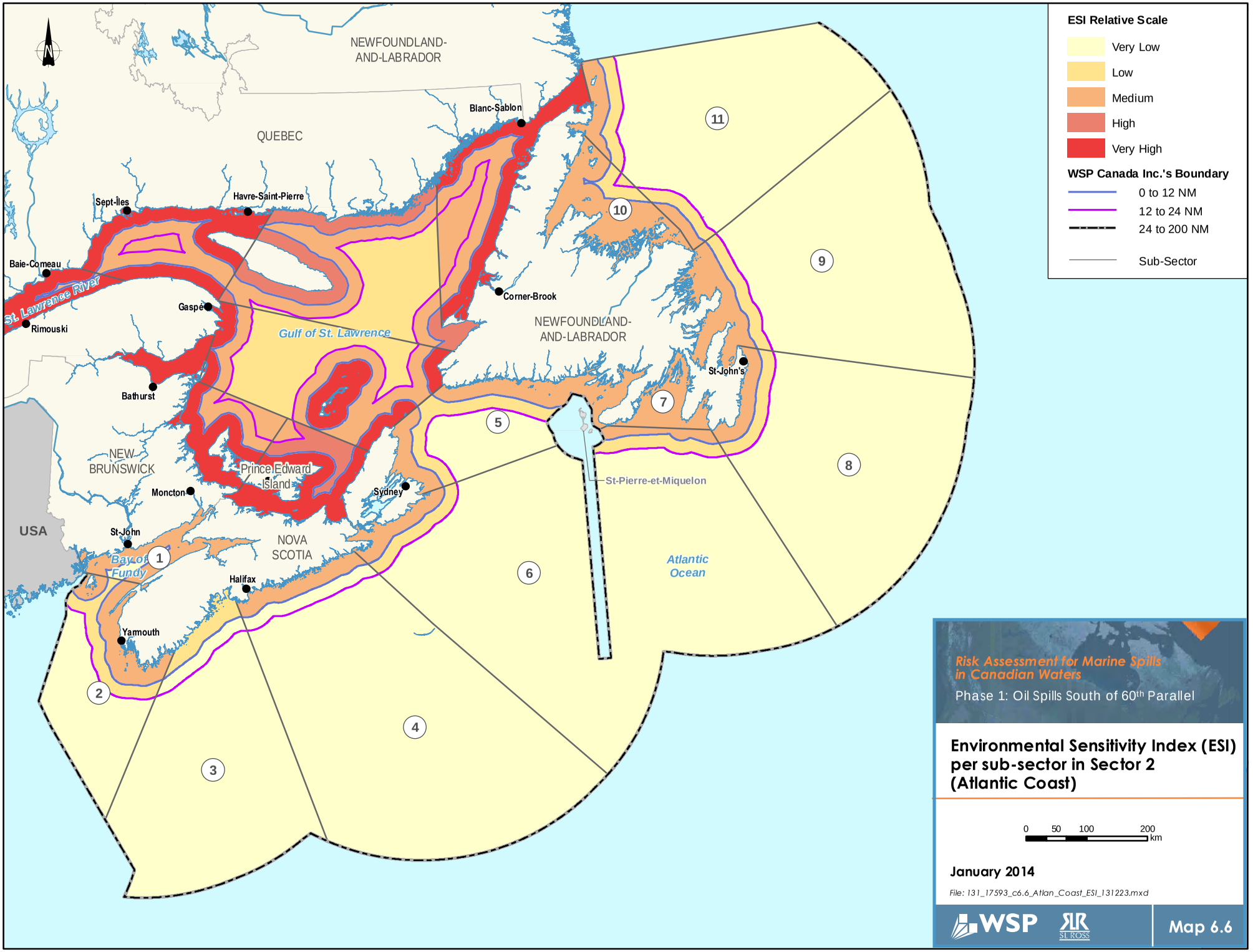
Map 6.5

Environmental Risk Index (ERI) for Fuel Oil Spill (volume m^3) in Sector 2 (Atlantic Coast)

January 2014

WSP

File: 131_17593_c6.5_Cargo_Fuel_Atlantic_131223.mxd


ESI Relative Scale
Very Low
Low
Medium
High
Very High
WSP Canada Inc.'s Boundary
0 to 12 NM
12 to 24 NM
24 to 200 NM
Sub-Sector
NEWFOUNDLAND-AND-LABRADOR
QUEBEC
Blanc-Sablon
Sept-Îles
Havre-Saint-Pierre
Baie-Comeau
St. Lawrence River
Rimouski
Gaspé
Corner-Brook
Gulf of St. Lawrence
NEWFOUNDLAND-AND-LABRADOR
St-John's
Bathurst
NEW BRUNSWICK
Prince Edward Island
Moncton
Sydney
St-Pierre-et-Miquelon
USA
St-John
NOVA SCOTIA
Bay of Fundy
Halifax
Atlantic Ocean
Yarmouth
1
2
3
4
5
6
7
8
9
10
11
Risk Assessment for Marine Spills in Canadian Waters
Phase 1: Oil Spills South of 60th Parallel
Environmental Sensitivity Index (ESI) per sub-sector in Sector 2 (Atlantic Coast)
0 50 100 200
km
January 2014
File: 131_17593_c6.6_Atlan_Coast_ESI_131223.mxd
WSP
SL ROSS
Map 6.6

The nearshore zone of the entire Atlantic coast sector has a medium ESI, except in sub-sector 3 (between Yarmouth and Halifax) where the ESI score is low. The Atlantic coastline offers particular physical and biological conditions which influence the biological productivity of the sector. The importance of the coastal zone for many biological functions (reproduction, feeding and wintering), the presence of many EBSAs and marine bird concentration areas as well as high commercial fisheries landings are also determining features of this sector.

7. ESTUARY AND GULF OF ST. LAWRENCE

7.1 Sector Description

In the context of the *National Ecosystem Status and Trends Report Program*, DFO produced in 2008 a portrait of the ecozone of the Estuary and the Gulf of St. Lawrence (EGSL) (Dufour *et al*., 2010). This large ecosystem encompasses parts of Quebec, New Brunswick, Prince-Edward-Island, Nova Scotia and Newfoundland and Labrador. This section summarizes the main characteristics of the area used to assess environmental sensitivity.

7.1.1 Physical Features

The EGSL, particularly the Gulf of St. Lawrence, is a semi-enclosed sea, covering an area of about 236,000 km^2 and containing 35,000 km^3 of water (including the St. Lawrence estuary), that opens up to the Atlantic Ocean through the Cabot Strait and the Strait of Belle Isle (Map 7.1). The most prominent geomorphic feature of the EGSL is the long and continuous Laurentian Channel (290 m in depth (average) and some 1,250 km in length). There are two other deep (> 200 m) channels: the Esquiman Channel which branches off from the Laurentian Channel and extends toward the Strait of Belle Isle, and the Anticosti Channel that branches off from the Esquiman Channel and extends into the Jacques-Cartier Strait north of Anticosti Island (Map 7.1). The Mecatina Through, in the northeast Gulf, reaches 235 m in depth and connects to the rest of the Gulf via narrow channels approximately 150 m deep. The deepest (540 m) part of the EGSL is observed just north of Cabot Strait. By contrast, the southern portion of the EGSL is a wide and shallow plateau (average depth of 60 m). These geomorphological features influence the circulation, mixing and characteristics of water masses. For example, the deep waters of the St. Lawrence enter from the Atlantic through the Laurentian Channel and are advected by estuarine circulation towards the channel head, at the Saguenay River mouth, where strong mixing occurs with near-surface waters. This upwelling phenomena increases nutrient availability in the upper waters column, and consequently, improves the biological productivity.

More than a quarter of the entire sector's shoreline (27.4%) corresponds to bedrock cliffs or verticals. The other shoreline types which are significantly abundant in this sector are pebble or cobble beaches or banks (12.8%), mixed-sediments beaches or banks (12.3%) and sand beaches or flats (10.1) (Map 7.1). Based on 1981-2010 February ice data, the entire sector is covered by ice during this period of the year (Map 7.1).

7.1.2 Biological Features

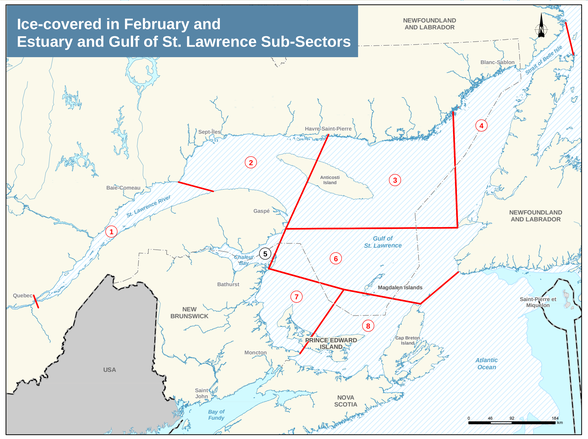
The EGSL represents one of the largest and most productive estuarine/marine ecosystems in Canada. This ecosystem is strongly influenced by ocean and climate variability in the North Atlantic, what is translated by large spatial and temporal variations in environmental conditions and oceanographic processes (e.g. variation of temperature and water circulation patterns, ice-cover modification, storm effects, etc.). This unique setting provides the conditions for highly diverse and productive biological community and trophic structure. The EGSL is also exposed to a wide variety of human pressures, essentially concentrated along the coast, except for commercial fisheries and maritime shipping which are occurring offshore.

Phytoplankton is found at the base of all aquatic food webs. The carrying capacity of marine ecosystems (e.g. diversity, abundance and recruitment) is highly dependent on variations in the abundance, timing and composition of the plankton. Phytoplankton also plays a crucial role in climate change through the export of fixed carbon dioxide during photosynthesis towards the deep oceans. In the EGSL sector, the production of phytoplankton is promoted by the mixing of water masses from both marine and freshwater environments which in turn support the high global biological productivity of the area.

There are ten Ecologically and Biologically Significant Areas (EBSAs) identified by DFO in the EGSL sector (Map 7.1). They are respectively located in western Cape Breton, St. George's Bay, western Northumberland Strait, southern fringe of the Laurentian Channel, south-western coast of the Gulf, lower Estuary, western Anticosti Island, northern Anticosti Island, strait of Belle Isle and west coast of Newfoundland. Essentially, these EBSAs are used as feeding, reproductive and wintering areas as well as migratory corridors by meroplankton, invertebrates, fishes and marine mammals, including special-status species. Among the species observed in this sector are lobster, snow crab, northern shrimp, capelin, Atlantic cod, grey seal, harbour seal, beluga and blue whale.

Most of the Atlantic sea birds use the EGSL for feeding, resting and breeding. Their distribution is a function of the presence of fish (e.g. capelin) on which they feed. In this sector, the highest density for colonial birds is that of the Herring Gull (208,814 couples), while the Snow Goose is the most abundant waterfowl specie (670,113 individuals). In this sector, the most important marine bird concentration areas and colonies are observed along the Gaspesian Peninsula (including Bonaventure Island), the Mingan Islands (Côte-Nord) as well as the Magdalen Islands.

Ice-covered in February and Estuary and Gulf of St. Lawrence Sub-Sectors



Sectors

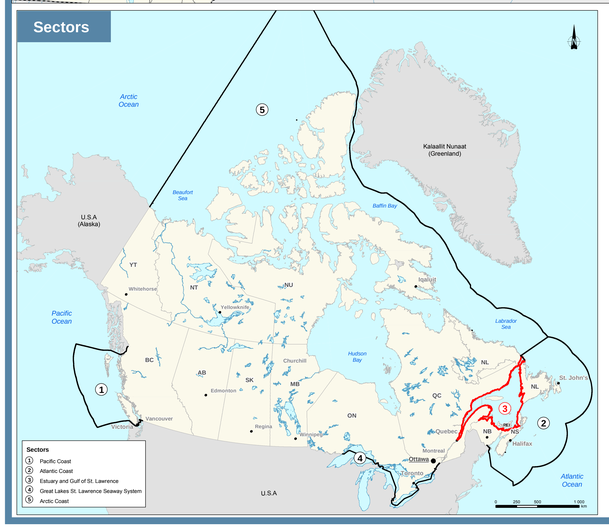


Table 1 Shoreline Types and Distribution

Shoreline Type	Length (km)	Proportion (%)[a]
Bedrock Cliff/Vertical	13,630.7	27.4
Bedrock (platform/ramp/shelf)	5,330.1	10.7
Boulder Beach or Bank	3,532.5	7.1
Man-made Structures	1,853.5	3.7
Marsh	220.2	0.4
Mixed Sediment (Sand, Gravel – Beach or Bank)	6,090.0	12.3
Mud Flat	610.6	1.2
Not Classified	4,530.4	9.1
Pebble/Cobble Beach or Bank	6,332.6	12.8
Salt Marsh	1,950.3	3.9
Sand Beach or Flat	5,014.3	10.1
Sediment Cliff	2.5	< 0.1
Vegetated Bank	9.7	< 0.1
Wetland	556.9	1.1
Total Shoreline in the Estuary and Gulf of St. Lawrence Sector	**49,664,3**	**100,0**

[a] *Rounding and periodicity of several relative abundance values mean that they do not add up to 100%, as evident in this table.*

Source: Environment Canada, 2013

Table 2 Characteristics of Ecologically and Biologically Significant Areas (EBSA)

EBSA	Particular Characteristics
1. Western Cape Breton	• Important aggregation area for meroplankton and demersal fishes. • Migratory corridor (spring and fall) for several demersal fish species, such as cod and white hake. • Summer feeding area for witch flounder and white hake. • Important feeding area for several pelagic fish species (alewife, spiny dogfish, herring, mackerel, capelin, rainbow smelt and silver hake). • High concentration of phytoplankton, zooplankton and invertebrates (brittle stars, starfish, basket stars, hermit crabs, whelks and squid). • Spawning and wintering area for herring. • Reproduction area for grey, hooded and harp seals.
2. St. George's Bay	• Largest array and abundance of meroplanktonic species in the Gulf of St. Lawrence. • Feeding area for several pelagic fish species (alewife, spiny dogfish, herring, mackerel and silver hake). • Nursery and wintering area for juvenile herring. • Only feeding area for butterfish population in the Gulf of St. Lawrence. • Main feeding (summer), spawning and rearing area for white hake in the Gulf of St. Lawrence. • Significant reproductive area (ice-covered) for grey, hooded and harp seals.
3. Western Northumberland Strait	• Presence of an isolated calico crab population in the area where they spend their entire life-cycle. • Large aggregation of winter skate in summer and early fall. • Concentration of several demersal fish species with limited range, such as white hake and windowpane. • Presence of giant scallop beds. • Significant area for marine mammals, such as seals.
4. Southern Fringe of the Laurentian Channel	• Area often used by pelagic and demersal fishes, by several marine mammal species (bottom diving species) and by benthic invertebrates (soft coral, anemones, Icelandic scallop, shortfin squid, lesser bobtail, northern Atlantic octopus, Pasiphaea multidentata shrimp, friendly blade shrimp and deepsea king crab). • Only known wintering area for several demersal fish species, including cod. • Migratory corridor (spring and fall) for cod and white hake. • Summer feeding area for witch flounder and white hake. • Only corridor that connects with the Atlantic Ocean. • Significant area for several species (herring, capelin, ribbon barracudina, spiny dogfish, pollock and silver hake) that serves multiple purposes (feeding ground, refuge). • Aggregation of phytoplankton and zooplankton.
5. South-Western Coast of the Gulf	• Feeding area for several pelagic fish species (herring, capelin, mackerel and American smelt) as well as for many marine mammal species, including harbour seal in the winter. • Unique site for winter skate. • Several herring spawning sites. • Major wintering area (Bay des Chaleurs) for herring juveniles. • Significant rearing area for cod, winter flounder and yellowtail flounder. • Area where the widest array of species and the greatest abundance are found (cod, winter flounder, American plaice, yellowtail flounder, decapod crustaceans). • Aggregation of phytoplankton and invertebrates.
6. Lower Estuary	• Intense primary and secondary production. • Presence of the largest concentrations of juvenile Greenland halibut, witch flounder and thorny skate in the entire Estuary and Gulf of St. Lawrence. • Significant area for marine mammals year-round (e.g. at least a dozen planktivorous and piscivorous species), as well as benthic invertebrates. • Presence of Icelandic scallop beds.
7. Western Anticosti Island	• Important aggregation area for meroplankton and demersal fishes. • High production and accumulation of phytoplankton during spring. • Significant area for producing and maintaining mesozooplankton, in the north-west of the Gulf of St. Lawrence in the lower estuary. • Exceptional area for meroplankton (entire periphery around Anticosti Island). • Important area for the emergence and development of northern shrimp. • Important area for spawning and reproduction of several faunal species. • Feeding area regularly used by more than six marine mammal species, including blue whale.
8. Northern Anticosti Island	• Exceptional area for meroplankton (entire periphery around Anticosti Island). • High concentration of phytoplankton, zooplankton and benthic invertebrates. • Concentration and reproduction area for Greenland halibut juveniles. • Feeding area for several pelagic fish species (capelin and herring) and for more than six marine mammal species, including blue whale.
9. Strait of Belle Isle	• High density of piscivorous marine mammals (at least nine species) during winter. • Capelin abundance. • Unique feeding area for several pelagic fish species (spiny dogfish, herring, sand lance and capelin). • Main spawning site during autumn for herring. • High benthic invertebrate densities, including highest concentration of shrimps. • Concentration and reproduction area for cod (Mecatina trough).
10. West Coast of Newfoundland	• Main concentration area for several demersal fish species, including cod juveniles, redfish, American plaice and Atlantic wolfish. • Main migratory corridor (Esquiman channel) for entire demersal fish populations, including cod and redfish.

Sources: DFO, 2007

Table 3 Important Key Species[a]

Category	Most Numerous Species		Total Number (All Species)
	Name	Number	
Colonial Birds	Herring Gull	9,361,986 couples	11,388,999 couples
Waterfowl	Snow Goose	326,081 ind.[b]	1,707,675 ind.
Shorebirds	Data not complete[c]	Data not complete[c]	-
Special-Status Species (COSEWIC)[d]	Endangered: 5 sp.	Threatened: 0	Special concern: 6 sp.

[a] *All numbers are based on spatial data information provided by CWS to GENIVAR and analysed in this project.*

[b] *A higher estimation for St. Lawrence valley has been estimated (814 000 individuals) in a recent report from CWS (Comité sur la sauvagine du Service canadien de la faune, 2010).*

[c] *Shorebirds counts for Québec so far not provided by CWS.*

[d] *Only birds related to marine environment considered, including Peregrine Falcon and Short-Eared Owl.*

Table 4 Type of Marine and Coastal Protected Area

Protected Area Type	Number	Surface Area (km²)
International Designation		
Important Bird Area	94	3,655.3
NEW BRUNSWICK		
Federal Designation		
Migratory Bird Sanctuary	1	0.2
National Park of Canada	2	240.7
National Wildlife Area	3	10.3
Provincial Designation		
Protected Natural Area	3	4.6
Provincial Park	7	3.8
NEWFOUNDLAND AND LABRADOR		
Federal Designation		
Ecological Reserve	2	33.9
National Park of Canada	1	1,780.4
Provincial Designation		
Provincial Park	4	11.6
NOVA SCOTIA		
Federal Designation		
National Wildlife Area	3	13.5
Provincial Designation		
Wilderness Area	1	277.0
PRINCE EDWARD ISLAND		
Federal Designation		
Marine Protected Area	2	9.2
Migratory Bird Sanctuary	1	2.1
National Park of Canada	1	38.1
Provincial Designation		
Privately Owned Natural Area	8	1.3
Privately Owned Natural Area (Int. & others)	1	0.3
Privately Owned Natural Area (Int.)	9	1.6
Privately Owned Natural Area (NCC PEI Inc.)	1	0.2
Provincial Park	1	3.8
Provincial Wildlife Management Area	8	13.2
Provincially Owned Natural Area	33	16.2
QUEBEC		
Federal Designation		
Migratory Bird Sanctuary	36	356.4
National Park of Canada	3	342.9
National Wildlife Area	5	36.7
Marine Park	1	1,256.7
Provincial Designation		
Provincial Park	2	603.7
Total	**233**	**8,713.7**

Source: Government of Canada, 2013; Environment Canada, 2013

Table 5 Demographic and Economic Overview

Total Coastal Population (2011)	2,107,360 inhabitants
NOVA SCOTIA	
Population	162,090 inhabitants
Urban Centers	Halifax, Sydney and New Glasgow
Key Economic Sectors	Commercial fisheries, forestry and tourism
NEW BRUNSWICK	
Population	542,195 inhabitants
Urban Centers	Saint-John, Moncton and Fredericton
Key Economic Sectors	Forestry, commercial fisheries and tourism
NEWFOUNDLAND AND LABRADOR	
Population	77,570 inhabitants
Urban Centers	St-John's, Mount Pearl and Corner Brook
Key Economic Sectors	Mining and mineral processing, forestry and commercial fisheries
QUEBEC	
Population	1,188,130 inhabitants
Urban Centers	Quebec city, Rimouski, Levis, Sept-Îles
Key Economic Sectors	Energy, tourism and transportation
PRINCE EDWARD ISLAND	
Population	137,375 inhabitants
Urban Centers	Charlottetown, Summerside and Kensington
Key Economic Sectors	Tourism, construction, primary resource-related manufacturing

Source: Statistics Canada, 2013; Canadian Encyclopedia, 2013

Risk Assessment for Marine Spills in Canadian Waters

Phase 1: Oil Spills Risk Assessment

Estuary and Gulf of St. Lawrence Sector 3

0 16.25 32.5 65 97.5 km

January 2014

File: 131_17593_Map7_1_S3_Estuary_St_Lawr_Env_131223.mxd

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Map 7.1

The coastal zone encompasses a number of ecosystems of smaller extent that have particularly high biodiversity as well as high primary and secondary production, and are therefore important for wildlife and humans using these resources (e.g. wetlands, eelgrass beds, etc.). It is also a reproductive, feeding and wintering area for some marine species, such as fish and marine mammals.

7.1.3 Human Features

Although the most productive, the coastal zone ecosystem is exposed to a wide variety of human pressures and uses (e.g. aquaculture, habitat destruction, addition of nutrients and contaminants, maritime shipping and commercial fishing) that pose a significant threat to its ecological integrity and sustainability.

Essentially, the coastal zone of the EGSL sector has several shoreline localities, with important urban centres, such as Moncton (New Brunswick), Corner Brook (Newfoundland and Labrador), Gaspé, Sept-Îles, Baie-Comeau and Rimouski (Quebec) and Charlottetown (Prince Edward Island). The coastal population was approximately 2,107,000 inhabitants in 2011.

The EGSL's key economic sectors are commercial fisheries, tourism, forestry, energy, transportation and mining. The value of commercial fisheries in the EGSL sector is approximately $465 million. The aquaculture is also an important source of capital in the EGSL sector. Shellfish and finfish aquaculture sites are fairly evenly distributed along the coast of Nova Scotia, Prince-Edward-Island, New Brunswick and Quebec. Mussel and oyster cultures are the main source of revenue in the EGSL shellfish industry. Port activities are particularly important in the local economies of Sept-Îles and Port-Cartier. Finally, the tourism industry also plays an important role in employment for certain regions.

Due to high habitat and wildlife diversity in the coastal zone, many areas have been protected by international, federal or provincial regulations. A total of 233 protected areas are present in the EGSL sector, which occupies 8,714 km^2. They include important bird areas (IBAs), marine protected areas, migratory bird sanctuaries, national parks of Canada, national wildlife areas, marine parks, wilderness areas, privately owned natural areas, provincial parks, provincial wildlife management areas and protected natural areas (Map 7.1).

7.2 Vessel Traffic Description

The following description and tables summarize the estimated spill frequency for the EGSL sector and its sub-sectors. Tables 7.1 to 7.3 indicate the potential spill frequency for each of the three oil types (crude oil cargo, refined oil cargo, and oil carried as fuel), for each of the spill size ranges considered, with a breakdown per sub-sector and zone (nearshore, intermediate and deep-sea). Summary maps indicate the combined frequency for all spill sizes and zone per oil type (Map 7.2).

The summary tables are presented with frequency as “return periods”, or average number of years between events.

Compared to other sectors of the country, there is a modest PSF with regards to spills of crude oil from cargo, with lost significant in the sector in sub-sectors 1, 2, and 3. For spills of refined product cargo, the PSFs in sub-sectors 1, 2, 3, and 6 are among the highest in the country.

Similarly, for spills of fuel, the PSFs of sub-sectors 1, 2, 3, and 6 are amongst the highest in the country, reflecting the high marine traffic in the sector; sub-sector 4 also has a significant PSF in this regard.

7.3 Overall Risk Results

The Environmental Risk Index (ERI) has been calculated for each oil type (crude oil, refined products and fuel), along a gradient of spill volumes (4 classes from 10 to 10,000 m^3). The following maps illustrate ERI values according to five categories of risk (from very low to very high). The definition of the categories involves a natural break calculation using ArcGIS (Table 7.4). Based on this method, class breaks are chosen in function of the best grouping of similar values and in order to maximize the differences between classes. A detailed map was produced for each zone and the following sub-sections provide an overview of the ERI results for each map.

Table 7.1 Cargo Crude Return Periods.

Sub-sector	Cargo Crude Return Periods (years)											
	Nearshore Zone (0-12 nm)				Intermediate Zone (12-24 nm)				Deep-sea Zone (24-200 nm)			
	S[a]	M[a]	L[a]	XL[a]	S[a]	M[a]	L[a]	XL[a]	S[a]	M[a]	L[a]	XL[a]
1	2,223	3,320	2,475	11,622	2,858	4,269	3,182	14,942	5,002	7,471	5,569	26,148
2	2,223	3,320	2,475	11,622	2,858	4,269	3,182	14,942	5,002	7,471	5,569	26,148
3	2,223	3,320	2,475	11,622	2,858	4,269	3,182	14,942	5,002	7,471	5,569	26,148
4	6,936	10,358	7,721	36,254	8,917	13,318	9,927	46,613	15,605	23,306	17,372	81,572
5	4,884,603	7,295,187	5,437,616	25,533,153	6,280,204	9,379,526	6,991,220	32,828,339	10,990,357	16,414,170	12,234,636	57,449,594
6	3,270	4,884	3,640	17,093	4,204	6,279	4,680	21,977	7,357	10,988	8,190	38,459
7	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-

a Spill size ranges: S = 10.0 to 99.9 m^3; M = 100.0 to 999.9 m^3; L = 1,000.0 to 9,999.9 m^3; XL = ≥ 10,000 m^3.

Table 7.2 Cargo Refined Return Periods.

Sub-sector	Cargo Refined Return Periods (years)											
	Nearshore Zone (0-12 nm)				Intermediate Zone (12-24 nm)				Deep-sea Zone (24-200 nm)			
	S[a]	M[a]	L[a]	XL[a]	S[a]	M[a]	L[a]	XL[a]	S[a]	M[a]	L[a]	XL[a]
1	65	393	1,659	-	84	505	2,133	-	147	884	3,732	-
2	65	390	1,649	-	84	502	2,120	-	146	879	3,710	-
3	66	396	1,673	-	85	510	2,151	-	149	892	3,765	-
4	207	1,240	5,235	-	266	1,594	6,730	-	465	2,789	11,778	-
5	1,523	9,138	38,585	-	1,958	11,749	49,609	-	3,427	20,561	86,816	-
6	82	493	2,083	-	106	634	2,678	-	185	1,110	4,686	-
7	16,334	98,004	413,813	-	21,001	126,006	532,045	-	36,752	220,510	931,079	-
8	1,277	7,662	32,351	-	1,642	9,851	41,594	-	2,873	17,239	72,790	-

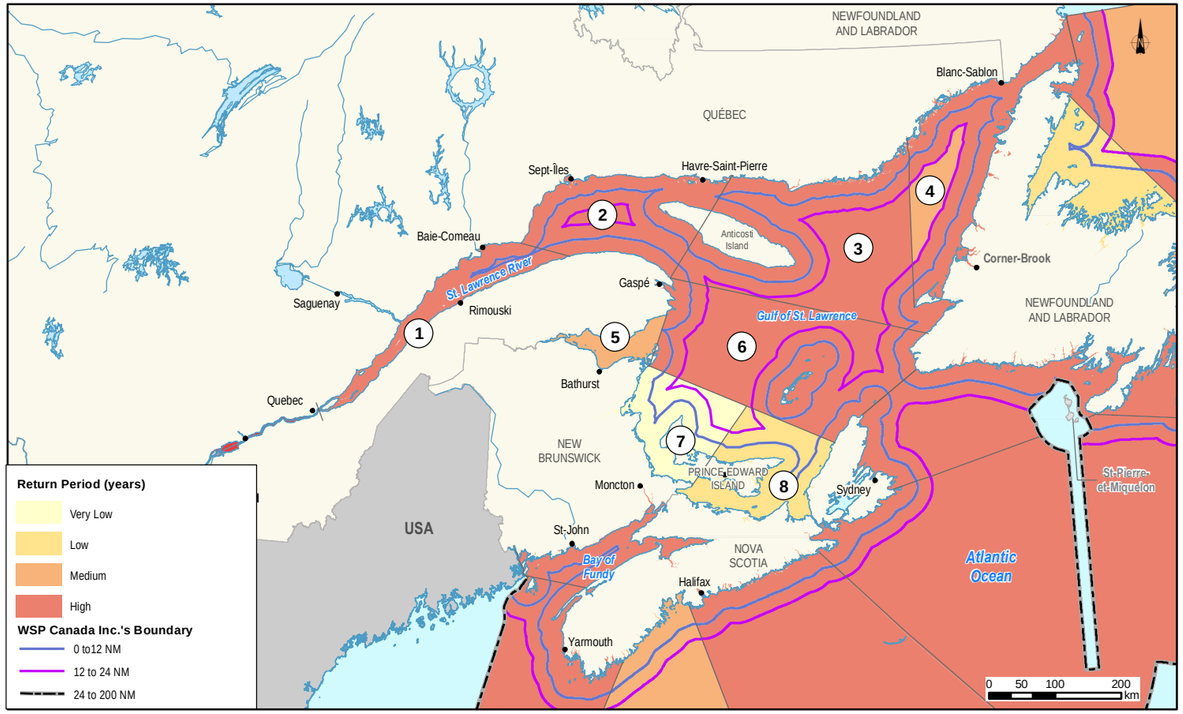
a Spill size ranges: S = 10.0 to 99.9 m^3; M = 100.0 to 999.9 m^3; L = 1,000.0 to 9,999.9 m^3; XL = ≥ 10,000 m^3.

Table 7.3 Fuel Return Periods

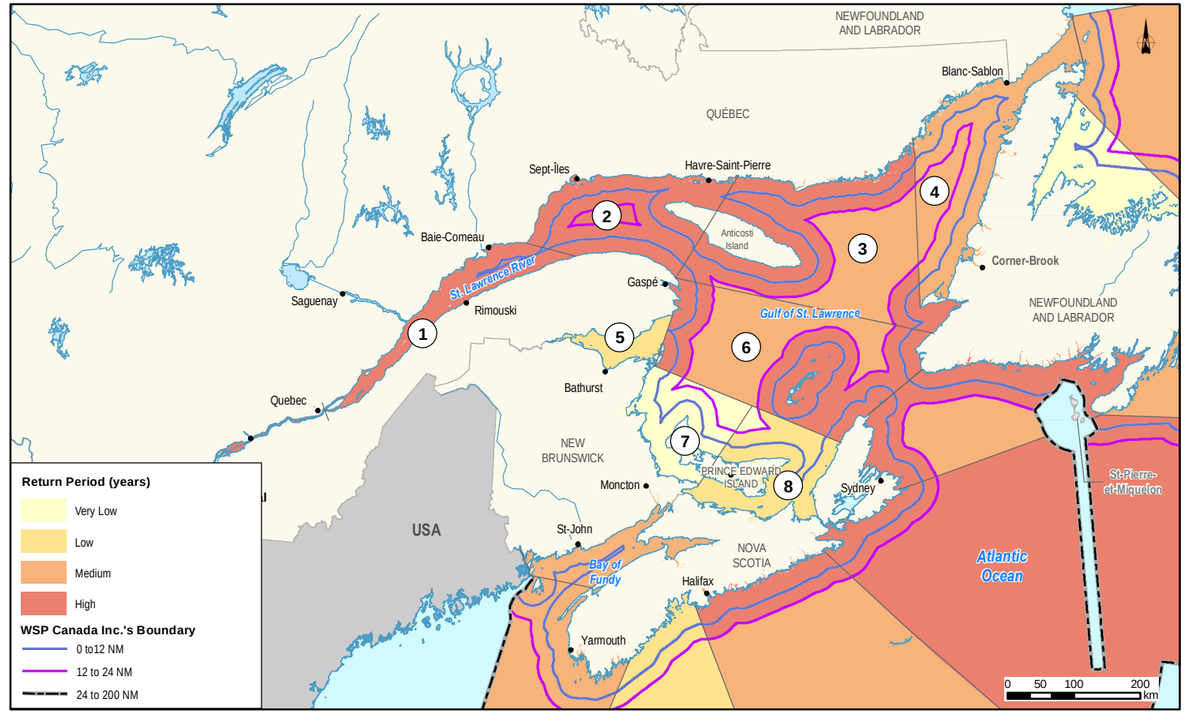
Sub-sector	Fuel Return Periods (years)											
	Nearshore Zone (0-12 nm)				Intermediate Zone (12-24 nm)				Deep-sea Zone (24-200 nm)			
	S[a]	M[a]	L[a]	XL[a]	S[a]	M[a]	L[a]	XL[a]	S[a]	M[a]	L[a]	XL[a]
1	12	39	3,596	-	16	50	4,623	-	28	87	8,091	-
2	15	47	4,384	-	19	61	5,637	-	34	106	9,864	-
3	17	55	5,115	-	22	71	6,577	-	39	124	11,509	-
4	68	214	19,907	-	87	276	25,594	-	152	482	44,790	-
5	700	2,216	205,859	-	900	2,849	264,676	-	1,575	4,986	463,183	-
6	23	73	6,753	-	30	93	8,683	-	52	164	15,195	-
7	147,662	467,596	43,436,237	-	189,851	601,195	55,846,590	-	332,239	1,052,092	97,731,532	-
8	5,274	16,700	1,551,294	-	6,780	21,471	1,994,521	-	11,866	37,575	3,490,412	-

a Spill size ranges: S = 10.0 to 99.9 m^3; M = 100.0 to 999.9 m^3; L = 1,000.0 to 9,999.9 m^3; XL = ≥ 10,000 m^3.

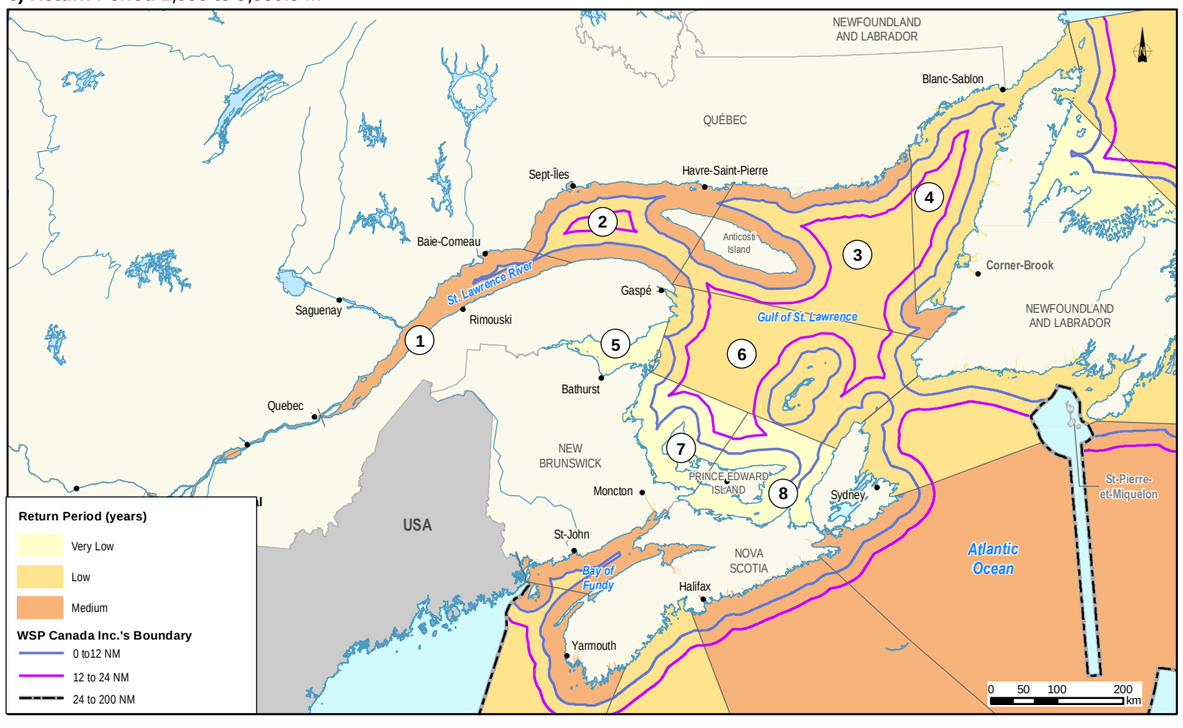
a) Return Period 10 to 99.9 m^3



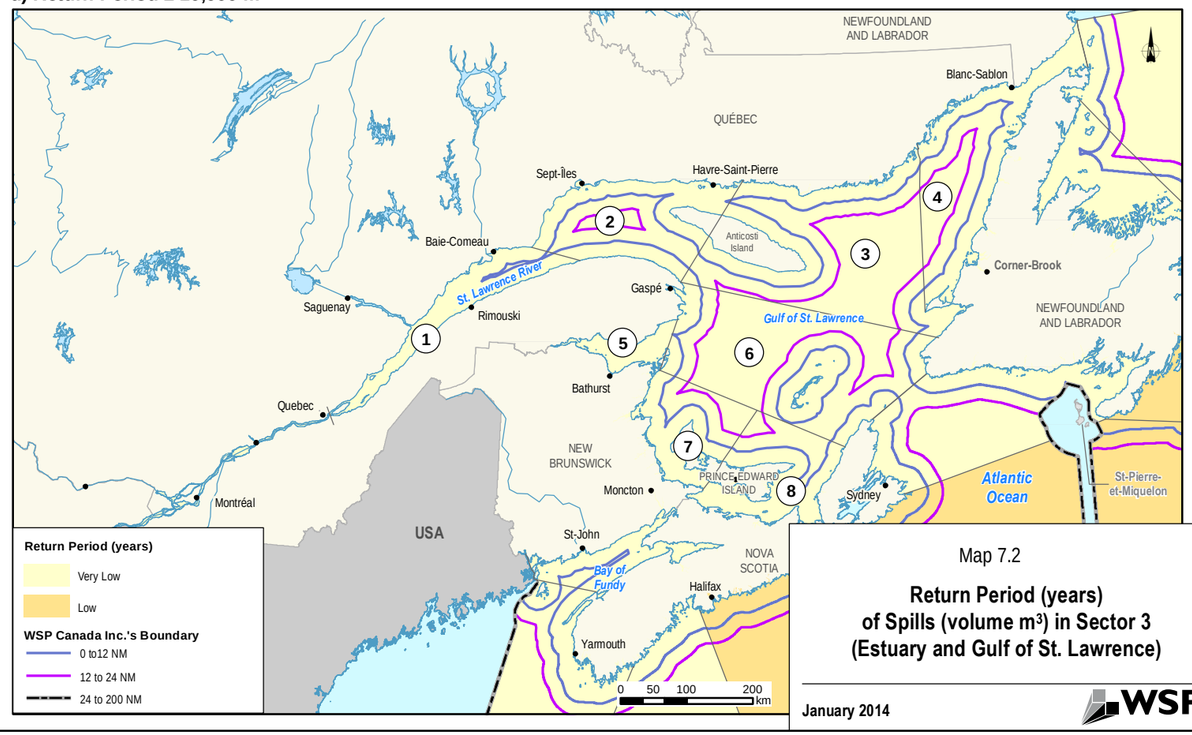
b) Return Period 100 to 999.9 m^3



c) Return Period 1,000 to 9,999.9 m^3



d) Return Period ≥ 10,000 m^3



Map 7.2

Return Period (years) of Spills (volume m^3) in Sector 3 (Estuary and Gulf of St. Lawrence)

January 2014

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Table 7.4 Class Breakdown to Determine Environmental Risk Index (ERI) Classes.

ERI Class	Natural Breakdown			
	10-99.9 m^3	100-999.9 m^3	1,000-9,999 m^3	≥ 10,000 m^3
Crude Oil				
Very High	134.8 to 347.6	628.3 to 1,221.6	8,601.2 to 37,798.7	3,727.1 to 9,613.1
High	62.1 to 134.8	366.5 to 628.3	3,482.9 to 8,601.2	1,718.4 to 3,727.1
Medium	28.3 to 62.1	169.7 to 366.5	1,537.5 to 3,482.9	783.0 to 1,718.4
Low	10.1 to 28.3	49.3 to 169.7	449.6 to 1,537.5	278.1 to 783.0
Very Low	0.0 to 10.1	0.0 to 49.3	0.0 to 449.6	0.0 to 278.1
Refined Oil				
Very High	4,608.7 to 58,806.7	735.0 to 2,346.9	932.1 to 1,535.2	7,895,456.7 to 23,298,700.7
High	794.3 to 4,608.7	267.2 to 735.0	336.4 to 932.1	3,004,643.6 to 7,895,456.7
Medium	305.5 to 794.3	130.0 to 267.0	132.2 to 336.4	1,238,071.0 to 3,004,643.6
Low	105.4 to 305.5	49.8 to 130.0	33.3 to 132.2	0.0 to 1,238,071.0
Very Low	0.0 to 105.4	0.0 to 49.8	0.0 to 33.3	0.0 to 0.0
Fuel Oil				
Very High	4,201.6 to 12,771.6	15,242.0 to 25,008.8	939.8 to 1,583.4	0.0 to 0.0
High	1,208.2 to 4,201.6	4,839.3 to 15,242.0	398.8 to 939.8	0.0 to 0.0
Medium	468.1 to 1,208.2	2,002.4 to 4,839.3	122.0 to 398.8	0.0 to 0.0
Low	155.3 to 468.1	685.5 to 2,002.4	41.4 to 122.0	0.0 to 0.0
Very Low	0.0 to 155.3	0,0 to 685.5	0,0 to 41.4	0.0 to 0.0

7.3.1 Crude Oil Environmental Risk Index

7.3.1.1 10 to 99.9 m^3 and ≥ 10,000 m^3 Oil Spill Sizes

Based on the ERI results illustrated on Map 7.3 (a and d) for 10 to 99.9 m^3 and for 10,000 m^3 and greater oil spill sizes, the following observations can be made:

- The highest ERIs values are observed in the nearshore and intermediate zones of the estuary (sub-sectors 1 and 2) as well as in the nearshore and intermediate zones of the Basse-Côte-Nord, including Anticosti Island (sub-sector 3). Overall, these zones have the highest volume values in the region as well as one of the highest in Canada (e.g. Sept-Îles port and only access point to the St. Lawrence Seaway system). In addition, these zones show a very high environmental sensitivity (ESI) explained by several variables, such as a high surface area of the coastal zone, an intense primary and secondary production, a high number of significant areas for marine mammals all throughout the year (influencing the BRI) as well as by the importance of the freight tonnage in these zones economy (influencing the HRI).

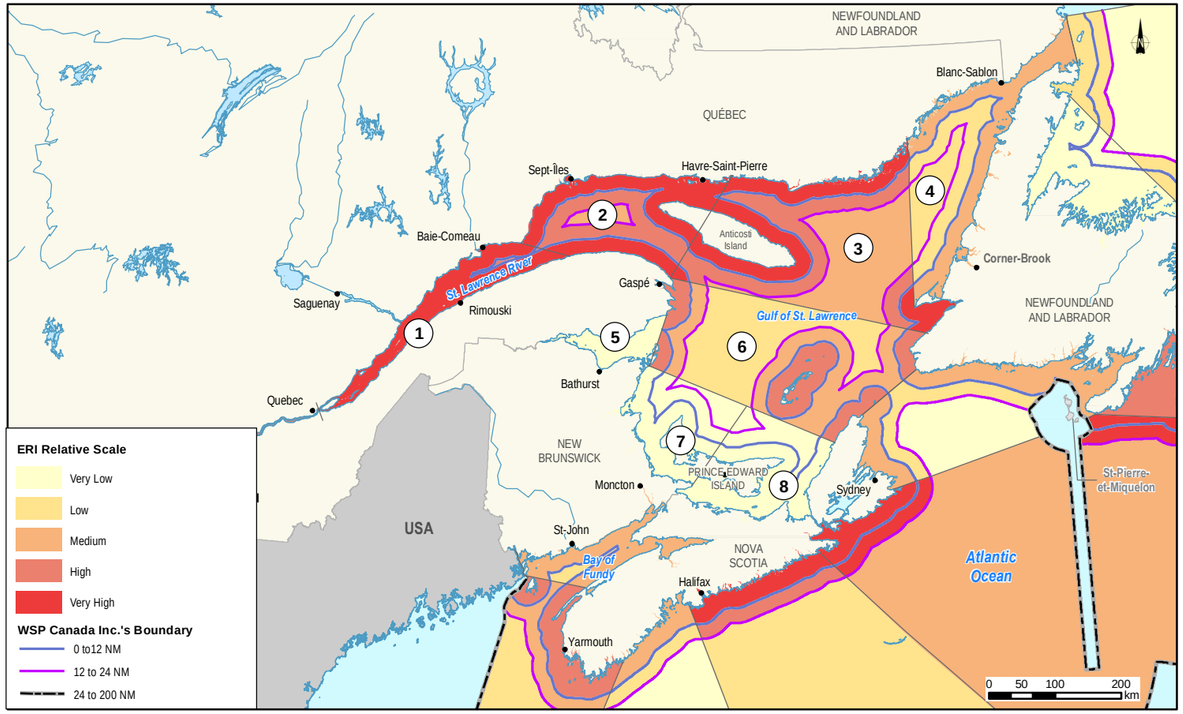
- The nearshore zone of sub-sector 6 shows a high ERI. The presence of the Laurentian Channel – the main EGSL seaway – explains the high volume of crude oil transported in this zone (influencing the spill frequency). In addition, this zone also shows a very high ESI explained by several variables, such as the complete ice-cover during winter, the presence of wetlands and eelgrass beds (influencing the PSI), the significant area for several fish species that serves multiple purposes (feeding ground, refuge), the concentration area for leatherback turtle and marine birds (influencing the BRI) as well as the importance of the tourism and the commercial fishery industries in this zone's economy (influencing the HRI).
- Sub-sector 4 shows a medium ERI for its nearshore zone. The medium spill frequency observed in this zone can be explained by the lower use of the Belle Isle Strait to transport crude oil. However, the ESI for the nearshore zone of sub-sector 4 is very high as a result of high or very high PSI, BRI and HRI values.
- The other EGSL sub-sectors (5, 7 and 8) show a very low ERI. Although the ESIs vary from medium to very high in these sub-sectors, the spill frequencies are very low as the crude oil volume transported is either very low or inexistent.

7.3.1.2 100 to 999 m^3 Oil Spill Size

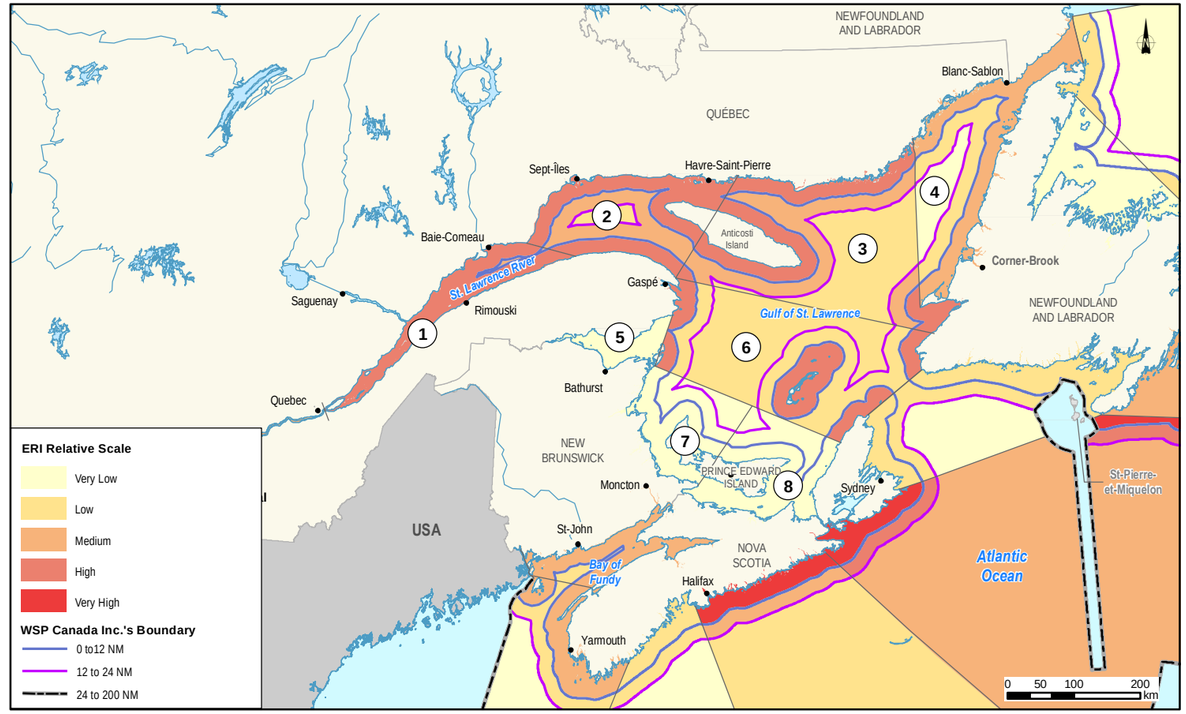
Map 7.3b allows for the following observations:

- There are no very high ERI values in the EGSL sector for the 100 to 999 m^3 oil spill size.
- The nearshore zone of the estuary (sub-sectors 1 and 2), the Basse-Côte-Nord, including Anticosti Island (sub-sector 3), as well as the nearshore zone of the sub-sector 6 (including Magdalen Islands) show a high ERI value. Although these zones have the highest spill frequency in the EGSL sector, these frequencies are less important than those observed in others sectors (e.g. Pacific and Atlantic). The ESI is very high, which is explained by several variables, such as a high surface area of the coastal zone, an intense primary and secondary production, a high number of significant areas for marine mammals all throughout the year (influencing the BRI) as well as the importance of the freight tonnage in these zones' economy (influencing the HRI).
- The nearshore zone of sub-sector 4 has a medium ERI. The medium spill frequency in this zone is explained by the lower use of the Belle Isle Strait to transport crude oil. However, the ERI value is also influenced by the very high value of the ESI caused by high or very high PSI, BRI and HRI values.

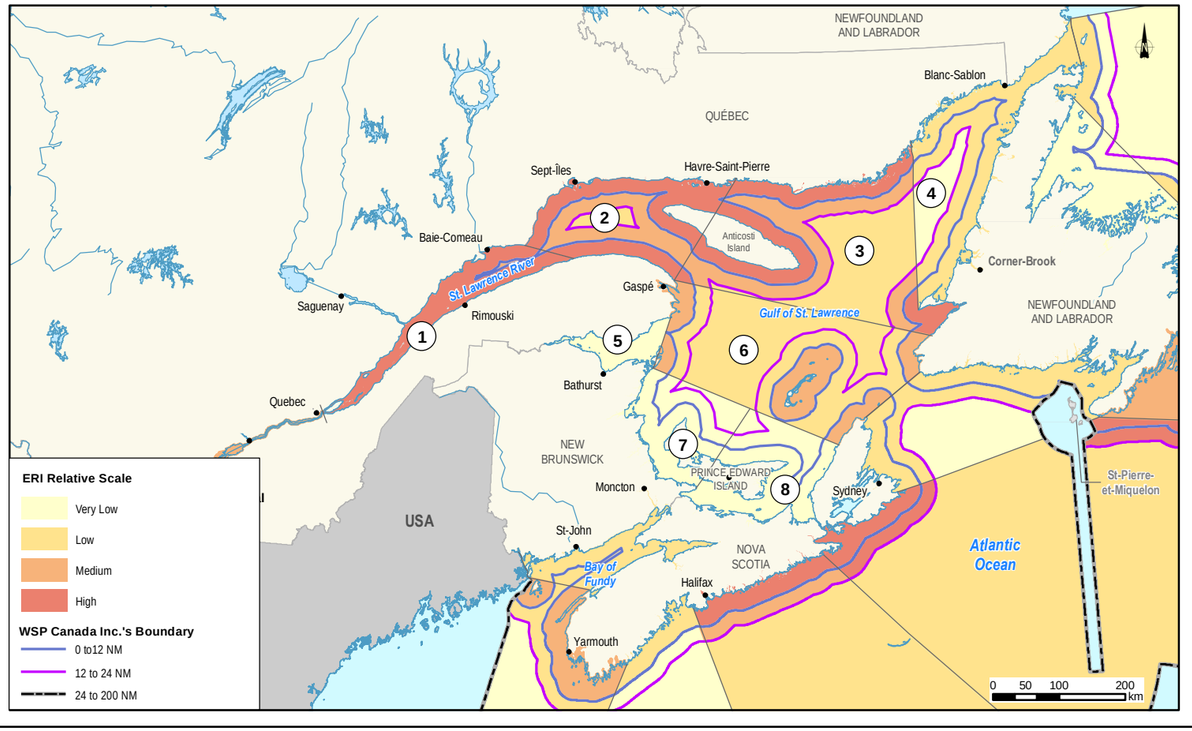
a) Spill Volume 10 to 99.9 m^3



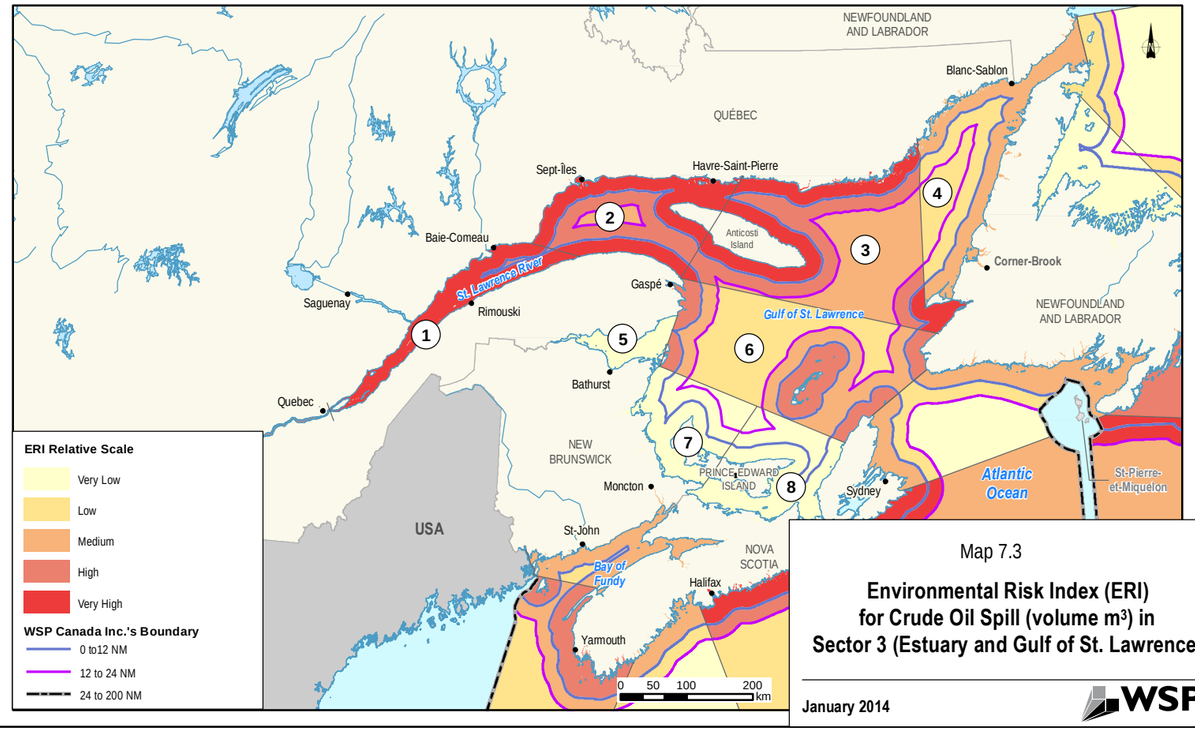
b) Spill Volume 100 to 999.9 m^3



c) Spill Volume 1,000 to 9,999.9 m^3



d) Spill Volume ≥ 10,000 m^3



Map 7.3

Environmental Risk Index (ERI) for Crude Oil Spill (volume m^3) in Sector 3 (Estuary and Gulf of St. Lawrence)

January 2014

WSP

File: 131_17593_c7.3_Cargo_Crude_Estuary_131223.mxd

- The other EGSL sub-sectors, including nearshore, intermediate and deep-sea zones, show ERI values which vary from low to very low. These results illustrate that these sub-sectors are less in use to transport 100 m^3 crude oil than other Canadian sub-sectors.

7.3.1.3 1,000 to 9,999 m^3 Oil Spill Size

Map 7.3c allows for the following observations:

- There are no very high ERI values in the EGSL sector for the 1,000 to 9,999 m^3 oil spill size.
- The nearshore zone of the estuary (sub-sectors 1 and 2) and the Basse-Côte-Nord, including Anticosti Island (sub-sector 3), has a high ERI value. Although these zones show the highest spill frequency in the EGSL sector, these frequencies are less important than those observed in other sectors (e.g. Pacific and Atlantic). The ESI is very high, which can be explained by several variables, such as a high surface area of the coastal zone, an intense primary and secondary production, a high number of significant areas for marine mammals all throughout the year (influencing the BRI) as well as the importance of the freight tonnage in these sub-sectors' economy (influencing the HRI).
- The nearshore zone of sub-sector 6 has a medium ERI value. Although this sub-sector features the Laurentian Channel, its spill frequency is moderate in comparison with the spill frequencies calculated in the Atlantic and the Pacific coasts. However, the ERI value is also influenced by a very high ESI resulting from high or very high PSI, BRI and HRI values.
- The other EGSL sub-sectors, including nearshore, intermediate and deep-sea zones, show ERI values which vary from low to very low. These results confirm that the ERI is less high for a 1,000 m^3 crude oil spill than in other sectors of Canada.

7.3.2 Refined Crude Environmental Risk Index

7.3.2.1 10 to 99.9 m^3 Oil Spill Size

Map 7.4a highlights the following observations:

- The highest ERIs values (high risk level) are observed in the nearshore zones of sub-sectors 1, 2, 3 and 6, due to the high spill frequency in these zones. Higher frequency values indicate larger volumes of refined oil traffic which increases the risks of spills in the area. Moreover, these zones show very high ESI values as a

result of very high and high PSI, BRI and HRI scores, which can be explained by the large surface area of the coastal zone, the intense primary and secondary production, the significant areas for marine mammals year-round as well as the importance of the freight tonnage in these zones' economy.

- The nearshore zones of sub-sector 4, the intermediate zones of sub-sectors 2, 3 and 6 all show medium ERI values. The medium ERI is caused by high frequencies combined with lower ESI values.
- The other EGSL zones show very low ERI scores. The spill frequencies are very low in comparison to the other Canadian zones.

7.3.2.2 100 to 999.9 m^3 Oil Spill Size

Map 7.4b presents the ERI values for the EGSL sector and their analysis allows for the following observations:

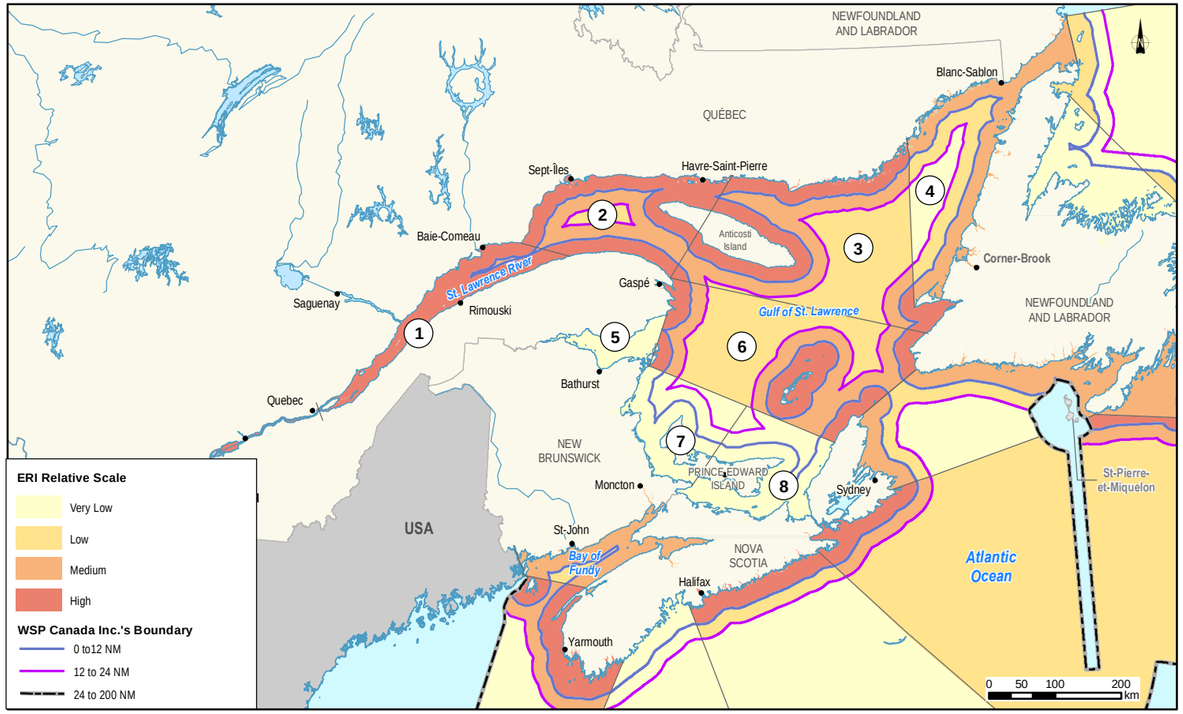
- Very high or high ERI values are present in the nearshore and intermediate zones of the estuary (sub-sectors 1 and 2), the nearshore and intermediate zones of the Basse-Côte-Nord (including Anticosti Island) (sub-sector 3), the nearshore and intermediate zones of sub-sector 6 (including Magdalen Islands) and the nearshore zone of sub-sector 4. These values are due to high spill frequency in these zones, as well as the very high ESI due to some sensitive physical, biological and human components.
- The deep-sea zones of sub-sectors 3 and 6 have medium ERIs. These zones are located east and south of Anticosti Island. Despite a low ESI, the medium risk is the result of elevated spill frequencies in these zones.
- ERI ranges from low to very low in all other zones within the sector.

7.3.2.3 1,000 to 9999.9 m^3 Oil Spill Size

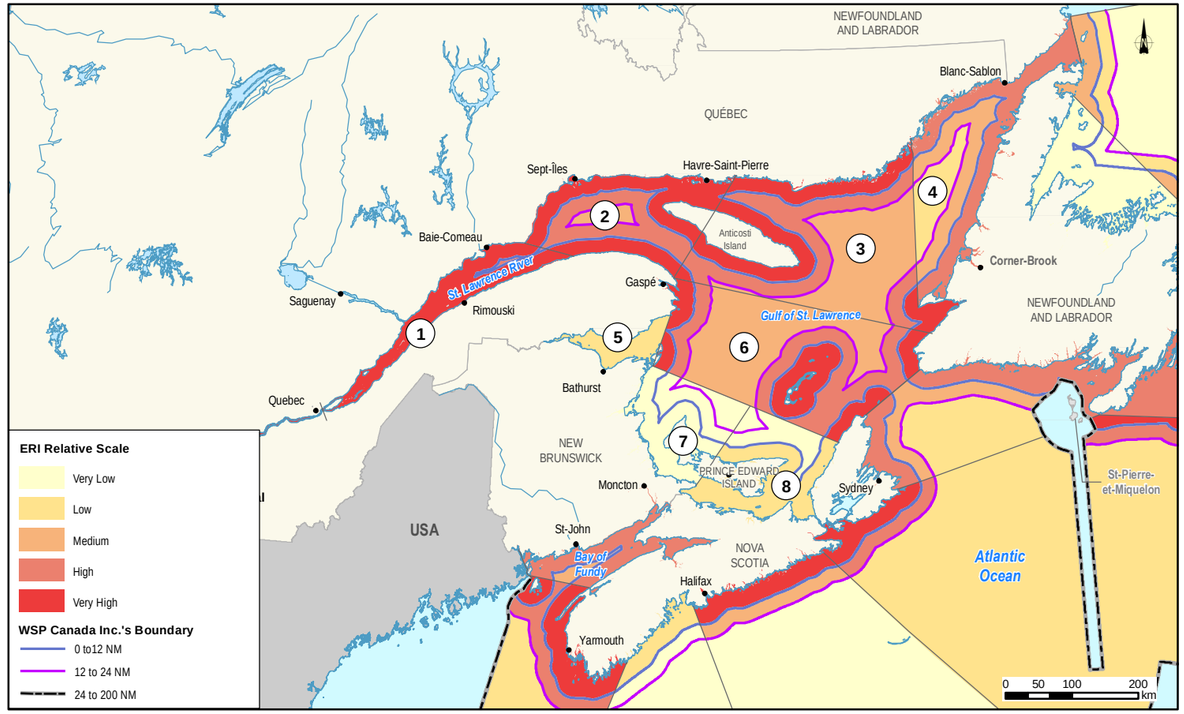
The Map 7.4c permits the following observations:

- All the EGSL zones show low or very low ERI values. Despite the high or very high ESI scores in most of the zones, the spill frequencies are very low since the refined oil volume transported in this sector is consequently very low or inexistent.

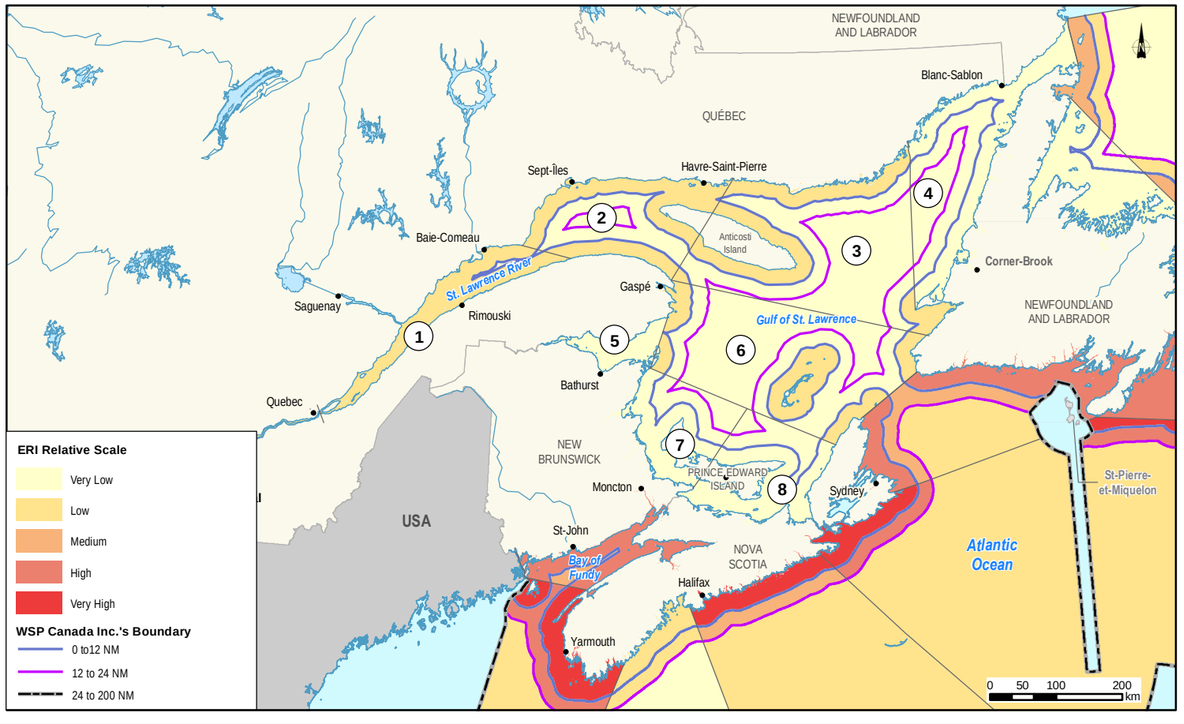
a) Spill Volume 10 to 99.9 m^3



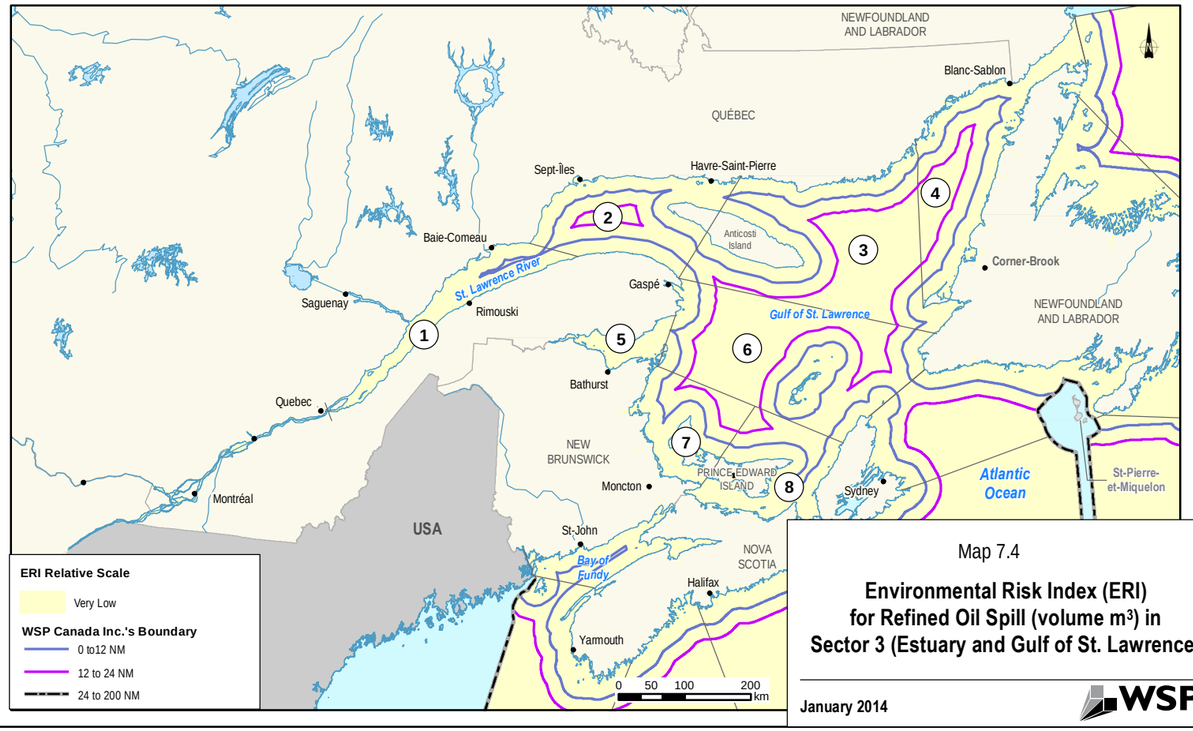
b) Spill Volume 100 to 999.9 m^3



c) Spill Volume 1,000 to 9,999.9 m^3



d) Spill Volume ≥ 10,000 m^3



Map 7.4

Environmental Risk Index (ERI) for Refined Oil Spill (volume m^3) in Sector 3 (Estuary and Gulf of St. Lawrence)

January 2014

WSP

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7.3.2.4 ≥ 10,000 m^3 Oil Spill Size

Map 7.4d allows for the following observations:

- All the EGSL zones show very low ERI values. Despite a high or very high ESI in most of the zones, the spill frequencies calculated are worthless. As a safety precaution (principle of sustainable development), a very low ERI has been given for this scenario.

7.3.3 Fuel Environmental Risk Index

7.3.3.1 10 to 99.9 m^3 Oil Spill Size

Based on the ERI results illustrated on Map 7.5a, the following observations can be made:

- The highest ERIs values are observed in the nearshore and intermediate zones of the estuary (sub-sectors 1 and 2), in the Basse-Côte-Nord (including Anticosti Island) (sub-sector 3), in sub-sector 6 (including Magdalen Islands) as well as in the nearshore zone of sub-sector 4. Overall, these zones have the highest vessel traffic in the sector as well as one of the highest in Canada (e.g. Sept-Îles port, Laurentian Channel and only access to the St. Lawrence Seaway system). In addition, these zones show a very high ESI explained by several variables, such as the large coastal zone, the intense primary and secondary production, the high number of significant areas for marine mammals year-round (influencing the BRI) as well as the importance of the freight tonnage in these zones economy (influencing the HRI).
- The deep-sea zones of sub-sectors 3 and 6 have medium ERIs. These zones are located east and south of Anticosti Island. Despite a low ESI, the medium risk results from elevated spill frequencies in these zones.
- The other EGSL sub-sectors (5, 7 and 8) show a low or a very low ERI. Although the ESIs vary from medium to very high in these sub-sectors, the spill frequencies are very low given that the fuel oil traffic is lower than in other Canadian sub-sectors.

7.3.3.2 100 to 9,999 m^3 Oil Spill Size

Map 7.5 (b and c) presents the ERI values for the EGSL sector and their analysis allows for the making of the following observations:

- There are no very high ERI values in the EGSL sector for the 100 to 9,999 m^3 fuel spill size.

- The nearshore zone of the estuary (sub-sectors 1 and 2), the Basse-Côte-Nord, including Anticosti Island (sub-sector 3), as well as the nearshore zone of sub-sector 6 (including Magdalen Islands) have a high ERI value. Although these zones show the highest traffic frequency in the EGSL sector, these frequencies are less important than those observed in the others zones. The ESI is very high, which can be explained by several variables, such as the large coastal zone, the intense primary and secondary production, the high number of significant areas for marine mammals year-round (influencing the BRI) as well as the importance of the freight tonnage in these zones' economy (influencing the HRI).
- The nearshore zone of sub-sector 4 has a medium ERI. The medium frequency observed in this zone can be explained by the lower use of the Belle Isle Strait to transport fuel oil. However, the ERI value is also influenced by the very high ESI score caused by high or very high PSI, BRI and HRI values.
- The other EGSL sub-sectors, including nearshore, intermediate and deep-sea zones, show ERI values which vary from low to very low. These results confirm that these sub-sectors are less used to transport 100 to 9,999 m^3 fuel oil than other Canadian sub-sectors.

7.3.3.3 ≥ 10,000 m^3 Oil Spill Size

Map 7.5d permits the following observations:

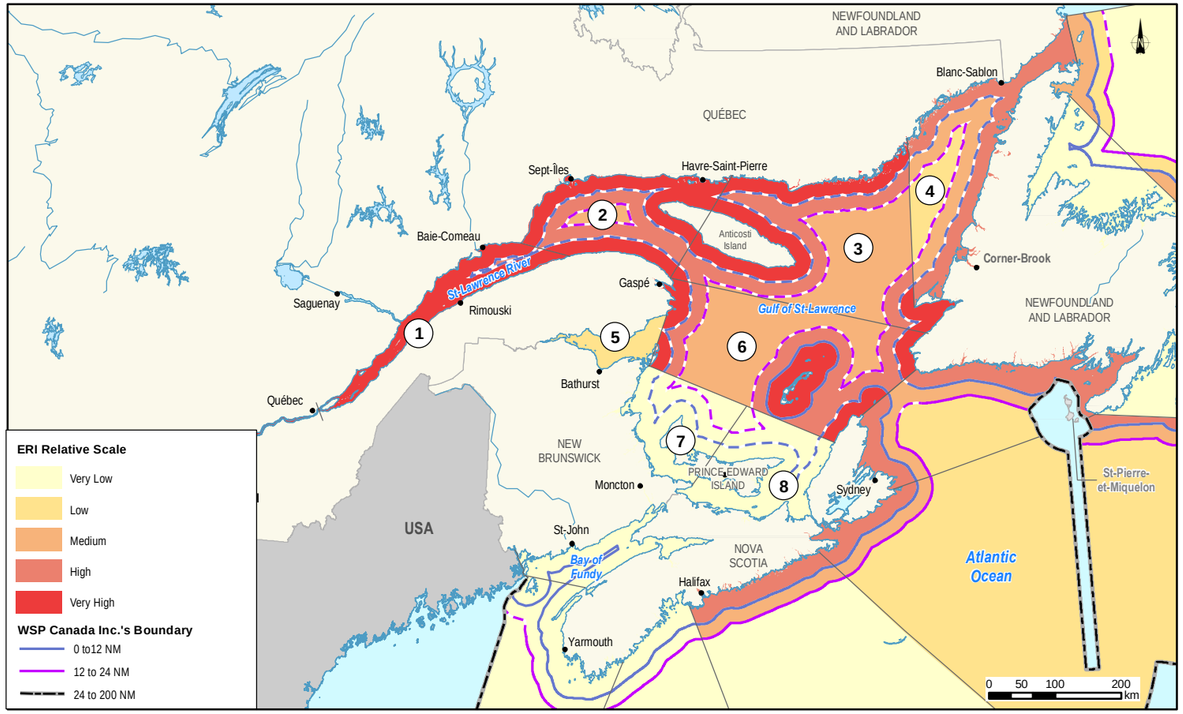
- All the EGSL sub-sectors show very low ERI values. Despite a high or very high ESI in most of the sub-sectors, the spill frequencies calculated are very small. As a safety precaution (principle of sustainable development), a very low ERI has been given to this scenario.

7.3.4 Environmental Sensitivity Index (ESI)

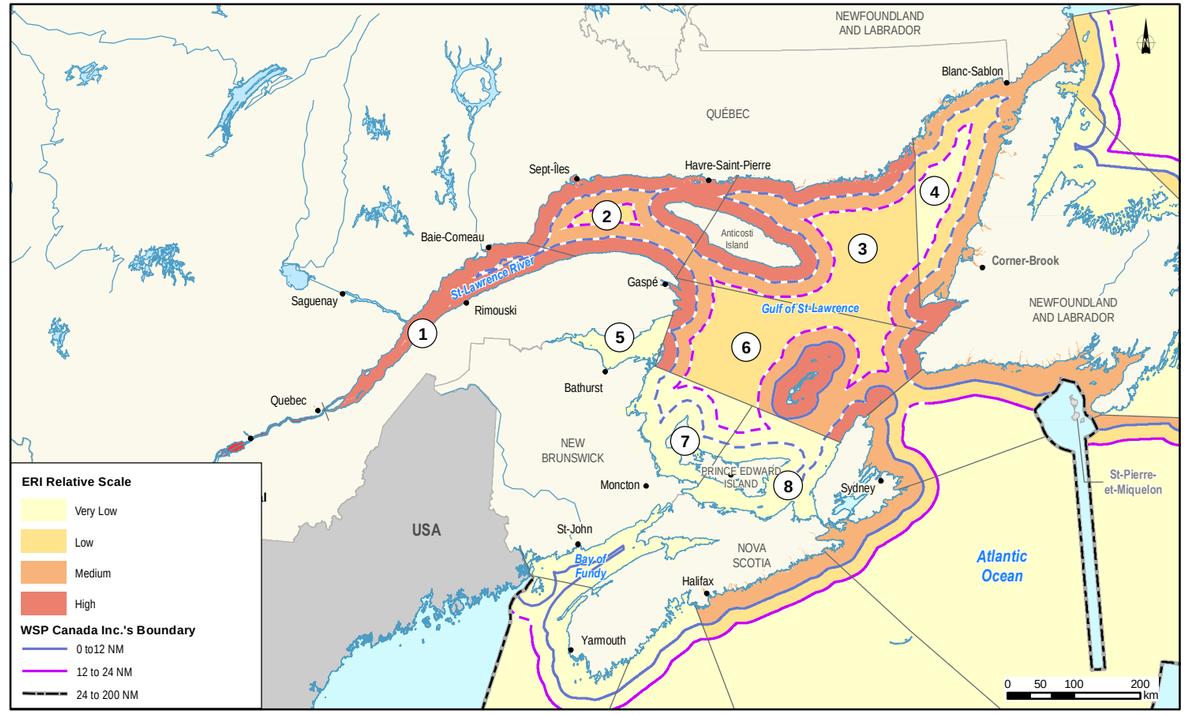
In addition to the very high and high ERI zones, there are several sensitive zones in the EGSL sector which may be affected by future increase in volumes (Map 7.6; Appendix 2 – Map C).

The nearshore zone and the intermediate zone of the entire EGSL sector show a very high or high ESI. The EGSL is a semi-enclosed sea and offers particular physical and biological conditions which increase the biological productivity of the area. The importance of the coastal zone for many biological functions (reproduction, feeding and wintering), the presence of large-scale EBSAs as well as many bird colonies and marine bird concentrations are also key features of this sector.

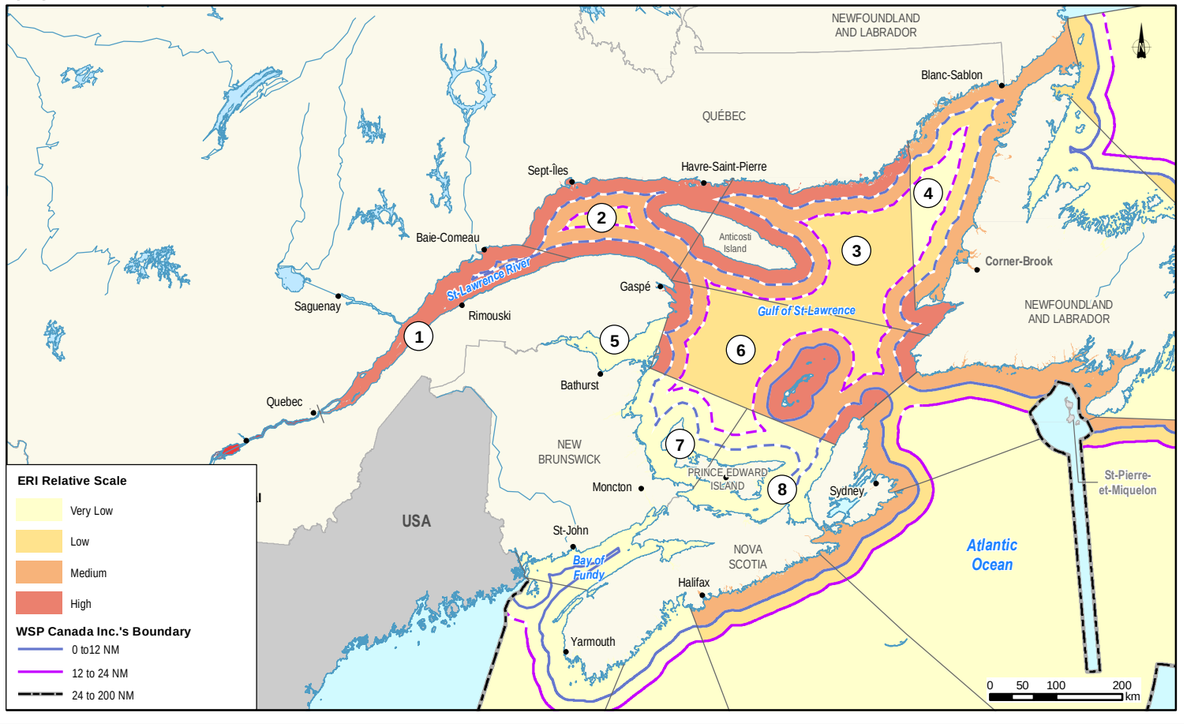
a) Spill Volume 10 to 99.9 m^3



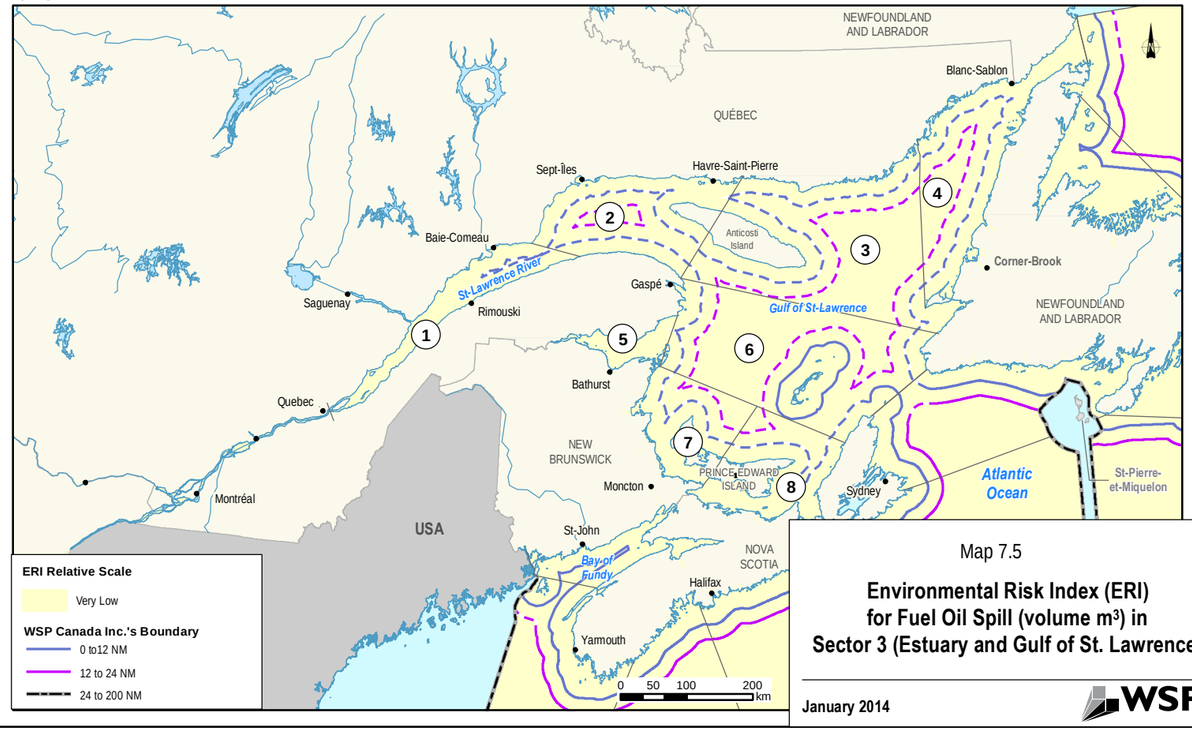
b) Spill Volume 100 to 999.9 m^3



c) Spill Volume 1,000 to 9,999.9 m^3



d) Spill Volume ≥ 10,000 m^3



Map 7.5

Environmental Risk Index (ERI) for Fuel Oil Spill (volume m^3) in Sector 3 (Estuary and Gulf of St. Lawrence)

January 2014

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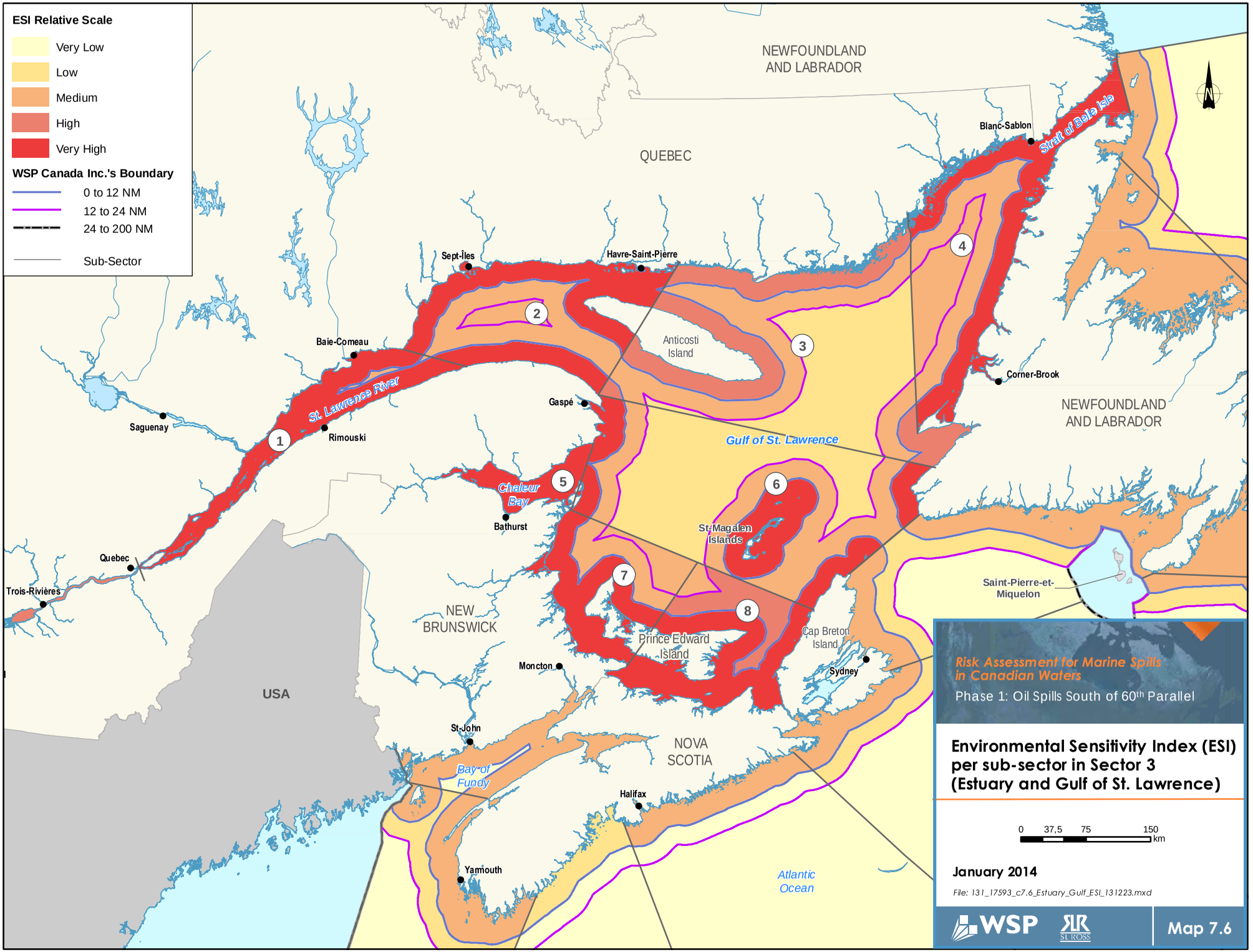
ESI Relative Scale
Very Low
Low
Medium
High
Very High
WSP Canada Inc.'s Boundary
0 to 12 NM
12 to 24 NM
24 to 200 NM
Sub-Sector
NEWFOUNDLAND AND LABRADOR
QUEBEC
NEW BRUNSWICK
NOVA SCOTIA
USA
Prince Edward Island
Cap Breton Island
Anticosti Island
St-Magalen Islands
Saint-Pierre-et-Miquelon
Gulf of St. Lawrence
St. Lawrence River
Chaleur Bay
Bay of Fundy
Atlantic Ocean
Strait of Belle Isle
Blanc-Sablon
Sept-Îles
Havre-Saint-Pierre
Baie-Comeau
Gaspé
Rimouski
Saguenay
Quebec
Trois-Rivières
Bathurst
Moncton
St-John
Halifax
Yarmouth
Corner-Brook
Sydney
1
2
3
4
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6
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8
N
Risk Assessment for Marine Spills in Canadian Waters
Phase 1: Oil Spills South of 60th Parallel
Environmental Sensitivity Index (ESI) per sub-sector in Sector 3 (Estuary and Gulf of St. Lawrence)
0 37,5 75 150
km
January 2014
File: 131_17593_c7.6_Estuary_Gulf_ESI_131223.mxd
WSP
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Map 7.6

8. GREAT LAKES/ST. LAWRENCE SEAWAY SYSTEM

8.1 Sector Description

The Great Lakes are the world's largest freshwater ecosystem, containing close to 20% of the world's fresh surface water (Map 8.1). Created by glacial erosion, the Great Lakes water is a key resource supporting unique ecosystems and providing significant services to the surrounding population. All Great Lakes share a boundary between Canada and the USA with the exception of Lake Michigan (entirely in the USA). As a consequence, care and management of the Great Lakes is shared between the Canadian and American governments, with the assistance of the bi-national International Joint Commission (IJC).

In this study, the Great Lakes/St. Lawrence Seaway System sector was divided into five sub-sectors that are the four Great Lakes located within the Canadian boundaries (Lake Superior, Huron, Erie and Ontario) and the St. Lawrence River. It is important to note that only Canadian waters within these lakes have been considered for the aim of this study.

8.1.1 Physical Features

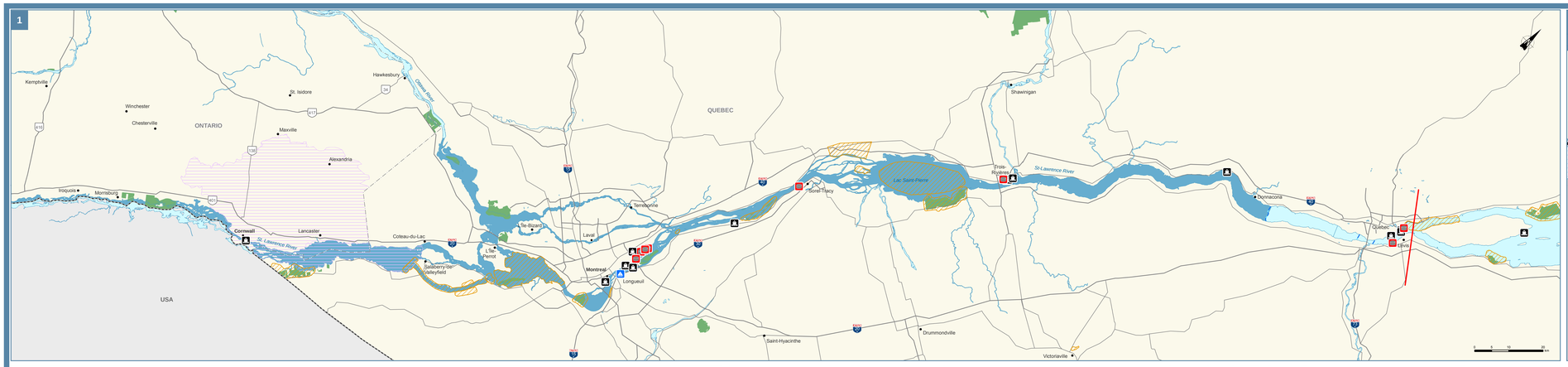
The Great Lakes/St. Lawrence River ecosystems were created by glacial erosion and represent a volume of water close to 23,000 km^3. The upper Great Lakes (Superior and Huron) are located on Canadian Shield Precambrian bedrock, where the climate is cold. These lakes are deep and characterized by a dendritic shoreline modeled by constant erosion. The lower Great Lakes (Erie and Ontario) are located on sedimentary bedrock originating from the retrieval of the Champlain Sea and are much shallower. Overall the Great Lakes have a small flow (about 1% of their total volume per year) and therefore a very high water residence time which makes them very sensitive to pollution originating from various sources such as watersheds (urban and agriculture runoff), atmospheric depositions and water sources such as spills. Pollution generally is an important stressor in several areas of the Great Lakes. To respond to severely polluted areas, both the American and Canadian governments identified Areas of Concerns (AOCs). The Great Lakes Water Quality Agreement provides a series of standards not to be exceeded to preserve the Great Lakes' health. These values are applied as targets to guide the remediation of AOCs. In Canada, 17 AOCs are identified across the basin. Although the necessity of attributing an AOC classification has resulted from a source of pollution (often of industrial origin), these areas are, however, also recognized as biological significant habitats.

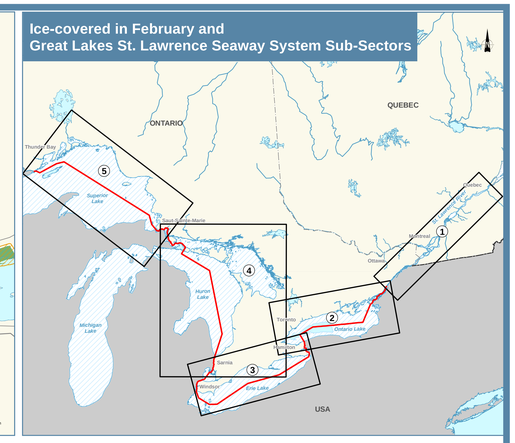
As the result of their shape and watershed development, Lake Erie, the shallowest of the Great Lakes, is the most perturbed by pollution whereas the largest and deepest Lake Superior could be considered is the least altered by pollution.

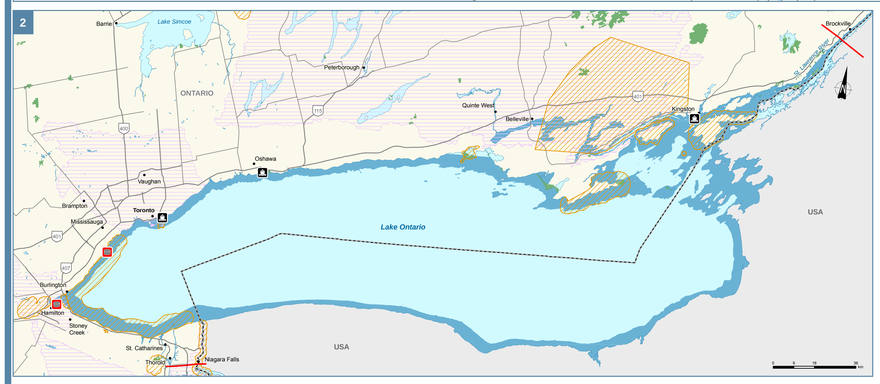
All the Great Lakes waters flow towards the Atlantic Ocean via the St. Lawrence River. In this sector, the sub-sector 1 represents the St. Lawrence River, starting at the Bay of Quinte and ending in Quebec City where water masses from the Gulf mix with the freshwater. The St. Lawrence River is considered one of the greatest rivers on earth, with a flow of about 6,000 m^3/s in Cornwall. The river is located on similar bedrock as the lower Great Lakes. The flow of the St. Lawrence River is regulated by several dams with the most important being the Moses Saunders Dam. The dams of the St. Lawrence River have modified the natural hydrological flow regime by reducing the amplitude of water level fluctuations and flow speed in rapids which in turn have altered the functioning of the St. Lawrence River ecosystems while increasing its services to humans.

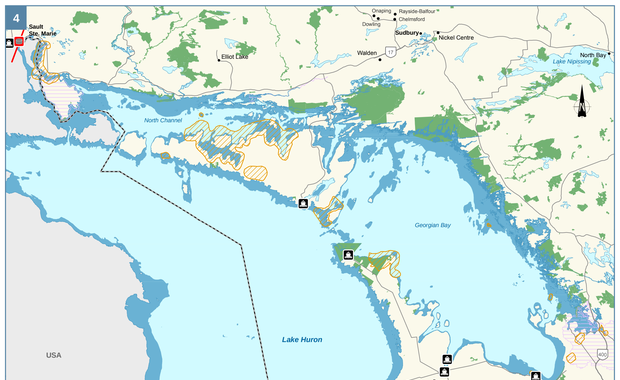
8.1.2 Biological Features

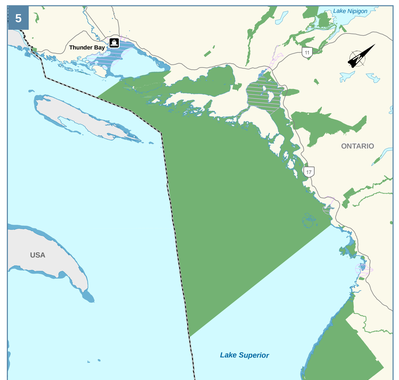
Due to their size and complex morphology, the Great Lakes support rich and diverse biological communities. The biological features in the Great Lakes differ between the offshore (pelagic) zone and the nearshore (littoral) zone. The littoral zone is generally defined as the limit where light is available in the water column and corresponds to the area with a depth of less than 25 m. The littoral zone is critical in terms of plant production and for substrate used as habitat for nearshore fish species as well as spawning habitats for pelagic fish species. In the pelagic zone, the majority of the water column is at a temperature close to the maximum water density (4 °C), a condition at which cold water species find their habitat (ex: Lake Trout). The separation between littoral and pelagic habitat is valid for all of the Great Lakes but Lake Erie as it is the shallowest. The productivity of the upper Great Lakes is low due to the poor nutrient content of runoff and low population density living in the watershed. The limitation in resources for these lakes allows for more complex trophic interactions and longer food webs due to higher niche diversity. Therefore, the upper Great Lakes may have a lower production due to low abundance in resources but a higher diversity in food web functions and structures. In contrast, the lower Great Lake, due to their shallower depth and extensive watershed development, are significantly more productive in terms of primary production and associated food web. As the result of abundant food sources, the lower Great Lakes support an abundant fishery but overall a less diverse set of ecosystem functions because of altered conditions.

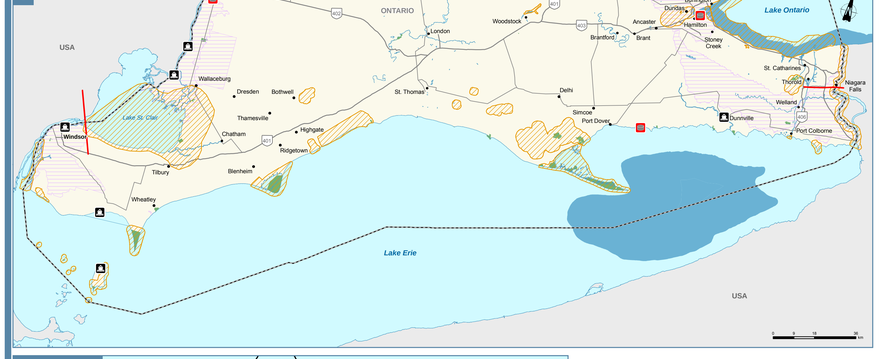


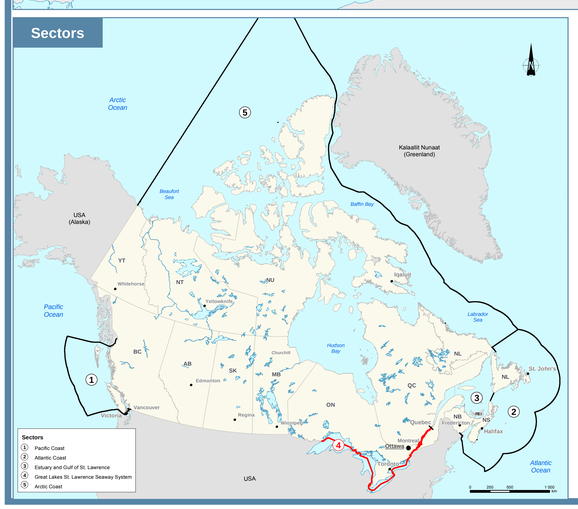












Environmental Components

- Coastal zone (0-25 m depth)
- Area of concern (AOC) — Table 2
- Important Bird Area (IBA) — Table 3
- Protected Area (National Park, etc) — Table 3
- Ice-covered in February
- Port
- Marina
- Major Oil Handling Facilities

Limits

- Limit of sub Sector
- International Border
- Interprovincial Border

Sources:
Base Map: ESRI Canada
IBA: http://www.ibacanada.ca
Protected Area: Atlas of Canada, Natural Ressources Canada
AOC (Area of concern): Environment Canada, 2013

Table 2 Area of Concern Major Environmental Issue.

Area of Concern	Major Environmental Issues
1. Bay of Quinte	• Excessive nutrient, from sewage treatment plants, particularly those that discharge directly to the Bay; faulty septic tanks and surface run-off from urban, agricultural and rural lands. • Habitat loss, in particular wetlands, due to shoreline development. • Contaminated sediments from historical activities along the shore of the Bay and in the watershed. • Beach closing resulting from bacterial contamination from sewage treatment plants, stormwater discharges and run off from agricultural and rural lands.
2. Detroit River	• Combined sewer overflows. • Municipal, industrial and non-point discharges. • Contaminated sediments. • Habitat loss and degradation. • Restrictions on fish consumption. • Quality of bottom-dwelling animal communities is impaired. • Restricted dredging activities due to contaminated sediments. • Public beaches are closed at times. • Overall aesthetic value of the river is low. • Water quality objectives are exceeded.
3. Hamilton Harbour	• Water quality and bacterial contamination. • Urbanization and land management. • Toxic substances and sediment remediation. • Fish and wildlife. • Public access and aesthetics. • Education and public information. • Research and monitoring.
4. Jackfish Bay	• Health of the fish communities including habitat. • Health of the wildlife communities. • Degraded aesthetics. • Condition of the sediments and the aquatic communities which utilize them.
5. Niagara River	• Restrictions on fish consumption. • Degradation of fish populations. • Bird or animal deformities. • Degradation of benthos. • Restrictions on dredging activities. • Eutrophication. • Beach closings. • Loss of fish and wildlife habitat.
6. Nipigon Bay	• Degradation of fish and wildlife populations – particularly the loss of walleye and yellow perch fisheries and decline in the brook trout and lake trout stocks. • Degradation of benthos (bottom-dwelling organisms) – undesirable algal growth on substrates in the lower Nipigon River. • Degradation of aesthetics on the waterfront. • Losses of habitat in the Nipigon River. • Water level fluctuations from the generation of electricity continue to affect streambank erosion and sediment load.
7. Peninsula Harbour	• Fish consumption advisories due to high levels of toxic contaminants. • Degraded fish communities. • Fish habitat destruction. • Degraded lake bottom communities. • Dredging restrictions due to contamination of the bottom sediments.
8. Port Hope	• Contaminated sediments in the harbour.
9. Spanish Harbour	• Tainting of fish flavour. • Impaired communities of bottom-dwelling organisms (benthos). • Nutrient enrichment.
10. St. Clair River	• Degradation of benthos (dynamics of benthic populations/communities). • Restrictions on fish consumption. • Degradation of aesthetics. • Loss of fish and wildlife habitat. • Restrictions on dredging activities. • Beach closings. • Bird or animal deformities or reproductive problems. • Restrictions on drinking water consumption or taste and odour problems. • Added cost to agriculture or industry.
11. St. Lawrence River	• Contaminants of concern in water, sediments and fish. • Bacterial contamination leading to beach closings. • Habitat destruction and degradation. • Excessive growth of nuisance aquatic plants. • Exotic species. • Fish and wildlife health impacts.
12. St. Marys River	• Restrictions on fish and wildlife consumption. • Unhealthy fish and wildlife populations. • Fish tumours and other deformities. • Unhealthy populations of bottom-dwelling organisms. • Restrictions on dredging. • Undesirable algae due to excess nutrients in the water. • Beach closures. • Poor aesthetics. • Loss of fish and wildlife habitat.
13. Thunder Bay	• Fish consumption restrictions. • Negative pressures on fish populations. • Dredging restrictions. • Loss of species abundance and diversity. • Reduced recreational opportunities. • Decline in aesthetic values.
14. Toronto and Region	• Restrictions on fish and wildlife consumption. • Beach closings. • Eutrophication or undesirable algae. • Restrictions on dredging activities. • Degradation of benthos. • Loss of fish and wildlife habitat. • Degradation of fish and wildlife populations. • Degradation of aesthetics.
15. Collingwood Harbour	• Nuisance growths of algae in the harbour. • Contaminated sediments.
16. Severn Sound	• Eutrophication. • Excessive algal production. • Changes in fish communities and habitat loss.
17. Wheatley Harbour	• Restriction on fish consumption. • Degradation of fish and wildlife populations. • Restrictions on dredging activities. • Eutrophication or undesirable algae. • Loss of fish and wildlife habitat.

Sources: Environment Canada, 2013

Table 3 Type of Marine and Coastal Protected Area

Protected Area Type	Number	Surface Area (km²)
International Designation		
Important Bird Area	94	3,655.3
New Brunswick		
Federal Designation		
Migratory Bird Sanctuary	1	0.2
National Park of Canada	2	240.7
National Wildlife Area	3	10.3
Provincial Designation		
Protected Natural Area	3	4.6
Provincial Park	7	3.8
Newfoundland and Labrador		
Federal Designation		
Ecological Reserve	2	33.9
National Park of Canada	1	1,780.4
Provincial Designation		
Provincial Park	4	11.6
NOVA SCOTIA		
Federal Designation		
National Wildlife Area	3	13.5
Provincial Designation		
Wilderness Area	1	277.0
PRINCE EDWARD ISLAND		
Federal Designation		
Marine Protected Area	2	9.2
Migratory Bird Sanctuary	1	2.1
National Park of Canada	1	38.1
Provincial Designation		
Privately Owned Natural Area	8	1.3
Privately Owned Natural Area (Int. & others)	1	0.3
Privately Owned Natural Area (Int.)	9	1.6
Privately Owned Natural Area (NCC PEI Inc.)	1	0.2
Provincial Park	1	3.8
Provincial Wildlife Management Area	8	13.2
Provincially Owned Natural Area	33	16.2
QUÉBEC		
Federal Designation		
Migratory Bird Sanctuary	36	356.4
National Park of Canada	3	342.9
National Wildlife Area	5	36.7
Marine Park	1	1,256.7
Provincial Designation		
Provincial Park	2	603.7
Total	**233**	**8,713.7**

Source: Government of Canada, 2013; Environment Canada, 2013

Table 4 Demographic and Economic Overview

Total Coastal Population (2011)	13,548,365 inhabitants
Quebec	
Population	4,771,745 inhabitants
Urban Centers	Montreal, Quebec city and Trois-Rivieres
Key Economic Sectors	Tourism, transportation, energy and agriculture
Ontario	
Population	8,776,620 inhabitants
Urban Centers	Toronto, Ottawa, Hamilton, London and Windsor
Key Economic Sectors	Agriculture, manufacturing and transportation

Source: Statistics Canada, 2013; Canadian Encyclopedia, 2013

Table 1 Shoreline Types and Distribution

Shoreline Type	Length (km)	Proportion (%)
Bedrock	2.2	< 0.1
Bedrock (Platform/Ramp/Shelf)	8,164.2	33.8
Boulder Beach or Bank	281.8	1.2
Man-made Structure	2,140.0	8.8
Marsh	1,131.8	4.7
Mixed Sediment Beach or Bank	624.9	2.6
Mud Flat	82.2	0.3
Not Classified	7,246.1	30.0
Pebble/Cobble Beach or Bank	2,376.3	9.8
Sand Beach or Bank	643.3	2.7
Sediment Cliff	227.1	0.9
Vegetated Bank	1,234.4	5.1
Wetland	19.1	0.1
Total Shoreline in Great Lakes and St. Lawrence Seaway System Sector	**26,287.3**	**100.0**

Source: Environment Canada, 2013

Risk Assessment for Marine Spills in Canadian Waters
Phase 1: Oil Spills Risk Assessment

Great Lakes – St. Lawrence Seaway System Sector 4

January 2014

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Map 8.1

The St. Lawrence River biology is remarkably diverse as a result of its size, flow conditions and habitat diversity. The river includes flowing habitats above the Moses Saunders dam and also fluvial lakes located between dams. The fluvial lakes of the St. Lawrence River are key ecosystems in terms of diversity and production: Lake Saint-Francis is the most productive lake in Ontario, in terms of fish production, and Lake Saint-Pierre is recognized as a UNESCO/RAMSAR site for its biodiversity.

The biology of the Great Lakes is impacted by invasive species most of which were introduced by ocean-vessels and ballast water exchanges. The number of invasive species in the Great Lakes is 183, and although no new species have been found since 2006, the Great Lakes still have the highest rate of invasion for freshwater systems worldwide.

8.1.3 Human Features

The economy of the Great Lakes region is very much dependent on the Great Lakes capacity to provide resources (water, energy, natural resources) or transportation via the Seaway. The Great Lakes' basin is home to 90% of Ontario's population and 40% of Canada's economic activity (Environment Canada, 2013). It provides drinking water to 8.5 million Canadians and support respectively 25% and 45% of Canada's agriculture and industrial capacity (Environment Canada, 2013). Most of the revenues and uses of the Great Lakes are concentrated in the lower Great Lakes as well as on the shores of the St. Lawrence River.

The Great Lakes (in particular Lake Erie and Lake Ontario) are known to contribute significantly to the Canadian fisheries revenue ($100M and $350M for commercial and recreational fisheries respectively).

Also, via the Seaway, the Great Lakes are connected to the rest of the world during the ice free period and most of the traffic involves the movement of vessels carrying goods from/to international destinations (St. Lawrence River) or minerals (aggregates) moving within the Great Lakes or outside of the basin. Therefore, possible spills occurring in the Great Lakes sector are not related to cargo or refined products but instead to fuel used to propel vessels.

8.2 Vessel Traffic Description

The following description and tables summarize the estimated spill frequency for the Great Lakes and St. Lawrence Seaway System sector and its sub-sectors. Tables 8.1 to 8.3 indicate the potential spill frequency for each of the three oil types (crude oil cargo, refined oil cargo, and oil carried as fuel), for each of the four spill size ranges, with a breakdown per sub-sector and zone (nearshore, intermediate and deep-sea). Summary maps indicate the combined frequencies of all spill sizes and zones per oil type (Map 8.2).

Table 8.1 Cargo Crude Return Periods

Sub-sector	Cargo Crude Return Periods (years)											
	Nearshore Zone (0-12 nm)				Intermediate Zone (12-24 nm)				Deep-sea Zone (24-200 nm)			
	S	M	L	XL	S	M	L	XL	S	M	L	XL
1	2,221	3,316	2,472	11,608	2,855	4,264	3,178	14,924	4,996	7,462	5,562	26,117
2	263,334	393,291	293,147	1,376,518	338,572	505,660	376,904	1,769,809	592,501	884,905	659,582	3,097,166
3	244,642	365,374	272,339	1,278,808	314,539	469,766	350,150	1,644,182	550,443	822,091	612,762	2,877,318
4	348,550	520,561	388,011	1,821,964	448,135	669,293	498,871	2,342,526	784,237	1,171,263	873,025	4,099,420
5	-	-	-	-	-	-	-	-	-	-	-	-

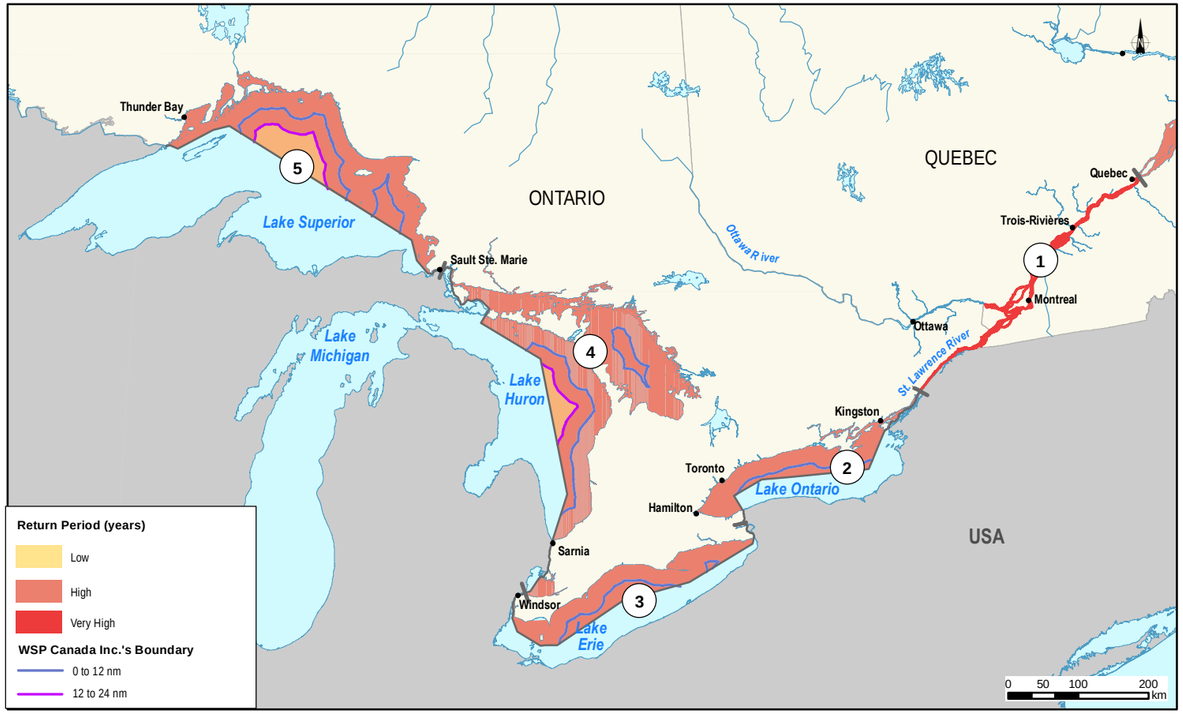
Table 8.2 Cargo Refined Return Periods

Sub-sector	Cargo Refined Return Periods (years)											
	Nearshore Zone (0-12 nm)				Intermediate Zone (12-24 nm)				Deep-sea Zone (24-200 nm)			
	S	M	L	XL	S	M	L	XL	S	M	L	XL
1	50	302	1,274	-	65	388	1,638	-	113	679	2,866	-
2	275	1,649	6,964	-	353	2,121	8,954	-	619	3,711	15,670	-
3	256	1,533	6,474	-	329	1,971	8,323	-	575	3,450	14,566	-
4	249	1,493	6,305	-	320	1,920	8,106	-	560	3,360	14,186	-
5	1,410	8,463	35,732	-	1,813	10,880	45,941	-	3,173	19,041	80,397	-

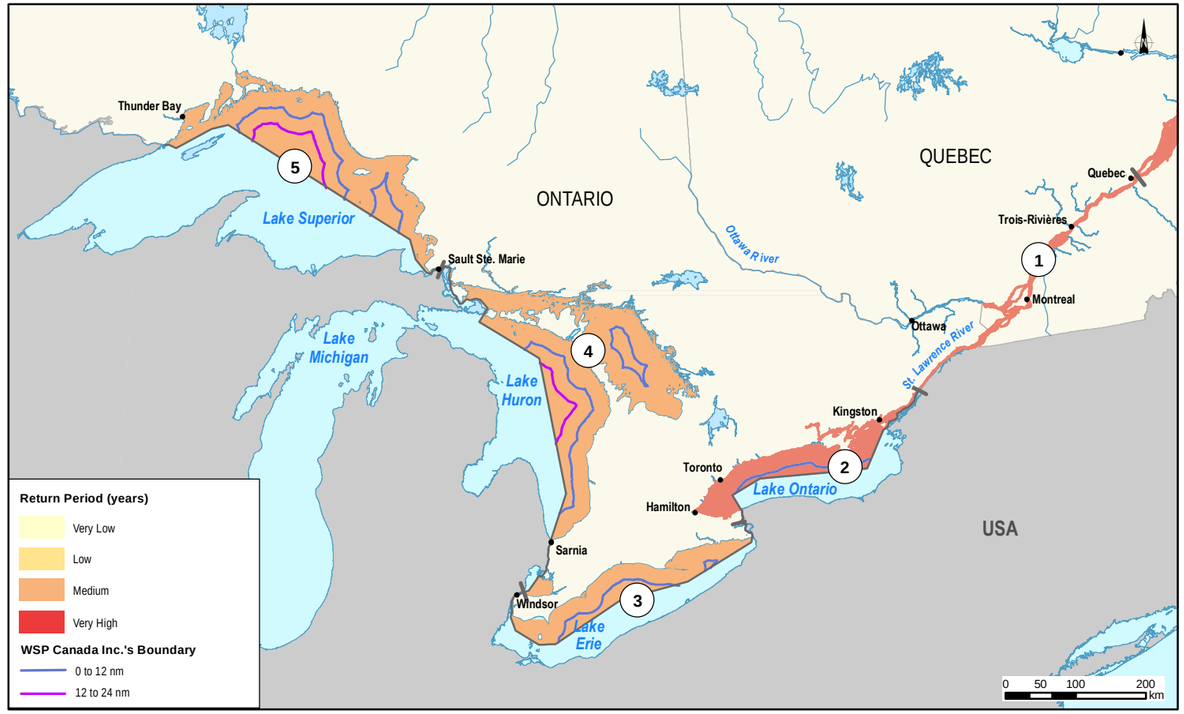
Table 8.3 Fuel Return Periods

Sub-sector	Fuel Return Periods (years)											
	Nearshore Zone (0-12 nm)				Intermediate Zone (12-24 nm)				Deep-sea Zone (24-200 nm)			
	S	M	L	XL	S	M	L	XL	S	M	L	XL
1	9	28	2,631	-	12	36	3,383	-	20	64	5,921	-
2	24	76	7,073	-	31	98	9,094	-	54	171	15,915	-
3	58	185	17,202	-	75	238	22,117	-	132	417	38,706	-
4	58	185	17,192	-	75	238	22,104	-	132	416	38,683	-
5	72	227	21,127	-	92	292	27,163	-	162	512	47,535	-

a) Return Period 10 to 99.9 m^3

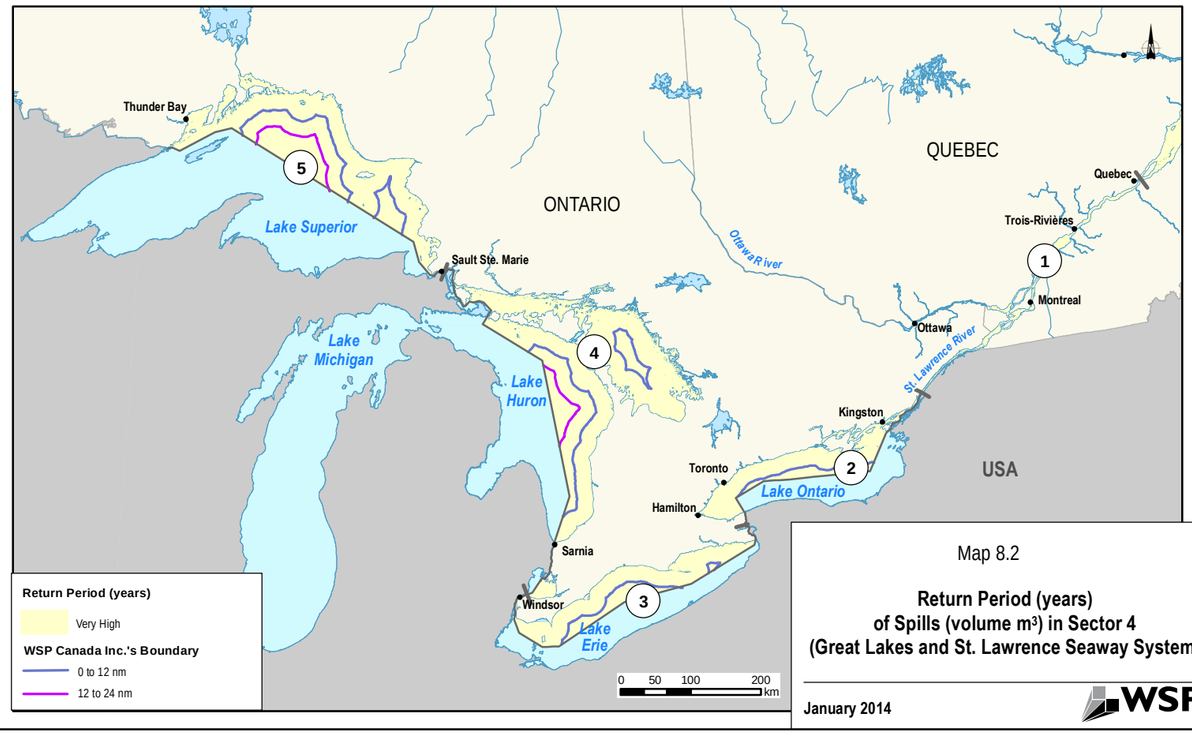


b) Return Period 100 to 999.9 m^3



c) Return Period 1,000 to 9,999.9 m^3

d) Return Period ≥ 10,000 m^3



Map 8.2

Return Period (years) of Spills (volume m^3) in Sector 4 (Great Lakes and St. Lawrence Seaway System)

January 2014

WSP

File: 131_17593_c8.2_Cargo_Return_period_Lakes_131223.mxd

For ease of comparison, the summary tables are presented with frequency as “return periods”, or average number of years between events.

For spill of crude oil cargo, there is a very low level of PSF in this sector as a whole, reflecting the low volumes of crude shipped through the sector.

For spill of refined product cargo, sub-sector 1 has a PSF amongst the highest in the country; sub-sectors 2, 3, and 4 also have significant PSFs in this regard.

Similarly, for spills of fuel, sub-sectors 1 and 2 have PSFs amongst the highest in the country, reflecting a high level of marine traffic in the sector; sub-sectors 3, 4, and 5 also have significant PSFs in this spill category.

8.3 Overall Risk Results

The Environmental Risk Index (ERI) has been calculated for each oil type (crude oil, refined products and fuel), along a gradient of spill volumes (4 classes from 10 to 10,000 m^3). The following maps illustrate ERI values according to five categories or risk (from very low to very high). The definition of the categories involves a natural break calculation using ArcGIS (Table 8.4). Based on this method, class breaks are identified that best group similar values and that maximize the difference between classes. A detailed map was produced for each zone and the following sub-sections provide an overview of the ERI results for each map.

Table 8.4 Class Breakdown to Determine Environmental Risk Index (ERI) Classes.

ERI Class	Natural Breakdown			
	10-99.9 m^3	100-999.9 m^3	1,000-9,999 m^3	≥ 10,000 m^3
Crude Oil				
Very High	134.8 to 347.6	628.3 to 1,221.6	8,601.2 to 37,798.7	3,727.1 to 9,613.1
High	62.1 to 134.8	366.5 to 628.3	3,482.9 to 8,601.2	1,718.4 to 3,727.1
Medium	28.3 to 62.1	169.7 to 366.5	1,537.5 to 3,482.9	783.0 to 1,718.4
Low	10.1 to 28.3	49.3 to 169.7	449.6 to 1,537.5	278.1 to 783.0
Very Low	0.0 to 10.1	0.0 to 49.3	0.0 to 449.6	0.0 to 278.1
Refined Oil				
Very High	4,608.7 to 58,806.7	735.0 to 2,346.9	932.1 to 1,535.2	7,895,456.7 to 23,298,700.7
High	794.3 to 4,608.7	267.2 to 735.0	336.4 to 932.1	3,004,643.6 to 7,895,456.7
Medium	305.5 to 794.3	130.0 to 267.0	132.2 to 336.4	1,238,071.0 to 3,004,643.6
Low	105.4 to 305.5	49.8 to 130.0	33.3 to 132.2	0.0 to 1,238,071.0
Very Low	0.0 to 105.4	0.0 to 49.8	0.0 to 33.3	0.0 to 0.0

Table 8.4 (cont.) Class Breakdown to Determine Environmental Risk Index (ERI) Classes.

ERI Class	Natural Break			
	10-99.9 m^3	100-999.9 m^3	1,000-9,999 m^3	≥ 10,000 m^3
Fuel Oil				
Very High	4,201.6 to 12,771.6	15,242.0 to 25,008.8	939.8 to 1,583.4	0.0 to 0.0
High	1,208.2 to 4,201.6	4,839.3 to 15,242.0	398.8 to 939.8	0.0 to 0.0
Medium	468.1 to 1,208.2	2,002.4 to 4,839.3	122.0 to 398.8	0.0 to 0.0
Low	155.3 to 468.1	685.5 to 2,002.4	41.4 to 122.0	0.0 to 0.0
Very Low	0.0 to 155.3	0,0 to 685.5	0,0 to 41.4	0.0 to 0.0

As differences in risk values between oil spill volumes are not very pronounced in the Great Lakes/St. Lawrence Seaway System sector, the following description per oil type includes all volumes confounded.

8.3.1 Crude Oil Environmental Risk Index

Map 8.3 permits the following observations:

- The crude oil ERI values for the Great Lakes sector are similar for the various spill volumes. Overall, the risk is very low for all the lakes and varies from high to very high for the St. Lawrence River (sub-sector 1). As mentioned in the traffic section, the volume of crude is very small in the Great Lakes basin and the values obtained for the crude oil ERI are consistent with the transport data.
- The highest values of the ERI (high risk) for crude observed for the St. Lawrence River (sub-sector 1) are found for spills of small volume (10 to 99.9 m^3) and for very large volumes (≥10,000 m^3). For the two intermediate volume categories, the risk is medium. These values are consistent with the traffic observed in the Montreal port area. In addition, the environmental sensitivity (ESI) of the St, Lawrence River sub-sector is higher than for the other sub-sectors, adding to the risk calculation in the sub-sector. The increase in the ESI in the sub-sector is due to the contribution of all physical, biological and human sensitivity indicators.

8.3.2 Refined Oil Environmental Risk Index

Map 8.4 permits the following observations:

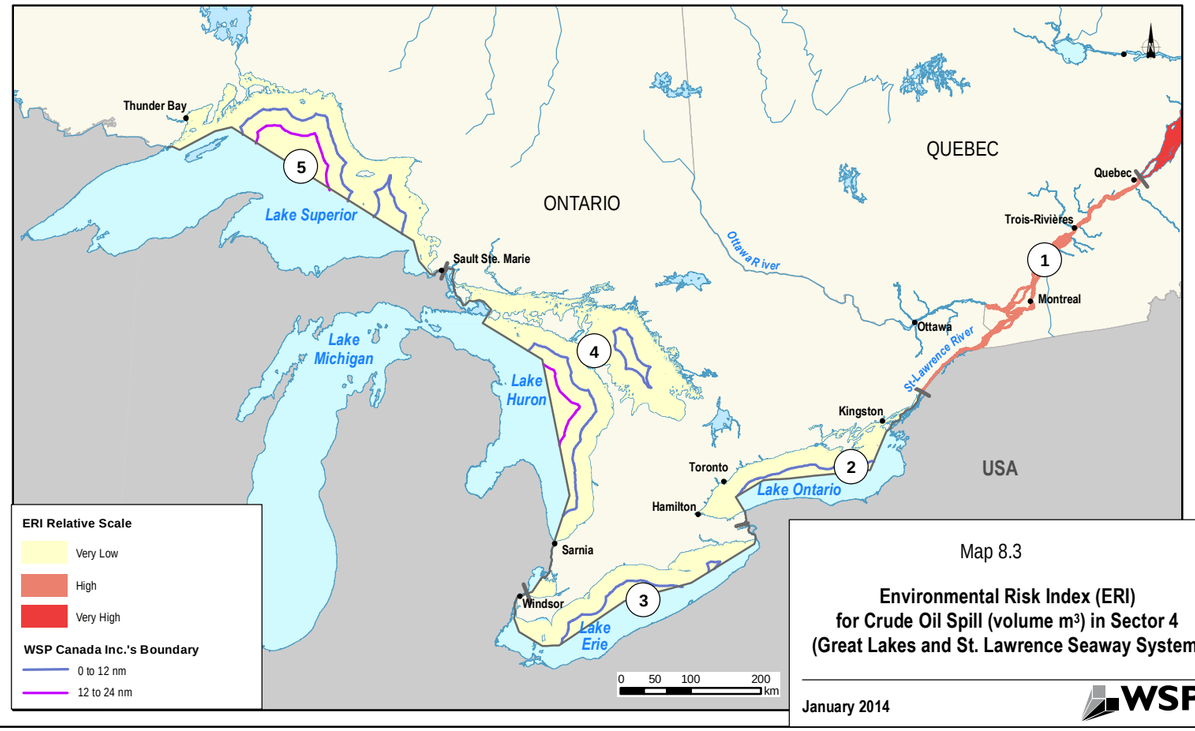
- The refined oil ERI covers the full range of risk values, with very low to low values observed in the upper lakes (Lake Superior) to very high risk observed in the most downstream location (St. Lawrence River). The risk values are correlated to ESI values. The higher risk values observed for the St. Lawrence River sub-sector result from the combined effects of physical, biological and human sensitivity.

a) Spill Volume 10 to 99.9 m^3

b) Spill Volume 100 to 999.9 m^3

c) Spill Volume 1,000 to 9,999.9 m^3

d) Spill Volume ≥ 10,000 m^3



Map 8.3

Environmental Risk Index (ERI) for Crude Oil Spill (volume m^3) in Sector 4 (Great Lakes and St. Lawrence Seaway System)

January 2014

WSP

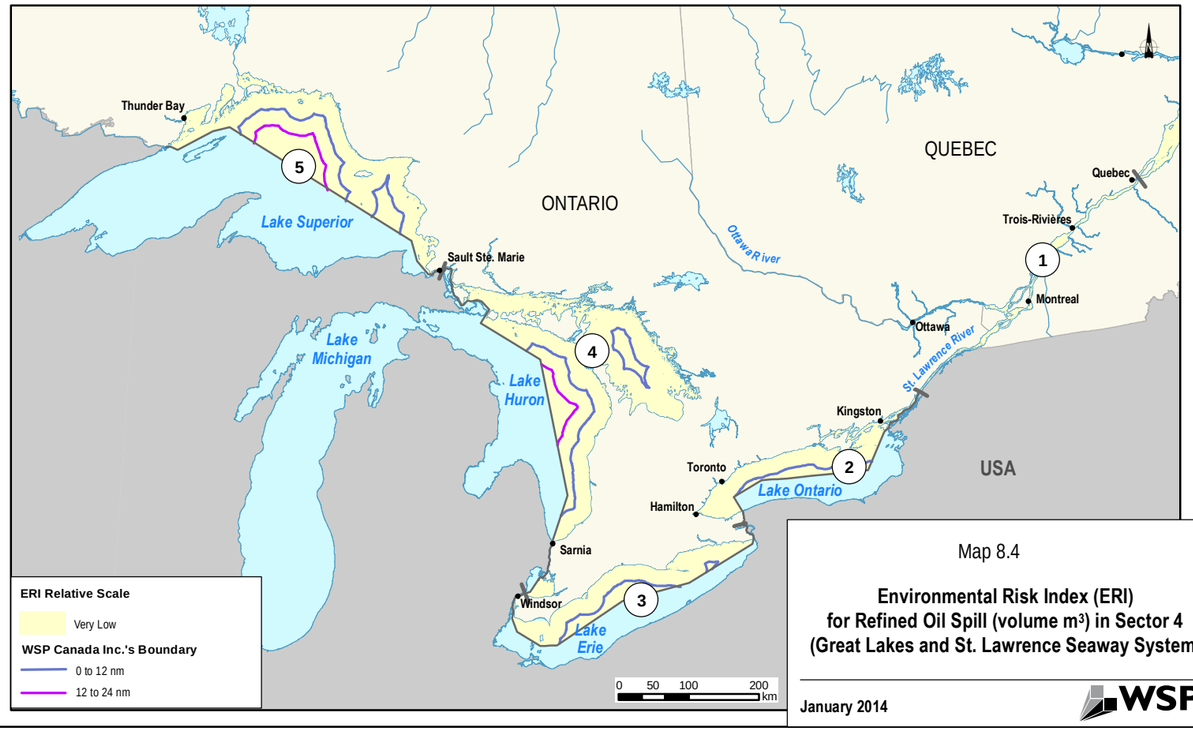
File: 131_17593_c8.3_Cargo_Crude_Lakes_131223.mxd

a) Spill Volume 10 to 99.9 m^3

b) Spill Volume 100 to 999.9 m^3

c) Spill Volume 1,000 to 9,999.9 m^3

d) Spill Volume ≥ 10,000 m^3



Map 8.4

Environmental Risk Index (ERI) for Refined Oil Spill (volume m^3) in Sector 4 (Great Lakes and St. Lawrence Seaway System)

January 2014

WSP

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- An increasing gradient of risk is observed for spill volumes of 100 to 999.9 m^3 and of 999.9 to 9999.9 m^3 from the deep-sea to the nearshore zones. This increase in risk is related to the increasing costs of cleanup activities as the spill reaches the shorelines and the increase in ESI scores (in particular PSI and HRI).
- The high ERI values observed for the St. Lawrence River (sub-sector 1) is due to a higher probability of spills. The Port of Montreal and the Gulf influence the probability in this sub-sector.
- The risk of spills is very low in Lake Superior due to the low traffic of refined oil products.

8.3.3 Fuel Oil Environmental Risk Index

Map 8.5 allows for the following observations:

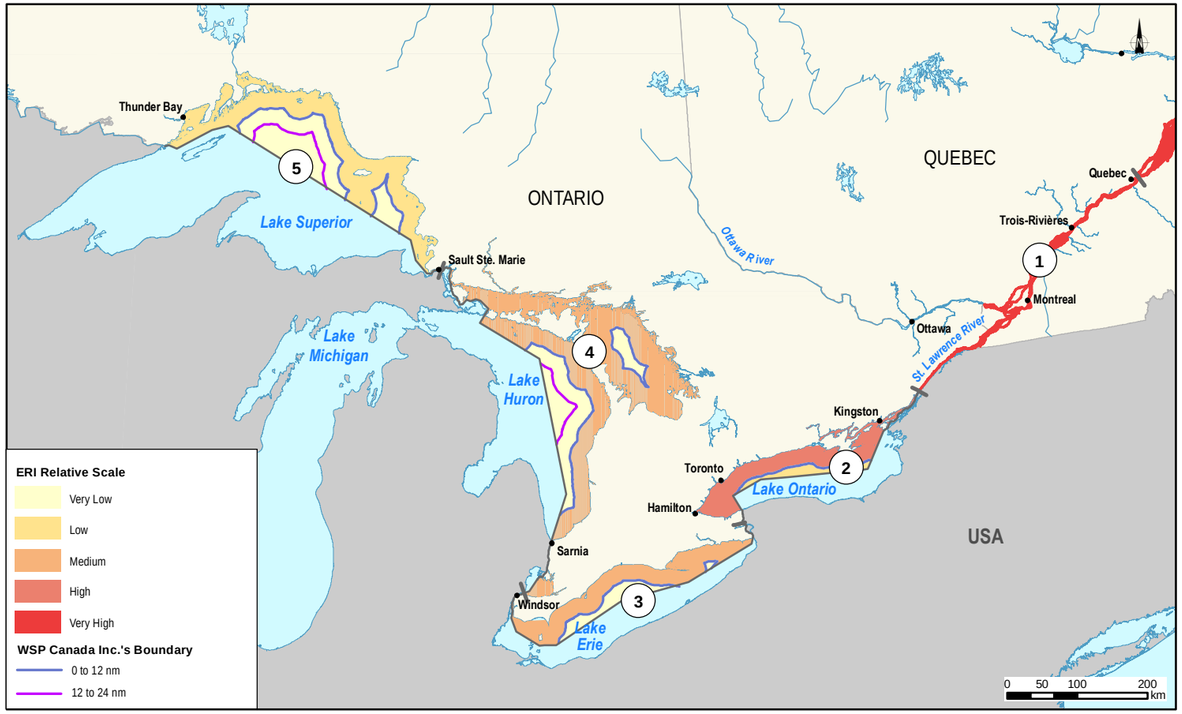
- The distribution of risk for fuel oil spills is similar for all four volumes of spills considered and ranges from very low to very high.
- As for cargo and refined products, values increase as you travel inshore (from deep-sea zones to nearshore zones), reflecting the influence of cleanup costs and environmental sensitivity.
- The comparison of risk between oil spill volumes indicates that a higher risk exists for the 10 to 99.9 m^3 spill volume in the lower Great Lakes (Lake Erie and Lake Ontario) as well in the upper Great Lake Huron. This higher risk is linked with the higher traffic in these sub-sectors. It is also important to note the increase in risk from upstream to downstream locations. Sub-sector 1 (St. Lawrence River) contributes to the fuel spill risk of the Great Lakes, which is further influenced by traffic originating from the Gulf of St. Lawrence.

8.4 Environmental Sensitivity Index

In addition to the very high and high ERI values in the zones, there are several sensitive zones in the Great Lakes and St. Lawrence Seaway System which may be affected by future increase in volumes (Map 8.6; Appendix 2 – Map D).

The nearshore zone of the entire St. Lawrence River (sub-sector 1) has a high ESI score, while the nearshore zone of Lake Ontario (sub-sector 2) has a medium ESI value. These zones offer particular physical, biological and human conditions which increase the oil spill sensitivity.

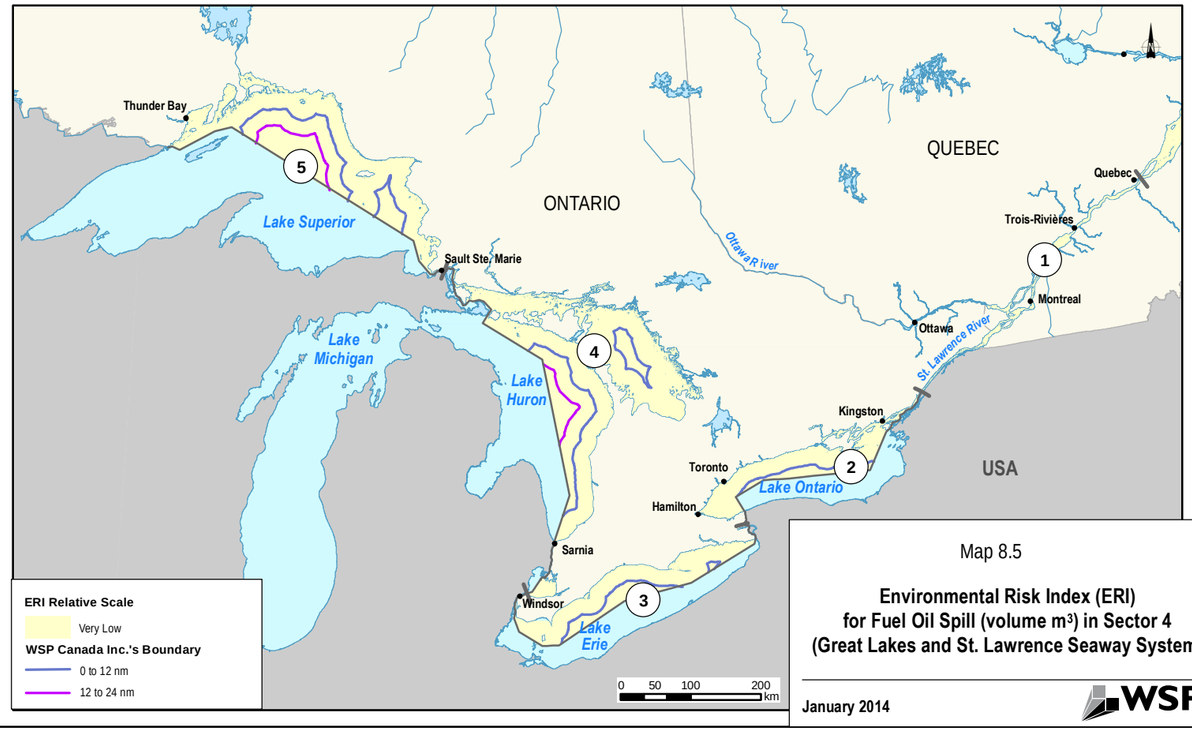
a) Spill Volume 10 to 99.9 m^3



b) Spill Volume 100 to 999.9 m^3

c) Spill Volume 1,000 to 9,999.9 m^3

d) Spill Volume ≥ 10,000 m^3



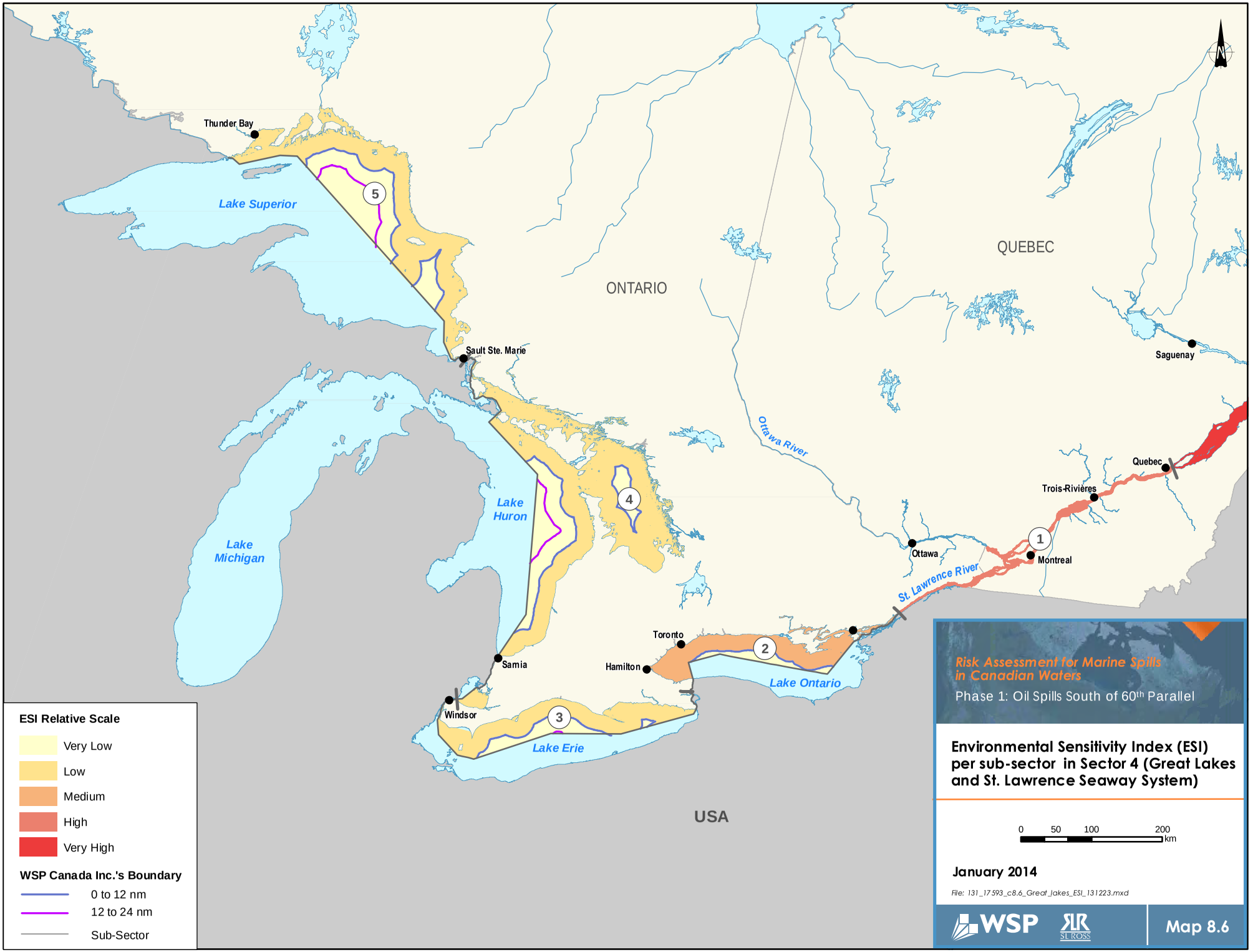
Map 8.5

Environmental Risk Index (ERI) for Fuel Oil Spill (volume m^3) in Sector 4 (Great Lakes and St. Lawrence Seaway System)

January 2014

WSP

File: 131_17593_c8.5_Cargo_Fuel_Lakes_131223.mxd


Thunder Bay
Lake Superior
5
ONTARIO
QUEBEC
Sault Ste. Marie
Saguenay
Ottawa River
Lake Huron
4
Lake Michigan
Quebec
Trois-Rivières
1
Ottawa
Montreal
St. Lawrence River
Toronto
2
Hamilton
Lake Ontario
Samia
Windsor
3
Lake Erie
USA
ESI Relative Scale
Very Low
Low
Medium
High
Very High
WSP Canada Inc.'s Boundary
0 to 12 nm
12 to 24 nm
Sub-Sector
Risk Assessment for Marine Spills in Canadian Waters
Phase 1: Oil Spills South of 60th Parallel
Environmental Sensitivity Index (ESI) per sub-sector in Sector 4 (Great Lakes and St. Lawrence Seaway System)
0 50 100 200
km
January 2014
File: 131_17593_c8.6_Great_lakes_ESI_131223.mxd
WSP
SL ROSS
Map 8.6

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

This study has examined the potential frequency of spills in Canadian waters and the potential consequences associated with these spills. Combined, these two measures indicate an overall spill risk for various sectors across Canadian waters.

The method applied to produce risk values is based on spreadsheets and GIS layers that could be easily updated in the future or used to provide risk predictions, when, for example, an increase in volume of a given oil type would be applied to a given sub-sector or zone.

Potential spill frequencies were estimated using a combination of Canadian and worldwide spill statistics. Frequency data are reported separately for three main spill types: spills of crude oil carried as cargo, spills of refined oil carried as cargo, and spills of oil carried as fuel. Frequencies are also reported for each of the 29 specified sub-sectors in Canada, according to various size categories, and for nearshore, intermediate, and deep-sea zones within each of the sub-sectors.

Risk values vary greatly across the country. Overall the highest values were observed for small size spills, due to their relatively higher frequency of occurrence. The risk of large size spills is generally low in Canada; despite using a wordwide spill frequency instead of a Canadian frequency (of zero). The risk generally increases in coastal areas compared with deep-sea zones with the exception of the Pacific sector where US traffic may increase offshore probabilities. This increase in risk in nearshore zones is related to an increase in environmental sensitivity.

9.2 Recommendations

9.2.1 Risk Reduction

This study has not examined the potential risk mitigation provided by risk reduction measures and can make no comment on their estimated effectiveness. Nonetheless, some general comments can be made on some of the key sources of risk:

- Fuel spills, while generally small in relative terms, rank somewhat prominently in terms of the estimated overall risk, including both estimated frequency and potential consequence.
- Spills of relatively modest volume, in the 10 to 1000 m^3 size range rank somewhat prominently in terms of the estimated overall risk, including both estimated frequency and potential consequence.

- Two sub-sectors in the Atlantic (4 and 6) and one in the Pacific (sub-sector 5) have relatively high exposure and risk (as ERI) to large-scale spills of crude oil as cargo. The risk in Pacific sub-sector 5 is somewhat problematic in that it is largely related to tanker traffic calling on refineries in Washington State; as such they are not subject to Canada's spill response regime.
- Zones noted as being of particularly high risk should be examined with regards to potential for improved prevention measures such as modification of travel routes, increased or modified identification of traffic lanes, and increased pilotage.

Based on the analysis in this study, the highest ranked zones in terms of spill risk are in:

- The Pacific coast sector: sub-sector 5;
- The Atlantic coast sector: sub-sectors 4 and 6, with a slightly lower high risk value in sub-sector 2;
- The EGSL sector: sub-sectors 1, 2 and 3, with a slightly lower high risk value in sub-sector 6;
- The Great Lakes/St. Lawrence Seaway System sector: sub-sector 1 (Maps 9.1 to 9.3; Tables 9.1 to 9.3).

The following tables identify the top 10 areas with the highest risk of spills for each oil type considered in this study. For crude oil and fuel, the trends were similar regardless of spill volumes and therefore, the ranking was generated for all volumes confounded. For refined products, because of large differences in the affected zones between spill volumes, the table provide a ranking of the zones for the 100 to 999.9 m^3 spill volum only. This category has the lowest returning period among all refined product spill volumes.

Table 9.1 Highest Crude Oil ERI Ranked Zones (all volumes confounded)

Crude Oil			
Rank	Sector	Sub-Sector No.	Zone
1	Atlantic Coast	6	Nearshore
2	Atlantic Coast	5	Nearshore
3	Atlantic Coast	4	Nearshore
4	Estuary and Gulf of St. Lawrence	2	Nearshore
5	Estuary and Gulf of St. Lawrence	1	Nearshore
6	Pacific Coast	5	Intermediate
7	Atlantic Coast	6	Intermediate
8	Estuary and Gulf of St. Lawrence	3	Nearshore
9	Estuary and Gulf of St. Lawrence	6	Nearshore
10	Great Lakes and St. Lawrence Seaway System	1	Nearshore