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10 MARINE MAMMALS AND SEA TURTLES

The Marine Mammal and Sea Turtle Valued Ecosystem Component (VEC) includes cetaceans (whales, dolphins, and porpoises), pinnipeds (seals) and sea turtles that are not considered at-risk species by the *Species at Risk Act* (SARA) or the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Marine mammal and sea turtle species at risk are described and assessed in Chapter 11.

10.1 Environmental Assessment Boundaries

10.1.1 Spatial and Temporal

10.1.1.1 Spatial

The Nearshore and Offshore Study Areas, Project Areas and Affected Areas are defined in the Environmental Assessment Methods Chapter (Section 4.3.2). The Nearshore and Offshore Study Areas and Project Areas are illustrated in Figures 10-1 and 10-2, for the nearshore and offshore, respectively. The Affected Areas for several Project activities have been determined by modelling (see ASA 2011a, 2011b; JASCO 2010; Stantec 2010b).

10.1.1.2 Temporal

The temporal boundary is defined in the Environmental Assessment Methods Chapter (Section 4.3.2.2). The nearshore and offshore temporal boundaries are summarized in Table 10-1.

Table 10-1 Temporal Boundaries of Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation / start-up / drilling as early as 2015 • Production year-round through to 2046 or longer • Potential expansion opportunities - as required, year-round through to end of Project • Decommissioning / abandonment: after approximately 2046

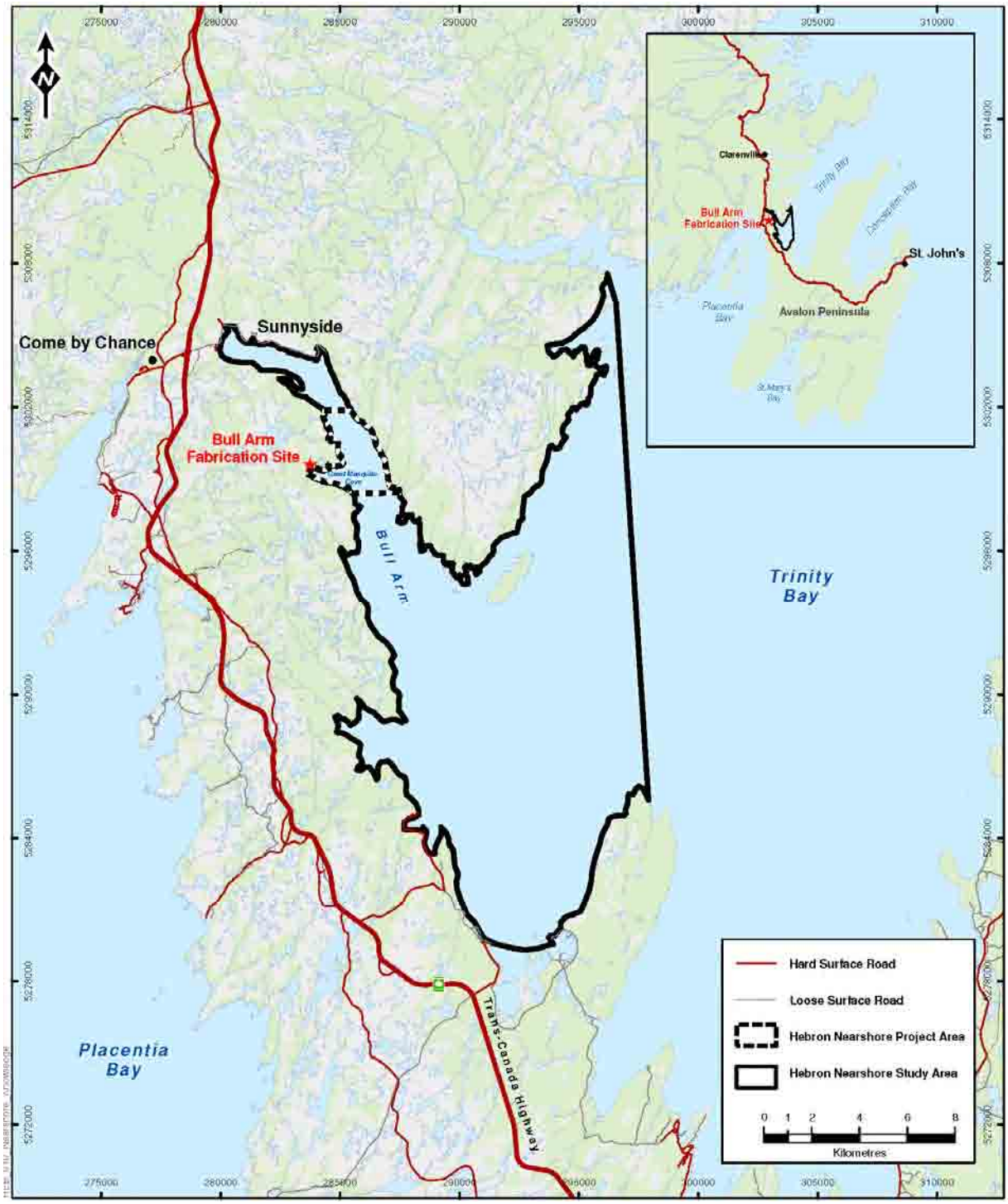


Figure 10-1 Nearshore Study and Project Areas

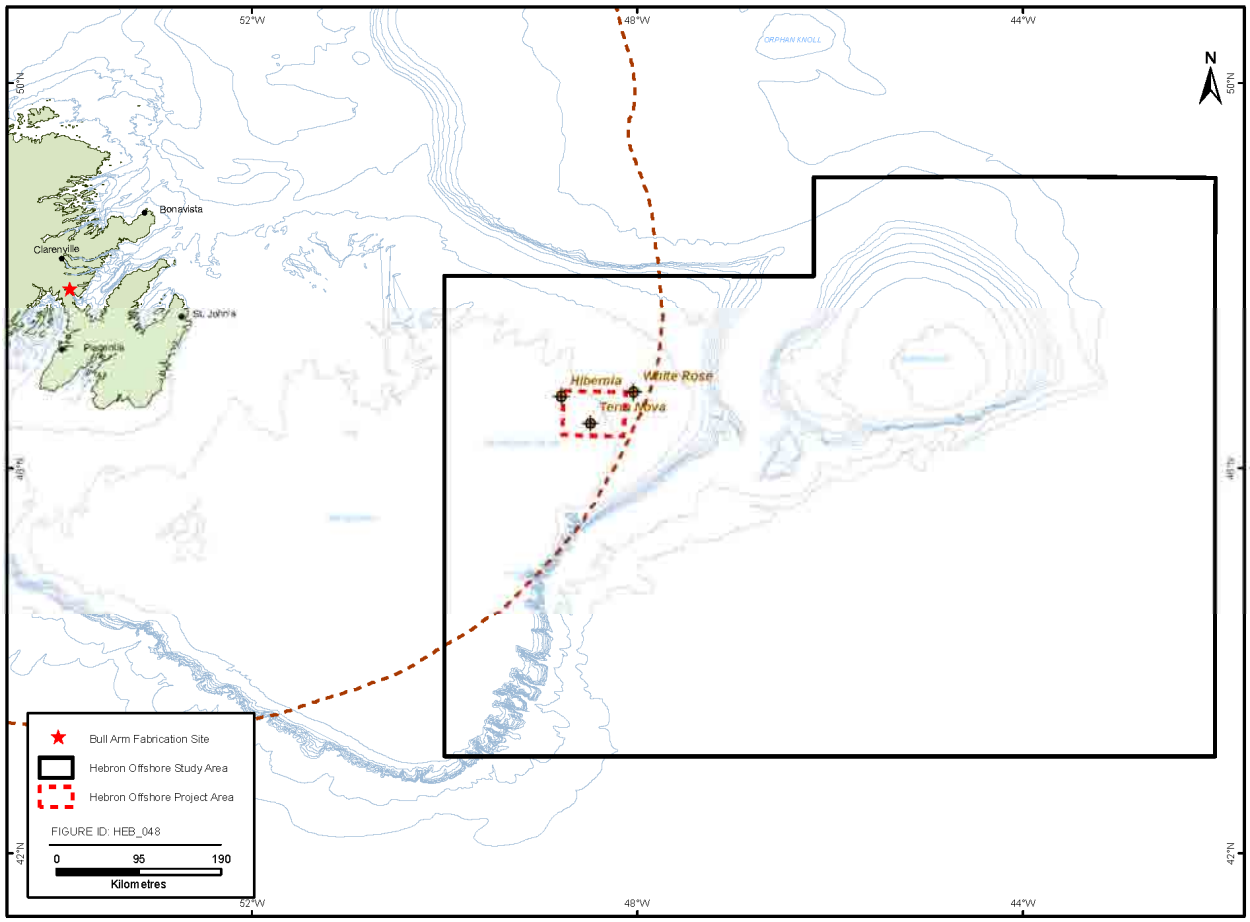


Figure 10-2 Offshore Study and Project Areas

10.1.2 Administrative

Marine mammals and sea turtles are protected under the federal *Fisheries Act*. Marine mammal and sea turtle species at risk are protected under SARA (refer to Chapter 11).

10.2 Definition of Significance

A significant adverse residual environmental effect is one that affects marine mammals or sea turtles by causing a decline in abundance or change in distribution of a population(s) over more than one generation within the Nearshore and/or Offshore Study Area. Natural recruitment may not re-establish the population(s) to its original level within several generations or avoidance of the area becomes permanent.

An adverse environmental effect that does not meet the above criteria is evaluated as not significant.

10.3 Existing Conditions

10.3.1 Marine Mammals

A total of 21 marine mammals, including five baleen whales (mysticetes), 12 toothed whales (odontocetes), and four true seals (phocids), are known to occur in the Nearshore and/or Offshore Study Areas (Table 10-2). The temporal and spatial distribution, habitat, and relevant SARA listings and COSEWIC designations for each species are presented in Table 10-2. At-risk species are described in greater detail in Chapter 11. Most marine mammals are seasonal inhabitants of the Study Areas, with both regions representing important foraging grounds for many species. The best available abundance estimates for each of the marine mammal species in the Northwest Atlantic, as well as for eastern Newfoundland, are provided in Table 10-3.

Table 10-2 Marine Mammals Known or Expected to Occur within the Nearshore and Offshore Study Areas

Species (Scientific Name)	Bull Arm Study Area		Hebron Study Area		Habitat	SARA Status[A]	COSEWIC Status[B]
	Occurrence	Season	Occurrence	Season			
Baleen Whales (Mysticetes)							
Humpback whale (*Megaptera novaeangliae*)	Common	Year-round, but mostly June-Sept	Common	Year-round, but mostly May-Oct	Coastal & banks	NS	NAR
Blue whale (*Balaenoptera musculus*)	Uncommon	Year-round, but mostly July-Sept	Uncommon	Year-round, but mostly June-Oct	Coastal & pelagic	Schedule 1: Endangered	E
Fin whale (*Balaenoptera physalus*)	Common?	June-Oct	Common	Year-round, but mostly June-Oct	Slope & pelagic	Schedule 1: Special Concern	SC
Sei whale (*Balaenoptera borealis*)	Rare	Summer	Uncommon	May-Sept	Offshore & pelagic	NS	DD
Minke whale (*Balaenoptera acutorostrata*)	Common	Year-round, but mostly June-Oct	Common	Year-round, but mostly May-Oct	Shelf, banks, & coastal	NS	NAR
Toothed Whales (Odontocetes)							
Sperm whale (*Physeter macrocephalus*)	Uncommon	Summer	Uncommon	Year-round, but mostly summer	Pelagic, slope, canyons	NS	NAR; LPC
Northern bottlenose whale (*Hyperoodon ampullatus*)[D]	Very Rare	Year-round?	Rare	Year-round?	Pelagic, canyons, slope	NS	NAR
Sowerby's beaked whale (*Mesoplodon bidens*)	Very Rare	Year-round?	Rare	Year-round?	Pelagic, deep, slope, canyon	Schedule 3: Special Concern	SC

Species (Scientific Name)	Bull Arm Study Area		Hebron Study Area		Habitat	SARA Status[A]	COSEWIC Status[B]
	Occurrence	Season	Occurrence	Season			
Killer whale (*Orcinus orca*)	Uncommon?	Year-round, but mostly June-Oct	Uncommon	Year-round, but mostly June-Oct	Widely distributed	NS	SC
Long-finned pilot whale (*Globicephala melas*)	Common	Year-round, but mostly July-Oct	Common	Year-round	Mostly pelagic	NS	NAR
Risso's dolphin (*Grampus griseus*)	Very Rare	Year-round?	Rare	Year-round?	Slope	NS	NAR
Common bottlenose dolphin (*Tursiops truncatus*)	Very Rare	Summer	Rare	Summer	Shelf & pelagic	NS	NAR
Short-beaked common dolphin (*Delphinus delphis*)	Uncommon	Summer	Common	June-Oct	Shelf & pelagic	NS	NAR
Striped dolphin (*Stenella coeruleoalba*)	Rare	Summer	Uncommon	July-Oct	Slope & pelagic	NS	NAR
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	Common	Year-round, but mostly June-Sept	Common	Year-round, but mostly June-Oct	Shelf & slope	NS	NAR
White-beaked dolphin (*Lagenorhynchus albirostris*)	Common	Year-round, but spring & fall	Common	Year-round, but mostly June-Sept	Shelf	NS	NAR
Harbour porpoise (*Phocoena phocoena*)	Common	Year-round?, but mostly summer	Uncommon	Year-round, but mostly May-Oct	Shelf	Schedule 2: Threatened	SC
True Seals (Phocids)							
Harbour seal (*Phoca vitulina*)	Uncommon?	Year-round	Rare	Year-round	Coastal	NS	NAR
Harp seal (*Phoca groenlandica*)	Uncommon?	Feb-May	Common	Dec-June	Ice & pelagic	NS	NC; LPC
Hooded seal (*Cystophora cristata*)	Uncommon?	Mostly late winter	Uncommon	Mostly late winter	Ice & pelagic	NS	NAR; LPC
Grey seal (*Halichoerus grypus*)	Rare	Year-round	Uncommon	Year-round	Coastal	NS	NAR

Notes:
Note additional information on Species at Risk is provided in Chapter 11
? Indicates uncertainty
A Species designation under SARA (Government of Canada 2009); NS = No Status
B Species designation under COSEWIC (COSEWIC 2010a); E = Endangered, T = Threatened, SC = Special Concern, DD = Data Deficient, NAR = Not At Risk, NC = Not Considered, LPC = Low-priority Candidate, MPC = Mid-priority Candidate, HPC = High-priority Candidate
C Refers to the Davis Strait population. The Scotian Shelf population is considered Endangered on Schedule 1 of *SARA* and Endangered by COSEWIC. It is unknown to which population individuals observed in the Study Areas would belong

Table 10-3 Population Estimates of Marine Mammals that Occur off Eastern Newfoundland

Species	NW Atlantic	Population Occurring off Eastern Newfoundland		
	Estimated Abundance[A]	Stock	Estimated Abundance	Source
Baleen Whales				
Humpback whale	11,570[B]	NL	1,700-3,200	Whitehead (1982); Katona and Beard (1990); Baird (2003)
Sei whale	Unknown	Nova Scotia	207	Waring *et al.* (2009)
Minke whale	188,000[D]	Can. E. Coast	3,312	Dufault (2005); Waring *et al.* (2009)
Toothed Whales				
Sperm whale	4,804[E]	NW Atlantic	Unknown	Reeves and Whitehead (1997); Waring *et al.* (2009)
Northern bottlenose whale	Unknown	North Atlantic	Unknown	Reeves *et al.* (1993)
Long-finned pilot whale	31,139[G]	NL	Tens of thousands	Hay (1982); Nelson and Lien (1996)
Risso's dolphin	20,479	Can. E. Coast	Rare	Baird and Stacey (1991)
Common bottlenose dolphin	81,588[H]	Can. E. Coast	Unknown	Waring *et al.* (2009)
Short-beaked common dolphin	120,743	NL	Seasonally abundant	Gaskin (1992)
Striped dolphin	94,462	Can. E. Coast	Unknown	Baird *et al.* (1993a)
Atlantic white-sided dolphin	63,368	Can. E. Coast	Unknown	Palka *et al.* (1997); Waring *et al.* (2009)
White-beaked dolphin	2,003	Can. E. Coast	Unknown	Waring *et al.* (2009)
True Seals				
Harbour seal	99,340	NL	Thousands (at least 1,000)	Hammill and Stenson (2000); Sjare *et al.* (2005a); COSEWIC (2007a)
Harp seal	5.9 million[I]	NL	Abundant	DFO (2007b)
Hooded seal	593,500[J]	NE NL	535,800	Hammill and Stenson (2006a)
Grey seal	304,000[K]	NL	Unknown	

Notes:
A "Best" estimates from the Northwest Atlantic (Waring *et al.* 2009), unless otherwise noted
B Estimate for North Atlantic (Stevick *et al.* 2003)
C Estimate for North Atlantic (US National Marine Fisheries Service (NMFS) 1998)
D Estimate for North Atlantic (IWC 2007; Waring *et al.* 2009)
E Estimate for North Atlantic (Waring *et al.* 2009)
F Estimate for all *Mesoplodon* spp. and *Ziphius cavirostris* combined in the Northwest Atlantic (Waring *et al.* 2009)
G Estimate may include both long- and short-finned pilot whales (Waring *et al.* 2009)
H Estimate for the Northwest Atlantic offshore stock, but may include coastal forms (Waring *et al.* 2009)
I Estimate for the Northwest Atlantic (DFO 2007b)
J Estimate for the Canadian Northwest Atlantic (Hammill and Stenson 2006a)
K Estimate for Sable Island, eastern Nova Scotia, and the Gulf of St. Lawrence breeding populations (Thomas *et al.* 2007)

In addition to the species listed in Table 10-2, four species may be rare visitors in one or both of the Study Areas: the beluga whale (*Delphinapterus leucas*), North Atlantic right whale (*Eubalaena glacialis*), ringed seal (*Pusa hispida*), and bearded seal (*Erignathus barbatus*). There have been occasional reports of beluga whales at the head of Trinity Bay and adjacent Newfoundland waters, mostly during summer months (Curren and Lien 1998; Ledwell and Huntington 2006). However, these records are considered extralimital. The distributions of both ringed and bearded seals are centred in the Arctic and pack ice of the sub-Arctic (Jefferson *et al.* 2008). Occasionally, small numbers of either species may stray into the Offshore Study Area, particularly in heavy ice years. While it is possible that these four species

could occur in the Study Areas, their presence is highly unlikely and they are not considered further in this document.

Marine mammal surveys of the Grand Banks, including the Offshore Study Area, were conducted over 25 years ago in support of the Hibernia EIS (Parsons and Brownlie 1981). These surveys represented the primary source of information on marine mammal distribution and abundance within the Jeanne d'Arc Basin for several years, but are not repeated for this report. However, marine mammal sightings from recent monitoring programs in and near the Offshore Study Area (including data from 2005 to 2008) as well as cetacean observations from Newfoundland waters compiled by Fisheries and Oceans Canada (DFO) and the Whale Release and Stranding Group are summarized and incorporated into the following species profiles, updating a previous summary in LGL (2006b). Marine mammals were also recorded during supply vessel transits in August and early September 1999 from St. John's to oil platforms in the Jeanne d'Arc Basin (Wiese and Montevecchi 1999). Marine mammal observations are also available from the Terra Nova Floating, Production, Storage and Offloading (FPSO) monitoring facility for 2007 and 2008, but these are limited in terms of observational effort and detail. Waring *et al.* (2009) provide additional information on the distribution, abundance, seasonality, and conservation status of marine mammals in the Northwest Atlantic. It should be noted that the "best estimates" of marine mammal population size in Waring *et al.* (2009) are largely based on aerial survey data that are typically uncorrected for dive times.

10.3.1.1 Recent Marine Mammal Monitoring in the Jeanne d'Arc Basin

There have been several recent marine mammal monitoring programs (from 2005 to 2008) conducted during seismic surveys in Jeanne d'Arc Basin and adjacent areas, which provide new information on the spatial and temporal distribution of marine mammals in the area. Relevant programs include: Husky Energy's seismic programs during October and November 2005 (Lang *et al.* 2006) and July and August 2006 (Abgrall *et al.* 2008a); Petro-Canada's seismic survey during June and July 2007 (Lang and Moulton 2008): and StatoilHydro and Husky Energy's seismic program from June to September 2008 (Abgrall *et al.* in prep.). However, the data represent only the late spring, summer and fall seasons (and typically only portions of the summer), and the number and types of marine mammals observed may be biased by potential responses to noise from the airgun arrays. Additional marine mammal sightings were recorded by Wiese and Montevecchi (1999) during supply vessel transits between St. John's and oil platforms in Jeanne d'Arc Basin during August and September 1999 (three roundtrips in both August and September). Marine mammals were also recorded during a research expedition from the southern Grand Banks, along the eastern slope, through the Flemish Pass, around the Orphan Basin, and through the northern Grand Banks on a return to St. John's in June and July 2004 (Lang and Moulton 2004).

A summary of marine mammal sightings during the 2005 to 2008 seismic monitoring programs in the Jeanne d'Arc Basin is provided in Table 10-4.

Table 10-4 Effort and Number of Marine Mammal Sightings in the Jeanne d'Arc Basin during Monitoring Programs Conducted as a Component of Seismic Surveys, 2005 to 2008

Species	Oct-Nov 2005[A]	July-Aug 2006[B]	June-July 2007[C]	May-Sept 2008[D]	Total
Effort (km)[E]	**1,895**	**2,731**	**2,511**	**6,734**	**13,871**
Humpback whale	27	178	5	138	348
Sei whale	0	0	0	1	1
Fin or sei whale	0	0	0	1	1
Minke whale	4	12	1	31	48
Unidentified baleen whale	14	21	1	84	120
Total baleen whales	45	211	7	255	518
Unidentified beaked whale	1	0	0	1	2
Unidentified toothed whale	0	1	0	0	1
Total large toothed whales	1	1	0	1	3
Long-finned pilot whale	0	2	1	2	5
Common dolphin	1	7	0	0	8
Atlantic white-sided dolphin	2	7	0	24	33
White-beaked dolphin	1	0	5	4	10
Unidentified dolphin	2	28	5	41	76
Total dolphins & porpoises	6	44	11	71	132
Unidentified Whale	4	33	1	9	47
Total Cetaceans	**56**	**289**	**19**	**336**	**700**
Harp seal	0	0	0	14	14
Unidentified seal	0	2	0	22	24
Total seals	**0**	**2**	**0**	**36**	**38**

Notes:
A Husky Energy's seismic program from 1 October to 8 November 2005 (Lang *et al.* 2006)
B Husky Energy's seismic program from 9 July to 17 August 2006 (Abgrall *et al.* 2008a)
C Petro-Canada's seismic program from 18 June to 14 July 2007 (Lang and Moulton 2008)
D StatoilHydro and Husky Energy's seismic program from 25 May to 28 September 2008 (Abgrall *et al.* in Prep.)
E Effort and sightings include those made in the designated "Seismic Analysis Area" or "Study Area" of each seismic program (*i.e.,* the areas where seismic data were actually acquired plus a zone around this area where the seismic vessel made the majority of its turns at the end of seismic lines; effort and sightings during transit to and from the Jeanne d'Arc basin were excluded). See text of each report for specific coordinates, but all encompass Jeanne d'Arc Basin and immediately adjacent areas

There were a total of 700 non-Species At Risk (SAR) cetacean sightings (including 518 baleen whale, three large toothed whale, 132 dolphin and porpoise, and 47 unidentified whale sightings) and 38 seal sightings within the Jeanne d'Arc Basin during seismic monitoring programs from 2005 to 2008. The majority of non-SAR baleen whale sightings identified to species consisted of humpback whales (91.3 percent of identified baleen whale sightings) followed by minke whales (12.6 percent). There were no confirmed identifications of sperm whales, Sowerby's beaked whales, or northern bottlenose whales. Perhaps with the exception of sperm whales, this was not unexpected, given that the seismic programs occurred in relatively shallow shelf waters. Most of the non-SAR dolphin and porpoise sightings in the

Jeanne d'Arc Basin were of unidentified species (57.6 percent of dolphin and porpoise sightings), but Atlantic white-sided dolphins were the most frequently identified species (58.9 percent of identified dolphin and porpoise sightings). The harp seal was the only identified seal in Jeanne d'Arc Basin during these monitoring programs (14 of 38 seal sightings). The distribution of marine mammal sightings observed during these surveys, relative to the proposed Offshore Study Area, are shown in Figure 10-3.

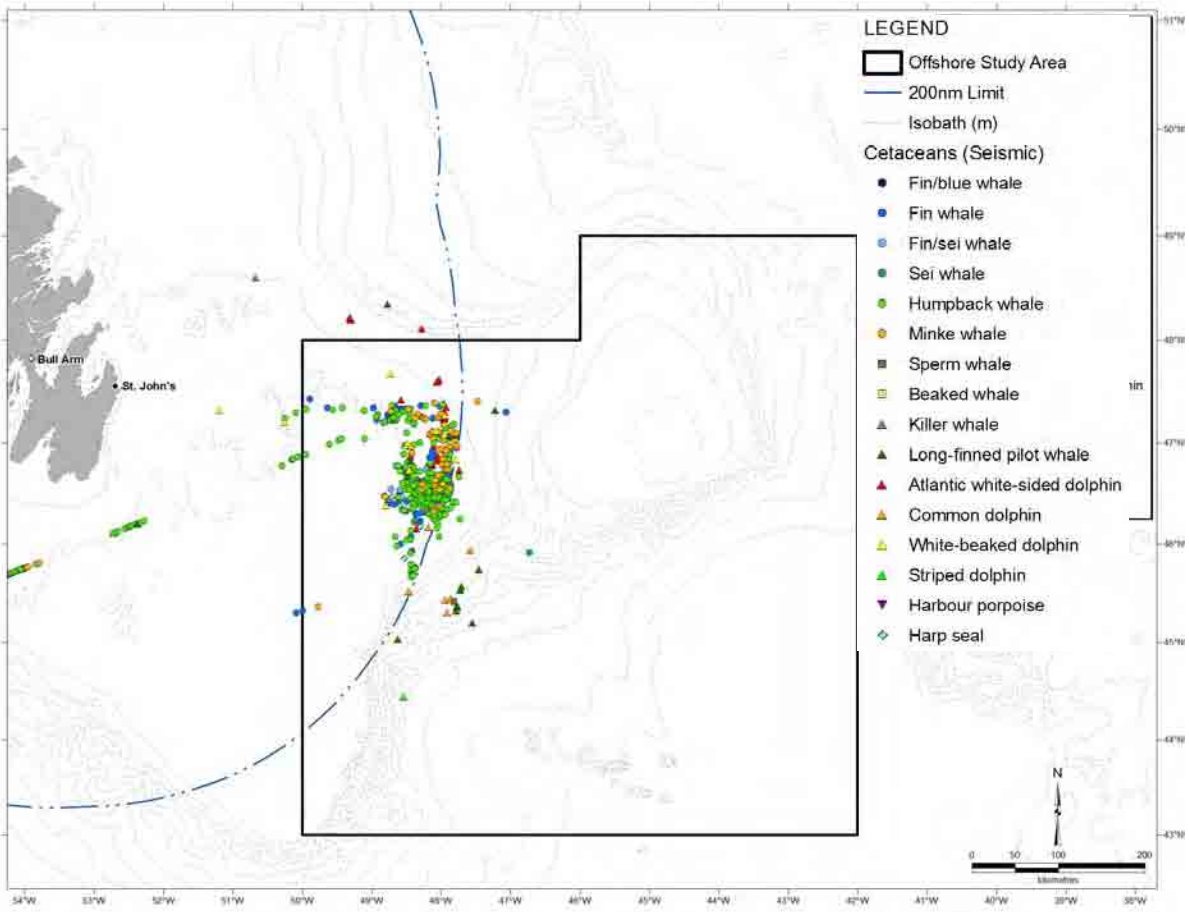


Figure 10-3 Locations of Marine Mammal Sightings Observed during Jeanne d'Arc Basin Seismic Surveys (2005 to 2008), Relative to the Offshore Study Area

Wiese and Montevecchi (1999) recorded 34 sightings of 282 individuals during the six round-trip surveys aboard a supply vessel travelling from St. John's to Jeanne d'Arc Basin. The majority of sightings were of humpback whales (11 sightings totalling 13 individuals). There were also sightings of minke and fin whales (eight and seven sightings, respectively). Most dolphin sightings were of Atlantic white-sided dolphins (seven sightings totalling 250 individuals). There was also a sighting of three killer whales recorded on August 24, 1999.

Lang and Moulton (2004) reported 20 sightings of marine mammals during a June to July 2004 research cruise from the southern Grand Banks, around Orphan Basin, and across the northern Grand Banks; long-finned pilot whales were the most frequently sighted species (six sightings), although there were

also several sightings of unidentified baleen whales and dolphins. Atlantic white-sided dolphins and fin whales were also identified.

In the adjacent Orphan Basin, several years of monitoring during seismic and controlled source electromagnetic (CSEM) surveys have also yielded hundreds of sightings of marine mammals. Orphan Basin has much greater water depths than Jeanne d'Arc Basin and different species were more frequently encountered in the Orphan Basin. For example, deep-diving sperm whales, northern bottlenose whales, and Sowerby's beaked whales were identified on several occasions in the Orphan Basin, and there have also been sightings of blue whales, bottlenose dolphins, and striped dolphins in the Orphan Basin (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b).

10.3.1.2 Fisheries and Oceans Canada Cetacean Sighting Database

DFO in St. John's (J. Lawson 2007, pers. comm.) is compiling a database of cetacean sightings in waters around Newfoundland and Labrador. These data provide some indication of what species can be expected to occur in the area, but they cannot, at this point in the development of the database, provide any fine-scale quantitative information as the database typically does not include observation effort. The coarse summary data pertaining to sightings within the Nearshore and Offshore Study Areas are provided in Tables 10-5 and 10-6; caveats associated with the DFO data are also presented.

Table 10-5 DFO Database Cetacean Sightings within the Nearshore Study Area, 1945 to 2007

Species	No. of Sightings	No. of Individuals	Month(s) Sighted
Humpback Whale	62	81	May-Aug
Minke Whale	57	64	May-Sept
White-beaked Dolphin	1	10	August

Source: DFO (2007c)

*Note the following caveats associated with the tabulated data:

- The sighting data have not yet been completely error-checked
- The quality of some of the sighting data is unknown
- Most data have been gathered from platforms of opportunity that were vessel-based. The inherent problems with negative or positive reactions by cetaceans to the approach of such vessels have not yet been factored into the data
- Sighting effort has not been quantified (*i.e.*, the numbers cannot be used to estimate true species density or real abundance)
- Both older and some more recent survey data have yet to be entered into this database. These other data will represent only a very small portion of the total data
- Numbers sighted have not been verified (especially in light of the significant differences in detectability among species)
- For completeness, these data represent an amalgamation of sightings from a variety of years (*e.g.*, since 1945) and seasons. Hence, they may obscure temporal or real patterns in distribution (*e.g.*, the number of pilot whales sighted in nearshore Newfoundland appears to have declined since the 1980s but the total number sighted in the database included here suggest they are relatively common)

Table 10-6 DFO Database Cetacean Sightings within the Offshore Study Area, 1945 to 2007

Species	No. of Sightings	No. of Individuals	Month(s) Sighted
Sei Whale	11	20	Feb, June, Aug, Sept
Humpback Whale	465	1,423	Jan, Mar-Dec
Minke Whale	42	63	April-Dec
Sperm Whale	45	125	Feb-Dec
Northern Bottlenose Whale	6	41	Mar, May, June, Sept
Long-finned Pilot Whale	76	1,187	Jan-Mar, May-Nov
Atlantic White-sided Dolphin	20	154	June-Oct
Common Dolphin	46	1,115	Mar, April, June-Oct, Dec
White-beaked Dolphin	21	89	Feb, Mar, June-Aug
Striped Dolphin	1	Not recorded	Aug

Source: DFO (2007c)
*Note the following caveats associated with the tabulated data:

- The sighting data have not yet been completely error-checked
- The quality of some of the sighting data is unknown
- Most data have been gathered from platforms of opportunity that were vessel-based. The inherent problems with negative or positive reactions by cetaceans to the approach of such vessels have not yet been factored into the data
- Sighting effort has not been quantified (*i.e.*, the numbers cannot be used to estimate true species density or real abundance)
- Both older and some more recent survey data have yet to be entered into this database. These other data will represent only a very small portion of the total data
- Numbers sighted have not been verified (especially in light of the significant differences in detectability among species)
- For completeness, these data represent an amalgamation of sightings from a variety of years (*e.g.*, since 1945) and seasons. Hence, they may obscure temporal or real patterns in distribution (*e.g.*, the number of pilot whales sighted in nearshore Newfoundland appears to have declined since the 1980s but the total number sighted in the database included here suggest they are relatively common)

Humpback whales and minke whales accounted for most non-SAR sightings in the DFO sightings database within the Nearshore Study Area (Table 10-5; Figure 10-4). There was also a single sighting of 10 white-beaked dolphins reported in the DFO database (Table 10-5; Figure 10-4).

By far, humpback whales accounted for most sightings in the Offshore Study Area. There were also several sightings of long-finned pilot whales (Table 10-6; Figure 10-5). Other commonly sighted marine mammals included minke whales and sperm whales. Common dolphins, white-beaked dolphins, and Atlantic white-sided dolphins were also frequently observed in the Offshore Study Area (Table 10-6; Figure 10-5).

Lawson and Gosselin (2009) provide preliminary abundance estimates of three mysticete and four small odontocete species based on aerial survey data collected off the south and northeast coasts of Newfoundland. It is difficult to comment on the distribution and relative abundance of cetacean species near the Hebron Study Area *versus* adjacent areas given the nature of the report. Overall densities (uncorrected for availability and perception biases) off the south coast of Newfoundland (0.002 cetacean sightings/km^2) were much higher than those (0.0005 cetacean sightings/km^2) off the northeast coast (Table 3 in Lawson and Gosselin (2009)). The south coast

survey stratum is adjacent to the western portion of the offshore Hebron Study Area. Overall, preliminary abundance estimates (uncorrected) for cetaceans off the south and northeast coasts of Newfoundland including 95 percent confidence intervals in parentheses are as follows:

- humpback whale - 1,427 (952 to 2,140)
- minke whale -1,315 (855 to 2,046)
- fin whale - 890 (551 to 1,435)
- white-beaked dolphin - 1,842 (1,188 to 2,854)
- white-sided dolphin - 1,507 (968 to 2,347)
- common dolphin - 576 (314 to 1,056)
- harbour porpoise - 1,195 (639 to 2,235)

10.3.1.3 Whale Entrapment Records

The Whale Release and Stranding Group produced yearly reports of whale entrapments and stranding from 2000 to 2008 (Ledwell *et al.* 2000, 2001, 2002; Ledwell and Huntington 2003, 2004, 2006, 2007, 2008, 2009). These reports include animals caught in fishing gear, stranded on land, observed dead at sea, and free-swimming on rare occurrences. In Trinity Bay, several reports were made for 2000 to 2008 (Table 10-7).

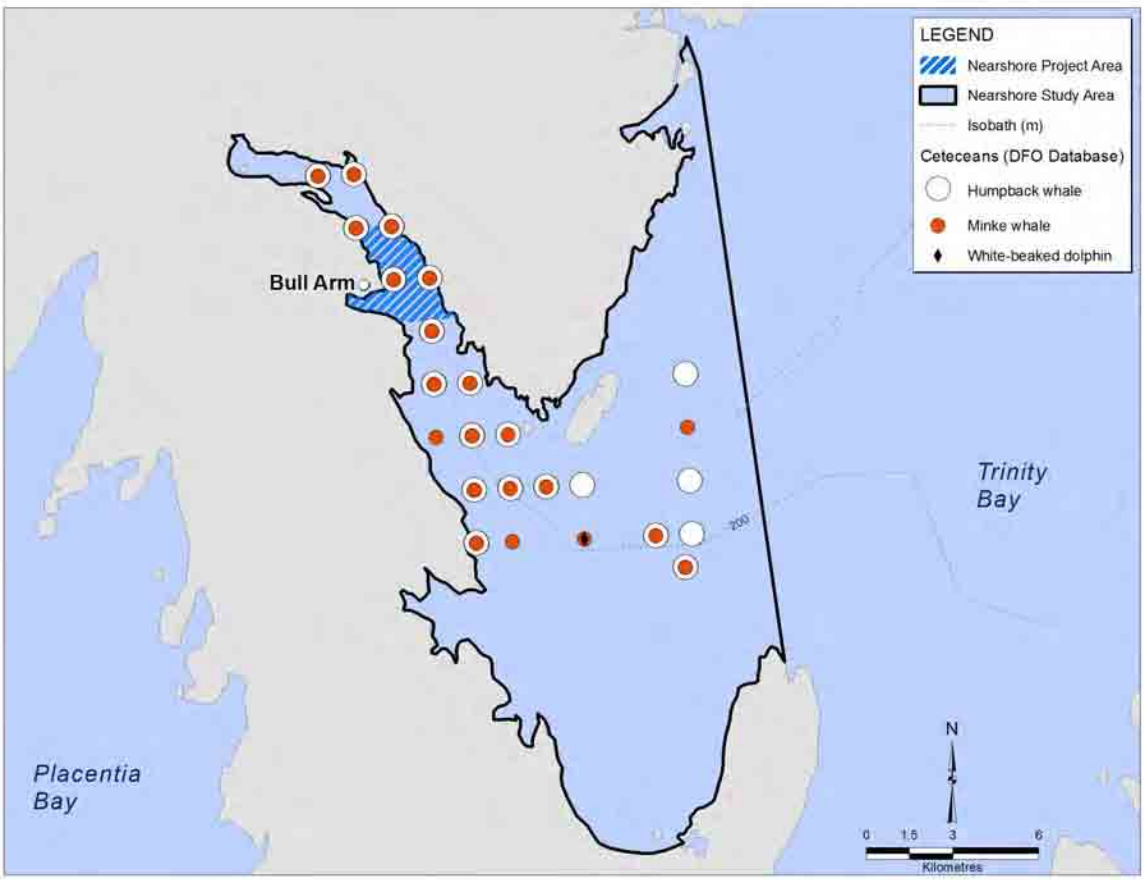


Figure 10-4 Sightings of Cetaceans within the Nearshore Study Area, Based on DFO Cetacean Sighting Database (1945 to 2007)

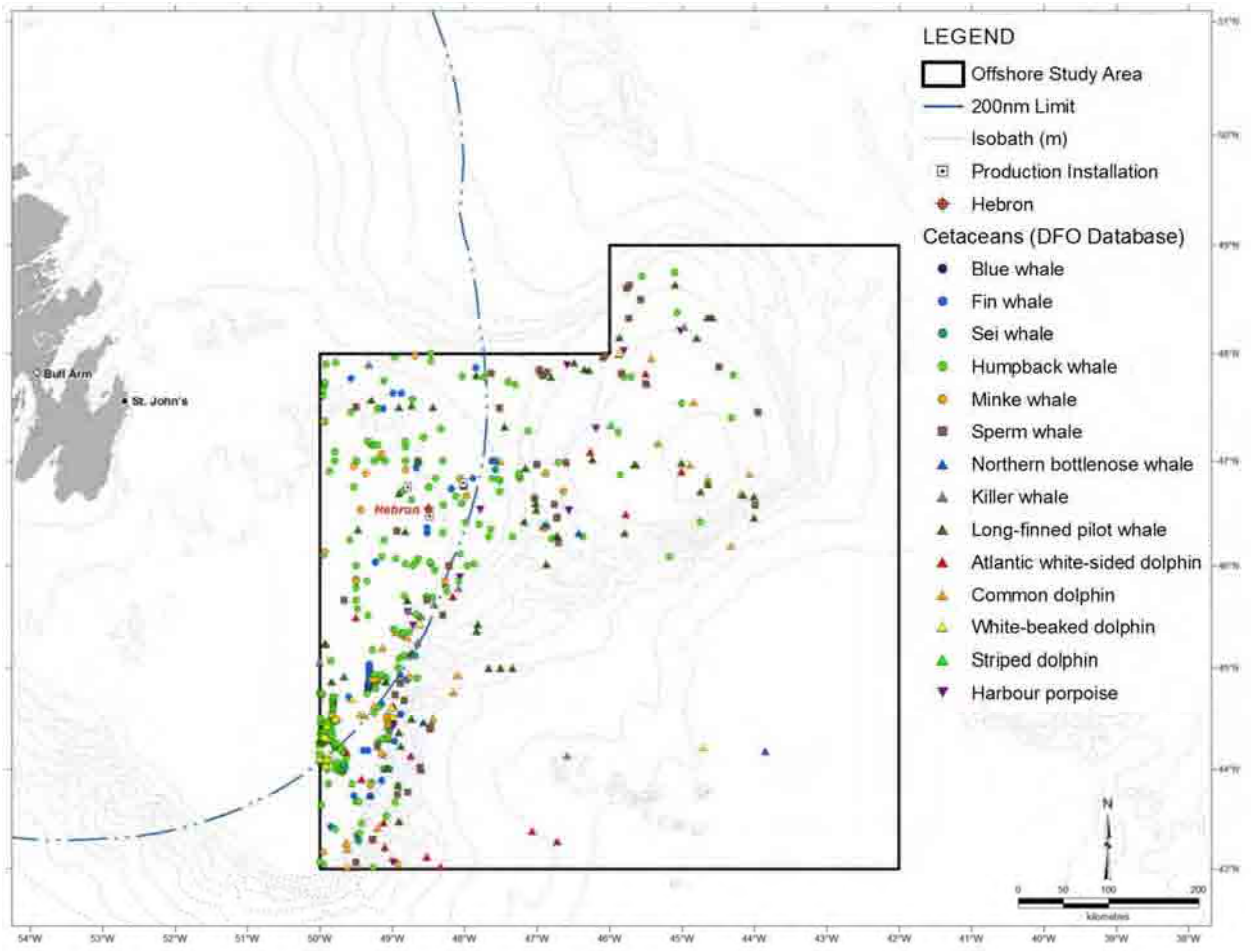


Figure 10-5 Sightings of Cetaceans within the Offshore Study Area, based on DFO Cetacean Sighting Database (1945 to 2007)

Table 10-7 Cetacean Entrapments and Strandings from 2000 to 2008

Species	Year(s)	Comments
Humpback whale	2001, 2002, 2006, 2007	Entrapped in fishing gear on 9 occasions
Minke whale	2005, 2007, 2008 (twice)	Entrapped in fishing gear
Minke whale	2008	Dead, drifting in Trinity Bay
Sei whale	2008	Stranded on shore and died
Sowerby's beaked whale	2008	Stranded dead on shore
Beluga whale	2005	Free-swimming, August
White-beaked dolphin	2005	Trapped by pack ice, March
Unkown Large whale	2002	Entrapped in fishing gear
Source: Ledwell *et al.* (2000, 2001, 2002); Ledwell and Huntington (2003, 2004, 2006, 2007, 2008, 2009)		

10.3.2 Species Profiles

10.3.2.1 Baleen Whales (Mysticetes)

Five species of baleen whales may occur in the Study Areas, two of which have garnered special status under SARA (see Section 11.3.2). Nearly all species of baleen whales became depleted due to commercial whaling, but it appears that some, including North Atlantic humpback whales, are showing signs of recovery (Best 1993). All of the species occurring in eastern Newfoundland presumably migrate to lower latitudes during winter months, although a small number of animals appear to remain in Newfoundland waters year-round.

An aerial survey of cetaceans was conducted in the Northwest Atlantic during the summer of 2007 (Lawson and Gosselin 2009). The most common species sighted during the Newfoundland portion of this survey was the humpback whale, followed by minke and fin whales (Lawson and Gosselin 2009). It was noted that few small cetaceans were sighted in the Newfoundland and Labrador Strata despite good conditions and significant effort. This may have resulted from the late arrival of cetaceans in the Newfoundland and Labrador region in 2007, as borne out by reports from fisheries officers, fishers, and tour operators, and the fact that more marine mammal sightings were recorded late in the survey (Lawson and Gosselin 2009).

Humpback Whale

Humpback whales have a cosmopolitan distribution, but typically occur in coastal regions or over the continental shelf (Jefferson *et al.* 2008). There are an estimated 11,570 individuals in the North Atlantic (Stevick *et al.* 2003), but Whitehead (1982) estimated a total of 1,700 to 3,200 animals in the Newfoundland and Labrador population. On the Southeast Shoal of the Grand Banks, approximately 900 individuals were estimated to use the area for summer foraging on capelin, their primary prey in Newfoundland waters (Whitehead and Glass 1985). The North Atlantic population is thought to be increasing (Stevick *et al.* 2003) and is no longer listed under SARA (COSEWIC 2003).

Humpback whales undergo annual migrations from summer foraging grounds in high latitudes to tropical breeding grounds during the winter. Four distinct summer foraging concentration areas in the North Atlantic have been described, based on genetic and individual identification studies: the Gulf of Maine, eastern Canada, western Greenland, and the eastern North Atlantic (Stevick *et al.* 2006). Winter breeding occurs in the West Indies in three primary areas: the Virgin Bank, Puerto Rico, and the Dominican Republic (Katona and Beard 1990). Additionally, not all individuals migrate to the tropics each year, with some presumably remaining near their foraging grounds in mid- and high-latitudes during winter (Clapham *et al.* 1993).

Humpback whales often occur singly or in small groups of two to three, but large aggregations can occur in feeding or breeding areas (Clapham 2000).

Hay (1982) reported an average group size of 2.87 animals (ranging from one to eight) for an August 1980 aerial survey off Newfoundland and Labrador, similar to group sizes of 1 to 10 observed on the Southeast Shoal of the Grand Banks during June and July of 1982 and 1983 (Whitehead and Glass 1985). During summer feeding periods, humpbacks generally dive for less than five minutes, and dives that last greater than 10 minutes are atypical (Clapham and Mead 1999).

The humpback whale is common in Newfoundland waters, especially during summer. Humpbacks begin arriving in offshore areas by April and remain until October; they occur in inshore areas primarily from June to September. Some humpbacks likely stay in Newfoundland waters year-round. In the Jeanne d'Arc Basin, humpback whales were the most commonly sighted baleen whale during each seismic survey from 2005 to 2008, making up approximately 91 percent of the identified non-SAR baleen whale sightings (Table 10-4). They were also the most frequently sighted baleen whale species in the Orphan Basin during seismic monitoring programs in 2004 and 2005 (Moulton *et al.* 2005, 2006b) and the second most frequently sighted baleen whale species during CSEM monitoring programs in 2006 and 2007 (Abgrall *et al.* 2008b). The humpback whale was the most frequently reported species in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6).

Humpback whales also frequently occur during the summer period in Trinity Bay. Hay (1982) reported a density of approximately 0.09 humpbacks per square nautical mile in Trinity Bay during an August 1980 aerial survey, a higher density than in any other nearshore region of Newfoundland that was surveyed (St. Mary's Bay to White Bay). Lien (1994) reported several humpback entrapments in fishing gear throughout Trinity Bay from 1979 to 1990, and Whitehead *et al.* (1980) estimated that approximately 255 animals moved north past the Bay de Verde Peninsula during June and July in 1978. The inshore abundance of humpback whales (and other baleen whale species) is related to the relative abundance of prey species, primarily capelin (Piatt *et al.* 1989), and several major capelin spawning beaches are found in Trinity Bay. In coastal areas of northern Newfoundland, humpback whales were most frequently observed feeding in waters less than one nautical mile from shore, although they also occurred in areas greater than 5 nm from shore (Perkins and Whitehead 1977). Over 19 days in June 1992, at least 71 individuals were uniquely identified in southern Trinity Bay, with 57 percent of sightings occurring approximately 3 to 9 km from Mosquito Cove in Bull Arm (Todd *et al.* 1996). The humpback whale was the most frequently reported species in the DFO cetacean sightings database in the Nearshore Study Area; there were 62 sightings of 81 individuals reported (Table 10-5). Thus, humpback whales are common in both Study Areas during early summer to fall, and a smaller number of animals may be present year-round.

Sei Whale

The distribution of sei whales is not well understood, but they are found in all oceans and appear to prefer mid-latitude temperate waters (Jefferson *et al.*

2008). There are two stocks of sei whales recognized in the Northwest Atlantic: a more well-known Nova Scotia stock whose distribution extends from the northeast United States to southern Newfoundland, and a Labrador Sea stock (Waring *et al.* 2009). The Nova Scotia stock is estimated to contain 207 individuals, but there is no current population estimate for the Labrador Sea stock (Waring *et al.* 2009). It is unclear to which population animals occurring off eastern Newfoundland belong.

Sei whales tend to be found in pelagic regions, most often in areas with steep bathymetric relief like continental shelf breaks, seamounts, canyons, or basins near banks and ledges (Kenney and Winn 1987; Gregr and Trites 2001). Sei whales typically occur alone or in groups of two to five, and females are larger than males (Jefferson *et al.* 2008). Although they sometimes consume small fish, primary prey consists of euphausiids and copepods (Flinn *et al.* 2002).

Mitchell and Chapman (1977) hypothesized that sei whales in the Northwest Atlantic are migratory, moving from spring feeding areas on or near Georges Bank to the Scotian Shelf in June and July, eastward to Newfoundland and the Grand Banks in late summer, back to the Scotian Shelf in fall, and offshore and south during winter. These authors estimated a minimum stock size of 870 individuals, based on mark-recapture data from the 1960s to 1970s. In the Jeanne d'Arc Basin, there has been one confirmed sei whale sighting and one possible sighting (either a sei or fin whale) (Table 10-4). However, sei whales were encountered several times in the Orphan Basin (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b).There were 11 sei whale sightings reported in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). The available information suggests that sei whales are present during summer and fall months, but are likely uncommon, in the Offshore Study Area.

There is little information on the presence of sei whales in Trinity Bay, but the sei whale tends to be a more pelagic species and is not typically reported in coastal Newfoundland. In addition, it is often difficult to differentiate between sei whales and fin whales in the field. It is possible that some reports of fin whales could actually be sei whales. A live sei whale was reported stranded off Catalina on August 11, 2008 and subsequently died (Ledwell and Huntington 2009). There were no sightings of sei whales reported in the DFO cetacean sightings database in the Nearshore Study Area (Table 10-5). Given the information available, sei whales are expected to be rare in the Nearshore Study Area throughout the year.

Minke Whale

The smallest of the baleen whales, minke whales are cosmopolitan in distribution and can be found in polar, temperate, and tropical waters (Jefferson *et al.* 2008). Four populations are recognized in the North Atlantic: the Canadian east coast, west Greenland, central North Atlantic, and northeastern North Atlantic stocks (Waring *et al.* 2009). An estimated 3,312 individuals occur in the Canadian east coast stock, which ranges from

the continental shelf of the northeast United States to the eastern half of Davis Strait (Waring *et al.* 2009).

Minke whales often occur singly or in small groups of two or three, although large aggregations can form in areas where prey concentrates (Jefferson *et al.* 2008). Off coastal portions of northern Newfoundland, Perkins and Whitehead (1977) most frequently observed single minke whales, but groups of up to five animals were occasionally observed. Occasionally minke whales approach vessels, but their small size, inconspicuous blows, and brief surface durations can make them otherwise challenging to detect at sea (Stewart and Leatherwood 1985). Foraging typically occurs over the continental shelf on small schooling fish, and minke whales appear to make short duration dives (Stewart and Leatherwood 1985). Seasonal movements in many parts of the world have been noted and generally mirror the abundance and distribution of their primary prey species (Macleod *et al.* 2004). Their presence in the Gulf of St. Lawrence has also been linked to thermal fronts that presumably function to concentrate prey (Doniol-Valcroze *et al.* 2007).

Minke whales regularly occur in coastal areas and the offshore banks of eastern Newfoundland. In the Jeanne d'Arc Basin, minke whales were the second most frequently observed non-SAR baleen whale (after humpback whales) during seismic monitoring programs, representing approximately 13 percent of all identified non-SAR baleen whale sightings (Table 10-4). There were also multiple minke whale sightings each year during monitoring programs in the Orphan Basin (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b). Minke whales were commonly reported in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). Thus, minke whales can be considered common in the Offshore Study Area, particularly from late spring to early fall.

The coastal presence of minke whales in eastern Newfoundland is linked to the presence and abundance of capelin (Sergeant 1963), with minke whales the second most frequently observed species (after humpback whales) in nearshore areas (Piatt *et al.* 1989). Minke whales were also the second most common cetacean to be entrapped in commercial fishing gear, with entanglements occurring throughout Trinity Bay from 1979 to 1990 (Lien 1994). In Trinity Bay, minke whales were once commercially harvested and landed at the South Dildo whaling station. Catches of minke whales were concentrated throughout the southwestern portion of Trinity Bay and primarily exploited juvenile males, females, and pregnant females (over 85 percent of mature females sampled were pregnant); catches were highest from May to July (Mitchell and Kozicki 1975), but continued until late October (Sergeant 1963). The minke whale was the second most commonly reported species in the DFO cetacean sightings database in the Nearshore Study Area; there were 57 sightings of minke whales (Table 10-5). Given the available information, minke whales are expected to be common in Trinity Bay during summer and are likely present at lower densities in early spring and winter.

10.3.2.2 Toothed Whales (Odontocetes)

Twelve species of toothed whales may occur in the two Study Areas (see Table 10-2). These species include the sperm whale, the largest living toothed whale (approximately 18 m for an adult male (Reeves and Whitehead 1997)), as well as one of the smallest odontocetes, the harbour porpoise (approximately 1.6 m for an average adult (COSEWIC 2006a)). Many of these species occur seasonally in the Study Areas, but little is known about their distribution and population sizes.

Sperm Whale

Sperm whales are widely distributed, occurring from the edge of polar pack ice to the equator, but are most common in tropical and temperate waters (Jefferson *et al.* 2008). Whitehead (2002) estimated a total of 13,190 sperm whales for the Iceland-Faroes area, the area northeast of it, and the east coast of North America combined, but Waring *et al.* (2009) only estimated a total of 4,804 sperm whales in the North Atlantic.

Sperm whale abundance and distribution in an area can vary in response to prey availability, particularly mesopelagic and benthic squid (Jaquet and Gendron 2002; Jaquet *et al.* 2003). Sperm whales tend to occur in deep waters off the continental shelf, particularly areas with high secondary productivity and steep slopes (Jaquet and Whitehead 1996; Waring *et al.* 2001). Distribution has also been linked to warm core rings of the Gulf Stream off the United States continental shelf, with sightings occurring in water depths from 1,539 to 4,740 m deep (Griffin 1999). Sperm whales routinely dive to hundreds of metres, with maximum depths up to 3,000 m; foraging dives may last up to an hour and occur at depths below 1,000 m (Whitehead and Weilgart 2000).

Males tend to range farther north than females, making sperm whales encountered in eastern Newfoundland more likely to be males. Adult females and juveniles form large aggregations in warm tropical and sub-tropical regions, but males typically occur singly or in small same-sex groups and occur at higher latitudes (Whitehead *et al.* 1992; Whitehead and Weilgart 2000; Whitehead 2003). However, males can also sometimes form large aggregations of 20 to 30 individuals (Whitehead 2003), and mixed groups containing females and juveniles have occasionally been observed in higher latitudes (*e.g.*, Whitehead and Weilgart 2000).

No sperm whales were observed within the Jeanne d'Arc Basin during seismic monitoring programs (Table 10-4), but were regularly sighted in deeper waters of Orphan Basin (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b). Sperm whales were commonly reported in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). Sperm whales may periodically occur in the Offshore Study Area, but are relatively uncommon; they would most likely be found in deeper portions of the Study Area and during summer months. It has been noted that sperm whales have been attracted to fishing operations on the Grand Banks and, therefore, may approach other vessels as well (DFO, pers. comm.).

Sperm whales have rarely been observed in coastal Newfoundland, and would be most likely in areas with deep water and steep slopes. There were no sightings of sperm whales reported in the DFO cetacean sightings database in the Nearshore Study Area (Table 10-5). Thus, sperm whale occurrences are expected to be uncommon in the Nearshore Study Area.

Northern Bottlenose Whale

Northern bottlenose whales occur only in the North Atlantic, predominantly in deep offshore areas, and have two (known) primary areas of concentration: The Gully and adjacent canyons of the eastern Scotian Shelf, and Davis Strait off northern Labrador (Reeves *et al.* 1993). The abundance of northern bottlenose whales in the Northwest Atlantic is unknown (Waring *et al.* 2009), but there are an estimated approximately 163 individuals in the Scotian Shelf population (Whitehead and Wimmer 2005). The Scotian Shelf population is considered to be of Special Concern by COSEWIC and Endangered on Schedule 1 of SARA, but the Davis Strait population has no status under SARA and is considered not at risk by COSEWIC (COSEWIC 2002a).

It appears that the Scotian Shelf population has a relatively restricted distribution. This population spends the majority of its time in The Gully (with a third of the population present there at any time), but nearby Shortland and Haldimand canyons are also extensively used; their home range is thought to be a few hundred kilometres or less (Wimmer and Whitehead 2004). On the Scotian Shelf, tagged northern bottlenose whales routinely dove to depths over 800 m and remained submerged for over an hour; the maximum recorded depth was 1,453 m (Hooker and Baird 1999a). Foraging appears to occur at depth, primarily for large and medium-bodied squid. Group sizes on the Scotian Shelf average around three individuals, and are rarely more than 10 individuals, with males forming long-term bonds while females do not seem to have preferred associates (Gowans *et al.* 2001).

For the purposes of this assessment, it is assumed that northern bottlenose whales which occur in the Hebron Offshore Study Area would belong to the Davis Strait population. There have been two sightings of beaked whales in the Jeanne d'Arc Basin during summer and fall seismic surveys (Table 10-4), one of which was confirmed as a species other than the northern bottlenose whale (Lang *et al.* 2006). However, there have been several confirmed sightings of northern bottlenose whales in the deeper Orphan Basin (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b). There were six sightings of northern bottlenose whales reported in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). The available evidence suggests that northern bottlenose whales likely occur at low densities, possibly year-round, in the deeper waters of the Offshore Study Area.

Northern bottlenose whales have occasionally been observed in coastal eastern Newfoundland, although most records are based on carcasses that have washed ashore. Lien (1994) reported that northern bottlenose whales were entrapped in inshore fishing gear on two occasions from 1979 to 1990, and Sergeant *et al.* (1970) described a single northern bottlenose whale taken at the South Dildo, Trinity Bay, whaling station in July 1953. Apparently a

second whale, associated with the one captured, remained free-swimming in the southern part of Trinity Bay for at least three additional days (Sergeant and Fisher 1957). Recently, northern bottlenose whales have stranded in Bonavista Bay (2004) and the south coast of Newfoundland (2005) and it is suspected that the whales were pursuing nearshore squid (J. Lawson, pers. comm., October, 2010). There were no sightings of northern bottlenose whales reported in the DFO cetacean sightings database in the Nearshore Study Area (Table 10-6). It appears possible that northern bottlenose whales may occur in the Nearshore Study Area, but sightings would be considered rare.

Long-finned Pilot Whale

Long-finned pilot whales are widespread in the North Atlantic (Jefferson *et al.* 2008). There is an estimated 31,139 individuals in the Northwest Atlantic (although that number could also contain some short-finned pilot whales) (Waring *et al.* 2009), and they are abundant year-round residents of Newfoundland waters (Nelson and Lien 1996). Hay (1982) estimated a total of 13,167 individuals in eastern Newfoundland and southern Labrador waters.

Pilot whales are sexually dimorphic, such that males are longer than females and have larger dorsal fins as well as more pronounced melons (Jefferson *et al.* 2008). Pilot whales studied in Nova Scotia seem to form long-term social groups of related individuals, with minimal dispersal from natal groups (Ottensmeyer and Whitehead 2003). Average group size was 20 individuals, but ranged from two to 135 (Ottensmeyer and Whitehead 2003). Pilot whales appear to associate with the continental shelf break, slope waters, and areas of high sub-surface relief, and often have inshore-offshore movements that coincide with their prey (Jefferson *et al.* 2008). Primary prey in nearshore Newfoundland has been identified as short-finned squid (Sergeant 1962), but they are also known to consume other species of cephalopod and fish (Nelson and Lien 1996).

Pilot whales are regular inhabitants of eastern Newfoundland. In the Jeanne d'Arc Basin, pilot whales were observed during all but the late fall 2005 seismic monitoring programs (Table 10-4), and were also frequently sighted in the Orphan Basin (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b). The long-finned pilot whale was the second most frequently sighted non-SAR species in the Offshore Study Area, according to the DFO cetacean sightings database (Table 10-6). Long-finned pilot whales are expected to be common year-round in the Offshore Study Area, particularly during summer months.

Pilot whales also frequently occur in coastal Newfoundland. Prior to 1900, small harvests of pilot whales were taken in Newfoundland bays by whalers and fishermen driving groups ashore; commercial whaling began in 1947, centred on Trinity Bay, and continued until 1972 (Abend and Smith 1999). Hay (1982) estimated a density of 0.1115 pilot whales per square nautical mile in Trinity Bay, based on an August 1980 aerial survey, but it is unknown how many pilot whales currently use Trinity Bay. During the commercial whaling period, whales entered the bay in July and remained through October (Sergeant 1962). There were no long-finned pilot whales reported in the DFO

cetacean sightings database in the Nearshore Study Area (Table 10-5). Long-finned pilot whales may occur in the Nearshore Study Area year-round, and are likely one of the most common odontocetes to be present during summer and fall.

Risso's Dolphin

Risso's dolphins are widely distributed in tropical and warm temperate oceans (Jefferson *et al.* 2008). In the Northwest Atlantic, 20,479 individuals are estimated to occur from Florida to eastern Newfoundland (Waring *et al.* 2009). Eastern Canada appears to be at the upper limit of the Risso's dolphin's range, where an unknown number occur, but are considered rare (Baird and Stacey 1991).

Risso's dolphin group sizes generally range from 10 to 100 animals, but groups of up to 4,000 individuals have been reported (Jefferson *et al.* 2008). They are often sighted in association with other cetacean species, and are thought to be deep divers. Squid are presumed to be their primary prey, but Risso's dolphins also consume crustaceans and other cephalopods (Jefferson *et al.* 2008). Risso's dolphins are primarily associated with steep portions of the continental slope that may concentrate cephalopod prey (Baumgartner 1997). Off the northeast United States coast, they are distributed along the continental shelf edge during spring, summer, and autumn, but range into pelagic regions during winter (Waring *et al.* 2009).

Risso's dolphins are relatively abundant in warm temperate and tropical waters, but rarely range as far north as eastern Canada waters (Baird and Stacey 1991). In the Jeanne d'Arc Basin, there have been no sightings of Risso's dolphins during summer and fall monitoring programs (Table 10-4), nor have any been recorded in the deeper Orphan Basin (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b). Also, Risso's dolphins have not been recorded in the DFO cetacean sightings (Table 10-6). While Risso's dolphins may occur in the Offshore Study Area, particularly deeper portions, their presence is likely to be rare.

There are no published records of Risso's dolphins occurring in coastal Newfoundland waters (nor stranding records). Given the available information on Risso's dolphins occurrence and preference for deep waters, their presence in the Nearshore Study Area is likely to be very rare.

Common Bottlenose Dolphin

Bottlenose dolphins are distributed widely in tropical and temperate waters, occupying a variety of habitats (Jefferson *et al.* 2008). In the Northwest Atlantic, there are two morphologically and genetically distinct stocks, referred to as the coastal and offshore forms (Hoelzel *et al.* 1998). The offshore form tends to occur along the outer continental shelf and slope in the Northwest Atlantic while the coastal form occurs from New York to the Gulf of Mexico along the Atlantic coast (Waring *et al.* 2009). The population of the offshore form, potentially ranging into eastern Newfoundland waters, is estimated to contain 81,588 individuals (Waring *et al.* 2009).

Groups of 2 to 15 animals are common among bottlenose dolphins, but they can also be observed offshore in groups of hundreds (Shane *et al.* 1986). Group organization can be fluid or long-term and is based on several factors like age, sex, individual relatedness, and reproductive condition (Connor *et al.* 2000). Bottlenose dolphins consume a variety of fish species, cephalopods, and shrimp by employing a number of foraging strategies (Connor *et al.* 2000).

The distribution of bottlenose dolphins in higher latitudes appears to be seasonal, with a more northerly range during summer months (Shane *et al.* 1986). Bottlenose dolphins are considered at the northern limit of their range in eastern Newfoundland waters (Baird *et al.* 1993b). None were sighted during the monitoring programs in the Jeanne d'Arc Basin (Table 10-4), but there was a single sighting of 15 individuals in the Orphan Basin (Moulton *et al.* 2006a). There were no bottlenose dolphins reported in the DFO cetacean sightings database (Table 10-6). While it is possible that bottlenose dolphins will occur in the Offshore Study Area, particularly during summer, they are likely to be rare.

There are no published records of bottlenose dolphins in nearshore eastern Newfoundland and this species was not recorded in the DFO cetacean sightings database (Table 10-5). The available information suggests that bottlenose dolphins will not occur in the Nearshore Study Area.

Short-beaked Common Dolphin

The short-beaked common dolphin is widely distributed over the continental shelf in temperate, tropical, and subtropical regions (Jefferson *et al.* 2008). In the Northwest Atlantic, their distribution ranges up to 47°N to 50°N off of Newfoundland (Jefferson *et al.* 2009). An estimated 120,743 individuals reside in the Northwest Atlantic (Waring *et al.* 2009), but an unknown number are found in eastern Canada (Gaskin 1992).

Short-beaked common dolphins form groups ranging in size from several dozens to over 10,000, often moving rapidly with many aerial behaviours like porpoising and bowriding (Jefferson *et al.* 2008). They are found in a variety of habitats, ranging from 100 to 2,000 m deep, but appear to prefer areas with high seafloor relief (Selzer and Payne 1988) and are often associated with features of the Gulf Stream (Hamazaki 2002). The abundance and distribution of short-beaked common dolphins also coincides with peaks in abundance of mackerel, butterfish, and squid (Selzer and Payne 1988).

Gaskin (1992) indicated that common dolphins can be abundant off the coast of Nova Scotia and Newfoundland for a few months during the summer. Whitehead and Glass (1985) reported seven sightings of common dolphins during surveys on the Southeast Shoal of the Grand Banks in June and July of 1982 and 1983, with group sizes ranging from five to 50 individuals. There were eight sightings of common dolphins on the Jeanne d'Arc Basin (Table 10-4). During monitoring programs in the adjacent Orphan Basin, there were a total of 13 common dolphin sightings (Moulton *et al.* 2006b; Abgrall *et al.* 2008b). There were 46 sightings of common dolphins reported in the DFO

cetacean sightings database in the Offshore Study Area (Table 10-6). During summer, it is likely that short-beaked common dolphins will occur in the Offshore Study Area.

Nearshore sightings of common dolphins in eastern Newfoundland are less frequent than offshore sightings. Whaling captains apparently did not frequently see common dolphins, but an individual dolphin was shot in Dildo Arm in Trinity Bay in July 1957 (Sergeant 1958, in Gaskin 1992). There were no common dolphins reported in the DFO cetacean sightings database in the Nearshore Study Area (Table 10-5). While they apparently can occur in Trinity Bay, the occurrence of common dolphins in the Nearshore Study Area is likely uncommon.

Striped Dolphin

Striped dolphins are widely distributed in global warm temperate to tropical waters, with their northern range in the Atlantic Ocean extending into eastern Canada waters (Baird *et al.* 1993a). There are an estimated 94,462 striped dolphins in the Northwest Atlantic (Waring *et al.* 2009), but an unknown number use eastern Canada waters (Baird *et al.* 1993a).

Striped dolphins can form large groups of thousands of animals, but usually are found in group sizes of several dozen to 500 (Jefferson *et al.* 2008). Preferred habitats for striped dolphins include deep water areas along the edge and seaward of the continental shelf, especially areas with warm currents (Baird *et al.* 1993a). Striped dolphin distribution has also been associated with upwelling area or convergence zones (Au and Perryman 1985). Archer and Perrin (1999) suggested that striped dolphins are feeding at depths of 200 to 700 m, with small mid-water fishes or squid representing their primary prey. Sightings off the northeastern US coast have been focused along the 1,000-m depth contour in all seasons and associated with the northern edge of the Gulf Stream and warm core rings (Waring *et al.* 2009).

Offshore waters of the Grand Banks are considered to be at the northern limit of the striped dolphin's range. No striped dolphins have been observed within Jeanne d'Arc Basin (Table 10-4), but a group of approximately 25 individuals was sighted in the southern portion of the Offshore Study Area in September 2008 (Abgrall *et al.* in prep.). During monitoring programs in the Orphan Basin, there were a total of three sightings (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b). There was a single report of a striped dolphin in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). The available information suggests that the presence of striped dolphins is likely to be uncommon in the Offshore Study Area, but they could potentially occur there during summer and fall.

There are no published records of striped dolphins occurring in coastal regions of eastern Newfoundland and this species was not recorded in the DFO cetacean sightings database (Table 10-5). Based on the paucity of striped dolphin nearshore records and the species apparent preference for

deep shelf edge and offshore waters, it is unlikely that striped dolphins will occur in the Nearshore Study Area.

Atlantic White-sided Dolphin

Atlantic white-sided dolphins are found in temperate and sub-Arctic regions of the North Atlantic, primarily in deep waters of the outer continental shelf and slope (Jefferson *et al.* 2008). At least three distinct stocks (Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea) may occur in the North Atlantic, but this has not been confirmed (Waring *et al.* 2009). There is an estimated 63,368 individuals in the Northwest Atlantic (Waring *et al.* 2009), but their abundance off eastern Newfoundland is unknown.

Atlantic white-sided dolphins are gregarious, with an average group size of 52.4 and ranging from two to 2,500; larger group sizes tend to be observed from August to October (Weinrich *et al.* 2001). Calving appears to occur from May to August, but peaks in June and July (Weinrich *et al.* 2001). Prey items range from cephalopods to pelagic or benthopelagic fishes like capelin, herring, hake, sandlance, and cod (Selzer and Payne 1988; Weinrich *et al.* 2001). Primary habitat appears to coincide with the 100-m depth contour of the continental shelf, with sightings more common in areas with high sub-surface relief with low sea surface temperatures and salinity (Selzer and Payne 1988).

Atlantic white-sided dolphins are regular inhabitants of eastern Newfoundland waters. They were the most frequently identified dolphin species during four years of summer and fall monitoring programs in the Jeanne d'Arc Basin (Table 10-4). Atlantic white-sided dolphins were also frequently observed in and near Orphan Basin (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b). There were 20 sightings of Atlantic white-sided dolphins reported in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). The available data indicates that Atlantic white-sided dolphins are common in the Offshore Study Area, particularly from June to October.

White-sided dolphins also occur in coastal eastern Newfoundland. Piatt *et al.* (1989) reported four sightings during June and July 1982-1985 from Witless Bay. Two male white-sided dolphins were driven ashore during a pilot whale harvest in Chapel Arm, Trinity Bay in July 1954 (Sergeant and Fisher 1957). Sergeant and Fisher (1957) indicated that white-sided dolphins were sighted during previous years in Trinity Bay and suggested that this species uses inshore Newfoundland waters during summer, often accompanying long-finned pilot whales, although they are less common than pilot whales. There were no Atlantic white-sided dolphins reported in the DFO cetacean sightings database in the Nearshore Study Area (Table 10-5). It is expected that white-sided dolphins are common in the Nearshore Study Area, mostly from June to September.

White-beaked Dolphin

White-beaked dolphins occur in cold temperate and sub-Arctic waters in the North Atlantic and have a more northerly distribution than most other dolphin

species (Jefferson *et al.* 2008). There are an estimated 2,003 individuals in the Northwest Atlantic (Waring *et al.* 2009), but it is unknown how many occur off eastern Newfoundland.

Sometimes white-beaked dolphins are observed in association with other cetacean species, and group sizes are typically less than 30 individuals; however, groups sizes ranging up to many hundreds have been recorded (Lien *et al.* 2001). Prey items include squid, crustaceans, and a variety of small mesopelagic and schooling fishes like herring, cod, haddock, and hake (Jefferson *et al.* 2008). White-beaked dolphins are generally observed in continental shelf and slope areas, but are also known to use shallow coastal regions (Lien *et al.* 2001). It is presumed that white-sided dolphins remain at relatively high latitudes throughout the fall and winter (Lien *et al.* 2001).

While less common than some other dolphin species, white-beaked dolphins are thought to be year-round residents of eastern Newfoundland. White-beaked dolphins were seen during each summer and fall in the Jeanne d'Arc Basin, other than 2006 (Table 10-4). White-beaked dolphins were also sighted in and near the Orphan Basin (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b). There were 21 sightings of white-beaked dolphins reported in the DFO cetacean sightings database in the Offshore Study Area (Table 10-6). Given the available information, it seems that white-beaked dolphins are common in the Offshore Study Area, especially during spring-fall.

White-beaked dolphins also occur in nearshore areas of eastern Newfoundland. Sergeant and Fisher (1957) suggested that white-beaked dolphins tend to occur in coastal Newfoundland during spring and fall, from at least March to May and October to November, with smaller group sizes (usually six to eight individuals) than those of Atlantic white-sided dolphins. Several reports of white-beaked dolphins in Conception Bay and Trinity Bay were provided, including reports of dolphins trapped by dense sea ice in the spring. Hay (1982) estimated a total of 5,539 individuals occur in eastern Newfoundland and southern Labrador based on observations during an August 1980 aerial survey, noting that high densities were recorded in Fortune and Placentia bays. One white-beaked dolphin sighting (of 30 animals) was reported in Witless Bay during the summers of 1982 to 1985 (Piatt *et al.* 1989). Fourteen white-beaked dolphins were trapped by wind-blown pack ice in Trinity Bay on 20 March 2005 (Ledwell and Huntington 2006). There was a single sighting of a group of 10 white-beaked dolphins reported in the DFO cetacean sightings database in the Nearshore Study Area (Table 10-5). White-beaked dolphins are likely common in the Nearshore Study Area during spring and fall, although they are generally less common than other dolphin species.

10.3.2.3 True Seals (Phocids)

Four species of seals are known to occur in the Nearshore and Offshore Study Areas (see Table 10-2). Several fish species (primarily cod, capelin, sand lance, and halibut) and invertebrates (generally squid and shrimp) are consumed by seals, but diets can vary considerably among years, seal species, geographic regions, and seasonally (Hammill and Stenson 2000).

Harbour Seal

Harbour seals have a widespread distribution in the northern hemisphere, but are generally only found in coastal waters (Jefferson *et al.* 2008). In the Northwest Atlantic, harbour seals range from northern Florida to northern Baffin Island and along Greenland's southern coast (Bigg 1981). There are an estimated 99,340 individuals in the Northwest Atlantic (Waring *et al.* 2009). Hammill and Stenson (2000) estimated a total of approximately 5,120 harbour seals in Newfoundland and Labrador in 1996, and further information suggests there may be at least 1,000 animals in coastal Newfoundland (Sjare *et al.* 2005a; COSEWIC 2007a).

Harbour seals are found in coastal areas, rarely more than 20 km from shore, and often enter bays, estuaries, and inlets where they sometimes also follow anadromous salmonids up coastal rivers (Baird 2001). They periodically haul out of the water at coastal sites, usually rocky outcroppings and intertidal ledges. Primary prey in Newfoundland include winter flounder, cod, and sculpins (Sjare *et al.* 2005a). In Nova Scotia, harbour seals pup in the spring, primarily in May and June, and pups are nursed for approximately 24 days (Bowen *et al.* 2001). No studies are available to describe pupping patterns in Newfoundland, but similar patterns are expected. Mating also tends to occur during pupping season. Moulting occurs from mid-summer to early fall, and harbour seals haul out more frequently than at other times of the year. Harbour seals are primarily considered a coastal species with limited dispersal from preferred haul out sites, but pups and juveniles have shown movements up to hundreds of kilometres over the continental shelf from haul out sites (Small *et al.* 2005). Harbour seals tagged in the St. Lawrence estuary were shown to migrate an average of 266 km to wintering locations exhibiting lower ice densities, but remained closer to shore (within 11 km) and in shallow areas, traveling only short distances (15 to 45 km), during ice-free conditions (Lesage *et al.* 2004).

Harbour seals are considered year-round residents of coastal Newfoundland (Sjare *et al.* 2005a). Relative to other seal species in Newfoundland waters, spatial and temporal distribution and abundance is poorly known (Hammill and Stenson 2000). None have been sighted during summer and fall observations on the northeastern Grand Banks, in the Jeanne d'Arc Basin or Orphan Basin (Moulton *et al.* 2005, 2006a; Lang *et al.* 2006; Abgrall *et al.* 2008a, 2008b; Lang and Moulton 2008). The Offshore Study Area is within the maximum range reported for harbour seals; however, harbour seals are unlikely to occur there based on their preference for coastal waters.

Sjare *et al.* (2005a) indicate that harbour seals do not regularly occur in Trinity Bay. Based on the absence of reports and sighting records within Trinity Bay, harbour seals are not expected to commonly occur in the Nearshore Study Area.

Harp Seal

The harp seal is found throughout the North Atlantic and Arctic Ocean, from the Gulf of St. Lawrence to Russia (Jefferson *et al.* 2008). Harp seals are the

most abundant seal in the Northwest Atlantic, with an estimated population size of 5.9 million in 2007 (DFO 2007b). The majority of these seals aggregate off the east coast of Newfoundland and Labrador to pup and breed, with the remainder of the animals whelping in the Gulf of St. Lawrence (Lavigne and Kovacs 1988).

Harp seal diets off eastern Newfoundland and Labrador were estimated to primarily consist of capelin, arctic cod, and sandlance, although Atlantic herring, Atlantic cod, redfish, and Greenland halibut were also significant contributors to their diet (Hammill and Stenson 2000). During the summer, the Northwest Atlantic population of harp seals is found in the Canadian Arctic and Greenland before migrating south in the fall (DFO 2000). Dedicated at-sea surveys and data from satellite-tagged animals indicate that harp seals spend the majority of their time in offshore areas of southern Labrador and eastern Newfoundland during the winter (Stenson and Sjare 1997; Lacoste and Stenson 2000). Pups are born on the ice in late February or March, are nursed for approximately 12 days, then mate as adults and disperse (DFO 2000). Births typically begin in early March and peak around March 8 to 10 (Stenson *et al.* 2005). Older seals also aggregate to moult off northeastern Newfoundland and in the northern Gulf of St. Lawrence in April and May before migrating northward (DFO 2000).

The Jeanne d'Arc Basin and adjacent areas overlap with regions where harp seals have been observed during January and February (Lacoste and Stenson 2000). In the Jeanne d'Arc Basin, there were 14 harp seal sightings (Table 10-4); all but one sighting occurred in June. There were also seven harp seal sightings in Orphan Basin (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b). Additionally, during years when pack ice extends into Jeanne d'Arc Basin, harp seals may use the region for spring pupping, mating, and moulting. Thus, from about December to June, harp seals will likely commonly occur in the Offshore Study Area.

Harp seals can also occur in nearshore areas of Newfoundland and Labrador during the spring, as evidenced by their incidental capture in the nearshore lumpfish fishery in northeast Newfoundland from April to July (Sjare *et al.* 2005b). However, local traditional knowledge suggests that harp seals (and harbour and grey seals) occur throughout Trinity Bay, although they may be more numerous in winter (DFO 2000). Based on the limited reports of harp seal occurrences in Trinity Bay, it is expected that they will be uncommon in the Nearshore Study Area.

Hooded Seal

Hooded seals occur in the North Atlantic, ranging from Nova Scotia to the high Arctic (Jefferson *et al.* 2008). However, it is not uncommon for hooded seals, particularly juveniles, to occur outside their normal range (Waring *et al.* 2009). There are four primary pupping and mating regions in the North Atlantic: the Gulf of St. Lawrence, northeast Newfoundland, Davis Strait, and east Greenland (Jefferson *et al.* 2008). A total of 593,500 individuals are estimated to occur in the Northwest Atlantic, with the majority of the

population, or 535,800 animals, pupping and mating off northeast Newfoundland (Hammill and Stenson 2006a).

Hooded seals seem to prefer deeper water and occur farther offshore than harp seals (Lavigne and Kovacs 1988). Birth takes place on the ice, and pups are weaned in about four days, after which pups are abandoned by the female (Lavigne and Kovacs 1988). On average, pupping off northeast Newfoundland is completed by 28 March, but has ranged from March 18 to April 4; pups may spend several more weeks on the ice before entering the water and dispersing (Hammill and Stenson 2006b). Following whelping, hooded seals aggregate in the pack ice off eastern Greenland to moult during June-July before dispersing to the Greenland Sea or Davis Strait during the summer and fall (see Hammill and Stenson 2006a). Little is known about their winter distribution, but they have been observed feeding around the northern edge of the Grand Banks during winter (Stenson and Kavanagh 1994). Recent work suggests that hooded seals move along the continental shelf to Davis Strait and Baffin Bay after moulting in July, followed by southerly migrations into the Labrador Sea before reaching breeding grounds in the spring (Andersen *et al.* 2009).

No hooded seals were sighted during the summer and fall monitoring programs in the Jeanne d'Arc Basin (Table 10-4), or during summer monitoring in the Orphan Basin (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b). Recent studies of satellite-tagged hooded seals indicate that at least some individuals enter the Offshore Study Area in February, presumably to reach the Flemish Cap for winter foraging (Andersen *et al.* 2009); seals have also been shown to transit through and near the Offshore Study Area during transit to moulting areas in May and June (Bajzak *et al.* 2009). The available information on their offshore distribution suggests that hooded seals may occasionally occur in the Offshore Study Area during winter and spring, particularly if seasonal pack ice extends into the Offshore Study Area.

Hooded seals that breed in the Gulf of St. Lawrence predominantly migrate along the eastern and southern Newfoundland coast and enter (in December prior to breeding) or exit (by May following breeding) the Gulf via Cabot Strait; thus, animals presumably at least pass the entrance to Trinity Bay (Hammill 1993; Andersen *et al.* 2009; Bajzak *et al.* 2009). Juvenile hooded seals may also occasionally wander deeper into Trinity Bay and other coastal areas of eastern Newfoundland, especially during winter and spring. Based on available information, it is expected that hooded seals would be uncommon visitors to the Nearshore Study Area.

Grey Seal

Grey seals are found throughout cold temperate to sub-Arctic waters of the North Atlantic, including areas of Nova Scotia, the Gulf of St. Lawrence, and Newfoundland (Jefferson *et al.* 2008). The largest breeding colony in the North Atlantic is on Sable Island, south of Nova Scotia, consisting of approximately 250,000 individuals (Thomas *et al.* 2007). There are an estimated 304,000 animals that breed on Sable Island, Nova Scotia's eastern shore, and in the Gulf of St. Lawrence, accounting for essentially all of the

pup production in the Northwest Atlantic (Thomas *et al.* 2007). An unknown number are found off eastern Newfoundland.

Grey seals tend to be less tied to coastal and island rookeries than are harbour seals, but foraging still appears to be restricted to continental shelf regions (Austin *et al.* 2006). Grey seal prey species include herring, Atlantic cod, and sandlance (Lesage and Hammill 2001). Pupping occurs between September and March, with a peak in January in Canada (Lesage and Hammill 2001).

The number of grey seals entering either Study Area is unknown, but is likely small. None have been sighted during summer and fall monitoring programs in the Jeanne d'Arc Basin (Table 10-4) or during summer in the Orphan Basin (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b). Based on available information, it is expected that grey seals would be rare in either the Offshore or Nearshore Study Area.

10.3.3 Sea Turtles

Sea turtles are likely not common in the Study Areas, but are important to consider given their threatened or endangered status, both nationally and internationally. Three species could potentially occur in the Nearshore and/or Offshore Study Areas (Table 10-8): the leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), and Kemp's ridley sea turtle (*Lepidochelys kempii*). Both leatherback and loggerhead sea turtles are seen with some regularity (although loggerheads to a lesser extent) off Newfoundland in summer and fall (Goff and Lien 1988; Witzell 1999; Ledwell and Huntington 2009). Less is known about the distribution of Kemp's ridley sea turtles in eastern Canada, but they are considered rare. Of these species, only the leatherback sea turtle is listed under COSEWIC and SARA (as Endangered on Schedule 1), but all three species have special status on a global scale (see species profiles). The leatherback sea turtle is described further and assessed in Section 11.3.2.6.

Table 10-8 Sea Turtles Known to Occur in the Nearshore and Offshore Study Areas

Species	Bull Arm Study Area		Hebron Study Area		*SARA* Status[A]	COSEWIC Status[B]	Known Activities	Habitat
	Occurrence	Timing	Occurrence	Timing				
Leatherback sea turtle	Uncommon	July-Oct	Uncommon	June-Nov	Schedule 1: Endangered	E	Feeding	Channel, bays
Loggerhead sea turtle	Very rare	Summer	Rare	Summer	NS	E	Feeding	Channel
Kemp's ridley sea turtle	Very rare	Summer	Very rare	Summer	NS	NC	Feeding	Channel

Notes:
A Species designation under SARA; NS = No Status
B Species designation by COSEWIC; E = Endangered, NC = Not Considered

Marine mammal monitoring programs, as discussed in Section 10.3.2.1, provide relevant information on the spatial and temporal distribution of sea turtles in the area. As noted earlier, the data represent only the late spring, summer and fall seasons (and typically only portions of the summer), and sea

turtle observations may be biased by potential responses to noise from the airgun arrays.

During the monitoring programs in the Jeanne d'Arc Basin, there was a single sighting of a loggerhead sea turtle approximately 240 km south of Jeanne d'Arc Basin in September 2008 (Abgrall *et al.* 2008a, in prep.). Other sightings of leatherback sea turtles are described in Chapter 11.

10.3.3.1 Fisheries and Oceans Canada Sighting Database

DFO in St. John's (J. Lawson 2007, pers. comm.) is compiling a database of sea turtle sightings in waters around Newfoundland and Labrador. These data provide some indication of what species can be expected to occur in the area, but they cannot, at this point in the development of the database, provide any fine-scale quantitative information as the database typically does not include observation effort. However, no additional sea turtle observations were reported in the Nearshore or Offshore Study Areas that were not already described in the offshore monitoring of seismic activity in Jeanne d'Arc Basin or in the sea turtle entrapment records maintained by the Whale Release and Stranding Group (see Section 11.3.2.6).

10.3.3.2 Species Profiles

Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle have a more restricted distribution than other sea turtles, primarily in the Gulf of Mexico (Spotila 2004). Some juveniles exhibit the widest range, sometimes feeding along the US east coast and rarely into the Canadian Atlantic (Spotila 2004). It is estimated that there are only approximately 5,000 nesting females worldwide (Spotila 2004), but it is unknown how many enter Canadian waters annually. Kemp's ridley turtles have not been considered by COSEWIC and have no status under SARA, but are listed as Critically Endangered on the Red List of Threatened Species (IUCN 2009).

Nesting is focused within a small region of the central and southern Gulf of Mexico during May to late July, and only immature turtles seem to travel outside the Gulf of Mexico into more northerly waters (Morreale *et al.* 2007). Musick *et al.* (1994) suggested that juvenile Kemp's ridley sea turtles that travel north of Cape Hatteras, North Carolina probably do so in April and return southward by November. In general, it appears the Kemp's ridley sea turtles prefer shallow water.

While adults rarely range beyond the Gulf of Mexico, juveniles have been sighted along the southeast coast of Newfoundland near St. Mary's Bay and along southern Nova Scotia (Ernst *et al.* 1994). There are apparently no sightings or reports of Kemp's ridley sea turtles in Trinity Bay or the Jeanne d'Arc Basin. The available information suggests that their presence in both areas is likely to be very rare and only occur during summer or fall.

10.4 Project-Valued Ecosystem Component Interactions

Project activities can interact with marine mammals to create the following potential environmental effects:

- Change in Habitat Quantity: includes interactions which limit habitat availability to marine mammals and sea turtles
- Change in Habitat Quality: includes interactions that may result in physical / physiological effects which occur as a result of a change in habitat quality
- Change in Habitat Use: includes interactions which affect the behaviour of marine mammals and sea turtles
- Potential Mortality: includes interactions which may cause the mortality of a marine mammal and/or sea turtle

The following sections describe how Project-VEC interactions during each phase of the Project may contribute to these potential environmental effects. For all Project phases in both the Nearshore and Offshore Project Areas, the activities that are most likely to interact with marine mammals and sea turtles are those that introduce noise into the water column and the activities that involve vessel traffic.

10.4.1 Nearshore Project Activities

In the Nearshore Project Area, underwater noise could result from Project activities such as bund wall construction (including pile-driving), in-water blasting, vessel traffic, dredging of the bund wall and possibly sections of the tow-out route to the deepwater site, removal of bund wall and disposal of materials, and geophysical surveys (*i.e.*, side scan sonar and geohazard surveys). These activities could affect the habitat quality and habitat use by marine mammals and sea turtles. In addition, activities such as in-water blasting and dredging to remove the bund wall, and vessel traffic could affect marine mammals and sea turtles through direct mortality. Bund wall construction may also affect marine mammals and sea turtles through a reduction in habitat quantity, but this effect is expected to be negligible.

10.4.2 Offshore

10.4.2.1 Offshore Construction / Installation

During the construction / installation phase in the Offshore Project Area, underwater noise will result from activities such as (possible) clearance dredging, helicopter overflights, operation of vessels, excavated drill centre(s) dredging, seismic surveys, other geophysical and geotechnical surveys, site preparation activities for OLS / Platform installation, installation of the Platform, OLS and flowlines, rock cover and/or concrete mattresses, and subsea equipment and hook-up to Platform and commissioning. These activities could affect habitat quality and habitat use by marine mammals and sea turtles. In addition, operation of vessels could lead to direct mortality of individuals via collisions. Placement of the Hebron Platform at the offshore

site location may also affect the marine mammals and sea turtles through a limited reduction in habitat quantity.

10.4.2.2 Operations / Maintenance

During the operations / maintenance phase in the Offshore Project Area, underwater noise can result from activities such as drilling operations from the Platform and from a mobile offshore drilling unit (MODU) at future excavated drill centres, production operations, helicopter overflights, vessel traffic, and geophysical and seismic surveys. These activities may affect habitat quality and habitat use. Other activities that may affect Marine Mammals and Sea Turtles, are discharges (*e.g.*, cooling water, storage displacement water, WBM drill cuttings and muds discharges from Hebron Platform, WBM and SBM drill cuttings and muds discharges from MODU drilling associated with potential expansion opportunities) and presence of structures (*e.g.*, subsea equipment in drill centres, Platform, OLS). In addition, there is limited potential for direct mortality of marine mammals and sea turtles via collisions with vessels.

10.4.2.3 Decommissioning / Abandonment

During the decommissioning / abandonment phase in the Offshore Project Area, vessel traffic and helicopter overflights will produce underwater noise which may affect marine mammals and sea turtles. As previously mentioned, these activities could affect habitat quality and habitat use. Also, there is some potential for direct mortality as a result of collisions with vessels.

10.4.3 Summary

A summary of the potential environmental effects resulting from Project-VEC interactions, including those of past, present, and likely future Projects, is provided in Table 10-9. This table includes accidents, malfunctions, and unplanned events.

Table 10-9 Potential Project-related Interactions: Marine Mammals and Sea Turtles

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Construction				
Nearshore Project Activities				
Presence of Safety Zone (Great Mosqito Cove Zone followed by a deepwater site Zone)				
Bund Wall Construction (*e.g.,* sheet/pile driving, infilling)	x	x	x	
Inwater Blasting		x	x	x
Dewater Drydock / Prep Drydock Area			x	
Concrete Production (floating batch plant)			x	

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Vessel Traffic (*e.g.*, supply, tug support, tow, diving support, barge, passenger ferry to/from deepwater site.)		x	x	x
Lighting			+	
Air Emissions		x		
Re-establish Moorings at Bull Arm deepwater site		x	+	
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)		x	x	
Removal of Bund Wall and Disposal (dredging / ocean disposal)		x	x	x
Tow-out of GBS to Bull Arm deepwater site		x	x	
GBS Ballasting and De-ballasting (seawater only)			x	
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site			x	
Hook-up and Commissioning of Topsides			x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	
Platform Tow-out from Deepwater SIte		x	x	
Offshore Construction / Installation				
Presence of Safety Zone				
OLS Installation and testing		x	x	
Concrete Mattress Pads / Rock Dumping over OLS offloading lines		x	x	
Installation of Temporary Moorings		x	x	
Platform Tow-out / Offshore Installation		x	x	
Underbase Grouting			x	
Possible Offshore Solid Ballasting			x	
Placement of Rock Scour Protection on Seafloor around Final Platform Location		x	x	
Hookup and Commissioning of Platform			x	
Operation of Helicopters		x	x	
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)		x	x	x
Air Emissions		x		
Lighting			+	
Potential Expansion Opportunities				
Presence of Safety Zone				
Excavated Drill Centre(s) Dredging and Spoils Disposal		x	x	
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation			x	
Hook-up and Commissioning of Drill Centres			x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	
Offshore Operations and Maintenance				
Presence of Safety Zone				

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Presence of Structures		x	x	
Lighting			+	
Maintenance Activities (*e.g.*, diving, ROV)			x	
Air Emissions		x		
Flaring				
Wastewater (e.g., produced water, cooling water, storage displacement water, deck drainage)		x		
Chemical Use / Management / Storage (*e.g.*, corrosion inhibitors, well treatment fluids)				
WBM Cuttings		x		
Operation of Helicopters		x	x	
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)		x	x	x
Surveys (*e.g.*, geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)		x	x	
Potential Expansion Opportunities				
Presence of Safety Zone				
Drilling Operations from MODU at Future Excavated Drill Centres		x	x	
Presence of Structures		x	x	
WBM and SBM Cuttings		x		
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)		x		
Geophysical / Seismic Surveys		x	x	
Offshore Decommissioning / Abandonment				
Presence of Safety Zone				
Removal of the Platform and OLS Loading Points		x	x	
Lighting			x	
Plugging and Abandoning Wells			x	
Abandoning the OLS Pipeline			x	
Operation of Helicopters		x	x	
Operation of Vessels (supply, support, standby and tow vessels / ROVs)		x	x	x
Surveys (*e.g.*, geophysical, geohazard, geotechnical, environmental, ROV, diving)		x	x	
Accidents, Malfunctions and Unplanned Events				
Bund Wall Rupture				
Nearshore Spill (at Bull Arm Site)		x	x	x
Failure or Spill from OLS		x	x	x
Subsea Blowout		x	x	x
Crude Oil Surface Spill		x	x	x
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Platform)		x	x	x
Marine Vessel Incident (*i.e.*, fuel spills)		x	x	x

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Collisions (involving Platform, vessel, and/or iceberg)		x	x	x
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (drilling and production)		x	x	
Terra Nova Development (production)		x	x	
White Rose Oilfield Development and Expansions (drilling and production)		x	x	
Offshore Exploration Drilling Activity		x	x	
Offshore Exploration Seismic Activity		x	x	
Marine Transportation (nearshore and offshore)		x	x	x
Commercial Fisheries (nearshore and offshore)		x	x	x
+ indicates a positive interaction and possible decrease in mortality				

10.5 Environmental Effects Analysis and Mitigation

Potential environmental effects on marine mammals and sea turtles during all phases of the Project are discussed by Project phase and summarized at the end of the chapter.

10.5.1 Construction and Installation

10.5.1.1 Change in Habitat Quantity

Nearshore

In the Nearshore Study Area, the bund wall footprint represents unavailable habitat for marine mammals, although the shallow water depth would prevent most marine mammals from occurring there even in the absence of the bund wall. Thus, bund wall construction will result in minimal habitat loss for the Marine Mammal and Sea Turtle VEC.

The removal of the bund wall in the Nearshore Study Area could make previously unavailable habitat accessible to marine mammals. However, this habitat will be in shallow water (and thus less preferable to most marine mammals, as noted above) and disturbed. Thus, most marine mammals would not preferentially use this habitat and it is expected to result in negligible habitat loss for Marine Mammal and Sea Turtle VEC.

Offshore

The footprint of the Hebron Platform in the Offshore Project Area would occupy a very limited area that may be used by pelagic and migratory marine mammal and sea turtle species. Thus, the placement of the Hebron Platform

at the offshore site location will result in minimal habitat loss for marine mammals and sea turtles.

Excavated drill centre(s) dredging may occur over a limited area in the Offshore Study Area that may be used by pelagic and migratory marine mammals and sea turtles. Species that are primarily benthic foragers (*e.g.*, some phocids) would be most affected by a disruption in benthic habitat. However, excavated drill centre(s) dredging in the Offshore Study Area will likely result in minimal habitat loss for marine mammals and sea turtles.

10.5.1.2 Change in Habitat Quality

This effect category includes interactions that may result in physical / physiological effects which occur as a result of a change in habitat quality. Activities that are most likely to affect marine mammals and sea turtles are blasting, pile-driving, and seismic surveys which produce impulsive sound levels high enough to cause physical/physiological effects in marine mammals (and likely sea turtles). As discussed in detail below, sound levels thought high enough to cause a "change in habitat quality" typically occur very close to the sound source. The following section also summarizes relevant mitigation measures which will be used during the Project. These measures are designed to minimize the risk of injury to marine mammals and sea turtles.

The environmental effects of noise on marine mammals (and likely sea turtles) are highly variable, and can be categorized as follows (based on Richardson *et al.* 1995):

- The noise may be too weak to be heard at the location of the animal *(i.e.*, lower than the prevailing ambient noise level, the hearing threshold of the animal at relevant frequencies, or both)
- The noise may be audible but not strong enough to elicit any overt behavioural response (*i.e.*, the animal may tolerate it)
- The noise may elicit behavioural reactions of variable conspicuousness and variable relevance to the well-being of the animal; these can range from subtle effects on respiration or other behaviours (detectable only by statistical analysis) to active avoidance reactions
- Upon repeated exposure, animals may exhibit diminishing responsiveness (habituation), or disturbance effects may persist; the latter is most likely with sounds that are highly variable in characteristics, unpredictable in occurrence, and associated with situations that the animal perceives as a threat
- Any anthropogenic noise that is strong enough to be heard has the potential to reduce (mask) the ability of marine mammals to hear natural sounds at similar frequencies, including calls from conspecifics, echolocation sounds of odontocetes, and environmental sounds such as surf noise or (at high latitudes) ice noise
- Very strong sounds have the potential to cause temporary or permanent reduction in hearing sensitivity, or other physical or physiological effects

(and in extreme cases (*i.e.*, exposure to large explosives), mortality). Received sound levels must far exceed the animal's hearing threshold for any temporary threshold shift to occur. Received levels must be even higher for a risk of permanent hearing impairment

To aid in the assessment of potential effects of noise from Project activities on the marine mammals and turtles of the Study Areas, a description of the hearing abilities of marine mammals and sea turtles, a review of noise criteria for assessing effects, and a review of known physical effects of relevant noise sources on the these animals are provided below.

Hearing Abilities of Marine Mammals and Sea Turtles

Marine mammals rely heavily on the use of underwater sounds to communicate and to gain information about their surroundings. Experiments also show that they hear and may react to many anthropogenic sounds.

The hearing abilities of baleen whales have not been measured directly. Behavioural and anatomical evidence indicates that they hear well at frequencies below 1 kHz (Richardson *et al.* 1995; Ketten 2000). For baleen whales as a group, the functional hearing range is thought to be about 7 Hz to 22 kHz and they constitute the "low-frequency" (LF) hearing group (Southall *et al.* 2007). The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than are the ears of the small toothed whales that have been studied directly. Thus, baleen whales are likely to hear low-frequency sounds (like airgun pulses and pile driving) farther away than can small toothed whales and, at closer distances, these sounds may seem more prominent to baleen than to toothed whales.

The small to moderate-sized toothed whales whose hearing has been studied have relatively poor hearing sensitivity at frequencies below 1 kHz, but extremely good sensitivity at, and above, several kHz. There are very few data on the absolute hearing thresholds of most of the larger, deep-diving toothed whales, such as the sperm and beaked whales. However, Mann *et al.* (2005) report that a Gervais' beaked whale showed evoked potentials from 5 to 80 kHz, with the most sensitivity at 80 kHz. Most of the odontocete species have been classified as belonging to the "mid-frequency" (MF) hearing group, and the MF odontocetes (collectively) have functional hearing from approximately 150 Hz to 160 kHz (Southall *et al.* 2007). However, individual species may not have quite so broad a functional frequency range. Very strong sounds at frequencies slightly outside the functional range may also be detectable. The remaining odontocetes (the porpoises, river dolphins, and members of the genera *Cephalorhynchus* and *Kogia*) are distinguished as the "high frequency" (HF) hearing group. They have functional hearing from approximately 200 Hz to 180 kHz (Southall *et al.* 2007).

Underwater audiograms have been obtained using behavioural methods for three species of phocid seals, two species of monachid seals, two species of otariids, and the walrus (reviewed in Richardson *et al.* 1995; Kastak and Schusterman 1998, 1999; Kastelein *et al.* 2002). The functional hearing range for pinnipeds in water is considered to extend from 75 Hz to 75 kHz

(Southall *et al.* 2007), although some individual species (especially the eared seals) do not have that broad an auditory range (Richardson *et al.* 1995). Compared to odontocetes, pinnipeds tend to have lower best frequencies, lower high-frequency cutoffs, better auditory sensitivity at low frequencies, and poorer sensitivity at the best frequency.

The limited available data indicate that the frequency range of best hearing sensitivity by sea turtles extends from approximately 250 to 300 Hz to 500 to 700 Hz (Ridgway *et al.* 1969; Bartol *et al.* 1999). Sensitivity deteriorates as one moves away from this range to either lower or higher frequencies. However, there is some sensitivity to frequencies as low as 60 Hz, and probably as low as 30 Hz.

Noise Criteria for Assessing Physical Effects

The US National Marine Fisheries Service (1995, 2000) has concluded that whales should not be exposed to impulse noise at received levels exceeding 180 dB re 1 µPa (rms). The corresponding limit for seals has been set at 190 dB. These exposure criteria used by the US National Marine Fisheries Service (NMFS) were intended as a precautionary estimate below which hearing impairment (Temporary Threshold Shift or TTS) would not occur from airgun pulses. There was no empirical evidence about whether higher levels of pulsed sound would cause hearing or other injuries. In Canada, minimum exposure criteria for injury to marine mammals (and sea turtles) have not been established. Some jurisdictions in Canada have used the 180 dB re 1 µPa (rms) criteria for whales to establish a safety zone for seismic surveys.

In recent years, a panel of experts have worked to produce scientific recommendations for updated marine mammal noise exposure criteria (Southall *et al.* 2007). For various marine mammal groups and sound types, Southall *et al.* (2007) propose levels above which there is a scientific basis for expecting that noise exposure would cause injury to occur. These new exposure criteria incorporate frequency-weighting functions (M-weighting; see Section 3.2.2 in JASCO (2010)) for assessing the effects of sound on marine mammals, which accounts for the major differences in auditory capabilities across marine mammal groups and species. Minimum exposure criteria for injury are defined as the energy level at which single exposure is estimated to cause onset of permanent hearing loss (Permanent Threshold Shift or PTS). TTS was not considered an injury (Southall *et al.* 2007). Southall *et al.* (2007) concluded that PTS might occur if cetaceans and pinnipeds were exposed to peak pressures exceeding 230 dB re 1 µPa (peak) (or 198 dB re 1 μPa^2-s) or 218 re 1 µPa (peak) (or 186 dB re 1 μPa^2-s), respectively.

Nearshore

Acoustic modelling was undertaken (see JASCO (2010)) to provide estimates of received sound levels for blasting, pile driving, and vessel operations in the Nearshore Study Area. The results are summarized below as they pertain to sound thresholds which are known or expected to cause environmental effects in marine mammals.

Pile Driving

As previously discussed, pile driving, either vibratory or impact, will be required during bund wall construction (placement of sheet piles) and possibly during placement of moorings at the deepwater site in Bull Arm.

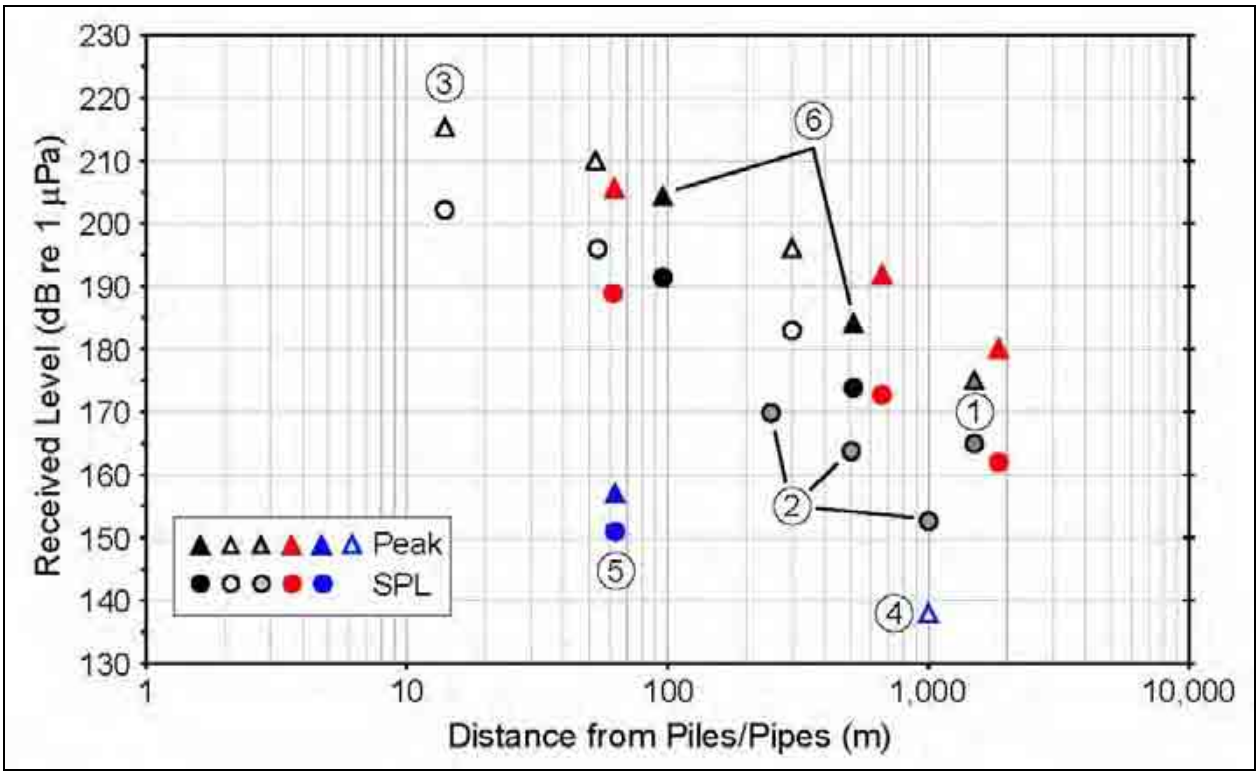
Pile driving produces impulsive sound levels high enough to cause hearing impairment effects, which may result in a change in habitat quality for marine mammals and sea turtles. Sound levels high enough to cause a change in habitat quality typically occur very close to the source.

Impact pile driving produces higher sound levels that are impulsive, whereas vibratory pile driving produces continuous sound at lower sound levels. The results of seven acoustic studies of impact pile (or pipe) driving are summarized in Figure 10-6 (HDR Alaska *et al.* 2006). The highest received sound level recorded during these studies was 202 dB re 1 uPa (rms) at 14 m (HDR Alaska *et al.* 2006). Sound levels from most impact pile driving sources diminished below 180 dB at distances less than 300 m. The dominant frequency range of pile driving is most likely related to differences in the size, shape and thickness of the piles. Most of the pulse energy typically falls between 50 to 2,000 Hz (HDR Alaska *et al.* 2006).

Results of acoustic modelling for the Nearshore Study Area (JASCO 2010) and available studies indicate that received sound levels >180 dB re 1 µPa (rms) do not typically extend beyond 300 m for pile-driving activities. Rather, acoustic modelling estimated that 180 dB re 1 µPa (rms) levels will extend to 260 m and 150 m at the bundwall and deepwater site, respectively. For 190 dB re 1 µPa (rms), sound levels occur at 60 m and 20 m from the bund wall and at the deepwater site, respectively. Thus, available information suggests that there is little risk for hearing impairment to marine mammals or sea turtles beyond 300 m from the pile driving equipment.

There is little risk for hearing impairment to marine mammals or sea turtles, given the sound levels typically recorded during impact pile-driving activities do not exceed 180 dB re 1 µPa (rms) beyond several hundred metres from the source. Sound levels which may cause PTS would occur much closer to the source. To the best of our knowledge, there is no evidence that marine mammals or sea turtles have experienced injury as a result of exposure to pile-driving sounds.

Underwater bubbles can inhibit sound transmission through water due to density mismatch and concomitant reflection and absorption of sound waves. The use of a bubble curtain around pile driving activity will be considered in consultation with DFO for this Project. Depending upon environmental conditions (*e.g.*, current), a bubble curtain can have negligible influence on reducing underwater sound levels to reducing sound levels by as much as 20 dB (S. Blackwell, pers. comm.).



Source: HDR Alaska *et al.* (2006)
Note: based on HDR Alaska *et al.* (2006; red symbols); (1) Greene (1999); (2) Wursig *et al.* (2000); (3) Reyff *et al.* (2002); (4) Johnson *et al.* (1986); (5) Blackwell *et al.* (2004); and (6) Blackwell and Burgess (2004)

Figure 10-6 Summary of Peak and Sound Pressure Levels of Impact Pile/Pipe Driving

A monitoring protocol for marine mammals (and sea turtles) will be established by ExxonMobil Canada Properties (EMCP) prior to the start of construction activities. This protocol will be developed in consultation with DFO and may include the following parameters:

- A trained observer will monitor a designated radius near pile driving activities for at least 30 minutes prior to activation of the pile driver. Acoustic modelling will be conducted prior to construction activities in the Nearshore Project Area to reflect actual pile driving scenarios
- If a marine mammal or sea turtle is detected within the designated zone (conservatively assume 180 and 190 dB re 1 uPa (rms), for cetaceans and seals, respectively) pile driving will not occur until the animal(s) have left the safety zone, or it has not been re-sighted for 30 minutes
- Pile driving activities will be halted if a marine mammal or sea turtle enters into the safety zone and will not be resumed until the animal has left the zone or 30 minutes have passed since the sighting
- For sea turtles, the 180 dB zone will be used

Blasting

Of all the Project activities, blasting is most likely to cause physical effects in marine mammals, without proper mitigation. Inwater blasting explosives have a short rise time to a high peak pressure which is likely responsible for hearing damage causing a change in habitat quality for marine mammals and

sea turtles during detonations (see *e.g.*, Ketten 1995). Explosives can cause mortality (see Section 10.5.1.4). Sound levels of 180 dB re 1 µPa (rms) are considered a precautionary criterion (NMFS 1995, 2000a, 2000b) below which hearing impairment (TTS) would not occur for cetaceans (and 190 dB re 1 µPa (rms) for pinnipeds). No comparable minimum exposure criteria for injury to marine mammals (and sea turtles) have been established in Canada.

Marine Mammals: Two humpback whales (found dead) with severe mechanical damage to their ears were linked to explosions at Mosquito Cove, Bull Arm during construction activities associated with the Hibernia Gravity Base Structure (GBS). Repeated sub-bottom blasting involving explosives (Tovex™) which ranged from 30 to 5,500 kg and averaged 960 kg were used (Todd *et al.* 1996). The auditory damage was similar to that in humans exposed to severe blast injury.

Sea Turtles: A controlled experiment using Kemp's ridley and loggerhead turtles designed to provide preliminary information on the extent of the impact zone created by the explosive removal of an offshore platform indicated that two individuals of each species that were exposed within 366 m of the explosion were rendered unconscious and one loggerhead turtle was rendered unconscious at a distance of 915 m (Klima *et al.* 1988). Other observed effects included the eversion of the cloacal lining through the anal opening of the Kemp's ridley exposed at 229 m and an abnormal pink coloration caused by dilated blood vessels at the base of the throat and flippers of all the loggerhead turtles that returned to normal in about three weeks. The received sound pressure levels were estimated to range from 209 dB re 1 µPa at 915 m to 221 dB re 1 µPa at 229 m (unspecified measure type; Klima *et al.* 1988).

Gitschlag and Herczeg (1994) reported the results from the placement of observers at offshore sites to monitor and protect sea turtles during explosive removals of oil and gas structures in the Gulf of Mexico. In 6,500 hours of monitoring at 106 structures, no injury (or mortality) of sea turtles was documented.

Results of acoustic modelling (JASCO 2010) for the largest single charge that is permissible under the DFO 100 kPa overpressure guideline (Wright and Hopky 1998), indicate that 180 and 190 dB re 1 uPa (rms) sound levels (un-weighted) occur at 2.7 km and 0.99 km, respectively, from the blast site. Because the peak in source spectrum occurs at low-frequency, the application of M-weighting, results in smaller 180 and 190 dB zones for mid- and high-frequency cetaceans (see Table 9 in JASCO (2010)). Southall *et al.* (2007) concluded that PTS might occur if cetaceans and pinnipeds were exposed to peak pressures exceeding 230 dB re 1 µPa (peak) (or 198 dB re 1 μPa^2-s) or 218 re 1 µPa (peak) (or 186 dB re 1 μPa^2-s), respectively. The corresponding ranges to these sound levels were not estimated during acoustic modelling but would occur much closer to the sound source than 180 and 190 dB re 1 uPa (rms) sound levels.

Sea turtles are rare within the Nearshore Study Area, particularly at times other than late summer and early fall. Species most likely to be affected

include those predicted to be common within the Nearshore Study Area, including humpback whales, possibly minke and pilot whales, and multiple dolphin species, and are likely to be common during the summer months.

Blasting parameters will be such that they adhere to the DFO guidance outlined in *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* (Wright and Hopky 1998). As a minimum, proposed guidelines (Wright 2002) indicate that detonations cannot knowingly occur within 500 m of any marine mammal, *"or alternately, there must be no visual contact by an observer using 7x35 power binoculars".*

A monitoring protocol for marine mammals will be established by EMCP prior to the start of construction activities. This protocol will be developed in consultation with DFO and may include the following parameters:

- Prior to blasting, a blast impact assessment will be undertaken to determine appropriate marine mammal and sea turtle exclusion zones and ensure that a 100 kPa charge is not exceeded
- The sound levels in the water column will be evaluated to determine a safety zone for marine mammals
- The feasibility of using a bubble curtain to reduce sound levels will also be investigated
- Received sound levels of 180 dB re 1 µPa (rms) for cetaceans and sea turtles, and 190 dB re 1 µPa (rms) for phocids, modelled as 2.7 and 0.99 km for a 100 kPa charge, respectively, will be used as a guide for these zones
- Sound levels during blasting will be monitored at the shoreline and in the water to modify exclusion zones based on in-field measurements. These zones will be monitored by a trained observer for 30 minutes prior to and during blasting operations in the marine environment, and blasting operations will be temporarily suspended or halted if a marine mammal or sea turtle is sighted within or about to enter the zone. Activities will not resume until the animal(s) has left the zone or it has not been re-sighted for 30 minutes
- Depending on the size of the designated safety zone, more than one trained observer placed in different areas of the safety zone may be needed to adequately monitor the zone. Monitoring techniques and results of acoustic modelling will be reviewed and approved by DFO prior to blasting operations

Vessel Traffic

Sound levels from vessel traffic associated with the Project are not expected to be high enough to cause physical or physiological effects on marine mammals or sea turtles (see Richardson *et al.* 1995), resulting in a change in habitat quality. It is expected that the greatest and most continuous vessel noise source during construction will result from tugs and barges (see Blackwell and Greene 2006). Sound levels that have the potential to induce hearing impairment in marine mammals and sea turtles (180 and 190 dB re 1 µPa (rms)) have been modelled to occur in an area less than 10 m from a

tug operating at high power levels in the Nearshore Study Area (JASCO 2010). Project activities involving vessel traffic will avoid concentrations of marine mammals and sea turtles whenever possible.

Geophysical Surveys

The geophysical surveys that may take place in the Nearshore Study Area include side scan sonar and geohazard surveys. These surveys produce noise at lower source levels than those of airgun pulses from seismic surveys. Sounds are also typically emitted in a narrow beam, short duration, and sometimes at frequencies outside the range of marine mammal and sea turtle hearing abilities. Therefore, geohazard surveys and side scan sonar are less likely to affect marine mammals and sea turtles than seismic surveys. It is expected that surveys will be minimized, when possible. Additional information on the effects of geohazard surveys is presented below under the discussion of offshore effects.

Surveys will likely increase the presence of vessels in the Nearshore Study Area, increasing the potential environmental effects of vessel traffic (see above). Additional mitigation measures associated with vessel traffic are described above.

Other Activities

Air emissions are expected to have a negligible effect on the habitat quality of the Marine Mammal and Sea Turtle VEC. It is expected that air emissions will be minimized, when possible. All other activities expected to affect habitat quality could also lead to effects on habitat use. The impact of these activities on the Marine Mammal and Sea Turtle VEC in the Nearshore Study Area are reviewed in Section 10.5.1.3 (Habitat Use).

Offshore

Geophysical Surveys

In the Offshore, geophysical surveys will include seismic as well as geohazard surveys. Both seismic and geohazard surveys use airgun arrays, a key difference is the larger array size used in seismic surveys. The potential physical / physiological effects of noise from the geohazards equipment (typically a small airgun array, boomer, side scan sonar, and echosounders) are of less concern than airgun pulses from 2-D and 3-D surveys given their relatively lower source levels, emittence in a narrow beam, short duration of the geohazards program, and that some equipment operates at frequencies outside the range of marine mammal and sea turtle hearing abilities.

The potential physical/physiological effects of seismic programs on marine mammals and sea turtles have recently been reviewed for the StatoilHydro's 3-D program in Jeanne d'Arc Basin (LGL 2008a: Section 5.6.4) Petro-Canada's 3-D program in Jeanne d'Arc Basin (LGL 2007a: Section 5.6.6) and for Husky's program in northern Jeanne d'Arc Basin (LGL 2005b:

Section 6.5.12; Moulton *et al.* 2006b: Sections 6.1.2 and 6.1.3). Geohazard surveys are less likely to impact marine mammals and sea turtles as reviewed in three Environmental Assessments for Jeanne d'Arc Basin in 2005 (LGL 2005a, 2005b, 2005c, 2005d) and an update to one of the environmental assessments in 2007 (LGL 2007a).

Temporary or permanent hearing impairment is a possibility when marine mammals and sea turtles are exposed to very strong sounds. The minimum sound level necessary to cause permanent hearing impairment is higher, by a variable and generally unknown amount, than the level that induces barely-detectable TTS. The level associated with the onset of TTS is often considered to be a level below which there is no danger of permanent damage. As discussed earlier, current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds exceeding 180 and 190 dB re 1 µPa (rms), respectively (NMFS 2000a, 2000b). However, those criteria were established before there was any information about the minimum received levels of sounds necessary to cause TTS in marine mammals. The 180 dB criterion for cetaceans is probably quite conservative (*i.e.*, lower than necessary to avoid auditory injury), at least for delphinids (Southall *et al.* 2007).

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur include stress, neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage. It is possible that some marine mammal species (*i.e.*, beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds.

TTS: The magnitude of TTS depends on the level and duration of noise exposure, among other considerations (Richardson *et al.* 1995). For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce TTS. The frequencies at which baleen whales are most sensitive are lower than those at which odontocetes are most sensitive, and natural background noise levels at those low frequencies tend to be higher. As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison 2004). From this, it is suspected that received levels causing TTS onset may also be higher in baleen whales. Based on available data, TTS is not expected to occur among baleen whales exposed to seismic sound given the strong likelihood that they would avoid an approaching airgun(s) (or vessel) before being exposed to levels high enough for there to be any possibility of TTS (NSF and L-DEO 2006a, 2006b; Wilson *et al.* 2006). This assumes that mitigation consisting of ramp-up (soft start) procedures is used when commencing airgun operations. It is assumed that this approach provides the opportunity for whales near the seismic vessel to move away before they are exposed to sound levels that might be strong enough to elicit TTS (Wilson

et al. 2006). However, the effectiveness of this procedure has not been empirically studied.

For toothed whales exposed to single short pulses, the TTS threshold appears to be, to a first approximation, a function of the energy content of the pulse (Finneran *et al.* 2002, 2005). Given the available data, the received sound energy level of a single seismic pulse (with no frequency weighting) might need to be approximately 186 dB re 1 $\mu Pa^2 \cdot s$ (*i.e.*, 186 dB SEL or approximately 221 to 226 dB peak-peak) in order to produce brief, mild TTS (Southall *et al.* 2007). Exposure to several strong seismic pulses that each have received levels near 175 to 180 dB SEL might result in slight TTS in a small odontocete, assuming the TTS threshold is (to a first approximation) a function of the total received pulse energy. For an odontocete closer to the surface, the maximum radius with greater than or equal to 186 dB SEL, or greater than or equal to 198 dB (rms), would be smaller. However, additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated, low-frequency pulses of airgun sound with variable received levels. At the present state of knowledge, it is necessary to assume that the effect is directly related to total energy, even though that energy is received in multiple pulses separated by gaps. However, the exposure levels necessary to cause TTS in toothed whales, when the signal is a series of pulsed sounds separated by silent periods, remains a data gap.

TTS thresholds for pinnipeds exposed to brief pulses (either single or multiple) of underwater sound have not been measured. There are some indications that, for corresponding durations of sound, the harbour seal may incur TTS at somewhat lower received levels than do small odontocetes (Kastak *et al.* 1999, 2005; Ketten *et al.* 2001; *cf*. Au *et al.* 2000). However, TTS onset in the California sea lion and northern elephant seal may occur at a similar sound exposure level as in odontocetes (Kastak *et al.* 2005).

There have been few studies that have directly investigated hearing or noise-induced hearing loss in sea turtles. The apparent occurrence of TTS in loggerhead turtles exposed to many pulses from a single airgun less than or equal to 65 m away (Moein *et al.* 1994) suggests that sounds from an airgun array could cause at least temporary hearing impairment in sea turtles if they do not avoid the (unknown) radius where TTS occurs. There is also the possibility of permanent hearing damage to turtles close to the airguns. However, there are few data on temporary hearing loss, and no data on permanent hearing loss in sea turtles exposed to airgun pulses.

PTS: When PTS occurs, there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness, while in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges. There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the likelihood that some mammals close to an airgun array might incur at least mild TTS (see Finneran *et al.* 2002), there has been speculation about the possibility that some individuals occurring very close to airguns might incur PTS (Richardson *et al.* 1995, p. 372). The specific

difference between the PTS and TTS thresholds has not been measured for marine mammals exposed to any sound type. When exposure is measured in SEL units, Southall *et al.* (2007) concludes the PTS-onset to TTS-onset for marine mammal exposure to impulse sound is at least 15 dB. Based on data from terrestrial mammals, a precautionary assumption is that the PTS threshold for impulse sounds (such as airgun pulses as received close to the source) is at least 6 dB higher than the TTS threshold on a peak-pressure basis, and probably more than 6 dB.

Although it is unlikely that airgun operations during most seismic surveys would cause PTS in marine mammals, caution is warranted given the limited knowledge about noise-induced hearing damage in marine mammals, particularly baleen whales. Commonly applied monitoring and mitigation measures, including visual monitoring, ramp-ups, and power-downs of the airguns when mammals are seen within the "safety radii", are expected to minimize the already-low probability of exposure of marine mammals to sounds strong enough to potentially induce PTS.

The study by Moein *et al.* (1994) indicates that sea turtles can experience TTS when exposed to moderately strong airgun sounds. However, there are no data to indicate whether or not there are any plausible situations in which exposure to repeated airgun pulses at close range could cause permanent hearing impairment in sea turtles.

Non-auditory Physiological Effects: Possible types of non-auditory physiological effects or injuries that could theoretically occur in marine mammals exposed to strong underwater sound might include stress, neurological effects, bubble formation, and other types of organ or tissue damage. However, studies examining such effects are limited. If any such effects do occur, they would probably be limited to unusual situations. Those could include cases when animals are exposed at close range for unusually long periods, or when the sound is strongly channeled with less-than-normal propagation loss, or when dispersal of the animals is constrained by shorelines, shallows.

In summary, very little is known about the potential for seismic survey (and geohazard survey) sounds to cause either auditory impairment or other non-auditory physical effects in marine mammals or sea turtles. Available data suggest that such effects, if they occur at all, would be limited to short distances. However, the available data do not allow for meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in these ways. Marine mammals that show behavioural avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are unlikely to incur auditory impairment or other physical effects.

As indicated in the Geophysical, Geological, Environmental and Geotechnical Program Guidelines C-NLOPB 2011), mitigation measures will be implemented consistent with those provided for in the Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment, including, but not limited to:

- Ramp-up of the airgun array over a minimum of 20 minutes
- Monitoring by a trained marine mammal observer
- Shutdown of the airgun array when a Schedule 1 endangered or threatened marine mammal or sea turtle is sighted within the 500 m safety zone
- Delay of ramp-up if any marine mammal or sea turtle is sighted within the 500 m safety zone

Considering the seismic survey mitigation measures, there will likely be minimal effects of seismic surveys on marine mammals and sea turtles.

Vessel Traffic

As stated above sound levels from vessel traffic associated with the Project are not expected to be high enough to cause physical or physiological effects in marine mammals or sea turtles (see Richardson *et al.* 1995), resulting in a change in habitat quality. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible.

Other Activities

Air emissions are expected to have a negligible environmental effect on the habitat quality of the marine mammal and sea turtle VEC. It is expected that air emissions will be minimized, when possible. In the case of surveys that do not include seismic airguns, the main environmental effect of surveys on the marine mammal and sea turtle VEC is the operation of vessels (described above). All other activities expected to affect habitat quality could also lead to environmental effects on habitat use. The environmental effects of these activities on the marine mammal and sea turtle VEC in the Offshore Study Area are reviewed in Section 10.5.1.3 (Habitat Use).

10.5.1.3 Change in Habitat Use

This effect category includes behavioural effects of project activities on marine mammals and sea turtles. Noise introduced into the water column has the greatest potential to affect the behaviour of marine mammals and sea turtles, as noise is associated with almost every aspect of the construction, operations and maintenance, and decommissioning and abandonment phases of the Project and this VEC is known to be sensitive to noise.

Behavioural reactions of marine mammals (and sea turtles) to sound are difficult to predict in the absence of site- and context-specific data. Reactions to sound, if any, depend on species, state of maturity, experience, current

activity, reproductive state, time of day, and many other factors (Richardson *et al.* 1995; Wartzok *et al.* 2004; Southall *et al.* 2007; Weilgart 2007). If a marine mammal reacts to an underwater sound by changing its behaviour or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (*e.g.*, Lusseau and Bejder 2007; Weilgart 2007).

Nearshore

Construction of the Bund Wall

Pile driving produces impulsive sounds whose levels are high enough to cause behavioural effects in marine mammals and sea turtles which may result in a change in habitat use. Southall *et al.* (2007) suggest that for all sound types, other than single pulses (like those from an explosive), behavioural effects will occur more commonly at sound levels below those involved with TTS or PTS. Based on available literature, a 160 dB re 1 µPa (rms) disturbance criterion is suggested for pile driving activities. Results of acoustic modelling (JASCO 2010) indicate that received sound levels greater than 160 dB re 1 µPa (rms) do not typically extend beyond 3.1 km for pile driving activities in the Nearshore Study Area at both the bund wall and deepwater mooring site. Rather, it is predicted that 160 dB re 1 µPa (rms) levels will extend to 2.9 km and 3.1 km from the bund wall and deepwater mooring site, respectively.

Indo-Pacific humpback dolphins (*Sousa chinensis*) that likely have similar hearing abilities as Northwest Atlantic delphinids occur in nearshore waters near Hong Kong, where in-water pile driving has been used extensively for building piers and other structures (Jefferson *et al.* 2009). A study indicated that some Indo-Pacific humpback dolphins exposed to sound pressure levels of 170 dB re 1 µPa (rms) remain within 300 to 500 m of the pile driving area before, during, and after operations (Würsig *et al.* 2000). Although some dolphins temporarily abandoned the work area, their numbers returned to close to those seen pre-construction during the follow-up survey seven months after construction activities ended (Würsig *et al.* 2000).

Several studies monitored harbour porpoises during construction of two offshore wind farms off the coast of Denmark (Tougaard *et al.* 2003, 2009; Carstensen *et al.* 2006; Teilmann *et al.* 2008). During pile driving activities (using both vibratory and impact techniques) at the Nysted offshore wind farm, a significant decrease in echolocating activities and abundance was reported within the construction area and in a reference area 10 km from the construction site. Two years after construction, echolocation and presumably porpoise abundance were significantly reduced (Carstensen *et al.* 2006; Teilmann *et al.*, 2008). During percussion pile driving at the Horns Reef wind farm, harbour porpoise acoustic activities declined, although the recovery to baseline occurred only hours after completion of these activities (Tougaard *et al.* 2003, 2009; Teilmann *et al.* 2008). Behavioural changes

during the construction period included a decrease in feeding behaviour and a decrease in the number of individuals in the area (Tougaard *et al.* 2003).

Ringed seals exposed to pile-driving pulses exhibited little or no reaction to impact pipe-driving sounds at a shallow water site in the Alaskan Beaufort Sea (Blackwell *et al.* 2004). At the closest point (63 m), received levels were 151 dB re: 1 µPa (rms) and 145 dB re: 1 μPa^2-s SEL. Harbour seal haul-out behaviour was affected by pile-driving at an offshore wind farm (Nysted) in the western Baltic (Edrén *et al.* 2004). The authors found a 31 to 61 percent reduction during periods with pile driving *versus* no pile driving in the number of seals hauled out at a beach approximately 10 km from the construction site. Sound levels were not measured and observations of seals in the water were not made. The authors suggest that seals may have spent more time in the water because this is a typical response to disturbance or the seals may have used an alternate haul-out site. At an adjacent wind farm to Nysted (Horns Rev), no seals were observed during ship-based surveys in the wind farm during pile driving. The reactions of harbour seals to the pile driving appeared short-term because aerial surveys did not reveal any decrease in overall abundance during the construction period (2002 to 2003) (or operation period 2004 to 2005; Teilmann *et al.* 2006).

Based on this limited information and the literature for marine mammal response to low-frequency impulsive sounds (like airgun pulses - see Richardson *et al.* 1995 and Nowacek *et al.* 2007), baleen and toothed whales would likely exhibit at least localized avoidance of the pile driving sites. There is some evidence to suggest that harbour porpoise echolocation activity may decline, at least temporarily, and that seals may exhibit at least short-term avoidance of the area.

There are currently no published data available for behavioural effects of pile driving on sea turtles. Of note, sea turtles are considered rare in inner Trinity Bay near the sites of potential pile driving.

Mitigation measures associated with limiting effects to habitat quality were previously described (see Section 10.5.1.2) and will additionally minimize potential effects to habitat use by marine mammals and sea turtles.

In-water Blasting

Behavioural disturbance, resulting in a change in habitat use, is a potential effect of blasting operations. However, there are no specific sound levels for blasting activities that are linked with behavioural effects on marine mammals and sea turtles. Southall *et al.* (2007) use the onset of TTS as a criterion for "behavioural" disturbance of cetaceans exposed to a single pulse (see page 448 in Southall *et al.* 2007). The unweighted peak sound pressure of 224 dB re 1 uPa (peak) and weighted SEL values of 183 dB re 1 uPa^2-s are recommended as disturbance criteria (*i.e.*, received levels that exceed either of these levels are considered to have greater potential to elicit a biologically significant behavioural response). For pinnipeds exposed to a single pulse in water, the peak sound pressure of 212 dB re 1 uPa (peak) and weighted SEL values of 171 dB re 1 uPa^2-s are recommended as disturbance criteria. The

US NFMS has often used a lower sound level criterion for disturbance of 160 dB re 1 uPa (rms) for marine mammals.

Acoustic modelling results (JASCO 2010) for the largest possible charge permissible under the DFO 100 kPa overpressure guideline (Wright and Hopky 1998) suggest that 160 dB re 1 µPa (rms) sound levels occur within 3.5 km from the blast site. Ranges to the criteria recommended by Southall *et al.* (2007) were not directly estimated but would be less than 1 km for cetaceans and less than 2.7 km for seals (see Table 9 in JASCO 2010).

Marine Mammals: Humpback whale responses to underwater (sub-bottom) explosions (associated with construction activity) at Mosquito Cove, Bull Arm, were monitored for a 19-day period in June 1992 (Todd *et al.* 1996). Surveys (photographic when possible) were conducted before, during and after explosions. Data were used to calculate residency, resighting rates, and net movement toward or away from the noise source. Acoustic recordings of the explosions as well as whale vocalizations were acquired. Explosives (Tovex™) ranged from 30 to 5,500 kg and averaged 960 kg. Todd *et al.* (1996) reported that received sound levels typically were 140 to 150 dB re 1 µPa (maximum 153 dB) near 400 Hz. The authors estimate a source level of 209 dB re 1 µPa at 1 m. It is not clear what acoustic metric is used (*i.e.*, rms, 0-peak, peak-peak), nor what broadband sound levels resulted from the blasts. Behavioural observations of humpbacks *in situ* on their foraging grounds suggest that the whales were not reacting to the intense acoustic stimuli from the detonations (Todd *et al.* 1996). It is unclear if an increase in humpback entrapments in fishing nets in the area were related to underwater explosions.

Toothed whales, including belugas, bottlenose dolphins, false killer whales, and killer whales exposed to small explosive charges (received sound level of 185 dB re 1 µPa in one study) found limited or no effect on these marine mammals (Richardson *et al.* 1995). At higher received levels, explosions may elicit responses. Two captive bottlenose dolphins exposed to sounds simulating distant underwater explosions showed behavioural avoidance to sound with received levels from 196 to 209 dB re 1 µPa (peak to peak; Finneran *et al.* 2000).

Pinnipeds seem quite tolerant of noise pulses from “small” explosives (Richardson *et al.* 1995). Firecracker-like explosives initially startle seals and sea lions, and often induce them to move away but avoidance wanes after repeated exposure. Northern fur seals breeding on land did not exhibit any obvious response to nearby (0.6 to 2 km) blasts from quarries (Gentry *et al.* 1990). South American fur seals and sea lions as well as grey seals exposed to blasting operations showed little or no reactions. There is little chance of masking of any marine mammal sounds, as blasting operations will be intermittent in nature and the sound pulse is very short.

Sea Turtles: No information on the environmental effects of blasting on sea turtles is currently available, but sea turtles are considered rare in inner Trinity Bay near the site of potential blasting, particularly during times other than late summer and early fall.

Species most likely to exhibit changes in habitat use include marine mammals common in the Nearshore Study Area during blasting activities.

Mitigation associated with habitat use will be as described for habitat quality (see Section 10.5.1.2).

Dredging

In the Nearshore Project Area, dredging of the bund wall and possibly sections of the tow-out route may be required during the construction of the GBS.

In nearshore shallow water regions, dredges can be strong sources of low-frequency underwater noise (Richardson *et al.* 1995). Because low-frequency sound attenuates rapidly in shallow water, underwater sound produced by dredging is normally undetectable at ranges beyond 25 km (Richardson *et al.* 1995). Dredging that occurs consistently over long periods can create a higher potential for disturbance, which could result in changes in habitat use, for marine mammals and sea turtles. Limited information is available on the behavioural changes of marine mammals (and none for sea turtles) resulting from dredging operations, but generally animals have been reported to continue using habitats near dredging operations.

Marine Mammals: Gray whales in Laguna Guerrero Negro provide the best documented case of a long-term change in baleen whale distribution as a result of industrial activities including dredging. It is thought that constant dredging operations needed to keep a channel open for shipping of salt (from 1957 to 1967) may have been the main source of disturbance to the whales and decline of whale numbers from 1964 to 1970 (Bryant *et al.* 1984). Gray whales reoccupied the lagoon after shipping of salt subsided. However, recent surveys suggest that the seasonal abundance of gray whales in the lagoon has decreased 90 percent since the 1980s. Fishermen in the area suggested that this decline of whales may be due to the natural closure of the lagoon entrance as sand accumulates in the absence of dredging (Urbán-Ramirez *et al.* 2003).

In the MacKenzie Estuary, Canada, belugas have been reported to approach as close as 400 m to stationary dredges, but were more sensitive to barge traffic associated with the dredging (Ford 1977; Fraker 1977). In contrast, in 1999, Cook Inlet beluga whales were seen in waters near the docks at the Port of Anchorage, Alaska, during vessel transits from a dredging operation near Fire Island, but no whales were observed near the dredging site itself (Moore *et al.* 2000).

Marine mammals common within the Nearshore Study Area during dredging activities, particularly those present for extended periods, are most likely to be affected.

Sea Turtles: There are currently no published data available regarding the behavioural effects of dredging on sea turtles. However, sea turtles are considered uncommon in the Nearshore Study Area.

Dredging operations will be temporary and of limited duration. Dredging may only be required to prepare the tow-out channel from Great Mosquito Cove to the deepwater site. It is planned that proper planning and equipment design will reduce the duration of dredging activities and hence, their environmental effect on marine mammals and sea turtles.

Vessel Traffic

Noise generated by vessels associated with the Project has the potential to disturb marine mammals and sea turtles, causing changes in habitat use. Marine mammal responses to ships are presumably responses to noise, but visual or other cues are also likely involved. Sound source levels for most small ships, including tugs and barges, are above the 160 dB re 1 µPa (rms) criterion considered for behavioural disturbance (Richardson *et al.* 1995). Specific sound levels or estimates are not available for the specific vessels or the cumulative noise levels from vessels that will be used during the Project, but it is expected that the greatest and most continuous vessel noise source during construction and operations / maintenance phases will be tugs and barges (see Blackwell and Greene 2006).

Acoustic modelling of a tug boat operating at high power was conducted at both the bund wall and deepwater mooring site (see JASCO 2010). Relative to other sources of construction noise, estimated sound levels from a single tug were much lower relative to other sources of construction noise. Sound levels of 160 dB re 1 uPa (rms) were estimated to occur within 140 m and 60 m of the tug at the bund wall and deepwater mooring site, respectively.

Factors such as species, maturity, experience, current behaviour state, reproductive state, and time of day likely affect marine mammal and sea turtle responses to vessels. Marine mammal response (or lack thereof) to ships and boats are summarized in Richardson *et al.* (1995, p. 252-274) for studies pre-1995. A review of more recent studies assessing the responses of marine mammals to the presence of vessels is included in LGL (2007a: Section 5.6.6.3). For baleen whales in general, available studies indicate that rapid changes in vessel speed, close approaches, and head-on approaches elicit behavioural responses, including avoidance of areas and changes in dive patterns or swim speeds. Variable reactions, from minor to overt, have been noted for toothed whales. Animal responses include reductions in foraging, possible habituation, increased diving, frequent changes in direction, approach and bow-riding, increased rate and sound level of vocalizations, modified behavioural state, general avoidance, or selection of different habitat. Seals sometimes investigate oncoming vessels while others appear to avoid vessels. No data are currently available on the response of sea turtles to vessel traffic, but they rarely occur in the Nearshore Study Area and typically only during late summer or early fall. Marine mammals occurring in the Nearshore Study Area during periods of increased vessel traffic are most likely to be affected.

Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible.

Additionally, vessels will maintain a steady vessel speed and course whenever possible.

Other Activities

Artificial light might attract prey species of the marine mammal and sea turtle VEC and result in a positive environmental effect on its habitat use. Air emissions are expected to have a negligible effect on the habitat quality of the marine mammal and sea turtle VEC. The creation of new moorings might attract prey species of the marine mammal and sea turtle VEC and result in a minimal positive environmental effect on its habitat use. The effects of tow-out of the Hebron Platform are most likely related to the presence of vessels and low-frequency engine noises discussed above. In the case of surveys that do not include seismic airguns, the main impact of surveys on the Marine Mammal and Sea Turtle VEC is vessel traffic (described above).

Offshore

Dredging

As described above for dredging activities in the Nearshore Study Area subsection, dredging that occurs consistently for extended periods could result in behavioural reactions and changes in habitat use for marine mammals and sea turtles. In general, the limited available information suggests that cetaceans tend to remain in occupied areas near dredging sites, but there is no available information on reactions of pinnipeds or sea turtles. Animals that remain near dredging activities for extended periods are most likely to be affected. Proper planning and equipment design will reduce the duration of dredging activities and hence, their environmental effect on marine mammals and sea turtles. Additionally, suction dredgers will be used to lessen sediment suspension during soil intake, and work periods will be minimized.

Vessel Traffic

The potential effects of vessel traffic on the habitat use of marine mammals and sea turtles were reviewed above in the Nearshore Study Area subsection. As described in that section and Section 10.5.1.2, project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible.

Helicopter Overflights

Helicopters will be used to transfer personnel to the Hebron Platform, drilling units, and possibly seismic vessels. Baleen whale responses to aircraft (pre-1995 studies) are summarized in Richardson *et al.* (1995, p. 249-252). Those observations showed that whales often react to aircraft overflights by hasty dives, turns, or other changes in behaviour. Responsiveness depends on the activities and situations of the whales (*e.g.*, gray whales; Moore and Clarke 2002). Whales actively feeding or socializing often seem rather non-

responsive. Whales in confined waters or with calves sometimes seem more responsive. In a more recent study, opportunistic observations of bowhead whale responses to a Bell 212 helicopter (and Twin Otter fixed-wing aircraft) were acquired during four spring migration periods in the Alaskan Beaufort Sea (Patenaude *et al.* 2002). The helicopter was found to have numerous prominent tones at frequencies up to approximately 340 Hz, with the most prominent peak at 22 Hz. Sound levels between the peaks were 10 to 15 dB above ambient noise levels. Helicopter overflights elicited detectable responses in 14 percent of 63 bowhead groups. Most observed reactions (abrupt dives, breaching, tail slapping, and brief surfacings) by bowheads (63 percent) to the helicopter occurred when it was at altitudes less than or equal to 150 m and lateral distances less than or equal to 250 m. In this and other studies, there was no indication that single or occasional aircraft overflights cause more than brief behavioural responses.

Toothed whale responses to aircraft (pre-1995 studies) are summarized in Richardson *et al.* (1995). Odontocetes reacting to aircraft may dive, slap the water with flippers or flukes, or swim away. The activity of a toothed whale sometimes appears to influence whether or not there is a behavioural response. In more recent studies, Richter *et al.* (2003) reported that male sperm whales off Kaikoura, New Zealand, spent more time at the surface and showed more frequent heading changes in the presence of aircraft (small fixed-wing planes and helicopters) involved in whale watching activities. The responses of beluga whales in the Alaskan Beaufort Sea to the noise of a Bell 212 helicopter (and Twin Otter fixed-wing aircraft) were assessed by Patenaude *et al.* (2002). Beluga whales reacted to the helicopter on 15 of 40 occasions. These reactions included immediate dives, changes in heading, changes in behavioural state, and apparent displacements. Reactions occurred more often when the helicopter passed at altitudes less than or equal to 150 m than when it passed at altitudes greater than 150 m and significantly (p = 0.004) more often when the helicopter's lateral distance from the whales was less than or equal to 250 m versus 250 to 500 m. Beluga whales reacted 50 percent of the time when the helicopter was stationary on the ice with the engines running. In this and other studies, there was no indication that single or occasional aircraft overflights cause more than brief behavioural responses in toothed whales.

Pinniped response to aircraft (pre-1995 studies) are summarized in Richardson *et al.* (1995). Pinnipeds hauled out on land or ice seem to be more responsive to overflights than pinnipeds in the water. Born *et al.* (1999) assessed the responses of ringed seals hauled out on the ice to overflights by fixed-wing twin-engine aircraft (Partenavia PN68 Observer) and a helicopter (Bell 206 III). Both aircrafts flew over seals at an altitude of 150 m. Overall, 6 percent of the seals (total = 5,040) escaped (left the ice) as a reaction to the fixed-wing aircraft and 49 percent of the seals (total = 227) escaped as a response to the helicopter. Some seals seem to habituate to frequent overflights. In this and other studies, there was no indication that single or occasional aircraft overflights cause more than brief behavioural responses in pinnipeds. Observations were made of ringed seal behaviour in response to industrial noise (pipe-driving, helicopter overflights) at an artificial island

(Northstar Island) in the Alaskan Beaufort Sea (Blackwell *et al.* 2004). During 55 h of observation, 23 observed ringed seals exhibited little or no reaction to any industrial noise except approaching Bell 212 helicopters; 10 seals looked at the helicopter, one seal departed from its basking site, and one seal showed no reaction.

There are currently no available systematic data on sea turtle reactions to helicopter overflights. Given the hearing sensitivities of sea turtles, they can likely hear helicopters, at least when the helicopters are at lower altitudes and the turtles are at relatively shallow depths. It is unknown how sea turtles would respond, but single or occasional overflights by helicopters would likely only elicit a brief behavioural response.

Thus, the available information suggests that helicopters flying at low altitude (*i.e.*, when approaching a landing site) may disturb some marine mammals directly in its flight path, or, in the case of seals, when they are hauled out. Occasional aircraft overflights cause only brief behavioural responses by marine mammals, and there is no available information on the reaction of sea turtles to aircraft overflight. Additionally, it is unlikely that large numbers of marine mammals will be overflown, especially at low altitude.

To avoid disturbance of marine mammals and sea turtles, the helicopter will avoid flying at low altitudes whenever it is safe to do so. Helicopters will typically only reduce altitude on approach for landing. Helicopter landings at offshore platforms would probably affect a very small area with a radius less than 500 m.

Seismic and Other Geophysical Surveys

A change in habitat use, resulting from behavioural disturbance and avoidance, is the most likely effect, if any, of seismic and geohazard surveys on marine mammals and sea turtles. The following text provides summaries and updated literature from recent seismic and geohazard survey environmental assessments prepared for the Jeanne d'Arc Basin. The reader is referred to LGL 2005b (Section 6.5.12); Moulton *et al.* 2006b (Sections 6.1.2 and 6.1.3); LGL 2007a (Section 5.6.6); and LGL 2008 for a detailed review of seismic effects and LGL 2005b, 2005c, 2005d, 2007a for a review of geohazard survey behavioural effects on marine mammals and sea turtles.

Marine Mammals: Baleen whales tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to airgun pulses at distances beyond a few kilometres, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, studies done since the late 1990s of humpback and migrating bowhead whales show that reactions, including avoidance, sometimes extend to greater distances than documented earlier. Avoidance distances often exceed the distances at which boat-based observers can see whales, so observations from the source vessel are biased. Studies indicate monitoring over broader areas may be needed to determine the range of potential effects of some larger seismic surveys (Richardson *et al.* 1999; Bain and Williams 2006; Moore and Angliss 2006).

Some baleen whales show considerable tolerance of seismic pulses (Stone and Tasker 2006). However, when the pulses are strong enough, avoidance or other behavioural changes become evident. Because the responses become less obvious with diminishing received sound level, it has been difficult to determine the maximum distance (or minimum received sound level) at which reactions to seismic become evident and, hence, how many whales are affected.

Studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160 to 170 dB re 1 µPa (rms) range seem to cause obvious avoidance behaviour in a substantial fraction of the animals exposed. In many areas, seismic pulses diminish to these levels at distances ranging from 4.5 to 14.5 km from the source. A substantial proportion of the baleen whales within this distance range may show avoidance or other strong disturbance reactions to the operating airgun array. In the case of migrating bowhead whales, avoidance extends to larger distances and lower received sound levels. Recent intensive study of western gray whales summering in feeding areas off Sakhalin Island, Russia showed that some whales (5 to 10 individuals) moved away from waters inshore of seismic operations to a core feeding area farther south (Yazvenko *et al.* 2007a) and that there was no measureable effect on bottom feeding by gray whales relative to the seismic survey (Yazvenko *et al.* 2007b).

Data on short-term reactions (or lack of reactions) of cetaceans to impulsive noises do not necessarily provide information about long-term effects. It is not known whether impulsive noises affect reproductive rate or distribution and habitat use in subsequent days or years. Furthermore, effects likely vary between species, location, past exposure to seismic sounds. In general, among mammals, baleen whales are relatively long-lived, mature late, have relatively low reproductive rates, and require high maternal investment in young. This is particularly true for bowhead and right whales, although both species are unlikely to occur in the Offshore Area. Thus, the female's ability to provide adequate care to her offspring during a prolonged period of dependency is critical to the continued recovery and long-term viability of the population. These natural history traits support the need to avoid certain seasons or locations as addressed in this analysis (Wilson *et al.* 2006).

Some populations of mysticetes have continued to grow despite increasing anthropogenic activities, including seismic activities. Long-term data on gray whales show that they continue to migrate annually along the west coast of North America despite intermittent seismic exploration (and much ship traffic) in that area for decades (Appendix A in Malme *et al.* 1984). Bowhead whales continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years. Bowheads were often seen in summering areas where seismic exploration occurred in preceding summers (Richardson *et al.* 1987). They also have been observed over periods of days or weeks in areas repeatedly ensonified by seismic pulses. However, it is not known whether the same individual bowheads were involved in these repeated observations (within and between years) in strongly ensonified areas.

Dolphins and porpoises are often seen by observers on active seismic vessels, occasionally at close distances (*e.g.*, bow-riding). However, some studies show avoidance (Stone and Tasker 2006). Belugas summering in the Beaufort Sea tended to avoid waters out to 10 to 20 km from an operating seismic vessel (Miller *et al.* 2005a). In contrast, recent studies show little evidence of reactions by sperm whales to airgun pulses, contrary to earlier indications.

A recent at-sea controlled experiment on the effects of airguns on sperm whales in the Gulf of Mexico indicated that sperm whales do not exhibit avoidance reactions to airguns (Miller *et al.* 2009). The experiment did, however, suggest that airgun exposure could lead to subtle changes in the sperm whale foraging behaviour, such as delaying foraging behaviour. One animal that was resting at the survey before the onset of airgun activity remained resting at the surface throughout the duration of airgun activity, but initiated a foraging dive shortly after the airguns ceased (Miller *et al.* 2009).

There are no specific data on responses of beaked whales to seismic surveys, but it is likely that most if not all species show strong avoidance due to their documented tendency to avoid vessels in general. Of note, northern bottlenose whales have been observed to approach within 400 m of seismic vessels operating in the Orphan Basin when the airgun arrays were active (Moulton *et al.* 2006a).

Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behaviour (Harris *et al.* 2001; Moulton and Lawson 2002; Miller *et al.* 2005b). These studies indicate that pinnipeds frequently do not avoid the area within a few hundred metres of an operating airgun array. However, limited telemetry work suggests that avoidance and other behavioural reactions may be stronger than evident to date from visual studies (Thompson *et al.* 1998).

As reviewed in LGL (2007a, 2007b), masking (*i.e.,* reduction in the effective communication or echolocation distance) is unlikely to be a significant issue for marine mammals exposed to the pulsed sounds from seismic and geohazard surveys.

In summary, short-term avoidance behaviour is not likely to cause any negative effects on the well-being of marine mammals. Furthermore, lack of avoidance is not necessarily a positive result if it means that the animals remain in a heavily ensonified area where (if the ship gets close enough) there is a possibility of temporary hearing loss or TTS (described earlier). In general, there seems to be a tendency for most baleen and toothed whales to show some limited avoidance of seismic vessels operating large airgun systems. Seals appear less likely to avoid seismic vessels operating airgun arrays.

Sea Turtles: There have been far fewer studies of the effects of airgun noise (or indeed any type of noise) on sea turtles than on marine mammals. Three studies (O'Hara and Wilcox 1990; Moein *et al.* 1994; McCauley *et al.* 2000) have focused on short-term behavioural responses of sea turtles in enclosures to single airguns; these studies showed that sea turtles generally

tend to show avoidance of an operating airgun at some received level. McCauley *et al.* (2000) found evidence of behavioural responses (increased swimming speed) by caged green and loggerhead turtles when the received level from a single small airgun (20 in^3 at 1500 psi) was 166 dB re 1 µPa (rms) and avoidance responses at 175 dB re 1 µPa (rms). Captive loggerhead sea turtles maintained a standoff range of about 30 m in response to a 10 in^3 airgun plus two 0.8 in^3 "poppers" operating at 2000 psi (O'Hara and Wilcox 1990). Avoidance appeared to have occurred at levels around 175 to 176 dB re 1 µPa (rms) (McCauley *et al.* 2000) or a few dB lower. Moein *et al.* (1994) also noted avoidance by enclosed loggerhead turtles in response to airgun sounds (up to 179 dB) at a mean range of 24 m; however, the avoidance response waned quickly. Moein *et al.* (1994) also noted that TTS apparently occurred in confined loggerhead turtles exposed to many pulses from a single airgun less than 65 m away. McCauley *et al.* (2000) estimated that, for a typical airgun array (2,678 in^3, 12-elements) operating in 100 to 120 m water depth, sea turtles may exhibit behavioural changes at approximately 2 km and avoidance around 1 km. Holst *et al.* (2006) reported behavioural changes and/or avoidance near a seismic vessel, but the distances or sound levels at which these responses occurred could not be determined.

The limited available data indicate that sea turtles will hear airgun sounds. Based on available data, it is likely that sea turtles will exhibit behavioural changes and/or avoidance within an area of unknown size near a seismic vessel. Seismic operations in or near areas where turtles concentrate are likely to have the greatest effect. There are no specific data that demonstrate the consequences to sea turtles if seismic operations do occur in important areas at important times of year. The Jeanne d'Arc Basin, including the Offshore Study Area, is not a breeding area for sea turtles and there are no known feeding areas or sensitive areas in part due to existing data gaps; thus, high concentrations of sea turtles are unlikely.

In summary, potential changes in habitat use of the Offshore Study Area by marine mammals and sea turtles resulting from seismic surveys include behavioural effects and avoidance. Baleen whales tend to avoid operating airguns, but at variable avoidance radii. Some dolphins occasionally approach active seismic vessels, but studies of toothed whale reactions to seismic surveys generally show temporary avoidance. Only slight (if any) avoidance has been shown by pinnipeds. Limited studies of the effects of seismic surveys on sea turtles suggest that they will exhibit behavioural and/or avoidance within some distance of an operating seismic vessel. Short-term avoidance behaviour, however, does not necessarily provide information about long-term effects such as reproductive rate or distribution and habitat use in subsequent days or years. Additionally, effects likely vary between species, location, and past exposure to seismic sounds.

Mitigation measures will be employed to minimize the potential for effects on marine mammals and sea turtles. To the extent possible, seismic surveys will occur outside of periods of spatial and temporal concentration of marine mammals and sea turtles. Additional mitigation measures to minimize

hearing impairment, as outlined by the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011) and described above in Section 10.5.1.2, will also help minimize any potential environmental effects on marine mammals and sea turtles.

Other Activities

The main impact of tow-out / offshore installation on the Marine Mammal and Sea Turtle VEC is vessel traffic (described above). In the case of surveys that do not include seismic airguns, the main environmental effect of surveys on the Marine Mammal and Sea Turtle VEC is the operation of vessels (described above). Air emissions are expected to have a negligible effect on the habitat quality of the marine mammal and sea turtle VEC. Sounds associated with construction (discussed for the Nearshore Study Area) are most likely to elicit minor behavioural disturbance, resulting in changes in habitat use, for marine mammals and sea turtles. Artificial light might attract prey species of the Marine Mammal and Sea Turtle VEC and result in a positive environmental effect on its habitat use.

10.5.1.4 Potential Mortality

There are few Project activities which are known to cause direct mortality of marine mammals and sea turtles. Collisions with vessels and exposure to in-water blasting may result in mortality. It is thought that some marine mammal species may be at risk of stranding and mortality from exposure to seismic survey noises; this is discussed below.

Nearshore

Blasting

The short rise time to a high peak pressure of shock pulses from explosives appears to be responsible for much of the damage, including mortality, to marine mammals during these detonations (Ketten 1995). Sound levels associated with mortality in marine mammals from blasting have not been established.

Marine Mammals: Humpback whale mortality was linked to explosions at Mosquito Cove, Bull Arm during construction activities associated with the Hibernia GBS. Repeated sub-bottom blasting involving explosives (Tovex™) which ranged from 30 to 5,500 kg and averaged 960 kg were used (Todd *et al.* 1996). Two dead humpbacks with severe mechanical damage to the ears were found near the site (distance to the explosions is unknown) of repeated subbottom blasting. The auditory damage was similar to that in humans exposed to severe blast injury. It is likely the humpbacks were killed as a result of exposure to shock waves (Ketten *et al.* 1993; Ketten 1995).

In addition to baleen whales, large explosions can kill dolphins. Chinese river dolphins, Irrawaddy dolphins, and finless porpoises have been killed by explosions in rivers (Richardson *et al.* 1995, p. 307).

There are several reports that pinnipeds near explosives (detonated in the water) were killed, including some pinnipeds exposed to charges in the kilogram or larger range (Richardson *et al.* 1995, pp. 306-307).

Sea Turtles: There are no systematic data available for effects of blasting on sea turtles. However, a comparison of the number of sea turtle strandings during periods of high and low numbers of offshore explosions suggests that underwater offshore explosions may result in direct or indirect sea turtle mortality (Klima *et al.* 1988). Gitschlag and Herczeg (1994) reported the results of observers who monitored sea turtles during explosive removals of oil and gas structures in the Gulf of Mexico. During 6,500 hours of monitoring at 106 structure removals (42 percent in water less than 15 m, 30 percent in water 15 to 30 m, 22 percent in water 30 to 60 m, and 7 percent in water greater than 60 m), no mortality (or injury) of sea turtles was documented.

Considering the mitigation measures outlined in Section 10.5.1.2, there is likely limited potential of direct mortality on marine mammals and sea turtles from blasting.

Vessel Traffic

The presence of vessels during various Project activities can increase the risk of direct mortality via vessel collisions with marine mammals and sea turtles.

Marine Mammals: Fin whales are the most commonly reported whale to be struck by vessels, followed by humpback whales and North Atlantic right whales (Jensen and Silber 2003; Vanderlaan and Taggart 2007). Blue whales, fin whales and humpback whales were all struck in similar proportions, but to a lesser degree than North Atlantic right whales (Vanderlaan and Taggart 2007). Minke whales, sei whales, and sperm whales were not as frequently struck, proportionally, but have been reported (Vanderlaan and Taggart 2007). Published accounts of ship strikes suggest that most whales are not seen beforehand or are seen at the last minute (Laist *et al.* 2001).

Evidence suggests that a greater rate of mortality and serious injury to large whales is correlated with a greater vessel speed at the time of a ship strike (Laist *et al.* 2001; Vanderlaan and Taggart 2007). Most lethal and severe injuries to large whales resulting from documented ship strikes have occurred when vessels were travelling at 14 knots or greater (Laist *et al.* 2001). Vanderlaan and Taggart (2007), using a logistic regression modelling approach based upon vessel strike records, found that for vessel speeds greater than 15 knots, the probability of a lethal injury (mortality or severely injured) approaches 1.0. The probability of lethal injury declined to approximately 0.2 at speeds of 8.6 knots (Vanderlaan and Taggart 2007).

In a review of 58 large whale ship strikes in which the vessel speed was known, the average speed of vessels involved in ship strikes that resulted in mortality or serious injuries to the whale was found to be 18.6 knots (Jensen and Silber 2003). The frequency of incidents of ship strikes more than doubled when vessel speeds were 13-15 knots as opposed to 10 knots or

less (Jensen and Silber 2003). Most lethal or severe injuries are caused by vessels >80 m in length (Laist *et al.* 2001).

Sea Turtles: Sea turtle injury or mortality may also occur due to collisions with vessels, particularly with vessels traveling at speeds >4 km/h (Hazel *et al.* 2007).

Large species of whales and sea turtles that spend extended periods near the surface would be particularly susceptible to ship strikes. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible, and vessels will maintain a steady speed and course in order to avoid potentially fatal collisions with the VEC. Particularly in the Nearshore Study Area, vessels associated with the Project will typically be engaged in activities that require a slow speed or maintenance of a stationary position, which will also reduce the risk of a collision. Vessels will deviate from their course to avoid marine mammals and sea turtles, if necessary.

Offshore

Vessel Traffic

As discussed for mortality associated with vessel traffic in the Nearshore Study Area, there is a risk of vessel collision with marine mammals and sea turtles resulting in serious injury or mortality. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible, and vessels will maintain a steady speed and course in order to avoid potentially fatal collisions with the VEC. Vessels will reduce speed whenever possible and deviate their course to avoid marine animals.

Seismic Surveys

As discussed in the Nearshore Study Area subsection, marine mammals close to underwater detonations of high explosives can be killed (Ketten *et al.* 1993; Ketten 1995). However, explosives are no longer used either for seismic research or for commercial seismic surveys in marine areas; they have been replaced by airguns and other non-explosive sources. Airgun pulses are less energetic and have slower rise times, and there is no specific evidence that they can cause serious injury, death, or stranding even in the case of large airgun arrays. However, the association of mass strandings of beaked whales with naval exercises and, in one case, a seismic survey (Malakoff 2002; Cox *et al.* 2006), has raised the possibility that beaked whales exposed to strong “pulsed” sounds may be especially susceptible to injury and/or behavioural reactions that can lead to stranding (*e.g.*, Hildebrand 2005; Southall *et al.* 2007). Hildebrand (2005) reviewed the association of cetacean strandings with high-intensity sound events and found that deep-diving odontocetes, primarily beaked whales, were by far the predominant (95 percent) cetaceans associated with these events, with 2 percent mysticete whales (minke). However, as summarized below, there is no definitive evidence that airguns can lead to strandings or mortality even for marine

mammals in close proximity to large airgun arrays. In addition, beaked whales are not expected in the relatively shallow waters of the Offshore Project Area where seismic surveys would be conducted.

There is no conclusive evidence of cetacean strandings or deaths at sea as a result of exposure to seismic surveys, but a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings. There were suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel *et al.* 2004); these were not well founded (IAGC 2004; IWC 2007). In September 2002, there was a stranding of two Cuvier's beaked whales in the Gulf of California, Mexico, when the Lamont-Doherty Earth Observatory of Columbia University seismic vessel *R/V Maurice Ewing* was operating a 20-airgun, 8,490-in^3 airgun array in the general area. The evidence linking the stranding to the seismic survey was inconclusive and not based on any physical evidence (Hogarth 2002; Yoder 2002). The ship was also operating its multibeam echosounder at the same time, but this had much less potential than the aforementioned naval sonars to affect beaked whales. Nonetheless, the Gulf of California incident plus the beaked whale strandings near naval exercises involving use of mid-frequency sonar suggest a need for caution in conducting seismic surveys in areas occupied by beaked whales until more is known about effects of seismic surveys on those species (Hildebrand 2005).

Sea turtle mortality has not been documented to occur as a result of exposure to seismic surveys.

The *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011) will be followed to minimize environmental effects on Marine Mammals and Sea Turtles.

The environmental effects of Project construction / installation activities on Marine Mammals and Sea Turtles are summarized in Table 10-10.

Given that Project activities are mostly localized, of low to medium magnitude, and reversible at the population level, there are not likely to be significant residual adverse environmental effects on marine mammals and sea turtles from construction or installation activities associated with the Project.

10.5.2 Operations and Maintenance

10.5.2.1 Change in Habitat Quantity

None of the Project activities during the operations and maintenance phase are expected to affect the habitat quantity of marine mammals and sea turtles.

Table 10-10 Environmental Effects Assessment: Construction and Installation

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Project Activities							
Bund Wall Construction (*e.g.*, sheet / pile driving, infilling)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use	• Equipment design • Potential use of bubble curtains • Safety Zone • Monitoring	2	3	3/1	R	2
Inwater Blasting	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adherence to *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* • Potential use of bubble curtains • Safety Zone • Monitoring	2	3	2/1	R[B]	2
Dewater Drydock / Prep Drydock Area	• Change in Habitat Use		1	1	2/1	R	2
Concrete Production (floating batch plant)	• Change in Habitat Use	• Equipment design	1	1	3/3	R	2
Vessel Traffic (*e.g.*, supply, tug support, tow, diving support, barge, passenger ferry to / from deepwater site)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course • Deviate course to avoid animals	1	3	3/6	R[B]	2
Lighting	• Change in Habitat Use (+)		1	1	3/6	R	2
Air Emissions	• Change in Habitat Quality		N	4	3/6	R	2
Re-establish Moorings at Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use (+)	• Equipment design • Bubble curtains • Safety Zone • Monitoring	1	1	2/1	R	2
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	• Change in Habitat Quality • Change in Habitat Use	• Planning • Equipment design	2	3	2/1	R	2
Removal of Bund Wall and Disposal (dredging / ocean disposal)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Bubble curtains • Safety Zone • Monitoring	2	3	2/1	R[B]	2
Tow-out of GBS to Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	3	1/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
GBS Ballasting and De-ballasting (seawater only)	• Change in Habitat Use		1	1	1/1	R	2
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	• Change in Habitat Use		1	1	2/2	R	2
Hook-up and Commissioning of Topsides	• Change in Habitat Use		1	1	2/2	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Quality • Change in Habitat Use	• Avoid animal concentrations when possible • Maintain steady speed and course when possible	1	3	2/1	R	2
Platform Tow-out of from deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	1	3/6	R	2
Offshore Construction / Installation							
OLS Installation and Testing	• Change in Habitat Quality • Change in Habitat Use	• Equipment design	1	2	2/1	R	2
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines	• Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Installation of Temporary Moorings	• Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Platform Tow-out / Offshore Installation	• Change in Habitat Quality • Change in Habitat Use		1	3	2/6	R	2
Underbase Grouting	• Change in Habitat Use	• Equipment design	1	1	2/1	R	2
Possible Offshore Solid Ballasting	• Change in Habitat Use		1	1	2/1	R	2
Placement of Rock Scour on Seafloor around Final Platform Location	• Change in Habitat Quality • Change in Habitat Use		1	1	2/1	R	2
Hook-up and Commissioning of Platform	• Change in Habitat Use		1	1	2/1	R	2
Operation of Helicopters	• Change in Habitat Quality • Change in Habitat Use	• Avoid low altitudes when possible	1	2	3/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course • Deviate course to avoid animals	1	3	3/6	R[B]	2
Air Emissions	• Change in Habitat Quality	• Equipment design	N	5	3/6	R	2
Lighting	• Change in Habitat Use (+)		1	1	3/6	R	2
Potential Expansion Opportunities							
Excavated Drill Centre(s) Dredging and Spoils Disposal	• Change in Habitat Quality • Change in Habitat Use	• Planning • Equipment design	1	3	2/1	R	2
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	• Change in Habitat Use		1	2	2/1	R	2
Hook-up and Commissioning of Drill Centres	• Change in Habitat Use		1	2	2/2	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Quality • Change in Habitat Use	• Adherenece to the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment (C-NLOPB 2011)	1	2	2/1	R	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
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Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Reversible at the population level but irreversible at the individual level

10.5.2.2 Change in Habitat Quality

As discussed previously, interactions that may result in physical / physiological effects are considered as a change in habitat quality. Noise effects from Project operations and maintenance activities can potentially diminish habitat quality and influence habitat use by marine mammals and sea turtles. Section 10.5.1.2 contains an extensive discussion on the effects of noise on marine mammals and sea turtles, including effects of vessel traffic and seismic surveys that may be conducted during the construction and/or operations phase of the Project. Refer to Section 10.5.1.3 for a detailed analysis of noise effects on habitat quality due to other Project activities that may be common to both construction and operations/maintenance phases (*e.g.*, vessel traffic, seismic surveys).

Other activities that may contribute to an effect on habitat quality during Project operations include discharges that may reduce water quality in the Offshore Study Area. Air emissions are expected to have a negligible effect on the habitat quality of marine mammals and sea turtles.

Sanitary and domestic waste water will be discharged during drilling and production operations. Organic matter from sanitary wastes will be quickly dispersed (after maceration) and degraded by bacteria, and food waste may be shipped ashore. The environmental effects on marine mammals and sea turtles swimming in the receiving waters containing small amounts of organic matter and nutrients will be minimal.

The discharge of any blowout preventer fluid from an offshore platform will not affect marine mammals because glycol-water mixes will be used and the BOP fluid will have a low toxicity.

Water-based cuttings and production fluids will be discharged overboard in accordance with the *Offshore Waste Treatment Guidelines* (National Energy Board (NEB) *et al.* 2010). Synthetic-based cuttings will be re-injected into the subsurface. Drilling activities are unlikely to produce concentrations of heavy metals in muds and cuttings that are harmful to marine mammals (Neff *et al.* 1980, in Hinwood *et al.* 1994). In addition, none of the marine mammals that regularly occur in the Offshore Study Area are known to feed on benthos in the area. The bearded seal, which is considered a benthic feeder, may occasionally occur in the Offshore Study Area, but typically occurs much farther north near ice. These activities are expected to have minimal environmental effect on marine mammals and sea turtles.

10.5.2.3 Change in Habitat Use

Many Project activities predicted to have an effect on habitat use during the operations / maintenance phase of the Project have been discussed above under construction (*e.g.*, seismic surveys, vessel and helicopter traffic) (refer to Section 10.5.1.3). Effects on habitat use specific to the operations phase are discussed below.

Drilling

Drilling may occur from the Hebron Platform and from MODUs at future excavated drill centres. Of note, dynamically positioned drill ships are typically noisier than semi-submersibles which, in turn, are noisier than jack-ups (Richardson *et al.* 1995). However, no sound level measurements are currently available for a platform.

Kapel (1979) reported numerous baleen whales – mainly fin, minke, and humpback whales – within visual range of active drillships off West Greenland. In more formal studies, bowhead whales reacted to drillship sounds within 4 to 8 km of a drillship when received levels were 20 dB above ambient or approximately 118 dB re 1 µPa (Greene 1985, 1987; Richardson *et al.* 1985b, 1990). Reaction was greater at the onset of the sound (Richardson *et al.* 1995). Thus, bowhead whales migrating in the Beaufort Sea avoided an area with a 10 km radius around a drillship, which corresponded to received sound levels of 115 dB re 1 µPa (Richardson *et al.* 1990). Some whales were less responsive and habituation may occur, so that in time bowheads may be seen within 4 to 8 km of a drillship (Richardson *et al.* 1985a, 1990). Sound attenuates less rapidly in the shallow Beaufort Sea where these experiments were conducted than in temperate waters with greater depths.

Off California, the reaction zone around a semi-submersible drilling unit was much less than 1 km for grey whales (Malme *et al.* 1983, 1984). Humpback whales showed no clear avoidance response to received drillship broadband sounds of 116 dB re 1 µPa (Malme *et al.* 1985).

Recently, the proximal part of the migration corridor of bowhead whales in the Alaskan Beaufort Sea has been monitored during construction, drilling, and production activities at an artificial island (Northstar) just inshore of the migration corridor (Richardson and Williams 2004). The primary objective of the monitoring program was to determine if, at high-noise times, underwater sound propagating from Northstar and its support vessels deflected the southern part of the bowhead migration corridor. An acoustical localization method was used to determine the locations of calling bowhead whales (Greene *et al.* 2004). Overall, the results showed evidence consistent with slight offshore displacement of the proximal edge of the bowhead migration corridor at some times when levels of underwater sound were unusually high. These high-noise occasions were attributable to support vessels operating near the production facility rather than to the island-based operation itself.

Beluga whales were exposed to playback sounds from a semi-submersible drill rig in an Alaskan river (Stewart *et al.* 1982). During the two tests, belugas swimming toward the sound source did not react overtly until they were within 50 to 75 m and 300 to 500 m, respectively; some belugas altered course to swim around the source, some increased swimming speed, and one reversed direction of travel. Reactions to sound from the semi-submersible drill unit were less severe than were reactions to motorboats with outboards (Stewart *et al.* 1982). Dolphins and other toothed whales show considerable tolerance

of drill rigs and their support vessels, particularly when there are not negative consequences from close approach to the activities (Richardson *et al.* 1995).

Ringed seals were often seen near drill ships drilling in the Arctic in summer and fall (several reports summarized by Richardson *et al.* 1995). Ringed seals and bearded seals approached and dove within 50 m of a projector transmitting drilling sound into the water (received sound levels were 130 dB re 1 μPa). More recent studies of seals near active seismic vessels (Harris *et al.* 2001; Moulton and Lawson 2002) confirm that seals are tolerant of offshore industrial activities.

There are currently no available systematic data on sea turtle reactions to noise from drilling rigs.

Other Activities

Potential effects of the presence of structures on marine mammals and sea turtles are mainly related to the effects of sound produced by offshore structures and activities. Marine mammals would most likely avoid the immediate area around drilling activities due to physical activities and underwater sound generated. Artificial light might attract prey species of the marine mammal and sea turtle VEC and result in a positive environmental effect on its habitat use.

10.5.2.4 Potential Mortality

As discussed in Section 10.5.2.1, the key routine Project activity which is most likely to result in mortality is the operation of vessels. The presence of vessels during various Project activities can increase the risk of direct mortality via vessel collisions with marine mammals and sea turtles. Large whales, particularly baleen whales, are the most commonly reported animals to be involved in vessel collisions, typically resulting in injury leading to indirect mortality or direct mortality. Additionally, evidence suggests that a greater rate of mortality and serious injury to large whales is correlated with a greater vessel speed at the time of a ship strike. Sea turtle injury or mortality may also occur due to collisions with vessels, particularly those traveling at high speeds. Large species of whales and sea turtles that spend extended periods near the surface would be most susceptible to ship strikes.

Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible, and vessels will maintain a steady speed and course in order to avoid potentially fatal collisions with the VEC. Speed will be minimized whenever possible and vessels will deviate from their course to avoid animals in their path. Section 10.5.1.4 includes additional detail on effects and mitigation related to vessel traffic and direct mortality effects.

The environmental effects of Project operations and maintenance activities on Marine Mammals and Sea Turtles are summarized in Table 10-11.

Table 10-11 Environmental Effects Assessment: Operations and Maintenance

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Structures	• Change in Habitat Quality • Change in Habitat Use		1	1	5/6	R	2
Lighting	• Change in Habitat Use (+)		1	1	5/6	R	2
Maintenance Activities (*e.g.*, diving, ROV)	• Change in Habitat Use		1	2	5/3	R	2
Air Emissions	• Change in Habitat Quality		N	5	5/6	R	2
Wastewater (*e.g.*, produced water, cooling water, storage displacement water, deck drainage)	• Change in Habitat Quality		1	1	5/6	R	2
WBM Cuttings	• Change in Habitat Quality	• Re-use of drill mud	1	1	5/2	R	2
Operation of Helicopters	• Change in Habitat Quality • Change in Habitat Use	• Avoid low overflights when possible	1	2	5/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course • Deviate course to avoid animals	1	3	5/6	R[B]	2
Surveys (*e.g.*, geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use • Change in Habitat Quality	• Adherenece to the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (C-NLOPB 2011)	1	2	3/2	R	2
Potential Expansion Opportunities							
Drilling Operations from MODU at Future Excavated Drill Centres	• Change in Habitat Quality • Change in Habitat Use		1	3	3/6	R	2
Presence of Structures	• Change in Habitat Quality • Change in Habitat Use		1	1	5/6	R	2
WBM and SBM Cuttings	• Change in Habitat Quality	• Adherence to *Offshore Waste Treatment Guidelines* (NEB *et al.* 2010)	1	1	5/6	R	2
Chemical Use and Management (BPO fluids, well treatment fluids, corrision inhibitors)	• Change in Habitat Quality		1	1	5/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Geophysical / Seismic Surveys	• Change in Habitat Quality • Change in Habitat Use	• Adherenece to the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (C-NLOPB 2011)	2	4	3/2	R	2

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Duration:
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2 = 1-12 months
3 = 13-36 months
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Frequency:
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R = Reversible
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Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Reversible at the population level but irreversible at the individual level

Given that Project activities are localized, of low to medium magnitude, and reversible, there are not likely to be significant adverse environmental effects on marine mammals and sea turtles from operations and maintenance activities associated with the Project.

10.5.3 Decommissioning and Abandonment

10.5.3.1 Change in Habitat Quantity

The removal of the Hebron Platform and OLS loading points will result in a minimal habitat gain for marine mammals and sea turtles. However, considering the lack of specific habitat in the offshore for marine mammals and limited offshore habitat use by turtles, the effect is not considered to be significant.

10.5.3.2 Change in Habitat Quality

Environmental effects of removing structures (Hebron Platform and OLS loading points), vessel traffic, helicopter traffic and surveys are decommissioning activities which could affect habitat quality. The potential effects of these activities are expected to be similar (or less than) those of construction or operation (assessed in Sections 10.5.1.2 and 10.5.2.2); therefore, no significant adverse environmental effects are predicted.

10.5.3.3 Change in Habitat Use

Environmental effects of removing structures (Hebron Platform and OLS loading points), plugging and abandoning wells, light emissions, vessel traffic, helicopter traffic and surveys are decommissioning activities which could affect habitat use. The potential effects of these activities are expected to be similar (or less than) those of construction or operation (assessed in Sections 10.5.1.3 and 10.5.2.3); therefore, no significant adverse environmental effects are predicted.

10.5.3.4 Potential Mortality

Similarly to construction and installation, and operations/maintenance phases, the key Project activity which has the potential to have an effect on direct mortality of marine mammals and sea turtles is the operation of vessels (assessed in Sections 10.5.1.4 and 10.5.2.4). The potential effects of this activity is expected to be similar (or less than) those of construction or operation; therefore, no significant adverse environmental effects are predicted.

The environmental effects of Project decommissioning and abandonment activities on Marine Mammals and Sea Turtles are summarized in Table 10-12.

Given that Project activities are mostly localized, of low magnitude, and reversible, there are not likely to be significant adverse environmental effects on marine mammals and sea turtles from decommissioning and abandonment activities associated with the Project.

10.5.4 Accidents Malfunctions and Unplanned Events

The following sections assess the effect of an accidental release of hydrocarbons in the nearshore and offshore. Spills in the nearshore would be attributable to vessel malfunctions and similar effects and mitigation discussed for the offshore is applicable to the nearshore scenarios; therefore, nearshore and offshore effects are assessed together. The type and probability of spills (blowout (surface and subsea) and batch) are discussed in Section 14.1 and spill trajectories on water in the Nearshore Study Area and Offshore Study Area are described in Sections 14.2 and 14.3, respectively. A detailed analysis is included in ASA (2011a, 2011b).

Oil spill response is included as part of the contingency planning undertaken for the Project and additional information regarding spill response planning is found is Section 14.4. Chapter 16 describes the Hebron Project's overall environmental management process.

Table 10-12 Environmental Effects Assessment: Decommissioning and Abandonment

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Removal of the Platform and OLS Loading Points	• Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Lighting	• Change in Habitat Use		1	1	3/5	R	2
Plugging and Abandoning Wells	• Change in Habitat Use		1	2	3/2	R	2
Abandoning the OLS Pipeline	• Change in Habitat Use		1	2	3/1	R	2
Operation of Helicopters	• Change in Habitat Quality • Change in Habitat Use	• Avoid low overflights when possible	1	2	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / barges / ROVs)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course	1	3	3/6	R/I [B]	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use • Change in Habitat Quality	• Adherenece to the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (C-NLOPB 2011)	1	2	3/2	R	2

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1 = < 1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Reversible at the population level but irreversible at the individual level

10.5.4.1 Change in Habitat Quality

There are several physical and internal functions that may be affected by oil fouling of marine mammals. Whales and seals rely on a layer of blubber for insulation, and so oil has little effect on thermoregulation. It can be assumed that if oil contacted the eyes, effects would be similar to that observed in ringed seals (conjunctivitis, corneal abrasion, and swollen nictitating membranes), and that continued exposure to eyes could cause permanent damage (St. Aubin 1990). Damage to the visual system would likely limit foraging abilities, as vision is an important sensory modality used to locate and capture prey, particularly for marine mammals.

Animals could ingest oil with water, contaminated food, or oil could be absorbed through the respiratory tract; absorbed oil could cause toxic effects (Geraci 1990). Species like the humpback whale, right whale, beluga (*Delphinapterus leucas*), and harbour porpoise that feed in restricted areas (for example, bays such as the Nearshore Study Area) may be at greater risk of ingesting oil (Würsig 1990). Some of the ingested oil is voided in vomit or feces but some is absorbed and could cause toxic effects (Geraci 1990). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt 1978, 1982). Whales exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin 1980, 1982). Only small traces of oil were found in the blubber of a grey whale and liver of a killer whale exposed to *Exxon Valdez* oil (Bence and Burns 1995).

Inhalation of vapours from volatile fractions of oil from a spill or blowout could potentially irritate respiratory membranes and hydrocarbons could be absorbed into the bloodstream (Geraci 1990). Grey seals that presumably inhaled volatile hydrocarbons from the *Braer* oil spill exhibited a discharge of nasal mucous, but no causal relationship with the oil was determined (Hall *et al.* 1996). Stressed individuals that could not escape a contaminated area would be most at risk. Absorbed oil can cause toxic effects such as minor kidney, liver, and brain lesions (Geraci and Smith 1976; Spraker *et al.* 1994), but contaminated animals could depurate this oil when returned to clean water (Engelhardt 1982). In baleen whales, crude oil could coat the baleen and reduce filtration efficiency, but these effects are considered to be reversible (Geraci 1990). Seals fouled externally with heavy oil may also encounter problems with locomotion, with flippers becoming stuck to their sides (Seargent 1991).

Gross histologic lesions developed in loggerhead sea turtles experimentally exposed to oil, but most effects were apparently reversed by the tenth day after exposure (Bossart *et al.* 1995). Oil may also reduce lung diffusion capacity, decrease oxygen consumption or digestion efficiency, or damage nasal and eyelid tissue (Lutz *et al.* 1989).

10.5.4.2 Change in Habitat Use

Several species of cetaceans and seals have been documented behaving normally in the presence of oil (St. Aubin 1990; Harvey and Dahlheim 1994;

Matkin *et al.* 1994). Studies of both captive and wild cetaceans indicate that they can detect oil spills. Captive bottlenose dolphins (*Tursiops truncatus*) avoided most oil conditions during daylight and darkness, but had difficulty detecting a thin sheen of oil (St. Aubin *et al.* 1985). Wild bottlenose dolphins exposed to the *Mega Borg* oil spill in 1990 appeared to detect, but did not consistently avoid contact with, most oil types (Smultea and Würsig 1995). This is consistent with other cetaceans behaving normally in the presence of oil (Harvey and Dahlheim 1994; Matkin *et al.* 1994). It is possible that cetaceans swim through oil because of an overriding behavioural motivation (for example, feeding). Some evidence exists that indicates dolphins attempt to minimize contact with surface oil by decreasing their respiration rate and increasing dive duration (Smultea and Würsig 1995).

There is conflicting evidence on whether seals detect and avoid spilled oil. Some oiled seals hauled out on land are reluctant to enter the water, even when disturbances from intense cleanup activities occur nearby (St. Aubin 1990; Lowry *et al.* 1994). In contrast, several thousand grey and harbour seals apparently left Chedabucto Bay, Nova Scotia, after the grounding of the *Arrow* (Mansfield 1970, in St. Aubin 1990), although this movement may have been caused by the increased human disturbance during cleanup activities rather than by the presence of oil (St. Aubin 1990). Harbour seals observed immediately after oiling appeared lethargic and disoriented, which may be attributed to lesions observed in the thalamus of the brain (Spraker *et al.* 1994). Other seals have been observed swimming in the midst of oil spills (St. Aubin 1990). Oiling of both mother and pups does not appear to interfere with nursing (Lowry *et al.* 1994).

It is unknown whether sea turtles can detect and avoid oil slicks. Gramentz (1988) reported that sea turtles did not avoid oil at sea, and sea turtles experimentally exposed to oil showed a limited ability to avoid oil (Vargo *et al.* 1986).

10.5.4.3 Potential Mortality

Most marine mammals, with the exception of fur seals, polar bears, and sea otters (none of these species are expected to occur in either Study Area), are considered to be not directly susceptible to deleterious effects of oil. There is no clear evidence implicating oil spills with the mortality of cetaceans (Geraci 1990), although there was a significant decrease and lack of recovery in the population size of a fish-eating killer whale pod that uses the area of the *Exxon Valdez* oil spill (Dahlheim and Matkin 1994). Continued monitoring over sixteen years indicates that the killer whale pod had still not returned to its pre-spill population abundance, and the population's rate of increase was significantly less than other fish-eating pods in the area (Matkin *et al.* 2008). Howell and Gentile (2006) recognize the continued impact to the single pod of orcas, but not for the Prince William Sound population as a whole. They believe that this continuing effect relates to the altered social structure (loss of key matriarchs) which was partly to result of the oil spill and partly a result from preceding mortality from human conflicts over fish. Another mammal-eating killer whale pod declined significantly following the spill and is now

listed as "Depleted" under the US *Marine Mammal Protection Act*, although there may have been other contributing factors in the decline (Matkin *et al.* 2008).

There may have been a long-term decline by 36 percent in the number of moulting harbour seals at oiled haul-out sites in Prince William Sound following the *Exxon Valdez* oil spill (Frost *et al.* 1994). Pup mortality at these beaches was 23 to 26 percent, which may have been higher than natural mortality. Further analyses do not support high mortality, but indicated that seals moved away from some oiled haul-out sites (Hoover-Miller *et al.* 2001). The release of fuel oil from the *Arrow* into Chedabucto Bay, Nova Scotia in 1970 resulted in the fouling of 500 seals within the bay and 50 to 60 harbour and 200 grey seals on Sable Island (200 km south of the spill). Twenty-four seals were found dead and some had oil in their mouths and stomachs (Anon. 1970, 1971, in St. Aubin 1990). Oiled grey and harbour seals were found on the coast of Nova Scotia and Sable Island again in 1979 when the oil tanker *Kurdistan* sank in Cabot Strait. No causal relationship between oiling and death was determined (Parsons *et al.* 1980, in St. Aubin 1990). No mortalities were reported after a well blowout near Sable Island in 1984 and only two oiled grey seals were observed (St. Aubin 1990).

Hall *et al.* (1983) observed seven live and three dead sea turtles following an oil well blowout in 1979; two of the carcasses had oil in the gut but no lesions, and there was no evidence of aspirated oil in the lungs. However, hydrocarbon residues were found in kidney, liver, and muscle tissue of all three dead turtles, and prolonged exposure to oil may have disrupted feeding behaviour and weakened the turtles.

Stressed individuals or those that could not escape a contaminated area would be most at risk to potentially deleterious effects. Animals exposed to heavy doses of oil for prolonged periods could experience mortality. In cases where oil goes ashore, harbour seals may be particularly at risk because they exhibit site fidelity (Boulva and McLaren 1979; Yochem *et al.* 1987). Sea turtles are not expected to go ashore, since nesting does not occur in northern latitudes. Prolonged exposure from oil at a preferred haul-out site could cause the death of some seals. However, Jenssen (1996) reported that oil has produced little visible disturbance to grey seal behaviour and there has been little mortality despite the fact that approximately 50 percent of grey seal pups at Norway's largest breeding colony are polluted each year by oil.

Spill modelling at the site of the Hebron Platform shows that the majority of spills are predicted to travel eastward (ASA 2011b). Modelling was conducted for well blow-outs of crude oil, with oil released at either the seafloor or from the top of the drilling platform and durations of 30 to 120 days. Short duration (less than 24 hours) small volume batch transfer spills of crude oil and diesel fuel were also modelled. Additional extended duration spill simulations were completed for platform blow-out scenarios to track oil remaining on the sea surface 200 days beyond termination of the blow-out. Blow-out simulations >30 days duration are predicted to have a 0 to 3 percent probability of reaching segments of the Newfoundland shoreline (primarily the southern Avalon Peninsula). However, this probability

increases to a maximum of 8 percent based on modelling of oil remaining 200 days beyond termination of a blow-out. If oil reaches the shoreline during summer (1 percent probability), it is predicted that approximately 5 km of shoreline may be oiled (at >0.01 mm thickness). If oil reaches the shoreline during winter (1 to 8 percent probability), it is predicted that up to 785 km of shoreline may be oiled (at >0.01 mm thickness).

Spill modelling based on the accidental release of fuel at the Bull Arm site predicts that 10.1 to 144.3 km of shoreline may be exposed to hydrocarbons (at 0.01 mm thickness) in the Nearshore Study Area. These predictions were based on modelling results in the absence of any spill intervention (ASA 2011a,b). Oil removal from the exposed and rocky shoreline of the Avalon Peninsula and Trinity Bay will be faster than removal from protected areas with softer substrate because of increased water penetration and flushing, and wave erosion (ASA 2011b). In addition, weathering processes (photolysis and biodegradation) will have reduced the amount of oil potentially reaching shorelines (ASA 2011b). Relatively few seals (primarily harbour and grey seals) are expected to use the shorelines of the southern Avalon and Trinity Bay for haul out. Mitigation measures will likely reduce effects of potential hydrocarbon spills on marine mammals in the Offshore and Nearshore Study Areas.

Tracker buoy data collected during the 2004 Terra Nova spill indicated that it took five weeks for the buoy to reach 40.00.0W and approximately 48.00.00N in November / December (and basically confirmed the oil spill trajectory modelling results conducted to date for the Grand Banks oil developments). If an uncontrolled spill (*i.e.*, no spill countermeasures implemented) lasted more than 120 days, the modelling predicts that oil from a surface or sub-surface blowout at the Hebron Platform will extend beyond the model domain area and, therefore, could potentially (less than 10 percent probability) reach an international coastline with a thickness greater than 0.01 mm. However, any oil that did reach an international shoreline would be patchy, weathered oil.

It is difficult to predict with precision the effects of accidental events on biota, especially as they relate to the geographic extent of the effects. Numerous parameters (*e.g.*, chemical composition of the hydrocarbon, behaviour of spilled substance at different times of year) influence hydrocarbon spill characteristics and there are many unknowns concerning specific effects on different marine mammal and sea turtle groups. It may be possible under calm conditions to clean up a large proportion of spilled petroleum hydrocarbons; however, only a small percentage offshore can be retrieved under typical wind and wave conditions, especially in winter. Therefore, there will be an emphasis on accident prevention at all phases of the Project.

Marine mammals and sea turtles are not considered to be at high risk from the effects of oil exposure, but some evidence implicates oil spills with seal mortality, particularly young seals. For marine mammals and sea turtles, it is probable that only small proportions of populations are at risk at any one time in either the Nearshore or Offshore Study Areas. Oil spill prevention measures, along with typical oil spill countermeasures (creating an oil spill response plan,

training, preparation, an equipment inventory, and conducting emergency response drills) will serve to reduce the number of animals exposed to oil.

Depending on the time of year, location of animals within the affected area, and type of oil spill or blow-out, the effects of a nearshore or offshore oil release on the health of cetaceans is predicted to range from negligible to low magnitude over varying geographic extents. Based on present knowledge of the Trinity Bay and Grand Banks ecosystems, the modelling exercises, and on past monitoring experience with large spills with much worse scenarios than offshore on the Grand Banks (*e.g.*, *Exxon Valdez*, *Arrow* and others), it can be predicted with confidence that an oil spill associated with the Project will not result in any significant residual environmental effects to marine mammals or sea turtles in the Study Areas.

The environmental effects of Project accidental events on Marine Mammals and Sea Turtles are summarized in Table 10-13.

Table 10-13 Environmental Effects Assessment: Accidental Events

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Spill (at Bull Arm Site)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	4-5	2/1	R[B]	2
Failure or Spill from OLS	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	6	2/1	R [B]	2
Subsea Blowout	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	6	3/1	R [B]	2
Crude Oil Surface Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	6	2/1	R [B]	2
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Platform)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	1	2/1	R [B]	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Marine Vessel Incident (*i.e.*, fuel spills)	• Change in Habitat Quality • Change in Habitat Use • Mortaliy	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	5	2/1	R [B]	2
Collisions (involving Platform, vessel, and/or iceberg)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	3	2/1	R [B]	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

[A] Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

[B] Potential Mortality effects reversible at the population level and irreversible at the individual level

10.5.5 Cumulative Environmental Effects

Marine exploration, commercial fishery activity, marine transportation, and existing production activity (*e.g.*, White Rose, Hibernia, and Terra Nova) all have the potential to interact with marine mammals and sea turtles (see Table 10-9). Hunting of marine mammals and sea turtles does not occur inside the Nearshore or Offshore Study Areas, other than a small harp seal harvest. Most, if not all, commercial seal hunting occurs outside the Study Areas in southern Labrador and northeast Newfoundland. It is very unlikely that routine activities associated with other marine exploration, existing production areas, marine transportation, and commercial fisheries have much environmental effect on Marine Mammals and Sea Turtles.

10.5.5.1 Nearshore

Cumulative environmental effects in the Nearshore Study Area are expected to be of a lower magnitude than those of the Offshore Study Area as fewer

activities have the potential to interact with the current Project (see Section 10.5.5.2 for cumulative environmental effects assessment of the Offshore Study Area).

10.5.5.2 Offshore

Commercial fishing activities may cause incidental mortalities or disturbance to marine mammals and sea turtles. It is predicted that the Project activities will not cause any mortality to marine mammals and sea turtles and thus, there will be no or negligible cumulative environmental effect from fishing.

Major shipping routes pass in proximity to the Offshore Study Area, and additional marine traffic (*e.g.*, cruise ships) typically occur inshore of the Offshore Study Area. Supply vessels and tankers are also associated with other developments on the Grand Banks. As assessed above, the most likely effect of vessel traffic on marine mammals and sea turtles is disturbance. It is predicted that the Project activities are very unlikely to cause any mortality and, thus, the cumulative environmental effects of marine transportation are predicted to be not significant.

Underwater sound associated with Project activities will likely have the greatest effect on marine mammals and sea turtles, particularly cetaceans. Most species will be able to hear sounds, if they are close enough, and will be able to avoid them if they so choose. Mitigation measures associated with seismic surveys are designed to prevent harm to marine mammals or sea turtles. Individuals traveling near one or more of the offshore developments or in proximity to other offshore exploration activities may be subject to cumulative environmental effects. However, these effects would most likely be limited to behavioural effects (*i.e.*, localized avoidance). Cumulative environmental effects of other developments and exploration activities on the Grand Banks are predicted to be not significant.

A major hydrocarbon spill or blowout on the Grand Banks could affect marine mammals and sea turtles to varying degrees depending upon type, size, location, timing, and species and life stages involved. A major spill is statistically very unlikely to coincide among multiple developments on the Grand Banks. Nonetheless, cumulative environmental effects could occur from chronic discharge of oil bilges at sea by ships transiting the area or from other activities that could affect marine mammals and sea turtles. Overall, the effects of accidental events on marine mammals and sea turtles were predicted to be not significant, and thus, the overall cumulative environmental effects on marine mammals and sea turtles are also likely to be not significant.

Given the predicted minimal environmental effects of other projects / activities, the large size of the Offshore Study Area and the prediction that the residual environmental effects of the proposed Project's routine activities on the Marine Mammal and Sea Turtle VEC through the difference Project phases are not significant (see Section 10.5.6), the cumulative environmental effects on the Marine Mammal and Sea Turtle VEC are also predicted to be not significant. This is consistent with the predicted significance of between-

project cumulative environmental effects on the Marine Mammal and Sea Turtle VECs in the recently completed *Husky Delineation / Exploration Drilling Program for Jeanne d'Arc Basin Area 2008-2017* (LGL 2007b) and *Petro-Canada Exploration Drilling Program for Jeanne d'Arc Basin 2009-2017* environmental assessments (Christian 2008).

10.5.6 Determination of Significance

The determination of significance is based on the definition provided in Section 10.2. It considers the magnitude, geographic extent, duration, frequency, reversibility and ecological context of each environmental effect within the Study Area, and their interactions, as presented in the preceding analysis. Significance is determined at the population level within the Study Area.

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and Marine Mammals and Sea Turtles, after taking into account any proposed mitigation, is summarized in Table 10-14.

The environmental effects of routine activities associated with the construction / installation, operations / maintenance and decommissioning / abandonment phases of the Project on the Marine Mammal and Sea Turtle VEC, are predicted to be *not significant* (Table 10-14).

The environmental effects of routine activities associated with Accidents, Malfunctions and Unplanned Events of the Project on the Marine Mammal and Sea Turtle VEC, are also predicted to be *not significant* (Table 10-14).

As required by CEAA, an analysis of potential effects to the sustainable use of renewable resources associated with this VEC has been considered. No significant adverse residual environmental effects on Marine Mammals and Sea Turtles are predicted that could affect renewable resource use.

Table 10-14 Residual Environmental Effects Summary: Marine Mammals and Sea Turtles

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	NS	3	N/A
Cumulative Environmental Effects	NS	3	N/A

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
KEY Residual Environmental Effects Rating: S = Significant Adverse Environmental Effect NS = Not Significant Adverse Environmental Effect	Level of Confidence in the Effect Rating: 1 = Low level of Confidence 2 = Medium Level of Confidence 3 = High level of Confidence		Probability of Occurrence of Significant Environmental Effect: 1 = Low Probability of Occurrence 2 = Medium Probability of Occurrence 3 = High Probability of Occurrence
A As determined in consideration of established residual environmental effects rating criteria B Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site C Includes decommissioning and abandonment of the GBS and offshore site D Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA			

10.5.7 Follow-up and Monitoring

The CEAA definition of "follow-up program" is "a program for (a) verifying the accuracy of the environmental assessment of a project, and (b) determining the effectiveness of any measures taken to mitigate the adverse environmental effects of the project". Follow-up programs serve as the primary means to determine and quantify change from routine operations on the receiving environment. Compliance monitoring on its own, does not satisfy the requirements for a follow-up program. Compliance monitoring is conducted to ensure that a project and its activities are meeting the relevant environmental standards, guidelines and regulations. Compliance monitoring will be conducted for the Project in accordance with regulatory requirements.

Specific Environmental Effects Monitoring (EEM) programs to verify the accuracy of assessment predictions and the efficacy of mitigation measures are not planned for Marine Mammals and Sea Turtles.

For nearshore Project activities where in-water blasting occurs, EMCP will implement a Marine Mammal observation program. The program will be developed in consideration of DFO blasting guidelines, and in consultation with DFO. For seismic activities in the Offshore Study Area, EMCP will implement a Marine Mammal and Sea Turtle observation program. The program will be consistent with the requirements outlined in the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011). Data on Marine Mammal and Sea Turtle observations will be provided to DFO and the C-NLOPB where applicable.

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11 SPECIES AT RISK

For the purposes of this assessment, Species at Risk (SAR) refers to those species of marine fish, mammals, birds and reptiles listed federally under the *Species at Risk Act* (SARA), and/or assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), which could potentially occur in either the Hebron Nearshore or Offshore Study Areas and, therefore, could be affected by Project activities. The assessment of SAR also includes the associated habitats that these species rely upon, as protected under SARA. Many of the issues of concern, and potential interactions with the Project, as well as mitigation measures and management strategies for SAR are similar to those presented for non-listed marine species in the Study Areas in other chapters of this report (*i.e.*, Chapter 7, 9 and 10). On an ecosystem basis, the listed and non-listed species and their habitats are often highly integrated. This section assesses the potential effects of Project activities on SAR.

11.1 Environmental Assessment Boundaries

11.1.1 Spatial

The Nearshore and Offshore Study areas, Project Areas and Affected Areas are defined in the Environmental Assessment Methods Chapter (Section 4.3.2). The Study Areas and Project Areas are illustrated in Figures 11-1 and 11-2 for the nearshore and offshore, respectively. The Affected Areas for several Project activities have been determined by modelling (see AMEC 2010; ASA 2011a, 2011b; JASCO 2010; Stantec 2010b).

11.1.2 Temporal

The temporal boundary is defined in the Environmental Assessment Methods Chapter (Section 4.3.2.2). The nearshore and offshore temporal boundaries are summarized in Table 11-1.

Table 11-1 Temporal Boundaries of Nearshore and Hebron Offshore Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation / start-up / drilling as early as 2015 • Production year-round through to 2046 or longer • Potential expansion opportunities - as required, year-round through to end of Project • Decommissioning / abandonment: after approximately 2046

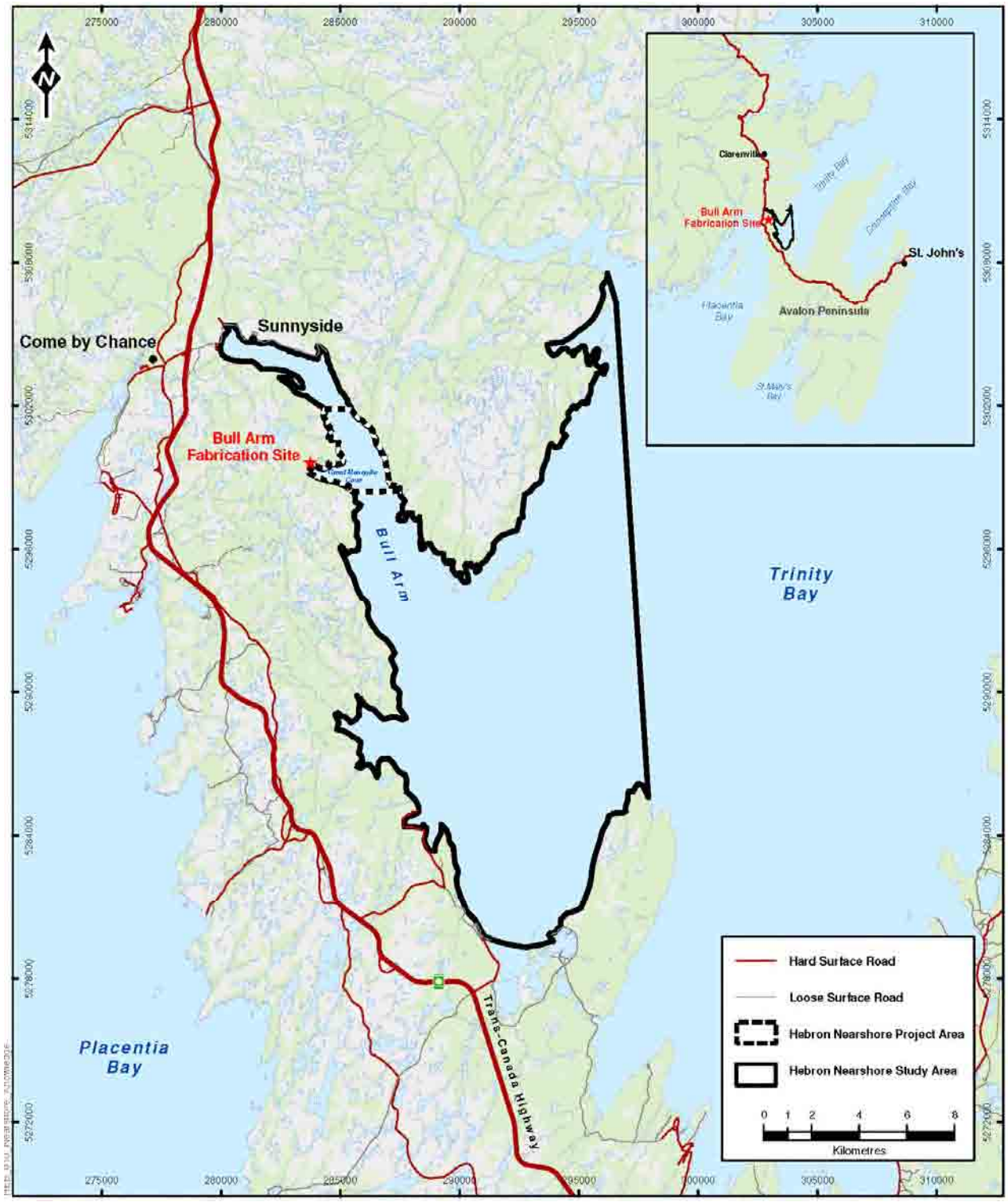


Figure 11-1 Hebron Nearshore Study and Project Areas

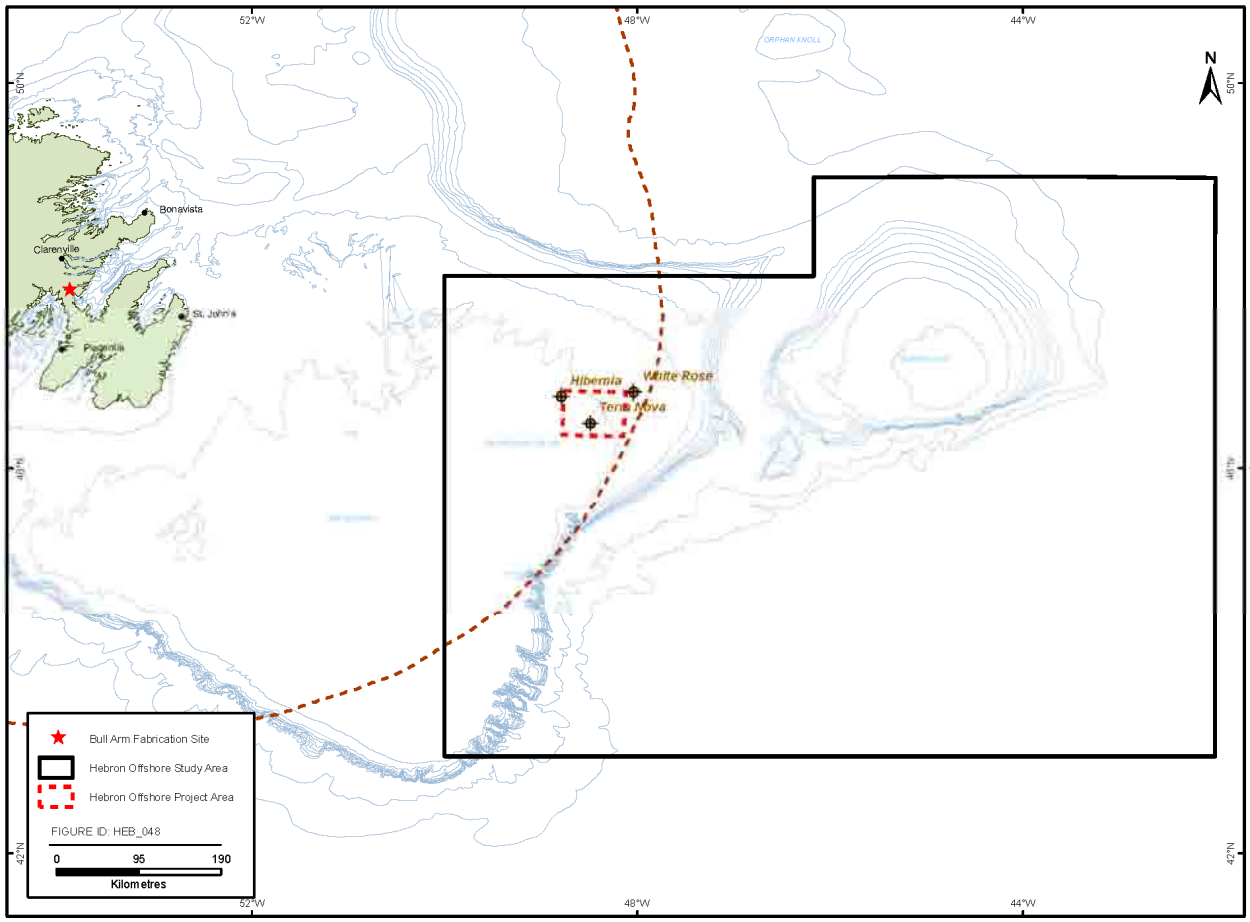


Figure 11-2 Hebron Offshore Study and Project Areas

11.1.3 Administrative

SAR are protected federally under the SARA, which is administered by Environment Canada, Parks Canada and Fisheries and Oceans Canada (DFO). The objective of SARA is to prevent Canadian indigenous species, subspecies and distinct populations of wildlife from becoming extirpated or extinct, to provide for the recovery of endangered or threatened species, and to manage species of special concern to prevent them from becoming endangered or threatened.

The official federal list of wildlife and plant SAR in Canada is Schedule 1 of SARA. Only species on Schedule 1 of SARA are subject to the permit and enforcement provisions of the *Act*. The List includes species of Special Concern, Extirpated, Endangered and Threatened Species. Schedules 2 and 3 of SARA contain species which had been assessed by COSEWIC prior to their adoption of new criteria in 1999. When SARA was proclaimed in 2003, the species in Schedule 2 and 3 were to be re-assessed by COSEWIC using the new criteria.

Section 32 of SARA prohibits the killing, harming, harassing, capturing or taking of an individual of a wildlife species that is listed as extirpated, endangered, or threatened. Section 33 prohibits the damage or destruction of the residence of an endangered, threatened or extirpated species.

Section 58 prohibits the destruction of critical habitat of any listed endangered or threatened species, or of any extirpated species for which a recovery strategy has been recommended. SARA defines critical habitat as the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified in the species' critical habitat in the recovery strategy or in an action plan for the species.

The main provisions of SARA are scientific assessment and listing of species, species recovery, protection of critical habitat, compensation, permits and enforcement. The *Act* also provides for development of official recovery plans for species found to be most at-risk, and management plans for species of Special Concern. As of March 2010, recovery strategies and/or management plans are in place for the blue whale (*Balaenoptera musculus)*, North Atlantic right whale (*Eubalaena glacialis*), Atlantic wolffish (*Anarhichas lupus)*, northern wolffish (*Anarhichas denticulatus)*, spotted wolffish (*Anarhichas minor)* and leatherback turtle (*Dermochelys coriacea)*.

Marine mammals and fish, including those species assessed at-risk, are protected in Canada through federal legislation under the *Fisheries Act.* Section 35 of the *Fisheries Act* prohibits the harmful alteration, disruption or destruction of fish habitat, while Section 36 prohibits the deposition of substances considered deleterious to fish. Marine mammals are included in the definition of fish under the *Act*. Environment Canada administers Section 36 of the *Fisheries Act* while DFO administers Section 35 of the *Act*. The *Marine Mammal Regulations* under the *Fisheries Act* stipulate that "*No person shall disturb a marine mammal except when fishing for marine mammals under the authority of these regulations*".

11.2 Definition of Significance

The criteria to evaluate the significance threshold for adverse environmental effects to SAR are defined as follows:

A significant, adverse residual environmental effect is one that, after application of feasible mitigation and consideration of reasonable Project alternatives:

- Will jeopardize the achievement of self-sustaining population objectives or recovery goals
- Is not consistent with applicable allowable harm assessments
- Will result in permanent loss of SAR critical habitat as defined in a recovery plan or an action strategy
- An incidental harm permit would not likely be issued

Due to the sensitive nature of SAR, residual adverse environmental effects on one individual may be considered significant.

A not-significant, adverse residual environmental effect is one that, after application of feasible mitigation and consideration of reasonable Project alternatives:

- Results in effects to individuals, residences or SAR critical habitat of listed species that does not jeopardize the survival or recovery of the species
- Is consistent with applicable allowable harm assessments
- Does not result in permanent loss of SAR critical habitat
- An incidental harm permit would likely be issued

11.3 Existing Conditions

A description of the physical environment within the Hebron Nearshore and Offshore Study Areas is provided in Chapter 3. Species profiles for non-listed Marine Fish and Fish Habitat, Marine Birds, and Marine Mammals and Sea Turtles are described in Sections 7.3, 9.3 and 10.3, respectively. While there is some overlap with these other report sections, the descriptions presented in this section focus exclusively on SAR.

The SAR that are most likely to be present and their expected use of the Hebron Study Areas are summarized in Table 11-2 and discussed in the subsections that follow.

Table 11-2 Species at Risk and Expected Use of Hebron Study Areas

SPECIES		SARA Status	COSEWIC Status	Expected Use of Hebron Study Areas	
Common Name	Scientific Name			Nearshore	Offshore
Fish					
Atlantic Cod (NL Population)	*Gadus morhua*	No Status	Endangered	Occurs	Occurs
American Plaice (NL Population)	*Hippoglossoides platessoides*	No Status	Threatened	Occurs	Occurs
American Eel	*Anguilla rostrata*	No Status	Special Concern	Occurs	Not likely to occur
Atlantic Wolffish	*Anarhichas lupus*	Schedule 1 – Special Concern	Special Concern	May occur	Occurs
Northern Wolffish	*Anarhichas denticulatus*	Schedule 1 - Threatened	Threatened	May occur	Occurs
Spotted Wolffish	*Anarhichas minor*	Schedule 1 - Threatened	Threatened	May occur	Occurs
Cusk	*Brosme brosme*	No Status	Threatened	Not likely to occur	Not likely to occur
Roughead Grenadier	*Macrourus berglax*	No Status	Special Concern	Not likely to occur	May occur
Roundnose Grenadier	*Coryphaenoides rupestris*	No Status	Endangered	Not likely to occur	May occur
Porbeagle Shark	*Lamna nasus*	No Status	Endangered	Not likely to occur	May occur
Blue Shark	*Prionace glauca*	No Status	Special Concern	Not likely to occur	Not likely to occur
Shortfin Mako	*Isurus oxyrinchus*	No Status	Threatened	Not likely to occur	Not likely to occur

SPECIES		SARA Status	COSEWIC Status	Expected Use of Hebron Study Areas	
Common Name	**Scientific Name**			**Nearshore**	**Offshore**
White Shark	*Carcharodon carcharias*	No Status	Endangered	Not likely to occur	Not likely to occur
Basking Shark	*Cetorhinus maximus*	No Status	Special Concern	Not likely to occur	Not likely to occur
Deepwater Redfish (northern population)	*Sebastes mentella*	No Status	Threatened		May occur
Acadian Redfish (Atlantic population)	*Sebastes fasciatus*	No Status	Threatened		May occur
Mammals					
Blue Whale	*Balaenoptera musculus*	Schedule 1 - Endangered	Endangered	May occur in small numbers	Likely to occur in small numbers.
North Atlantic Right Whale	*Eubalaena glacialis*	Schedule 1 - Endangered	Endangered	Not likely to occur	Unknown
Fin Whale	*Balaenoptera physalus*	Schedule 1 – Special Concern	Special Concern	Occurs	Occurs
Sowerby's Beaked Whale	*Mesoplodon bidens*	Schedule 1 – Special Concern	Special Concern	Not likely to occur	Likely to occur in small numbers
Killer Whale	*Orcinus orca*	No Status	Special Concern	May occur in small numbers	Likely to occur in small numbers
Harbour Porpoise	*Phocoena phocoena*	Schedule 2 - Threatened	Special Concern	Likely to occur in small numbers	Likely to occur in small numbers
Birds					
Red Knot (*rufa*)	*Calidris canutus*	No Status	Endangered	Occurs	Does not occur offshore.
Ivory Gull	*Pagophila eburnea*	Schedule 1 - Endangered	Endangered	May occur	May occur
Reptiles					
Leatherback Sea Turtle	*Dermochelys coriacea*	Schedule 1 - Endangered	Endangered	May occur	Likely to occur in small numbers
Loggerhead Sea Turtle	*Caretta caretta*	No Status	Endangered	Not likely to occur	May occur
Note: Species listed on Schedule 1 of SARA are officially listed as SAR, while the species listed on Schedules 2 and 3 are species subject to reassessment by COSEWIC. The tables and document are dated as designations may change at any time					

11.3.1 Marine Fish Species at Risk

Site-specific fish and fish habitat data were collected from the Hebron Offshore Study Area during surveys in 2001 (Chevron 2002; 2003). These data are complemented by environmental effects monitoring (EEM) survey data collected by operators of adjacent offshore oil and gas projects since 1994, and by several descriptions of existing conditions for marine fish and fish habitat for other environmental assessments overlapping with the Hebron Offshore Study Area. DFO Research Vessel data from 3Lt have also been reviewed along with relevant fish and fish habitat primary literature for the Hebron Offshore Study Area.

Within the Nearshore Study Area, several fish and fish habitat baseline and EEM surveys from 1991 were conducted as part of the Hibernia Gravity Base Structure (GBS) construction project. Since then, an ocean disposal monitoring survey was conducted in Great Mosquito Cove (Lee 2005) and an extensive fish and fish habitat survey of Great Mosquito Cove was conducted for the Hebron Project in August 2009. Several researchers from Memorial University and DFO have conducted studies on fish and fish habitat within the Nearshore Study Area and those primary scientific papers were also used to compile existing information.

11.3.1.1 Atlantic Cod (Newfoundland and Labrador Population)

COSEWIC assessed the Newfoundland and Labrador and Laurentian North populations of Atlantic as endangered in 2003 and 2010, respectively. Neither population is currently listed under SARA. No SARA recovery or management plans are in place. The Newfoundland and Labrador Population occurs within the Hebron Nearshore and Offshore Study Areas. Cod in this population inhabit the waters ranging from immediately north of Cape Chidley (northern tip of Labrador) southeast to Grand Banks off eastern Newfoundland. For management purposes, cod in this population are treated as three separate stocks by DFO: Northern Labrador cod; "Northern" cod (*i.e.*, those found off southeastern Labrador, the Northeast Newfoundland Shelf and the northern half of Grand Banks (NAFO Divisions 2J3KL); and Southern Grand Banks cod.

Cod within Trinity Bay are primarily a localized stock or “bay population”, but there is mixing with the offshore areas outside Trinity Bay and Bonavista Bay (DFO 2008b). Pinsent and Methven (1997) suggested that juvenile cod collected inshore in southern Trinity Bay originate from a combination of both inshore and offshore spawning events.

Atlantic cod eggs and larvae are planktonic during the spring and early summer. Larvae and pelagic juveniles are primarily zooplankton feeders but benthic and epibenthic invertebrates become the primary diet upon settlement.

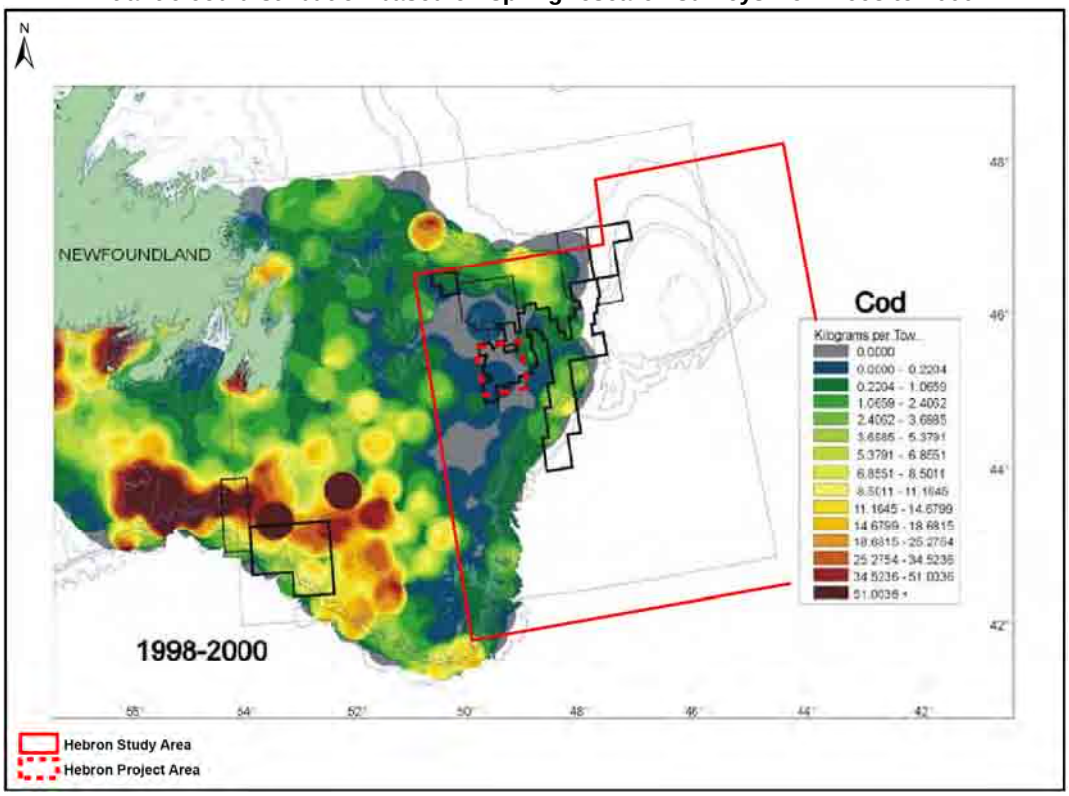
Pelagic juveniles can occupy rock reef, cobble, eelgrass (*Zostera marina*) beds and sand bottom (Tupper and Boutilier 1995a). Tupper and Boutilier (1995b) assumed that settling also occurred on macroalgae habitat, as noted by Keats *et al.* (1985) off eastern Newfoundland. Shallow water depths (<5 m) and a strong attraction to features on most substrata, except sand, afford settled juveniles an environment conducive to growth and survival (Tupper and Boutilier 1995a; Grant and Brown 1998). Juvenile cod primarily eat pelagic crustaceans, especially zooplankton, but also eat benthic species (*e.g.*, gammarids and harpacticoids) (Grant and Brown 1998). Capelin is a major prey item for inshore adult cod (Lilly 1987), depending on the season (O’Driscoll and Rose 2000).

Historically, much of the northern cod stock (NAFO Divisions 2J3KL) migrated between overwintering areas in deep water near the shelf break and feeding areas in the shallower waters both on the plateau of Grand Banks and along the coasts of Labrador and eastern Newfoundland. Some cod remained in the inshore deep water during the winter. These cod spawned on the northeast Newfoundland shelf in late winter and spring, and then migrated shoreward across the shelf to the inshore feeding grounds, annually traversing distances of 500 km and more. Distribution maps (Figure 11-3) based on spring and fall DFO research vessel surveys between 1998 and 2000 indicate that catches of Atlantic cod within the Hebron Offshore Project Area were low (Kulka *et al.* 2003).

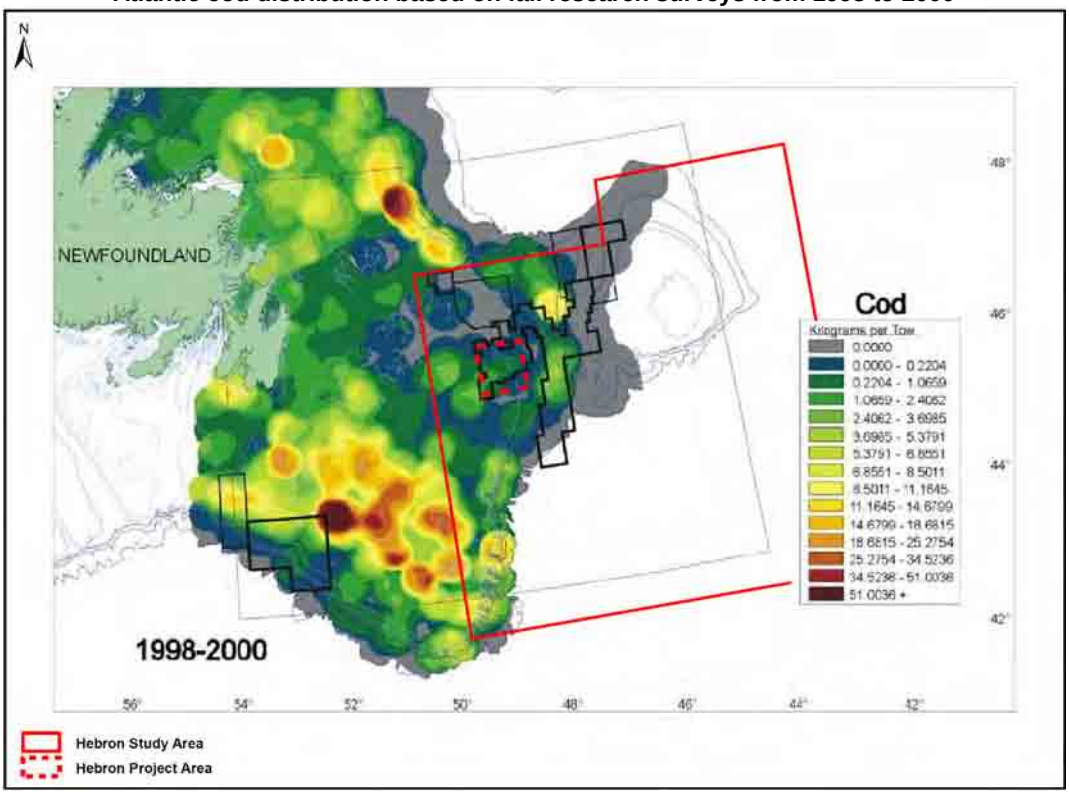
Based on annual autumn DFO research vessel trawl surveys, offshore abundance and biomass indices have been increasing since 2003 and spawning stock biomass has been increasing since 2005. The average abundance, biomass and spawning stock biomass of cod in the offshore over the last three years are 8 percent of the average during the 1980s. Winter acoustic surveys in 2007 and 2008 found a dense aggregation of cod in a traditional over-wintering area along the shelf edge in southern 3K. The aggregation in 2008 was much larger than was observed in 2007, and included approximately 20 percent mature fish.

There are three identified Sensitive or Special Areas (described and assessed in Chapter 12) within the Hebron Offshore Study Area that are related to Atlantic cod. The Southeast Shoal and Tail of the Banks Ecologically and Biologically Significant Areas (EBSA), proposed by DFO, is known as a spawning and nursery area for 3NO cod. The Southeast Shoal Vulnerable Marine Ecosystem (VME), proposed by NAFO, is located in the same area. The Virgin Rocks EBSA, proposed by DFO, supports spawning and breeding of Atlantic cod.

Atlantic cod distribution based on spring research surveys from 1998 to 2000



Atlantic cod distribution based on fall research surveys from 1998 to 2000



Grey shading represent areas sampled with no catch rate values.

Source: Kulka *et al.* 2003.

Figure 11-3 Atlantic Cod Spring and Fall Distribution

11.3.1.2 American Plaice

American plaice (Newfoundland population) was assessed as Threatened by COSEWIC in April 2009, but is not listed under SARA. Therefore, no SARA recovery strategies or management plans are currently in place. American plaice is widely distributed on both sides of the North Atlantic, from the Barents Sea to the British Isles in the east, and from northern Baffin Island to Rhode Island in the west. This population occurs from Hudson Strait to the southern limit of the Grand Banks, and westward north of the Laurentian Channel to the southwestern corner of Newfoundland (COSEWIC 2009). On the Grand Banks, they are found on both the northern and southern portions at low densities. The area of highest biomass of American plaice is at the southern part of the Grand Banks straddling NAFO Unit Areas 3NO (Morgan *et al.* 2003b). Distribution maps based on spring and fall research vessel surveys between 1992 and 2000 indicate that American plaice occur within the Offshore Project Area during both the spring and the fall (Kulka *et al.* 2003).

American plaice was likely the most abundant flatfish in the Northwest Atlantic, and the Newfoundland fishery was once the largest flatfish fisheries in the world (COSEWIC 2009). Over a 47-year period, abundance has declined approximately 96 percent. Overfishing is a major cause of decline, but an apparent increase in natural mortality in the 1990s, when the largest part of the decline occurred, may have contributed (COSEWIC 2009) to its decline. The decline now appears to have ceased, but numbers remain below the precautionary threshold estimated for this stock. Other possible contributing factors to the decline of the stock include: poorly regulated by-catches; selective gear size; cropping large individuals and reducing population reproductive potential. In addition, natural mortality has increased, which reduces the ability of the population to withstand fishing mortality. There have been signs of an increase on the Tail of the Bank since the mid-1990s (Kulka *et al.* 2003). However, overall, current population estimates are between 3 and 5 percent of the early 1980s level (Dwyer *et al.* 2003).

The species appears to be relatively sedentary, with a home range of less than 50 km (Pitt 1969; Morgan and Brodie 1991). However, evidence exists of a seasonal migration off the Grand Banks in the winter to warmer waters along the shelf edge (Morgan and Brodie 1991). American plaice in both the Hebron Nearshore and Offshore Study Areas are of the 3LNO stock, which has its northern boundary just north of the Grand Banks (Bowering and Brodie 1991). The 2J3K stock is mostly concentrated on the northeastern slopes of the Grand Banks, at depths between 92 and 183 m (Walsh 1982). American plaice occur in both the Hebron Nearshore and Offshore Study Areas. They can be found within the Hebron Offshore Project Area at low densities during spring and fall (Figure 11-4).

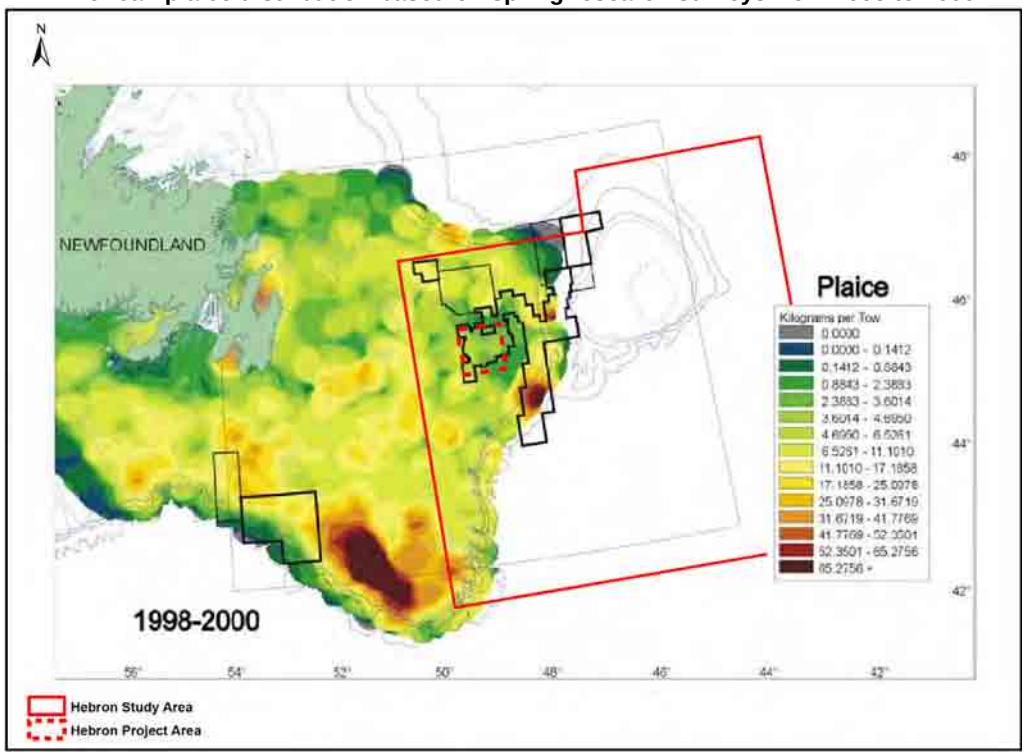
Females in spawning condition may be found throughout the Grand Banks (Morgan 2001), indicating the lack of a specific spawning ground. American plaice spawning is most intensive on the northern Grand Banks and occurs primarily from April to June at depths of 50 to 200 m (Morgan 2001). In recent years, spawning has occurred within the Hebron Offshore Study Area in June (Figure 11-5), but historically, within the area, spawning occurs in May (Ollerhead *et al.* 2004).

American plaice eggs float near the surface and hatch within 11 to 14 days at temperatures of 3.9°C. Larvae are concentrated near the thermocline at approximately 20 m (Frank *et al.* 1992) until they reach a length of approximately 25 mm, the average length for settlement (Scott and Scott 1988). Larvae, therefore, may settle to substrate far removed from where the eggs were fertilized. However, plaice larvae are retained on the eastern edge of the Grand Banks by the Labrador Current. Juveniles are typically found over homogenous silt or mud substrates (Walsh 1991). Adult plaice seem to prefer sand substrates over a mix of sand and gravel or gravel alone (Morgan 2000).

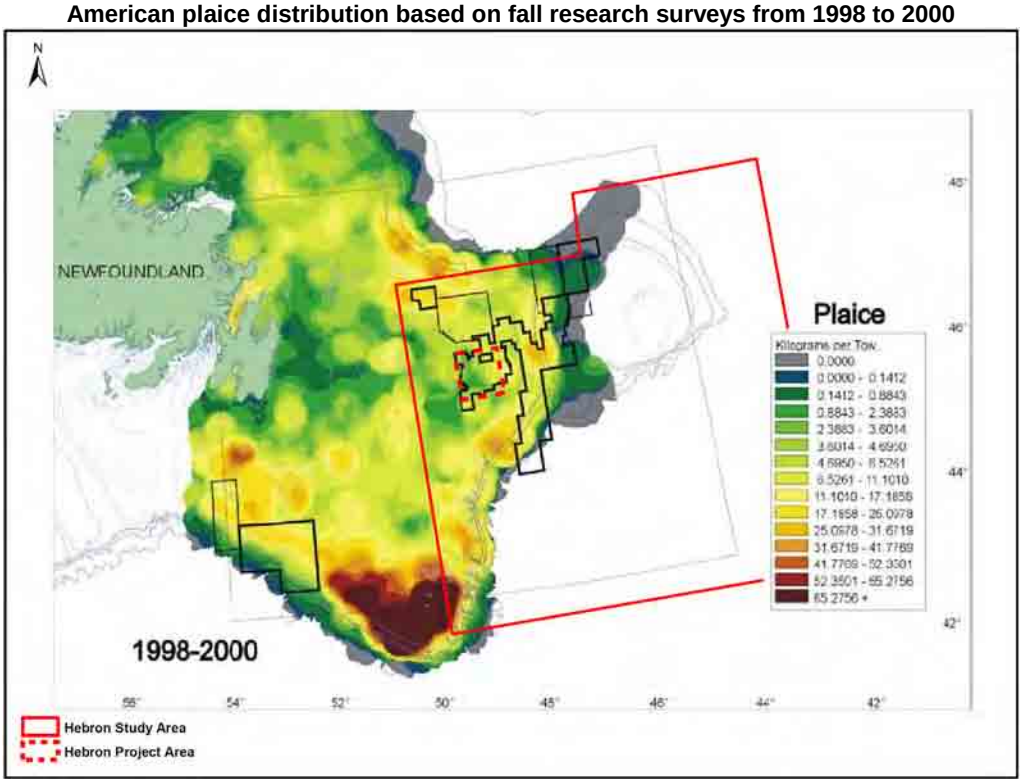
Juvenile American plaice prey upon echinoderms, especially brittle stars, but also sand dollars and sea urchins. As adults, their diets shifts more to sand lance and capelin, and the echinoderms become secondary (Methven 1999). Plaice appear to feed heavily in April, after a winter of fasting. Feeding rates are high during the summer and decrease in fall or early winter (Morgan and Brodie 1991).

As with Atlantic cod, there are three identified Sensitive or Special Areas (described and assessed in Chapter 12) within the Hebron Offshore Study Area that are related to American plaice. The Southeast Shoal and Tail of the Banks EBSA, proposed by DFO, contains important habitat for American plaice. The Southeast Shoal VME, proposed by NAFO, is located in the same area. The Virgin Rocks EBSA, proposed by DFO, supports spawning and breeding of plaice.

American plaice distribution based on spring research surveys from 1998 to 2000



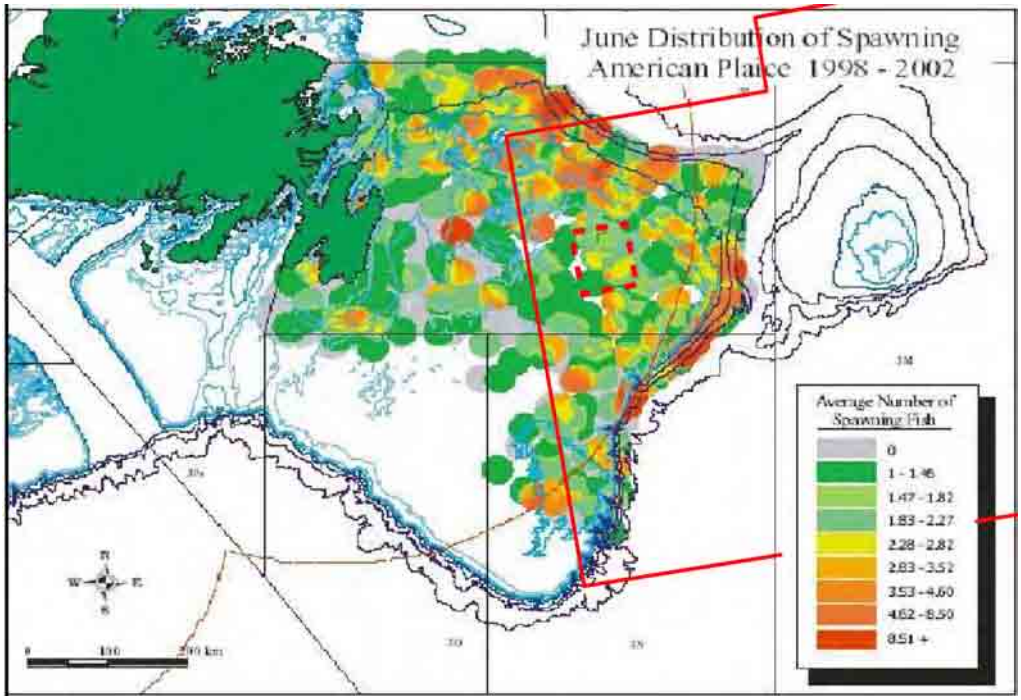
American plaice distribution based on fall research surveys from 1998 to 2000



Grey sections represent areas sampled with no catch rate values (Plaice on map refers to American plaice)

Source: Kulka *et al.* 2003

Figure 11-4 American Plaice Distribution



Grey sections represent survey sets where no fish were caught

Source: Ollerhead *et al.* 2004

Figure 11-5 June Distribution of Spawning American Plaice, 1998 to 2002

11.3.1.3 American Eel

The American eel was assessed by COSEWIC as a species of Special Concern, but is not listed under SARA. Therefore, no SARA recovery strategies or management plans are currently in place. Eels likely occur within the Hebron Nearshore Study Area as they enter or leave the Deer Harbour River or Bellevue River. Eels migrate from the rivers during August and September, and return in May. They are not likely to occur in the Hebron Offshore Study Area.

Eels from over the world spawn in the Sargasso Sea. Hatched larvae drift towards the Continental Shelf, where they metamorphose into small, transparent glass eels. As glass eels move into inshore waters, they develop pigmentation and become elvers. Elver arrival generally occurs in May and early June on the Atlantic coast. Some elvers remain in shallow protected salt water, some move into estuaries and some move into fresh water. Elvers become yellow eels, which have a dark back and a yellowish belly. Sexual differentiation occurs during the yellow phase.

The historic Canadian range includes accessible fresh water, estuaries and coastal marine waters connected to the Atlantic Ocean, up to the mid-Labrador coast. Continental shelves are used by juvenile eels arriving from the spawning grounds, and by silver eels returning to the spawning grounds. They are primarily benthic inhabitants, using substrate and bottom debris as protection and cover. Eels are not likely to occur in the offshore Study Area.

Long-term indices are not available for Newfoundland, but electrofishing survey results for the Northeast Brook on Trepassey Bay suggest a decline from the early 1980s to the mid-1990s (COSEWIC 2006b). A similar downward trend is found in densities in the Highlands River on Newfoundland's west coast. In Newfoundland and Labrador yellow and silver eels are fished principally in rivers, but there are many rivers which are not exploited. Although seven exploratory elver licenses were issued in 2004 in Newfoundland, fishing and effort data are not available. Possible causes of the observed decline, including habitat alteration, dams, fishery harvest, oscillations in ocean conditions, acid rain and contaminants, may continue to impede recovery (COSEWIC 2006b).

11.3.1.4 Wolffish

Wolffish, also known as catfish, are solitary bottom-dwelling fish. Wolffish are distributed at northern latitudes in moderately deep water in the Atlantic, Pacific and Arctic Oceans. Wolffish have a large distribution in the Northwest Atlantic, inhabiting most of the Labrador and Newfoundland shelves from the Davis Strait south to the Gulf of Maine (Kulka and DeBlois 1996). The Atlantic wolffish, the northern wolffish and the spotted wolffish occur within the Hebron Nearshore and/or Offshore Study Areas.

While the decline in abundance and biomass estimates for the three wolffish species has occurred throughout Newfoundland waters, it seems that the decline has been greater in the more northern areas (Divisions 2J, 3K and northern 3L) than in the southern areas (southern 3L, 3N, 3O) (Simpson and Kulka 2002).

Although not common, wolffish were identified in the Nearshore Study Area during a remotely operated vehicle (ROV) survey of fish habitat in Bull Arm, completed in August 2009.

Although no wolffish catches were reported in the Newfoundland-landed catches in 3Lh, 3Li, 3Lr and 3Lt during 2005 to 2008, two of the three wolffish species are known to occur within the Hebron Offshore Project Area. Further information on the distribution of wolffish is found in the following sections.

Since 1998, 87 15-minute trawl tows have been conducted as part of the Hibernia EEM Program, which is within the Hebron Study Area. Wolffish have only been collected in two of those tows, one Atlantic and one spotted wolffish. No wolffish were collected during the 2008 Terra Nova EEM program during sampling for American plaice.

A recovery strategy has been developed for northern wolffish, spotted wolffish and Atlantic wolffish (Kulka *et al.* 2007). A primary recommendation of the recovery strategy is the need for additional research and understanding of the biology and life history of these species. At the present time, critical wolffish habitat has not been specifically defined.

Atlantic Wolffish

Atlantic wolffish (striped wolffish) are listed as special concern on Schedule 1 of SARA. On the western side of the North Atlantic, they occur off the coast of west Greenland and southern Labrador, in the Strait of Belle Isle and the Gulf of St. Lawrence. It is also found off the east and west coasts of Newfoundland and on the Grand Banks. The Atlantic wolffish is a large bottom-dwelling predatory marine fish. Adults can weigh almost 20 kg and reach a length of 150 cm. Atlantic wolffish are found over hard clay bottoms at depths up to 918 m around Newfoundland and Labrador (Kulka *et al.* 2007), and in shallow nearshore waters during the summer. Mature Atlantic wolffish migrate to shallow, inshore waters in the spring and spawn in September (Simpson and Kulka 2002). Spawning typically occurs in boulder habitats; eggs are laid in a mass that adheres to the seafloor and the eggs are guarded by the male (Barsukov 1959; Keats *et al.* 1985; Kulka *et al.* 2007). Eggs hatch by mid-December. While the larvae are pelagic, they seldom swim near surface waters. The entire larval stage is spent close to where the eggs were deposited (see Simpson and Kulka 2002).

In the Northwest Atlantic, Atlantic wolffish feed primarily on benthic invertebrates such as echinoderms, molluscs and crustaceans, as well as small amounts of fish. No predators of adult Atlantic wolffish have been identified, but juveniles have been found in the stomachs of Atlantic cod (Scott and Scott 1988).

Available data indicate that the number of Atlantic wolffish in Canadian waters has declined by 87 percent from the late-1970s to the mid-1990s. The number of locations where the species occurs has declined and the range where the species is abundant may be shrinking. Even though the population has measurably declined, it is thought to be very widespread and to still exist in relatively large numbers (SARA website 2010). There are no data available on the direct causes of the declines of Atlantic wolffish in the Atlantic. The Atlantic wolffish was commercially fished at one time as a target species, but now only as bycatch. The impact of incidental capture of wolffish in many fisheries is thought to be the leading cause of human induced mortality (Kulka *et al.* 2007).

Atlantic wolffish migrate inshore during the spring and spawn in the autumn, with eggs hatching before mid-December. During an ROV survey of fish habitat in Mosquito Cove in August 2009, two Atlantic wolffish were identified. Their location is provided in Figure 11-6. The wolffish were observed at a depth of approximately 35 m, in 80 to 90 percent boulder habitat, which has been identified as potential spawning habitat (Barsukov 1959; Keats *et al.* 1985; Kulka *et al.* 2007). Of the 660,200 m^2 surveyed during the August 2009 habitat survey, approximately 800 m^2 (0.12 percent) was recorded as having 80 to 90 percent boulder coverage.

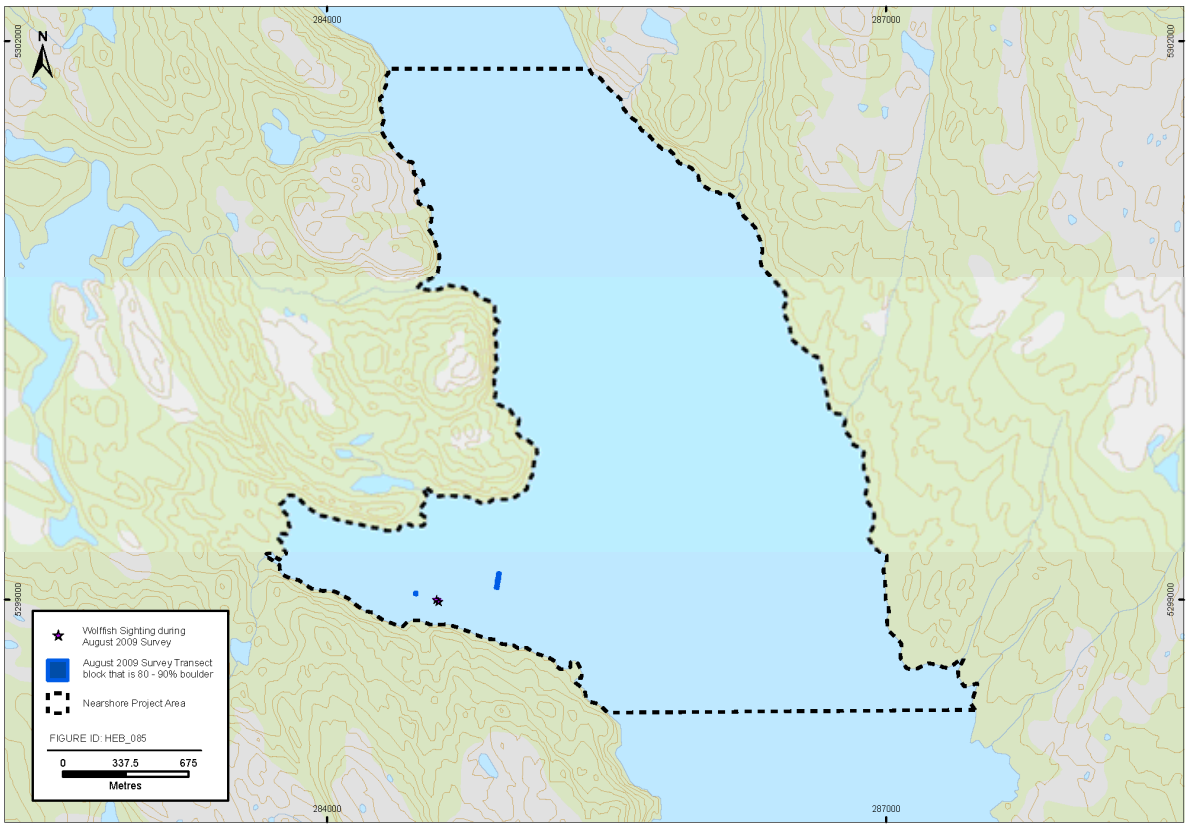


Figure 11-6 Location of Observed Wolffish during August 2009 Habitat Survey

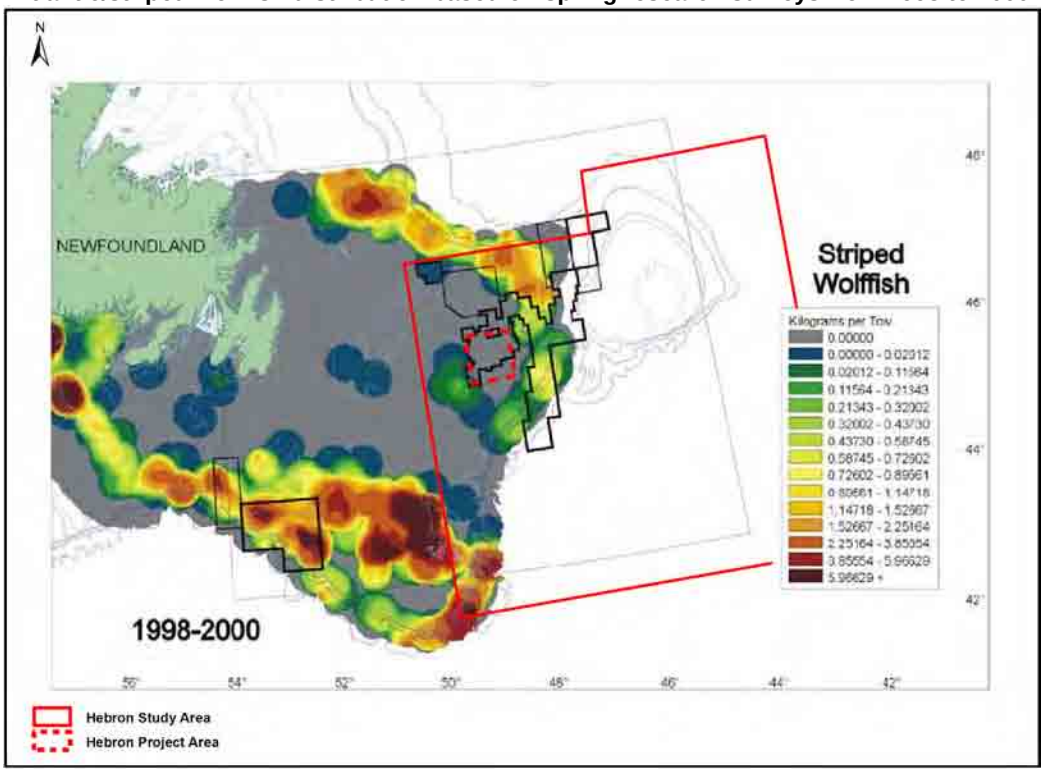
Distribution maps (Figure 11-7) based on spring and fall DFO research vessel surveys between 1998 and 2000 indicate that catches of Atlantic Wolffish within the Hebron Offshore Project Area were low. Higher concentrations occur in other areas of the Hebron Offshore Study Area, particularly the areas to the south and north of the Hebron Offshore Project Area.

There are two identified Sensitive or Special Areas (described and assessed in Chapter 12) within the Hebron Offshore Study Area that are related to the Atlantic wolffish. The Southeast Shoal and Tail of the Banks EBSA, proposed by DFO, is known to support the densest concentration of Atlantic wolffish. The Southeast Shoal VME, proposed by NAFO, is located in the same area.

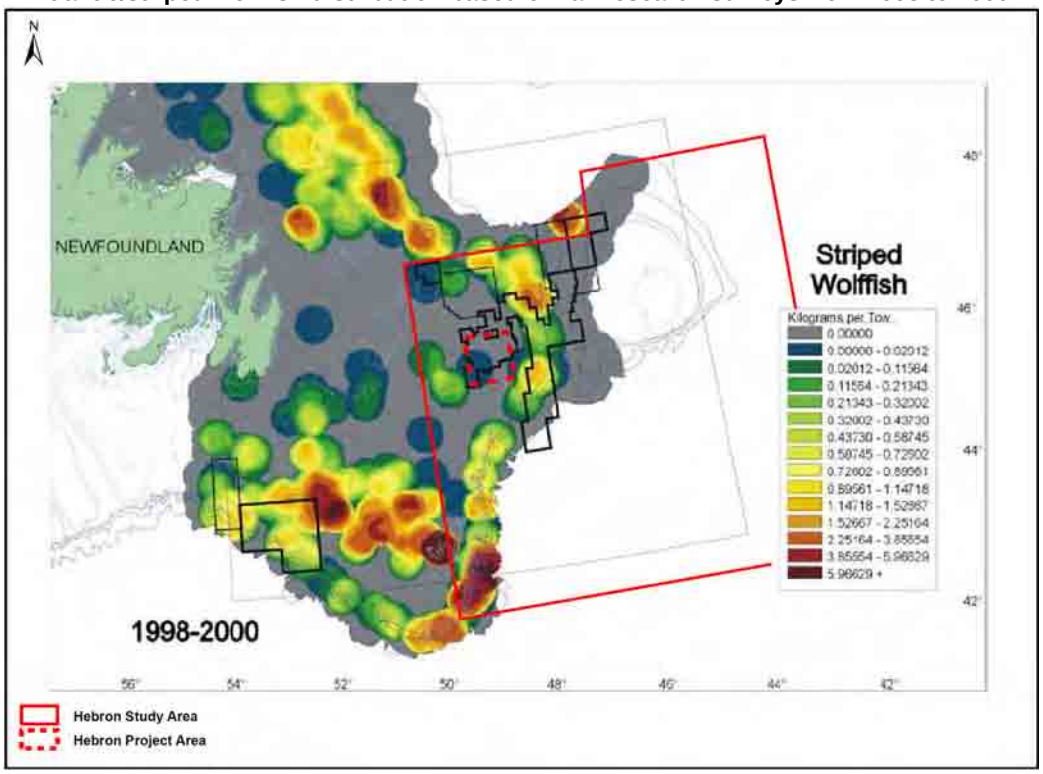
Northern Wolffish

Northern wolffish in the Northwest Atlantic is treated as a single population and is listed as Threatened on Schedule 1 of SARA due to the rapid decline along the Northeast Newfoundland / Labrador Shelf and the Grand Banks. This species prefers depths from 500 to 1000 m, though it has been recorded at depths less than 200 m and more than 1,500 m (Kulka *et al.* 2007; Scott and Scott 1988). Given this range, it is possible that this species of wolffish could be present in the Hebron Nearshore Study Area where the Bull Arm area reaches a depth of approximately 200 m. It is known to occur in the Hebron Offshore Study Area, with a lower occurrence in the Hebron Offshore Project Area (Figure 11-8).

Atlantic/striped wolffish distribution based on spring research surveys from 1998 to 2000

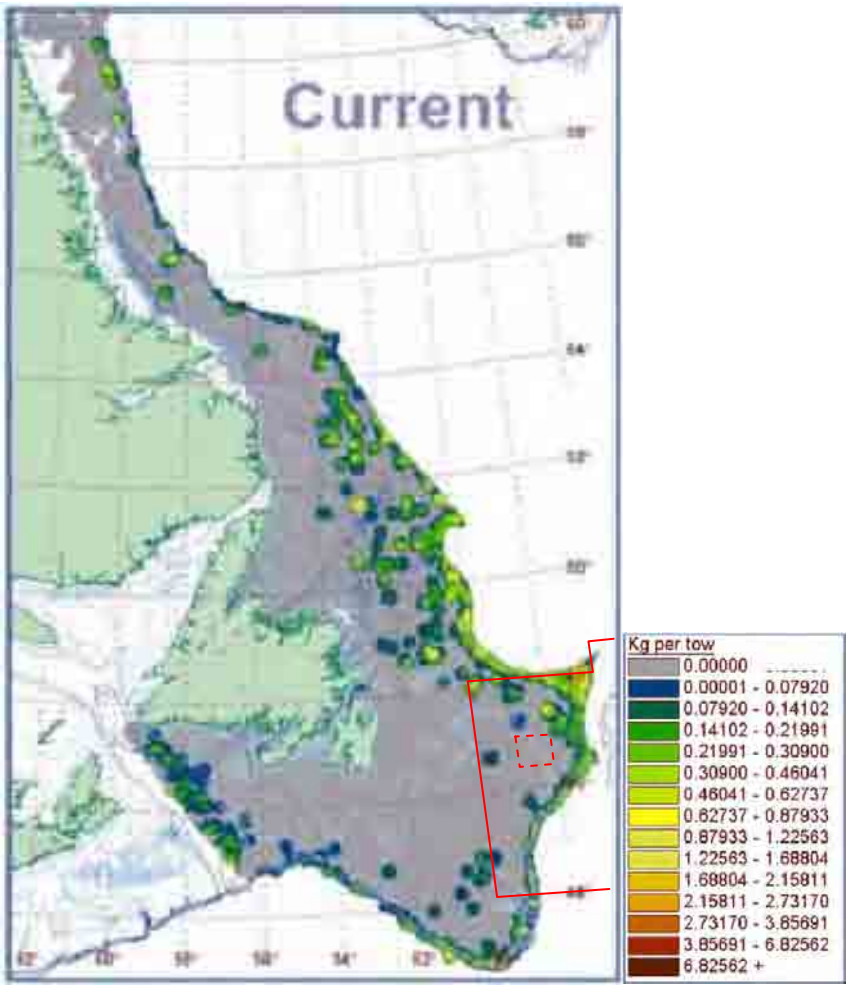


Atlantic/striped wolffish distribution based on fall research surveys from 1998 to 2000



Grey sections represent areas sampled with no catch rate values. Source: Kulka *et al.* 2003

Figure 11-7 Atlantic Wolffish Distribution, 1998 to 2000



Surveys occurred during all 12 months, but most were conducted in the spring and fall

Source: Kulka *et al.* 2004c

Figure 11-8 Northern Wolffish Distribution, 1995 to 2003

Northern wolffish are pelagic fish, spending a great deal of time swimming and feeding in open waters. In summer, mature females lay up to 30,000 extremely large eggs in a nest on the sea floor. Adult northern wolffish are somewhat sedentary and are non-migratory. The northern wolffish favours open Continental Shelf water that is cold (usually between 2°C to 5°C). This species is thought to prefer a rocky or muddy sea floor, but is found over various types of ocean bottoms. There is little known about the reproductive biology of this species, but spawning is believed to occur late in the year (DFO 2004b). Fertilized eggs are deposited on the bottom, but larvae are pelagic (Simpson and Kulka 2002).

Although the northern wolffish is not targeted by the fishing industry, it is taken as bycatch by offshore trawlers. Groundfish trawls also accidentally kill or maim individuals. Bottom trawling for fish, and dredging for scallops and clams, can damage spawning habitat by disturbing rocks and boulders, which are used for shelter and spawning nests.

Spotted Wolffish

Spotted wolffish, which are treated as a single population in the Northwest Atlantic, are listed as Threatened on Schedule 1 of SARA, due to the rapid decline along the northeast Newfoundland/Labrador Shelf and the Grand Banks. In the western North Atlantic, they occur primarily off northeast Newfoundland. Since 1978, scientific surveys in the western Atlantic show a 96 percent decline in the Canadian population of spotted wolffish over three generations of wolffish. Spotted wolffish are a predatory bottom-dweller, inhabiting waters of 56 to 1046 m, but usually found at depths of 200 to 750 m (Kulka *et al.* 2007). As with the northern wolffish, this species could potentially occur in the Hebron Nearshore Study Area, but it is more likely to be present in the Hebron Offshore Study Area.

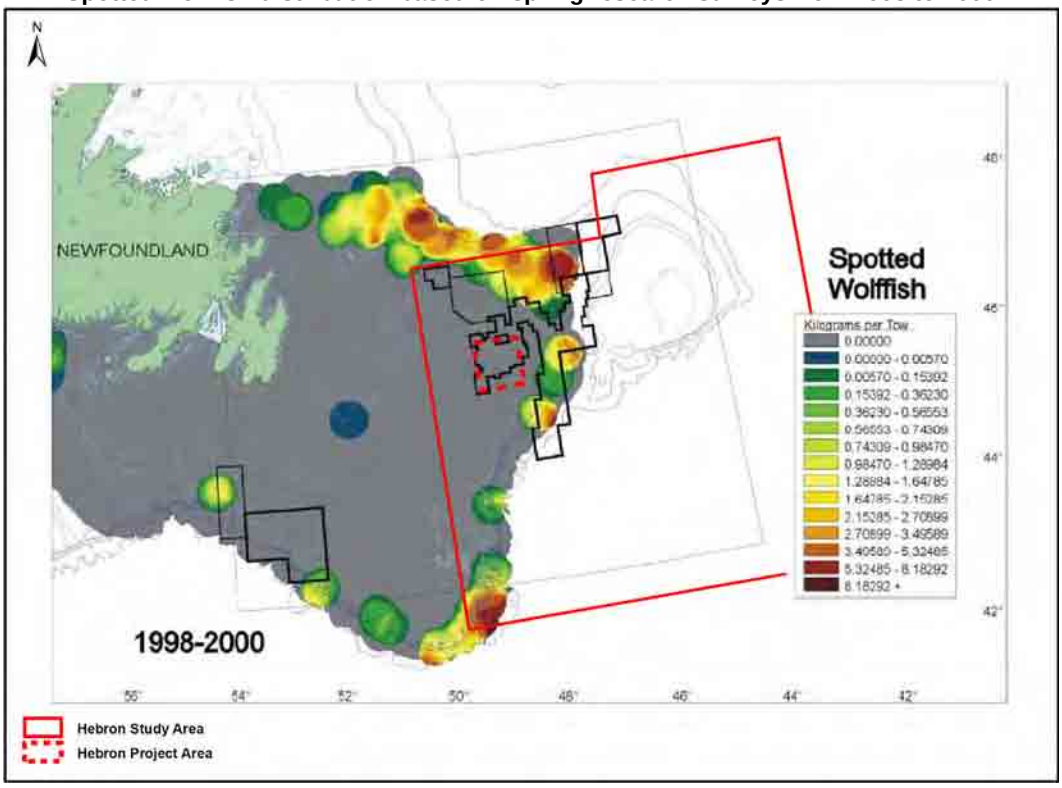
Spotted wolffish spawning is thought to occur late in the year (DFO 2004b). Spotted wolffish are found over various ocean-bottom types. The spotted wolffish favours cold, open continental shelf water, with water temperatures between 2°C to 5°C. Distribution maps (Figure 11-9) based on spring and fall DFO research vessel surveys between 1998 and 2000 indicate that catches of Spotted wolffish within the Hebron Offshore Project Area were low.

The Northeast Shelf and Slope EBSA, proposed by DFO and described and assessed in Chapter 12 as one of the identified Sensitive or Special Places within the Hebron Offshore Study Area, is known to support aggregations of Spotted wolffish in the spring.

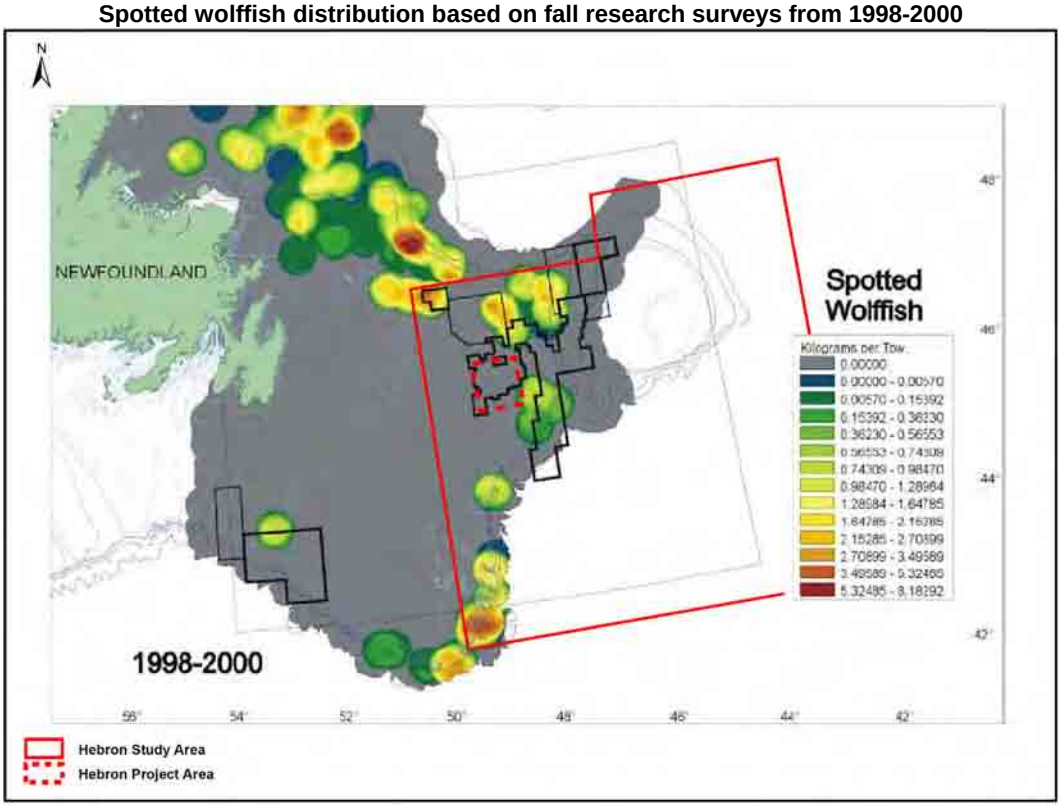
11.3.1.5 Cusk

Cusk are considered Threatened by COSEWIC, but currently have no status under *SARA*. Cusk are at the extreme northern fringe of their range on the southern Grand Banks and would only be itinerant in the Hebron Offshore Project Area. Cusk were rare or absent in each year of DFO surveys from 1980 to 2000 within the Hebron Offshore Study Area. When present, they were located sporadically on the Flemish Cap, and around the Nose and Southwest Slope of the Grand Banks (Kulka *et al.* 2003). They are not likely to occur in the Hebron Nearshore Study Area.

Spotted wolffish distribution based on spring research surveys from 1998 to 2000



Spotted wolffish distribution based on fall research surveys from 1998-2000



Grey sections represent areas sampled with no catch rate values. Source: Kulka *et al.* 2003.

Figure 11-9 Spotted Wolffish Distribution, 1998 to 2000

11.3.1.6 Grenadier

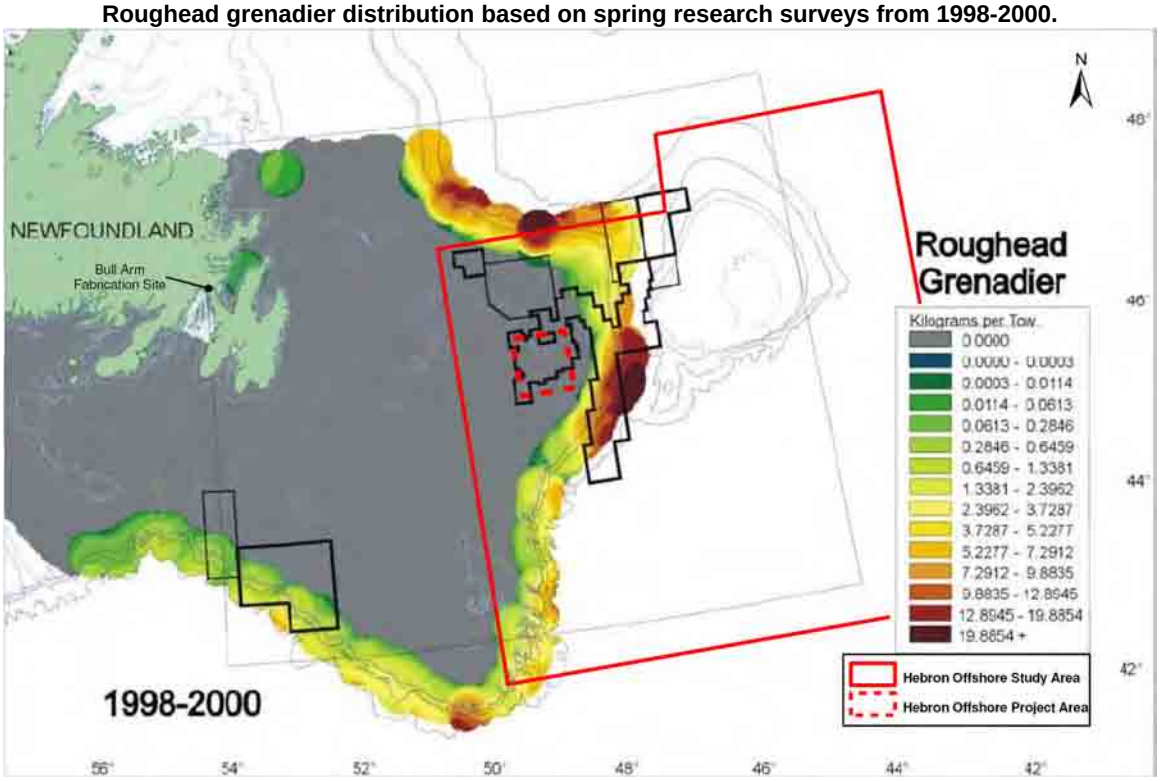
Roughead grenadier were assessed by COSEWIC as a species of Special Concern, but currently have no status under *SARA*. Roughead are primarily a deepwater species located on the slope of the northeast Newfoundland Shelf, the Flemish Pass and along the edge of the Grand Banks (Kulka *et al.* 2003). Roughead grenadier have been reported within and near the Hebron Offshore Study Area during DFO spring and fall surveys for several years (Kulka *et al.* 2003). Concentrations of roughead have been higher in the Hebron Offshore Study Area during fall surveys (Figure 11-10). Spawning occurs during winter and early spring and is believed to occur on the southern and southeastern slope of the Grand Banks (Scott and Scott 1988). Larger grenadier eat molluscs, shrimp and a variety of fish. Smaller individuals prefer bivalves, shrimp, starfish and polychaetes (Scott and Scott 1988).

Roundnose grenadier are listed as Endangered by COSEWIC, but currently have no status under *SARA*. Roundnose grenadier have increased in abundance in recent years along the edge of the Grand Banks (Figure 11-11), primarily along the southeast slope (Kulka *et al.* 2003). Roundnose are nocturnal pelagic feeders. Their diet varies by location, but is composed primarily of lanternfish on the northeastern slope of the Grand Banks (Scott and Scott 1988). Feeding is apparently seasonal and peaks during fall and winter, diminishing during the summer (Scott and Scott 1988). Predators of the roundnose grenadier include Greenland halibut, whales and redfish (Scott and Scott 1988). Little is known about the spawning time.

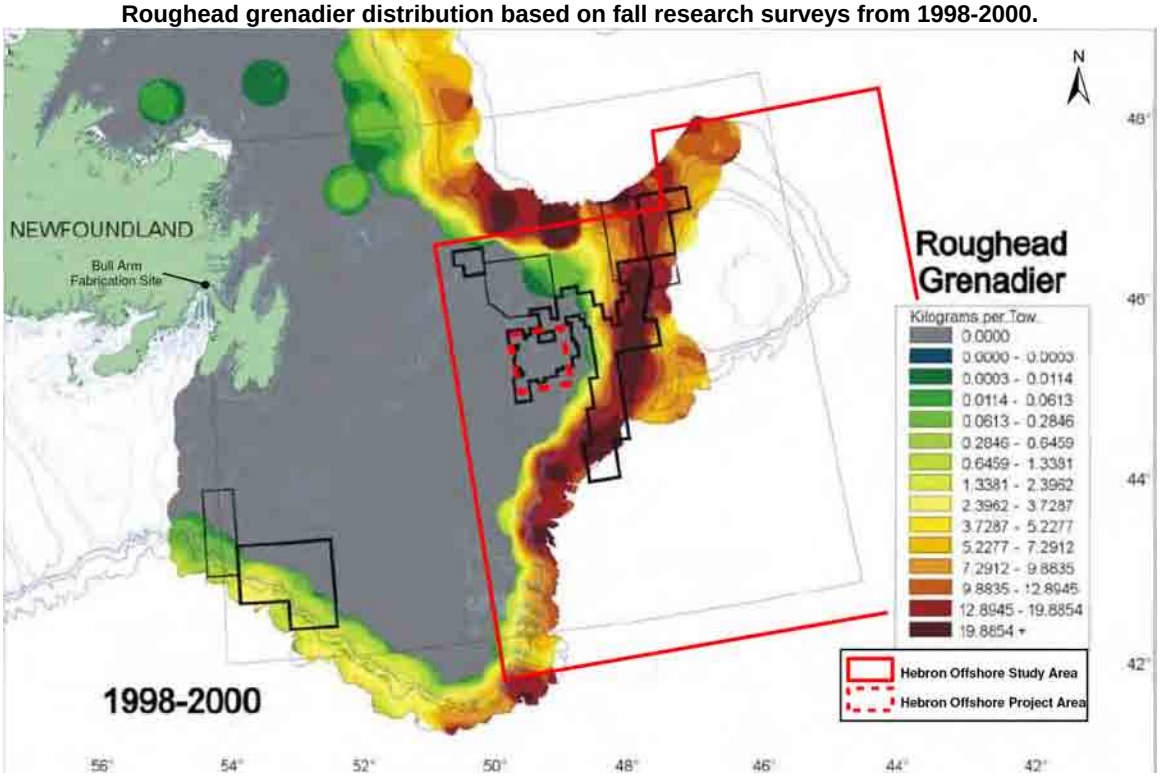
11.3.1.7 Porbeagle Shark

Porbeagle shark is considered Endangered by COSEWIC and is currently not listed by SARA. Therefore, there are no SARA recovery or management strategies in place. Porbeagle shark is a large cold-water pelagic shark distributed in the western Atlantic from Greenland to Bermuda (COSEWIC 2004). In the waters off Newfoundland, it is widely distributed, and can be specifically found on the St. Pierre Bank and in the Laurentian Channel in the spring and summer months (Scott and Scott 1988). The porbeagle shark is believed to constitute a single population in the Northwest Atlantic. The porbeagle shark is unlikely to occur in the Hebron Nearshore Study Area and may occur in the Hebron Offshore Study Area.

Roughead grenadier distribution based on spring research surveys from 1998-2000.



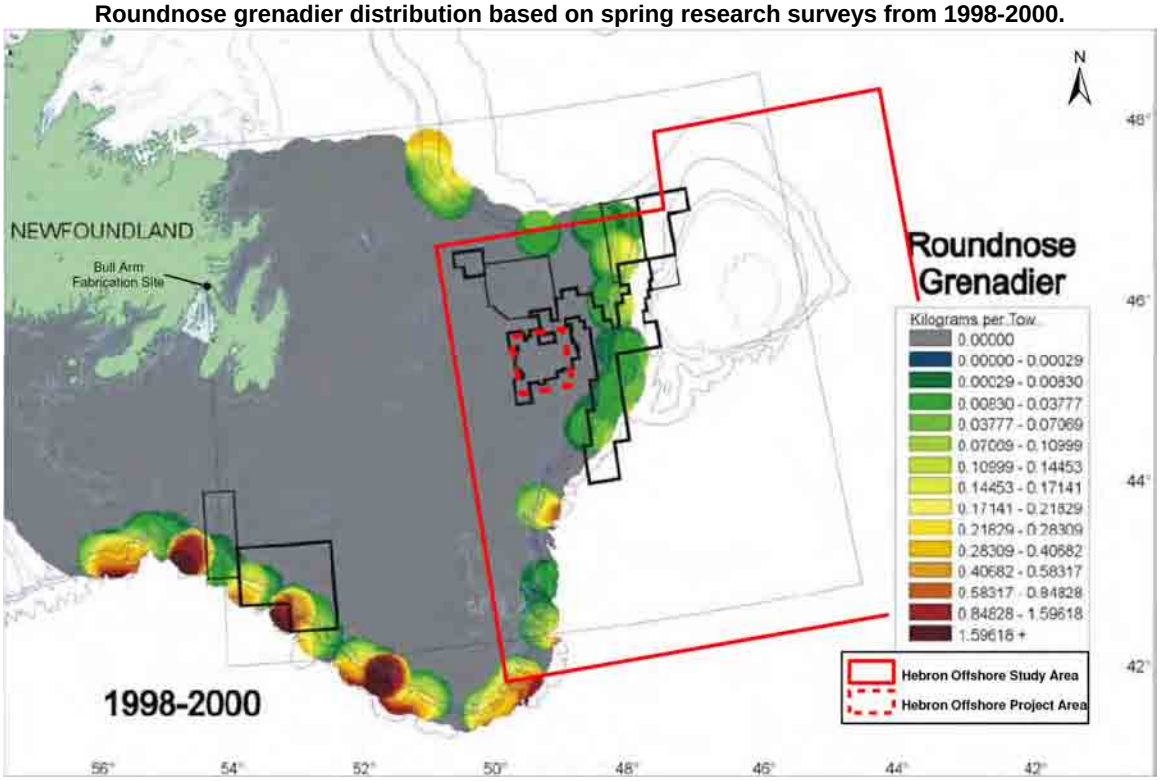
Roughead grenadier distribution based on fall research surveys from 1998-2000.



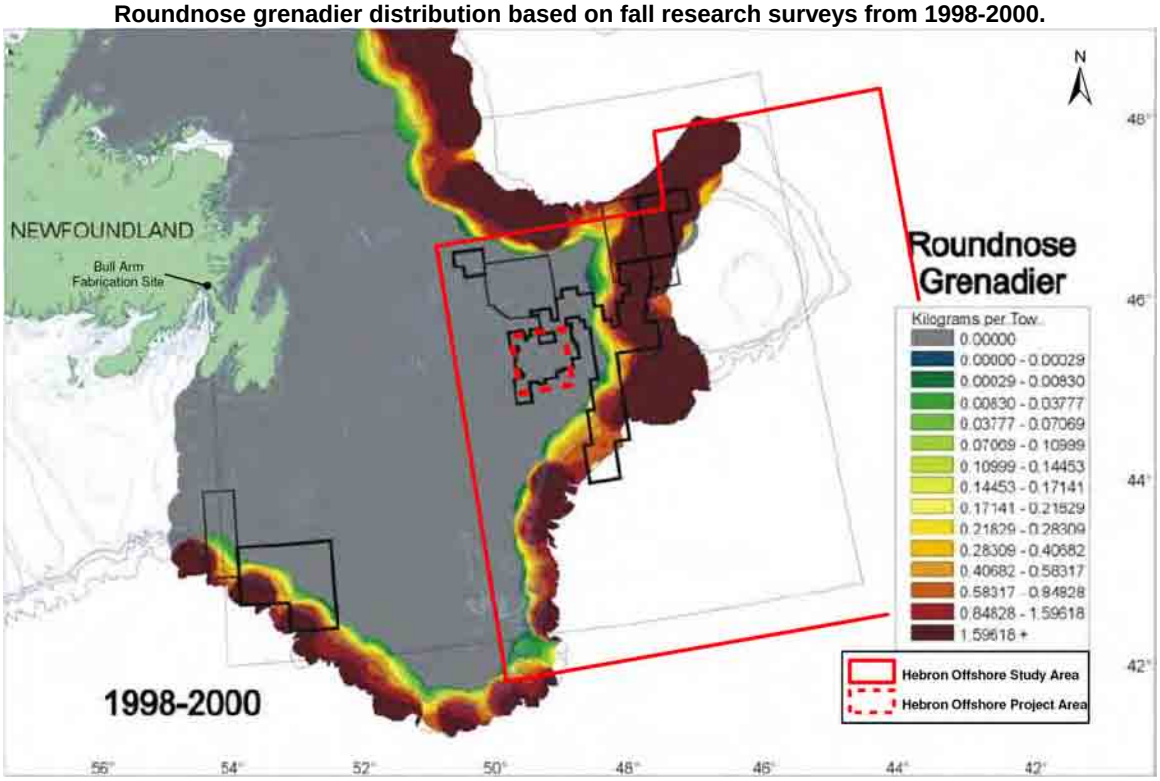
Grey sections represent areas sampled with no catch rate values. Source: Kulka et al. 2003.

Figure 11-10 Roughead Grenadier Distribution

Roundnose grenadier distribution based on spring research surveys from 1998-2000.



Roundnose grenadier distribution based on fall research surveys from 1998-2000.



Grey sections represent areas sampled with no catch rate values. Source: Kulka et al. 2003.

Figure 11-11 Roundnose Grenadier Distribution

Adults undertake annual migrations between the Gulf of Maine and Georges Bank, to the waters off Newfoundland and the Gulf of St. Lawrence, at a preferred temperature between 5°C and 10°C (Campana *et al.* 2001, cited in COSEWIC 2004). They may be found singly or in schools, and are occasionally found close to shore in shallow water during the summer (Campana 2001, cited in COSEWIC 2004). They are primarily a mid-water species and feed opportunistically on benthic, pelagic and epipelagic fish species (Joyce *et al.* 2002, cited in COSEWIC 2004), such as the lancetfish (*Alepisaurus* spp.), cod and flatfish. Squid also constitute a major portion of their diet (Joyce *et al.* 2002).

Mating is believed to occur from August to November in the Cabot Strait, off southern Newfoundland and on the Grand Banks. Gestation is approximately eight to nine months and self-reliant young are born from early April to early June (Jensen *et al.* 2002, cited in COSEWIC 2004). Juveniles are not known to migrate and are most common on the Scotian Shelf. Prior to 1991, the most abundant age-class off southern Newfoundland in the fall months was 10 to 15 years old. This is consistent with the use of the area as a mating ground. Between 1998 and 2000, the most abundant age classes in this area were less than age 3 (Campana *et al.* 2002).

Abundance of porbeagle has declined greatly since it was commercially harvested in the 1990s (COSEWIC 2004). Its life history characteristics, including late maturity and low fecundity, make this species vulnerable to overexploitation (COSEWIC 2004).

11.3.1.8 Blue Shark

The blue shark is considered to have a single, highly migratory population in the North Atlantic, a portion of which is present in Canadian waters seasonally. They can be found throughout Atlantic Canada waters, with a peak occurrence in the late summer and fall. Blue sharks have been found in southeastern Newfoundland and the Grand Banks, mainly between July and December. The abundance index is considered to best represent the whole population and has declined 60 percent from 1986 to 2000, but another index shows no long-term trend for the whole population from 1971 to 2003 (COSEWIC 2006c). The blue shark was assessed by COSEWIC as a species of Special Concern. It is considered not likely to occur in either the Hebron Nearshore or Offshore Study Areas.

Blue sharks are pelagic, most commonly encountered offshore between the surface of the water and 350 m. They prefer offshore habitats, but have been observed inshore on occasion (COSEWIC 2006c). Water temperature appears to influence their depth and latitudinal distributions, as well as size and sex distributions. Blue sharks are known to occur in waters between 5.6°C to 28°C.

Canada's waters (Atlantic and Pacific) provide habitat for primarily sub-adult (immature) individuals, although adult (mature) specimens are occasionally encountered. Occurrence of blue sharks within the Study Area and Project Area is considered rare.

This species is a relatively productive shark (mature at four to six years, with 25 to 50 pups every two years), but other species are susceptible to increased mortality from several sources, including from human activities. The primary threat against this species is as a bycatch in the pelagic longline fisheries. Although the threat is understood and is reversible, it is not being effectively reduced through management. Assessing the effect of bycatch on the population would benefit from more reliable information regarding survival rate of the discarded individuals. Blue sharks used to be taken in both the porbeagle shark and swordfish fisheries. It appears that recent fishery catches in the North Atlantic have been several tens of thousands of tons annually. Estimated Canadian bycatch has been declining since the early 1990s and recently have averaged approximately 600 t/yr. Loss of habitat is not considered a threat for this species (COSEWIC 2006c).

11.3.1.9 Shortfin Mako

COSEWIC assessed the shortfin mako shark as Threatened in 2006, and is currently under consideration for SARA listing. At this time, there are no SARA recovery strategies or management plans in place.

The shortfin mako has been recorded from Georges and Browns Bank, along the Continental Shelf of Nova Scotia, the Grand Banks off Newfoundland and even into the Gulf of St. Lawrence. These sharks are not abundant in Canadian waters, due to their preference for warm waters, but neither are they uncommon. The species is highly migratory, with tagging results suggesting that there is a single, well-mixed population in the North Atlantic. Atlantic Canada represents the northern extension of their range, and most of their population is believed to reside in more temperate waters. In Canadian waters, the shortfin mako is most closely associated with warm waters such as the Gulf Stream. They prefer temperate to tropical waters, with temperatures between 17°C and 22°C. The shortfin mako would be considered a rare occurrence within the Hebron Nearshore or Offshore Study and Project Areas.

They occur from the surface to 500 m depths and typically well offshore, but shortfin makos have occasionally been observed in littoral zones. They feed on fish and marine mammals. There are no known breeding areas in Canadian waters. The status of the shortfin mako population in Canadian waters was assessed for the first time in 2004, revealing the north Atlantic population had declined since 1986. There are no known shark surveys or fishery-independent surveys for shortfin mako in Canadian waters. Therefore, abundance indices are based on data from commercial or recreational fisheries. Shortfin mako used to be taken in both the porbeagle and swordfish fisheries. There are no reliable means for estimating the total abundance of mature individuals in Canadian waters. Shortfin mako bycatch by foreign fleets in the North Atlantic are the most important source of mortality for the population. In Atlantic Canada, shortfin makos have at times been misidentified as porbeagle shark.

11.3.1.10 Basking Shark

The Atlantic population of basking shark has recently been assessed as a species of Special Concern by COSEWIC; it has no status under SARA (SARA 2010). The basking shark is found in the western North Atlantic from northern Newfoundland south to Florida and occurs in Canadian Waters from May to September (Scott and Scott 1988). It is the second largest fish, with a maximum length of 15 m (COSEWIC 2010b), but average from 5 to 7 m in the Atlantic region (Scott and Scott 1988). Females do not reach maturity until 16 to 20 years old and gestate to 2.6 to 3.5 years (producing litters of approximately six young), resulting in extremely low productivity. The Canadian population ranges from approximately 5,000 to 10,000 individuals (COSEWIC 2010b).

The primary threat to the basking shark is incidental by-catch from trawl, longline and gillnet fisheries and collision with shops (COSEWIC 2010b).

11.3.1.11 White Shark

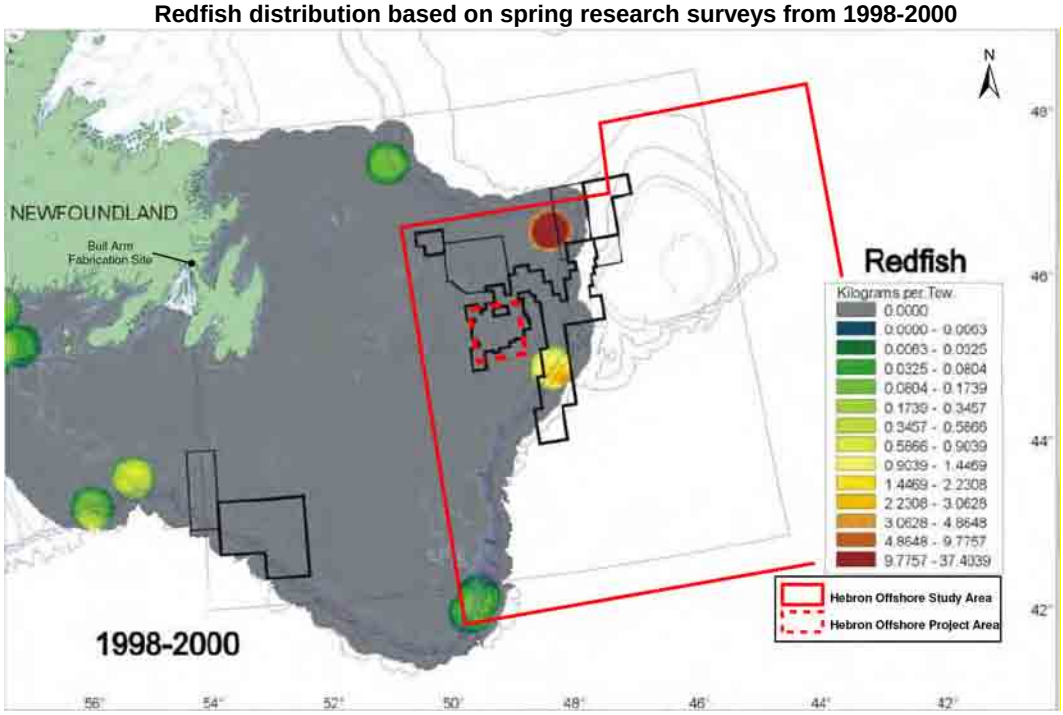
White sharks are rare in Canadian waters and are recorded mostly in the Bay of Fundy area. They are extremely rare as far north as the Hebron Nearshore or Offshore Study Areas. The white shark was assessed by COSEWIC as a Threatened species. At this time, there are no SARA recovery strategies or management plans in place.

11.3.1.12 Redfish

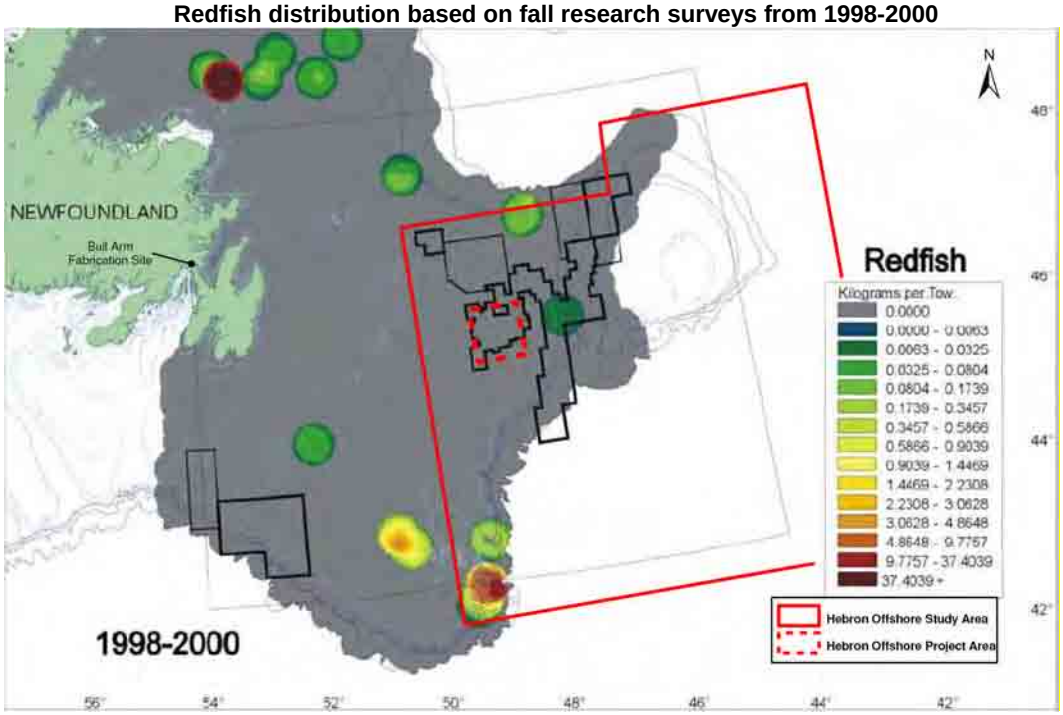
There are primarily two species of redfish in the Hebron Offshore Study Area, Acadian redfish (*Sebastes fasiatus*) (Atlantic population) and the deepwater redfish (*Sebastes mentella*) (northern population). These species are very similar in appearance and are managed together and not separated in the fishery (DFO 2004c). They are most abundant at depths between 100 to 700 m, along the edge and upper slope of the Continental Shelf, primarily on the outer edge of the northeast Newfoundland Shelf, the Flemish Cap, and along the Laurentian Channel slope. Redfish occurrence within the Hebron Offshore Study Area is patchy and variable (Kulka et al. 2003), but more likely to occur in the spring than fall (Figure 11-12). Redfish are slow-growing and long-lived. They are pelagic, nocturnal feeders, preying primarily on copepods, shrimp, amphipods and euphausiids; lancetfish (*Alepisaurus* spp.) and lanternfish also make up a small component of the diet of larger redfish (Methven 1999). Mating takes place in the fall and larvae hatch within the female and are released during April to July (LGL 2005e). Spawning on the northeastern edge of Grand Banks occurs in June at depths greater than 200 m (Ollerhead *et al.* 2004). Live larvae, as opposed to gametes, are released from April to July over the Grand Banks. Redfish larvae have been abundant during pelagic surveys on the northern Grand Banks in August and September (Anderson *et al.* 1999). In the early 1990s, the landings of redfish in Unit 1 (NAFO Divisions 4RST) dropped from approximately 60,000 tonne in 1993 to approximately 19,500 tonne in 1994 (DFO 2001); the directed redfish fishery was closed in 1995 as a result of low stock levels (DFO 2001; LGL 2007d). In April 2010, the status of both species of redfish potentially found in

the Project Areas was re-examined and both the northern population of deepwater redfish and the Atlantic population of Acadian redfish were designated as Threatened. The deepwater redfish has decline by 98 percent since 1984 and the Acadian redfish has declined by 99 percent, in areas of historical abundance over two generations. The major treats to both species are directed fishing and incidental harvest (COSEWIC 2010c).

Redfish distribution based on spring research surveys from 1998-2000



Redfish distribution based on fall research surveys from 1998-2000



Grey sections represent areas sampled with no catch rate values. Source: Kulka et al. 2003

Figure 11-12 Redfish Distribution

11.3.2 Marine Mammal and Sea Turtle Species at Risk

Six species are included in marine mammal and sea turtle SAR: the blue whale, fin whale, Sowerby's beaked whale, killer whale, harbour porpoise, and leatherback sea turtle (see Table 11-2). The blue whale, fin whale and leatherback sea turtle are listed on Schedule 1 of SARA. Neither the Hebron Nearshore nor Hebron Offshore Study Areas represent critical habitat for these species. It is also possible that North Atlantic right whale (*Eubalaena glacialis*) may occur in the Hebron Offshore Study Area, but their occurrence is considered extremely rare. As such, this species is not considered further in this chapter.

At the time of this writing, no recovery strategies were available for these species other than blue whale (Beauchamp *et al.* 2009), the North Atlantic right whale (Brown *et al.* 2009) and leatherback sea turtle (Atlantic Leatherback Turtle Recovery Team 2006).

Species profiles for each of the marine mammal and sea turtle SAR are provided below.

11.3.2.1 Blue Whale

The blue whale is cosmopolitan in distribution, but tends to be more common in pelagic than coastal environments (Jefferson *et al.* 2008). Following large-scale depletion from industrial whaling, blue whales occur at low densities in the North Atlantic (COSEWIC 2002b). The National Marine Fisheries Service (NMFS) (1998) estimated that up to 1,400 individuals are found in the North Atlantic. The size of the Northwest Atlantic population is currently unknown, but Beauchamp *et al.* (2009) cites experts that estimate that the number of mature animals is unlikely to exceed 250 individuals and are observed year round on the Grand Banks. Blue whales are considered Endangered by COSEWIC and Schedule 1 of SARA, and are on the Red List of Threatened Species (COSEWIC 2010a; IUCN 2009).

A Recovery Strategy was recently finalized and published for the Northwest Atlantic population of blue whales (Beauchamp *et al.* 2009). The Recovery Strategy targets the identification of critical habitat for the blue whale by 2014. The Strategy identifies nine threats to the blue whale population including whaling, natural mortality, anthropogenic noise, food availability, contaminants, collisions with vessels, whale watching, accidental entanglement in fishing gear, epizootics and toxic algal blooms, and toxic spills (Beauchamp *et al.* 2009). It concludes that the recovery of the Northwest Atlantic blue whale population is feasible and sets a target of increasing the current population to 1,000 mature individuals.

Blue whales are most often observed as single animals, but also occur in small groups (Jefferson *et al.* 2008). Blue whales are regular occupants of the Gulf of St. Lawrence, where at least 308 individuals have been uniquely identified (Sears *et al.* 1987) and average group size is 1.4 (although concentrations of 20 to 40 animals have also been seen) (Sears *et al.* 1991). Euphausids are their primary prey in the Gulf of St. Lawrence, where they commonly feed near the 100 m depth contour (Sears *et al.* 1987) and their

distribution has been linked to heterogeneous seafloor topography and the presence of thermal fronts (Doniol-Valcroze *et al.* 2007).

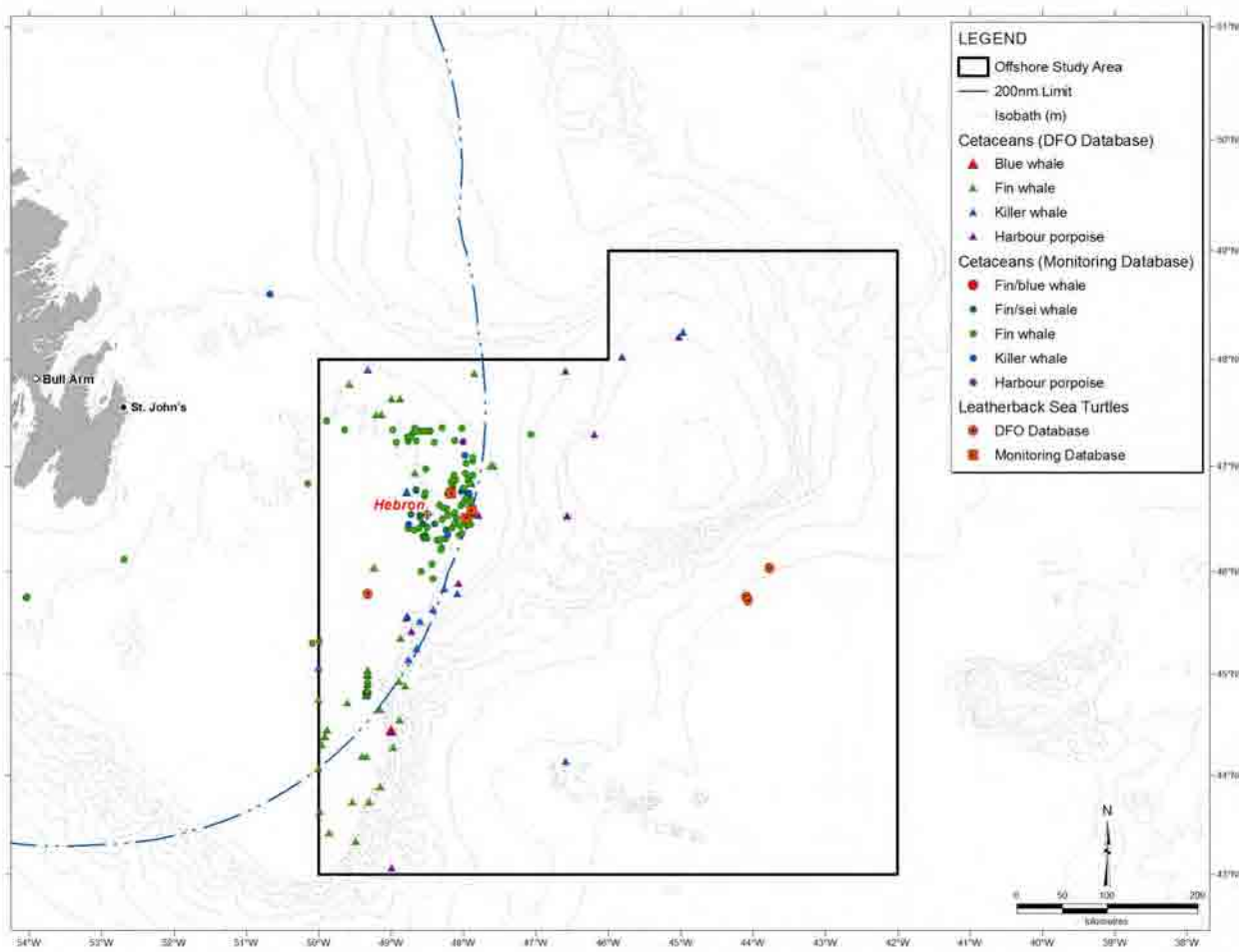
Relative to other cetacean species, blue whales are uncommon in eastern Newfoundland waters. There was a single possible blue whale sighting (recorded as a fin or blue whale) during seismic monitoring programs in the Jeanne d'Arc Basin, and only two sightings in the adjacent Orphan Basin (both occurring in August and water depths >2,000 m; Abgrall *et al.* 2008b) (see Figure 11-13). There was only one sighting of a blue whale reported in the DFO cetacean sightings database within the borders of the Hebron Offshore Study Area (Figure 11-13; DFO 2007c). Blue whales are not expected to commonly occur in the Hebron Offshore Study Area.

Blue whale records have been more common off the south coast of Newfoundland. In general, the available monitoring results suggest that baleen whales are typically less abundant on the Grand Banks in late fall versus summer, and it is possible that blue whales occur in the Hebron Offshore Study Area at low densities.

Blue whales are not expected to commonly occur in the Hebron Nearshore Study Area. There is little available information on the presence of blue whales in Trinity Bay. No blue whales were reported in the DFO cetacean sightings database in the Hebron Nearshore Study Area (DFO 2007c).

11.3.2.2 Fin Whale

Fin whales are found in oceans worldwide, making seasonal migrations between low-latitude wintering areas and high-latitude feeding grounds (COSEWIC 2005). Fin whales have a cosmopolitan distribution, but are most common in temperate and polar regions (Jefferson *et al.* 2008). It is one of the most frequently observed cetacean species in Continental Shelf waters of the Northwest Atlantic, from the mid-United States to eastern Canada (Waring *et al.* 2009). An estimated 35,500 fin whales occur in the North Atlantic (IWC 2007), with 2,269 to 2,814 found in the Northwest Atlantic (COSEWIC 2005; Waring *et al.* 2009). In Canada, fin whales are classified as of Special Concern on Schedule 1 of SARA and by COSEWIC (COSEWIC 2010a). They are also considered Endangered on the Red List of Threatened Species (IUCN 2009).



Source: Based on DFO (2007c) and seismic monitoring programs (2005 to 2008)

Figure 11-13 Locations of Marine Mammal and Sea Turtle SAR Sightings in the Offshore Study Area

Genetic analyses suggest that there are likely several different populations of fin whales in the North Atlantic, with western North Atlantic animals distinct from those in Iceland, West Greenland and the eastern North Atlantic (Bérubé *et al.* 1998). Fin whales use lunge feeding to consume euphausiids and small fishes, and their distribution has been associated with thermal fronts or shallow areas with heterogeneous sub-surface topography that may help concentrate their prey (Woodley and Gaskin 1996; Doniol-Valcroze *et al.* 2007). They often occur singly or in small groups of two to seven animals, but have also been observed in feeding aggregations of up to 20 individuals, sometimes with humpback and minke whales (Jefferson *et al.* 2008). Average fin whale group size off eastern Newfoundland was reported as 2.6 during an aerial survey in August 1980 (Hay 1982).

Fin whales regularly occur in eastern Newfoundland waters, particularly from early summer to late fall. Of the identified baleen whales, fin whales were the second most commonly sighted species (after humpback whales) in the Jeanne d'Arc Basin during seismic monitoring programs from 2005 to 2008 with 69 sightings; there was at least one sighting each year from May to October (Figure 11-13). There were also several fin whale sightings within

the Hebron Offshore Study Area or west of the Jeanne d'Arc Basin in 2005, and six other sightings in 2008 (Lang *et al.* 2006; Abgrall *et al.* in prep.). Fin whales were also frequently observed in deep waters (typically >2,000 m) of the adjacent Orphan Basin during summer, most often in July and August (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b). According to the DFO cetacean sightings database, the fin whale was the second most frequently sighted species in the Hebron Offshore Study Area; there were 80 sightings of 162 individuals (Figure 11-13; DFO 2007c). Fin whales likely occur in the Hebron Offshore Study Area year-round, but are most common from June to October.

Fin whales are also common in coastal regions of Newfoundland, with group size linked to the size of capelin schools, their primary summer prey. In the nearshore, group sizes ranged from 1 to 10 individuals (Whitehead and Carlson 1988). Fin whales appear to be slightly less common than minke and humpback whales in the nearshore environment (Piatt *et al.* 1989), and have occasionally been recorded as entangled in nearshore fishing gear (Lien 1994). Fin whales were more often observed feeding in the middle of large deep-water bays, over 1 nautical mile (nm) from shore, relative to minke and humpback whales that most frequently fed less than 1 nm from shore (Perkins and Whitehead 1977). Hay (1982) estimated a density of 0.0118 fin whales per square nautical mile in Trinity Bay during an August 1980 aerial survey, an intermediate density relative to other surveyed regions of coastal Newfoundland (from St. Mary's Bay to White Bay). Fin whales were occasionally reported in the Hebron Nearshore Study Area in the DFO cetacean sightings database; there were six sightings of seven individuals reported (DFO 2007c). Fin whales could commonly occur in the Hebron Nearshore Study Area, especially from June to October.

11.3.2.3 Sowerby's Beaked Whale

The Sowerby's beaked whale is found only in the cold temperate waters of the North Atlantic, where just one record in the Northwest Atlantic occurs outside the area between Labrador and New England (MacLeod 2000; MacLeod *et al.* 2006). The number of Sowerby's beaked whales in eastern Newfoundland is unknown, and the best population estimate for the Northwest Atlantic (of 3,513 individuals) combines sightings of all *Mesoplodon* spp. and *Ziphius cavirostris* (but these other species have more southerly distributions) (Waring *et al.* 2009). Sowerby's beaked whales are considered of Special Concern by COSEWIC and on Schedule 1 (Special Concern) of SARA (COSEWIC 2010a), but they are considered Data Deficient on the Red List of Threatened Species (IUCN 2009).

Little is known, in general, about beaked whales, but most information on Sowerby's beaked whales in Newfoundland is based on stranding records or a few opportunistic sightings (Lien and Barry 1990). Sowerby's beaked whales are also relatively difficult to detect at sea due to their short surface durations, apparent offshore distribution, and barely detectable blows (Hooker and Baird 1999b). They have most often been observed in deep waters and continental shelf edges or slopes (Kenney and Winn 1987; COSEWIC 2006d)

and presumably make deep dives to forage on medium to large-bodied squid (COSEWIC 2006d).

Sowerby's beaked whales are expected to occur most frequently in deeper waters, although in relatively low numbers, of the Hebron Offshore Study Area. There were two unidentified beaked whale sightings during seismic monitoring in the Jeanne d'Arc Basin during 2005 to 2008 (Section 10.3.1.1). One of these sightings was deemed a species other than a northern bottlenose whale, and the observer suggested that it was likely a Sowerby's beaked whale (Lang *et al.* 2006). There was only one confirmed sighting of a Sowerby's beaked whale during four years of monitoring in the adjacent and deeper Orphan Basin; the sighting of four individuals occurred in 2,500 m of water during September (Moulton *et al.* 2005, 2006a; Abgrall *et al.* 2008b). There were no sightings of Sowerby's beaked whales reported in the DFO cetacean sightings database in the Hebron Offshore Study Area (DFO 2007c).

Lien (1994) reported that there was one record of a Sowerby's beaked whale entangled in a nearshore fishing gear during the period of 1979 to 1990. There have also been occasional strandings of individuals or groups (of up to six individuals) in eastern Newfoundland, dating from 1952 to 2004 (COSEWIC 2006d). Causes of death were typically not determined, and it is unknown if these whales entered nearshore waters prior to death or if the carcasses washed ashore. One Sowerby's beaked whale was found dead, stranded on 22 May 2008 in Harcourt, Trinity Bay (Ledwell and Huntington 2009). There were no sightings of Sowerby's beaked whales reported in the DFO cetacean sightings database in the Hebron Nearshore Study Area (DFO 2007c). It is possible, but very unlikely, that Sowerby's beaked whales will occur in the Hebron Nearshore Study Area.

11.3.2.4 Killer Whale

Killer whales have a cosmopolitan distribution, occurring in oceans from polar pack-ice to the equator, but seem to be most common in coastal waters at higher latitudes (COSEWIC 2008; Jefferson *et al.* 2008). It is unknown how many killer whales occur in the Northwest Atlantic (Waring *et al.* 2009). In Newfoundland and Labrador, at least 63 animals have been individually identified to date (Lawson *et al.* 2007). Killer whales in Atlantic Canada were recently assessed by COSEWIC as of Special Concern, but currently have no status under SARA (COSEWIC 2010a). They are considered Data Deficient on the Red List of Threatened Species (IUCN 2009).

Killer whales exhibit marked sexual dimorphism, with adult males having a much more pronounced and taller dorsal fin and being generally larger than females (Ford *et al.* 2000). Generally, killer whale movements are linked to the distribution and abundance of their primary prey, which can include fish, marine mammals, marine birds and cephalopods (Ford *et al.* 2000). Sympatric killer whales populations in some regions have divergent preferred prey, presumably as a mechanism to share available resources (Baird 2000). For example, there are distinct fish- or marine mammal-eating killer whale populations in the northeast Pacific that sometimes overlap temporally and

geographically. Killer whales in Atlantic Canada have been observed approaching, attacking, and/or consuming other cetaceans, seals, marine birds, and several species of fish; it is not known if local populations specialize on particular prey groups (Lawson *et al.* 2007). Most groups in Newfoundland and Labrador are comprised of three to seven individuals, and some individuals have been documented moving as much as hundreds of kilometres between re-sightings from year to year (Lawson *et al.* 2007). In the northeast Pacific, long-term and stable associations are maintained among matrilineal-related individuals and pods within fish-eating populations, as well as within mammal-eating populations, although to a lesser extent among the latter (Bigg *et al.* 1990). It is unknown whether such associations are maintained in the Northwest Atlantic, but preliminary social groups have been identified by Lawson *et al.* (2007).

Killer whales are considered a year-round resident of eastern Newfoundland, although they occur in relatively low densities (Goff and Lien 1988; Lawson *et al.* 2007). In the Jeanne d'Arc Basin, there were four killer whale sightings (totalling 21 individuals) during the 2008 seismic monitoring program (Figure 11-13); two sightings occurred in each of June and September, group sizes ranged from 1 to 12 individuals, and water depths ranged from 65 to 153 m (Abgrall *et al.* in prep.). Outside of Jeanne d'Arc Basin, a single killer whale was also sighted to the northwest in October 2005 (Lang *et al.* 2006). There was also one sighting of three individuals in August 1999 during a supply vessel transit between oil platforms in the Jeanne d'Arc Basin and St. John's (Wiese and Montevecchi 1999).

Whitehead and Glass (1985) recorded two sightings (one of 15 individuals and the other of 12) during surveys of the Southeast Shoal (southeastern Grand Banks) during June and July in 1982 and 1983. In August 2007, a single killer whale was sighted during monitoring in the Orphan Basin (Abgrall *et al.* 2008b). There were 17 sightings of killer whales reported in the DFO cetacean sightings database in the Hebron Offshore Study Area (Figure 11-13; DFO 2007c). The available information suggests that killer whales occur year-round at low densities in the Hebron Offshore Study Area, but are most common during summer.

Killer whales have also been observed in coastal areas of eastern Newfoundland (Mitchell and Reeves 1988). Killer whales were occasionally reported to be associated with minke or pilot whales being pursued by shore-based whalers from Dildo, Trinity Bay (Mitchell and Reeves 1988). There was a single sighting of a pair of killer whales reported in the DFO cetacean sightings database in the Hebron Nearshore Study Area (DFO 2007c). Given the available information, killer whales likely occur year-round in the Hebron Nearshore Study Area, but only occasionally and predominantly during spring to fall.

11.3.2.5 Harbour Porpoise

Harbour porpoises are found in Continental Shelf regions of the Northern Hemisphere, and from southern Baffin Island to New England in the Northwest Atlantic (Jefferson *et al.* 2008). At least three populations of

harbour porpoises exist in the Northwest Atlantic, including the eastern Newfoundland and Labrador, Gulf of St. Lawrence, and Gulf of Maine / Bay of Fundy populations (Palka *et al.* 1996; Wang *et al.* 1996). There is an unknown number of harbour porpoises in the Northwest Atlantic, as well as in the Newfoundland population (COSEWIC 2006a). The Northwest Atlantic population of harbour porpoises was assessed by COSEWIC as a species of Special Concern and is listed as Threatened on Schedule 2 of SARA (COSEWIC 2010a), but harbour porpoises are considered of Least Concern on the Red List of Threatened Species (IUCN 2009).

Harbour porpoises tend to occur singly or in small groups of up to three animals, but occasionally form larger groups (COSEWIC 2006a). They consume small schooling fishes and apparently prefer areas with coastal fronts or topographically generated upwellings over the Continental Shelf, although there also appears to be an offshore component to their distribution (Westgate *et al.* 1998; Read 1999). Harbour porpoises appear to have an annual reproduction cycle; pregnant females were collected during late summer and early autumn from the Gulf of Maine/Bay of Fundy population (Palka *et al.* 1996).

There is little information regarding movements and distribution of the Newfoundland and Labrador population (COSEWIC 2006a). Harbour porpoises occur in coastal shelf waters of Labrador and the eastern and southeastern Newfoundland coasts during spring and summer. They range up to Baffin Bay and deeper waters of the Labrador Sea during summer, but the offshore boundaries of their spring and summer distributions are unknown (Palka *et al.* 1996). The winter range for this population is undefined (Palka *et al.* 1996; COSEWIC 2006a). During summer and fall monitoring in the Jeanne d'Arc Basin from 2005 to 2008, there was a single harbour porpoise sighting of two individuals; the water depth at the time of the sighting was 165 m (Lang *et al.* 2006). Harbour porpoises were sighted more frequently in the deeper Orphan Basin, including nine and one sighting during monitoring programs in 2005 and 2004, respectively (Moulton *et al.* 2005, 2006a). There were thirteen sightings of harbour porpoises reported in the DFO cetacean sightings database in the Hebron Offshore Study Area (Figure 11-13; DFO 2007c). While harbour porpoises may occur in the Hebron Offshore Study Area throughout the year, they are likely uncommon relative to other cetacean species and generally are observed from spring to fall.

Harbour porpoises often occur in coastal Newfoundland waters during summer months. Inshore fisherman reported porpoise bycatch in cod traps during June and July, and they have been observed in southern Trinity Bay from late May to late July (Sergeant and Fisher 1957). Sergeant and Fisher (1957) also indicated that porpoises leave Trinity Bay after late July. Lawson *et al.* (2004) estimated that approximately 1,500 to 3,000 harbour porpoises were incidentally caught during the 2002 nearshore cod gillnet fishery in Newfoundland, a year with much reduced fishing effort relative to previous years. Bycatch reports occurred most often from July to September, but bycatch was also reported during the remainder of the year (Lawson *et al.*

2004). There were eight sightings of harbour porpoises reported in the DFO cetacean sightings database in the Hebron Nearshore Study Area (DFO 2007e; Section 10.3.1.2). Harbour porpoises are expected to be common in the Hebron Nearshore Study Area based on available reports and sighting data, at least during summer.

11.3.2.6 Leatherback Sea Turtle

The leatherback sea turtle is the largest and widest ranging of sea turtles, occurring from sub-polar foraging grounds to tropical and sub-tropical nesting areas; it is found in the world's oceans (Spotila 2004). Globally, there are an estimated 26,000 to 43,000 individuals (Dutton *et al.* 1999), but there are no estimates of the population size in Canada. Adult leatherbacks are considered regular seasonal inhabitants of Newfoundland waters (Goff and Lien 1988; Witzell 1999). Leatherback sea turtles are assessed as Endangered by COSEWIC and listed as Endangered Schedule 1 of SARA (COSEWIC 2010a). The Red List of Threatened Species lists leatherback sea turtles as Critically Endangered (IUCN 2009).

Adult leatherback sea turtles make routine migrations between temperate and tropical waters, presumably to optimize foraging in high latitudes and nesting in the tropics (Spotila 2004). In the North Atlantic, they are predominantly pelagic, with wide-ranging oceanic movements, and consume primarily gelatinous zooplankton (Hays *et al.* 2004; Eckert 2006; Witt *et al.* 2007). They nest from March to July in the Caribbean and Central and South America (Spotila 2004). Leatherbacks satellite-tagged off of Cape Breton and mainland Nova Scotia during summer months remained off eastern Canada and the northeastern US coast before migrating south in October (James *et al.* 2005). Tags remained attached to some of these animals to observe return migrations northward; animals left their nesting areas during February and March and typically arrived in the Northwest Atlantic (north of 38°N) during June. Most individuals returned to within several hundred kilometres of where they were observed during the previous year, and some individuals ranged into areas just east of St. John's and along the edge of the Grand Banks. Individuals that have been sampled in Nova Scotia areas are either large sub-adults or adults, with a significant sex-bias towards females (1.86 females:1 male) among mature individuals (James *et al.* 2007).

Leatherbacks are often observed off Nova Scotia and Newfoundland from June to October, with peak occurrence in August and September. They are the most likely sea turtle to occur within either the Hebron Nearshore or Offshore Study Area. Witzell (1999) described the distribution of sea turtles incidentally captured in the U.S. pelagic longline fishery from 1992 to 1995; nearly half of the leatherbacks caught in an area from the Caribbean to Labrador were captured in waters on and east of the 200 m isobath off the Grand Banks (although effort was also predominantly concentrated in these areas). Animals were caught in this area from June to November, but catches were highest from July to September. Twenty leatherbacks were reported off Newfoundland between 1976 and 1985, including an individual swimming amongst icebergs in Trinity Bay (Goff and Lien 1988).

Three leatherbacks were sighted during summer and fall monitoring programs in the Jeanne d'Arc Basin (Figure 11-13; Abgrall *et al.* 2008a; in prep.), and a single sighting occurred in the Downing Basin (approximately 70 NW of the Project) in June 2008 (Ledwell and Huntington 2009). There were also four leatherback sea turtle sightings within the Offshore Study Area in the DFO database (Figure 11-13; DFO 2007c). Leatherback sea turtles are expected to occur in low densities within the Hebron Offshore Study Area during summer and fall, particularly from July to September.

Leatherbacks are also known to wander into Trinity Bay during summer and fall with some regularity. As noted above, Ledwell and Huntington (2009) described several leatherback reports in Trinity Bay, occurring from August to October 2008, with the majority occurring from September 19 to 28. They have also been recorded in Trinity Bay during previous years. The available information suggests that leatherback sea turtles will occur occasionally within the Hebron Nearshore Study Area during summer and fall, particularly in August and September.

A Recovery Strategy for the Leatherback Turtle has been developed (Atlantic Leatherback Turtle Recovery Team 2006). It identifies several threats to turtles in the marine environment including entanglement in fishing gear, collisions, marine pollution, and acoustic disturbances. Critical habitat for this species has not yet been identified.

11.3.2.7 Loggerhead Sea Turtle

Loggerhead sea turtles occur in temperate and tropical areas of the Atlantic, Pacific, and Indian oceans, with the majority of nesting occurring along the western rims of the mid- and equatorial Atlantic and Indian oceans (Spotila 2004). Globally, there are an estimated 43,000 to 45,000 nesting females (Spotila 2004). Its distribution is largely constrained by water temperature and it does not generally occur where the water temperature is below 15°C (Brazner and McMillan 2008), which limits its northern range. Loggerhead sea turtles are considered Endangered by COSEWIC (2010d) and have no status under SARA. This species is listed as Endangered on the Red List of Threatened Species (IUCN 2009).

Loggerheads can migrate considerable distances between near-equatorial nesting areas that are occupied from late April to early September (Spotila 2004) and temperate foraging areas, some moving with the Gulf Stream into eastern Canada waters during the summer and fall (Hawkes *et al.* 2007). Information to date indicates a seasonal population of juvenile loggerheads in Atlantic Canada (Witzell 1999; COSEWIC 2010d) but the number occurring in Canadian waters is unknown. While foraging at sea, loggerheads likely consume gelatinous zooplankton and squid (Spotila 2004); there is no diet information available for Canadian waters (DFO 2010d).

Loggerheads may be seen in the open seas during migration and foraging. They have not been reported in the Project Area but have been reported south of the Flemish Cap in the eastern portion of the Study Area (COSEWIC 2010d). Most loggerhead records offshore Newfoundland have occurred in

deeper waters south of the Grand Banks and sightings have extended as far east as the Flemish Cap (Figures 6 and 7 in COSEWIC 2010d). None were sighted during summer and fall seismic monitoring programs in the Jeanne d'Arc Basin, although one was observed 237 km south of that area in early September 2008 (Abgrall *et al.* in prep.). While the available information suggests that loggerhead sea turtles do occur in the eastern portion of the Offshore Study Area, their presence is likely limited to small numbers and during late summer to fall.

There are no records or reports of loggerhead sea turtles occurring in Trinity Bay, or any other nearshore area of Newfoundland. It is possible that loggerhead sea turtles could occur in the Nearshore Study Area, but their presence is presumed to be very rare.

11.3.3 Marine Birds Species at Risk

There are two marine bird SAR that could potentially occur in the Hebron Nearshore and/or Offshore Study Areas: the Red Knot and Ivory Gull. No recovery strategies exist, nor have critical habitat areas been assessed, for either species.

11.3.3.1 Red Knot

Three subspecies of Red Knot (*Calidris canutus*) occur in Canada and have been assessed independently by COSEWIC (2007b): *Calidris canutus rufa* (Endangered), *Calidris canutus roselaari* (Threatened), and *Calidris canutus islandica* (Special Concern). To date, the subspecies of Red Knot (*rufa* subspecies) that occurs in Newfoundland and Labrador has not been listed on SARA Schedule 1. As a whole, Red Knot is considered of Least Concern on the Red List of Threatened Species (IUCN 2009). The breeding range of *Calidris canutus rufa* is confined to the central Canadian Arctic with primary wintering grounds located in Tierra del Fuego and Patagonia, Argentina and Chile. The subspecies *roselaari*, comprised of three subpopulations, includes two populations that winter in Florida / southeast US and northeast Brazil, which presumably breed in the central and western Canadian Arctic. *Calidris canutus islandica* breeds in the Canadian High Arctic (and Greenland) and winters along the European coast.

During migration, Red Knot prefers staging areas of sandy beaches near the mouths of bays, tidal inlets and estuaries where they feed on benthic and epifaunal bivalves and other invertebrates (Harrington 2001). On the eastern seaboard, Delaware Bay serves as an important spring staging area for *rufa* and *roselaari* knots to replenish food reserves prior to continuing northward migration. A large component of the diet of Red knots and other shorebirds at Delaware Bay are horseshoe crab (*Limulus polyhemus*) eggs (Castro and Myers 1993). Overfishing in the late 1990s has resulted in a reduction in the availability of both breeding crabs and egg densities. Consequently, reduced food availability has led to Red Knots being unable to obtain adequate energetic requirements before the flight to Arctic breeding grounds, at least in some years (Baker *et al.* 2004). The most important staging areas in eastern Canada for *rufa* knots are along the north shore of the St. Lawrence River.

The current population size for *Calidris canutus rufa* is 13,500 to 15,000 adults, based on counts from the wintering areas in Tierra del Fuego and Patagonia (COSEWIC 2007b). This represents a population decrease of 70 percent since 1982, which is supported by similar declines throughout its migration range, as opposed to a redistribution or range shift. The recent estimate for the *Calidris canutus roselaari* subpopulation wintering in Florida / southeast US is approximately 3,375 adults, a decline of 70 percent since 1982. The overall decline for this subspecies is 47 percent (COSEWIC 2007b). The population of *Calidris canutus islandica* wintering in Europe is greater than 200,000 adults, but has declined by about 17 percent since the late 1990s.

Red Knot is an uncommon southbound migrant during autumn in coastal Newfoundland. In Newfoundland, Red Knots are found on open sandy beaches, often with rotting kelp piles and extensive mud flats. Bellevue Beach, Trinity Bay, is ideal habitat for Red Knot, where it occurs annually from late August to September / October with counts ranging up to a maximum of 23 individuals (B. Mactavish, LGL Ltd., unpublished data 2009). There are no other locations of particularly good Red Knot feeding habitats in southern Trinity Bay. While Red Knot is known to occur in the Hebron Nearshore Study Area, it would not be present in the Hebron Offshore Study Area.

11.3.3.2 Ivory Gull

The Ivory Gull has a circumpolar breeding distribution and is associated with pack ice throughout the year. In Canada, Ivory Gull breeds exclusively in Nunavut. Breeding colonies occur on southeastern Ellesmere Island, eastern Devon Island and northern Baffin Island. Among Canadian waters, Ivory Gulls occur among the pack ice of the Davis Strait, the Labrador Sea, Strait of Belle Isle, and northern Gulf of St. Lawrence. The Ivory Gull is assessed as Endangered by COSEWIC, and listed as Endangered on Schedule 1 of SARA, and considered Near Threatened on the Red List of Threatened Species (COSEWIC 2010a; IUCN 2009).

In comparison to most gulls, Ivory Gulls have reduced reproductive output, in that they usually only lay one to two eggs (Haney and MacDonald 1995). They depart from colonies immediately following breeding for offshore foraging areas associated with the ice edge of permanent, multi-year pack ice. At sea, the Ivory Gull is a surface-feeder where its main prey includes small fish and macro-zooplankton. It is also an opportunistic scavenger of carrion found on ice and marine mammals killed by large predators (Haney and MacDonald 1995).

Currently, the Canadian breeding population is estimated at 500 to 600 individuals (COSEWIC 2006e). Surveys conducted from 2002 to 2005 indicate a total decline of 80 percent and an annual decline of 8.4 percent over the last 18 years. If this decline continues at a steady rate, the breeding population will decrease by a further 62 percent over the next decade, to approximately 190 individuals. A March 2004 survey conducted within the pack ice off the coast of Newfoundland and Labrador observed a decrease in

Ivory Gull observations as compared to 1978 results. The number of Ivory Gulls observed per 10-minute watch period were 0.69 and 0.02 individuals for 1978 and 2004, respectively (COSEWIC 2006e). Considering that changes to the breeding environment have been insignificant, causes for the observed decline are likely related to factors occurring during migration or on the wintering grounds (Stenhouse 2004).

During heavy ice winters, the Ivory Gull may occasionally reach the northern part of the Hebron Offshore Study Area late in the winter or early spring when sea ice reaches the maximum southern extremity. The thirty-year median of ice concentration shows ice extending into the northern edge of the Grand Banks east to 48°W from late February to late March. A total of 21 Ivory Gulls reported from drill platforms on the northeast Grand Banks from 1999 to 2002 seems improbable, especially considering that most sightings were reported during ice-free periods.

Occasional sightings of Ivory Gulls are reported along the eastern coastlines of Newfoundland and Labrador, particularly the Northern Peninsula of Newfoundland. It is considered extremely rare in and near the Hebron Nearshore Study Area because it typically winters well north of Trinity Bay. However, on 17 January 2009 a single adult Ivory Gull was observed at Islington, Trinity Bay and two adult and one immature Ivory Gull were observed nearby at Hearts Delight, Trinity Bay (B. Mactavish, LGL Limited, unpublished). These sightings were part of an unusual influx of Ivory Gulls in southern Newfoundland In January 2009.

11.4 Marine Fish Species at Risk

11.4.1 Project-VEC Interactions

Potential interactions between the Project and marine fish SAR are similar to what is described for non-listed marine fish in Chapter 7. The key difference with SAR is that the abundance and spatial and temporal presence of these species differs considerably from non-listed species. SAR are typically less abundant and are more widely dispersed in the marine environment. These factors affect the likelihood of Project activities interacting with SAR and their respective habitats.

Project activities with similar interactions on marine fish SAR have been grouped into four categories to provide a complete and comprehensive environmental effects analysis. Instead of assessing each Project activity separately, the grouping of activities with similar potential effects on Marine Fish SAR, allows for a cumulative assessment of within-Project activities.

The interactions summary categories are:

- Change in Habitat Quantity
  - Project activities that may result in physical alteration of fish habitat, and may be declared a harmful alteration, disruption or destruction (HADD) of fish habitat by DFO and require a Section 35(2) *Fisheries Act* Authorization

- Change in Habitat Quality
  - Project activities that may result in a change in the biological or physical properties of fish habitat. For example, Project activities creating suspended sediment in the water column, creating contamination, affecting a potential food source, or otherwise potentially causing sub lethal physiological effects on marine fish SAR are assessed as potential changes in fish habitat quality
- Change in Habitat Use
  - Project activities that may result in marine fish SAR changing their behaviour. Some activities may cause avoidance behaviour in fish or shellfish, whereas other activities may attract some species
- Potential Fish Mortality
  - Project activities that may result in marine fish SAR mortality

11.4.1.1 Nearshore

The primary nearshore Project activities during construction that could potentially interact with marine fish SAR include:

- Construction of the bund wall for the drydock at Great Mosquito Cove
- Subsequent removal of the bund wall and possible at-sea disposal of bund wall material
- Possible dredging along sections of the tow-out route to allow the GBS to transit to the Bull Arm deepwater site
- Dredge spoils disposal
- Underwater noise from sheet pile installation during bund wall construction, blasting and vessel traffic
- Watering and dewatering of the drydock

11.4.1.2 Offshore

Offshore Construction / Installation

The primary offshore Project activities during construction and installation that could potentially interact directly or indirectly with marine fish SAR include:

- Dredging during the construction of excavated drill centre (potential expansion opportunity)
- Dredge spoils disposal
- Site preparation activities for OLS / Platform installation
- Installation of Hebron Platform, flowlines and Offshore Loading System (OLS), concrete mattresses and/or rock cover
- Installation of subsea equipment and flowlines, including placement of flowline protection measures (rock cover, concrete mattresses), hook-up to the Hebron Platform and commissioning (potential expansion opportunity)

- Installation of subsea equipment and flowlines, including placement of flowline protection measures, hook-up to the Hebron Platform and commissioning (potential expansion opportunity)
- Vessel traffic
- Geophysical surveys (possibly seismic, geohazards and/or geotechnical surveys)

Operations / Maintenance

The primary offshore Project activities / components during operations and maintenance that could potentially interact directly or indirectly with marine fish SAR include:

- Operational discharges (*e.g.*, cooling water, storage displacement water, firewater, produced water, grey/black water (refer to Chapter 2 for all operational discharges))
- Drill cuttings and muds discharges (WBM from the Hebron Platform, WBM and SBM from mobile offshore drilling unit (MODU) drilling associated with potential expansion opportunities)
- Geophysical, geological, environmental and geotechnical surveys, as required
- Presence of Structures (*e.g.*, subsea equipment in drill centres, Hebron Platform, OLS, flowlines)

11.4.1.3 Decommissioning / Abandonment

The primary decommissioning and abandonment activities that could potentially affect marine fish SAR is the removal of structures / materials on or above the seafloor (Hebron Platform, OLS, flowlines, subsea infrastructure in drill centres). All exposed hard surfaces are expected to be colonized during the life of the Project. Removal of such structures will remove the artificial reef effect likely created by these structures, thereby reducing localized productivity. The removal of the structures may create temporary localized turbidity as well.

11.4.1.4 Accidents, Malfunctions, and Unplanned Events

During the construction and operation phases of the Hebron Project, there are several hydrocarbon products onboard vessels, barges, drill rigs and platforms. These include crude oil, diesel oil, synthetic drilling mud, synthetic drill (base) fluid, lubricating oils, and hydraulic oils. Spills may occur as a result of human error, equipment failure or loss of well control (blow-out). An oil spill, although highly unlikely, could affect marine fish SAR and potentially occur during the construction, operation and maintenance, and/or decommissioning phases of the Project.

11.4.1.5 Summary

A summary of the potential environmental effects resulting from Project-VEC interactions, including those of past, present, and likely future projects, is

provided in Table 11-3. This table includes accidents, malfunctions, and unplanned events.

Table 11-3 Potential Project-related Interactions: Marine Fish Species at Risk

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Construction				
Nearshore Project Activities				
Presence of Safety Zones (Great Mosquito Cove zone followed by a deepwater site zone)				+
Bund Wall Construction (*e.g.*, sheet / pile driving, infilling)	x	x	x	x
Inwater Blasting	x	x	x	x
Dewater Drydock / Prep Drydock Area	x	x	x	
Concrete Production (floating batch plant)		x		
Vessel Traffic (*e.g.*, supply, tug support, tow, diving support, barge, passender ferry to / from deepwater site)		x	x	
Lighting			x	
Air Emissions				
Re-establish Moorings at Bull Arm deepwater site		x	x	
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	x	x	x	x
Removal of Bund Wall and Disposal (dredging / ocean disposal)	x	x	x	x
Tow-out of GBS to Bull Arm deepwater site		x	x	
GBS Ballasting and De-ballasting (seawater only)		x	x	
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site		x	x	
Hook-up and Commissioning of Topsides		x	x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	x
Platform Tow-out from Deepwater site		x	x	
Offshore Construction / Installation				
Safety Zone				+
OLS Installation and Testing	x	x	x	x
Concrete Mattress Pads/Rock Dumping over OLS Offloading Lines	x	x	x	
Installation of Temporary Moorings		x	x	
Platform Tow-out / Offshore Installation			x	
Underbase Grouting		x		
Possible Offshore Solid Ballasting		x		
Placement of Rock Scour Protection on Seafloor around Final Hebron Platform Location	x	x	x	
Hookup and Commissioning of Hebron Platform		x		
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)		x	x	
Air Emissions				
Lighting			x	
Potential Expansion Opportunities				
Presence of Safety Zone				+
Excavated Drill Centre Dredging and Spoils Disposal	x	x	x	x
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	x	x	x	x
Hook-up and Commissioning of Drill Centres		x	x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	x
Offshore Operations and Maintenance				
Presence of Safety Zone				+
Presence of Structures	x	x	x	

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Lighting			x	
Maintenance Activities (*e.g.*, diving, ROV)			x	
Air Emissions				
Flaring				
Wastewater (*e.g.*, produced water, cooling water, storage displacement water), deck drainage		x	x	
Chemical Use / Management/Storage (*e.g.*, corrosion inhibitors, well treatment fluids)		x	x	
WBM Cuttings	x	x	x	
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)		x	x	
Surveys (*e.g.*, geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)		x	x	x
Potential Expansion Opportunities				
Presence of Safety Zone			x	+
Drilling Operations from MODU at Future Excavated Drill Centres	x	x	x	
Presence of Structures	x	x	x	
WBM and SBM cuttings	x	x	x	
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)		x	x	
Geophysical/Seismic Surveys		x	x	x
Offshore Decommissioning / Abandonment				
Presence of Safety Zone			x	x
Removal of the Hebron Platform and OLS Loading Points	x	x	x	x
Lighting			x	
Plugging and Abandoning Wells		x	x	
Abandoning the OLS Pipeline		x	x	
Operation of Helicopters				
Operation of Vessels (supply, support, standby and tow vessels / ROVs)		x	x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	x
Accidents, Malfunctions and Unplanned Events				
Bund Wall Rupture		x		x
Nearshore Spill (at Bull Arm Site)		x	x	x
Failure or Spill from OLS		x	x	x
Subsea Blow-out		x	x	x
Crude Oil Surface Spill		x	x	x
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform)		x	x	x
Marine Vessel Incident (*i.e.*, fuel spills)		x	x	x
Collisions (involving Hebron Platform, vessel, and/or iceberg)		x	x	x
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (HSE) (drilling and production)		x	x	
Terra Nova Development (production)		x	x	
White Rose Oilfield Development and Expansions (drilling and production)		x	x	
Offshore Exploration Drilling Activity		x	x	
Offshore Exploration Seismic Activity		x	x	
Marine Transportation (Nearshore and Offshore)		x	x	
Commercial Fisheries (Nearshore and Offshore)	x	x	x	x
+ indicates a positive interaction and possible decrease in mortality				

11.4.2 Environmental Effects Analysis and Mitigation Measures

Potential environmental effects of the Project on non-listed marine fish species are assessed and described in detail in Section 7.5. Many of the issues of concern with respect to environmental effects for SAR, as well as mitigation measures and management strategies, are similar to those presented for non-listed marine fish species in the Nearshore and Offshore Study Areas. On an ecosystem basis, the listed and non-listed species and their habitats are often highly integrated.

11.4.2.1 Construction and Installation

Change in Habitat Quantity

Nearshore

The predicted change in marine fish habitat quantity as a result of Project activities in the nearshore is assessed in Section 7.5.1.1. As stated in this section, while construction of the bund wall, dredged areas and any in-water dredge spoil disposal areas may be declared a habitat alteration, disruption and destruction (HADD) by DFO, a habitat compensation program will be developed in conjunction with DFO and area fishers as a mitigation measure for the net loss of fish habitat resulting from the Hebron Project.

The marine fish SAR species most likely to occur in the Hebron Nearshore Study Area include Atlantic cod, American plaice, and American eel. In addition, Atlantic wolffish may occur. For all of these species, habitat in the Nearshore Project Area has not been assessed as critical habitat. Habitat compensation programs may be designed to address SAR and/or non-listed fish species. Portions of the remaining bund wall, if 80 to 90 percent boulder, may create potential Atlantic wolffish spawning habitat.

Offshore

Activities affecting habitat quantity during offshore construction include Hebron Platform and OLS installation / protection, flowline installation and excavated drill centre construction. The predicted change in marine fish habitat quantity as a result of Project activities in the offshore is also assessed in Section 7.5.1.1. As with the nearshore and in accordance with the DFO policy of no net loss of fish habitat, a habitat compensation program will be developed in conjunction with DFO and area fishers as a mitigation measure for the net loss of fish habitat resulting from the Hebron Project.

The marine fish SAR species known to occur in the Offshore Study Area include Atlantic cod, American plaice, Atlantic wolffish, northern wolffish, and spotted wolffish. Porbeagle shark may occur, while the other species considered in this assessment are not likely to occur in this area.

For each of these species, the Hebron Offshore Project Area, which encompasses the extent of any change in habitat quantity as a result of Project activities, is of lesser importance to these species in terms of distribution and productivity than other regions within the Hebron Offshore

Study Area. The Hebron Offshore Project Area has not been identified as critical habitat for any of these species.

With the proposed habitat compensation program, the predicted recovery of benthic communities and general productivity of disturbed areas after several generations and the lower importance of the Project Area to these species, any reduction of habitat quantity as a result of Project activities will be of minimal importance to the marine fish SAR.

Change in Habitat Quality

Nearshore

There are several Project activities in the nearshore that could affect the quality of fish habitat for marine fish SAR. Bund wall construction and removal, drydock dewatering, concrete washwater discharge, dredging, blasting and pile driving are the primary nearshore construction activities which could affect the quality of fish habitat in the Nearshore Project Area. The potential effects of these activities include suspended sediment, contamination, and noise and blasting. These effects are fully assessed in Section 7.5.1.2 and mitigation is proposed. This assessment and mitigation is considered applicable to the marine fish SAR species that may occur in the nearshore.

As stated in Section 7.5.1.2, shellfish and eggs and larvae of shellfish and finfish are more susceptible to the effects of sedimentation. Fish SAR are not known to spawn within the Hebron Nearshore Study Area, but newly settled juvenile cod are known to occur and Atlantic wolffish were observed in potential spawning habitat (80 to 90 percent boulder habitat). The localized area of effect from suspended solids and the high potential for reversibility will limit the magnitude of effects as a result of sedimentation.

The EEM results within Bull Arm during the Hibernia GBS construction phase (Christian and Buchanan 1998) tested for the effects of contamination and indicated no detectable effect on fish health as measured by Mixed Function Oxygenase activity, histopathology, bile metabolites or gill parasitism. Mitigation measures will be in place to reduce the risk of contamination during nearshore construction.

With respect to noise and blasting, fish with swim bladders and specialized auditory couplings to the inner ear (*e.g.*, herring) are considered to be most sensitive to sound pressure. Fish with a swim bladder but without a specialized auditory coupling (*e.g.*, Atlantic cod) are moderately sensitive, while fish with a reduced or absent swim bladder (*e.g.*, wolffish, American plaice and American eel) have low sensitivity (Fay 1988).

In-water blasting will be temporary and will be governed by a series of mitigation measures designed to reduce potential effects on marine fish SAR (including wolffish). Any blasting that may be required will adhere to DFO's *Guidelines for Use of Explosives in Canadian Fisheries Waters* (Wright and Hopky 1998).

Offshore

There are several construction and installation activities in the Offshore Project Area that could affect the quality of fish habitat. Installation of the OLS, flowlines, and Hebron Platform; and geophysical surveys (possibly seismic, VSP, geohazard surveys and/or geotechnical surveys) are the primary offshore construction activities which could affect the quality of fish habitat. Dredging of excavated drill centres and spoils disposal (a potential expansion opportunity) could also potentially affect the quality of fish habitat. The potential effects of these activities include suspended sediment, contamination and noise. These effects are assessed in Section 7.5.1.2 for non-listed fish species. This assessment along with the proposed mitigation measures are considered equally applicable to the protection of marine fish SAR. Seismic activities associated with the Project will adhere to the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment,* as referenced in the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011).

Change in Habitat Use

Nearshore

The increased noise and activity levels associated with dredging, bund wall construction, vessel traffic, blasting, lights and surveys (*e.g.*, geophysical, geohazard, geotechnical, environmental) may affect habitat use by causing avoidance or attraction of marine fish SAR. These effects and potential mitigation are fully discussed in Section 7.5.1.3 for non-listed fish species and are considered applicable to marine fish SAR.

Acoustic modelling of pile driving and blasting at the drydock site in Great Mosquito Cove was conducted. The pile driving model estimated a source level of 216 dB re 1 µPa @ 1 m and that a sound pressure of >190 dB re 1 µPa (rms) will extend to approximately 300 to 400 m from the bottom of Great Mosquito Cove, depending on distance of the bund wall from the shoreline (JASCO 2010). Underwater noise levels from a tug vessel were estimated at 185 dB re µPa @ 1 m during transit and as 193 dB re µPa @ 1 m when the vessel is doing an anchor pull. These are conservative assumptions used for modelling (JASCO 2010). The sound pressure level emitted by the tug is not expected to cause any physical injury to fish, since the 193 dB is the maximum sound pressure expected within 1 m of the tug's propeller (see JASCO 2010). There is limited risk of these interactions occurring given that fish are expected to avoid the area near in-water construction activity.

If blasting were required in Great Mosquito Cove (to provide adequate draft or channel width for the GBS tow-out to the deepwater site), results of acoustic modelling for the largest single charge that is permissible under the DFO 100 kPa overpressure guideline (Wright and Hopky 1998) indicate that greater than 200 dB re 1 uPa (rms) sound exposure levels would occur for approximately 50 m from the blast source, and that sound pressures of between 190 and 199 dB re 1 uPa (rms) sound levels would occur from the

mouth of Great Mosquito Cove to the eastern side of Bull Arm (JASCO 2010). Sound exposure levels in excess of 214 dB re 1 uPa (rms) are not expected from this blasting scenario and therefore, injury to egg and larval stages is not expected (Turnpenny and Nedwell 1994). However, egg masses located in the potential Atlantic wolffish spawning habitat may be subject to increased predation if male Atlantic wolffish abandon the nest due to noise.

Most available literature indicates that the effects of noise on fish are transitory, and if short-lived and outside a critical period, are expected not to translate into biological or physical effects. In most cases, it appears that behavioural effects on marine fish SAR (including Atlantic wolffish) as a result of noise should result in negligible effects on individuals and populations.

Offshore

Dredging of excavated drill centres and spoils disposal; installation of the OLS, flowlines, and Hebron Platform; and geophysical, seismic, geohazard and/or geotechnical surveys) are the primary offshore construction activities which could affect the behaviour of marine fish SAR and therefore habitat use. Seismic surveys are expected to produce the highest levels of sound pressure of all the geophysical surveys proposed for this Project. The effects of seismic activities on habitat use in the offshore environment are fully discussed in Section 7.5.1.3, along with proposed mitigation. While this discussion is in the context of non-listed fish species, it is also considered applicable to marine fish SAR.

Atlantic cod may also occur within the Hebron Offshore Project Area. Although cod is being re-assessed by COSEWIC, it is not a species listed under Schedule 1 of SARA. Compared to other species, cod is considered a moderately sensitive species in terms of hearing. A measurable behavioural response is anticipated in the range of 160 to 188 dB re 1 µPa (Turnpenny and Nedwell 1994), likely a temporary avoidance of the immediate area around the noise. DFO (2004a) concludes that some fish exposed to seismic sounds are likely to exhibit a startle response, a change in swimming pattern and/or a change in vertical distribution. However, these effects are expected to be short term and of low ecological significance except where fish reproductive activity may be affected. The greatest risk from noise would also apply to cod eggs and larvae near the surface. Cod larvae may be present on the northern Grand Banks from May to July (Dalley *et al.* 2000). Cod have not spawned near the Offshore Project Area in recent years, but have done so historically (Ollerhead *et al.* 2004).

Wolffish may also occur within the Hebron Offshore Project Area, although in lower densities than elsewhere in the Hebron Offshore Study Area. The Recovery Strategy for Northern Wolffish and Spotted Wolffish and Management Plan for Atlantic Wolffish in Canada (Kulka *et al.* 2007) specifically addresses the potential effects of seismic activity on wolffish. While the report concludes that the impact of seismic activity needs to be quantified with respect to wolffish and their habitat and little is known about the possible effect on wolffish species at any stage of their life history, it is acknowledged that there are no documented cases of mortality of any fish

species upon exposure to seismic sound under field operating conditions (DFO 2004b).

The life stage most likely to be affected by seismic activity is the near surface larval stages. Adults and eggs are generally found on or near bottom at distances of 100 to 900 m away from the surface, reducing the potential for any harm from seismic activities. Therefore, there is a greater potential for effects from seismic activity that overlaps with periods of larval hatching. Kulka *et al.* (2007) speculate that it is possible that wolffish adults guarding nests could leave the area of disturbance to the detriment of the egg cluster, although there is no information to confirm potential effects for wolffish.

Seismic activities associated with the Project will adhere to the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011).

Potential Mortality

Nearshore

Mortality of marine fish SAR during nearshore construction could result from dredging, spoils disposal, bund wall construction and blasting. These effects and proposed mitigation are fully described in Section 7.5.1.4. Past construction experience with the Hibernia Project indicates that suspended sediment levels are unlikely to reach the levels required to incur mortality in finfish (Christian and Buchanan 1998).

The blasting program in the nearshore will be designed to minimize the risk of mortality to fish. Nearshore and in-water blasting will adhere to DFO's Guidelines for Use of Explosives in Canadian Fisheries Waters (Wright and Hopky 1998), which is designed to mitigate fish mortality. In-water sound exposure levels in excess of 214 dB re 1 uPa (rms) are not expected from this blasting scenario (see JASCO 2010) and therefore, fish mortality of marine fish SAR (including Atlantic wolffish) is not expected (Turnpenny and Nedwell 1994).

Offshore

Dredging of excavated drill centres and spoils disposal; installation of the OLS, flowlines, and Hebron Platform; and geophysical, seismic, geohazard and/or geotechnical surveys) have the potential to cause mortality of marine fish SAR. These effects and proposed mitigation are fully described in Section 7.5.1.4 in the context of non-listed marine fish.

Mortality of finfish is unlikely due to increased suspended solids. If elevated levels of suspended solids result from dredging operations before or during a plankton bloom, a localized decrease in primary productivity could result from the inhibition of light penetration. In turn, the food supply for pelagic life stages of fish SAR could be diminished. This could have a localized effect on prey selection for juveniles in some fish species. Juvenile American plaice are the mostly likely fish SAR to be exposed to elevated suspended solids.

Wolffish species and Atlantic cod spawning areas are outside potential dredging areas (Kulka *et al.* 2007, DFO 2009c).

The environmental effects of the Project during the construction and installation phase and the mitigations to be implemented are summarized in Table 11-4. Where there is more than one potential effect, the evaluation criteria rating is assigned to the effect with the greatest potential for harm.

Table 11-4 Environmental Effects Assessment: Construction and Installation - Marine Fish Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Project Activities							
Presence of Safety Zones (Great Musquito Cove zone followed by a deepwater site zone)	• Potential decrease in Mortality (+)		1	2	2/6	R	2
Bund Wall Construction (*e.g.*, sheet / pile driving, infilling)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Bubble curtains or in-water siltation control meadures, if feasible • HADD authorization and compensation • Investigate feasibility of using washed-rock in bund wall construction	1-3	1	3/1	R	2
Inwater Blasting	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adherence with *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* • Bubble curtains, if required • Compliance with terms of Section 32 *Fisheries Act* authorization (if required)	1-3	2	2/1	R	2
Dewater Drydock and Prep of Drydock Area	• Change in Habitat Quality • Change in Habitat Use		1	1	2/1	R	2
Concrete Production (floating batch plant)	• Change in Habitat Quality	• Washwater from the cleaning of mixers, mixer trucks and concrete delivery systems will be directed to a settling basin • The settling basin will be cleaned on an as required basis to ensure that the retention capacity is maintained at all times	1	1	3/3	R	2
Vessel Traffic (*e.g.*, supply, tug support, tow, diving support, barge.)	• Change in Habitat Quality • Change in Habitat Use	• Vessels will use steady speed thereby minimizing noise.	1	1	3/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Lighting	• Change in Habitat Use		1	1	3/6	R	2
Re-establish Moorings at Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	1	2/1	R	2
Dredging of Bund Wall and Possibly Sections of Tow-out Route (may require at-sea disposal)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Investigate use of in-water siltation control • Fish Habitat Compensation	1	1	2/1	R	2
Removal of Bund Wall and Disposal (dredging / ocean disposal).	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• In-water siltation control measures, if feasible • Compliance with terms of Section 32 *Fisheries Act* authorization (if required)	1	2	2/1	R	2
Tow-out of GBS to Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	1	1/1	R	2
GBS Ballasting and De-ballasting (seawater only)	• Change in Habitat Quality • Change in Habitat Use	•	1	1	1/1	R	2
Complete GBS Construction and Mate Topsides at deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	1	2/2	R	2
Hook-up and Commissioning of Topsides	• Change in Habitat Quality	• EMCP will implement a chemical management system, similar to one used during operations offshore	1	1	2/2	R	2
Surveys (*e.g.*, geophysical, geotechnical, environmental)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Surveys will only use the power required to attain the data , therby minimizing noise. • Adherence to the Statement	1	1	2/1	R	2
Platform Tow-out from deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	1	3/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Offshore Construction / Installation							
Presence of Safety Zone	• Potential descrease in Mortality (+)		1	2	3/6	R	2
OLS Installation and Testing	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Minimal seabed disturbance, where possible • EMCP will implement a chemical management system • Adherence to relevant regulations	1	2	2/1	R	2
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines	• Change in Habitat Quantity • Change in Habitat Use • Change in Habitat Quality	• Minimal seabed disturbance, where possible • EMCP will implement a chemical management system • Adherence to relevant regulations	1	2	2/1	R	2
Installation of Temporary Moorings	• Change in Habitat Quality • Change in Habitat Use		1	1	2/1	R	2
Platform Tow-out / Offshore Installation	• Change in Habitat Use		1	4	2/6	R	2
Underbase Grouting	• Change in Habitat Quality	• Use of best practices, continous improvement programs and best available technology	1	1	2/1	R	2
Possible Offshore Solid Ballasting	• Change in Habitat Quality		1	1	2/1	R	2
Placement of Rock Scour Protection on Seafloor around Final Platform Location	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use		1	1	2/1	R	2
Hookup and Commissioning of Platform	• Change in Habitat Quality		1	1	2/1	R	2
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / diving / ROVs)	• Change in Habitat Quality • Change in Habitat Use		1	2	3/6	R	2
Lighting	• Change in Habitat Use		1	1	3/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Potential Future Expansion Opportunities							
Presence of Safety Zone	• Potential decrease in Mortality (+)		1	2	3/6	R	2
Excavated Drill Centre Dredging and Spoils Disposal	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Fish Habitat Compensation	1	2	2/1	R	2
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Minimal seabed disturbance (including seabed debris survey), where possible • Fish Habitat Compensation	1	2	2/1	R	2
Hook-up and Commissioning of Drill Centres	• Change in Habitat Quality • Change in Habitat Use	• All chemicals will be screened in accordance with EMDC chemical selection management protocols	1	2	2/2	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adhere to *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (C-NLOPB 2011)	1	2	2/1	R	2

KEY

Magnitude:
1 = Low: <10 percent of thepopulation or habitat in the Study Area will be affected.
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected.
3 = High: >25 percent of the population or habitat in the Study Area will be affected.

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

No significant residual adverse environmental effects on marine fish SAR from construction and installation activities nearshore and offshore are expected. Effects are generally low in magnitude, of limited geographic extent and reversible. Project environmental effects are not expected to contravene the prohibitions of SARA (Sections 32(1), 33, 58(1)).

11.4.2.2 Operations and Maintenance

Change in Habitat Quantity

The potential effects of the Project during the operations and maintenance phase on fish habitat quantity will result from the presence of new subsea structures and WBM drill cuttings. There may also be environmental effects associated wit WB and SBM cuttings discharge from a potential future MODU. Primarily the Hebron Platform, and the rock mattress and/or concrete mattress cover over the flowline and OLS will provide new hard substrate habitat to be colonized and perform as an artificial reef. This is more fully discussed in Section 7.5.2.1. No adverse environmental effects are likely for marine fish SAR as a result of changes in habitat quantity during Project operations and maintenance.

The placement of physical structures on or in the bottom substrate / water column could affect wolffish habitat although in a very spatially limited manner compared to the widespread distribution of wolffish and their habitat (Kulka *et al.* 2007). Wolffish and cod are the most likely marine fish SAR to be attracted by the habitat complexity introduced by subsea structures like flowlines and rock piles, but the attraction may be offset by avoidance at other subsea structures during drilling and dredging activities due to sound. If wolffish or cod are attracted to the structures, the Safety Zones around each structure (minimum of 500 m) should eliminate the chance of individuals being caught in commercial by-catch while they remain in the area.

The environmental effects of excavated drill centre construction are discussed in Section 7.5.1.2. It is anticipated that the same potential environmental effects on non-species at risk marine fish would be applicable to marine fish SAR.

Change in Habitat Quality

Operational discharges (WBMs, seawater discharges, storage displacement water, produced water, drill cuttings, grey and black water; drains) could affect habitat quality for marine fish SAR. In addition, the environmental effect of the discharge of cuttings from a MODU at future excavated drill centres could also affect habitat quality of marine fish SAR. The effects of both drilling and liquid discharges are fully discussed in Section 7.5.2.2 in the context of non-listed fish species. This discussion, along with the proposed mitigation is considered applicable to marine fish SAR.

The environmental effects of drill cuttings discharge from MODU drilling on fish habitat quality are discussed in Section 7.5.2.2. It is anticipated that the same potential environmental effects on non-species at risk marine fish would be applicable to marine fish SAR.

Change in Habitat Use

During the Hebron Project operations and maintenance phase, there is potential for noise generated by geophysical surveys, dredging, vessel traffic, and drilling to affect marine fish SAR habitat use. In addition, the environmental effect of the discharge of cuttings from a MODU at future excavated drill centres could also affect habitat use of marine fish SAR. These effects are fully assessed in Section 7.5.2.3 in the context of non-listed species and this discussion is considered applicable to marine fish SAR.

Since wolffish, cod and plaice are benthic species, they are not expected to be attracted to the surface by increased illumination due to the rig and vessel lights or flares. There are no reports of the porbeagle shark being attracted to lights.

The environmental effects of noise from MODU drilling are discussed in Section 7.5.2.3. It is anticipated that the same potential environmental effects on non-species at risk marine fish would be applicable to marine fish SAR.

Potential Mortality

Seismic surveys have the potential to cause mortality of larval stages of native fish SAR. These effects and proposed mitigation are fully described in Section 7.5.1.4. Operational discharges of WBMs are not likely to result in mortality of marine fish SAR given the motility of each of the species. The presence of a Safety Zone may in effect serve to as a refuge for marine fish SAR.

11.4.2.3 Summary of Environmental Effects of Operation and Maintenance Activities on Marine Fish Species at Risk

The environmental effects of the Project during the operations and maintenance phase and the mitigations to be implemented are summarized in Table 11-5. Where there is more than one potential effect, the evaluation criteria rating is assigned to the effect with the greatest potential for harm.

Operations and maintenance activities are not expected to result in any significant adverse environmental effects on marine fish SAR and habitat. Environmental effects are generally low in magnitude, limited in geographic extent and reversible. The presence of structures and Safety Zones will create reef and refuge effects, respectively. Results from the EEM programs at Hibernia, White Rose and Terra Nova have confirmed the respective assessment predictions of no significant environmental effect on the marine environment for those production projects.

Table 11-5 Environmental Effects Assessment: Operations and Maintenance – Marine Fish Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Offshore Operations and Maintenance							
Presence of Safety Zone	• Potential decrease in Mortality (+)		1	2	5/6	R	2
Presence of Structures	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use	• Minor positive reef effect, no mitigation required	1	1	5/6	R	2
Lighting	• Change in Habitat Use		1	1	5/6	R	2
Maintenance Activities (*e.g.*, diving, ROV)	• Change in Habitat Use		1	1	5/3	R	2
Wastewater (*e.g.*, produced water, cooling water, storage displacement water, deck drainage)	• Change in Habitat Quality • Change in Habitat Use		1	2	5/6	R	2
Chemical Use / Management / Storage (*e.g.*, corrosion inhibitors, well treatment fluids)	• Change in Habitat Quality • Change in Habitat Use	• Screening of chemical in accordance with EMDC's chemical management system	1	2	5/6	R	2
WBM Cuttings	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use	• Re-use of drill mud	1	2	5/2	R	2
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)	• Change in Habitat Use • Change in Habitat Quality		1	1	5/6	R	2
Surveys (*e.g.*, geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adhere to the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (C-NLOPB 2011)	1	3	3/2	R	2
Potential Expansion Opportunities							
Presence of Safety Zone	• Potential decrease in Mortality (+) • Change in Habitat Use (+)		1	2	5/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Drilling Operations from MODU at Future Excavated Drill Centres	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use		1	1	3/6	R	2
Presence of Structures	• Change in Habitat Quantity • Change of Habitat Quality • Change of Habitat Use		1	1	5/6	R	2
WBM and SBM Cuttings	• Change in Habitat Quantity • Change in Habitat Quality		1	2	5/6	R	2
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)	• Change in Habitat Quality • Change in Habitat Use	• Screening of chemical in accordance with EMDC's chemical management system	1	1	5/6	R	2
Geophysical / Seismic Surveys	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adhere to *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (C-NLOPB 2011)	1	3	3/2	R	2

KEY

Magnitude:
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2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected.
3 = High: >25 percent of the population or habitat in the Study Area will be affected.

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects.

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

ExxonMobil Canada Properties (EMCP) will monitor the SARA registry. If new species that are likely to occur in the Study Areas are added to Schedule 1, or if recovery strategies or monitoring plans are implemented, mitigation measures will be reviewed and updated where required, to ensure that they meet their requirements of the SARA.

11.4.2.4 Offshore Decommissioning and Abandonment

The Hebron Project will be decommissioned and abandoned according to C-NLOPB requirements and *Newfoundland Offshore Petroleum Production and Conservation Regulations* and any other applicable laws and industry practices at that time.

Change in Habitat Quantity

The removal of offshore subsea infrastructure during Project decommissioning and abandonment may affect the quantity of fish habitat in the Hebron Offshore Project Area for marine fish SAR present at that time; however, of less magnitude and geographic extent than during Project construction (see Section 7.5.1.1). The removal of the Hebron Platform, rock and/or concrete mattress cover structures over the OLS and or flowlines, will remove the reef and refuge effect that these structures created.

Change in Habitat Quality

Project decommissioning and abandonment activities may affect the quality of habitat for the marine fish SAR present at that time during the removal of subsea structures through vessel noise and suspended sediments. The environmental effects of these activities are expected to be similar in nature to those of construction, but of less magnitude and geographic extent. Potential effects of noise and suspended sediments on fish habitat quality are discussed in Section 7.5.3.2.

Change in Habitat Use

Project decommissioning and abandonment activities could affect the behaviour of marine fish SAR present at that time and therefore habitat use. The noise and underwater activity required for removal of subsea structures (*e.g.*, OLS, flowlines and wellhead) will be similar in nature to those of construction, but of less magnitude and geographic extent. Potential effects of noise and underwater activity on fish habitat use are discussed in Section 7.5.3.3.

Potential Mortality

Project decommissioning and abandonment activities have the potential to cause mortality of marine fish SAR present at that time during the removal of subsea structures. Activities will be similar in nature to those of construction, but of less magnitude and geographic extent. Potential for underwater construction activity to cause mortality of fish is discussed in Section 7.5.3.4.

A minor negative environmental effect could result from the removal of a Safety Zone around the Hebron Platform, OLS and flowlines. The refuge effect created by the Safety Zone for some species will be removed upon Project decommissioned and abandoned.

The environmental effects of the Project during the decommissioning and abandonment phase and the mitigations to be implemented are summarized in Table 11-6. Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm.

Table 11-6 Environmental Effects Assessment: Decommissioning and Abandonment – Marine Fish Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Safety Zone	• Potential Mortality • Change in Habitat Use		1	2	3/6	R	2
Removal of the Platform and OLS Loading Points	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Use of best practices, continous improvement programs and best available technology	1	2	2/1	R	2
Lighting	• Change in Habitat Use	• Use of best practices, continous improvement programs and best available technology	1	1	3/5	R	2
Plugging and Abandoning Wells	• Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continous improvement programs and best available technology	1	1	3/2	R	2
Abandoning the OLS Pipeline	• Change in Habitat Quality • Change in Habitat Use	• Use of best practices, continous improvement programs and best available technology	1	2	3/1	R	2
Operation of Vessels (supply, support, standby and tow vessels / barges / ROVs)	• Change in Habitat Quality • Change in Habitat Use	• Excessive power will not be used therefore reducing noise	1	3	3/6	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adhere to the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (C-NLOPB 2011)	1	3	3/2	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context

KEY

Magnitude:
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

Decommissioning and abandonment activities are not expected to result in any significant adverse environmental effects on the marine fish SAR present at that time and their associated habitat. Environmental effects are generally low in magnitude, limited in geographic extent and reversible.

11.4.3 Accidents, Malfunctions and Unplanned Events

The environmental effect of an accidental release of hydrocarbons without the implementation of control measures in the Hebron Nearshore and Offshore Study Areas on marine fish and fish habitat is fully assessed in Section 7.5.4. This assessment is considered applicable to SAR.

11.4.3.1 Change in Habitat Quantity

As described in Section 7.5.4.1, Habitat Quality (nearshore and offshore) could be affected by an uncontained release of marine diesel or IFO-180 or from a blowout offshore. In addition, an accidental release of cuttings and muds (WBMs and/or synthetic-based muds (SBMs)) would likely be contained within the cuttings footprint resulting from routine drilling activities, so would not be considered a loss of available habitat to marine SAR.

11.4.3.2 Change in Habitat Quality

As described in Section 7.5.4.2, the quality of fish habitat is most vulnerable to a diesel spill in the Nearshore Study Area. In the unlikely event of spill (and in the unlikely absence of a spill response), diesel fuel is expected to

reach the shoreline (see Section 14.2). The quality of habitat for marine fish SAR would be most affected by the toxic effects of diesel on potential prey items in shallow subtidal habitats. American plaice are the most likely marine fish SAR to use shallow subtidal habitats within the Nearshore Study Area.

The quality of marine fish SAR habitat in the Nearshore and Offshore Study areas may also be affected by a spill on the surface of the water where eggs or larvae within the slick may experience sub lethal effects, depending on concentration and duration of exposure to hydrocarbons. Depending on the magnitude and extent of a surface spill, pelagic life stages of American plaice or wolffish may be present in the Nearshore and Offshore Study Areas.

In the unlikely event of a subsea blow-out in the Offshore Study Area, the quality of habitat for marine fish SAR is compromised by hydrocarbons in surficial sediments on the seafloor. The availability and condition of prey for American plaice and wolffish would potentially be affected by a subsea blow-out.

Tracker buoy data collected during the 2004 Terra Nova spill indicated that it took five weeks for the buoy to reach 40.00.0W and approximately 48.00.00N in November / December (and basically confirmed the oil spill trajectory modelling results conducted to date for the Grand Banks oil developments). If an uncontrolled spill (*i.e.*, no spill countermeasures implemented) lasted more than 120 days, the modelling predicts that oil from a surface or sub-surface blow-out at the Hebron Platform will extend beyond the model domain area and, therefore, could potentially (less than 10 percent probability) reach an international coastline with a thickness greater than 0.01 mm (*i.e.*, a sheen). However, any oil that did reach an international shoreline would be patchy, weathered oil.

11.4.3.3 Change in Habitat Use

As described in Section 7.5.4.3, an accidental event in the Nearshore or Offshore Study areas could cause a change in fish behaviour and thus affect use of a particular habitat. Juvenile and adult finfish have been known to avoid contaminated areas (Irwin 1997). The ability of fish to avoid a contaminated area must be considered within the context of their habitat requirements. Presumably, if fish were avoiding an area of contamination, they would seek the next uncontaminated area of similar habitat. The habitat seeking behaviour may have consequences on the mortality rates of juvenile fish through predation and on the success of foraging of all life stages, if alternate habitats are not readily available. This scenario is more applicable to the Nearshore Study Area; however, since a spill offshore is unlikely to affect benthic habitat use.

11.4.3.4 Potential Mortality

Fish and shellfish mortality in the Nearshore Project Area may result from the unlikely event of a rupture in the bund wall. Depending on the rate of collapse of the bund wall, some fish near the rupture point maybe entrained in the

surge of water into the drydock area. Fish outside the immediate entrainment area would likely avoid the risk.

In the unlikely event of a spill in either the Nearshore or Offshore Study Areas, lethal effects on eggs and larvae are more likely during an oil spill than adult fish mortality. Eggs and larvae tend congregated in the upper water column where they maybe directly exposed if they occur at the same time and in the same space as an oil spill. This is fully discussed in Section 7.5.4.4. Given the high rate of natural mortality of eggs and larvae, the environmental effects of a localized spill would be undetectable, and recruitment to a population would not be affected unless more than 50 percent of the larvae in a large portion of a spawning area were lost (Rice 1985).

Oil spill prevention will be incorporated into the design and operations of the Hebron Project. All offshore systems and structures, procedures and programs will be designed with consideration of preventing the loss of any hydrocarbons or chemicals. EMCP will also undertake all of the necessary planning, training, and exercising to ensure that the appropriate spill response capability is in place for all phases of the Project, in the unlikely event of an accident release. Oil spill response will be included as part of the contingency planning undertaken for the Project.

The environmental effects of the potential accidental events and the mitigations to further reduce the likelihood of occurrence and potential effects is summarized in Table 11-7. Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm.

Due to the reversibility and limited duration of an accidental event, potential residual environmental effects of a spill (hydrocarbon or chemical), blow-out or bund wall rupture on marine fish SAR and fish habitat is considered adverse but not significant and not likely to occur. Natural recruitment is expected to re-establish the population to its original level and avoidance of the area is expected to be temporary should an accidental event occur.

Table 11-7 Environmental Effects Assessment: Accidental Events – Marine Fish Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Bund Wall Rupture	• Change in Habitat Quality • Potential Mortality	• Prevention through design standards and maintenance • Emergency Response Contingency Plan	1	1	1/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Spill (at Bull Arm Site)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Emergency Response Contingency Plan • Spill Response Plan	1	3	2/1	R	2
Failure or Spill from OLS	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance • Emergency Response Contingency Plan • Spill Response Plan	1	5	2/1	R	2
Subsea Blow-out	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance • Emergency Response Contingency Plan • Spill Response Plan	2	5	3/1	R	2
Crude Oil Surface Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Emergency Response Contingency Plan • Spill Response Plan • Prevention through design standards and maintenance	1	5	2/1	R	2
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Emergency Response Contingency Plan • Spill Response Plan	1	1	2/1	R	2
Marine Vessel Incident (*i.e.*, fuel spills)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Emergency Response Contingency Plan • Spill Response Plan • Ship operations will adhere to Annex I of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78)	1	35	2/1	R	2
Collisions (involving Platform, vessel, and/or iceberg)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Prevention through design standards and maintenance	1	3	2/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context

KEY

Magnitude:
1 = Low: <10 percent of the population or habitat in the Study Area will be affected.
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected.
3 = High: >25 percent of the population or habitat in the Study Area will be affected.

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

11.4.4 Cumulative Environmental Effects

11.4.4.1 Nearshore

Cumulative environmental effects on marine fish SAR and fish habitat in the Hebron Nearshore Study Area could occur as a result of the proposed Project in combination with commercial fisheries, which can contribute to physical disturbance during trawling and noise effects, and marine transportation, which can contribute to contamination and noise effects.

It is unlikely that nearshore routine activities associated with marine transportation would have much adverse direct environmental effects on marine fish SAR and fish habitat within the Nearshore Study Area. There is some recreational marine transportation, but other than commercial fisheries-related transportation; there is little commercial vessel traffic within the Nearshore Study Area.

11.4.4.2 Offshore

In the Hebron Offshore Study Area, cumulative environmental effects on marine fish SAR and fish habitat could occur as a result of the proposed Project in combination with the following activities:

- Hibernia Oil Development and Hibernia Southern Extension (drilling and production)
- Terra Nova Development (drilling and production)
- White Rose Oilfield Development and Expansions (drilling and production)
- Offshore exploration drilling activity
- Offshore exploration seismic activity
- Marine transportation and
- Commercial fisheries

A full assessment of the cumulative environmental effects on marine fish and fish habitat offshore is found in Section 7.5.5.2 and is considered applicable to marine fish SAR as well.

For marine fish SAR, overfishing, habitat degradation, pollution and natural variability of the population have caused adverse environmental effects. Fishing pressure and subsequent bottom dragging techniques are significant stresses on some fish resources. Cod are assessed as endangered by COSEWIC due to overfishing. Fishing pressures are expected to remain high to meet market demands which continue the decline or lack of recovery in some fish stocks. Bottom dragging fish gear impacts fish habitat by removing plants, corals, sessile food items, overturning rocks, levelling rock outcrops and re-suspending sediments, ultimately homogenizing the habitat. The proposed Project will represent a negligible incremental increase to the overall cumulative environmental effects to fish SAR as the effect on the seafloor will be localized, of short duration, and any affects on habitat are not expected to overlap between projects. As discussed earlier, the Hebron Offshore Project Area has not been identified as critical habitat for any of the marine fish SAR being assessed and most species occur are less likely to frequent the Project Area than other parts of the Study Area.

Given that the predicted environmental effect of the proposed Project is not significant and given that other oil and gas activities in the Hebron Offshore Project Area are likely to have similar environmental effects on fish and fish habitat and given the limited nature of commercial fishing in the area, and the temporal and spatial overlap with other projects is limited, the cumulative environmental effects of the Project on marine fish SAR are predicted to be not significant. No additional mitigation or follow-up, beyond that identified in Section 7.5.7, is considered necessary.

11.4.5 Determination of Significance

The determination of significance is based on the definition provided in Section 11.2. It considers the magnitude, geographic extent, duration, frequency, reversibility and ecological context of each environmental effect within the Study Area, and their interactions, as presented in the preceding

analysis. Significance is determined at the population level within the Study Area.

Project construction, operation and decommissioning activities, including malfunctions and accidents and cumulative environmental effects, are predicted to have a not significant residual adverse environmental effect on marine fish SAR. Several of the SAR considered in the assessment are not likely to occur in the Hebron Nearshore or Offshore Project Areas, and there is no critical habitat in the Hebron Nearshore or Offshore Project Areas for any of the species considered. Due to the lack of critical habitat, the transient nature of movements of SAR in the Project Areas, and the low probability of interactions with Project activities, no significant adverse environmental effects are expected on habitat quantity, quality or use, or due to mortality. Mitigative measures planned for the project will also reduce the potential for adverse environmental effects on SAR.

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and marine fish SAR, after taking into account any proposed mitigation, is summarized in Table 11-8.

As required by CEAA, an analysis of potential environmental effects to the sustainable use of renewable resources associated with this VEC has been considered. No significant adverse residual environmental effects on marine fish SAR are predicted that could affect renewable resource use.

Table 11-8 Residual Environmental Effects Summary: Marine Fish Species at Risk

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	NS	2	N/A
Cumulative Environmental Effects	NS	2	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Environmental Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

A As determined in consideration of established residual environmental effects rating criteria
B Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site
C Includes decommissioning and abandonment of the GBS and offshore site
D Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

11.4.6 Follow-up and Monitoring

EMCP will implement nearshore and offshore EEM programs. The development of the programs will consider fish SAR that may be affected by Project activities.

A fish habitat compensation program will also be implemented.

A monitoring program may be implemented in accordance with the *Canadian Environmental Protection Act* respecting Ocean Disposal.

11.5 Marine Mammal and Sea Turtle Species at Risk

11.5.1 Project-Valued Ecosystem Component Interactions

Potential interactions between the Project and non-listed marine mammals and sea turtles are evaluated in Chapter 10. The nature of the interactions between the Project and marine mammal and sea turtle SAR will be similar to what is described in this chapter.

Potential interactions between nearshore / offshore Project activities and marine mammal and sea turtle SAR are provided in Table 11-9. Project-VEC interactions are categorized into four types of effects:

- Change in Habitat Quantity: includes interactions which limit habitat availability to marine mammal and sea turtle SAR
- Change in Habitat Quality: includes interactions that may result in physical / physiological effects which occur as a result of a change in habitat quality
- Change in Habitat Use: includes interactions which affect the behaviour of marine mammal and sea turtle SAR
- Potential Mortality: includes interactions which may cause the mortality of a marine mammal and/or sea turtle SAR

For all Project phases in both the nearshore and offshore Project Areas, the activities that are most likely to interact with marine mammals and sea turtles are those that introduce noise into the water column and the activities that involve vessel traffic.

Table 11-9 Potential Project-related Interactions: Marine Mammal and Sea Turtle Species at Risk

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Construction				
Nearshore Project Activities				
Presence of Safety Zone (Great Mosquito Cove zone followed by a deepwater site zone)				
Bund Wall Construction (*e.g.*, sheet / pile driving, infilling)	x	x	x	
Inwater Blasting		x	x	x

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Dewater Drydock / Prep Drydock Area			x	
Concrete Production (floating batch plant)			x	
Vessel Traffic (*e.g.*, supply, tug support, tow, diving support, barge, passenger ferry to / from		x	x	x
Lighting			x	
Air Emissions		x		
Re-establish Moorings at Bull Arm deepwater site		x	x	
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require		x	x	
Removal of Bund Wall and Disposal (dredging / ocean disposal)		x	x	x
Tow-out of GBS to Bull Arm deepwater site		x	x	
GBS Ballasting and De-ballasting (seawater only)			x	
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site			x	
Hook-up and Commissioning of Topsides			x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	
Platform Tow-out from deepwater site		x	x	
Offshore Construction / Installation				
Presence of Safety Zone				
OLS Installation and testing		x	x	
Concrete Mattress Pads/ Rock Dumping over OLS Offloading Lines		x	x	
Installation of Temporary Moorings		x	x	
Platform Tow-out / Offshore Installation	x	x	x	
Underbase Grouting			x	
Possible Offshore Solid Ballasting			x	
Placement of Rock Scour Protection on Seafloor around Final Platform Location		x	x	
Hookup and Commissioning of Platform			x	
Operation of Helicopters		x	x	
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)		x	x	x
Air Emissions		x		
Lighting			x	
Potential Expansion Opportunities				
Presence of Safety Zone				
Excavated Drill Centre(s) Dredging and Spoils Disposal		x	x	
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform,			x	
Hook-up and Commissioning of Drill Centres			x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)		x	x	
Offshore Operations and Maintenance				
Presence of Safety Zone				
Presence of Structures		x	x	
Lighting			x	
Maintenance Activities (*e.g.*, diving, ROV)			x	
Air Emissions		x		
Flaring				
Wastewater (*e.g.,* produced water, cooling water, storage displacement water, deck drainage)		x		

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Chemical Use / Management/Storage (*e.g.*, corrosion inhibitors, well treatment fluids)		x		
WBM Cuttings		x		
Operation of Helicopters		x	x	
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges /		x	x	x
Surveys (*e.g.*, geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical,		x	x	
Potential Expansion Opportunities				
Presence of Safety Zone				
Drilling Operations from MODU at Future Excavated Drill Centres		x	x	
Presence of Structures			x	
WBM and SBM cuttings		x		
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)		x		
Geophysical / Seismic Surveys		x	x	
Offshore Decommissioning / Abandonment				
Presence of Safety Zone				
Removal of the Platform and OLS Loading Points	x	x	x	
Lighting			x	
Plugging and Abandoning Wells			x	
Abandoning the OLS Pipeline			x	
Operation of Helicopters		x	x	
Operation of Vessels (supply, support, standby and tow vessels / ROVs)		x	x	x
Surveys (*e.g.*, geophysical, geological, environmental, ROV, diving)		x	x	
Accidents, Malfunctions, and Unplanned Events				
Bund Wall Rupture			x	
Nearshore Spill (at Bull Arm Site)		x	x	x
Failure or Spill from OLS		x	x	x
Subsea Blow-out		x	x	x
Crude Oil Surface Spill		x	x	x
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS,		x	x	x
Marine Vessel Incident (*i.e.*, fuel spills)		x	x	x
Collisions (involving Platform, vessel, and/or iceberg)		x	x	x
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (HSE) (drilling and production)		x	x	
Terra Nova Development (production)		x	x	
White Rose Oilfield Development and Expansions (drilling and production)		x	x	
Offshore Exploration Drilling Activity		x	x	
Offshore Exploration Seismic Activity		x	x	
Marine Transportation (nearshore and offshore)		x	x	x
Commercial Fisheries (nearshore and offshore)		x	x	x

11.5.1.1 Nearshore

In the Nearshore Project Area, underwater noise can result from Project activities such as bund wall construction (including pile-driving), in-water blasting, vessel traffic, dredging of the bund wall and possibly sections of the tow-out route to the deepwater site, removal of the bund wall and disposal of materials, and surveys (*i.e.*, geophysical, geohazard, and geotechnical data acquisition). These activities can affect the habitat quality and habitat use by marine mammal and sea turtle SAR. In addition, activities such as in-water blasting and blasting to remove the bund wall, and vessel traffic could affect marine mammal and sea turtle SAR through mortality. Bund wall construction may also affect marine mammals and sea turtles through a limited reduction in habitat quantity.

11.5.1.2 Offshore

Offshore Construction / Installation

During the construction / installation phase in the Hebron Offshore Project Area, underwater noise will result from activities such as (possible) clearance dredging, helicopter overflights, operation of vessels, excavated drill centre dredging, seismic surveys, and other geophysical and geotechnical surveys. These activities could affect habitat quality and habitat use by marine mammal and sea turtle SAR. Other activities that may affect marine mammals and sea turtle SAR include site preparation activities for OLS / Hebron Platform installation and potential expansion opportunities (dredged spoil disposal, installation of subsea equipment and flowlines, placement of flowline protection measures and hook-up to Hebron Platform and commissioning). In addition, operation of vessels could lead to mortality of individuals via collisions. Placement of the Hebron Platform, OLS and flowlines, rock cover and/or concrete mattresses at the offshore site location could also affect the marine mammal and sea turtle SAR through a very limited reduction in habitat quantity.

Operations / Maintenance

During the operations / maintenance phase in the Hebron Offshore Project Area, underwater noise will result from activities such as drilling operations from the Hebron Platform and from a MODU at future excavated drill centres, production operations, helicopter overflights, vessel traffic, presence of subsea equipment and seismic / geohazard surveys. These activities could affect habitat quality and habitat use. Other activities that may contribute to an effect on habitat quality during Project operations include discharges that may reduce water quality in the Offshore Project Area. In addition, there is limited potential for mortality of marine mammal and sea turtle SAR via collisions with vessels.

11.5.1.3 Decommissioning / Abandonment

During the decommissioning / abandonment phase in the Hebron Offshore Project Area, vessel traffic and helicopter overflights and the removal of structures on or above the seafloor will produce underwater noise which may affect marine mammals and sea turtles. As previously mentioned, these activities can affect habitat quality and habitat use. Also, there is some potential for mortality as a result of collisions with vessels.

11.5.1.4 Accidents, Malfunctions, and Unplanned Events

During the construction and operation phases of the Hebron Project, there are several hydrocarbon products carried and used onboard vessels, barges, drill rigs and platforms. These include crude oil, diesel oil, synthetic drilling mud, synthetic drill (base) fluid, lubricating oils, and hydraulic oils. Hydrocarbon spills may occur as a result of human error, equipment failure or loss of well control (blow-out). An oil spill, although highly unlikely, could affect marine mammal and sea turtle SAR and potentially occur during the construction, operation and maintenance, and/or decommissioning phases of the Project. Potential transboundary effects are discussed in Section 11.4.3.2.

11.5.2 Environmental Effects Analysis and Mitigation Measures

Potential environmental effects of the Project on non-listed marine mammals and sea turtle species are assessed and described in detail in Chapter 10. Many of the issues of concern with respect to environmental effects for SAR, as well as mitigation measures and management strategies, are similar to those presented for non-listed marine species in the Study Area in other chapters of this report. On an ecosystem basis, the listed and non-listed species and their habitats are often highly integrated.

The marine mammal and sea turtle SAR that are likely to occur in the Hebron Nearshore Project Area are fin whales and harbour porpoises. The killer whale may occur in small numbers and the blue whale and Sowerby's beaked whale are considered unlikely to occur in the nearshore area. The leatherback turtle may also occur. These are the species upon which the following assessment focuses.

In the Hebron Offshore Project Area, the fin whale is considered the most likely SAR marine mammal to occur, while the harbour porpoise and killer whale may be regular occupants occurring only in small numbers. The Sowerby's beaked whale and blue whale are uncommon in the Offshore Project Area, although Sowerby's beaked whale may be more common in the deep water portions of the Offshore Study Area. The leatherback turtle may also regularly occur, but in small numbers.

11.5.2.1 Construction and Installation

Change in Habitat Quantity

Nearshore

As discussed and assessed in Section 10.5.1.1, while there will be very minimal loss of marine habitat associated with nearshore Project construction, this habitat will be in shallow water. Thus, most marine mammal and sea turtle SAR would not preferentially use this habitat and it is expected to result in a negligible habitat loss for these species. The Hebron Nearshore Project Area has not been identified as critical habitat for any of the marine mammal and turtle SAR considered in this assessment.

Offshore

As discussed and assessed in Section 10.5.1.1, the area of habitat likely to be affected by offshore construction activities would result in a very minimal habitat loss for marine mammal and sea turtle SAR. The Hebron Offshore Project Area has not been identified as critical habitat for any of the marine mammal and turtle SAR considered in this assessment.

Change in Habitat Quality

Changes in habitat quality may result in physical/physiological effects upon the marine mammal and sea turtle SAR. Activities most likely to affect the marine mammal and sea turtle SAR for this Project are blasting, pile-driving, and seismic surveys which produce impulsive sound levels high enough to cause physical / physiological effects in marine mammals (and likely sea turtles). The environmental effects of noise on marine mammals and sea turtles is fully assessed in Section 10.5.1.2. The identified mitigation measures to minimize the risk of injury to marine mammals and sea turtles are considered applicable to SAR as well as non-listed species.

Nearshore

The assessment of noise levels associated with pile driving (Section 10.5.1.2) indicate that there is little risk for hearing impairment to marine mammals or sea turtles beyond 300 m from the pile driving equipment. A monitoring protocol for marine mammals will be established by EMCP prior to the start of construction activities. This protocol will be developed in consultation with DFO and may include the following parameters.

- A trained observer will monitor a designated radius near pile driving activities for at least 30 minutes prior to activation of the pile driver. If a marine mammal or sea turtle (including SAR) is detected within the designated zone (conservatively assume 180 and 190 dB re 1 uPa (rms), for cetaceans and seals, respectively) pile driving will not occur until the animal(s) have left the safety zone, or it has not been re-sighted for 30 minutes

- Pile driving activities will be halted if a marine mammal or sea turtle (including SAR) enters into the safety zone and will not be resumed until the animal has left the zone or 30 minutes have passed since the sighting
- For sea turtles, the 180 dB zone will be used

Of all the Project activities, blasting is most likely to cause physical effects in marine mammals, without proper mitigation. The potential effects of blasting on marine mammals and sea turtles are fully assessed in Section 10.5.1.2. Blasting parameters will be such that they adhere to the DFO guidance outlined in "*Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters*" (Wright and Hopky 1998). In addition, prior to blasting, a blast impact assessment will be undertaken to determine appropriate marine mammal and sea turtle exclusion zones and these will be implemented during blasting activities. Further detail on this proposed mitigation is found in Section 10.5.1.2.

Sound levels from vessel traffic associated with the Project are not expected to be high enough to cause physical or physiological effects on marine mammals or sea turtles (Richardson *et al.* 1995). Project activities involving vessel traffic will avoid concentrations of marine mammals and sea turtles whenever possible.

Sounds produced from geohazard surveys generally occur at lower source levels than those of airgun pulses from seismic surveys. Sounds are also typically emitted in a narrow beam, short duration, and sometimes at frequencies outside the range of marine mammal and sea turtle hearing abilities. Standard mitigation measures will be followed for any surveys that use a “seismic air source to generate acoustic waves that propagate through the earth” as per the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* as appended to the *Geophysical, Geotechnical, Environmental and Geological guidelines* (C-NLOPB 2011).

Offshore

The potential effects of seismic and geohazard sounds on marine mammals and sea turtles in the offshore are fully assessed in Section 10.5.1.2 and considered applicable to SAR. Mitigation measures identified for non-listed species are also considered applicable to marine mammal and sea turtle SAR.

In summary, very little is known about the potential for seismic survey (and geohazard survey) sounds to cause either auditory impairment or other non-auditory physical effects in marine mammal or sea turtle SAR. Available data suggest that such effects, if they occur at all, would be limited to short distances. However, the available data do not allow for meaningful quantitative predictions of the numbers (if any) of marine mammals or turtles that might be affected in these ways. Marine mammals that show behavioural avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are unlikely to incur auditory impairment or other physical effects.

Mitigation measures will follow those outlined in the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment as appended to Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NLOPB 2011) considering the seismic survey mitigation measures, there will likely be minimal effects of seismic surveys on marine mammal and sea turtle SAR.

As with the nearshore, sound levels from vessel traffic associated with the Offshore Project activities are not expected to be high enough to cause physical or physiological effects on marine mammal or sea turtle SAR (Richardson *et al.* 1995). Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible.

Change in Habitat Use

Noise introduced into the water column has the greatest potential to impact the behaviour of marine mammals and sea turtles, as noise is associated with almost every aspect of the construction, operations and maintenance, and decommissioning and abandonment phases of the Project and this VEC is known to be sensitive to noise. The potential for this effects on marine mammals and sea turtles is fully assessed in Section 10.5.1.3 and is considered applicable to marine mammal and sea turtle SAR.

Nearshore

Pile driving produces impulsive sound levels high enough to cause behavioural effects in marine mammal and sea turtle SAR which may result in a change in habitat use. Based on the assessment in Section 10.5.1.3, baleen and toothed whales would likely exhibit at least localized avoidance of the pile-driving sites. There is some evidence to suggest that harbor porpoise echolocation activity may decline, at least temporarily, and that seals may exhibit at least short-term avoidance of the area. There are currently no published data available for behavioural effects of pile driving on sea turtles. Of note, sea turtles are considered rare in inner Trinity Bay near the sites of potential pile driving. Proposed mitigation measures for pile-driving activities should minimize potential effects to habitat use by marine mammal and sea turtle SAR.

Behavioural disturbance, resulting in a change in habitat use, is also a potential effect of blasting operations. However, there are no specific sound levels for blasting activities that are linked with behavioural effects on marine mammals and sea turtles. But as blasting operations will be intermittent in nature and the sound pulse is very short and as further discussed in Section 10.5.1.3, there is little chance of masking of any marine mammal sounds. No information on the environmental effects of blasting on sea turtles is currently available, but sea turtles are considered rare in inner Trinity Bay near the site of potential blasting, particularly during times other than late summer and early fall. The mitigation measure discussed earlier for nearshore blasting operations will serve to further minimize any environmental effects on marine mammal and sea turtle SAR.

Limited information is available on the behavioural changes of marine mammals (and none for sea turtles) resulting from dredging operations, but generally animals have been reported to continue using habitats near dredging operations. Marine mammals common within the Nearshore Study Area during dredging activities, particularly those present for extended periods, are most likely to be affected. Sea turtles are considered uncommon in the Nearshore Study Area. Dredging operations will be temporary and of limited duration. It is planned that proper planning and equipment design will reduce the duration of dredging activities and hence, their environmental effect on marine mammal and sea turtle SAR.

Noise generated by vessels associated with the Project has the potential to disturb marine mammals and sea turtles, causing changes in habitat use. Marine mammal and sea turtle responses to ships are presumably responses to noise, but visual or other cues are also likely involved. Tugs and barges will likely produce the greatest and most continuous vessel noise during construction in the Hebron Nearshore Study Area. Factors such as species, maturity, experience, current behaviour state, reproductive state, and time of day likely affect marine mammal responses to vessels. No data are currently available on the response of sea turtles to vessel traffic, but they rarely occur in the Hebron Nearshore Study Area and typically only during late summer or early fall. Marine mammals occurring in the Hebron Nearshore Study Area during periods of increased vessel traffic are most likely to be affected. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles, including SAR, whenever possible. Additionally, vessels will maintain a steady vessel speed and course whenever possible.

Offshore

As with the nearshore, dredging that occurs consistently for extended periods is most likely to result in behavioural reactions and changes in habitat use for marine mammal and sea turtle SAR. In general, the limited available information suggests that cetaceans tend to remain in occupied areas near dredging sites, but there is no available information on reactions of pinnipeds or sea turtles. It is planned that proper planning and equipment design will reduce the duration of dredging activities and hence, their environmental effect on marine mammal and sea turtle SAR. Additionally, suction dredgers will be used to lessen sediment suspension during soil intake, and work periods will be minimized.

The potential effects of vessel traffic on the habitat use of marine mammals and sea turtles are discussed above for the nearshore. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles, including SAR, whenever possible.

The potential behavioural effects of helicopter overflights in the offshore on marine mammals and sea turtles is assessed in Section 10.5.1.3 and considered appropriate to SAR. Available information suggests that helicopters flying at low altitude (*i.e.*, when approaching a landing site) may disturb some marine mammals directly in its flight path. Occasional aircraft

overflights cause only brief behavioural responses by marine mammals, and it is unlikely that large numbers of marine mammals will be overflown, especially at low altitude. There is no available information on the reaction of sea turtles to aircraft overflight, but single or occasional overflights by helicopters would likely only elicit a brief behavioural response. To avoid disturbance of marine mammals and sea turtles, the helicopter will avoid flying at low altitudes whenever it is safe to do so. Helicopters will typically only reduce altitude on approach for landing. Helicopter landings at offshore platforms would probably affect a very small area with a radius less than 500 m.

A change in habitat use, resulting from behavioural disturbance and avoidance, is the most likely effect of seismic and geohazard surveys on marine mammals and sea turtles, including SAR. A full assessment of this potential effect is found in Section 10.5.1.3 and is considered appropriate to SAR as well as non-listed species. In summary, potential changes in habitat use of the Hebron Offshore Study Area by marine mammals and sea turtles, including SAR resulting from seismic surveys include behavioural effects and avoidance. Baleen whales tend to avoid operating airguns, but at variable avoidance radii. Some dolphins occasionally approach active seismic vessels, but studies of toothed whale reactions to seismic surveys generally show temporary avoidance. Only slight (if any) avoidance has been shown by pinnipeds. Limited studies of the effects of seismic surveys on sea turtles suggest that they will exhibit behavioural and/or avoidance within some distance of an operating seismic vessel. Short-term avoidance behaviour, however, does not necessarily provide information about long-term effects such as reproductive rate or distribution and habitat use in subsequent days or years. Additionally, effects likely vary between species, location, and past exposure to seismic sounds.

Mitigation measures will be employed to minimize the potential for effects on marine mammals and sea turtles. Mitigation measures will follow those outlined in the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* as appended to *the Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011).

Potential Mortality

Nearshore

Sound levels associated with mortality in marine mammals from blasting have not been established. The short rise time to a high peak pressure of shock pulses from explosives appears to be responsible for much of the damage, including mortality, to marine mammals during these detonations (Ketten 1995). While there is potential for mortality of marine mammals or sea turtles to occur as a result of nearshore blasting (Section 10.5.1.4), the mitigation measures proposed for this Project will make this occurrence unlikely.

The risk of mortality due to vessel collisions is also of concern (Section 10.5.1.4). Large species of whales like blue and fin whales and sea turtles that spend extended periods near the surface would be particularly

susceptible to ship strikes. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles, including SAR, whenever possible, and vessels will maintain a steady speed and course in order to avoid potentially fatal collisions with the VEC. Particularly in the Hebron Nearshore Study Area, vessels associated with the Project will typically be engaged in activities that require a slow speed or maintenance of a stationary position, which will also reduce the risk of a collision. Vessels will deviate from their course to avoid marine mammals and sea turtles, if necessary.

Offshore

As discussed for the nearshore, there is a risk of vessel collision with marine mammal and sea turtle SAR resulting in serious injury or mortality. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles, including SAR, whenever possible, and vessels will maintain a steady speed and course in order to avoid potentially fatal collisions with the VEC. Vessels will reduce speed whenever possible and deviate their course to avoid marine animals.

The potential for seismic surveys to result in serious injury, death, or stranding for marine mammals and sea turtles is assessed in Section 10.5.1.4 and is considered applicable to SAR. This discussion concludes that there is no definitive evidence that airguns can lead to strandings or mortality even for marine mammals in close proximity to large airgun arrays. Sea turtle mortality has not been documented to occur as a result of exposure to seismic surveys. The mitigation measures outlined in the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* as appended to the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011) will be followed to minimize environmental effects on marine mammals and sea turtles, including SAR.

The environmental effects of the Project construction and installation activities on marine mammal and sea turtle SAR are summarized in Table 11-10.

Given that Project activities are mostly localized, of low to medium magnitude, and reversible at the population level, there are not likely to be significant residual adverse environmental effects on marine mammal and sea turtle SAR from construction or installation activities associated with the Project. Project environmental effects are not expected to contravene the prohibitions of SARA (Sections 32(1), 33, 58(1)).

Table 11-10 Environmental Effects Assessment: Construction and Installation – Marine Mammal and Sea Turtle Species at-Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Project Activities							
Bund Wall Construction (*e.g.*, sheet / pile driving, infilling)	• Change in Habitat Quantity • Change in Habitat Quality • Change in Habitat Use	• Potential use of bubble curtains • Safety Zone • Monitoring	2	3	3/1	R	2
Inwater Blasting	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adherence with *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* • Potential use of bubble curtains • Safety Zone • Monitoring	2	3	2/1	R/I [B]	2
Dewater Drydock / Prep Drydock Area	• Change in Habitat Use		1	1	2/1	R	2
Concrete Production (floating batch)	• Change in Habitat Use		1	1	3/3	R	2
Vessel Traffic (*e.g.*, supply, tug support, tow, diving support, barge)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course • Deviate course to avoid animals	1	3	3/6	R/I [B]	2
Lighting	• Change in Habitat Use		1	1	3/6	R	2
Air Emissions	• Change in Habitat Quality		N	4	3/6	R	2
Re-establish Moorings at Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use	• Potential use of bubble curtains • Safety Zone • Monitoring	1	1	2/1	R	2
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	• Change in Habitat Quality • Change in Habitat Use	• Planning • Equipment design	2	3	2/1	R	2
Removal of Bund Wall and Disposal (dredging / ocean disposal)	• Change in Habitat Quality • Change in Habitat Use	• Potential use of bubble curtains • Safety Zone • Monitoring	1	3	2/1	R	2
Tow-out of GBS to Bull Arm deepwater site	• Change in Habitat Quality • Change in Habitat Use		1	3	1/1	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
GBS Ballasting and De-ballasting (seawater only)	• Change in Habitat Use		1	1	1/1	R	2
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	• Change in Habitat Use		1	1	2/2	R	2
Hook-up and Commissioning of Topsides	• Change in Habitat Use		1	1	2/2	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental)	• Change in Habitat Quality • Change in Habitat Use	• Avoid animal concentrations when possible • Maintain steady speed and course when possible	1	3	2/1	R	2
Platform Tow-out from deepwater site	• Change in Habitat Use		1	1	3/6	R	2
Offshore Construction / Installation							
OLS Installation and Testing	• Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines	• Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Installation of Temporary Moorings	• Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Platform Tow-out / Offshore Installation	• Change in Habitat Quality • Change in Habitat Use		1	3	2/6	R	2
Underbase Grouting	• Change in Habitat Use		1	1	2/1	R	2
Possible Offshore Solid Ballasting	• Change in Habitat Use		1	1	2/1	R	2
Placement of Rock Scour on Seafloor around final Platform Location	• Change in Habitat Quality • Change in Habitat Use		1	1	2/1	R	2
Hookup and commissioning of Platform	• Change in Habitat Use		1	1	2/1	R	2
Operation of Helicopters	• Change in Habitat Quality • Change in Habitat Use	• Avoid low altitudes when possible	1	2	3/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course	1	3	3/6	R/I [B]	2
Air Emissions	• Change in Habitat Quality		N	5	3/6	R	2
Lighting	• Change in Habitat Use		1	1	3/6	R	2
Potential Expansion Opportunities							
Excavated Drill Centre(s) Dredging and Spoils Disposal	• Change in Habitat Quality • Change in Habitat Use	• Planning	1	3	2/1	R	2
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	• Change in Habitat Use		1	2	2/1	R	2
Hook-up and Commissioning of Drill Centres	• Change in Habitat Use		1	2	2/2	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental)	• Change in Habitat Quality • Change in Habitat Use	• Adherenece to the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (C-NLOPB 2011)	1	2	2/1	R	2

KEY

N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Reversible at the population level but irreversible at the individual level

11.5.2.2 Operations and Maintenance

Change in Habitat Quantity

None of the Project activities during the Operations and Maintenance phase are expected to affect the habitat quantity of marine mammal and sea turtle SAR.

Change in Habitat Quality

Noise effects from Project operations and maintenance activities can potentially diminish habitat quality and influence habitat use by marine mammal and sea turtle SAR. These potential noise effects are discussed above in Section 10.5.2.1.

Other activities that may contribute to an effect on habitat quality during Project operations include discharges that may reduce water quality in the Hebron Offshore Study Area. Air emissions are expected to have a negligible effect on the habitat quality of marine mammal and sea turtle SAR. These discharges are fully assessed in Section 10.5.2.2 for marine mammals and sea turtles and this assessment is considered applicable to SAR, including identified mitigation. These activities are expected to have minimal effect on marine mammal and sea turtle SAR.

Change in Habitat Use

Many Project activities predicted to have an effect on habitat use during the operations and maintenance phase of the Project have been discussed above under construction (*e.g.*, seismic surveys, vessel and helicopter traffic). Effects on habitat use specific to the operations phase including noise associated with drilling are assessed in Section 10.5.2.3 for marine mammals and sea turtles and are considered applicable to SAR.

Potential effects of the presence of structures on marine mammals and sea turtles including SAR are mainly related to the effects of sound produced by offshore structures and activities. Marine mammals would most likely avoid the immediate area around drilling activities due to physical activities and underwater sound generated. Artificial light might attract prey species of the marine mammal and sea turtle SAR and result in a positive environmental effect on its habitat use.

Potential Mortality

As discussed above for the construction phase, the key routine Project activity which is most likely to result in mortality is the operation of vessels. The presence of vessels during various Project activities can increase the risk of mortality via vessel collisions with marine mammal and sea turtle SAR. Large species of whales (such as blue and fin whales) and sea turtles (like leatherback sea turtles) that spend extended periods near the surface would be most susceptible to ship strikes. Project activities involving vessel traffic will avoid spatial and temporal concentrations of marine mammals and sea turtles whenever possible, and vessels will maintain a steady speed and

course in order to avoid potentially fatal collisions with marine mammals and sea turtles, including SAR. Vessels will deviate from their course to avoid animals in their path.

The environmental effects of operation and maintenance activities on Marine Mammal and Sea Turtle SAR are summarized in Table 11-11.

Given that Project activities are mostly localized, of low to medium magnitude, and reversible, there are not likely to be significant residual adverse environmental effects on marine mammal and sea turtle SAR from operations and maintenance activities associated with the Project.

Table 11-11 Environmental Effects Assessment: Operations and Maintenance – Marine Mammal and Sea Turtle Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Structures	• Change in Habitat Quality • Change in Habitat Use		1	1	5/6	R	2
Lighting	• Change in Habitat Use		1	1	5/6	R	2
Maintenance Activities (*e.g.*, diving, ROV)	• Change in Habitat Use		1	2	5/3	R	2
Air Emissions	• Change in Habitat Quality		N	5	5/6	R	2
Wastewater (*e.g.,* produced water, cooling water, storage displacement water, deck drainage)	• Change in Habitat Quality		1	1	5/6	R	2
Chemical Use/Management / Storage (*e.g.*, corrosion inhibitors, well treatment fluids)	• Change in Habitat Quality		1	1	5/6	R	2
WBM Cuttings	• Change in Habitat Quality		1	1	5/2	R	2
Operation of Helicopters	• Change in Habitat Quality • Change in Habitat Use	• Avoid low overflights when possible	1	2	5/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course • Deviate course to avoid animals	1	3	5/6	R/I[B]	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Surveys (*e.g.*, geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use • Change in Habitat Quality	• Adhere to the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (C-NLOPB 2011)	1	2	3/2	R	2
Potential Expansion Opportunities							
Drilling Operations from MODU at Future Excavated Drill Centres	• Change in Habitat Quality • Change in Habitat Use		1	3	3/6	R	2
Presence of Structures	• Change in Habitat Use		1	1	5/6	R	2
WBM and SBM Cuttings	• Change in Habitat Quality	• Treatment of SBM cuttings in accordance with the OWTG	1	1	5/6	R	2
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)	• Change in Habitat Quality		1	1	5/6	R	2
Geophysical / Seismic Surveys	• Change in Habitat Quality • Change in Habitat Use	• Adherence to *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (C-NLOPB 2011) • Safety Zone • Monitoring • Delay start, shutdown • Ramp-up source	2	4	3/2	R	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2= Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
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4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Reversible at the population level but irreversible at the individual level

11.5.2.3 Offshore Decommissioning and Abandonment

Change in Habitat Quantity

The removal of the Hebron Platform and OLS loading points will result in a minimal habitat gain for marine mammal and sea turtle SAR. However, considering the lack of specific habitat for marine mammals and limited habitat use by turtles, the effect is not considered to be significant.

Change in Habitat Quality

Removing structures (Hebron Platform and OLS loading points), plugging and abandoning wells, light emissions, vessel traffic, helicopter traffic and surveys are decommissioning activities which could affect habitat quality. The potential effects of these activities are expected to be similar (or less than) those of construction or operation and maintenance (assessed in Sections 10.5.1.2 and 10.5.2.2); therefore, no significant adverse environmental effects are predicted.

Change in Habitat Use

Removing structures (Platform and OLS loading points), plugging and abandoning wells, light emissions, vessel traffic, helicopter traffic and surveys are decommissioning activities which could affect habitat use. The potential effects of these activities are expected to be similar (or less than) those of construction or operation (assessed in Sections 10.5.2.1 and 10.5.2.2); therefore, no significant adverse environmental effects are predicted.

Potential Mortality

Similarly to construction, and operations / maintenance phases, the key Project activity which has the potential to have an effect on mortality of marine mammal and sea turtle SAR is the operation of vessels (see Chapter 10). The potential effects of this activity is expected to be similar (or less than) those of construction or operation; therefore, no significant adverse environmental effects are predicted.

The environmental effects of Project decommissioning and abandonment on marine mammal and sea turtle SAR are summarized in Table 11-12.

Given that Project activities are mostly localized, of low magnitude, and reversible, there are not likely to be significant adverse environmental effects on marine mammal and sea turtle SAR from decommissioning and abandonment activities associated with the Project.

Table 11-12 Environmental Effects Assessment: Decommissioning and Abandonment – Marine Mammal and Sea Turtle Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Removal of the Platform and OLS Loading Points	• Habitat Quantity • Change in Habitat Quality • Change in Habitat Use		1	2	2/1	R	2
Lighting	• Change in Habitat Use		1	1	3/5	R	2
Plugging and Abandoning Wells	• Change in Habitat Use		1	2	3/2	R	2
Abandoning the OLS Pipeline	• Change in Habitat Use		1	2	3/1	R	2
Operation of Helicopters	• Change in Habitat Quality • Change in Habitat Use	• Avoid low overflights when possible	1	2	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / barges / ROVs)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Avoid animal concentrations when possible • Maintenance of steady speed and course	1	3	3/6	R/I [B]	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use • Change in Habitat Quality	• Adhere to the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (C-NLOPB 2011)	1	2	3/2	R	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected.[B] Reversible at the population level but irreversible at the individual level

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Potential mortality effects reversible at the population level and irreversible at the individual level

11.5.3 Accidents, Malfunctions and Unplanned Events

The effect of an accidental release of hydrocarbons without the implementation of control measures in the nearshore and offshore on marine mammals and sea turtles is assessed in Section 10.5.4 and considered applicable to SAR. Spills in the nearshore would be attributable to vessel malfunctions and similar effects and mitigation discussed for the offshore are applicable to the nearshore scenarios; therefore, nearshore and offshore effects are assessed together.

It is difficult to predict with precision the effects of accidental events on biota, especially as they relate to the geographic extent of the effects. Numerous parameters (*e.g.*, chemical composition of the hydrocarbon, behaviour of spilled substance at different times of year) influence hydrocarbon spill characteristics and there are many unknowns concerning specific effects on different marine mammal and sea turtle groups.

For marine mammal and sea turtle SAR, it is probable that only small proportions of populations are at-risk at any one time in either the Nearshore or Offshore Study Area (see Section 10.5.4). Typical oil spill countermeasures (oil spill response plan, training, preparation, an equipment inventory, and conducting emergency response drills) and the associated disturbance would likely reduce the number of animals exposed to oil. Depending on the time of year, location of animals within the affected area, and type of oil spill or blow-out, the effects of a Nearshore or Offshore oil release on the health of cetaceans is predicted to range from negligible to low magnitude over varying geographic extents (Table 11-13). These geographic extents were based on modelling results in the absence of any spill intervention (ASA 2011a, 2011b). Based on present knowledge of the Trinity Bay and Grand Banks ecosystems, the modelling exercises, and on past monitoring experience with large spills with much worse scenarios than offshore on the Grand Banks, it can be predicted with confidence that an oil spill associated with the Project will not result in any significant residual environmental effects to marine mammal or sea turtle SAR in the Study Areas.

11.5.4 Cumulative Environmental Effects

Hebron Project activities are considered in combination with the following activities in the assessment of cumulative environmental effects:

- Hibernia Oil Development and Hibernia Southern Extension (drilling and production)
- Terra Nova Development (drilling and production)
- White Rose Oilfield Development and Expansions (drilling and production)
- Offshore exploration drilling activity
- Offshore exploration seismic activity
- Marine transportation and
- Commercial fisheries

Table 11-13 Environmental Effects Assessment: Accidental Events – Marine Mammal and Sea Turtle Species at-Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Bund Wall Rupture	• Change in Habitat Use		1	1	1/1	R	2
Nearshore Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	4-5	2/1	R/I [B]	2
Failure or Spill from OLS	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	6	2/1	R/I [B]	2
Subsea Blow-out	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	6	3/1	R/I [B]	2
Crude Oil Surface Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	6	2/1	R/I [B]	2
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Platform)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	1	2/1	R/I [B]	2
Marine Vessel Incident (*i.e.*, fuel spills)	• Change in Habitat Quality • Change in Habitat Use • Mortaliy	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	5	2/1	R/I [B]	2
Collisions (involving Platform, vessel, and/or iceberg)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	1	3	2/1	R/I [B]	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
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Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Potential mortality effects reversible at the population level and irreversible at the individual level

11.5.4.1 Nearshore

Cumulative environmental effects in the Nearshore Study Area are expected to be of a lower magnitude than those of the Offshore Study Area as fewer activities have the potential to interact with the current Project (see Section 11.5.4.2 for cumulative environmental effects assessment of the Offshore Study Area).

11.5.4.2 Offshore

The potential for cumulative environmental effects on marine mammal and sea turtle SAR is essentially the same as the potential cumulative environmental effects on non-listed species, although it is acknowledged that due to the status of these populations, they may be more vulnerable to even limited Project effects compared to more stable populations. In general, the proposed Project's contribution to any cumulative environmental effects is limited in comparison to the influences on these species throughout their range that have caused these species to reach their current population levels.

Routine offshore oil and gas activities that can affect marine mammals at-risk include geophysical surveys, construction and drilling and production activities. As discussed in previous sections, the most likely environmental effects from these activities are disturbance. As described above, all operators must adhere to the *Geophysical, Geological, Environmental and*

Geotechnical Guidelines (C-NLOPB 2011), thereby reducing the potential for cumulative environmental effects from geophysical surveys.

Marine mammal reaction to construction is likely temporary avoidance behaviour. Richardson *et al.* (1995) predicted the radius for a response to noise during development and production activities for baleen and odontocetes to be less than 100 m. Collisions between support vessels and marine mammals at-risk are not likely given the vessel speeds within the Project Area. No cumulative environmental effects are expected with helicopter traffic due to the localized and temporary nature of this disturbance. The overall potential for cumulative environmental effects of these projects and activities on marine mammal SAR is considered non significant.

Routine offshore oil and gas activities resulting in noise and disturbance impacts to sea turtles could result in cumulative environmental effects. Few studies have been undertaken on the effects of anthropogenic noise on sea turtles; however, it is assumed that noise from the various offshore sources could result in temporary disturbance to individuals. Although the environmental effects of noise from this Project are not expected to be significant, it will add noise that sea turtles are exposed to within the Study Area. Sea turtles densities are low in the Project Area. There is no evidence to suggest that oil and gas activities and increased vessel traffic result in adverse significant environmental effects to sea turtles populations. Based on the environmental effects criteria, the disturbance effects are considered non-significant and not to add measurably to cumulative environmental effects on sea turtles.

In offshore Newfoundland waters, leatherback turtles feeding in the area may be affected by entanglement in and ingestion of debris. Entanglements in fishing lines, lobster pot lines, nets and other fishing gear have been reported. Sea turtles either ingest baited hooks or become entangled or hooked externally or both (Witzell 1999; Smith 2001). There is no known directed take of sea turtles in Canadian waters. The take of sea turtles at sea or on nesting beaches in other areas is seen as a threat to all species of sea turtles.

Given the predicted minimal effects of other projects / activities, the large size of the Offshore Study Area and the prediction that the residual environmental effects of the proposed Project's routine activities on the marine mammal and sea turtle SAR through the difference Project phases are not significant (see Section 11.5.5), the cumulative environmental effects on marine mammal and sea turtle SAR are also predicted to be not significant.

11.5.5 Determination of Significance

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and marine mammal and sea turtle SAR, after taking into account any proposed mitigation, is summarized in Table 11-14.

Table 11-14 Residual Environmental Effects Summary: Marine Mammal and Sea Turtle Species at Risk

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	NS	3	N/A
Cumulative Environmental Effects	NSW	3	N/A

KEY

Residual Environmental Effects Rating:
- S = Significant Adverse Environmental Effect
- NS = Not Significant Adverse Environmental Effect

Levels of Confidence in the Effect Rating:
- 1 = Low level of Confidence
- 2 = Medium Level of Confidence
- 3 = High level of Confidence

Probability of Occurrence of Significant Environmental Effect:
- 1 = Low Probability of Occurrence
- 2 = Medium Probability of Occurrence
- 3 = High Probability of Occurrence

A As determined in consideration of established residual environmental effects rating criteria
B Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site
C Includes decommissioning and abandonment of the GBS and offshore site
D Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

The environmental effects of routine activities associated with the construction / installation, operations / maintenance, and decommissioning / abandonment phases of the Project on marine mammal and sea turtle SAR are predicted to be *not significant* (Table 11-14).

The environmental effects of routine activities associated with accidents, malfunctions and unplanned events of the Project on the marine mammal and sea turtle SAR are also predicted to be *not significant* (Table 11-14).

As required by CEAA, an analysis of potential effects to the sustainable use of renewable resources associated with this VEC has been considered. No significant adverse residual environmental effects on marine mammal and sea turtle SAR are predicted that could affect renewable resource use.

11.5.6 Monitoring

For nearshore Project activities where in-water blasting occurs, EMCP will implement a marine mammal observation program. The program will be developed in consideration of DFO blasting guidelines, and in consultation with DFO. For seismic activities in the Offshore Study Area, EMCP will implement a marine mammal and sea turtle observation program. The program will be consistent with the requirements outlined in the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011). Data on marine mammal and sea turtle observations will be provided to DFO and the C-NLOPB where applicable.

Specific follow-up programs to verify the accuracy of assessment predictions and the efficacy of mitigation measures are not planned for marine mammal and sea turtle SAR.

11.6 Marine Bird Species at Risk

11.6.1 Project-VEC Interactions

Potential interactions between the Project and non-listed marine birds are evaluated in Chapter 9. The nature of the interactions between the Project and marine bird SAR will be similar to what is described in these sections. In the nearshore, the Project could interact with the Red Knot or Ivory Gull. In the offshore, the Ivory Gull is the only marine bird SAR expected to occur in the Study Area.

Potential interactions between nearshore/offshore project activities and marine bird SAR are provided in Table 11-15. Project-VEC interactions are categorized into four types of effects:

- Change in Habitat Quantity: includes interactions which limit habitat availability to marine birds
- Change in Habitat Quality: includes interactions that may result in physical / physiological effects which occur as a result of a change in habitat quality
- Change in Habitat Use: includes interactions which affect the behaviour of marine birds and
- Potential Mortality: includes interactions which may cause the mortality of a marine bird

Table 11-15 Potential Project-related Interactions: Marine Bird Species at Risk

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Construction				
Nearshore Project Activities				
Presence of Safety Zone (Great Musquito Cove zone followed by a deepwater site zone)				
Bund Wall Construction (*e.g.*, sheet / pile driving, infilling)	x		x	
Inwater Blasting		x	x	x
Dewater Drydock / Prep Drydock Area			x	
Concrete Production (floating batch plant)			x	
Vessel Traffic (*e.g.*, supply, tug support, tow, diving support, barge, passenger ferry to / from deepwater site)			x	
Lighting		x	x	
Air Emissions		x		
Re-establish Moorings at Bull Arm deepwater site			x	

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)			x	
Removal of Bund Wall and Disposal (dredging / ocean disposal)		x	x	
Tow-out of GBS to Bull Arm deepwater site			x	
GBS Ballasting and De-ballasting (seawater only)			x	
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site			x	
Hook-up and Commissioning of Topsides			x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)			x	
Platform Tow-out from deepwater site	x		x	
Offshore Construction / Installation				
Presence of Safety Zone				
OLS Installation and Testing			x	
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines			x	
Installation of Temporary Moorings			x	
Platform Tow-out / Offshore Installation			x	
Underbase Grouting			x	
Possible Offshore Solid Ballasting			x	
Placement of Rock Scour Protection on Seafloor around Final Platform Location			x	
Hookup and Commissioning of Platform			x	
Operation of Helicopters			x	
Operation of Vessels (supply, support, standby and tow vessels / barges / diving / ROVs)			x	
Air Emissions		x		
Lighting		x	x	
Potential Expansion Activities				
Presence of Safety Zone				
Excavated Drill Centre(s) Dredging and Spoils Disposal			x	
Installation of Pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation			x	
Hook-up and Commissioning of Drill Centres			x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)			x	
Offshore Operations and Maintenance				
Presence of Safety Zone				
Presence of Structures			x	
Lighting		x	x	
Maintenance Activities (*e.g.* diving, ROV)			x	
Air Emissions		x		
Flaring			x	x
Wastewater (*e.g.*, produced water, cooling water, storage displacement water, deck drainage)		x		x
Chemical Use/Management / Storage (*e.g.*, corrosion inhibitors, well treatment fluids)		x		
WBM Cuttings		x		
Operation of Helicopters			x	

Project Activities, Physical Works Discharges and Emissions	Potential Environmental Effects			
	Habitat Quantity	Habitat Quality	Habitat Use	Mortality
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)			x	x
Surveys (*e.g.*, geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)		x	x	
Potential Expansion Opportunities				
Presence of Safety Zone				
Drilling Operations from MODU at Future Excavated Drill Centres			x	
Presence of Structures			x	
WBM and SBM cuttings		x		
Chemical Use and Management (BOP fluids, well treatment fluids, corrision inhibitors)		x		
Geophysical / Seismic Surveys		x	x	
Offshore Decommissioning / Abandonment				
Presence of Safety Zone				
Removal of the Platform and OLS Loading Points			x	
Lighting		x	x	
Plugging and Abandoning Wells			x	
Abandoning the OLS Pipeline			x	
Operation of Helicopters			x	
Operation of Vessels (supply, support, standby and tow vessels / ROVs)			x	
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)			x	
Accidents, Malfunctions and Unplanned Events				
Bund Wall Rupture		x	x	
Nearshore Spill (at Bull Arm Site)		x	x	x
Failure or Spill from OLS		x	x	x
Subsea Blow-out		x	x	x
Crude Oil Surface Spill		x	x	x
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Platform)		x	x	x
Marine Vessel Incident (*i.e.*, fuel spills)		x	x	x
Collisions (involving Platform, vessel, and/or iceberg)		x	x	x
Cumulative Environmental Effects				
Hibernia Oil Development and Hibernia Southern Extension (drilling and production)	x	x	x	x
Terra Nova Development (production)	x	x	x	x
White Rose Oilfield Development and Expansions (drilling and production)	x	x	x	x
Offshore Exploration Drilling Activity	x	x	x	x
Offshore Exploration Seismic Activity			x	
Marine Transportation (nearshore and offshore)			x	x
Commercial Fisheries (nearshore and offshore)			x	x

11.6.1.1 Nearshore

Nearshore Project activities may have effects on habitat quantity, habitat quality, and habitat use for marine bird SAR. Activities most likely to cause disturbance (*i.e.*, change in habitat use) include pile driving (bund wall construction), blasting, vessel traffic and dredging. Lighting during periods of darkness may attract marine bird SAR, which may strike vessels or infrastructure leading to injury or strandings (although SAR are more likely to become airborne again after stranding than some non-listed marine birds). Several activities (*e.g.*, blasting, dredging, pile driving, and vessel traffic) may also lead to temporary disturbance of marine birds in a localized area. Direct mortality of marine bird SAR is not expected to be an environmental effect of most routine activities in the Hebron Nearshore Study Area.

11.6.1.2 Offshore

Offshore Construction / Installation

Offshore construction / installation activities may result in effects on habitat use, and, to a lesser extent, habitat quality and habitat quantity (*e.g.*, placement of Hebron Platform). Activities most likely to cause disturbance (*e.g.*, effects on habitat use) include the operation of helicopters, the operation of vessels, seismic surveys and dredging activities. Lighting at night throughout the Project may attract Ivory Gull, which may strike vessels or platform infrastructure leading to injury, strandings, and mortality. However, Ivory Gull are less likely to strand than other marine bird species (such as Leach's Storm-Petrel, discussed in Chapter 9) since they can easily become airborne again after landing. The risk of hearing impairment to Ivory Gull from seismic surveys is low as this species would not spend considerable amounts of time below the surface of the water or in close proximity to airgun pulses. In addition, several activities may also lead to temporary disturbance of Ivory Gull in a localized area. With the exception of collisions with infrastructure, mortality of Ivory Gull is not expected to be an environmental effect of activities in the Offshore Study Area during the construction / installation Phase.

Operations / Maintenance

Operations / maintenance activities may result in changes to habitat quality and habitat use, with flaring being the primary routine Project activity that may result in mortality effects. Lighting and flaring at night and periods of low visibility for the duration of the Project may attract Ivory Gull, which may strike vessels or platform infrastructure leading to injury, strandings, and mortality (although Ivory Gull are more likely to become airborne again after stranding than some other marine birds). Activities that are most likely to cause disturbance include the operation of helicopters, the operation of vessels and seismic surveys. The discharges of fluids or solids could foul the feathers of Ivory Gull and possibly lead to ingestion of non-biological substances, which may lead to mortality. The risk of hearing impairment to Ivory Gull from

seismic surveys is low as this species would not spend considerable amounts of time below the surface of the water or in close proximity to airgun pulses.

Decommissioning / Abandonment

Effects of Project decommissioning / abandonment activities may affect habitat use by Ivory Gull, similarly to those effects experienced during the construction and operations phases. Lighting may attract birds, which may strike vessels or platform infrastructure leading to injury, strandings, or mortality (although, as noted above, this is less of a concern for Ivory Gull than other marine birds). In addition, the operation of helicopters and vessels may also lead to temporary disturbance in a localized area.

Accidents, Malfunctions and Unplanned Events

The unintentional release of hydrocarbons is the primary accidental event with the potential to affect marine bird SAR. An oil spill, although unlikely, could occur during the construction, operation and maintenance, and/or decommissioning phases of the Project. Accidental events could result in a change in habitat quality and/or mortality.

11.6.2 Environmental Effects Analysis and Mitigation Measures

Potential environmental effects of the Project on non-listed marine bird species are assessed and described in detail in Chapter 9. Many potential effects for marine bird SAR, as well as mitigation measures and management strategies, are similar to those presented for non-listed marine bird species.

There is limited information and few detailed studies regarding the effects of construction and offshore industrial activities on marine birds. However, noise and routine discharges are the most likely activities to affect the habitat quality of marine birds, while lighting, vessel traffic and helicopter overflights are the most likely activities to affect the habitat use of marine birds. Blasting and flaring, as well as collisions with infrastructure, may also lead to mortality of marine birds.

Two species comprise the marine bird SAR VEC: the Red Knot and the Ivory Gull (see Table 11-2). As stated previously, neither marine bird species is common in the Nearshore or Offshore Study Area.

11.6.2.1 Construction

Change in Habitat Quantity

Nearshore

In the Nearshore Project Area, construction of the bund wall could result in a limited reduction of available habitat. However, it should be noted that this will represent a relatively small footprint within an area that has previously been disturbed during construction activities of other projects (*i.e.*, does not represent a loss of important marine bird habitat).

Offshore

The placement of the Platform at the offshore site location could result in minimal habitat loss for the Ivory Gull. Given the relatively small footprint of the Hebron Platform within total available habitat, rare occurrence of the Ivory Gull offshore, and reversibility of the effect once the Hebron Platform is removed, this effect is not considered to be significant.

Change in Habitat Quality

The effects of Project construction activities on habitat quality for marine birds are fully assessed in Section 9.5.1.2 and are considered applicable to marine bird SAR, including the identified mitigation.

Nearshore

Pile driving produces impulsive sound levels high enough that it may temporarily disturb marine bird SAR that are present in close proximity. The effects of pile driving on the Red Knot or Ivory Gull are not known. Pile driving activities will occur in a small area and it is unlikely that either species will occur in close proximity to the bund wall location.

As described in Section 9.5.1.2, blasting is the construction activity that is most likely to affect marine bird SAR in the Nearshore Study Area. Underwater shock waves resulting from blasts could injure or kill birds that are present at the time of the blast. Birds that are underwater are more likely to be affected than those on the surface of the water. Available information suggests that the estimated safe ranges to avoid death or severe injury for birds on the surface, 1 m below the surface, and at 15 m depth are 8, 119 and 262 m, respectively. No information is available on the likelihood of injury to birds on the shore at the time of a blast, but it is expected that effects will be reduced versus birds on the water. In the case of the Red Knot and Ivory Gull, it is very unlikely that either species will occur within 300 m of the blasting location in the Nearshore Study Area. Furthermore, neither species spends considerable time below the water's surface.

EMCP will develop protocols that will include an observer placed nearby the blasting site to monitor if the Red Knot or Ivory Gull is present within the safety zone of the blast location. If a bird enters the safety zone, blasts will be delayed until the birds(s) move outside the designated safety zone (which will be determined in consultation with the Canadian Wildlife Service (CWS) after details of the blasting program are known).

Increased lighting at night or in low-light periods, can attract birds, which may cause them to strike lights and associated infrastructure. This effect is much more likely for marine birds other than the Red Knot and Ivory Gull. Given the reduced susceptibility of these species and their rare presence in the vicinity of lighted structures associated with the Project, no individuals are expected to be affected due to lighting.

Offshore

The Red Knot is not expected to occur in the Offshore Study Area and will not be considered further in the assessment of offshore activities. Activities that are most likely to affect the Ivory Gull include lighting, operation of vessels, operation of helicopters, and seismic surveys.

As described above, Ivory Gulls could be attracted to lights at night or in low visibility conditions (*e.g.*, fog). This effect is much more likely for marine birds other than the Ivory Gull, as described in Section 9.5.1.2. Given the reduced susceptibility of the Ivory Gull and its rare presence in the vicinity of lighted offshore structures associated with the Project, no individuals are expected to be injured due to lighting in the Offshore Study Area.

Sounds from seismic surveys may cause physical effects to marine birds that are underwater and are in close proximity to operating airguns. However, the Ivory Gull is not expected to dive more than 1 m below the water's surface, and thus has a much reduced risk of adverse environmental effects of seismic sound exposure. Therefore, the remaining disturbance effects related to seismic surveys on the Ivory Gull are those associated with the operation of vessels. However, Ivory Gulls are only expected to occur occasionally in the Offshore Study Area (*i.e.*, during the winter), when the likelihood of seismic operations is reduced.

Change in Habitat Use

Nearshore

Very little information is available specific to the effects of construction or offshore operations on either the Ivory Gull or the Red Knot. One study (Burger *et al.* 2007) included an assessment of Red Knot disturbance by humans, cars, airplanes and dog presence. The shorebirds that were studied, responded most strongly to the presence of dogs and did not return to the location within the 10-minute post-disturbance monitoring period. Red Knots also appeared to be more responsive to humans than to cars or planes, showing moderate signs of recovery to pre-disturbance levels within 30 seconds of car or plane disturbance relative to periods greater than the defined 10 minutes for human disturbance. In the same study, Laughing and Herring Gulls recovered to pre-disturbance levels within 5 minutes. When studying the relative number of estuarine waterbirds as a function of distance to human-made structures, Burton *et al.* (2002) found that Red Knot numbers were measurably lower in areas where a human footpath was within 150 m. However, no such effects were observed in association with roads, railroads, or towns.

The Red Knot or Ivory Gull may be temporarily disturbed by passing vessels associated with activities in the Nearshore Study Area. The limited available information suggests that the Red Knot is temporarily disturbed by boat presence, although the approach distances that elicit disturbance are not known. Some gull species may also be attracted to vessels, but it is unknown if Ivory Gulls are attracted to vessels. Vessels of large size, which are fast-

moving, or move with an erratic course are more likely to disturb birds, but vessels operating within the Nearshore Study Area will typically be moving at slow speeds or will remain stationary for extended periods of time.

To the extent practicable, vessels associated with the Project will maintain a steady course and speed. Vessels will maintain a distance from Bellevue Beach to avoid disturbing the Red Knot, particularly from late August to October. Areas where the Ivory Gull or Red Knot occur in the Nearshore Study Area will be avoided to the extent practicable.

For Red Knot in particular, known areas of use have been identified for this species at Bellevue Beach. This location is outside of the Nearshore Project Area and therefore would have little interaction with routine Project construction activities other than passing vessel traffic.

Offshore

As described above, vessel operations may lead to temporary and localized disturbance of the Ivory Gull. However, the Ivory Gull could also be attracted to Project vessels, similar to responses seen in other gull species, particularly if food waste or other waste is discharged overboard. Vessels will maintain a steady speed and course, and waste discharges from vessels will be limited to the extent practicable and will conform with MARPOL requirements. Most marine birds flush or dive in response to low-flying aircraft, presumably including the Ivory Gull, but it is thought that the significance of these disturbances is low for infrequent flights at low altitudes. Low altitude flights will typically only occur during landings in the Offshore Study Area.

As with current regular helicopter servicing of offshore platforms in the Jeanne d'Arc Basin, helicopters used for the Project will likely be based at St. John's Airport and will generally fly "straight" to the Offshore Study Area. Helicopters will be directed to avoid the closest marine bird colonies (*e.g.*, Witless Bay Ecological Reserve) and any known concentrations. *The Wilderness and Ecological Reserves Act* states that no aircraft will fly lower than 300 m or take off or land within the reserve during the period 1 April to 1 September.

Potential Mortality

The only routine Project construction / installation activity that may result in mortality of marine birds SAR is blasting in the nearshore. The mitigation in place for blasting (*i.e.*, use of an observer near the blasting site to monitor if the Red Knot or Ivory Gull is present within the safety zone of the blast location) will reduce the potential for any injury or mortality to marine bird SAR as a result of nearshore construction activities.

The environmental effects of Project construction/installation on marine bird SAR are summarized in Table 11-16.

Table 11-16 Environmental Effects Assessment: Construction and Installation – Marine Bird Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Nearshore Project Activities							
Bund Wall Construction (*e.g.*, sheet / pile driving, infilling)	• Change in Habitat Quantity • Change in Habitat Use		1	2	3/1	R	2
Inwater Blasting	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Adherence with *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* • Monitor appropriate safety zone for diving birds	1	2	2/1	R/I [B]	2
Dewater Drydock / Prep Drydock Area	• Change in Habitat Use		1	1	2/1	R	2
Concrete Production (floating batch)	• Change in Habitat Use		1	1	3/3	R	2
Vessel Traffic (*e.g.,* supply, tug support, tow, diving support, barge, passenger ferry to / from deepwater site)	• Change in Habitat Use	• Maintain steady course and speed	1	2	3/6	R	2
Lighting	• Change in Change in Habitat Quality • Change in Habitat Use	• Proper release of stranded birds per CWS protocol	1	2	3/6	R	2
Air Emissions	• Change in Habitat Quality		N	4	3/6	R	2
Re-establish Moorings at Bull Arm deepwater site	• Change in Habitat Use		1	1	2/1	R	2
Dredging of Bund Wall and Possibly Sections of Tow-out Route to deepwater site (may require at-sea disposal)	• Change in Habitat Use		1	1	2/1	R	2
Removal of Bund Wall and Disposal (dredging/ocean disposal)	• Change in Habitat Quality • Change in Habitat Use	• Monitor appropriate safety zone for SAR	1	2	2/1	R	2
Tow-out of GBS to Bull Arm deepwater site	• Change in Habitat Use		1	1	1/1	R	2
GBS Ballasting and De-ballasting (seawater only)	• Change in Habitat Use		1	1	1/1	R	2
Complete GBS Construction and Mate Topsides at Bull Arm deepwater site	• Change in Habitat Use		1	1	2/2	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Hook-up and Commissioning of Topsides	• Change in Habitat Use		1	1	2/2	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental)	• Change in Habitat Use		1	1	2/1	R	2
Platform Tow-out from deepwater site	• Change in Habitat Use		1	1	3/6	R	2
Offshore Construction/Installation							
OLS Installation and Testing	• Change in Habitat Use		1	2	2/1	R	2
Concrete Mattress Pads / Rock Dumping over OLS Offloading Lines	• Change in Habitat Use		1	2	2/1	R	2
Installation of Temporary Moorings	• Change in Habitat Use		1	1	2/1	R	2
Platform Tow-out / Offshore Installation	• Change in Habitat Use • Change in Habitat Quantity		1	4	2/6	R	2
Underbase Grouting	• Change in Habitat Use		1	1	2/1	R	2
Possible Offshore Solid Ballasting	• Change in Habitat Use		1	1	2/1	R	2
Placement of Rock Scour Protection on Seafloor around Final Platform Location	• Change in Habitat Use		1	1	2/1	R	2
Hook-up and Commissioning of Platform	• Change in Habitat Use		1	1	2/1	R	2
Operation of Helicopters	• Change in Habitat Use	• Avoid active marine bird colonies, including Witless Bay Ecological Reserve • Avoid flying at low altitudes, where possible	1	1	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / shutle tankers / barges / diving / ROVs)	• Change in Habitat Use	• Maintain minimum distance of 2 km from active marine bird colonies • Maintain steady course and speed	1	2	3/6	R	2
Air Emissions	• Change in Habitat Quality		N	5	3/6	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use	• Proper release of stranded birds	1	2	3/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Potential Expansion Opportunities							
Excavated Drill Centre(s) Dredging and Spoils Disposal	• Change in Habitat Use		1	1	2/1	R	2
Installation of pipeline(s) / Flowline(s) and Testing from Excavated Drill Centre(s) to Platform, plus Concrete Mattresses, Rock Cover, or Other Flowline Insulation	• Change in Habitat Use		1	2	2/1	R	2
Hook-up and Commissioning of Drill Centres	• Change in Habitat Use		1	2	2/2	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use		1	3	2/1	R	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2= Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Potential mortality effects reversible at the population level and irreversible at the individual level

Given that Project activities are highly localized, of low to medium magnitude, and reversible, there are not likely to be significant adverse environmental effects on marine bird SAR from construction or installation activities associated with the Project. Project environmental effects are not expected to contravene the prohibitions of SARA (Sections 32(1), 33, 58(1)).

11.6.2.2 Operations and Maintenance

The environmental effects and mitigation measures of routine operations in the Offshore Study Area on marine birds, including SAR, are assessed in Section 9.5.2. The Red Knot is not expected to occur in the Offshore Study Area and will not be considered further in the assessment of offshore activities.

Change in Habitat Quantity

None of the Project activities in the Offshore Study Area during the operations and maintenance phase are predicted to result in changes in habitat quantity for marine birds SAR.

Change in Habitat Quality

Primary Project activities that could result in changes in habitat quality for Ivory Gulls include lighting and flaring, operational discharges and seismic surveys. Lighting and seismic surveys are discussed above for construction (Section 11.6.2.1).

Night-migrating or night-active marine birds might be attracted by flaring in the Offshore Study Area, similar to the effect described for lighting (above). This is less likely to affect the Ivory Gull. The heat and noise generated by the flare may also deter marine birds from the immediate area under most night-time conditions. When attracted to the flare, marine birds may strike infrastructure and become injured or strand. However, the Ivory Gull is more likely to become airborne again after stranding than other marine birds (see Chapter 9). EMDC will develop protocols for monitoring marine birds. As in the case of lighting (described above), a program to search the platform in the morning, followed by release of stranded birds (per the protocol of Williams and Chardine (1999)) will reduce the impact on marine birds.

Gulls may be attracted to vessels and the platform; these birds may rest on the water, making them more likely to come in contact with discharges. Some marine birds, particularly gulls, may be attracted to sewage particles, but the small amount discharged below the surface over short periods are unlikely to increase the abundance of marine birds in the Hebron Offshore Study Area. To minimize the possibility of fouling marine bird feathers, fluids will be discharged below the water's surface whenever possible. It is predicted that the residual environmental effect of fluid/solid storage or discharge on the habitat quality of marine birds in the Offshore Study Area will affect a limited area and be of low magnitude.

Change in Habitat Use

Potential changes in habitat use during Hebron Project operations relate primarily to the presence of the structures (and associated lighting), vessel and helicopter traffic, seismic surveys, and other activities that generate noise / light that could induce temporary and localized disturbance of marine birds.

The physical structure of the platform and support vessels could affect marine birds by attracting them. Additionally, it is possible that the artificial reef effect, created by stationary structures will affect marine bird prey. Shearwaters, Northern Fulmars, and gulls are the species most likely to be attracted to the platform and may rest on the water nearby. It is unknown if Ivory Gull are attracted to structures like other gull species.

Various other activities associated (*e.g.*, lighting, flaring) with the operations and maintenance phase in the Offshore Study Area may induce temporary and localized disturbance of marine birds. These activities are not expected to occur near any Ivory Gull nesting colonies, so will not affect that portion of their life cycle. Disturbance is possible for small feeding concentrations of marine birds that are common in the Offshore Study Area; however, Ivory Gull would not be considered common in the Offshore Project Area. It is expected that bird behaviour would likely return to normal shortly after the completion of these activities (if disturbed at all).

11.6.2.3 Potential Mortality

It is possible that marine birds attracted by gas flaring at night might become incinerated, collide with platform structures, or strand on the platform, thereby causing mortality (Russell 2005; Montevecchi 2006). However, this is less likely to affect the Ivory Gull than other marine bird species.

As discussed in greater detail below in the effects assessment for accidental malfunctions and unplanned events, exposure to oil can be fatal to marine birds. Although free oil is usually removed from produced water before discharge, oil sheens are sometimes associated with produced water discharges (*e.g.*, ERIN Consulting Ltd. and OCL Services Ltd. 2003). Data on the relationship between sheen thickness and lethality to marine birds are lacking (Hartung 1995).

The environmental effects of Project operations and maintenance on marine bird SAR are summarized in Table 11-17.

Given that Project activities are mostly localized, of low magnitude, and reversible, there are not likely to be significant adverse environmental effects on marine bird SAR from the operation and maintenance activities associated with the Project.

EMCP will monitor the SARA registry. If new species that are likely to occur in the Study Areas are added to Schedule 1, or if recovery strategies or monitoring plans are implemented, mitigation measures will be reviewed and updated where required, to ensure that they meet their requirements of the SARA.

Table 11-17 Environmental Effects Assessment: Operations and Maintenance – Marine Bird Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Presence of Structures	• Change in Habitat Use		1	1	5/6	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use	• Proper release of stranded birds	1	2	5/6	R	2
Maintenance Activities (*e.g.,* diving, ROV)	• Change in Habitat Use		1	1	5/3	R	2
Air Emissions	• Change in Habitat Quality		N	5	5/6	R	2
Flaring	• Change in Habitat Use • Potential Mortality		1	1	5/6	R/I [B]	2
Wastewater (*e.g*., produced water, storage displacement water, deck drainage)	• Change in Habitat Quality • Potential Mortality	• Subsurface discharge	1	2	5/6	R/I [B]	2
Chemical Use / Management / Storage (*e.g.*, corrosion inhibitors, well treatment fluids)	• Change in Habitat Quality		1	1	5/6	R	2
WBM Cuttings	• Change in Habitat Quality	• Subsurface discharge	1	1	5/2	R	2
Operation of Helicopters	• Change in Habitat Use	• Avoid active marine bird colonies, including Witless Bay Ecological Reserve • Avoid flying at low altitudes where possible	1	4	5/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / shuttle tankers / barges / ROVs)	• Change in Habitat Use	• Maintain minimum distance of 2 km from active marine bird colonies • Maintain steady course and speed	1	4	5/6	R	2
Surveys (*e.g.*, geophysical, 2D / 3D / 4D seismic, VSP, geohazard, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use • Change in Habitat Quality	• Maintain steady course and speed	1	3	3/2	R	2
Potential Expansion Opportunities							
Drilling Operations from MODU at Future Excavated Drill Centres	• Change in Habitat Use		1	1	3/6	R	2
Presence of Structures	• Change in Habitat Use		1	1	5/6	R	2
WBM and SBM Cuttings	• Change in Habitat Quality	• Subsurface discharge	1	2	5/6	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Chemical Use and Management (BOP fluids, well treatment fluids, corrosion inhibitors)	• Change in Habitat Quality		1	1	5/6	R	2
Geophysical / Seismic Surveys	• Change in Habitat Quality • Change in Habitat Use		1	3	3/2	R	2

KEY

Magnitude:
N = Negligible: There may be some environmental effect but it is not considered to be measurable
1 = Low: <10 percent of the population or habitat in the Study Area will be affected
2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
1 = <1 km^2
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3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
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3 = 13-36 months
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Frequency:
1 = <11 events/year
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3 = 51-100 events/year
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5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm
B Potential mortality effects reversible at the population level and irreversible at the individual level

11.6.2.4 Offshore Decommissioning and Abandonment

None of the Project activities in the Offshore Study Area during the decommissioning and abandonment phase are predicted to result in changes in habitat quantity, or mortality for marine bird SAR. Lighting may affect habitat quality as discussed previously during the construction and operation and maintenance Phases. Changes in habitat use are described below.

Activities associated with the removal of the Hebron Platform and OLS loading points may induce temporary and localized disturbance of marine bird SAR. These activities are not expected to occur near any known nesting colonies, so will not affect that portion of marine bird life cycles. Disturbance is possible for small feeding concentrations of marine birds that are common in the Offshore Study Area; however, Ivory Gull is not considered common in the Offshore Project Area.

Effects and mitigation associated with lighting, vessel traffic and helicopter traffic have been discussed under the construction (Section 11.6.2.1) and are applicable to the decommissioning / abandonment phase.

The environmental effects of Project decommissioning and abandonment on marine bird SAR are summarized in Table 11-18.

Table 11-18 Environmental Effects Assessment: Decommissioning and Abandonment – Marine Bird Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effect[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context
Removal of the Platform and OLS Loading Points	• Change in Habitat Use		1	2	2/1	R	2
Lighting	• Change in Habitat Quality • Change in Habitat Use	• Proper release of stranded birds	1	1	3/5	R	2
Plugging and Abandoning Wells	• Change in Habitat Use		1	1	3/2	R	2
Abandoning the OLS Pipeline	• Change in Habitat Use		1	2	3/1	R	2
Operation of Helicopters	• Change in Habitat Use	• Avoid active marine bird colonies • Avoid flying at low altitudes where possible	1	2	3/6	R	2
Operation of Vessels (supply, support, standby and tow vessels / ROVs)	• Change in Habitat Use	• Maintain minimum distance of 2 km from active marine bird colonies • Maintain steady course and speed	1	3	3/6	R	2
Surveys (*e.g.*, geophysical, geological, geotechnical, environmental, ROV, diving)	• Change in Habitat Use	• Maintain steady course and speed	1	2	3/2	R	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effect[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological / Socio-economic Context

KEY

Magnitude:
- N = Negligible: There may be some environmental effect but it is not considered to be measurable
- 1 = Low: <10 percent of the population or habitat in the Study Area will be affected
- 2 = Medium: 11 to 25 percent of the population or habitat in the Study Area will be affected
- 3 = High: >25 percent of the population or habitat in the Study Area will be affected

Geographic Extent:
- 1 = <1 km^2
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- 4 = 101-1,000 km^2
- 5 = 1,001-10,000 km^2
- 6 = >10,000 km^2

Duration:
- 1 = < 1 month
- 2 = 1-12 months.
- 3 = 13-36 months
- 4 = 37-72 months
- 5 = >72 months

Frequency:
- 1 = <11 events/year
- 2 = 11-50 events/year
- 3 = 51-100 events/year
- 4 = 101-200 events/year
- 5 = >200 events/year
- 6 = continuous

Reversibility:
- R = Reversible
- I = Irreversible

Ecological / Socio-economic Context:
- 1 = Area is relatively pristine or not adversely affected by human activity
- 2 = Evidence of adverse environmental effects

A Where there is more than one potential environmental effect, the evaluation criteria rating is assigned to the environmental effect with the greatest potential for harm

The potential effects of decommissioning activities are expected to be similar (or less than) those of construction or operation; therefore, no significant adverse environmental effects are predicted.

11.6.3 Accidents, Malfunctions and Unplanned Events

The potential effects of accidents, malfunctions and unplanned events without the implementation of control measures on marine birds are fully assessed in Section 9.5.4 and considered fully applicable to marine bird SAR.

Known seasonal habitat for Red Knot has been identified at Bellevue Beach. Spill modelling at the Bull Arm site shows that there is a 1 to 10 percent probability of a diesel fuel spill reaching Bellevue Beach. This probability increases to 10 to 30 percent for IFO-180 fuel released in summer. These probabilities were based on modelling results in the absence of any spill intervention (ASA 2011a, 2011b). The Ivory Gull is also considered an occasional seasonal visitor to both the Nearshore and Offshore Study Areas; therefore, the likelihood of an accidental spill affecting numbers of individuals would be unlikely. Potential transboundary effects are discussed in Section 11.4.3.2.

Mitigation for accidental hydrocarbon spills will consist of following the protocols detailed in the spill response plan. A spill response plan will identify sensitive areas in the nearshore area that may be affected by oil spills.

Response plans will identify specific countermeasures for these sensitive areas, specific to the shoreline type. Depending on the nature and tiered response required, mitigations include the provision for spill response equipment and the rescue and rehabilitation of oiled marine birds. Marine bird rehabilitation will be facilitated through ExxonMobil's North American support network. These procedures will minimize the potential mortality from such accidental events.

The environmental effects of Project accidents, malfunctions and unplanned events on marine bird SAR are summarized in Table 11-19. The geographic extents provided in Table 11-19 were based on modelling results in the absence of any spill intervention (ASA 2011a, 2011b).

Table 11-19 Environmental Effects Assessment: Accidental Events– Marine Bird Species at Risk

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Bund Wall Rupture	• Change in Habitat Quality • Change in Habitat Use	• Prevention through design standards and maintenance • Emergency Response Contingency Plan	1	1	1/1	R	2
Nearshore Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	2	4-5	2/1	R/I [B]	2
Failure or Spill from OLS	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	6	2/1	R/I[B]	2
Subsea Blow-out	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	6	3/1	R/I[B]	2
Crude Oil Surface Spill	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	6	2/1	R/I[B]	2

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects[A]				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Platform)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	1	2/1	R/I[B]	2
Marine Vessel Incident (*i.e.*, fuel spills)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	3	5	2/1	R/I[B]	2
Collisions (involving Platform, vessel and/or iceberg)	• Change in Habitat Quality • Change in Habitat Use • Potential Mortality	• Oil spill response plan • Training, preparation, equipment inventory, prevention, and emergency response drills	2	3	2/1	R/I[B]	2

KEY

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Frequency:
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R = Reversible
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Ecological / Socio-economic Context:
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2 = Evidence of adverse environmental effects

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B Potential mortality effects reversible at the population level and irreversible at the individual level

11.6.4 Cumulative Environmental Effects

Marine oil and gas exploration, commercial fishery activity, marine transportation and existing production activity (*e.g.*, White Rose, Hibernia, and Terra Nova) could affect marine birds (see Table 11-15). Hunting of marine birds occurs in the Nearshore Study Area, but not for SAR. It is unlikely that routine activities associated with other offshore oil and gas exploration, existing production areas, marine transportation, and commercial fisheries have substantive environmental effects on marine bird SAR (see, for example, LGL 2007d; Christian 2008). The one exception would be an accidental hydrocarbon spill or blow-out in the Offshore Study Area.

11.6.4.1 Nearshore

Cumulative environmental effects in the Nearshore Study Area are expected to be of a lower magnitude than those of the Offshore Study Area, as fewer activities may interact with the current Project (see Section 11.6.4.2 for cumulative environmental effects assessment of the Offshore Study Area).

11.6.4.2 Offshore

With respect to marine bird SAR, the main projects and activities that could result in cumulative environmental effects include other oil and gas activities, tankering, shipping and commercial shipping. Effects of seismic activities on marine birds were considered to be negligible; therefore, no significant cumulative adverse environmental effects are predicted with respect to a spatial overlap of seismic programs within the Affected Area. As described above, the Project is a sufficient distance from other platforms in the region to not have a cumulative environmental effect with respect to attraction of birds to lights and flares.

It was estimated that an annual average of 315,200 (±45,600) marine birds suffered oil-related mortalities due to the effects of oiling from illegal bilge pumping and chronic spills from vessel off southeast Newfoundland during the winter periods, 1998 to 2001 (Weise and Robertson 2004). Any cumulative environmental effects of oiling from illegal bilge pumping and chronic spills as a result of other vessel activities would be additive and density dependent. Operations will be managed to minimize the probability of Project-related spills from the Hebron Platform and, in the unlikely event of a spill, implement appropriate spill response measures in an attempt to minimize effects.

11.6.5 Determination of Significance

The determination of significance is based on the definition provided in Section 11.2. It considers the magnitude, geographic extent, duration, frequency, reversibility and ecological context of each environmental effect within the Study Area, and their interactions, as presented in the preceding analysis. Significance is determined at the population level within the Study Area.

Project construction, operation and maintenance and decommissioning activities, including malfunctions and accidents and cumulative environmental effects, are predicted to be not significant on marine bird SAR. Due to the lack of critical habitat, the transient and occasional nature of movements of SAR in the Project Area and the low probability of interactions with Project activities, no significant adverse environmental effects are expected on habitat quantity, quality or use, or due to mortality. Mitigation measures planned for the project will also reduce the potential for adverse environmental effects on SAR.

The significance of potential residual environmental effects, including cumulative environmental effects, resulting from the interaction between Project-related activities and marine bird SAR, after taking into account any proposed mitigation, is summarized in Table 11-20.

As required by CEAA, an analysis of potential environmental effects to the sustainable use of renewable resources associated with this VEC has been considered. No significant adverse residual environmental effects on marine SAR or their respective habitats are predicted that could affect renewable resource use.

Table 11-20 Residual Environmental Effects Summary: Marine Birds Species at Risk

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Construction / Installation[B]	NS	3	N/A[D]
Operation and Maintenance	NS	3	N/A
Decommissioning and Abandonment[C]	NS	3	N/A
Accidents, Malfunctions and Unplanned Events	S	1	1
Cumulative Environmental Effects	NS	2	N/A

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Environmental Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

A As determined in consideration of established residual environmental effects rating criteria
B Includes all Bull Arm activities, engineering, construction, removal of the bund wall, tow-out and installation of the Hebron Platform at the offshore site
C Includes decommissioning and abandonment of the GBS and offshore site
D Effect is not predicted to be significant, therefore the probability of occurrence rating is not required under CEAA

11.6.6 Follow-up and Monitoring

For MODU drilling operations, EMCP will implement a marine bird observation program similar to those conducted during exploration drilling programs in the Newfoundland and Labrador Offshore Area. EMCP supports initiatives such as the recent Environmental Studies Research Fund marine bird monitoring program and will investigate the development of a marine bird observation program from Hebron Project supply vessels, where space is available. Marine bird monitoring protocols will take into consideration those established by CWS. Data will be provided to the C-NLOPB and CWS.

Specific follow-up programs to verify the accuracy of assessment predictions and the efficacy of mitigation measures are not planned for marine bird SAR.

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12 SENSITIVE OR SPECIAL AREAS

Sensitive or Special Areas have been selected as a Valued Ecosystem Component (VEC) due to stakeholder and regulatory concerns about the vulnerability of sensitive or special areas to potential Project-related effects, including potential exposure to contaminants from operational discharges and accidental spills from the Project. Sensitive or Special Areas are often identified with rare or unique marine habitat features, habitat that supports sensitive life stages of valued marine resources, and/or critical habitat for species of special conservation status. For the purposes of this assessment, Sensitive or Special Areas are defined as:

- An area that is afforded some level of protection under federal or provincial legislation (*i.e.*, National Parks, ecological reserves, *Oceans Act* Marine Protected Areas (MPAs), National Marine Conservation Areas (NMCAs), National Historic Sites, fishery management areas)
- An area that may be under consideration for such legislative protection (*i.e.*, potential or proposed coastal or marine protected areas)
- An area that is known to have particular ecological or cultural importance and is not captured under federal or provincial regulatory frameworks (*e.g.*, corals; spawning, nursery, rearing, or migratory areas; areas of high productivity; rare or unique habitats; Important Bird Areas (IBAs); Ecologically and Biologically Significant Areas (EBSAs); areas of traditional harvesting activities)

The above definition is based on that used by the C-NLOPB (2009a). The identification of an area as sensitive or special does not automatically imply that this area will require the application of non-typical mitigations or restriction on activities. The timing, spatial extent, and nature of proposed Project activities, in addition to mitigations prescribed by legislation, will determine the level of restriction or mitigation that will be required.

As per the Scoping Document (C-NLOPB 2009), the Sensitive or Special Areas included in this assessment include important or essential habitat to support marine resources (see Chapters 7 to 10) or areas identified through the Placentia Bay-Grand Banks (PBGB) Large Ocean Management Area (LOMA) Integrated Management Plan Initiative. In the Nearshore Study Area, these Sensitive or Special Areas include capelin beaches (*e.g.*, Bellevue Beach) and eelgrass beds (Figure 12-1). Offshore Sensitive or Special Areas include those designated by the Northwest Atlantic Fisheries Organization (NAFO), specifically the Southeast Shoal Vulnerable Marine Ecosystem (VME) and various canyon areas and seamount and knoll VMEs. In addition, the following EBSAs, as identified by Fisheries and Oceans Canada (DFO), occur within the Offshore Study Area: Northeast Shelf and Slope; Virgin Rocks (immediately adjacent to the Offshore Study Area); Lily Canyon-Carson Canyon and Southeast Shoal and Tail of the Banks (Figure 12-2). The special areas atlas prepared by the Canadian Parks and Wilderness Society (CPAWS 2009) is also referenced where a special area has been identified within either the Nearshore or Offshore Study Area. The Bonavista

Cod Box is located outside of the Offshore Study Area and is therefore not considered.

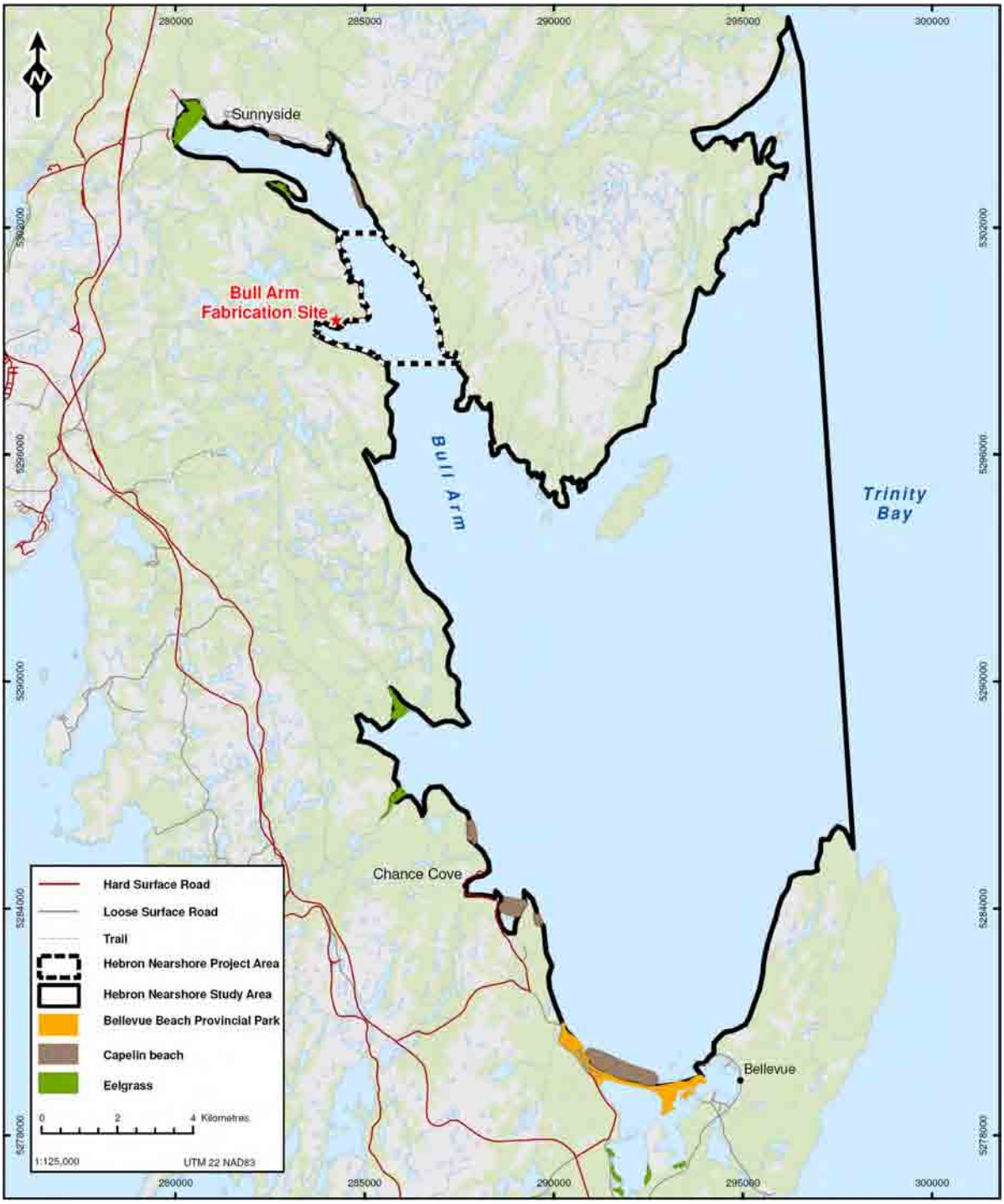


Figure 12-1 Identified Sensitive or Special Areas within the Nearshore Study Area

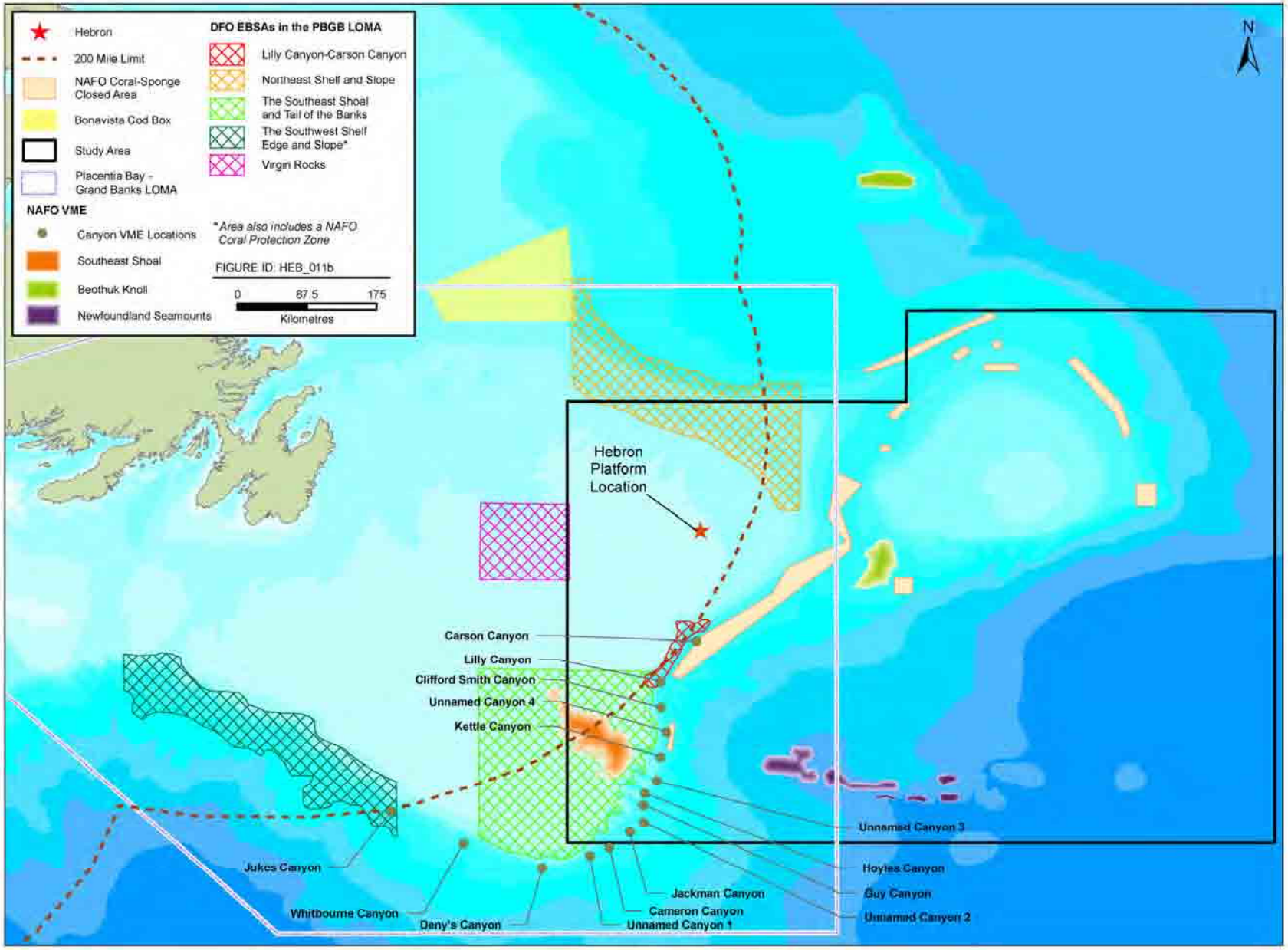


Figure 12-2 Identified Sensitive or Special Areas within the Offshore Study Area

This VEC is directly linked to several other VECs as Sensitive or Special Areas represent the physical habitat areas supporting biological resources that are also assessed separately including, Marine Fish and Fish Habitat (Chapter 7), Marine Birds (Chapter 9), Marine Mammals and Sea Turtles (Chapter 10) and Species at Risk (Chapter 11).

12.1 Environmental Assessment Boundaries

12.1.1 Spatial and Temporal

12.1.1.1 Nearshore

The Nearshore Study Area and Nearshore Project Area are defined in the Environmental Assessment Methods Chapter (Chapter 4). The affected area will vary by Project activity, the nature of the VEC and the sensitivity of different species within the VEC. The Affected Areas for several Project activities have been determined by modelling (see AMEC 2010; ASA 2011a, 2011b; JASCO 2010; Stantec 2010b).

The temporal boundary for the environmental assessment is determined by the schedule and duration of Project activities. These are further described in Table 12-1.

Table 12-1 Temporal Boundaries of Study Areas

Study Area	Temporal Scope
Nearshore	• Construction: 2011 to 2016, activities will occur year-round
Offshore	• Surveys (geophysical, geotechnical, geological, environmental): 2011 throughout life of Project, year-round • Construction activities: 2013 to end of Project, year-round • Site preparation / start-up / drilling as early as 2015 • Production year-round through to 2046 or longer • Potential expansion opportunities - as required, year-round through to end of Project • Decommissioning / abandonment: after approximately 2046

12.1.1.2 Offshore

The Offshore Study Area and Offshore Project Area are defined in the Environmental Assessment Methods Chapter (Chapter 4). For this VEC, the Offshore Affected Area of most relevance is that for an accidental oil spill. The identified Offshore Sensitive or Special Areas are all located outside of the predicted zones of influence of routine Project-related activities.

As well, while the Affected Area for an oil spill in some cases may overlap with a portion of an identified sensitive or special area, in these cases the assessment considers the potential for Project-related environmental effects on the identified area as a whole.

Ecologically, some of the identified Sensitive or Special Areas would be more vulnerable to Project-related environmental effects at certain times of the year and these vary between areas dependent on the species known to use the

habitat. For instance, the Northeast Shelf and Slope EBSA is known to attract aggregations of spotted wolffish and Greenland halibut in the spring. The Lily Canyon-Carson Canyon EBSA attracts year-round aggregations of marine mammals for feeding and overwintering.

12.1.2 Administrative

The administrative boundaries for Sensitive or Special Areas overlap with those for Marine Fish and Fish Habitat as many of the identified sensitive or special areas are related to the protection of critical life stages of marine fish. A full discussion of administrative boundaries related to Marine Fish and Fish Habitat is found in Section 7.1.3.

Protection of marine sensitive areas is also provided by DFO's *Oceans Act*. The *Oceans Act*, which was passed in 1997, allows for the development of a national oceans strategy based on the principles of sustainable development, integrated management and the precautionary approach. Importantly, the *Act* also authorizes DFO to provide enhanced protection to marine areas which are determined to be ecologically or biologically significant (DFO 2004d). The Offshore Project Area is within an area currently being considered as part of an Integrated Management Plan for the PBGB LOMA. As part of this plan, DFO has identified EBSAs, which may require specific management measures. Some EBSAs may be put forward as Areas of Interest for MPA status and other EBSAs may be considered for protection under other management tools. The potential management implications for these EBSAs are still being determined through ongoing planning processes within DFO. Currently, none of the EBSAs within the Offshore Study Area (Figure 12-2) have been recommended as Areas of Interest or are subject to any special legislated protection measures or restrictions, although it is acknowledged that these may be implemented for some of the EBSAs at some point in the future.

Other Sensitive or Special Areas within the Offshore Study Area are those identified by NAFO, which has committed to identifying VMEs in the offshore environment. A number of proposed VMEs have been identified offshore Newfoundland, within the context of managing deep sea fisheries and their potential environmental implications of these activities. Other than restrictions on fishing in these areas, there are no management procedures in place that would be applicable to or affect planned Project activities.

Sensitive or Special Areas can also be linked to the federal *Species at Risk Act* (SARA), which protects the critical habitat of species assessed as Threatened or Endangered. Where identified, Sensitive or Special Areas are known to support Species at Risk; these are identified within the description of existing conditions.

12.2 Definition of Significance

A significant adverse residual environmental effect is one that alters the valued habitat of the identified Sensitive or Special Areas physically, chemically or biologically, in quality or extent, to such a degree that there is a

decline in abundance of key species or species at risk or a change in community structure, beyond which natural recruitment (reproduction and immigration from unaffected areas) would not return the population or community to its former level within several generations.

An adverse residual environmental effect that does not meet the above threshold is considered to be not significant.

12.3 Existing Conditions

The following description of Sensitive or Special Areas in the Nearshore Study Area is based on existing data sources, supplemented by information supplied by local fishers in the area (B. Warren, pers. comm.). The description of Sensitive or Special Areas in the Offshore Study Area is based on existing government and scientific sources.

12.3.1 Nearshore

Two types of Sensitive or Special Areas are identified and considered in the nearshore: eelgrass beds and capelin beaches.

12.3.1.1 Eelgrass Beds

Eelgrass (*Zostera marina* L.) is a type of submerged aquatic vegetation that grows in estuaries and shallow bays. It is a perennial flowering plant that grows both by vegetative growth and by seed germination. Eelgrass abundance varies seasonally, with winter die-off and spring / summer re-growth, and annually due to a variety of factors. These can include physical and chemical disturbance, changes in nutrient availability, and changes in water quality parameters such as turbidity and salinity (Eelgrass Fact Sheet, http://www.oregon.gov/DSL/SSNERR/tides/tidesA13_eelgrassfacts.pdf).

Eelgrass has been recently assessed by DFO, and in eastern Canada, DFO has determined that eelgrass has characteristics which meet the criteria of an Ecologically Significant Species (DFO 2009i). These criteria include the following:

- By its structure, it creates habitat that is used preferentially by other species
- It physically support(s) other biota, and provides either settlement substrate or protection for this associated community
- It is abundant enough and sufficiently widely distributed to influence the overall ecology of that habitat

Eelgrass beds perform important ecological functions including filtering of the water column, stabilizing sediment, and buffering shorelines from erosion (DFO 2009i). Eelgrass beds are highly productive ecosystems due to both rapid turnover of eelgrass leaves and epiphytic algae on leaf surfaces and represent a valuable component of the coastal food chains and contributor to the nutrient cycle. Densities of a variety of invertebrate species are high in eelgrass beds as they feed on the epiphytes on eelgrass. The organisms, in

turn, support higher trophic levels. The fish species that are likely to be present in the eelgrass include juvenile and adult cunner, juvenile lumpfish, juvenile lobster and pelagic juvenile Atlantic cod (between June and October), recently post-settled demersal juvenile Atlantic cod and herring. Eelgrass beds are also an important feeding area for some species of migrating birds.

Eelgrass is considered to meet the criteria for an ESS as severe perturbation of these species is deemed to have far greater ecological consequences than an equal perturbation of most other species associated with this community (DFO 2009i). Based on current knowledge, eelgrass, where it presently exists, can have controlling influence over key aspects of the nearshore marine ecosystem structure and function.

Based on existing surveys, eelgrass is distributed around Newfoundland with the greatest abundance on the southwest coast (DFO 2009i). While eelgrass occurs commonly in eastern Canada where there are suitable conditions, it is generally absent from rocky, high energy coastlines or areas of high turbidity. Therefore, eelgrass is constrained in many coastal areas around Newfoundland by both coastal features and the extent of ice scour. While there are no estimates of areal coverage in Newfoundland, except in a small number of individual embayments (*e.g.*, Newman Sound), there are several large beds on the west coast of the island. The location of several eelgrass beds within the Nearshore Study Area, as identified by local fishers (B. Warren, pers. comm.), is provided on Figure 12-1.

Declines in eelgrass beds have been documented around the world with possible explanations for these declines in the Maritime Provinces including eutrophication, disturbance by invasive green crab (*Carcinus maenas*), human activities, and environmental changes (DFO 2009i). In Newfoundland, however, there appears to be a general increase in eelgrass abundance in the last decade based on local knowledge. The increases in some locations may be due to improved conditions for eelgrass (milder temperatures, more favourable sea ice conditions) (DFO 2009i).

12.3.1.2 Capelin Beaches

Capelin *(Mallotus villosus)* have been addressed in the Marine Fish and Fish Habitat VEC; Section 7.3.2.4 provides a description of expected spawning behaviour of this species.

Local fishers (B. Warren, pers. comm.) have identified five smaller capelin beaches within the Nearshore Study Area (Figure 12-1). In addition, Bellevue Beach is located in the southern extent of the Nearshore Study Area. It is one of largest capelin spawning beaches on the east coast of Newfoundland and has been the subject of an annual production survey since 1990 (Nakashima and Wheeler 2002). Demersal spawning of capelin near Bellevue Beach is also reported (CPAWS 2009). Eelgrass, kelp and Irish moss beds have also been reported in the area of Bellevue Beach (CPAWS 2009).

Historically, capelin have spawned on Newfoundland beaches in June and July as three- and four-year-old fish. Beginning early in the 1990s, several

changes in spawning behaviour were observed and continue to occur (DFO 2008c) as documented from observations at Bellevue Beach. Spawning now generally occurs four weeks later in July and August and is comprised of mostly two- and three-year-old fish. The amount of off-beach spawning is assumed to vary from year to year. As well, the average size of mature capelin continues to be smaller than that observed in the 1980s. While the initial shift in spawning behaviour appeared to be linked to below-average seawater temperatures, these trends have continued over time despite higher seawater temperatures since the mid-1990s.

DFO (2008c) indicates that Bellevue Beach continues to be a key spawning beach for capelin, with egg deposition in Bellevue Beach in 2007 being the fifth highest since 1990 and larval emergence from Bellevue Beach in 2007 being the fourth highest since 1990. While there are no recent estimates of abundance available for the entire capelin stock, spring acoustic surveys estimated abundances that are considerably lower than those from the late 1980s. Increases in the offshore abundance of capelin in 2007 and 2008 from spring acoustic surveys complement observations by fish harvesters that abundance has been increasing since 2006.

12.3.2 Offshore

The following text describes the Sensitive or Special Areas identified in the Offshore Study Area (refer to Figure 12-2); the descriptions are based on existing sources of data.

The Nearshore and Offshore Project Areas are within an area currently being considered as part of an Integrated Management Plan for the Placentia Bay-Grand Banks (PBGB) Large Ocean Management Area (LOMA) and falls within Canada's Newfoundland-Labrador Shelves Marine Ecoregion. This is relevant as the biogeographic classification system is used for: i) assessing and reporting on ecosystem status and trends; and ii) spatial planning for the conservation of ecosystem properties and management of human activities. As part of the LOMA plan, DFO has identified EBSAs that may require special management measures. Some EBSAs may be put forward as Areas of Interest for MPA status and other EBSAs may be considered for protection under other management tools. EBSAs are tools that are used to highlight an area of high biological or ecological significance and as such additional protections or management strategies may be applied to these areas. None of the EBSAs overlap with the Offshore Project Area. There are no MPAs within or immediately adjacent to the Offshore Project Area.

12.3.2.1 Ecologically and Biologically Significant Areas

As stated above, the Offshore Project Area is within an area currently being considered as part of an Integrated Management Plan for the PBGB LOMA. As part of this plan, DFO has identified EBSAs which may require specific management measures. None of the EBSAs overlap with the Offshore Project Area (Figure 12-2). The closest, which is the Northeast Shelf and Slope EBSA, is located 39 km from the Offshore Project Area. The other EBSAs are all located south of the Project Area, with the exception of the

Virgin Rocks, which is adjacent to the western boundary of the Offshore Study Area.

EBSAs are identified based on pre-established criteria, including primary criteria of uniqueness, aggregation and fitness consequences and secondary criteria of resilience and naturalness (DFO 2004d). In total, 11 EBSAs have been identified, evaluated and ranked for the PBGB LOMA (DFO 2007d). Of these 11, the Southeast Shoal and Tail of the Banks EBSA was given the highest priority ranking. The other three EBSAs being considered within this assessment were ranked in the bottom four. Each of these areas and the rationale for selection as an EBSA is provided in more detail below as described in DFO (2007d).

The Southeast Shoal and Tail of the Banks Ecologically and Biologically Significant Area

The Southeast Shoal and Tail of the Banks EBSA is an area east of 51°W and south of 45°N, extending to the edge of the Grand Bank (DFO 2007d). The Southeast Shoal has the warmest bottom water temperatures on the Grand Banks and a well-defined gyre making it very productive area for plankton (CPAWS 2009). It is unique in that it is the only shallow sandy offshore shoal in the LOMA, it contains relict populations of blue mussel, wedge clam and capelin associated with beach habitats, and it contains the highest benthic biomass on the Grand Bank. It is also known to be:

- The only known offshore spawning site for capelin
- The single nursery area of the entire stock of yellowtail flounder
- A spawning area for several groundfish species (American plaice, yellowtail flounder and Atlantic cod)
- An important nursery area for NAFO Division 3NO cod and American plaice
- An area that attracts large aggregations of marine mammals (especially humpbacks and northern bottlenose) and marine birds due to presence of forage species
- An area with the densest concentration of striped wolffish (listed as 'special concern' SARA and assessed as "special concern" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)
- An area which supports the highest density of American plaice on the Grand Banks since the mid-1990s

The Southeast Shoal and Tail of the Banks EBSA is a naturally dynamic sandy bottom habitat that is subject to regular physical disturbance by wave action from storms and is thus less sensitive to disturbance. Fishing has greatly altered the ecosystem within the EBSA and, therefore, DFO (2007d) concludes that ecosystem and community resilience in the Southeast Shoal area has been diminished and is likely sensitive to further disturbance.

Northeast Shelf and Slope Ecologically and Biologically Significant Area

The Northeast Shelf and Slope EBSA is on the northeastern Grand Bank, starting at the Nose of the Bank, from 48°W to 50°W, and from the edge of

the shelf (*e.g.*, 200 m depth contour) to the 1,000 m depth contour (Figure 12-2). It is ranked ninth of the eleven identified EBSAs in the PBGB LOMA and is identified as an EBSA because portions of the area are known for:

- Aggregations of spotted wolffish (listed as "threatened" under SARA and assessed as "threatened" under COSEWIC) in spring
- High concentrations of Greenland halibut in spring
- Aggregations of marine mammals, particularly harp seals (Sackville Spur west), hooded seals (Sackville Spur east) and pilot whales
- Two important coral areas at Tobin's Point and Funk Island Spur (CPAWS 2009).

While the area is important to the function of some species, it is not considered otherwise unique. The area is also not considered particularly sensitive to disturbance as compared to other slope areas occurring in the region.

Lily Canyon-Carson Canyon Ecologically and Biologically Significant Area

Lily Canyon-Carson Canyon is an area from 44.8°N to 45.6°N along the 200 m depth of the southeast slope of Grand Bank and is ranked eighth of the eleven identified EBSAs in the PBGB LOMA. The area is assigned a low ranking for uniqueness as various other canyons occur throughout the Grand Banks, and while the area is important to the feeding and productivity of Iceland scallops, the species is known to occur elsewhere. The EBSA received a high ranking for aggregation as a high proportion of Iceland scallops are known to occur in the canyons, as well as year-round aggregations of marine mammals for feeding and overwintering (CPAWS 2009). The EBSA is also ranked high for fitness consequences (*i.e.*, the degree that natural activities take place that contribute significantly to the survival or reproduction of a species or population) and naturalness as the area remains highly productive, and the deeper parts of the canyons are relatively undisturbed.

Virgin Rocks Ecologically and Biologically Significant Area

The Virgin Rocks EBSA comprises the area from 46°N to 46.8°N and from 50°W to 51°W (located outside of but immediately adjacent to the Offshore Study Area). It is ranked lowest in priority of the 11 identified EBSAs. The area is considered geologically unique, as large nearly exposed rocks on the Grand Banks are a one of a kind geological feature/habitat in the LOMA. The area is known to attract aggregations of capelin and marine birds and support spawning and breeding of Atlantic cod, American plaice and yellowtail flounder, although these species are known to spawn elsewhere (CPAWS 2009). While the physical habitat of this EBSA has low sensitivity to disturbance, intensive fishing has resulted in the decline of several of the traditionally abundant species in the area thereby reducing the resiliency of the community and ecosystem.

12.3.2.2 Northwest Atlantic Fisheries Organization Vunerable Marine Ecosytems

As identified above in Section 12.2.2, NAFO has committed to identifying candidate VMEs using criteria that have received general consensus internationally (*i.e.*, the Food and Agriculture Organization (FAO) of the United Nations *International Guidelines for the Management of Deep Sea Fisheries in the High Seas*) (NAFO 2008). The NAFO Ecosystem Working Group has proposed a number of VMEs, including many of the canyons along the shelf edge, seamounts and knolls, the Southeast Shoal, cold seeps, and carbonate mounds and hydrothermal vents, in the NAFO regulatory area.

Candidate VMEs are identified within the context of managing deep sea fisheries and their potential environmental implications of these activities. Therefore, the focus in identifying candidate VMEs has been on the areas that are currently fished (where the necessary benthic data to identity candidate VMEs is available), or that are currently technically feasible for fishing. For this reason, VMEs are being defined where data has been collected and where the bottom depth is less than the presumed current maximum trawl depth of approximately 2,000 m (NAFO 2008). Areas outside of the existing fishing area will be subject to new fishing area protocols in the future, and VMEs will be later identified as part of that process. Identified and delineated VMEs in the existing fishing areas will likely be subject to additional management measures aimed to protect the high species biodiversity within these special regions (NAFO 2008).

The FAO guidelines suggest five criteria for identifying VMEs:

- Uniqueness or rarity
- Functional significance of the habitat – discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life-history stages (*e.g.*, nursery grounds or rearing areas), or of rare, threatened or endangered marine species
- Fragility – an ecosystem that is highly susceptible to degradation by anthropogenic activities
- Life-history traits of component species that make recovery difficult – ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics: slow growth rates, late age of maturity, low or unpredictable recruitment, or long-lived
- Structural complexity – an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features

Sessile and very low mobility organisms (*e.g.*, corals, sponges, bivalves) were identified by NAFO (2008) as the most likely foundation organisms for VMEs. Corals create vertical relief and increase the availability of microhabitats. This in turn attracts and provides for aggregations of feeding species, a nursery area for juveniles, fish spawning aggregation sites and attachment substrate for fish egg cases and sedentary invertebrates. These functions are known to be served by deep water coral habitats, creating areas high in invertebrate biodiversity and supporting a large abundance of fish. Concentrations of sponges, particularly those of large size, are also known to be habitat-forming

structures, often with numerous other species living within and around their body structures.

Bottom trawling is known to have deleterious effects on complex habitats. The structural characteristics and long-lived nature of some deep water corals make them especially vulnerable to damage by the mechanical effects of bottom fishing activities. In identifying coral VME components, the size, structural complexity, gregariousness, fragility, vulnerability to fishing gears, rarity, longevity, role in the ecosystem (associated species, biodiversity) and international recognition of status were considered.

Canyon Vunerable Marine Ecosytems

Geological features, such as canyons are known to support vulnerable species, communities or habitats and therefore qualify as VMEs (NAFO 2008). Canyon ecosystems can support diverse biological communities, including sensitive structure-forming coldwater corals and deep sea fishes (Gordon and Fenton 2002; Rutherford and Breeze 2002).

Thirteen offshore canyons, which occur along the continental shelf break, have been identified as potential VMEs and are located within the Hebron Offshore Study Area (NAFO 2008). These include: Denys Canyon, Unnamed Canyon 1, Cameron Canyon, Jackman Canyon, Unnamed Canyon 2, Guy Canyon, Hoyles Canyon, Unnamed Canyon 3, Kettle Canyon, Unnamed Canyon 4, Clifford Smith Canyon, Lilly Canyon, and Carson Canyon (Figure 12-2).

The upper limit of these canyons were delineated by the 200 m depth contour, while the lower limit varied but generally was determined by the 2,000 m depth contour. NAFO recognizes that the ecology of these canyons is not well documented, but has based their proposals on research from other canyons such as The Gully (Gordon and Fenton 2002), which suggests that these features support vulnerable species and communities.

Seamounts and Knolls Vunerable Marine Ecosytems

A seamount is an elevation of the sea floor, 1,000 m or higher, that can be flat-topped or peaked and can occur as isolated peaks or as a chain of peaks. Ecosystems surrounding these features are considered sensitive to anthropogenic disturbance because they are comprised of species that are mostly slow-growing, long-lived, late to mature, and experience low natural mortality. Corals and sponges are often associated with these features, as well as aggregations of deep sea fishes.

In proximity to the Offshore Study Area, there is one seamount chain, the Newfoundland Seamounts, located in deep water beyond the continental slope and one isolated knoll, known as the Beothuk Knoll (Figure12-2). Despite the lack of detailed survey information, there is evidence of the occurrence of coldwater corals and potentially vulnerable deep sea fishes on these seamounts, which is why they have been proposed as VMEs (NAFO 2008).

Proposed Southeast Shoal Vunerable Marine Ecosytems

The Southeast Shoal is the shallowest area on the southeastern Grand Banks (Figure 12-2) and attracts many fish and marine mammal species that feed in summer and apparently overwinter (NAFO 2008; CPAWS 2009). Although the area is shallow and much of the bottom is comprised of sand, the Southeast Shoal is still considered to qualify as a VME based on several of the suggested FAO criteria.

The area is considered physically unique on the Grand Banks, as the last area to remain above sea level prior to the last glacial period. As past beach habitat, it supports two possible relict bivalve populations, including the wedge clam (*Mesoderma deauratum*). It is the only known offshore area for the spawning of 3NO capelin (currently under moratorium) and is important habitat for several other species under moratorium or at-risk, including cod, American plaice and striped wolffish. The Southeast Shoal is an area of high productivity and biodiversity, and is an important feeding area for several marine mammals, including humpback whales, as well as for various marine birds. The proposed VME is located within the boundaries of DFO's Southeast Shoal and Tail of the Banks EBSA.

12.4 Project-Valued Ecosystem Component Interactions

12.4.1 Nearshore

With respect to eelgrass beds and potential interactions with nearshore Project-related activities, the major concern is the potential for physical and/or chemical alteration or disturbance of areas in which eelgrass is present. Eelgrass beds (Figure 12-1) are located at sufficient distance from the Nearshore Project Area such that there is no potential for physical disturbance of these sensitive habitats from routine Project activities and physical works, including Project-related sedimentation. Eelgrass is common in areas of high sedimentation such as estuaries (Short *et al.* 2002). There is potential for species that use eelgrass bed habitats (including pelagic juvenile Atlantic cod (between June and October) and recently post-settled demersal juvenile Atlantic cod) to experience disturbance and/or avoidance effects due to Project-related noise and lights. These potential effects are fully considered and assessed in the respective VECs (*i.e.*, Marine Fish and Fish Habitat, Marine Birds). The residual adverse environmental effects have been rated as not significant and these interactions are not further assessed in this VEC.

There is potential for eelgrass beds to be physically affected by an accidental spill in the nearshore environment during construction, which could result in a potential widespread die-off of meadows as will as individual plants. This potential interaction is fully assessed below (Section 12.5.1.1).

Similar to eelgrass beds, the identification of potential interactions between capelin beaches and Project activities has to be inclusive of the potential for physical alteration or disturbance of capelin beaches and potential interactions with spawning capelin within the Nearshore Study Area. Routine

Project activities and physical works are not expected to spatially overlap with capelin beaches in a manner that could result in measureable physical alteration or disturbance of these habitats. While spawning capelin could interact with various Project activities that generate noise and lights, the resulting potential for disturbance / avoidance has been fully assessed in the Marine Fish and Fish Habitat VEC (Chapter 7) and the residual adverse environmental effects have been rated as not significant. This effect is not further assessed in this VEC.

There is potential for capelin beaches to be physically affected by an accidental oil spill in the nearshore environment during construction resulting in a reduction of habitat quality. This potential interaction is fully assessed below.

12.4.2 Offshore

The identified Sensitive or Special Areas located in or proximate to the Offshore Study Area are all located outside of the Hebron Offshore Project Area (Figure 12-2). The closest identified Sensitive or Special Area is the Northeast Shelf and Slope EBSA, which is located 39 km from the Project Area. Due to the degree of separation, there will be no spatial overlap and resulting interactions between routine Project activities and the identified Offshore Sensitive or Special Areas.

There is potential for a number of accidental event scenarios resulting in release of hydrocarbons to interact with identified Sensitive or Special Areas within the Offshore Study Area, resulting in a reduction of habitat quality. The potential for interactions as a result of accidents, malfunctions and/or unplanned events is fully assessed in Section 12.5.1.2.

12.4.3 Summary

In summary, both the nearshore and offshore assessments are limited to the potential for interactions resulting from accidents, malfunctions and/or unplanned events. This interaction creates the potential for changes in habitat quality. For nearshore eelgrass beds, there is also the potential for mortality of individual plants as a result of oiling. Effects on species using the sensitive areas (*e.g.*, change in habitat use and direct mortality) are addressed in their respective VEC sections (Marine Fish and Fish Habitat (Chapter 7), Marine Birds (Chapter 9), Marine Mammals and Sea Turtles (Chapter 10) and Species at Risk (Chapter 11)) and are not further assessed in this VEC.

As the potential for interactions between Project activities and the Sensitive or Special Areas in the Nearshore and Offshore are limited to accidental events which are not considered likely Project effects, cumulative environmental effects are not assessed in relation to these accidental events.

A summary of the potential environmental effects resulting from Project-VEC interactions resulting from accidents, malfunctions and unplanned events is included in Table 12-2.

Table 12-2 Potential Project-related Interactions: Sensitive or Special Areas

Project Activities and Physical Works	Potential Environmental Effects	
	Habitat Quality	Mortality
Accidents, Malfunctions and Unplanned Events		
Nearshore Bund Wall Rupture		
Nearshore Spill (at Bull Arm Site)	x	x[A]
Offshore Failure or Spill from OLS	x	
Offshore Subsea Blowout	x	
Offshore Crude Oil Surface Spill	x	
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform) [B]	x	
Marine Vessel Incident (*i.e.*, fuel spills)	x	
Collisions (involving Platform, vessel, and/or iceberg)[B]	x	

A A spill could result in mortality of individual plants in the eelgrass beds. The potential for mortality of other species using Sensitive or Special Areas, including marine fish, birds, mammals and species at risk are assessed in their respective VECs (Sections 7.5, 9.5, 10.5, 11.4, 11.5 and 11.6, respectively)

B Interactions can occur both nearshore and offshore

12.5 Environmental Effects Analysis and Mitigation

12.5.1 Accidents, Malfunctions and Unplanned Events

Although unlikely, an accidental event can occur at any time of the year, and therefore a conservative approach has been taken in conducting the following effects assessment, assuming that an accidental event could occur at the most sensitive time of year for any of the identified Sensitive or Special Areas.

12.5.1.1 Nearshore

The assessment of the nearshore environment is limited to oiling of eelgrass beds and capelin beaches (refer to Figure 12-1) as a result of an accidental release of hydrocarbons during the construction of the Hebron Gravity Base Structure at the Bull Arm Fabrication Site. This assessment considers the unlikely worst case scenario of a construction vessel accident resulting in 100 m^3 of marine diesel or 1,000 m^3 of IFO-180 (a heavier form of diesel) of fuel being spilled without any response or action to contain or clean up the spill. Based on the results of the spill modelling (ASA 2011a), spills of 100 m^3 of marine diesel have a 60 percent chance of hitting the Bull Arm shoreline in summer, and 30 percent probability to do so in the winter season. IFO-180 spills of 1,000 m^3 have a 100 percent chance of impacting the Bull Arm shoreline in the summer and a 90 percent chance during the winter season without the application of spill response measures. Conservatively, the following assessment is based on the worst-case scenario of diesel fuel reaching these Sensitive or Special Areas.

Eelgrass Beds

Sea grasses are sensitive to hydrocarbon uptake and oiling. Direct contact with oil causes eelgrass plants to lose their leaves Dean *et al.* 1998). As eelgrass leaves are rough and without a mucous layer like many seaweeds, oil will readily stick. Direct oiling can occur where eelgrass beds occurs in very shallow water and form a canopy layer on the water surface, allowing oiling of the floating eelgrass tops (Den Hartog and Jacobs 1980). However, direct oiling is uncommon, with uptake of hydrocarbon from the water column being the main concern. Moderate hydrocarbon concentrations in the water column for a few hours or low concentrations for a few days will result in mortality of individual plants, with a bed of eelgrass possibly taking several years to recover from die-off resulting from oiling (Fingas 2001).

The effects of oil spills can be more pronounced for eelgrass beds growing in sheltered bays that are poorly flushed, as oil will tend to persist for longer periods resulting in chronic contamination (Dean and Jewett 2001). The timing of a spill will also influence the nature of the effects. In the spring, seed production and viability could be affected (Beak Consultants 1975), while a spill in late summer or winter when leaf sloughing is at its peak, may encounter mats of drift blades which will tend to catch and retain oil for later decomposition in the intertidal zone. Hatcher and Larkum (1982) also indicates that the surfactants applied to mitigate oil spills could have a permanent and more significant detrimental effect on eelgrass than the spill itself.

Studies of the effects of oil spills on eelgrass communities have been conducted in association with the *Exxon Valdez* oil spill in Prince William Sound, Alaska, and the *Amoco Cadiz* spill near Roscoff, France, and are discussed below. The results of both studies indicate that recovery of the eelgrass beds can occur within a couple of years, although there may be a longer effect for some components of the benthic communities. Thus, it is the associated faunal communities that tend to be more sensitive to hydrocarbon pollution than the eelgrass plants themselves. There is very little information on the effect of diesel oil on eelgrass in particular. Even though diesel can be more toxic than crude oil initially, these studies are useful in assessing the longer term effects of polycyclic aromatic hydrocarbons (PAHs) in the sediment of an eelgrass bed.

Dean *et al.* (1998) compared populations of eelgrass at oiled versus reference sites between 1990 and 1995 following the *Exxon Valdez* spill. Injury to eelgrass beds in heavily oiled bays appeared to be slight and did not persist for more than a year after the spill. Populations recovered from possible injuries by 1991 and there were no differences in shoot or flowering shoot densities between oiled and reference sites in 1990 or subsequent years.

Jewett and Dean (1997) did report effects on eelgrass communities as a result of the *Exxon Valdez* spill. Dominant taxa within the eelgrass community, including infaunal amphipods, infaunal bivalves, helmet crabs, and leather stars were less abundant at oiled than at reference sites in 1990.

Other taxa, including several families of opportunistic or stress-tolerant infaunal polychaetes and gastropods, epifaunal polychaetes and mussels, and small cod, were more abundant at oiled sites. By 1995, there was evidence of a recovery of most, but not all, community constituents. Exceptions may relate to oiling or the inherent site differences not associated with the oil spill (Harwell and Gentile 2006). Some evidence of slight hydrocarbon contamination still existed at some sites, and three infaunal bivalves, two amphipods, a crab, and a sea star were still more abundant at reference sites than at oiled sites.

These results are consistent with observations reported by Den Hartog and Jacobs (1980). During 1976 to1978, the ecology of eelgrass communities near Roscoff (France) was studied. When a spill of crude oil and bunker fuel occurred in March 1978 and covered the eelgrass communities in question, the study was continued to document the effects of this spill. The results indicated that the eelgrass itself and the general structure of the eelgrass beds showed little effects from the spill. In the short-term, plants had black "burnt" leaves, but these were shed according to the pattern normal for the species. The study of mobile animals demonstrated that the oil spill had a considerable, but selective influence: effects on the Gastropoda were minimal; representatives of the Cumacea, Tanaidacea and Echinodermata recovered within a year; effects on the Isopoda were detectable but questionable due to low numbers before the spill occurred; and the effects on Amphipoda was of high magnitude (of the 26 species found before the oil spill 21 were not observed after the spill).

Den Hartog and Jacobs (1980) speculated that the difference in effect may have been attributable to the location of the eelgrass beds below the level of mean low water neap tide, which implied that contact between the oil slick and the eelgrass lasted only for at most six hours a day. During this time, the flat-lying eelgrass leaves formed a buffer between the oil slick and the bottom. Due to the firm rhizome mat, mixing of oil and sediment was not possible in the eelgrass bed. This could result in filter feeders such as most Amphipoda and some families of Polychaeta being more affected. The *Amoco Cadiz* spill occurred in the early spring, just after the winter peak of a number of littoral organisms, and before the start of the rapid development of the eelgrass. The authors were uncertain of potential fate and effects of a spill in the summer.

Bokn *et al.* (1993) discussed the effects of the water-accommodated fractions of diesel on rock shore populations. In a rocky littoral, diesel oil spills usually result in extensive animal mortalities, and variable, but less severe impacts on seaweeds (*e.g.*, Blumer *et al.* 1971; Pople *et al.* 1990). Data for the Solbergstrand mesocosms suggest that animal populations were most affected by oil treatments and indicate that a chronic low-level exposure to water-accommodated fractions of diesel oil may have only limited direct effect on seaweed stocks (Bokn *et al.* 1993).

Research on eelgrass disturbance and recovery in Newfoundland coastal waters suggests that eelgrass may recover from disturbance (*i.e.*, physical removal) in two to three years (Laurel *et al.* 2003); however, only the removal

of the above-substrate biomass (shoots and blades) was investigated, as underground rhizomes remained intact after the disturbance. The recovery of eelgrass meadows could take much longer if any spill resulted in appreciable mortality of the underground rhizomes in affected eelgrass beds.

Should an accidental spill of diesel hydrocarbons occur in the nearshore environment as a result of this Project, plans will be in place to quickly initiate response and clean-up measures, limiting the potential for diesel to reach eelgrass beds. In the scenario of a diesel hydrocarbon spill in Bull Arm reaching areas with eelgrass beds present (10 percent or less probability of this occurring based on modelling results (ASA 2011a) without the implementation of spill countermeasures), existing knowledge and experience indicates that damage to eelgrass would likely be slight with recovery occurring within a year of the spill. Exposure and subsequent recovery should be aided by the coastal features of the study area (*i.e.*, this area would not be considered sheltered or poorly flushed). Experience from the sites of other spills indicates that there could be a change in the composition of mobile benthic communities associated with the eelgrass beds. While most components are likely to recover within several years following a spill, some taxa such as Amphipoda and some families of Polychaeta, may take longer to return. In addition, relatively low levels of oil retained in intertidal or shallow subtidal sediments could potentially affect a variety of species. Payne et al. (1988, in Hurley and Ellis 2004) conducted laboratory experiments that exposed male winter flounder to sediments contaminated with a range of Venezuelan crude oil concentrations for approximately four months and observed sub-lethal effects from sediment containing aromatic hydrocarbons as low as 1 ppm. Considering the community level effects of the invertebrate community within an eelgrass bed, the residual adverse environmental effect of an accidental event in the worst case scenario is rated as significant. The probability of this residual adverse environmental effect occurring is considered low as: accidental events will be prevented through spill prevention procedures; a contingency plan will be in place to limit exposure of sensitive areas to hydrocarbons should a spill occur; and modelling has indicated that the probability of an uncontained spill of diesel fuel reaching an eelgrass bed is 10 percent or less.

Capelin Beaches

Pebble beaches where capelin are known to spawn are shore accumulations of coarse sediment that form in a higher energy wave environment compared to sand beaches. They are permeable (except to semi-solid oils) with a mobile and unstable surface layer that supports little life.

Oil that interacts with pebble beaches is less likely to stay stranded at lower tide zones, but will be more concentrated on the upper beach. Oil persistence is a function of oil type, penetration depth, and wave energy. Oil will penetrate a pebble beach to occupy the spaces between pebbles, although oil-in-sediment amounts are usually very low. Very light oil, such as diesel, though able to penetrate the sediment, would be washed through the beach sediment and into the sea by wave action. This is assumed to be the

likely fate of a diesel fuel spill in the Hebron Nearshore Study Area, although some small amounts could become buried in the sediments.

Sensitive flora and fauna may be adversely affected by diesel fuel on shore and in the water column. A spill between May and July could likely interact with a capelin spawning event (up to 100 percent (IFO-180) probability based on modelling results without the implementation of spill countermeasures). If this occurs during the spawning period, the spill would not only affect the physical beach environment, but may also affect fish and fish eggs and larvae. This potential effect has also been addressed in the Marine Fish and Fish Habitat VEC (Section 7.5.4).

As discussed above, the typical fuel used by marine vessels is (a marine diesel and IFO-180 (a heavier diesel that is more persistent). Several diesel oil spills have been studied in the past, focusing on the physical properties and movement of diesel, along with the biological effects of diesel in the marine environment (Hooper and Morgan 1999). Diesel has been found to have an immediate toxic effect on many intertidal organisms, including periwinkles, limpets, gastropods, amphipods and most meiofaunal organisms within several kilometres of the original spill (Wormald 1976; Stirling 1977; Pople *et al.* 1995; Cripps and Shears 1997). One such spill was found to have contaminated the water and shoreline with diesel within a 2 km radius of the original spill. Intertidal areas were most directly affected, but all components of the surrounding ecosystem were contaminated during the first weeks after the spill. Hydrocarbons were detected in tissues from birds, limpets, algae, calms, fish and crustaceans in harbours a couple of kilometres away (Kennicutt *et al.* 1991). Based on this, eggs and larvae within the beach would be more at risk from the physiological effects of a spill, being unable to actively avoid the fuel.

Recruitment to a population would not be affected unless more than 50 percent of the larvae in a large portion of the spawning area were lost (Rice 1985). Thus, while the effects of a spill in the nearshore environment during capelin spawning are considered significant in relation to spawning success at beaches in the Hebron Nearshore Study Area, the effect of this relatively localized spill on egg and larval survival would likely be undetectable at the population level given the high rate of natural mortality (Leggett *et al.* 1983). There are many capelin beaches along the coast of Newfoundland that would remain unaffected.

Recommended mitigation for oiling of pebble / cobble beaches is to flush the area with water quickly, while the spilled oil is still fresh. Low-pressure flushing may assist in moving light oil (such as diesel) through the sediment into the ocean for collection. Manual cleaning can also be effective, although sediment removal should be avoided. Responders must be careful to minimize sediment removal. All cleanup methods employed require measures to ensure the collection and proper disposal of oil as it is liberated from the shore.

The following response methods are recommended for pebble beaches in British Columbia and include recommendations applicable to diesel fuels (http://www.env.gov.bc.ca/eemp/resources/pdf/shorelines_and_diesel.pdf):

- Natural recovery is preferred for small spills of light oils (*e.g.*, diesel) in remote areas
- Flooding can flush mobile oils from surface and subsurface sediments for collection
- Low-pressure cold washing can flush mobile oil from surface and subsurface sediments (more effective for viscous oils than flooding)
- Manual removal minimizes the amount of oiled and un-oiled sediments that may be collected (not practical for deeply penetrated / buried oil) and is useful for asphalt patches, tar patties and oiled debris in smaller areas
- Mechanical removal of oiled sediment is useful for large amounts of semi solid oils (front-end loaders may be the equipment of choice)
- Sorbents may be helpful for recovering small volumes of light / medium oils
- Mechanical tilling / aeration is appropriate for light oils in surface and subsurface sediments used in combination with surf washing
- Sediment reworking or surf washing is appropriate on exposed coasts after mobile oil is removed or for small areas of oiled sediments (minimizes erosion) but is dependent on availability of wave energy
- Avoid excessive removal of sediment (natural replacements are slow and it could lead to erosion of the beach)
- Avoid large volumes of waste that contain low amounts of oil from sediment removal
- Avoid spreading oil into lower tidal zones or flushing it deeper into sediments

A contingency plan, specific for nearshore construction activities at Bull Arm, will take into account various coastal habitats in the nearshore environment and will adjust to incorporate response and clean-up measures as appropriate.

While considered unlikely, there is a low potential for diesel fuel to be carried into the sediments and become buried. In this scenario, hydrocarbon contamination can persist for years before natural physical and biological degradation diminishes potential effects. In this case, the sensitive life stages of eggs and larvae can continue to affect the productivity of the capelin beach. Therefore, the residual adverse environmental effect is rated as significant.

The likelihood of a spill occurring is low; spill prevention procedures, education and training will be implemented site-wide. In the event of a spill, a contingency plan will be in place to limit exposure of sensitive areas to hydrocarbons.

12.5.1.2 Offshore

In the Offshore Study Area, the Sensitive or Special Areas, as discussed in Section 12.2, have a combination of unique physical features, which in turn

result in high productivity and/or aggregations of species. In assessing the potential environmental effects of an accidental event on these Sensitive or Special Areas, it is important to consider the potential habitat effects as well as the potential effects on the species that may be present in the area should an accidental event occur. Therefore, there is potential overlap with the environmental effects assessment undertaken for other VECs, including, Fish and Fish Habitat (Chapter 7), Marine Birds (Chapter 9), Marine Mammals and Sea Turtles (Chapter 10) and Species at Risk (Chapter 11). This is discussed below.

Note that the following assessments are based on the conservative approach that hydrocarbons from an accidental event were to reach the Sensitive or Special Area at the most sensitive time of year. Spill prevention and contingency plans will be in place to reduce both the likelihood of an accidental event occurring and the likelihood of hydrocarbons reaching any of the Sensitive or Special Areas identified in the offshore. The areas discussed in the following paragraphs are shown in Figure 12-2.

The Southeast Shoal and Tail of the Banks Ecologically and Biologically Significant Area

The Southeast Shoal and Tail of the Banks EBSA contains a shallow sandy offshore shoal that is unique in the LOMA. While an accidental event is unlikely to affect the substrate within this area, hydrocarbons on the surface or in the water column as a result of a spill may affect the species present in the area. Capelin, Atlantic cod and yellowtail flounder may spawn here and aggregations of striped wolffish, marine mammals (especially humpbacks and northern bottlenose), and marine birds are known to occur.

This Sensitive or Special Area is located 158 km south of the Hebron Project Area. Spill trajectory models indicate that hydrocarbon from a spill at the Project Area without the implementation of countermeasures would interact with this Sensitive or Special Area. If hydrocarbons did reach the area, fish eggs and larvae present at that time could be affected. Yellowtail larvae can be near the surface for several days to two weeks, and have been caught on the Grand Bank from June to September (Walsh 1992). Thus, there is potential for effects on larvae if a spill occurred in August and September. Yellowtail flounder are batch spawners, with individuals from the same population spawning multiple times throughout the season, so population level effects are not expected.

Based on the above, any decline in productivity is unlikely to be at a level beyond which natural recruitment would not return the population or community to its former level within several generations. The residual adverse environmental effect is, therefore, rated as not significant. The potential for adverse environmental effects to occur as a result of the Project is also considered unlikely given the low probability of an accidental event occurring.

Northeast Shelf and Slope Ecologically and Biologically Significant Area

The Northeast Shelf and Slope EBSA is the closest Sensitive or Special Area to the Project Area at a distance of 39 km north to northeast. Based on spill trajectory models for a spill during any month of the year, there is a probability of 30 percent or less that hydrocarbons from an accidental event (without the implementation of countermeasures) will reach this EBSA. Habitat in the area is not considered particularly unique, although it is known to support aggregations of wolffish and Greenland halibut in spring, and aggregations of marine mammals, particularly harp seals, hooded seals and pilot whales. The potential residual adverse environmental effects of oiling on fish, birds, marine mammals and those individual species considered at-risk has been assessed separately (see Chapters 7, 9, 10 and 11, respectively) and is rated as not significant. This rating is considered applicable to this EBSA as the effects will be temporary and at a level from which natural recruitment could return the population or community to its former level within several generations.

Lily Canyon-Carson Canyon Ecologically and Biologically Significant Area

The Lily Canyon-Carson Canyon EBSA is located 91 km south east of the Project Area. Spill trajectory models indicate that hydrocarbon from a spill at the Project Area without the implementation of countermeasures would interact with this Sensitive or Special Area. Lily Canyon-Carson Canyon is similar to other canyon habitat that occurs along the slope of the Grand Banks, but is particularly important for Iceland scallops, and marine mammals aggregate in the area to feed and overwintering. As any hydrocarbons from an accidental event would be present at the surface or in the water column, the bottom habitat present in this EBSA is unlikely to be affected. Benthic species, like Iceland scallops, are also at low risk of potential effects. The residual adverse environmental effects of oiling on marine mammals have been assessed separately (see Chapter 10) and rated as not significant. While there is a potential for productivity of the EBSA to be diminished if hydrocarbons from accidental releases reach this EBSA, the effects will be temporary and at a level from which natural recruitment could return the population or community to its former level within several generations.

Virgin Rocks Ecologically and Biologically Significant Area

The Virgin Rocks EBSA is considered geologically unique as the rocks are near the surface on the middle of the Grand Bank. Schools of capelin have been reported to occur which would attract marine birds. Atlantic cod, American plaice and yellowtail flounder are reported to spawn near the Virgin Rocks (Ollerhead *et al.* 2004). The Virgin Rocks EBSA is located 90 km to the west of the Project Area and is actually located adjacent to the western boundary of the Study Area (*i.e.*, immediately adjacent to but outside of the Study Area; Figure 12-2). Trajectory models indicate that hydrocarbon released during an accidental event would generally move in an easterly direction. Therefore, based on modelling, there is less than a 10 percent probability that hydrocarbons will reach this EBSA. As any hydrocarbons

from an accidental event would be present at the surface or in the water column, the bottom habitat present in this EBSA is unlikely to be affected. Any adverse environmental effects on individuals of fish eggs and larvae and marine birds are assessed separately in Chapters 7 and 9, respectively. While there is a potential for productivity of the EBSA to be diminished if hydrocarbons reach this EBSA, the effects will be temporary and at a level from which natural recruitment could return the population or community to its former level within several generations. Therefore, the residual adverse environmental effect on this EBSA is rated as not significant.

Canyon Vulnerable Marine Ecosystems

The potential canyon VMEs identified within the Offshore Study Area are known to support diverse biological communities, including sensitive structure-forming coldwater corals and deep sea fishes. Spill trajectory models indicate that hydrocarbon from a spill at the Project Area without the implementation of countermeasures would interact with this Sensitive or Special Area. Hydrocarbons reaching these VMEs at the surface or even the water column would be unlikely to adversely affect sensitive deepwater corals and deep sea fishes located at or near the seafloor. The productivity and diversity of the benthic community is therefore not at risk and the residual adverse environmental effects are therefore rated as not significant.

Seamounts and Knolls Vulnerable Marine Ecosystems

Like the canyon VMEs, seamount and knolls support communities of invertebrate species that are mostly slow growing, long-lived, late to mature, and experience low natural mortality. Corals and sponges are often associated with these features, as well as a variety of deep sea fishes. Spill trajectory models indicate that hydrocarbon from a spill at the Project Area without the implementation of countermeasures would interact with this Sensitive or Special Area. Hydrocarbons reaching these VMEs at the surface or in the water column would be unlikely to adversely affect sensitive deep-water corals and/or sponges on the ocean floor and deep sea fishes. The productivity and diversity of the benthic community is not considered at risk and the residual adverse environmental effects are therefore rated as not significant.

Proposed Southeast Shoal Vulnerable Marine Ecosystem

The proposed VME is located within the boundaries of DFO's Southeast Shoal and Tail of the Banks EBSA. Therefore the assessment provided above for the Southeast Shoal and Tail of the Banks EBSA is considered applicable to this VME (*i.e.*, not significant).

A summary of the residual environmental effects assessment from accidental events on Sensitive or Special Areas is provided in Table 12-3.

Table 12-3 Environmental Effects Assessment: Accidental Events

Project Activity	Potential Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/ Socio-economic Context
Nearshore Spill	• Change in Habitat Quality • Potential Mortality (For eelgrass beds only)	• Emergency Response Contingency Plan • Spill prevention and Response Plan	3	3	2/1	R	2
Offshore Failure or Spill from OLS	• Change in Habitat Quality	• Oil spill prevention and response procedures	1	5	2/1	R	2
Offshore Subsea Blowout	• Change in Habitat Quality	• Oil spill prevention and response procedures	1	5	2/1	R	2
Offshore Crude Oil Surface Spill	• Change in Habitat Quality	• Oil spill prevention and response procedures	1	5	2/1	R	2
Other Spills (fuel, chemicals, drilling muds or waste materials on the drilling unit, GBS, Hebron Platform)[A]	• Change in Habitat Quality	• Oil spill prevention and response procedures	1	1	2/1	R	2
Marine Vessel Incident (*i.e.*, fuel spills)	• Change in Habitat Quality	• Oil spill prevention and response procedures	1	5	2/1	R	2
Collisions (involving Platform, vessel and/or iceberg)[A]	• Change in Habitat Quality	• Oil spill prevention and response procedures	1	3	2/1	R	2

KEY

Magnitude:
1 = Low: <10 percent of any Sensitive or Special Area will be affected
2 = Medium: 11 to 25 percent of any Senstitive or Special Area will be affected
3 = High: >25 percent of any Sensitive or Special Area will be affected

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = < 1 month
2 = 1-12 months.
3 = 13-36 months
4 = 37-72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11-50 events/year
3 = 51-100 events/year
4 = 101-200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological / Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity
2 = Evidence of adverse environmental effects

A Activity can occur both nearshore and offshore

12.5.2 Cumulative Environmental Effects

CEAA requires that environmental assessments consider the cumulative environmental effects that are likely to result from the Project in combination with other projects or activities. For the Sensitive or Special Areas VEC, the assessment of potential Hebron Project-related environmental effects for both the nearshore and offshore are limited to accidental events, and are considered unlikely to occur, because of spill prevention activities and spill response procedures. Therefore an assessment of cumulative environmental effects in relation to these accidental events is not required under CEAA or considered appropriate here.

The potential for Project-related cumulative environmental effects on the various species that may use these Sensitive or Special Areas, but may also be present in the Nearshore and Offshore Project Areas at other times and therefore exposed to routine Project activities, is considered and assessed in the respective VECs (*i.e.*, Marine Fish and Fish Habitat (Chapter 7), Marine Birds (Chapter 9), Marine Mammals and Sea Turtles (Chapter 10), and Species at Risk (Chapter 11)).

12.5.3 Determination of Significance

The determination of significance is based on the definition provided in Section 12.2. It considers the magnitude, geographic extent, duration, frequency, reversibility and ecological context of each environmental effect within the Study Area, and their interactions, as presented in the preceding analysis (Table 12-4).

Table 12-4 Residual Environmental Effects Summary: Sensitive or Special Areas

Phase	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Accidents, Malfunctions and Unplanned Events	S	3	1

KEY

Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect

Level of Confidence in the Effect Rating:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence

Probability of Occurrence of Significant Environmental Effect:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

A As determined in consideration of established residual environmental effects rating criteria

Significant adverse residual environmental effects are predicted for identified Sensitive or Special Areas in the Nearshore Study Area; however, no significant adverse residual environmental effects are predicted for identified Sensitive or Special Areas in the Offshore Study Area. Using a precautionary approach, it is concluded that there is potential for a significant residual

adverse environmental effect to the Sensitive or Special Areas VEC should hydrocarbons from an accidental event reach the identified nearshore eelgrass beds. However, the likelihood of a significant residual adverse environmental effect occurring is considered low.

12.5.4 Follow-up and Monitoring

Potential Project effects assessed in association with this VEC are limited to accidental events. Depending on the nature, timing and extent of an accidental event associated with the Project, a monitoring program will be implemented to determine environmental effects related to the event (refer to Chapter 14 for more information on accidental event mitigation and contingency plans). This would be particularly important for sensitive or special nearshore areas, where experience from other accidental events indicates the potential for multi-year effects.

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13 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

13.1 Introduction

The *Hebron Development Project Scoping Document* (Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) 2009) requires a description of relevant physical environment parameters, including "Effects of the environment on the Project". Section 2(1) of the *Canadian Environmental Assessment Act* (CEAA) defines environmental effect to include "any change to the project that may be caused by the environment". This chapter provides a discussion of the expected and potential effects of the oceanographic environment on the Project's design, construction and operation.

Currently, there are three operating oil and gas fields on the Grand Banks within approximately 50 km of the proposed Hebron Project location. One is producing using a Gravity Base Structure (GBS) platform (Hibernia) and the other two (White Rose and Terra Nova) are being developed with Floating Production Storage and Offloading vessels. The Hibernia project has been in operation since 1997 and has produced over 680 MMbbls of oil. The Terra Nova project commenced operations in 2002 and has produced over 294 MMbbls, whereas White Rose has been operational since 2005, with over 141 MMbbls of oil produced to date. As with the Hebron Project, these developments were designed to withstand the environmental conditions that occur in this area, and they have demonstrated that oil and gas projects can be successfully operated in the same environmental conditions within which Hebron will be situated.

13.2 Context

Ultimately, to mitigate the effects of the physical environment on the Project, there must be adequate planning, design and operations procedures that consider the expected normal and extreme physical environmental conditions that may be encountered.

There must also be adequate monitoring and forecasting of physical environment conditions. Through adequate monitoring and forecasting, Project activities can be adjusted to maintain a safe working environment. All outside activities are affected by the physical environment.

This description considers those marine environment parameters discussed in Sections 3.1.2 and 3.2.2 for the Nearshore and Offshore Study Areas, respectively.

13.3 Nearshore Potential Marine Effects

13.3.1 Bathymetry

Nearshore bottom topography is complicated, with steep drops along the coast and narrow central channels and small coves. During construction of the GBS, bathymetry will be considered for installation of mooring systems and for marine operations and traffic management such as barge towing, vessel and remotely-operated vehicle (ROV) manoeuvring.

The GBS drydock site is situated in Great Mosquito Cove. The cove is 1.5 km long and has an average width of 500 m. The GBS drydock is approximately 16.5 m deep and has a diameter of 180 m. The coastline approaching Great Mosquito Cove drops sharply to depths of 30 to 88 m and in the Cove, depths increase from 13 to 33 m at only 300 m from shore, reaching 45 m in the middle. At the mouth of Great Mosquito Cove, the water is deep, ranging from 51 to 132 m near the centre of Bull Arm.

Bathymetry may be a factor during tow-out, depending on final GBS dimensions and route selected. If required, dredging may be undertaken within the tow-out channel to provide sufficient depth.

All of these factors will be considered in the Project development; however, none of these suggest that a bathymetric “effect” on the Project could occur. These sorts of activities have been successfully carried out previously for other developments.

13.3.2 Wind, Waves and Currents

Extreme wind, waves and currents have the potential to increase stress on surfaces and vessels and disrupt scheduling of marine operations. Wind, waves and currents will be considered during construction of the GBS, mooring system design, barge manoeuvring, tow vessel, support vessel and ROV operations.

For the nearshore, extreme wind, waves and currents can affect towing operations and vessel manoeuvring and increase stress on moorings, which can lead to mooring failure. Also, extremes can increase stress on or over-top the bund wall and/or row(s) of sheet pile that surround the existing GBS drydock facility at Bull Arm, leading to flooding and/or failure of the bund wall.

The *Hibernia Development Project Environmental Specifications* (Topside Engineering 1992) reports a 100-year extreme maximum significant wave height (Hs) of 2.6 m and extreme heights of 4.8 m for two deepwater sites in Bull Arm in winter months. The 100-year extreme current for deepwater sites in Bull Arm ranges from 1 m/s at depths of 5 to 80 m to 0.4 m/s at the surface (Section 3.1.3.2).

Site-specific weather and oceanographic data are typically collected as part of a physical environment monitoring program, which would enhance the physical database for the area, and will be collected for the Hebron Project.

These values and their potential effects will be considered for all marine Project activities in the nearshore region.

All wind, wave and current extreme value estimates will be considered in the design of moorings and the operation of vessels and barges.

13.3.3 Tsunamis

A detailed discussion on tsunamis is provided in Section 3.1.2.3. The following is a summary of observations from that Section.

While tsunamis have been observed in eastern Newfoundland and their effects can be devastating, they are not a frequent occurrence in this part of Canada. Based on the limited historical record, it can be estimated that a return period of approximately 50 to 100 years, or longer for a destructive tsunami like the 1929 event, might be possible for parts of Newfoundland; this would likely be much longer for Bull Arm, given its more sheltered location (compared with the tip of the Burin Peninsula in 1929) from the open ocean. The fact that construction nearshore will take place over approximately four years, a relatively "short" lifetime, means that the likelihood of occurrence during this period is low and therefore, it is estimated there is a low risk of tsunamis effects for the Project nearshore.

13.3.4 Tides, Water Levels, and Storm Surge

The first stage of GBS construction will be to re-instate the drydock at Great Mosquito Cove. The drydock will be enclosed by a bund wall and/or row(s) of sheet pile that will subsequently be removed (ExxonMobil Canada Properties (EMCP) 2009). Tides and storm surges can raise water levels considerably. Therefore, the potential exists for flooding of the drydock and this will be considered during the construction phase.

An estimate of 100-year maximum water level is +1.52 m above mean water level (MWL) (Marex 1992). This includes the standard deviation of the MWL, the dominant (M2 and S2) tide, the 50-year storm surge and the standard deviation of the 50-year surge. A 100-year minimum water level of -1.20 m below MWL is similarly estimated.

A more conservative estimate of extreme maximum water level would be +1.68 m above MWL taken as the sum of highest astronomical tide (HAT) (0.80 m above MWL) and the 100-year positive surge amplitude (0.88 m above MWL). Similarly, a more conservative estimate of extreme minimum water level would be -1.45 m below MWL taken as the sum of lowest astronomical tide (LAT) (-0.91 m below MWL) and the 100-year negative surge amplitude (-0.54 m below MWL) (Marex 1992).

All tide, water level and storm surge extreme estimates will be considered in the design of moorings and the operation of vessels and barges.

13.3.5 Temperature

The design, construction and installation of the GBS will consider the sea temperature. Low water temperatures can lead to vessel icing and exposure

to water at this temperature may pose a risk to personnel and to exposed surfaces. There will be need for winter protection during open construction.

Surface sea temperature in the area can fall below 0°C from January to August; therefore, exposure to water at this temperature may pose a risk to personnel and to exposed surfaces. The combination of low air and sea temperature, strong winds and high waves can lead to vessel icing. A vessel, or structure in the case of the GBS, itself is also a critical factor for icing potential. The size and hull design (which may affect the amount of spray produced) and the amount of superstructure present (which can act as a "trap" for spray accumulation) are other considerations.

13.3.6 Sea Ice and Icebergs

Pack ice presence in Trinity Bay from year to year is variable, based on a review of the weekly Canadian Ice Service (CIS) charts from 1983 to 2008, inclusive (Environment Canada CIS 2010). Trinity Bay has pack ice in one form or another present on a ratio of one-in-three years. Most sea ice within the bay is formed off southern Labrador and drifts south to enter the bay around the mid-March timeframe. From mid-March through to early May, the bay experiences first year ice (see Table 3-10), which can range in thickness from 30 to 120 cm.

The Trinity Bay region does not lie on a primary aerial ice reconnaissance route; the low numbers of icebergs sighted each year, therefore, may be related to the low number of flights over that area. If this is true, the number of icebergs in the Trinity Bay area may be under-detected and under-reported. In addition, iceberg distribution can fluctuate greatly from year to year. The maximum number of icebergs sighted in one year (1979) over the period of study was 129; the mean annual number for Trinity Bay is 32. The majority (89 percent) of the icebergs observed in Trinity Bay fall within the small to medium categories.

Sea ice conditions will be monitored and managed in accordance with the Ice Management Plan. The Ice Management Plan, which will be developed for offshore operations, will outline requirements for monitoring and managing sea ice conditions for the Hebron Platform.

13.3.7 Geohazard

While there are not enough data at Bull Arm to rule out the presence of any geohazards, it does have a successful track record as a development site.

13.3.8 Climate Change

The nearshore construction will take place over approximately four years, a relatively short period, so that climate change is unlikely to have an environmental effect within that timeframe.

13.4 Offshore Potential Marine Effects

13.4.1 Bathymetry

Depending on final Hebron Platform dimensions, and route selected, bathymetry, particularly clearance over the Offshore Project Area, will be relevant for Hebron Platform tow-out and installation on the seabed, though no "effect" of the bathymetry is expected. The tow-out routes will be carefully selected and confirmed for suitability (depth). If required, sections of the tow-out channel may require dredging.

13.4.2 Wind, Waves and Currents

Extreme wind, waves and currents have the potential to increase stress on surfaces and vessels and disrupt scheduling and operations. The design, installation and operation of the Hebron Platform, offshore loading system (OLS) and supporting infrastructure will consider wind, wave and currents loads. Wind, wave and current data are typically collected as part of a physical environment monitoring program, which would enhance the physical database for the area.

The Hebron Metocean Criteria (ExxonMobil 2009) reports a 1-year return period extreme Hs of 10.5 m and associated 1-hour wind speed at 10 m of 26.2 m/s. The 100-year return period extreme Hs is 14.8 m, with an associated 1-hour wind speed of 33.2 m/s. The maximum individual wave height for a 1-year return period is 19.7 m, and for 100-years is 27.8 m. Extreme crest elevations are 13.3 m for a 1-year return period and 19.4 m for 100-years.

Estimates of one-year return period currents range from 0.64 m/s near-surface to 0.46 m/s at mid-depth, to 0.42 m/s near-bottom (ExxonMobil 2009). One hundred-year return period currents range from 1.16 m/s near-surface to 0.77 m/s at mid-depth, to 0.66 m/s near-bottom. The near-surface value of 1.16 m/s is comparable to the maximum measured currents reported by Bedford Institute of Oceanography of 0.96 m/s at 18 m (Gregory *et al.* 1996). The largest near-surface currents occur from August to October, while mid-depth and near-bottom currents are greatest from September to March (ExxonMobil 2009).

Wave conditions offshore will limit supply vessel loading and offloading of cargo. In addition, vessel iceberg towing and spill response operations, if required, would be affected. The sea state may limit the safety and effectiveness of supply vessel operations (*e.g.*, deployment and use of spill containment equipment, or the deflection of icebergs).

Based on favourable persistence analysis of historical Grand Banks conditions, the average length of time that, in any given month, seas (including swell) will persist below the given Beaufort Force (BF) (see Table 13-1) sea state thresholds[1] is illustrated in Figure 13-1.

[1] Beaufort Scale (*e.g.*, http://www.tc.gc.ca/MarineSafety/Tp/Tp10038/80-wi-beaufort-scale.htm)

Table 13-1 Beaufort Force Scale

Hs (m)	Beaufort Force Scale
<1.0	3
≥1.0 and ≤1.5	4
>1.5 and ≤0.5	5
>2.5 and ≤4.0	6
>4.0 and ≤5.5	7
>5.5 and ≤7.5	8
>7.5 and ≤10.0	8
>10.0 and ≤12.5	10
>12.5 and ≤16.0	11
>16	12

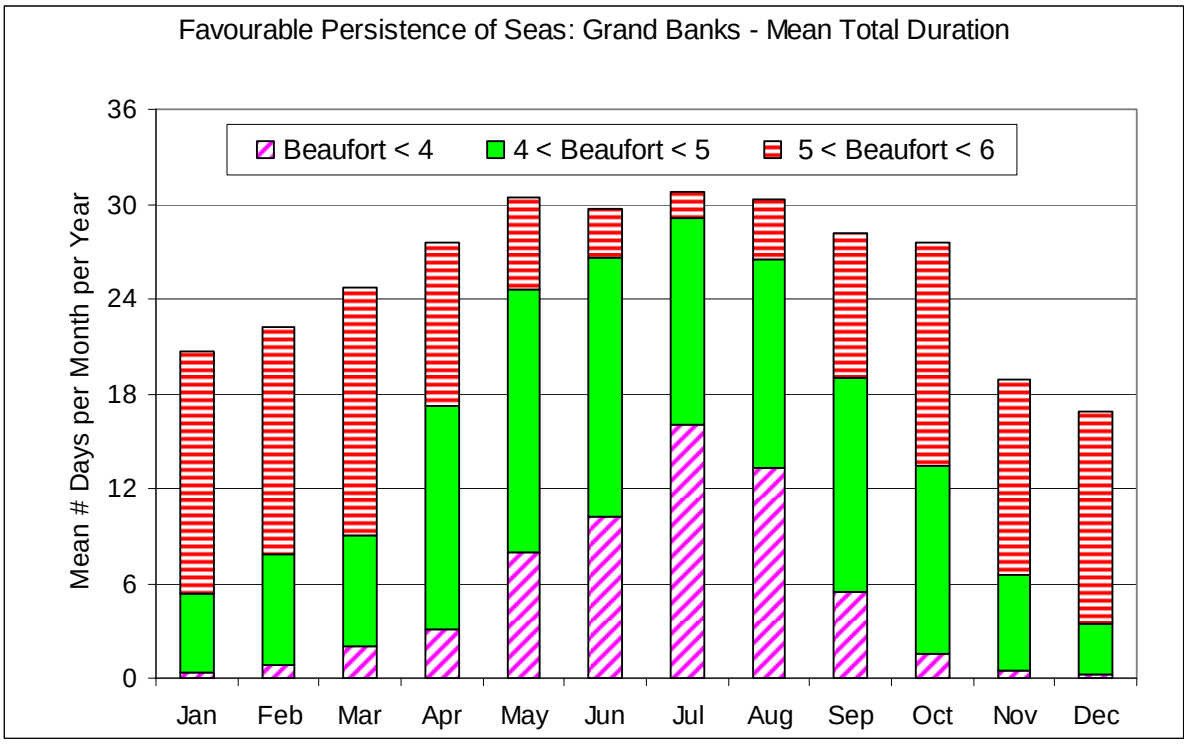


Figure 13-1 Favourable Persistence of Seas: Grand Banks - Mean Total Duration

The analysis was of the nine-year Hibernia wind, wave, and current (for five-year) time-series, where waves include swell. BF was assigned based on Hs, with the following mapping as a function of probable maximum height of waves:

An intent of the work is to quantify conditions and show that while seas can get quite large on the Grand Banks, there are windows of opportunity that, depending on the threshold, may be conducive to marine operations. For example, in November to February, less than one day per month would have conditions that are below BF4 (Hs = 1.5 m), while in June to August, it is over 10 days per month. During the winter, approximately 8 to 12 days per month could have conditions persist above BF6 (*i.e.*, waves over 4 m, near gale

force or higher). Conversely, in the summer, these conditions will be experienced rarely, as the bars top out at approximately 30 days; conditions are more favourable to marine operations in summer.

Another wave-related environmental influence on vessel operations is iceberg towing and deflection, which can be routinely required during ice season. Marine conditions can play an important role in the success of these activities. Several observations (*e.g.*, as recently described by McClintock *et al.* 2007) are noted here in this regard.

Propeller washing, generally a successful technique for small ice mass deflection, can be difficult in high seas and reduced in its effectiveness. High sea states can further complicate matters, as they may affect the success of radar detection of smaller icebergs and growlers.

High sea states can sometimes increase the risk of tow line slippage during iceberg towing. Tow techniques, including the two-vessel iceberg net tow (C-CORE 2004), offer benefits of improved safety (including less crew time on back decks of supply vessels) and efficiency in higher sea states, and is one potential mitigation of wave effects on vessel operations.

These examples serve to illustrate, that in addition to design considerations, the marine environment can affect Project activities. EMCP will establish appropriate plans and procedures for all activities to maximize the safety of personnel, equipment and the environment, and to optimize the likelihood for success in all such undertakings.

13.4.3 Tsunamis

A detailed discussion on tsunamis is provided in Section 3.2.2.3. The following is a summary of observations as relates to potential effects.

The wave height of a passing tsunami offshore is small, approximately 1 m or less, and is not expected to be an issue for the offshore operation, particularly given the long period of the waves. Associated current speeds up to 70 cm/s could possibly be a concern for moorings and hoses. Tsunamis Warning Systems are aimed at managing coastal risk; however, they may also provide useful mitigative information for offshore operations. Given the low likelihood of tsunami occurrence and the anticipated low consequence should they occur, no tsunami effects offshore are anticipated.

13.4.4 Tides and Storm Surges

Tides and storm surges can cause an increase or decrease of water levels as large as 50 cm. These factors will be considered for the tow-out, installation and operation of the Hebron Platform.

13.4.5 Temperature

Sea temperature, combined with strong winds and high seas, is a contributing factor for marine vessel and structure icing during Project operations in winter.

13.4.6 Sea Ice and Icebergs

The Hebron location has experienced sea ice incursions in approximately 25 percent of the years spanning 1972 to 2008. These incursions are bi-modal and have peak probabilities centered on two periods: the first peak in the last week of February; and the second in the first week of April. The duration of the incursions vary from a low of one week to a high of seven weeks. Of the 11 years that ice was present, the average duration was three weeks. These statistics are based on Environment Canada CIS's Sea Ice Charts (1983 to 2008).

The number of icebergs drifting south of 48°N each year has varied from a low of zero in 1966 and 2006 to a high of 2,202 in 1984, with the average over the last 20 years (using 1989 to 2008 PAL data) ranging between 725 to 752 icebergs. Of these, only a small proportion has passed through the Offshore Project Area. Over the last 10 years, the average annual number of icebergs sighted in the Hebron Offshore Project Area has been 31. The majority (73 percent) of the icebergs south of 48°N fall within the small to medium categories.

The design, installation and operation of the Hebron Platform, OLS and supporting infrastructure will consider sea ice and icebergs. An Ice Management Plan will be prepared and ice conditions will be monitored.

13.4.7 Geohazard

In terms of other constraints to development, no shallow faults have been identified that penetrate the near-surface stratigraphy within the vicinity of the Hebron Platform. Potential shallow gas pockets have not been identified within the upper 100 m or more of the sediment column (McGregor and Fugro Jacques GeoSurveys 1998; Sonnichsen and King 2005). Boulders may be present at, or beneath the seabed, and potentially at depths of tens of metres sub-seabed (Sonnichsen and King 2005). As evidenced in seismic profiles, there is potential for near-surface channels within the Offshore Project Area. A detailed geohazard assessment will have to be performed at any drilling locations selected, via a dedicated geohazard survey (or based on existing data) as per Canada-Newfoundland and Labrador offshore Petroleum Board (C-NLOPB) guidelines.

The earthquake-generation process in eastern Canada is indirect, and potential zones of weakness are widespread, resulting in diffuse seismicity patterns. Earthquakes may take place on a series of buried crustal faults, in locations that cannot be precisely foreseen. Most earthquakes show predominantly thrust faulting, with some strike-slip component, consistent with high regional compressive stresses; however, there are not any focal mechanisms for earthquakes in the Jeanne d'Arc or other nearby basins. The Hebron Platform is located within the eastern Canadian continental margin that is characterized by low to moderate levels of seismic activity, with infrequent large earthquakes (URS Corporation 2006) While overall rates of seismicity are relatively low, there are zones of clustered higher rate seismicity and historical earthquakes up to Magnitude 7.3 (1929 Grand Banks

earthquake) have occurred in the region. There are currently no data indicating known seismic source faults in the vicinity of the proposed Hebron Platform. A seismic hazards study determined the following return periods for various levels of earthquakes at the Hebron Platform (URS Corporation 2006):

- Abnormal Level Earthquake: 3,000 years
- Extreme Level Earthquake: 600 years
- Operating Level Earthquake: 300 years
- Safety Level Earthquake: 3,000 years

The Operating and Safety Level Earthquake risk levels are usually determined by the facility owner (URS Corporation 2006).

13.4.8 Climate Change

A detailed discussion on climate change is provided in Section 3.2.6. The following is a summary of considerations for the offshore:

- Sea-level rise: Estimates of sea level rise globally over the next 50 years due to climate change alone are from 2.5 cm (Kolker and Hameed 2007) to as much as 15 cm (Hu *et al*. 2009). The productive life of the Hebron Project is currently estimated at 30 years; therefore, sea level rise to some degree may occur. The design of the Hebron Platform will account for sea level rise
- Waves: Increased storm intensity may result in higher associated peak wave heights and more frequent occurrence of extreme wave events. However, climate simulations for the next century show almost no change in peak Hs for the western North Atlantic, consistent with recent trends in observed data. With increased temperature, more tropical storms can be expected to survive farther north, bringing with them higher waves during the tropical storm season. The design of the Hebron Platform will account for more frequent occurrence of peak wave heights
- Sea Surface Temperatures: there is considerable uncertainty as to the question of warming sea surface temperatures, since glacial melt north of Newfoundland would exert a cooling influence on the offshore waters. A slight change of sea surface temperature may not directly affect the Project, but may contribute to increased storm frequency and icing intensity

The Project will be designed to withstand these possible variations in normal and extreme marine environment conditions.

13.4.9 Biofouling

Biofouling epiflora and epifauna are usually found in the photic zone, and the species found in the upper 50 m (during studies in the North Sea) are primarily comprised of seaweeds, hydroids, soft corals, anemones and mussels. Below 50 m, the biofouling communities are primarily comprised of hydroids, soft corals, anemones and tubeworms (Welaptega 1993, in Husky 2000).

While biofouling epifauna and epiflora do attach themselves to the walls of the Hibernia platform within the depths of light penetration, they do not make visual inspections more difficult or contribute to fatigue or corrosion to the infrastructure of the platform (HMDC 2005).

13.5 Environmental Events

The selection of appropriate events is a key to identifying risks that are most realistic within the context of the assessment (Table 13-2). In order to accomplish this, it is necessary to address a wide range of events. The following is a discussion of the events that could be considered as having a potential effect, together with how adverse that effect might be, and an indication of mitigations that should be implemented to reduce the hazard.

Table 13-2 Environmental Effects on the Project

Marine Environmental Event	Mitigation
Nearshore Events	
Wind / Waves – ROV operations	Safe Operating Procedures, Site Monitoring / Forecasts
Wind / Waves – barge, tug or support vessel operations	Safe Operating Procedures, Site Monitoring / Forecasts
Wind / Waves – access to GBS at deepwater site	Safe Operating Procedures, Site Monitoring / Forecasts / FEED / Facility Design
Waves – bund wall failure	Site Monitoring / Forecasts / FEED / Facility Design
Waves / Currents – mooring failure	Site Monitoring / Forecasts / FEED / Facility Design
Storm surges / high water levels - flooding and damage to drydock/bund wall	Site Monitoring / Forecasts / FEED / Facility Design
Sea Temperature - contributor to vessel and structure icing potential	Site Monitoring / Forecasts
Sea Temperature - exposure to personnel	Safe Operating Procedures
Offshore Events	
Tsunamis – OLS / Tanker disruption (high currents)	Warning Systems, Site Monitoring / Forecasts / FEED / Facility Design
Wind / Waves – tug or support vessel operations (*e.g.*, ice, spill response, Search and Rescue)	Safe Operating Procedures, Site Monitoring / Forecasts
Waves / Low water level – affecting Hebron Platform installation on seabed	Safe Operating Procedures, Site Monitoring / Forecasts / FEED / Facility Design
Currents – OLS / Tanker disruption	Site Monitoring / Forecasts
Sea Temperature - contributor to vessel and structure icing potential	Site Monitoring / Forecasts / FEED / Facility Design
Sea Temperature - exposure to personnel	Safe Operating Procedures
Seasonally-occurring Sea Ice and Icebergs	Ice Management Plan / FEED / Facility Design
Climate Change – Sea level rise	FEED / Facility Design
Climate Change - Waves	FEED / Facility Design
Climate Change - Sea Surface Temperature	FEED / Facility Design
Climate Change - Sea Ice and Icebergs	Ice Management Plans / FEED / Facility Design

13.5.1 Mitigation Measures

The range of effects on the Project due to the physical environment can range from minor facility improvement to catastrophic failure. The primary mitigation tool is the use of sound planning. All engineering design will adhere to national / international standards. These standards document the proper engineering design for site-specific normal and extreme physical environmental conditions and provide design criteria that the regulatory agencies consider satisfactory for withstanding the potential physical environmental conditions. These codes consider physical environmental criteria such as temperature, wind, snow, wave and ice loading, and drainage. In addition, the design life is taken into consideration so that materials are chosen with sufficient durability and corrosion resistance.

Physical management of icebergs in the Offshore Study Area is conducted well up-stream in an attempt to deflect any icebergs that may encroach on the operational areas of production facilities. In general terms, most physical iceberg management consists of towing or deflecting the iceberg off its free-drifting track. The attempts historically consisted of deploying a long floating tow rope around the iceberg, and then applying force with a supply vessel in the direction they desired the iceberg to move. In the past 30 years, other methods have been used with varying degrees of success, but this basic method has remained the staple of iceberg management, having been used in nearly 500 documented iceberg tows. The recent development of an iceberg tow net has gained popularity for management operation on the Grand Banks. The iceberg tow net was designed to reduce the amount of rope slippage and provide a reduction in iceberg rolling while being managed.

Sea ice management procedures have long been used in Canadian water (*e.g.*, to break up sea ice to assist shipping). Because of the loose nature of the pack in the area of the Grand Banks, sea ice management primarily consists of using support vessels to break up any large ice floes that meet or exceed the design limits of the facility. Over the 2008 and 2009 ice seasons, experience has been gained using water cannons to open a path in the pack as it advanced towards facilities. The method used a support vessel stationed a few hundred metres ahead of the production facility. By sweeping the vessels water cannon left and right, a path or lead is opened up, keeping the loose pack clear of the facility.

Beginning in late 1988, all operators on the Grand Banks adopted a coordinated ice management approach. Under this system, the joint operators share ice information and ice management resources, along with adopting a strategy and procedures for managing icebergs over the whole Jeanne d'Arc Basin area. EMCP will explore synergies with existing operations regarding ice management.

13.5.2 Definition of Significance

A significant effect of the environment on the Project is determined to be one that:

- Harms Project personnel or the public
- Results in a substantial delay in construction (*e.g.*, more than one season) or shutdown of producing operations
- Damages infrastructure and compromises public safety
- Damages infrastructure to the extent that repair is not economically or technically feasible

It should be noted that:

- Tsunami frequency or likelihood is improbable for nearshore (unlikely so as to assume will not occur) and remote for offshore (unlikely but possible) (*i.e.*, these are <<10 events/year)
- Particularly with climate change events, there is an element of uncertainty as to the "change" and whether it is greater or less (*e.g.*, for large waves) and/or by how much (*e.g.*, sea level rise).

13.6 Conclusion

The Project design and operations planning incorporates metocean criteria. Physical metocean site monitoring will be undertaken. As such, no significant effects on the Project are anticipated. The effects of ice, including icebergs, on the Project are predicted to be minimal. GBS design basis incorporates the potential for ice impact with the structure. This, in addition to the provision of ice management procedures, will result in a minimal effect from sea ice or icebergs on the Project. Therefore, there are no likely significant environmental effects on the Project.

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14 ACCIDENTAL HYDROCARBON SPILL EVENTS

A hydrocarbon spill or accidental release is the accidental event of greatest concern because it can result in higher magnitudes of environmental effects, compared to other Project-environment interactions. A hydrocarbon spill can affect marine mammals and birds, and the commercial fishery. For these reasons, it is important to understand the probability of its occurrence and fate, for planning and response purposes. To this end, the probability of varying sizes of hydrocarbon spills have been estimated using historical data from Newfoundland and other offshore oil and gas development regions, and the trajectories of credible spill scenarios have been modelled. The results are presented in this chapter.

For the purposes of the environmental assessment, two types of accidental events during drilling and production operations – blow-outs and "batch" spills – are assessed. Blow-outs are continuous spills lasting hours, days or weeks that could involve the discharge of large volumes of associated gas into the atmosphere, discharge of crude oil and certain amounts of gas condensate (a very low viscosity, highly volatile type of liquid petroleum oil) into surrounding waters. Blow-outs could occur from accidents during development drilling, well-completion activities, workovers and various production activities including wirelining, coiled tubing and snubbing operations. Batch spills are instantaneous or short-duration discharges of hydrocarbon that could occur from accidents on the drilling or production platforms where hydrocarbon is stored and handled. An oil spill could potentially occur during offloading and/or transfer of crude oil at the offshore loading system (OLS).

Compared with other industries that have potential for discharging petroleum hydrocarbon into the marine environment, the industry of exploring, developing and producing offshore oil and gas (the offshore E&P industry) has a good record. A recent study on marine hydrocarbon pollution by the US National Research Council (NRC 2002) indicates that accidental petroleum discharges from platforms contribute only 0.07 percent of the total petroleum input to the world's oceans (0.86 thousand tonnes per year versus 1,300 thousand tonnes per year - see Table 14-1).

This section derives spill and blow-out statistics for the Hebron Project from world-wide statistics. The practices and technologies that will be used on the Project are world-class and will be in accordance with Canadian regulations and best practices.

The petroleum industry usually uses the oil volume unit of petroleum barrel (bbl), which is different than a US barrel and a British barrel. There are 6.29 bbl in 1 cubic metre (m^3) and there are approximately 7.5 bbl per tonne. Most spill statistics used here are taken from publications that use the oil volume units of bbl, and bbl are used in the subsequent statistical analysis as a result.

Table 14-1 Best Estimate of Annual Releases (1990 to 1999) of Petroleum by Source

Source	North America in thousands of tonnes	World-wide in thousands of tonnes
Natural Seeps	**160**	**600**
Extraction of Petroleum	**3.0**	**38**
Platforms	0.16	0.86
Atmospheric Deposition	0.12	1.3
Produced waters	2.7	36
Transportation of Petroleum	**9.1**	**150**
Pipeline Spills	1.9	12
Tank Vessel Spills	5.3	100
Operational Discharges (cargo washings)	Na [A]	36
Coastal Facility Spills	1.9	4.9
Atmospheric Deposition	0.01	0.4
Consumption of Petroleum	**84**	**480**
Land-Based (River and Runoff)	54	140
Recreational Marine Vessel	5.6	nd [B]
Spills (non-tank vessels)	1.2	7.1
Operational Discharges (vessels 100 GT)	0.10	270
Operational Discharges (vessels <100 GT)	0.12	nd [C]
Atmospheric Deposition	21	52
Jettisoned Aircraft Fuel	1.5	7.5
TOTAL	**260**	**1,300**

Source: NRC 2002
Notes:
A Cargo washing is not allowed in US waters, but is not restricted in international waters. Thus, it was assumed that this practice does not occur frequently in US waters
B World-wide populations of recreational vessels were not available
C Insufficient data were available to develop estimates for this class of vessels

Data sources used in this chapter have varying dates of publication. Sources such as the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE, until recently known as the Minerals Management Service, MMS) are updated regularly, and the most recent data available are used in this report. Other sources used, notably Scandpower (2000), and NRC (2002) have not been updated.

14.1 Hydrocarbon Spill Probabilities

Spill probabilities are discussed separately for blow-outs and for other “batch” spills from drilling and production platforms, and for a range of spill sizes. The definitions of oil spill sizes are provided in Table 14-2.

Table 14-2 Definition of Hydrocarbon Spill Sizes

Hydrocarbon Spill Type	Spill Size	
	bbl	m^3
Extremely Large	>150,000	>23,850
Very Large	>10,000	>1,590
Large	>1,000	>159
Small	<1	<0.159
Note: The top three categories are cumulative; for example, the large-spill category (>1,000 bbl) includes the very large and extremely large spills, and the very large category includes extremely large spills. This follows the approach used by BOEMRE statisticians upon which the "large" spill frequencies are derived. For the small category, more detailed statistics are available and a further breakdown is made with discrete size ranges, specifically: 50 to 999 bbl, 1 to 49 bbl, 1 L to 1 bbl (159 L), and less than 1 L.		

14.1.1 Extremely Large and Very Large Oil Spills from Blow-outs

In the oil and gas industry, a distinction is made between two stages of petroleum field drilling: exploration drilling (including "delineation" drilling), where knowledge of the geological and depositional environment is speculative or limited; and development drilling, where the structure is better defined and drilling is under better control. Because exploration drilling at the Hebron site is now completed, the analysis concentrates on statistics related to development drilling, although reference is made to exploration-related statistics where appropriate. Blow-outs can also happen during production, workovers and well completion activities, and these are also addressed.

In Canada, there have been no large petroleum spills from blow-outs. In the US, since offshore drilling began in the mid-1950s, there have been three oil-well blow-outs involving hydrocarbon spills greater than 50,000 bbl. Therefore, data from jurisdictions beyond North America must be used to develop a reasonable database on very large and extremely large oil-well blow-outs. All world-wide blow-outs involving the spillage of more than 10,000 bbls each are listed in Table 14-3.

Using the definition of "extremely large" spills (*i.e.*, hydrocarbon spills greater than 150,000 bbls), there have been six such spills in the history of offshore drilling, one of which occurred during development drilling, three of which occurred during production or workover activities and two occurred during exploration drilling.

14.1.1.1 Blow-outs during Drilling

Spill frequencies are best expressed in terms of a risk exposure factor such as number of wells drilled. On a world-wide basis it has been estimated that 66,469 offshore development wells were drilled as of May 2010 (Deloitte 2010).

Table 14-3 Historical Extremely and Very Large Hydrocarbon Spills from Offshore Oil Well Blow-outs

Area	Reported Spill Size (bbl)	Date	Operation Underway	Duration (days)	Intervention Method
Extremely Large Spills (>150,000 bbl)					
US, Gulf of Mexico (GOM)[A]	4,000,000	2010	Exploration drilling	91	Relief well
Mexico (*Ixtoc 1*)[B]	3,000,000	1979	Exploratory Drilling	293	Relief well
Iran[C]	see note	1983	Production	--	
Mexico	247,000	1986	Workover	??	
Nigeria	200,000	1980	Development Drilling	14	Bridged
North Sea / Norway	158,000	1977	Workover	7	Capped
Very Large Spills (10,000)					
Iran	100,000	1980	Development Drilling	8	
US, Santa Barbara	77,000	1969	Production (Platform)	11	Capped
Saudi Arabia	60,000	1980	Exploratory Drilling	8	Capped
Mexico	56,000	1987	Exploratory Drilling	51	
US, S. Timbalier 26	53,000	1970	Wireline	138	Relief well & Capping
US, Main Pass 41	30,000	1970	Production (Platform)	49	Capped (three relief wells also initiated)
Australia[D]	30,000	2009	Development drilling (primarily gas)	74	Relief well
US, Timbalier Bay / Greenhill	11,500	1992	Production	11	
Trinidad	10,000	1973	Development Drilling	4	

Source: Gulf 1981, updated to 2010 by reference to the Oil Spill Intelligence Report and other sources

A Varying estimates of spill volume, most recent estimate reported

B Spill volume widely believed to be underestimated

C The Iranian Norwuz oil well blow-outs in the Gulf of Arabia, which started in February 1983, were not caused by exploration or drilling accidents, but were a result of military actions during the Iraq / Iran war

D Currently under investigation, spill volume is best estimate and may be subject to revision

There has been one extremely large spill during offshore development drilling, so the frequency up to 2010 is (1/66,469) 1.5x 10^{-5} spills per well drilled, or one such spill for every 66,000 wells drilled. A similar analysis can be done for very large spills. Up to 2010, four development-drilling blow-outs have produced spills in the very large spill category (including spills in the extremely large category; refer to Table 14-3) including the recent incident in Australia. The spill frequency for these is (4/66,469) 6.0 x 10^{-5} spills per well drilled, or one such spill per every 17,000 wells drilled.

14.1.1.2 Blow-outs during Production and Workovers

Table 14-3 shows that there were two extremely large (not including the 1983 war-related spill in Iran) and six very large hydrocarbon spills from blow-outs during production and workovers (including extremely large spills in the very large category. Lack of production statistics makes it difficult to develop an exact risk exposure for these events. However, it is estimated that the total oil produced offshore on a world-wide basis up to 2002 has been approximately 125 billion bbl, and that the total producing oil well years has been 250,000 well-years (based on information in Gulf (1981), NAS (1985), E&P Forum (1992), MMS (1997) and current internet sources). Generally, in analyzing accidents in the oil and gas industry, the exposure variable of "well-years" is used to normalize data for the continuous operation of production. This exposure is also convenient to use for workovers inasmuch as these maintenance activities, although not continuous, usually occur with regularity, approximately every five to seven years during the lifetime of a well.

On this basis, the world-wide frequency of extremely large hydrocarbon spills from oil-well blow-outs that occurred during production or workovers is 8.0×10^{-6} blow-outs/well-year. For very large, the number is 2.4×10^{-5} blow-outs/well-year.

14.1.1.3 Summary of Extremely Large and Very Large Oil Spills from Blow-outs

The above calculation of spill frequencies is based on an estimate of 250,000 oil-well years of world-wide experience and does not include gas-well experience, which, according to US OCS activity, could be 75 percent as much as oil-well experience. In other words, the frequencies calculated above, however low, are actually substantially lower when considering gas-well experience as well as oil-well experience. Because world-wide gas-well experience is not easy to estimate, the above spill frequencies will be used as a conservative case.

Finally, it is emphasized that the very low spill frequencies derived above for extremely large spills are based on spills in countries (except Norway) that do not generally have regulatory standards as stringent as those existing in North America. For example, one of the largest hydrocarbon spills in history, the *Ixtoc I* oil-well blow-out in the Bay of Campeche, Mexico, that occurred in 1979, was caused by drilling procedures (used by PEMEX, Mexico's national oil company) that are not practiced in US or Canadian waters and that are contrary to US and Canadian regulations and to the accepted practices within the international oil and gas industry. Therefore, extremely large spill frequencies in North America are expected to be even lower.

In spite of this declining trend, large blow-out events can still occur. On April 20, 2010, a fire and explosion occurred on Transocean's Deepwater Horizon drilling facility while drilling an exploration well on British Petroleum's Mississippi Canyon Block 252, approximately 66 km offshore Louisiana in the US GOM. At the time of writing this report, the cause of this incident is still under investigation. The well was initially reported to be discharging

approximately 5,000 bbls per day; more recent estimates place the rate at 12,000 to 19,000 bbl/day.

Despite this recent event, the overall trend of spills and blow-outs is decreasing world-wide. A spill of the magnitude of the Deepwater Horizon blow-out in recent years is unprecedented. An investigation will likely result in lessons learned in terms of improved technology, operational, safety and environmental procedures. However, in spite of potential improvements and advancements in spill prevention technology and practices, there still remains an element of safety and environmental risk in any drilling operation.

With respect to the Hebron Project, there will be an estimated 40 development wells drilled, and an estimated 200 well-years of production[1]. Using the above world-wide spill frequency statistics as a basis for prediction, the spill frequencies estimated for the Project would be as follows:

- Predicted number of extremely large hydrocarbon spills from blow-outs during a drilling operation, based on an exposure of wells drilled: $40 \times 1.5 \times 10^{-5} = 6.0 \times 10^{-4}$
- Predicted number of very large hydrocarbon spills from drilling blow-outs based on an exposure of wells drilled: $40 \times 6.0 \times 10^{-5} = 2.4 \times 10^{-3}$
- Predicted number of extremely large hydrocarbon spills from production / workover blow-outs, based on an exposure of well-years: $200 \times 8.0 \times 10^{-6} = 1.6 \times 10^{-3}$
- Predicted number of very large hydrocarbon spills from production / workover blow-outs, based on an exposure of well-years: $200 \times 2.4 \times 10^{-5} = 4.8 \times 10^{-3}$

14.1.2 Blow-outs Involving Smaller Discharges of Oil or Only Gas

Gas blow-outs from offshore wells that do not involve a discharge of liquid petroleum are generally believed to be relatively innocuous to the marine environment. However, such blow-outs may represent a threat to human life and property because of the possibility of explosion and fire.

Two sources are used for historical statistics on blow-outs involving only gas or small hydrocarbon discharges. A particularly good source for US blow-outs is the BOEMRE web page (www.boemre.gov), because BOEMRE keeps track of spills down to 1 bbl in size. This is not the case in other parts of the world. Scandpower (2000) provides a report on blow-outs in the North Sea and in the US GOM, although the report provides no information as to whether or not hydrocarbon spills were involved in the reported blow-outs.

The US Outer Continental Shelf (OCS) data, representing the 34-year period from 1972 to 2006, are provided in Table 14-4 (Note that BOEMRE updates their data on a regular basis, but the most recent data they have published is for 2006). There are no large spills in the entire database. The 2010

[1] Assumes half of all development wells are “oil producers” and that production wells have an average well-life of 10 years.

blow-out in the US Gulf of Mexico (US GOM) would fit into the extremely large category, but is classified as an exploratory well.

The total number of development wells drilled in the US OCS from 1972 to 2006 is not shown in Table 14-4, but an estimate of 21,000 can be inferred from other sections of MMS (1997), E&P Forum (1996) and from current internet sources. The number of blow-outs from development drilling is 87 (with the four blow-outs from sulphur drilling removed); therefore, the blow-out frequency is 4.1×10^{-3} blow-outs per well drilled.

The statistic, based mostly on US OCS drilling and blow-out records over the past 30 years, is derived on a conservative basis and does not take into account recent improvements in safety and blow-out prevention that have tended to reduce blow-out frequencies. There is also concern over gas releases and their effect on workers. For this reason, a more realistic assessment of the probability of a gas blow-out is required. The main factors that need to be re-considered are: (1) the differences between "shallow gas" blow-outs and deep-well blow-outs; (2) special blow-out prevention activities that exist for deep well drilling in Canada; and (3) decreases in blow-out frequency in recent years due to improvements in blow-out prevention. All three issues are covered thoroughly in Scandpower (2000).

Table 14-4 Blow-outs and Spillage from US Federal Offshore Wells, 1972 to 2006

Year	Well Starts	Drilling Blow-outs				Non-drilling Blow-outs								
		Exploration		Development		Production		Workover		Completion		Total Blow-outs		OCS Production
		No.	bbl	No.	bbl	No.	bbl	No.	bbl	No.	bbl	No.	bbl	MMbbl
1972	845	2	0	2	0	1	0	0	0	0	0	5	0	396.0
1973	820	2	0	1	0	0	0	0	0	0	0	3	0	384.8
1974	816	1	0	1	0	4	275	0	0	0	0	6	275	354.9
1975	372	4	0	1	0	0	0	1	0	1	0	7	0	325.3
1976	1,038	1	0	4	0	1	0	0	0	0	0	6	0	314.5
1977	1,064	3	0	1	0	1	0	3	0	1	0	9	0	296.0
1978	980	3	0	4	0	0	0	3	0	1	0	11	0	288.0
1979	1,149	4	0	1	0	0	0	0	0	0	0	5	0	274.2
1980	1,307	3	0	1	0	2	1	1	0	1	0	8	1	274.7
1981	1,284	1	0	2	0	1	0	3	64	3	0	10	64	282.9
1982	1,035	1	0	4	0	0	0	4	0	0	0	9	0	314.5
1983	1,151	5	0	5	0	0	0	2	0	0	0	12	0	350.8
1984	1,386	3	0	1	0	0	0	1	0	0	0	5	0	385.1
1985	1,000	3	0	1	0	0	0	2	40	0	0	6	40	380.0
1986	1,538	0	0	1	0	0	0	1	0	0	0	2	0	384.3
1987	772	2	0	0	0	3	0	1	0	2	60	8	60	358.8
1988	1,007	1	0	1	0	0	0	1	0	0	0	3	0	332.7
1989	911	2	0	[A]5	0	3	0	1	0	0	0	11	0	313.7
1990	987	1	0	1	0	0	0	3	9	1	0	6	9	304.5
1991	667	3	0	[B]3	0	0	0	0	0	0	0	6	0	326.4
1992	943	3	100	0	0	0	0	0	0	0	0	3	100	337.9

Year	Well Starts	Drilling Blow-outs				Non-drilling Blow-outs								
		Exploration		Development		Production		Workover		Completion		Total Blow-outs		OCS Production
		No.	bbl	No.	bbl	No.	bbl	No.	bbl	No.	bbl	No.	bbl	MMbbl
1993	717[C]	1	0	2	0	0	0	0	0	0	0	3	0	352.7
1994	717[C]	0	0	0	0	0	0	1	0	0	0	1	0	370.4
1995	717[C]	1	0	0	0	0	0	0	0	0	0	1	0	429.2
1996	921	1	0	1	0	0	0	0	0	2	0	4	0	433.1
1997	1,333	1	0	3	0	0	0	0	0	1	0	5	0	466.0
1998	1,325	1	0	1	0	2	0	3	0	0	0	7	2	490.5
1999	364	1	0	2	0	0	0	1	0	0	0	5	0	534.6
2000	1,061	5	200	4	0	0	0	0	0	0	0	9	200	551.6
2001	1,007	1	0	4	1	2	0	2	0	1	0	10	1	591.5
2002	828	1	0	2	0	2	350	1	1	0	0	6	351	602.1
2003	835	1	0	1	0	2	1	1	10	0	0	5	11	594.7
2004	861	2	16	0	0	0	0	2	1	0	0	4	17	567.0
2005	1,232	3	0	1	0	0	0	0	0	0	0	4	0	497.4
2006	1,586	0	0	0	0	0	0	1	0	1	50	2	50	503.1
Total	**34,576**	**67**	**316**	**91**	**1**	**24**	**627**	**39**	**125**	**15**	**110**	**207**	**1181**	**13,963.9**

A Two of the drilling blow-outs occurred during drilling for sulphur
B Two of the drilling blow-outs occurred during drilling for sulphur
C Estimated: cumulative total correct

14.1.2.1 Shallow Gas versus Deep Blow-out

A blow-out might occur if shallow gas is encountered unexpectedly during drilling operations. The driller has interest in shallow gas from the mudline to approximately 914 m (3,000 feet) and below. Gas that is trapped in the shallow sediments can originate from deeper gas reservoirs, but can also come from biogenic activity in the shallow sediments. The probabilities of the various blow-out categories are shown in Table 14-5, abstracted from Scandpower (2000).

The values in Table 14-5 (for the US GOM) are reasonably consistent with the values in Table 14-4, which show 29 blow-outs for the period 1980 to 1997. This means that the BOEMRE (the US regulator) classifies “blow-outs” in Table 14-5 as *all* categories in Table 14-5 (*i.e.*, well releases as well as blow-outs). The blow-out frequency from Table 14-5 for the US GOM is $28/8{,}466 = 3.3 \times 10^{-3}$ blow-outs / releases, which is close to the value derived earlier (4.1×10^{-3}).

The important statistic to note in Table 14-5 is that the vast majority of blow-outs and well releases are of the shallow gas variety. Specifically, the breakdown for shallow gas blow-out frequency versus deep blow-out frequency is shown in Table 14-6. It is clearly seen that: (1) shallow gas blow-out frequencies are approximately four times lower in the North Sea compared to the US GOM OCS; and (2) deep blow-out / release frequencies can be (*e.g.*, for the US GOM) as much as six times lower than shallow gas blow-out / releases.

Table 14-5 Development Drilling and Blow-outs in the US Gulf of Mexico Outer Continental Shelf and North Sea, 1987 to 1997

Area	Number of Development Wells	Shallow Gas Blow-outs	Shallow Gas Release during Drilling	Deep Blow-outs	Deep Well Releases during Drilling	Total Blow-outs and Releases
US GOM	8,466	13	10	4	1	28
UK	3,086	1	0	0	2	3
Norway	1,202	1	1	0	0	2
Totals	12,754	15	11	4	3	33

Source: after Scandpower (2000)

Notes:

- A blow-out is an incident where hydrocarbons flow from the well to the surface, all barriers are non-functional and well control can only be regained by means that were not available when the incident started
- A deep blow-out is defined as one that occurs after the Blow-out Preventor (BOP) is set
- A shallow gas blow-out is a release of gas prior to the BOP being set
- A well release is an incident where hydrocarbons flow from the well to the surface and is stopped by one or several barriers that were available when the incident started. In this case, hydrocarbons do not enter the environment

Table 14-6 Blow-out Frequencies for the US Gulf of Mexico and North Sea, 1980 to 1997

	Shallow Gas Blow-out / Release		Deep Blow-out / Release	
	US GOM	North Sea	US GOM	North Sea
Blow-outs / Releases per Wells Drilled	27×10^{-4}	7.0×10^{-4}	5.9×10^{-4}	4.7×10^{-4}
Wells Drilled per Blow-out / Release	370	1400	1700	2100

Deep blow-outs (and not well releases) are the primary concern because releases by definition do not involve a discharge of hydrocarbons into the environment. There have been four deep blow-outs from development drilling in the US GOM and none in the North Sea from 1987 to 1997 (Table 14-5). The reason for this, according to Scandpower (2000), is that North Sea operators are required by law to always have two barriers during exploration and development drilling, and this is not the case in the US. Regulations in Canada (*i.e.*, two barriers) are similar to those in the North Sea, so it is fair to derive blow-out frequencies for Canada on the basis of North Sea statistics.

Finally, it is worth noting (Table 14-7) that shallow gas blow-out frequencies in the North Sea and in the US GOM have been on the decline in the most recent years of the record.

A more recent study by IAOGP (2010), is based on the 20-year record to 2005, and indicates a deep blow-out frequency of 4.8×10^{-5} blow-outs per well drilled. Using this figure results in a probability of one blow-out for every 21,000 wells drilled.

Table 14-7 Shallow Gas Exploration and Development Drilling Blow-out Frequencies over Time, 1980 to 1997

Time Period	No. of Blow-outs	Number of Exploration and Development Wells Drilled	Blow-out Frequency
18 years (1980 to 1997)	53	22,084	24.0×10^{-4}
10 years (1988 to 1997)	23	13,870	16.6×10^{-4}
5 years (1993 to 1997)	5	7,581	6.6×10^{-4}
3 years (1995 to 1997)	1	4,924	2.0×10^{-4}
Source: Scandpower (2000)			

14.1.2.2 Blow-outs During Production Operations

The best accident exposure variable to use for production and wireline operations is well-years. It is also convenient to link completions and workovers to well-years of operation. The number of oil and gas well-years for the population in Table 14-4 from 1972 through 2006 can be estimated from other tables in MMS references; the number is approximately 250,000 producing well-years.

For all the gas-producing areas and oil-producing areas of the US OCS, 78 blow-outs occurred during production, workovers and completions (Table 14-4). This yields a blow-out frequency of 78/250,000 = 3.12×10^{-4} blow-outs per well-year. The equivalent number for the US OCS and North Sea areas for the period 1980 to 1997 is 1.83×10^{-4} blow-outs per well-year (Table 14-8).

Table 14-8 Frequency over Time of Blow-outs during Production, Wireline Operations, Workovers and Completions, US Gulf of Mexico and North Sea, 1980 to 1997

Period	Blow-outs: Production and Wireline	Blow-outs: Completions and Workovers	Total Blow-outs	Well-years	Blow-out Frequency
18 years (1980 to 1997)	10	21	31	168,583	1.83×10^{-4}
10 years (1988 to 1997)	3	7	10	108,357	9.92×10^{-5}
5 years (1993 to 1997)	1	3	4	55,188	7.25×10^{-5}
3 years (1995 to 1997)	1 [a]	3	4	34,895	1.15×10^{-4}
Source: Scandpower (2000)					

As was done for the case of blow-outs during development drilling, it is important to note that blow-out frequencies during production operations in the North Sea and in the US GOM have been on the decline over recent years (Table 14-8).

IAOGP (2010) does not allow a comparison for each of the operations listed in Table 14-8, but confirms the overall blow-out frequency for production, wireline operations, completions and workovers in recent years. The data, based on the 20-year record to 2005, indicate an overall blow-out frequency for these operations of 1.85×10^{-4} blow-outs per well year, based on 33 incidents over 177,474 well-years.

A certain percentage of the blow-outs involved some discharge of hydrocarbon. Of the 78 blow-outs that occurred during the four operations of production, wirelining, workovers and completions, only 12, or 15.4 percent, involved hydrocarbon (note that the average size of the 12 spills was only 72 bbl). Therefore, the frequency of blow-outs that produced a hydrocarbon spill from well blow-outs during the four above-noted operations is calculated to be $0.154 \times 1.85 \times 10^{-4} = 2.8 \times 10^{-5}$ blow-outs/well-year.

14.1.2.3 Summary of Blow-out Frequencies Involving Smaller Discharges of Oil or Only Gas

There are an estimated 40 wells to be drilled for the Project, so the likely number of deep blow-outs during development drilling becomes $40 \times 4.8 \times 10^{-5} = 1.92 \times 10^{-3}$.

For gas blow-outs occurring during production and workovers, the statistic for Hebron becomes 200 well-years x 1.17×10^{-4} blow-outs/well-year $= 2.34 \times 10^{-2}$.

For gas blow-outs that occur during production and workovers that involve some hydrocarbon discharge (>1 bbl), the statistic for Hebron becomes 200 well-years x 2.8×10^{-5} blow-outs/well-year $= 5.6 \times 10^{-3}$.

14.1.3 Large Platform Spills

There have been very few large spills from platforms operating in US OCS waters. In addition to the six from blow-outs noted in Table 14-3 there have been seven others, which includes all US platform spills up to the present (Table 14-9). Note, that this does not include the 2010 Deepwater Horizon blow-out, which occurred during exploration drilling.

Table 14-9 Hydrocarbon Spills of Greater than or Equal to 1,000 bbl from Platforms on the US Outer Continental Shelf, 1964 to 2010

Date	Location	Size (bbl)	Cause
04/08/64	Eugene Island Block 208	2,559	Collision
10/03/64	Eugene Island Ship Shoal	11,869	Hurricane (7 platforms)
07/19/65	Ship Shoal Block 29	1,688	Blow-out (condensate)
01/28/69	Santa Barbara Channel	77,000[A]	Blow-out
03/16/69	Ship Shoal Block 72	2,500	Collision, weather
02/10/70	Main Pass Block 41	30,000	Blow-out
12/01/70	South Timbalier Block 26	53,000	Blow-out
01/09/73	West Delta Block 79	9,935	Storage tank rupture
11/23/79	Main Pass Block 151	1,500[B]	Collision, weather, tank spill
11/13/80	High Island Block 206	1,456	Pump failure, hurricane, tank spill
09/29/92	Timbalier Bay / Greenhill	11,500[C]	Production well blow-out
09/24/05	Cameron / Eugene Is. / Green Canyon	3,915	Hurricane (9 platforms)

Source: BOEMRE OCS Spill Database, April 2010, www.boemre.gov/stats/index.htm

A Estimates vary between 10,000 to 77,000 bbl

B Refined product

C This spill was in Louisiana State waters and not OCS waters, but is included for interest

All but two of the OCS spills in Table 14-9 occurred prior to 1980. BOEMRE statisticians responsible for analyzing and predicting hydrocarbon spill frequencies associated with offshore oil and gas activities in the OCS have decreased the estimate gradually over the past 15 years, mostly in recognition of a statistical trend towards lower spill frequency. The estimate derived from statistics in Anderson and LaBelle (2001) is 1.5×10^{-5} spills/well-year for spills equal or greater than 1,000 bbl and 5.5×10^{-6} spills/well-year for spills equal or greater than 10,000 bbl[2].

The production well-years for Hebron is 200; therefore, the predicted number over the 30-year life of the Project would be $200 \times 1.5 \times 10^{-5} = 3 \times 10^{-3}$ events for 1,000-barrel spill, and $200 \times 5.5 \times 10^{-6} = 1.1 \times 10^{-3}$ events for a 10,000 barrel spill.

Note that the above statistic for spills >10,000 bbl (*i.e.*, 5.5×10^{-6} spills/well-year) is almost four times smaller than the statistic derived earlier for production blow-out spills >10,000 bbl (*i.e.*, 2.0×10^{-5}). This is impossible because the first category includes blow-out spills. The reason for the anomaly is that the US record was used for the former and the world-wide record was used for the latter. The world-wide statistic is higher than the US-derived one because the former was developed on a very conservative basis, which considered an exposure of only oil wells and not gas wells.

It is noted that there has been one production-related spill in Newfoundland and Labrador waters greater than 1,000 bbl, in 2004. There have been no spills greater than 10,000 bbl. Given the limited statistical database of Newfoundland and Labrador production operations, the US statistics are used in the frequency calculation.

14.1.4 Platform Spills Involving Small Discharges

Small spills occur with some regularity at offshore platforms. The data in Table 14-10 are derived from a more detailed table in MMS (1997) and covers small spills of all pollutants from facilities and operations on Federal OCS leases from the period 1971 to 1995. The spills involved various pollutants including crude oil, condensate, refined product, mineral oil and diesel. The period between 1971 and 1995 involved the production of 8.5 billion bbl of oil and condensate and 186,058 well-years of oil and gas production activity (MMS 1997). See Table 14-10 for the spill frequency.

Table 14-10 Frequency of Platform Spills in the Ranges of 1 to 49.9 bbl and 50 to 999 bbl (US OCS 1971 to 1995)

Spill Size Range	Number of Spills
1 to 49.9 bbl	1,898
50 to 999 bbl	90
Total volume of 1,898 + 90 spills = 123,023 bbl	

[2] These numbers are derived from statistics developed by Anderson and LaBelle (2001), who use an exposure of "billions of barrels of oil produced" and consider the period 1964 to 1999. During this period, 46,000 bbl of oil were produced per well-year, considering both oil and gas wells. The frequencies derived by the authors for spills greater than 1,000 bbl and 10,000 bbl are 0.32 and 0.12 spills per billion bbl produced, respectively. The equivalent numbers for the last 15 years are considerably less.

There have been very few large spills related to development or production in Canadian waters, which has necessitated the use of US and world-wide statistics. However, there is a reasonably-sized database on small spill incidents in Newfoundland and Labrador waters. Spill statistics are maintained and reported by the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) (C-NLOPB 2010d).

Production in Newfoundland and Labrador waters commenced in 1997 at the Hibernia location, with Terra Nova coming on stream in 2001 and White Rose in 2004. Using the well statistics on the C-NLOPB website, these three fields have a total of 472 producing well-years to the end of 2010. Tables 14-11 through 14-14 provide an overview of spill statistics for the Newfoundland and Labrador Offshore area. The spill incidents involving 1 bbl or more of hydrocarbon during that period are listed in Table 14-11. These spills include spills of crude, diesel and other hydrocarbons resulting from production and loading operations. Spills of synthetic-based muds are provided in Table 14.14. As noted in Section 14.1.3, there was one crude oil spill greater than 1,000 bbl, in 2004.

Table 14-11 Frequency of Platform Spills in the Ranges of 1 to 49.9 bbl and 50 to 999 bbl (Newfoundland and Labrador Waters, 1997 to 2010)

Spill Size Range	Number of Spills
1 to 49.9 bbl	12
50 to 999 bbl	0

A disproportionate number (7 of 12) of these spills occurred in the first three years of operations, so it is reasonable to focus on the more recent years of production experience (Table 14-12). For the years 2000 to 2010, there were a total of 452 producing well-years.

Table 14-12 Frequency of Platform Spills in the Ranges of 1 to 49.9 bbl and 50 to 999 bbl (Newfoundland and Labrador Waters, 2000 to 2010)

Spill Size Range	Number of Spills
1 to 49.9 bbl	5
50 to 999 bbl	0

For the smallest size range, statistics from Newfoundland and Labrador operations can be used, but as there have been zero spills in the second category, US GOM statistics will be used. Based on this, the frequency of spills in the range of 1 to 49.9 bbl is 1.1×10^{-2} (5/452) and for the range 50 to 99 bbl is 4.8×10^{-4} (90/186,058).

The C-NLOPB also provides a statistical record of spills of greater than 1 L but less than 1 bbl (159 L), and of spills of 1 L and less; these are presented in Table 14-13. As in the previous category of spill size, a disproportionate number of these spills occurred in the first three years of operations, so it is reasonable to focus on the more recent years of production experience – 2000 to 2010. For these years (2000 to 2010), there were a total of 452 producing well-years, with 86 spills in the 1 to 159 L category, and 218 spills less than 1 L. Note that the totals in Table 14-13 indicate all spills

from 1997 to 2010. Based on this, the average spill frequency is 0.190 spills per well-year in the 1 to 159 L category, and 0.482 spills per well-year less than 1 L.

Table 14-13 Record of Very Small Spills in Newfoundland and Labrador Waters, 1997 to 2010

Year	Spills Greater Than 1 L and Less Than 159 L (1 bbl)		Spills of 1 L and Less	
	Number	Total volume (L)	Number	Total volume (L)
1997	7	123	0	0
1998	20	638	3	1.6
1999	23	636.4	9	4.72
2000	2	62	2	1.1
2001	7	126	8	4.21
2002	5	25.6	19	5.2
2003	10	185.8	9	2.48
2004	18	188.9	30	8.97
2005	11	180.7	28	8.96
2006	5	20	27	9.24
2007	3	93	34	4.28
2008	11	335.5	22	2.89
2009	11	288.3	22	4.97
2010	3	20.3	17	4.21
Total	136	2923.5	230	62.83

Regarding spills from the OLSs for all production facilities from 1997 to 2010, there were 10 spills greater than 1 L. Of these, one was in the range of 1 to 49.9 bbl, none in the 50 to 999 bbl range, and none greater than 1,000 bbl.

14.1.5 Spills of Synthetic-based Muds

The C-NLOPB records spills of synthetic-based mud (SBM) and fluids, and these are summarized in Table 14-14 for the years 1997 through 2010. In the largest such spill to date, in 2004, approximately 96,600 L (608 bbl) of SBM were spilled from the diverter line of the GSF Grand Banks at the White Rose location. The spill frequency is calculated based on the 219 wells spudded during this period.

Table 14-14 Spills of Synthetic-based Muds, 1997 to 2010

Spill Size Range	Number of Spills	Frequency, per well
>1 L	36	0.16
159 to 7,934 L (1 to 49.9 bbl)	18	0.082
7,935 to 159,000 L (50 to 999 bbl)	5	0.023
>159,000 L (1,000 bbl)	0	0

14.1.6 Summary of Blow-out and Spill Frequencies

The calculated hydrocarbon spill probabilities for the Project are summarized in Table 14-15.

Table 14-15 Summary of Probable Number of Blow-outs and Spills for the Hebron Project

Event	Historical Frequency	Hebron Exposure[B] (per project Life)	Probable number of occurences (over project life)
Blow-outs			
1. Deep blow-out during development drilling	4.8×10^{-5}/wells drilled	40 wells drilled	1.92×10^{-3}
2. Blow-out during production involving some hydrocarbon discharge >1 bbl	2.8×10^{-5}/well-years	200 well-years	5.6×10^{-3}
3. Development drilling blow-out with hydrocarbon spill >10,000 bbl	6.0×10^{-5}/wells drilled	40 wells drilled	2.4×10^{-3}
4. Development drilling blow-out with hydrocarbon spill >150,000 bbl	1.5×10^{-5}/wells drilled	40 wells drilled	6.0×10^{-4}
5. Production / workover blow-out with hydrocarbon spill >10,000 bbl	2.4×10^{-5}/well-year	200 well-years	4.8×10^{-3}
6. Production / workover blow-out with hydrocarbon spill >150,000 bbl	8.0×10^{-6}/well-year	200 well-years	1.6×10^{-3}
Platform Spills[A] (including blow-outs)			
7. Hydrocarbon spill >10,000 bbl	5.5×10^{-6}/well-year	200 well-years	1.1×10^{-3}
8. Hydrocarbon spill >1000 bbl	1.5×10^{-5}/well-year	200 well-years	3×10^{-3}
9. Hydrocarbon spill 50 to 999 bbl	4.8×10^{-4}/well-year	200 well-years	9.6×10^{-2}
10. Hydrocarbon spill 1 to 49 bbl	1.1×10^{-2}/well-year	200 well-years	2.2 spills over the life of the Project
11. Hydrocarbon spill 1 L to 1 bbl (159 L)	0.190/well-year	200 well-years	38 spills over the life of the Project
12. Hydrocarbon spill less than 1 L	0.482/well-year	200 well-years	96.4 spills over the life of the Project

A Platform spills greater than 150,000 bbl are not included in the table as it would simply duplicate the statistic for blow-outs greater than 150,000 bbls: it would be virtually impossible to have a spill of this size from anything other than a blow-out.

B Hebron Exposure is the number of events ove the life of the Project. This is either defined as number of well-years for production related activities, or number of wells drilled for drilling related activities.

14.1.7 ExxonMobil Experience

As reported by the C-NLOPB and CNSOPB, since 2001, ExxonMobil drilling operations in eastern Canada have not had a reportable spill greater than 1 bbl for the 63 wells drilled in the region. There were 14 wells drilled with a jack-up drilling unit in Nova Scotia, 46 wells were drilled from the Hibernia Platform, and three wells were drilled from floating mobile offshore drilling units (MODU) in Nova Scotia and on the Grand Banks. In the Newfoundland and Labrador offshore area, ExxonMobil has not had a crude spill greater than 1 L associated with its drilling operations.

ExxonMobil's well control philosophy is focused on prevention using safety / risk management systems, management of change procedures and global

standards. ExxonMobil has a mature Operations Integrity Management System (OIMS) that emphasizes relentless attention to Safety, Well Control and Environmental Protection. This includes proper preparation for wells (well control equipment inspections / tests), detecting the influx early, closing-in the well efficiently (personnel training / drills) and circulating out the kick with kill-weight mud in a controlled manner.

Defining "blow-out" as an uncontrolled flow that was not brought under control using the rig's well control system, the last offshore drilling "blow-out" experienced by Exxon was in the GOM in 1983 (Penrod 52 jackup rig). The last offshore "blow-out" was experienced by Mobil in the North Sea in 1990 (*Maersk Vinlander* semisubmersible rig). Both were shallow gas "blow-outs" with no personnel injuries or release of liquid hydrocarbons to the sea. ExxonMobil has had other well control incidents, but were safely brought under control using well control equipment and procedures. None escalated into "blow-outs".

Since the implementation of OIMS (circa 1992), neither Exxon nor ExxonMobil have experienced a "blow-out" during offshore drilling operations.

14.2 Fate and Behaviour of Hebron Hydrocarbon Spills in the Nearshore Study Area (Trajectory Modelling)

A spill trajectory modelling exercise, specific for Hebron Project activities in Bull Arm, Trinity Bay, was undertaken. This section provides an overview of the results of the modelling. The full report is provided in Applied Science Associates (ASA) 2010a.

The objective of this work is to undertake spill trajectory modelling for the accidental release of marine diesel fuels in Bull Arm, Trinity Bay. ASA used its SIMAP model system to simulate spills of fuel oil in Bull Arm, Trinity Bay. The model uses wind data obtained from model hindcasts and field measurements and current data from a hydrodynamic model. The SIMAP model was used in stochastic and deterministic modes to determine the range of possible water surface, subsurface and shoreline hydrocarbon contact predicted to occur. A complete description of the spill trajectory model is provided in the full report (ASA 2011a).

14.2.1 Model Inputs and Spill Scenarios

In the event of an accidental release of diesel at the Bull Arm construction site, the primary objective would be to stop the flow and implement spill countermeasures as quickly as possible. Spill response equipment will be contained on-site and staff will be trained to effectively respond to any accidental event.

Marine-based activities may primarily involve vessels that use standard marine diesel. The estimated maximum fuel storage capacity is approximately 100 m^3 per vessel. The mating of the topsides with the GBS, and likely tow-out of the GBS to the offshore location, (single events) may require larger vessels that use a heavier marine diesel product, Intermediate

fuel oil (IFO-180). The total fuel capacity of these vessels is approximately 1,000 m^3. Therefore, for the purposes of environmental assessment, two fuels were used in the simulation of spills. Simulations were performed for releases on the water surface both summer and winter conditions. The following spill scenarios were modelled:

- Instantaneous surface release of 100 m^3 of marine diesel fuel, summer, winter (no ice), and winter with approximately 65 percent ice coverage (ice coverage in Bull Arm can range from 0 to 100 percent through the winter season, depending on the month and the severity of the winter). Vessel operations during the construction of the Hebron GBS will likely not occur when ice concentration exceeds 65 percent broken ice coverage; therefore, all winter spill scenarios with sea ice present assume that Bull Arm and Trinity Bay are covered with a 65 percent concentration.
- Instantaneous surface release of 1,000 m^3 of (IFO-180), summer, winter (no ice), and winter with approximately 65 percent ice coverage
- All models were run for 30 days

Simulations of the fuel oil spills in Bull Arm use multiple 30-year wind speed and direction time series from the MSC50 model grid nodes in combination with a 30-year modified wind- time series in Bull Arm. Two separate hydrodynamic simulations were carried out using the HYDROMAP model in order to capture the combined tide and wind-driven currents in Bull Arm and Trinity Bay. Tidal current simulations were conducted to develop tidally-driven surface currents over the entire region. Wind-driven current simulations were conducted for eight wind directions using a constant wind speed of 8 m/s and then added to the tidal current simulation to create a combined current. This results in a current field covering Trinity Bay and Bull Arm that accounts for tide and wind-driven currents and is used to drive the oil spill simulations. A total of 18 scenarios (three oil threshold criteria times six spill scenarios) were modelled for the nearshore area.

The shoreline in Bull Arm was defined as one of two types: the beaches in Bull Arm were classified as Gravel Beach, and the remainder of the shoreline was classified as Seaward Rocky Shore. The eelgrass beds are subtidal habitats and not considered a shoreline type with oil holding capacity. The shoreline width, maximum oil thickness and oil removal half-times used in the oil spill modeling are listed in Table 14-16.

Table 14-16 Shoreline Width, Maximum Shoreline Oil Thickness and Removal Half-life Times for Various Shore Types

Shore Type	Width (m)	Maximum Oil Thickness (mm)	Oil Removal Half-time (days)
Exposed Rocky Shore	3	0.5	1
Gravel Beach	6	2	10
Source: Based On Gundlach 1987			

Spill trajectories were simulated for 30 days because at this point, the fuel oil has lost most of its volatile components, has reached its minimum thickness,

and if it has exited Trinity Bay, is moving out into the open sea by the end of the 30-day period.

14.2.2 Model Outputs

14.2.2.1 Stochastic Model Results

The stochastic model was used to determine the probability of finding hydrocarbons on the water surface, on the shoreline and in the water column exceeding the following thickness and concentration thresholds:

- Surface diesel average thickness >0.01 mm (10 µm)
- Shoreline diesel average thickness over a shoreline segment >0.01 mm (10 µm)
- Subsurface diesel (entrained in water) average concentration >10 ppb

The stochastic analysis provides two types of information to describe the potential spills: 1) areas that might have oil contact (as defined by a threshold oil thickness of 0.01 mm) and the associated probability; and 2) the shortest time required for hydrocarbons to reach any location and/or threshold in the areas predicted to have oil contact. This information is presented for surface oil, shoreline oil and subsurface oil in maps and in summary tables in this report. Total hydrocarbons, the group of chemical that make up crude oil, are divided into two categories, aromatic hydrocarbons, the toxic component of oil, and aliphatic hydrocarbons. For this study only the non-dissolved total hydrocarbons are tracked.

All results describe probabilities of oil occurring at the surface, in the water column, or at the shoreline; they do not depict an actual spill event, nor do they include the use of any spill countermeasures (*e.g.*, booms, skimmer, dispersants).

SIMAP's stochastic simulation results provide insight into the probable behaviour of potential oil spills under the environmental conditions expected to occur in the study area during each season. The 100 individual model simulations from each stochastic model scenario were ranked to determine the individual spill resulting in the 95^{th} percentile for shoreline oiling, water surface oiling and for oil entrained in the water column. For example, the 95^{th} percentile spill for surface oiling is the single spill resulting in a surface area oiled at a thickness exceeding 0.01 mm that is greater than or equal to 95 percent of all spills simulated.

Summer winds are more often from the southwest, which can drive diesel onto the northeast coast of Bull Arm. Any diesel exiting Bull Arm in the summer will most likely be driven northeastward up and out of Trinity Bay. Winter winds are most often from the northwest, which can move surface oil out of Bull Arm and onto the shoreline at the southern end of Trinity Bay, and less frequently towards the northeast and the mouth of Trinity Bay. The probability and minimal arrival time from a release of 100 m^3 marine diesel and 1,000 m^3 IFO-180 in summer and winter are provided in Figures 14-1 to 14-4. Note, for any of these simulations, they were modelled without the use of spill response equipment (*i.e.,* booms, skimmers, dispersants, *etc.*).

The following figures do not represent the size of a potential spill; rather, the figures show the probability of finding 0.01 mm of diesel on the surface of the water at any location over the model time period. Hence, the time for surface oiling, also shows the time for the probability of surface oiling to occur, and does not represent an actual slick. In addition, the results do not include the use of any spill countermeasures (*i.e.,* booms, skimmers, absorbents, dispersants).

Entrained marine diesel oil is predicted to exceed a concentration of 10 ppb 100 percent of the time within Bull Arm during the summer and winter seasons. Probabilities of finding 0.01 mm diesel oil on the water's surface drop quickly outside of Bull Arm to 10 to 30 percent during summer and winter seasons for a small area of southwest Trinity Bay. IFO-180 is a highly viscous fuel that shows almost no entrainment into the water column.

Without the use of spill countermeasures, the smaller volume 100 m^3 marine diesel spills are predicted to have a 10 to 20 percent probability of leaving Bull Arm during the summer and a 30 to 40 percent probability of leaving Bull Arm under winter conditions. Spills of 1,000 m^3 of IFO-180 have a 60 to 70 percent probability of leaving Bull Arm during the summer, and a 70 to 80 percent probability of entering Trinity Bay during the winter season.

The model predicts that oil from both the 100 m^3 marine diesel and 1,000 m^3 IFO-180 spills have a small (<5 percent) probability of leaving Trinity Bay (via the northeast corner of the model grid. This oil is >10 days old, the volatile components have evaporated, the oil is at the minimum thickness and moving into open ocean.

Spills of 100 m^3 of marine diesel have a 60 percent chance of making contact with the Bull Arm shoreline in summer, and a 30 percent probability in the winter season. IFO-180 spills of 1,000 m^3 have a 100 percent chance of contacting the Bull Arm shoreline in the summer and a 90 percent chance during the winter season. The minimum time to potential shoreline contact is 0 to 1 days within Bull Arm.

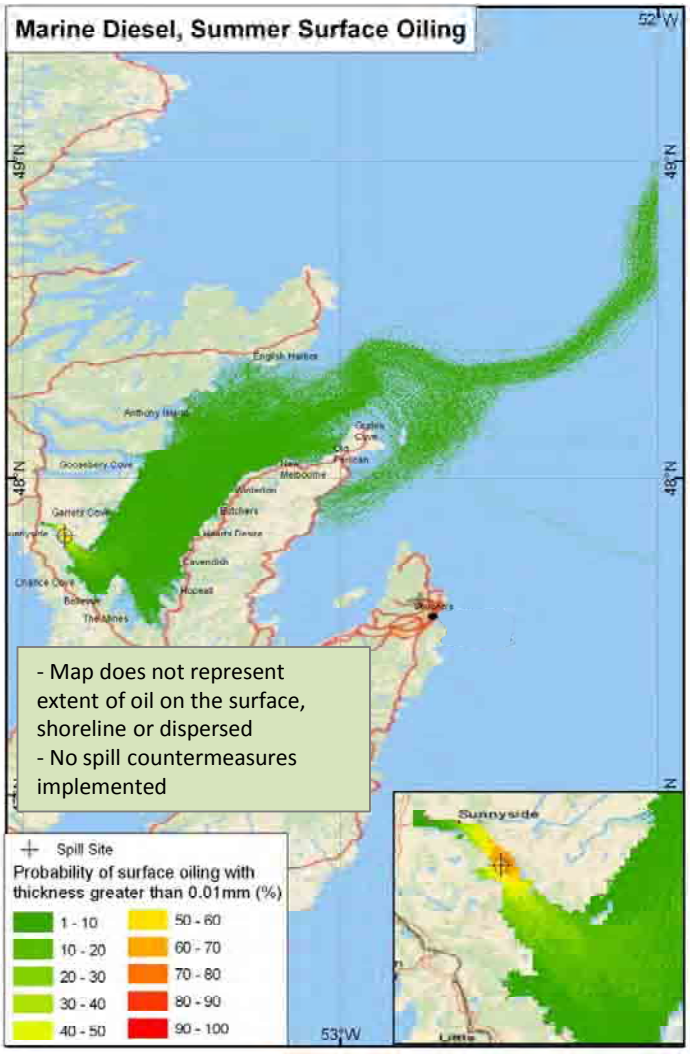


Figure 14-1 Probability of Surface Contact from a Release of 100 m^3 of Marine Diesel at the Bull Arm Site in Summer

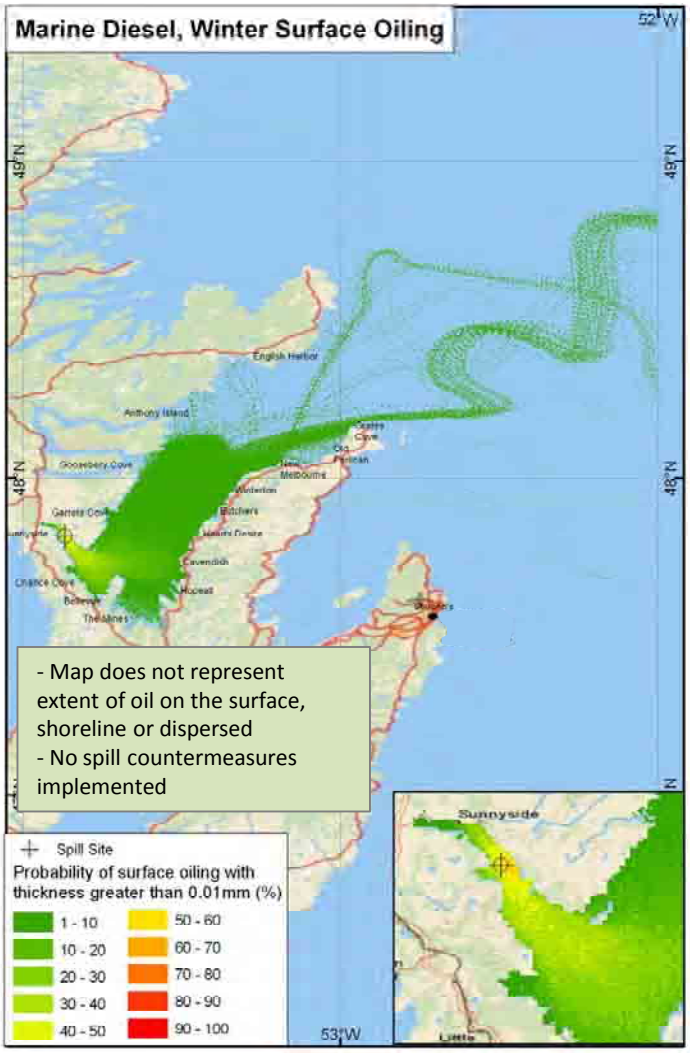


Figure 14-2 Probability of Surface Contact from a Release of 100 m^3 of Marine Diesel at the Bull Arm Site in Winter

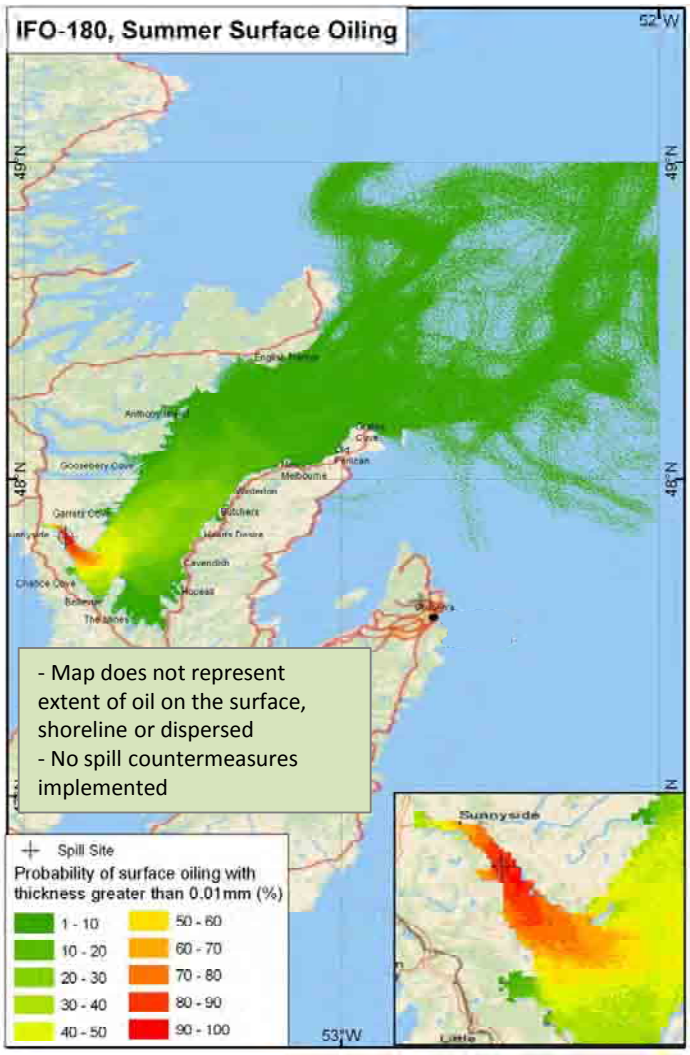


Figure 14-3 Probability of Surface Contact from a Release of 1,000 m^3 of Intermediate Fuel Oil (IFO-180) at the Bull Arm Site in Summer

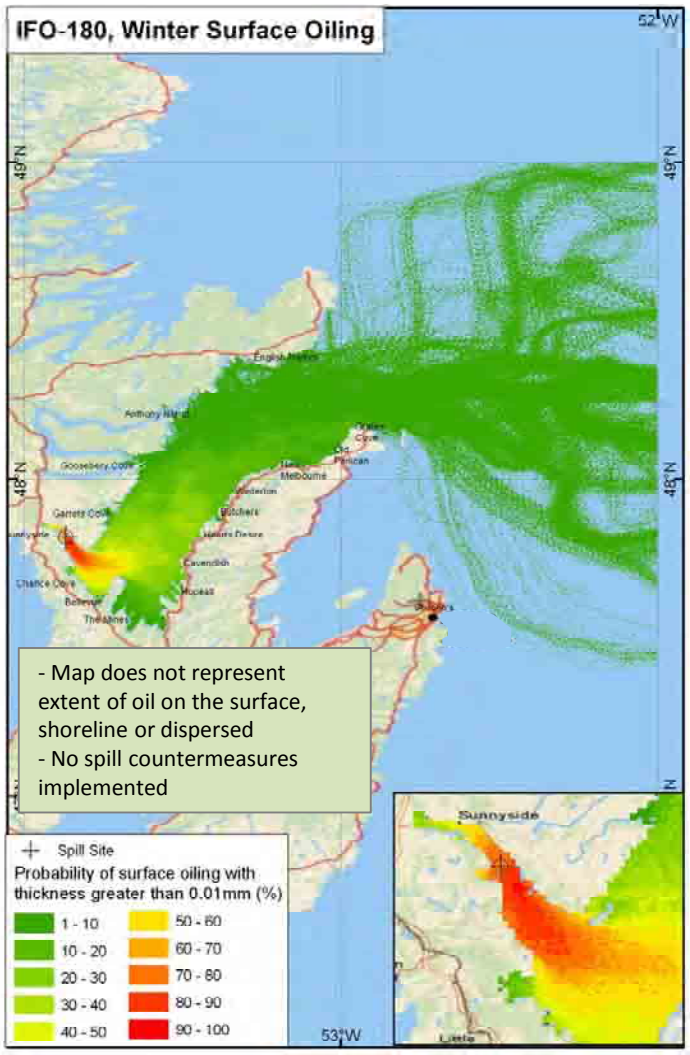


Figure 14-4 Probability of Surface Contact from a Release of 1,000 m^3 of Intermediate Fuel Oil (IFO-180) at the Bull Arm Site in Winter

14.2.2.2 Deterministic Model Results

The deterministic trajectory and fate simulations using the 3D Fates Model are performed for the 95th percentile simulations identified in each stochastic analysis as defined in Section 14.2.2. The 95th percentile result is chosen because it represents the upper end of the possible results (only 5 percent of simulations result in a larger value). The 18 simulations (three oil threshold criteria times six spill scenarios) provide a time history of oil weathering over the duration of the spill, expressed as the volume of spilled oil on the water surface, on the shore, evaporated, entrained in the water column and decayed.

Each scenario simulates the movement and weathering of the spilled oil for a period of 30 days, a length of time sufficient to allow for all of the weathering processes to occur. The mass balance results for all of the deterministic spill scenarios at the end of the 30-day simulation are provided in Table 14-17.

Table 14-17 Summary of Deterministic Model Mass Balance at the End of the 30-day Simulations

Oil Release	95th Percentile	Season	Surface Oil (m^3) >0.01 mm Thickness	Evaporated Oil (m^3)	Entrained Oil (m^3) > 10 ppb	Oil Ashore (m^3) >0.01 mm Thickness	Decayed Oil (m^3)
100 m^3 Marine Diesel	Sea Surface Oiling	Summer	0	52	19	16	13
		Winter - No Ice	0	13	65	0	22
		Winter – Ice	0	49	0	44	7
	Shoreline Oiling	Summer	0	56	18	14	12
		Winter - No Ice	0	25	46	10	19
		Winter – Ice	0	50	1	42	7
	Subsurface Oiling	Summer	0	18	59	2	21
		Winter - No Ice	0	11	66	1	22
		Winter – Ice	0	51	0	43	6
1,000 m^3 IFO-180	Sea Surface Oiling	Summer	30	170	0	420	220
		Winter - No Ice	20	160	0	510	210
		Winter – Ice	0	160	0	680	160
	Shoreline Oiling	Summer	0	170	0	610	220
		Winter - No Ice	0	160	0	610	220
		Winter – Ice	0	170	0	690	140
	Subsurface Oiling	Summer	0	155	0	475	200
		Winter - No Ice	25	155	0	570	210
		Winter – Ice	80	170	0	580	170

Results of the deterministic modelling for shoreline exposure to hydrocarbons with average thickness greater than 0.01 mm are depicted in Figures 14-5 to 14-10. It should be kept in mind that each map displays the results from a different individual simulation and depict one possible outcome for a spill at the Bull Arm site.

If a spill of marine diesel oil or IFO-180 was to occur, and spill countermeasures were not implemented, the spill trajectory model predicts the following results. Spills of 100 m^3 of marine diesel oil, representing the 95th percentile for surface contact, are predicted to remain entirely within Trinity Bay during the winter and to result in small amounts of weathered oil leaving the Bay during summer. In the winter season, approximately 12 percent of the diesel fuel is predicted to evaporate by the end of the 30-day simulation; more than 50 percent of the diesel fuel is predicted to evaporate in the summer season spill. The difference in evaporation is due to higher winter wind speeds, which entrain more oil in the water column, making it unavailable for evaporation.

Without the implementation of spill countermeasures, spills of 100 m^3 of marine diesel oil representing the 95th percentile for shoreline contact are predicted to affect much of the Bull Arm shoreline and isolated segments of the Trinity Bay shoreline in both the summer and winter seasons.

Spills of 100 m^3 of marine diesel oil representing the 95th percentile for entrained oil are predicted to exceed the 10 ppb concentration threshold for all of Bull Arm and for an area of southwest Trinity Bay in both the summer and winter seasons.

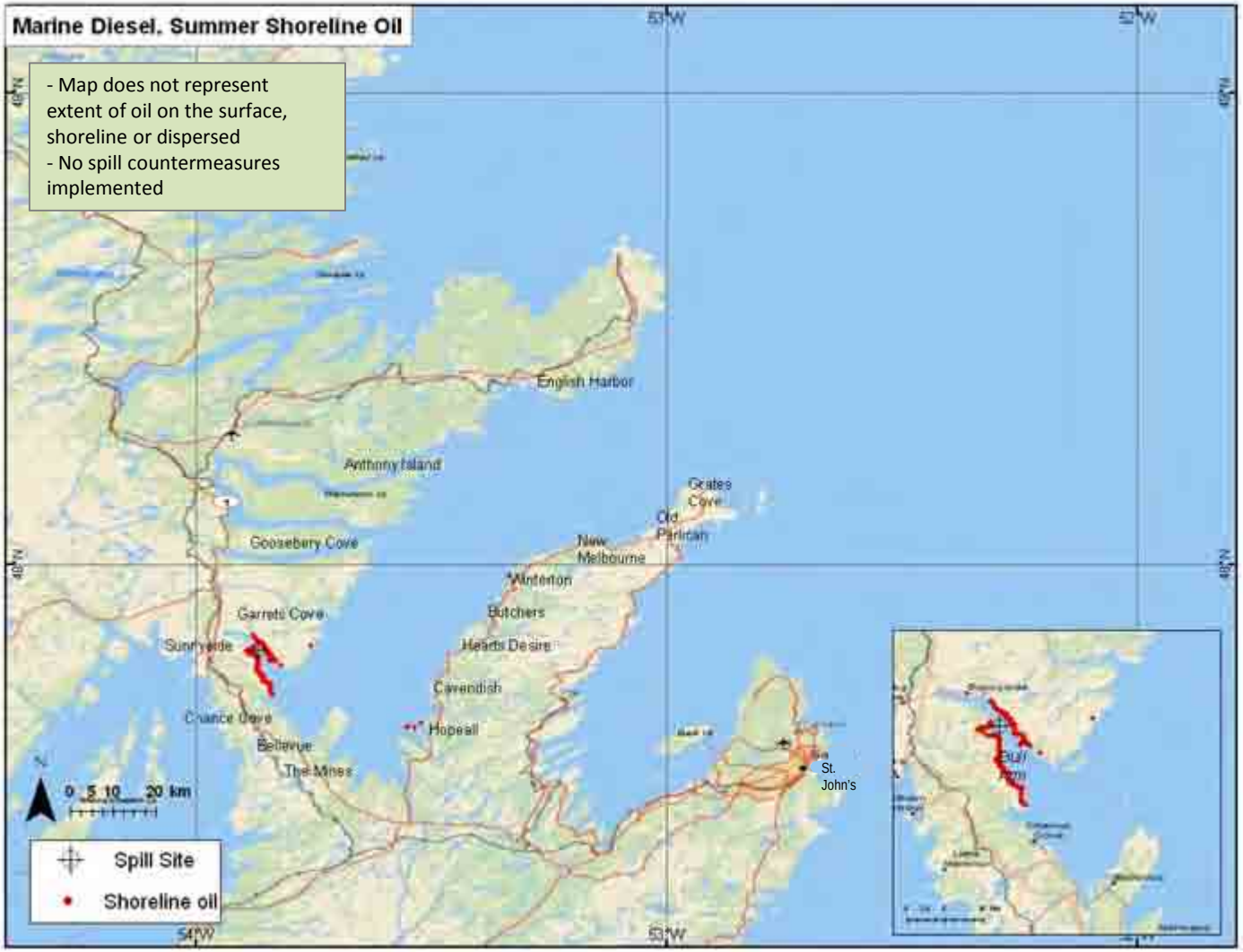
The presence of 65 percent ice cover reduces the sea surface area covered by marine diesel oil but results in more widespread shoreline effects. The presence of ice on the sea surface restricts the movement of surface oil, resulting in a reduced surface oil footprint. Because the surface oil footprint is reduced, the thickness of that surface slick must be increased to contain the same volume of oil. It is likely that the thicker surface slick contains sufficient oil volume so that when it goes ashore, the thickness threshold for shoreline contact is exceeded. Ice cover substantially reduces the area predicted to exceed the entrained oil concentration of 10 ppb. This is because the presence of 65 percent ice cover reduces the effectiveness of the wind to entrain oil into the water column.

Spills of 1,000 m^3 IFO-180 are predicted to make surface contact in Bull Arm and extend the length of Trinity Bay during the summer and winter seasons. Approximately 16 percent of the IFO-180 is predicted to evaporate by the end of the 30-day simulation during both the summer and winter seasons. The IFO-180 is highly viscous, which limits its entrainment and enhances conditions for evaporation.

Spills of 1,000 m^3 of IFO-180, representing the 95th percentile for shoreline contact, are predicted to make contact with much of the Bull Arm shoreline and segments of the Trinity Bay shoreline in both the summer and winter seasons. The summer shoreline contact is restricted to the east and west shorelines in the southern half of Trinity Bay. Winter season shoreline contact is restricted to primarily the east coast of Trinity Bay.

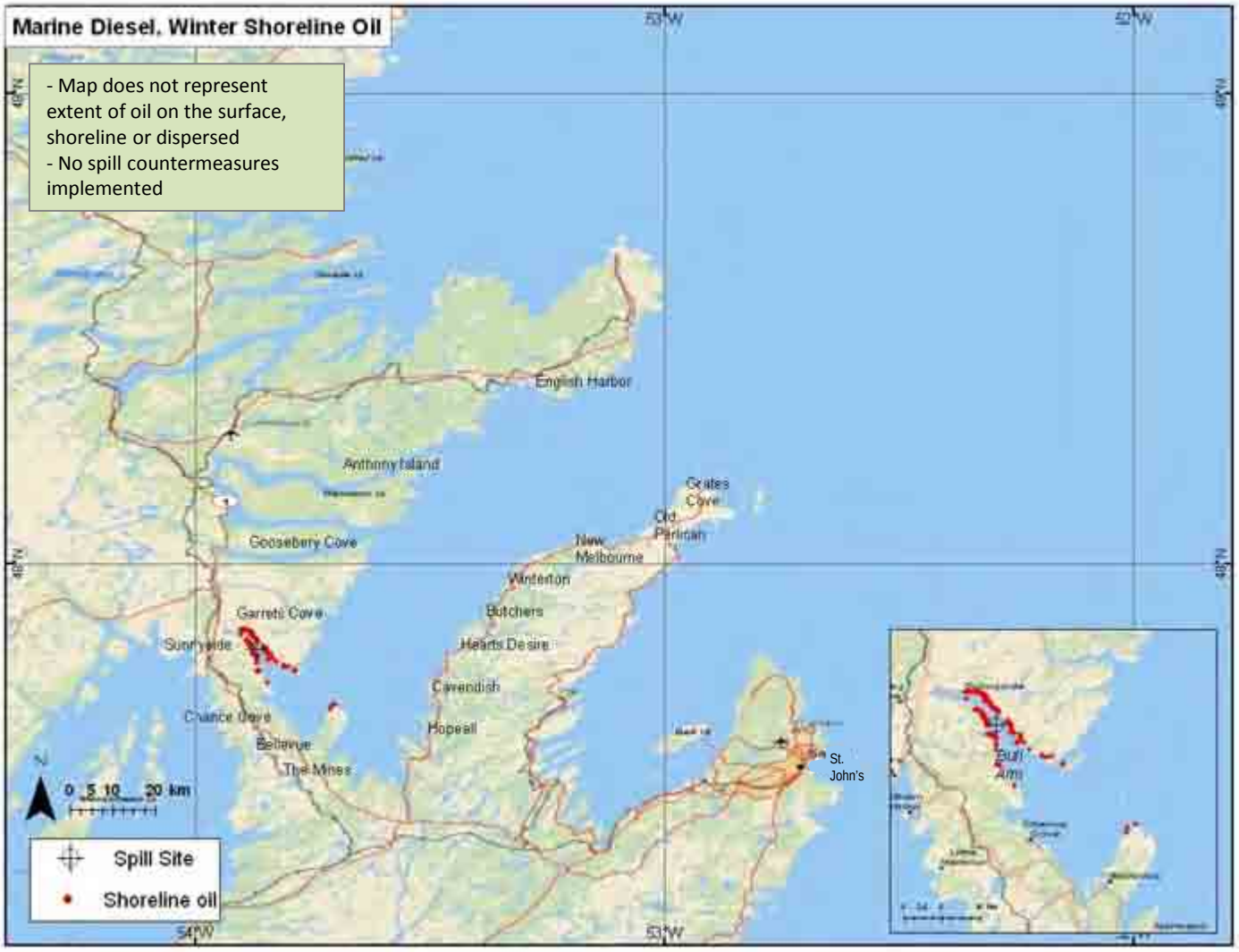
Spills of 1,000 m^3 of IFO-180, representing the 95th percentile for entrained oil, are predicted to exceed the 10 ppb concentration threshold for small areas of Bull Arm close to the release site. The IFO-180 is highly viscous and does not readily entrain.

The presence of 65 percent ice cover reduces the sea surface area covered by IFO-180 and does not substantially change shoreline contacts compared with the no-ice condition. The presence of 65 percent ice cover is predicted to eliminate any entrained oil concentrations greater than 10 ppb.



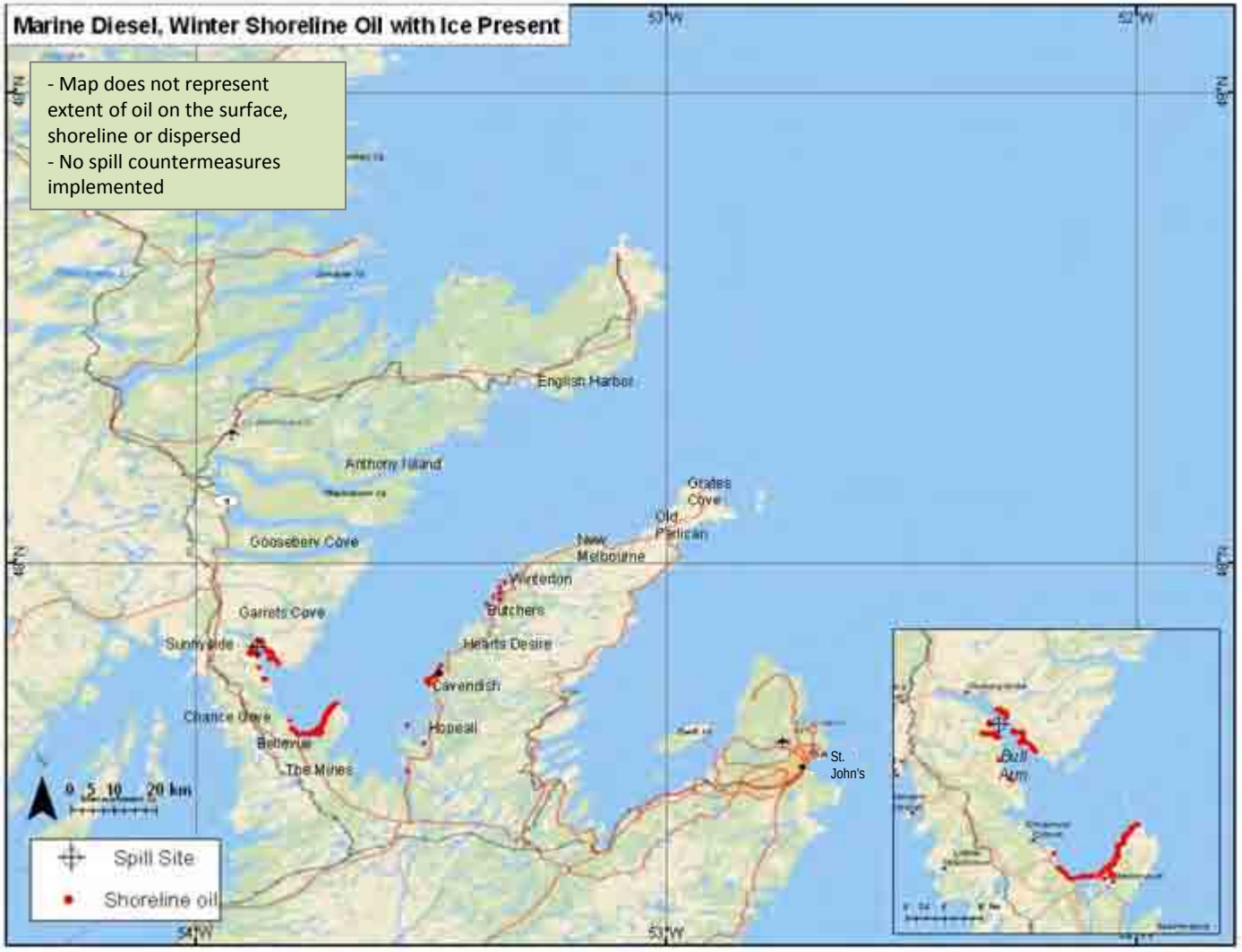
Note: Red colour highlights the areas of predicted shoreline contact.

Figure 14-5 Shoreline Exposure to Hydrocarbons (mm) for 95th Percentile Run with Average Thickness Greater than 0.01 mm for a 100 m^3 Release of Marine Diesel in the Summer



Note: Red colour highlights the areas of predicted shoreline contact.

Figure 14-6 Shoreline Exposure to Hydrocarbons (mm) for 95th Percentile Run with Average Thickness Greater than 0.01 mm for a 100 m^3 Release of Marine Diesel in the Winter



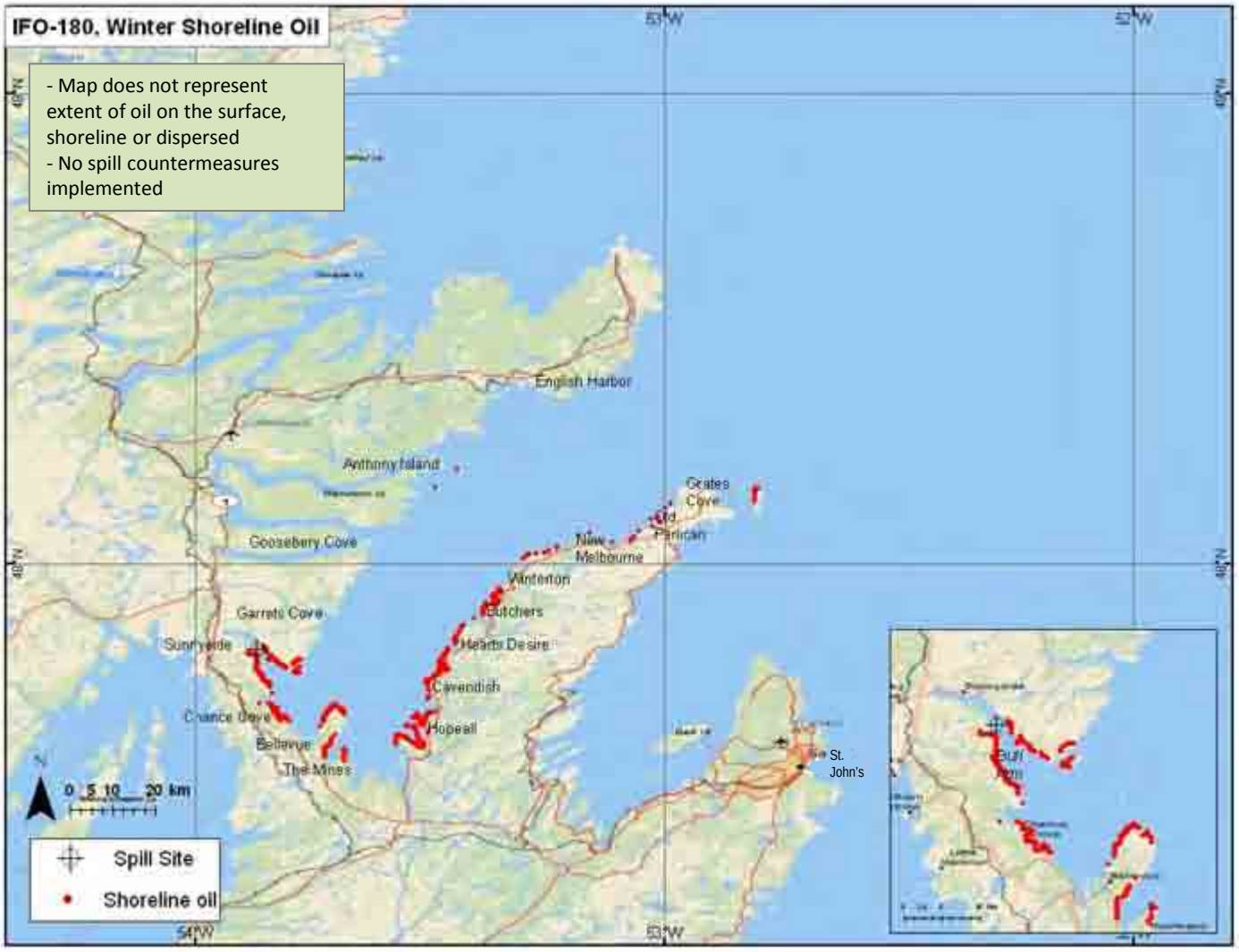
Note: Red colour highlights the areas of predicted shoreline contact.

Figure 14-7 Shoreline Exposure to Hydrocarbons (mm) for 95th Percentile Run with Average Thickness Greater than 0.01 mm for a 100 m^3 Release of Marine Diesel in the Winter with 65 Percent Ice Coverage



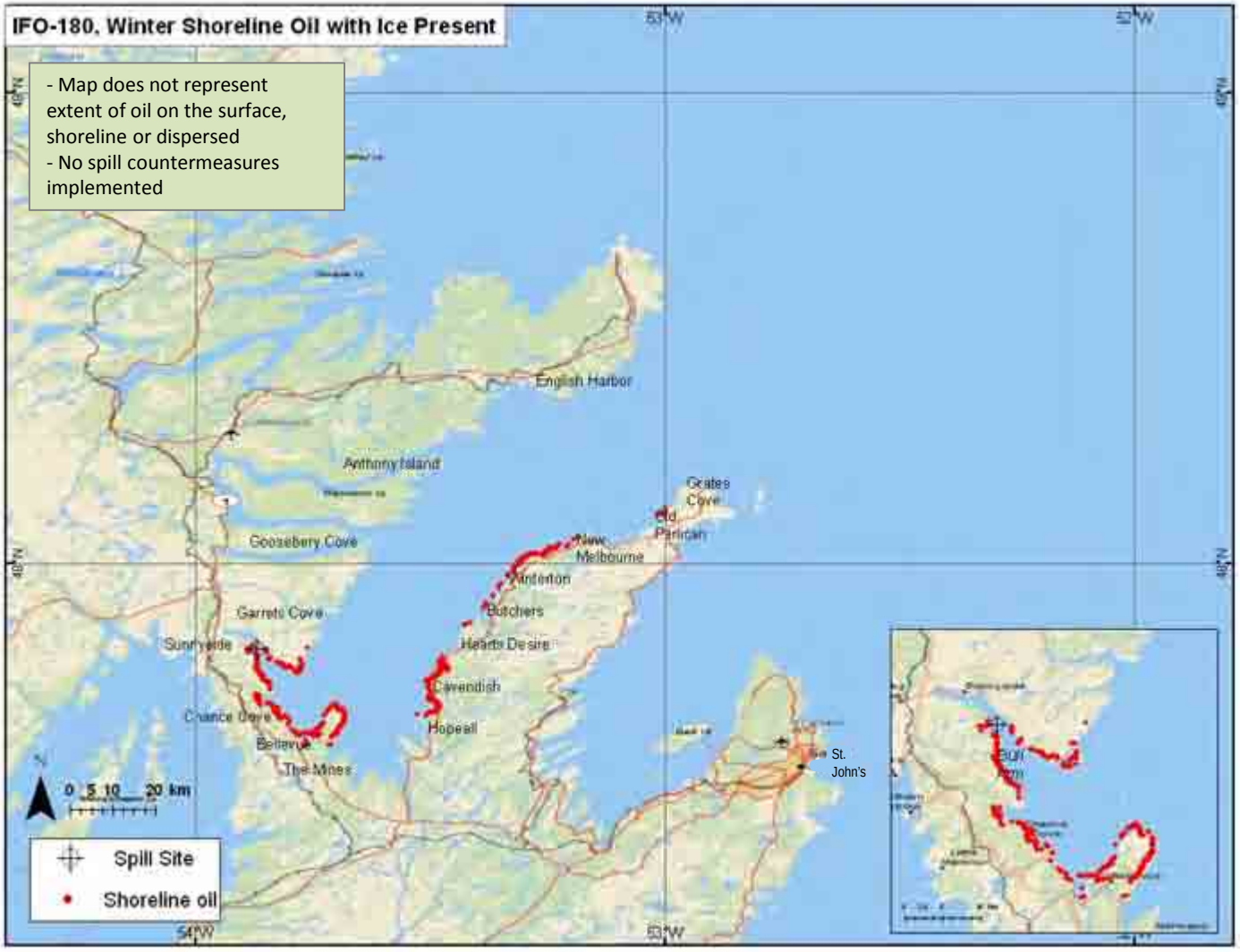
Note: Red colour highlights the areas of predicted shoreline contact.

Figure 14-8 Shoreline Exposure to Hydrocarbons (mm) for 95th Percentile Run with Average Thickness Greater than 0.01 mm for a 1,000 m^3 Release of IFO-180 in the Summer



Note: Red colour highlights the areas of predicted shoreline contact.

Figure 14-9 Shoreline Exposure to Hydrocarbons (mm) for 95th Percentile Run with Average Thickness Greater than 0.01 mm for a 1,000 m^3 Release of IFO-180 in the Winter



Note: Red colour highlights the areas of predicted shoreline contact.

Figure 14-10 Shoreline Exposure to Hydrocarbons (mm) for 95th Percentile Run with Average Thickness Greater than 0.01 mm for a 1,000 m^3 Release of IFO-180 in the Winter with 65 Percent Ice Coverage

14.2.3 Model Summary

Summer winds are more often from the southwest which drives oil onto the northeast coast of Bull Arm. Any oil exiting Bull Arm in the summer is driven northeastward up Trinity Bay. Winter winds are most often from the northwest which moves surface oil out of Bull Arm and onto the shoreline at the southern end of Trinity Bay and less frequently towards the northeast and the mouth of Trinity Bay.

Without the implementation of spill countermeasures, the smaller volume 100 m^3 marine diesel spills are predicted to have a 10 to 20 percent probability of leaving Bull Arm during the summer and a 30 to 40 percent probability of leaving Bull Arm under winter conditions. Spills of 1,000 m^3 of IFO-180 have a 60 to 70 percent probability of leaving Bull Arm during the summer, and a 70 to 80 percent probability of entering Trinity Bay during the winter season.

The model predicts that oil from both the 100 m^3 marine diesel and 1,000 m^3 IFO-180 spills have a small (<5 percent) probability of leaving Trinity Bay. Some of the surface oil exits the northeast corner of the model grid. This oil is >10 days old, the volatile components have evaporated; the oil is at the minimum thickness and moving into open ocean.

Spills of 100 m^3 of marine diesel have a 60 percent chance of hitting the Bull Arm shoreline in summer, and 30 percent probability to do so in the winter season. IFO-180 spills of 1,000 m^3 have a 100 percent chance of impacting the Bull Arm shoreline in the summer and a 90 percent chance during the winter season.

Entrained marine diesel oil from a 100 m^3 spill is predicted to exceed a concentration of 10 ppb 100 percent of the time within Bull Arm during the summer and winter seasons. Probabilities drop quickly outside of Bull Arm to 10 to 30 percent during summer and winter seasons for a small area of southwest Trinity Bay. IFO-180 is a highly viscous fuel that shows almost no entrainment into the water column for spills of 1,000 m^3.

Results from the stochastic model simulations are summarized in Table 14.18.

Table 14-18 Summary of Surface Oiling from the Stochastic Simulations of Marine Diesel and Intermediate Fuel Oil-180 Released at the Bull Arm Site

Oil Release	Season	Surface Area Oiled at >0.01 mm (km^2)	Shoreline Oiled at >0.01 mm (km)	Entrained Oil Volume after 30 days (m^3)
100 m^3 Marine Diesel	Summer	581.4	19.8	58.6
	Winter	371.2	10.1	65.3
1,000 m^3 IFO-180	Summer	1,524.8	144.3	0.017
	Winter	1,670.5	137.5	0.024

14.3 Fate and Behaviour of Hebron Hydrocarbon Spills from a Platform or Seafloor Blow-out in the Offshore Study Area (Trajectory Modelling)

Hydrocarbon spill trajectory analysis for the Grand Banks has been previously carried out for environmental assessments for offshore exploration drilling and production programs. As a result of the Deepwater Horizon incident (2010) in the Gulf of Mexico, the approach taken here represents a departure from what has been done for most other trajectory studies either here on the Grand Banks or elsewhere in the world. A thorough analysis was done of potential situations that could result in an uncontrolled release of hydrocarbons in the Offshore Study Area. This analysis included an upper end estimate of potential flow rates should a blow-out occur and a rigorous estimate as to how long it could take to stop the flow of fluids from the well. Such an event results in putting a significant amount of oil on the sea's surface, rivalling that of the Deepwater Horizon incident, and modelling its movement for extended periods of time.

The present exercise provides an analysis using recent environmental data inputs and presents results in the context of the Hebron setting and neighbouring oil production platforms. ASA (2010b) provides a discussion of the spill trajectory analysis.

The SIMAP model was used to simulate crude oil spills at the Hebron offshore site. The model scenarios use wind data obtained from model hindcasts and field measurements, and current data from multiple hydrodynamic models. The SIMAP model was used in stochastic and deterministic modes to determine the range of possible oiling predicted to occur at the water surface, entrained in the water column or deposited on the shoreline. The ASA blow-out model simulates the near-field dynamics of the plume of gas / oil mixture discharged from the seafloor well blow-out, and the SIMAP model simulates the far-field transport and weathering of the oil released into the water column or at the surface (see ASA 2010b for a complete description of the model and its results).

14.3.1 Model Inputs and Spill Scenarios

There are two types of spill events that may occur during production operations at the Hebron Platform: batch spills and blow-outs. Batch spills are instantaneous or short-duration discharges of hydrocarbons that could occur from the handling and/or transfer of hydrocarbons (*i.e.*, loading of diesel). Blow-outs are uncontrolled releases of fluids (crude oil and water) and gases from underground reservoirs.

The scenarios presented consider the rate at which oil could flow under a well blow-out scenario for the Hebron Field. This rate was derived based on existing knowledge of Hebron crude properties, known reservoir properties for the Hebron field and assumptions made for specific well conditions at the time of the blow-out. Reservoirs differ greatly from one to another and their properties (pressure, volume, oil / gas ratio) are unique to each reservoir.

Therefore, the flow rates described below reflect the properties of the Hebron Field. Historical flow rates from other spill events are not predictive of what would happen in other reservoirs; however, they can be used to put specific events into perspective.

Flow rates for Hebron platform wells were estimated at 5,600 m^3/d (approximately 35,000 bbl/d) based on the Hebron reservoir properties, assuming a blow-out to atmosphere (*e.g.*, approximately 70 m above mean sea level) and accounting for the viscous (thick - difficult to flow) nature of the oil from this reservoir.

Flow rates for MODU wells were estimated at 3,200 m^3/d (approximately 20,000 bbl/d) based upon the properties of its reservoir, a seafloor blow-out (approximately 90 m below sea level) and a lighter, less viscous oil. ExxonMobil's well control philosophy is focused on prevention using safety / risk management systems, management of change procedures and global standards. ExxonMobil has a mature OIMS that emphasizes relentless attention to Safety, Well Control and Environmental Protection. This includes proper preparation for wells (well control equipment inspections / tests), detecting the influx early, closing-in the well efficiently (personnel training / drills) and circulating out the kick with kill-weight mud in a controlled manner.

In the event of a blow-out, ExxonMobil's primary objective would be to stop the flow as quickly as possible. For both surface and seafloor wells, this would involve shutting in at the wellhead and killing the well through the wellhead. Relief well drilling, and the subsequent dynamic kill, is considered a back-up strategy in the event shut-in and/or killing through the wellhead is not possible or is unsuccessful.

In developing these scenarios the following factors were considered. Spill trajectory modelling was conducted for two potential scenarios where the blowout might occur above sea level from the platform or at the seafloor while drilling from a Mobil Offshore Drilling Unit (MODU).

Platform Blow-out (above sea level to the atmosphere):

- For a blow-out through a surface wellhead, multiple options are available to stop the flow, depending on the magnitude and composition of the flow, configuration of the blow-out preventer (BOP) and the accessibility of the wellhead. If the wellhead is accessible, capping the well would result in a relatively short flow duration, as surface capping equipment, such as safety valves for inside pipe flow, are maintained on the rig and manual BOP closing is possible. Depending on the scenario, the duration to cap the well and stop flow may be within just a few hours, or if initial attempts are unsuccessful, is estimated at two to three weeks. If a fire renders the platform inaccessible, the most appropriate method to access the well would be evaluated given the condition of the platform and surrounding wells.
- If Platform-based well interventions were not successful, the time it would take to secure a drilling unit locally, secure the required well equipment, mobilize the unit to the Hebron location, and drill a relief well is estimated to be 100 days in the summer months and 120 in the winter months. If a

MODU was sourced internationally, approximately 144 days in the summer months and 165 days in the winter months would be required to plan and execute the full relief well program.

Seafloor Blow-out (while drilling from a MODU):

- If the seafloor wellhead is accessible and the drilling rig on the MODU is intact, operational and can work over the wellhead, the rig would be used to cap or kill the well. In this scenario, multiple options exist to kill the well, including wellbore intervention to perform a dynamic kill or to set a packer. In addition, using the existing BOP stack or a capping BOP stack to shut-in the well is also possible. If the drilling rig is intact and the wellbore is accessible, a dynamic kill could take place within days of the blow-out. If it is necessary to assemble and mobilize a capping stack and a second MODU, then a time period of approximately 60 days would be required. If a MODU is available locally and the rig stack can be used as a capping stack, this time period is reduced to 30 days.
- If it is not possible to work over the wellhead, or if the wellhead is inaccessible, then a relief well will be required to kill the well. If a MODU was sourced locally, the time it would take to secure a drilling unit locally, secure the required well equipment, mobilize the unit it to the Hebron location, and drill a relief well is estimated to be 100 days in the summer months and 120 in the winter months. If a MODU was sourced internationally, approximately 144 days in the summer months and 165 days in the winter months would be required to plan and execute the full relief well program.

As stated above, the probability of a blow-out from development drilling or production operations resulting in the need to drill a relief well is low. Therefore, for the purposes of environmental assessment, the environmental effects analysis will focus on two plausible, albeit low probability blow-out events: a Platform blow-out flowing crude oil at a rate of 5,600 m^3/d for 30 days, and a seafloor blow-out flowing crude oil at a rate of 3,200 m^3/d for 100 days. The batch spills modelled include an instantaneous release of 800m^3 of diesel, and a batch release of 5,000 m^3 crude from the offshore loading system. Additional information on the spill trajectory modelling results can be found in the spill trajectory report completed by Applied Science Associates, Inc. (ASA 2010b).

Note that the 30 day duration blow-out scenarios were also run using a 60-day duration in order to track the oil for an additional 30 days. These extended simulations use the same blow-out duration, rate of release and total release volume as the 30 days scenarios; however, the model run time was extended to 60 days.

Also note that the types of oil differ for each of the blow-out scenarios due to the different reservoirs. The characteristics of the oil types used in the spill simulations are listed in Table 14-19.

Table 14-19 Characteristics of Oil used in Spill Trajectory Modelling

Oil	Spill	API Gravity	Density (g/cm^3)	Viscosity (cP)
Hebron D-94 Crude	Platform blow-out Batch OLS Transfer	20.1	0.92691 @ 25° C	265.374 @ 25° C
Ben Nevis L55 Well	Seafloor blow-out	30.8	0.8711 @ 15° C	15.556 @ 25° C
Marine Diesel Fuel	Batch Transfer Spills	37.6	0.82910 @ 25° C	4.0 @ 25° C

Wind data for offshore model simulations were obtained from two sources: MSC50 Wind Hindcast (Swail *et al.* 2006), a model reanalysis product that provides hindcast winds for the North Atlantic for the period 1954 through 2008 at sites clustered around the Hebron Platform; and National Centers for Environmental Prediction at multiple locations (more widely spaced) across the North Atlantic. Annual wind directions and speeds from the MSC50 model hindcast data were obtained for Grid Point M6010632 (adjacent to the Hebron Platform). The wind comes from all directions at this site but it comes most frequently from the northwest through the south. There is seasonality in the wind at this location that differentiates the summer and winter seasons. Winter wind speeds are higher than in summer and more frequently from the west and north. Oil spill simulations were run using summer and winter season winds in order to capture the seasonal differences. Currents for the North Atlantic region were acquired from the HYbrid Coordinate Ocean Model circulation model, an ocean general circulation model that evolved from the Miami Isopycnic-Coordinate Ocean Model (Halliwell *et al.* 1998, 2000; Bleck 2002). Hindcast currents from the HYbrid Coordinate Ocean Model were obtained for the period November 2003 through September 2010 for the North Atlantic region. These currents were used in SIMAP for modeling oil spills originating at the Hebron Platform and from the seafloor blow-out. Spill trajectory modelling in the winter months was run with and without ice present. The presence of sea ice in Newfoundland and Labrador waters was below normal during the winter of 2009-2010 (CIS 2010). The total accumulated ice coverage in east Newfoundland waters set a new record low during last year's winter season. Ice data used for oil spill modelling were obtained from the National Snow and Ice Data Center for the months of February and March, 1990 to define the ice coverage for these months. The SIMAP model accounts for the presence of ice at 0 to 30 percent, 30 to 80 percent and 80 to 100 percent when calculating surface oil advection, evaporation, entrainment into the water column and surface oil spreading.

14.3.2 Model Output

14.3.2.1 Stochastic Model Results

The stochastic model is used to determine the probability of finding oil on the water surface, the shoreline and in the water column based on specified thickness and concentration thresholds. The thresholds used for the stochastic model simulations in this study include:

- Average thickness of surface oil >0.01 mm (10 µm)

- Average thickness of oil over the shore segment (length of one grid cell times typical width for the shoreline type) >0.01 mm (10 µm)
- Average concentration of oil entrained in water (over the water cell) >10 ppb

Winds and currents at the Hebron Platform are such that the majority of spills are predicted to travel eastward. The distance traveled is controlled by the blow-out duration. Simulations of blow-outs of 100 days or longer duration and without any response or interdiction are predicted to oil large areas of the North Atlantic.

Winter wind speeds are higher than in summer and more frequently from the west and north, which drives oil greater distances to the east than summer winds. Both summer and winter spill simulations of greater than 30 days duration are predicted to reach segments of the Newfoundland shoreline.

Both of the crude oils used in the simulations are persistent and do not disperse into the water column readily from natural processes. This characteristic, combined with the long duration release of oil into the water, result in most of the oil remaining on the sea surface. The area of sea surface oiled increases linearly with an increase in total spill volume.

The probability for surface oiling exceeding the above thresholds for the 30-day Hebron Platform blow-out scenario in the summer and winter and winter in ice seasons are depicted in Figures 14-11 to 14-13. The probability for surface oiling exceeding the above thresholds for the 30-day / 60-day extended Hebron Platform blow-out scenario in the summer, winter and winter (with ice) seasons are depicted in Figures 14-14 to 14-16. The probability for surface oiling exceeding the above thresholds for the Hebron seafloor blow-out scenario for 100 days in summer and 120 days winter (with and without ice) are depicted in Figures 14-17 to 14-19. The probability for surface oiling exceeding the above thresholds for the Hebron Platform blow-out 100 and 120 days scenarios are very similar to the seafloor 100-day and 120-day cases; these figures can be found in ASA 2010b. It should be noted that the maps do not show that oil will cover the entire area depicted, only the probability that surface oil will enter the model domain in excess of the given threshold (*i.e.*, > 0.01 mm thickness) sometime during the modeling period.

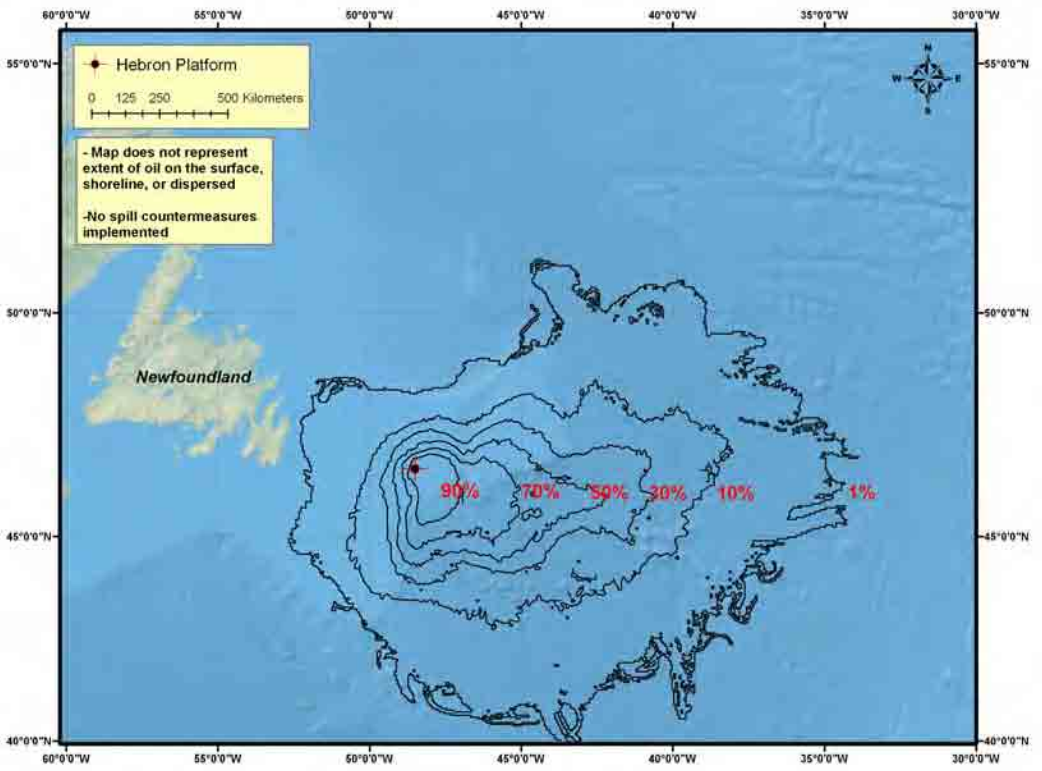


Figure 14-11 Surface Oiling Probabilities Greater than 0.01 mm from a Hebron Platform Blow-out of 5,600 m^3/day over a 30-day Period during Summer

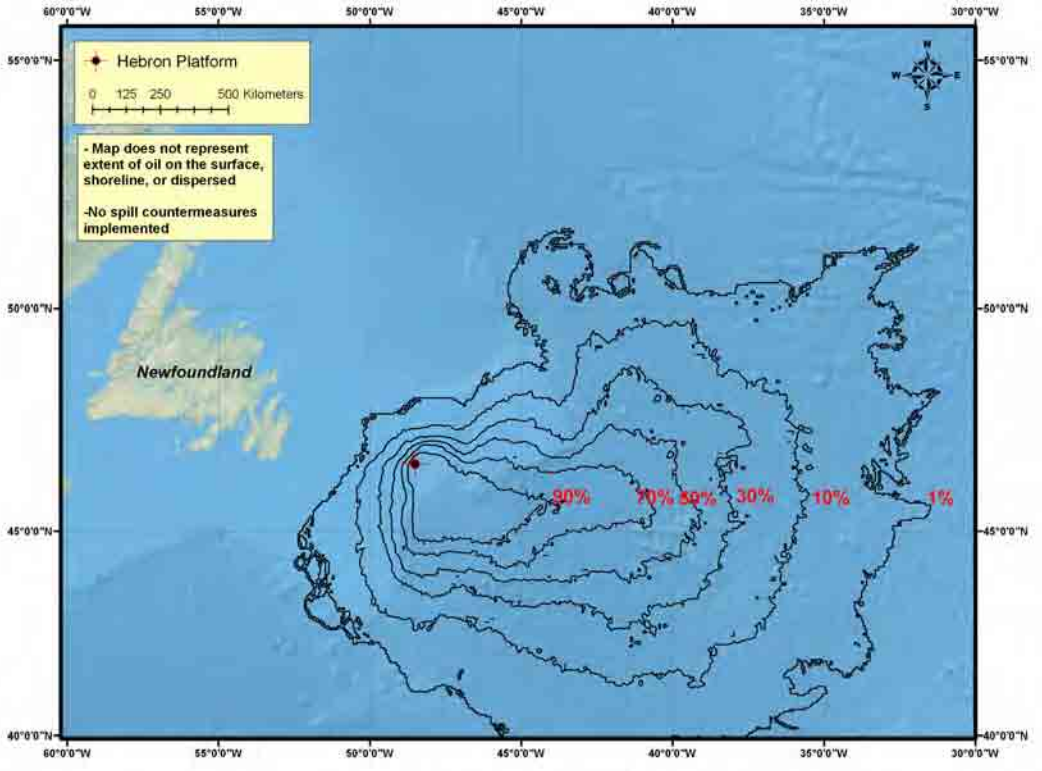


Figure 14-12 Surface Oiling Probabilities Greater than 0.01 mm from a Hebron Platform Blow-out of 5,600 m^3/day over a 30-day Period during Winter

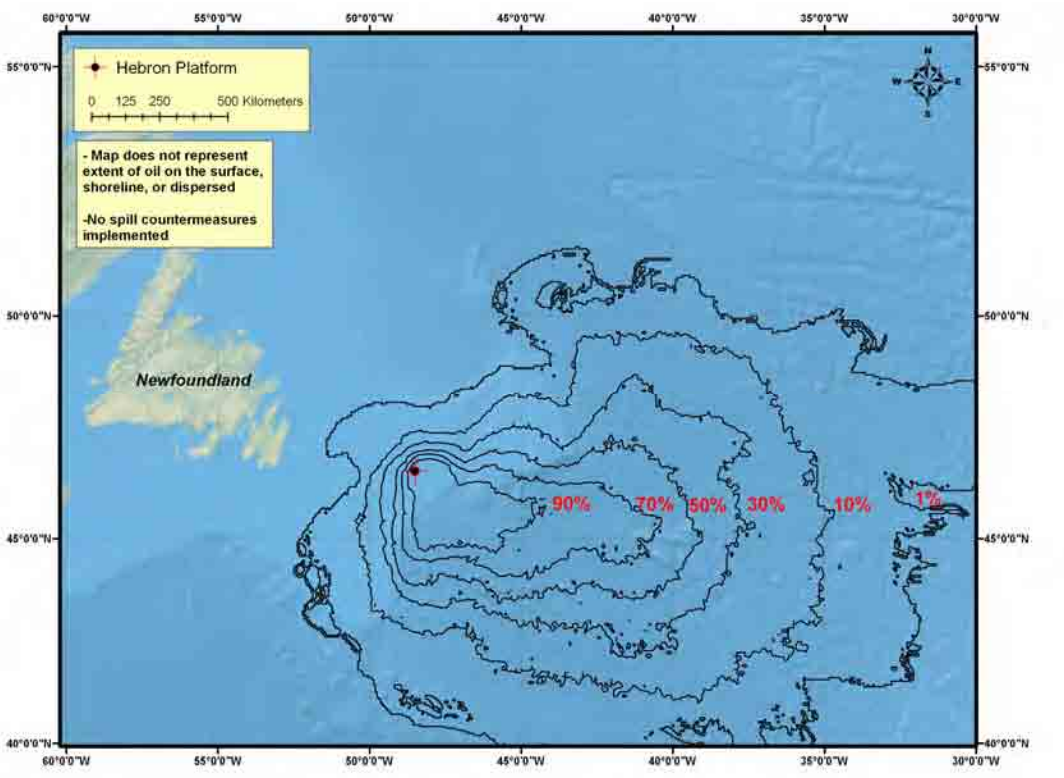


Figure 14-13 Surface Oiling Probabilities Greater than 0.01 mm from a Hebron Platform Blow-out of 5,600 m^3/day over a 30-day Period during Winter (ice present)

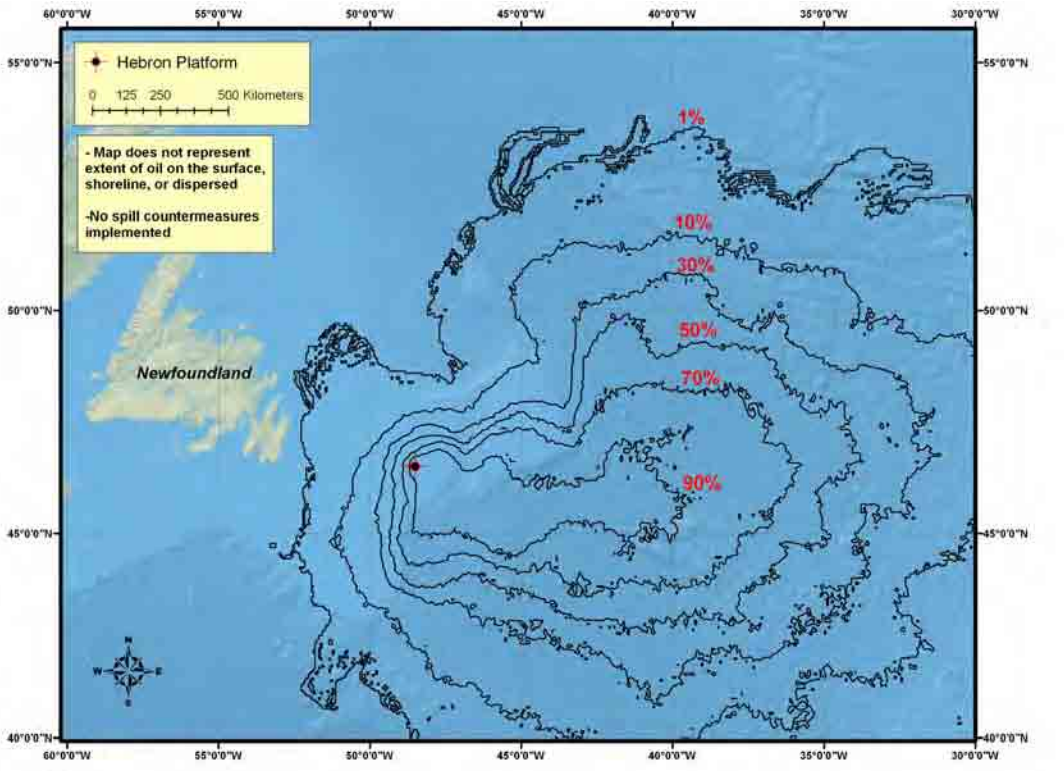


Figure 14-14 Surface Oiling Probabilities Greater than 0.01 mm from a Hebron Platform Blow-out of 5,600 m^3/day over a 30-day Period Simulated for 60 Days during Summer

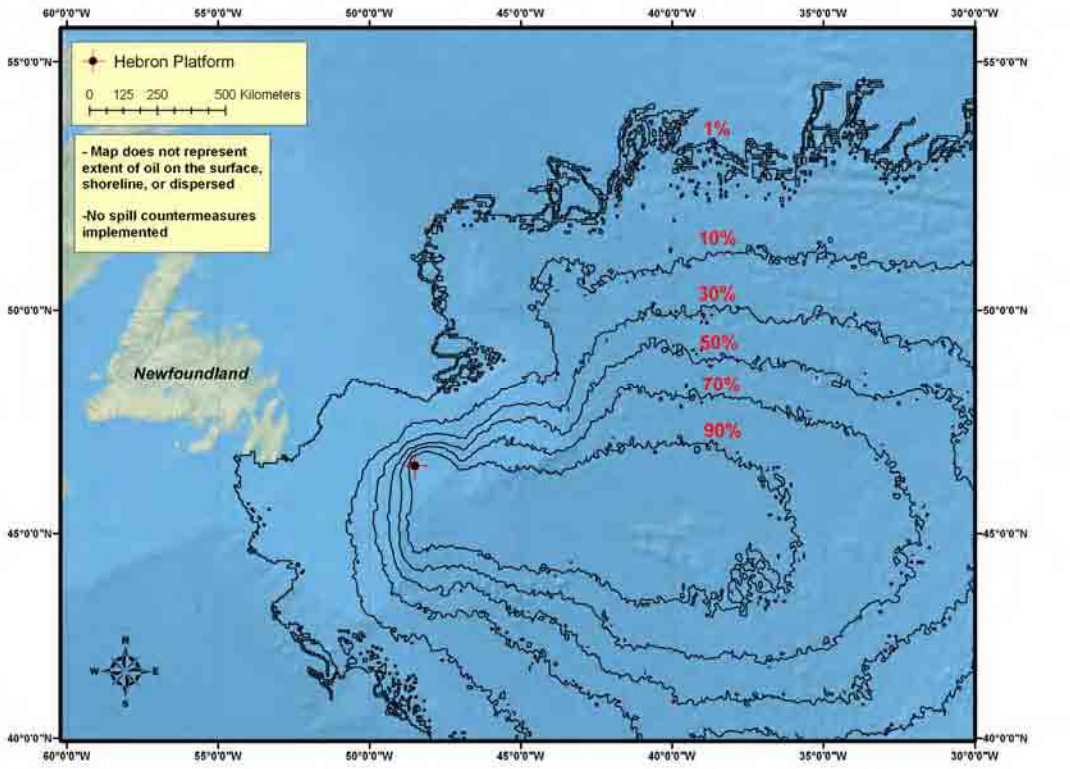


Figure 14-15 Surface Oiling Probabilities Greater than 0.01 mm from a Hebron Platform Blow-out of 5,600 m^3/day over a 30-day Period Simulated for 60 Days during Winter

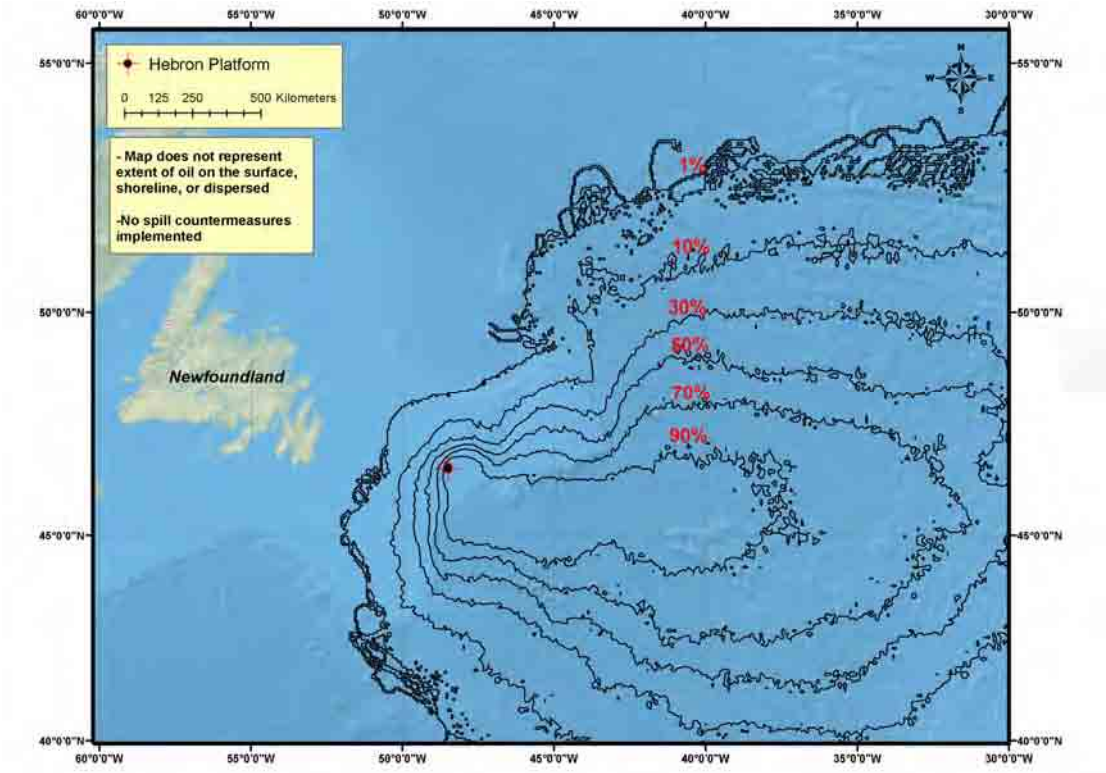


Figure 14-16 Surface Oiling Probabilities Greater than 0.01 mm from a Hebron Platform Blow-out of 5,600 m^3/day over a 30-day Period Simulated for 60 Days during Winter (ice present)

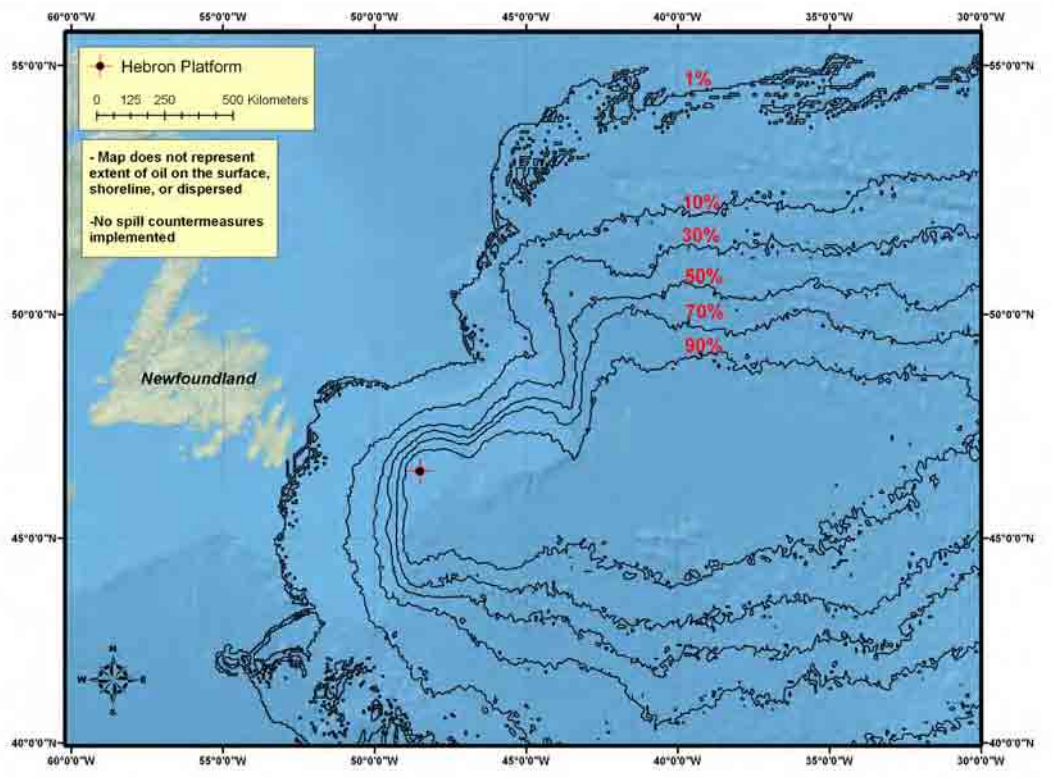


Figure 14-17 Surface Oiling Probabilities Greater than 0.01 mm from a Seafloor Blow-out over a 100-day Period during Summer

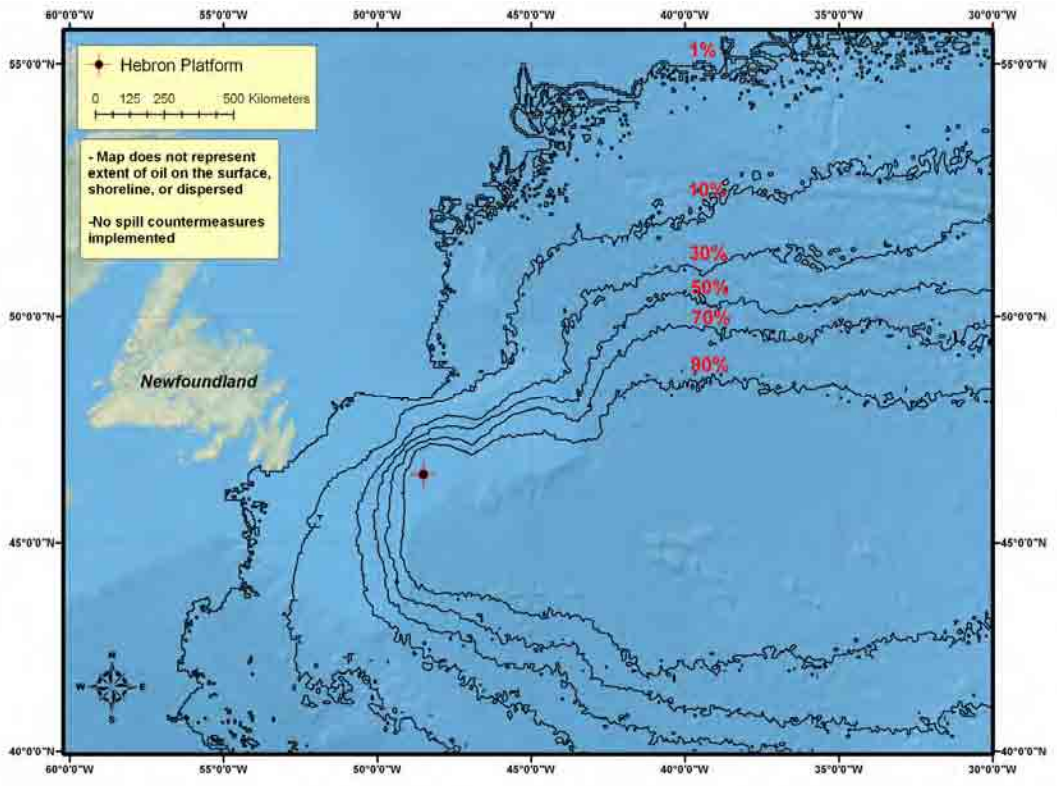


Figure 14-18 Surface Oiling Probabilities Greater than 0.01 mm from a Seafloor Blow-out over a 120-day Period during Winter

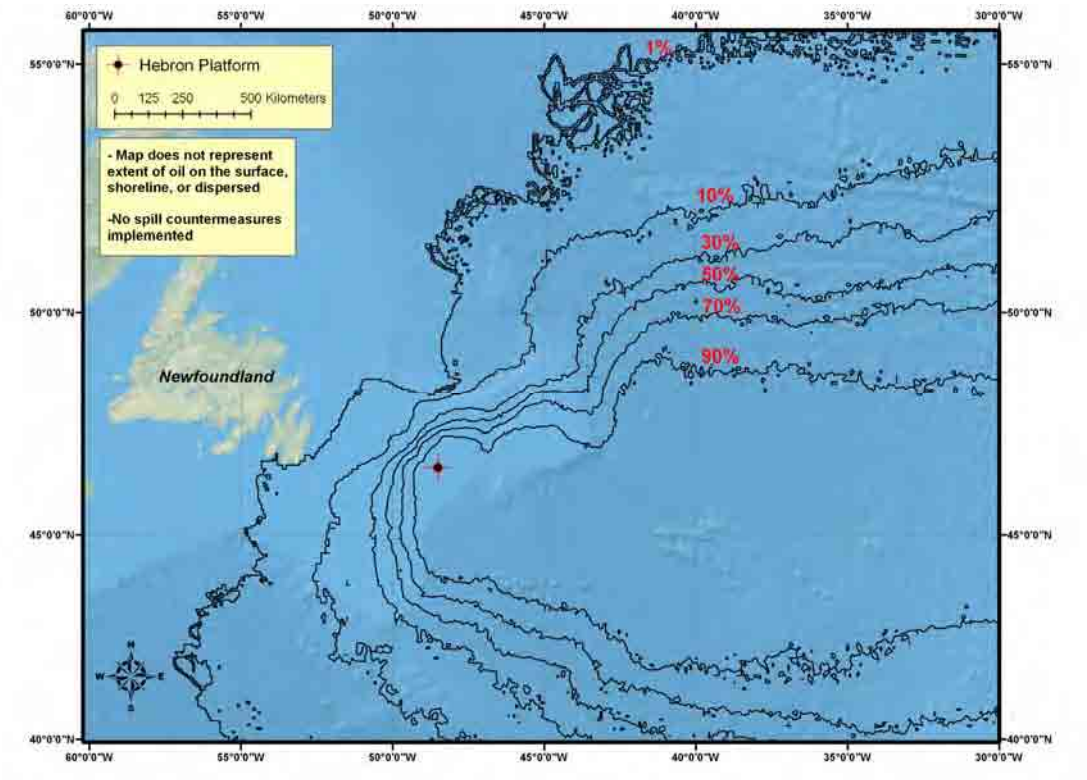


Figure 14-19 Surface Oiling Probabilities Greater than 0.01 mm from a Seafloor Blow-out over a 120-day Period during Winter (with ice present)

Not all of the stochastic model simulations predict oil will hit the Newfoundland coast. For those simulations where shoreline contact is predicted, there is a less than 5 percent probability that oil from either a platform or seafloor blow-out will reach the Newfoundland shore without the implementation of spill countermeasures. The stochastic model shoreline contact summary is provided in Table 14-20. The values listed in the table are from the individual spill from each stochastic model scenario that resulted in the maximum amount of oil on the Newfoundland shore. A zero probability of contact means that none of the 100 spills completed in the stochastic model scenario reached the Newfoundland coastline; a 1 percent probability of shoreline contact means that one of the 100 runs reached the shoreline. The predicted affected shoreline during summer and winter from a Hebron Platform and seafloor blow-out is illustrated in Figures 14-20 to 14-26.

Table 14-20 Newfoundland Stochastic Model Shoreline Contact Summary

Scenario	Probability of Oiling (%)	First Arrival of Oil (days)	Shoreline Length Oiled (km)	Shoreline Area Oiled (m^2)	Expected Mean Mass (g/m^2)
Hebron Platform Blow-out					
Surface 30 day Summer	0	-	-	-	-
Surface 30 day Winter	0	-	-	-	-
Surface 30 day Extended Run Summer	0	-	-	-	-
Surface 30 day Extended Run Winter	1	41	142.7	428,100	20
Surface 30 day Extended Run Winter w/ice	0	-	-	-	-
Surface 100 day Summer	1	23	5.3	15,900	0.2
Surface 120 day Winter	1	108	285.5	856,500	20
Surface 120 day Winter w/ice	3	21	137.8	413,500	60
Seafloor Blow-out					
Seafloor 100 day Summer	1	39	5.3	15,900	0.8
Seafloor 120 day Winter	3	21	127.2	381,600	39
Seafloor 120 day Winter w/ice	1	40	116.6	349,900	20
Batch Spills					
Marine Diesel Batch Transfer Summer	0	-	-	-	-
Marine Diesel Batch Transfer Winter	0	-	-	-	-
Diesel Mairne Batch Transfer Winter – w/ice	0	-	-	-	-
Crude Oil Batch OLS Transfer Summer	0	-	-	-	-
Crude Oil Batch OLS Transfer Winter	0	-	-	-	-
Crude Oil Batch OLS Transfer Winter – w/ice	0	-	-	-	-
Note: Values listed are from the individual spill within each stochastic scenario that resulted in the largest volume of oil stranded on the shore					

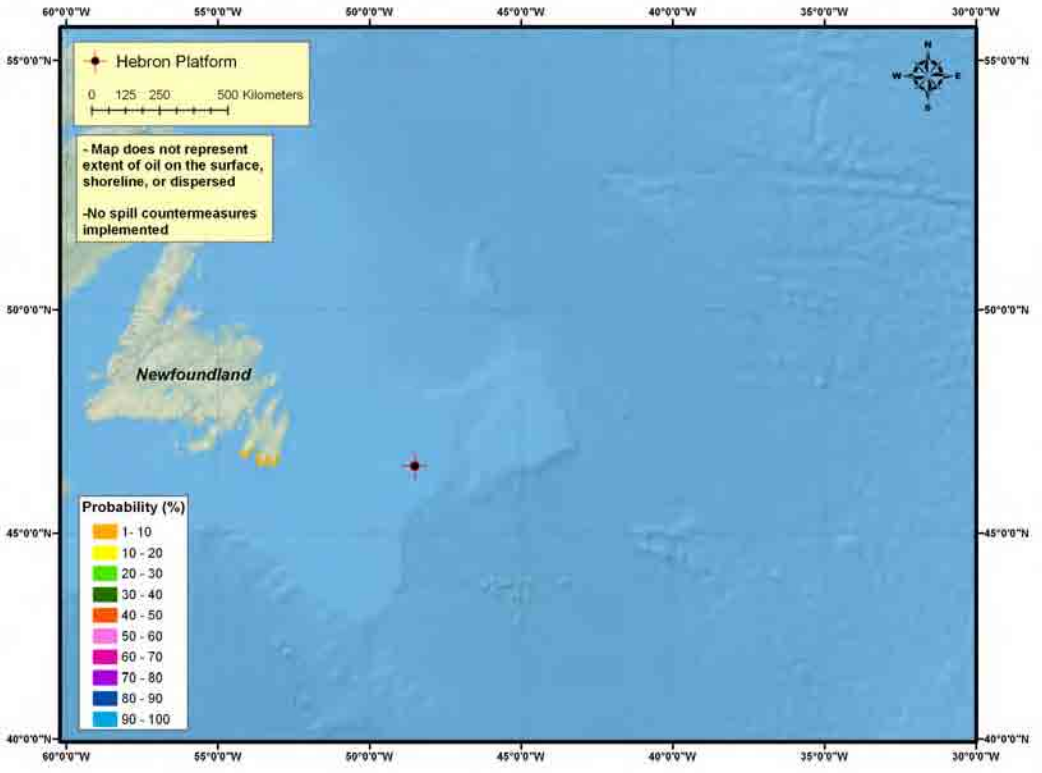


Figure 14-20 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Surface Blow-out, 30-Day Extended (60-day) Run Winter

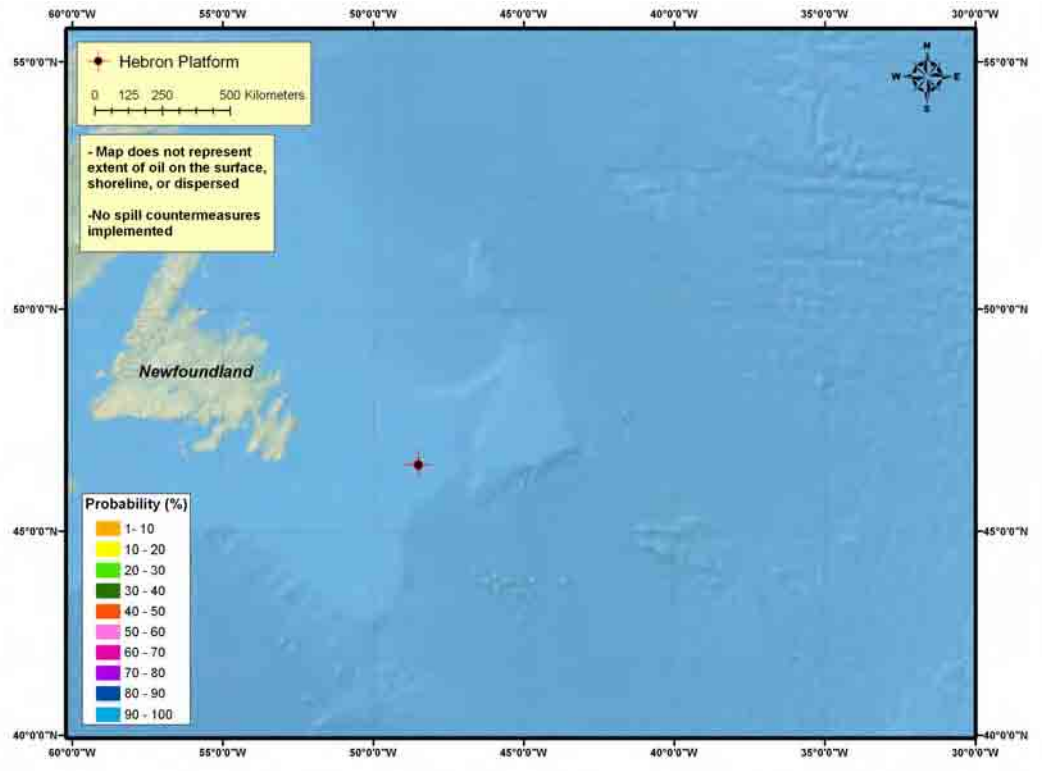


Figure 14-21 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Surface Blow-out, 100 Days Summer

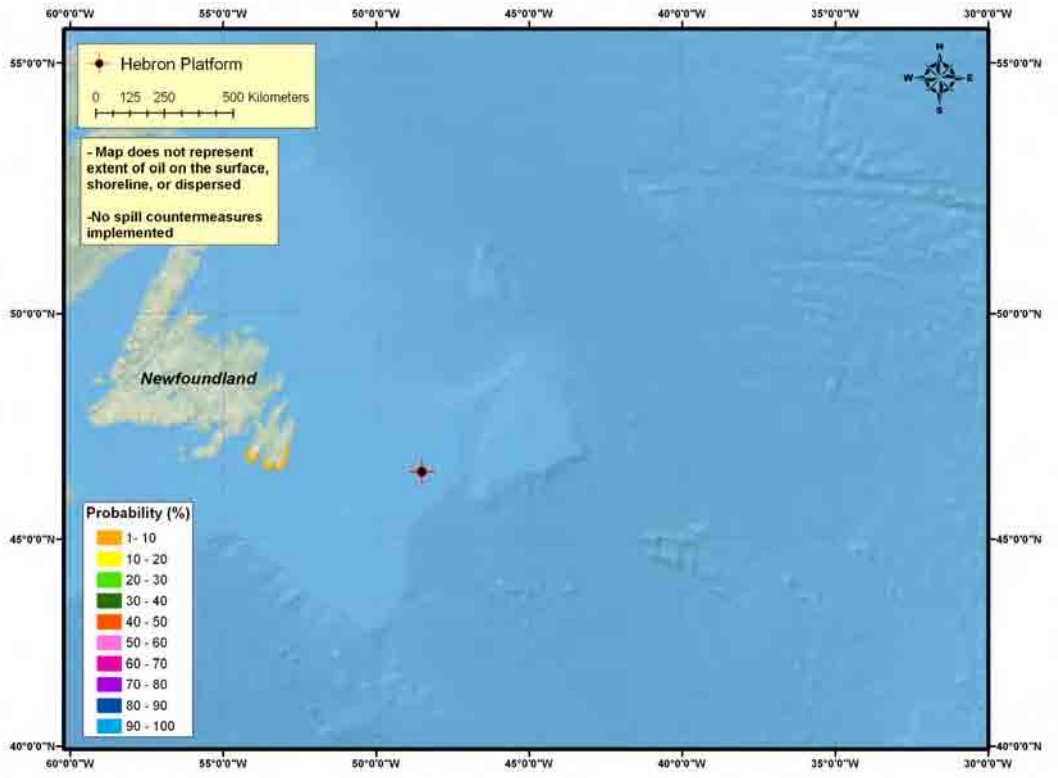


Figure 14-22 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Surface Blow-out, 120 Days Winter

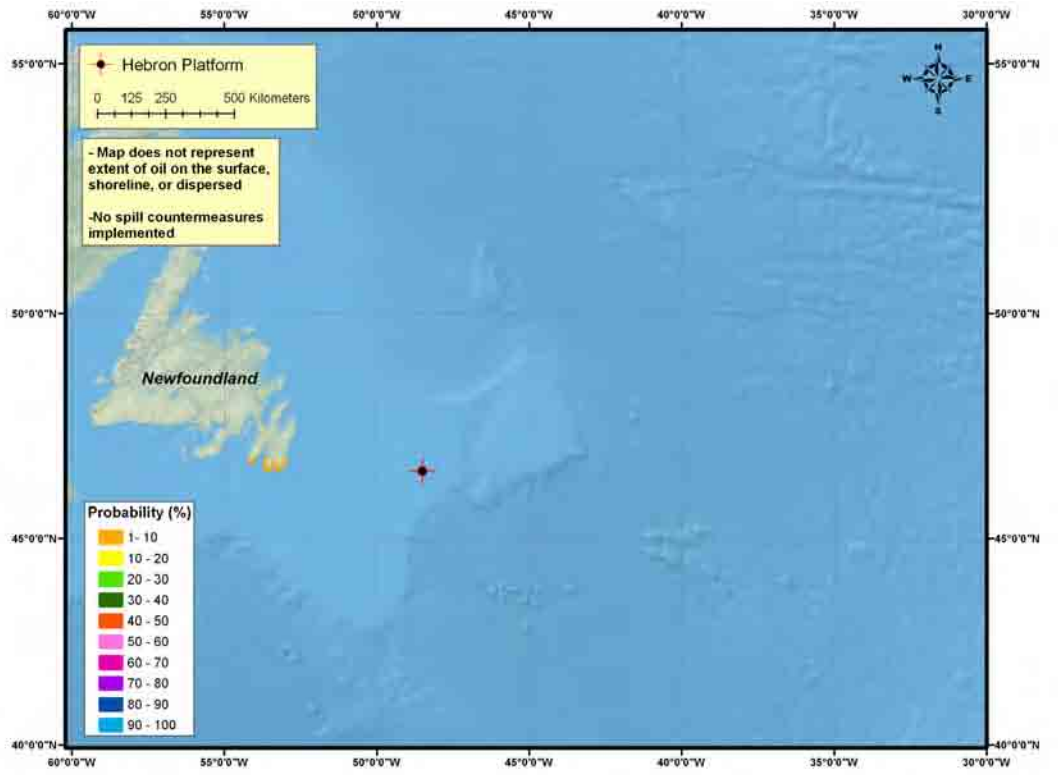


Figure 14-23 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Surface Blow-out, 120 Days Winter (with ice present)

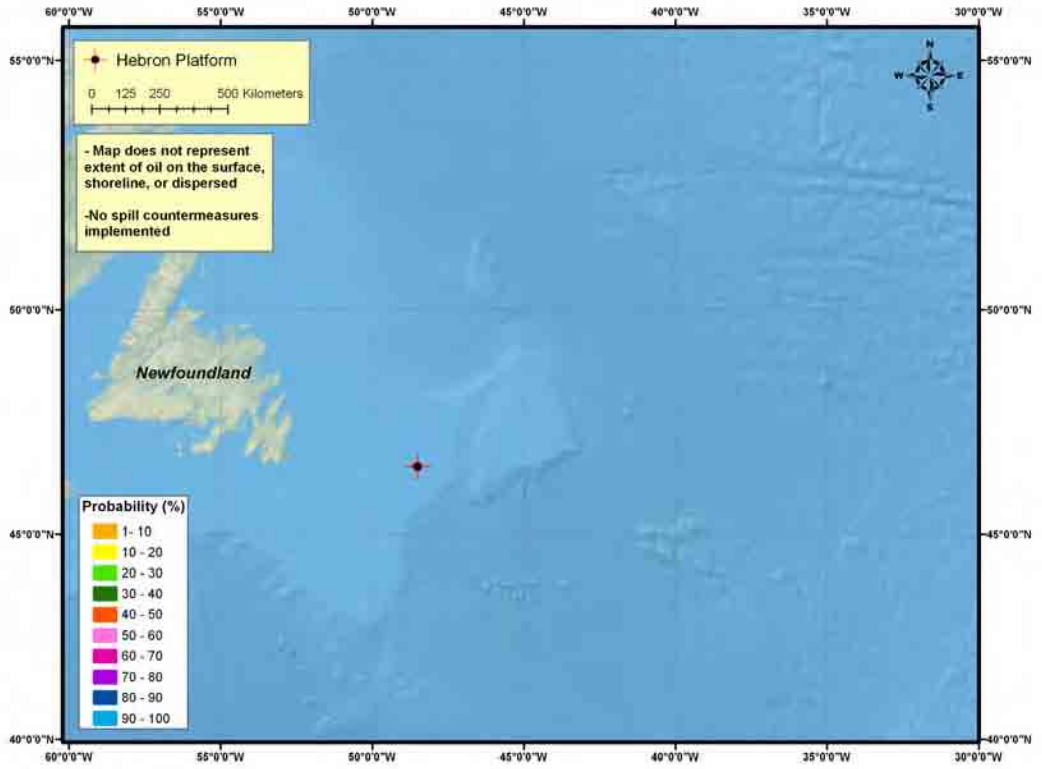


Figure 14-24 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Seafloor Blow-out, 100 Days Summer

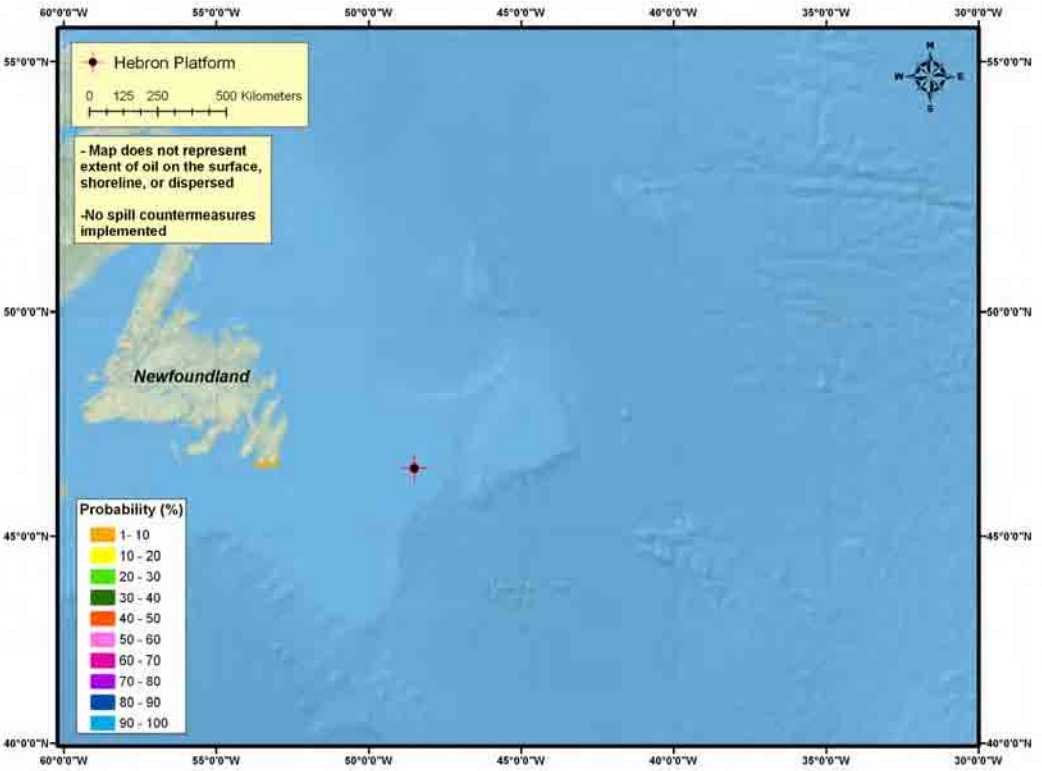


Figure 14-25 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Seafloor Blow-out, 120 Days Winter

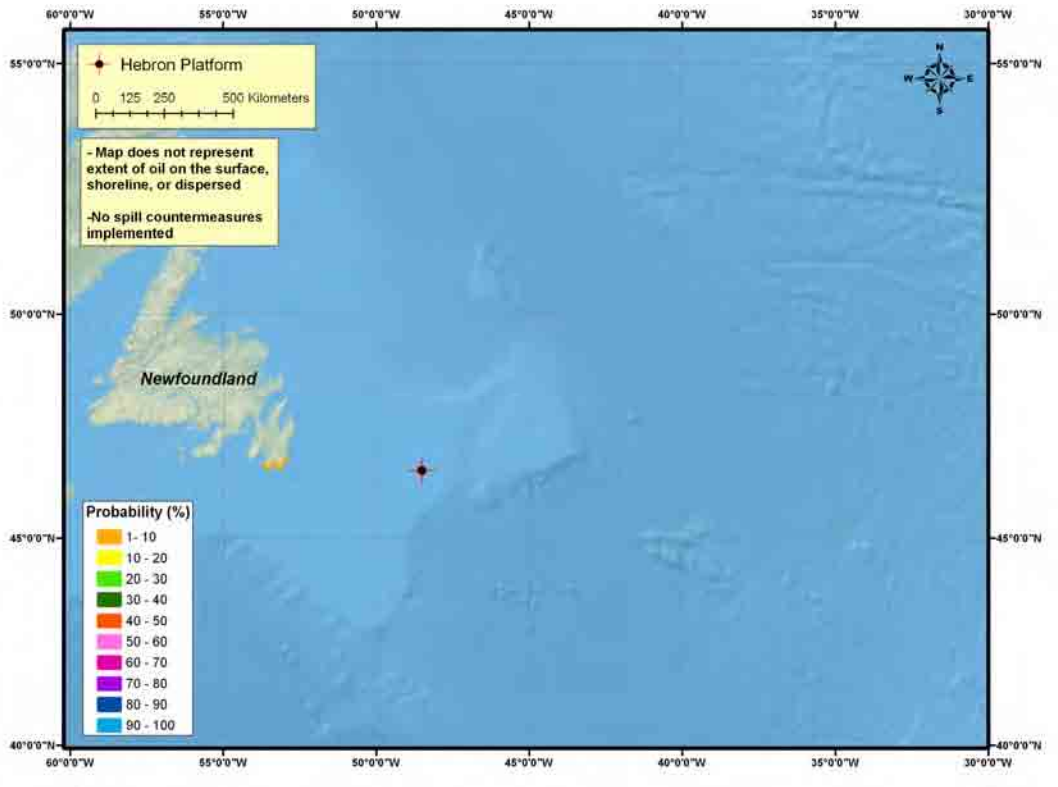


Figure 14-26 Probability of Shoreline Contact for Oil Thickness Greater than 0.01 mm; Seafloor Blow-out, 120 Days Winter (with ice present)

14.3.2.2 Deterministic Model Results

The deterministic model results depict the results from one model simulation chosen from the 100 individual simulations completed by the stochastic model. The simulations were selected because they result in the 95th percentile for sea surface oiling area, shoreline oiling length or entrained oil volume. It should be kept mind that each map displays the results from a different simulation.

The deterministic model was used to investigate individual spill events identified in the stochastic model as resulting in the 95th percentile for surface oiling. The deterministic model results show the maximum surface oil thickness for the entire spill period as areas of color corresponding to oil thickness (see Table 14-21).

Table 14-21 Summary of Offshore Deterministic Model Results

Release Type	Spill Scenario	Total Spill Volume (m^3)	Surface Oil (%)	Evap. (%)	Water Column (%)	Oil Ashore (%)	Oil Decayed (%)
Platform Blow-out (5,600 m^3/day (35,000 bpd))	Summer: 30 day	168,000	79	8.2	0.2	0	12.6
	Winter: 30 day	168,000	79	8.3	0.2	0	12.5
	Winter – ice: 30 day	168,000	79	7.8	0.2	0	13
	Summer: 30/60 day	168,000	56	11.7	0.3	0	32.0
	Winter: 30/60 day	168,000	56	11.3	0.3	0.2	32.2
	Winter – ice 30/60 day	168,000	56	11.3	0.3	0.01	32.4
	Summer: 100 day	560,000	56	10.2	0.2	0.02	33.6
	Winter: 120 day	672,000	51	11.4	0.3	0.4	36.9
	Winter – Ice: 120 day	672,000	51	11.2	0.3	0.4	37.1
Seafloor Blow-out (3,200 m^3/day (20,000 bpd))	Summer	320,000	35	28.6	9.9	0	26.5
	Winter	384,000	31	29.8	9	0.09	30.1
	Winter - ice	384,000	29	32.3	9.1	0.2	29.4
Batch Transfer (Marine Diesel)	Summer	800	0	45.2	39.6	0	15.2
	Winter	800	0	6.4	69.7	0	23.9
	Winter - ice	800	0	6.2	69.8	0	24.0
Batch OLS Transfer (Crude Oil)	Summer	5,000	64	12.9	0.5	0	22.6
	Winter	5,000	64	12.5	0.5	0	23.0
	Winter - Ice	5,000	64	12.6	0.4	0	23.0

Note: The percentages in the table are the fraction of oil volume in each location or weathering category at the end of the simulation

The volume of oil remaining on the sea surface at the end of each Hebron Platform model simulation ranges from 51 to 79 percent of the total volume released. In general, as the oil release duration increases, the fraction of oil remaining on the sea surface decreases. This relative decrease in surface oil corresponds with an increase in the rate of natural decay. Decay, which accounts for 12 to 37 percent of the total Hebron Platform blow-out spill volume, occurs as the result of photolysis, a chemical process energized by ultraviolet light from the sun, and by biological breakdown from organisms in the water. The decrease in surface oil over time may in some instances correspond to surface oil stranding on the shoreline, reducing the amount of oil on the surface. While the fraction of surface oil volume is predicted to decrease over time, the sea surface area covered by oil thicker than 0.01 mm

is predicted to increase as the duration of the blow-out increases. The increase in sea surface area exposed to oil is due to the rapid and continual spreading of the surface slick. The fraction of oil lost to evaporation does not vary greatly, ranging from 7.8 to 11.4 percent of the total volume released. The amount of oil entrained in the water column through natural dispersion processes is less than 0.5 percent for all Hebron Platform blow-out spill scenarios.

The volume of oil remaining on the sea surface at the end of each of the seafloor blow-out simulations ranges from 29 to 35 percent, considerably less than the Hebron Platform blow-outs. The seafloor blow-out introduces oil directly into the water column where oil makes up 9 to 10 percent of the spilled volume throughout the duration of the blow-out. As with the Hebron Platform blow-out, as the oil release duration increases, the fraction of oil remaining on the sea surface decreases due to an increasing rate of natural decay. Decay accounts for 26 to 30 percent of the released oil. Oil lost to evaporation in the seafloor blow-out spills is predicted to be more than twice the amount in the Hebron Platform blow-outs, ranging from approximately 29 to 32 percent. This is due primarily to differences in the physical and chemical makeup of the platform crude oil modelled compared to the seafloor crude oil modelled.

14.3.3 Batch Spills

Similar to the blow-out releases of crude oil, marine diesel and crude oil released in batch transfer spills are predicted to travel primarily toward the east away from Newfoundland. The marine diesel fuel is more easily dispersed into the water column than the crude oil and modelling predicts slightly higher entrained oil fractions for these spills. The marine diesel is capable of achieving a smaller minimum thickness than the crude oil, resulting in a relatively higher sea surface area exposed to oil. None of the batch transfer spills are predicted to reach the Island of Newfoundland shoreline (Figures 14-27 to 14-22).

None of the marine diesel oil released in the batch transfer spill remains on the sea surface at the end of the 30-day simulation. This is primarily because the diesel is more readily entrained into the water column than the crude oil and in the summer season has a higher rate of evaporation. Between 40 and 70 percent of the diesel is predicted to become entrained in the water column, while 0.4 to 0.5 percent of the crude will entrain. The model predicts between 15 and 24 percent of the diesel and 22 to 23 percent of the crude will decay.

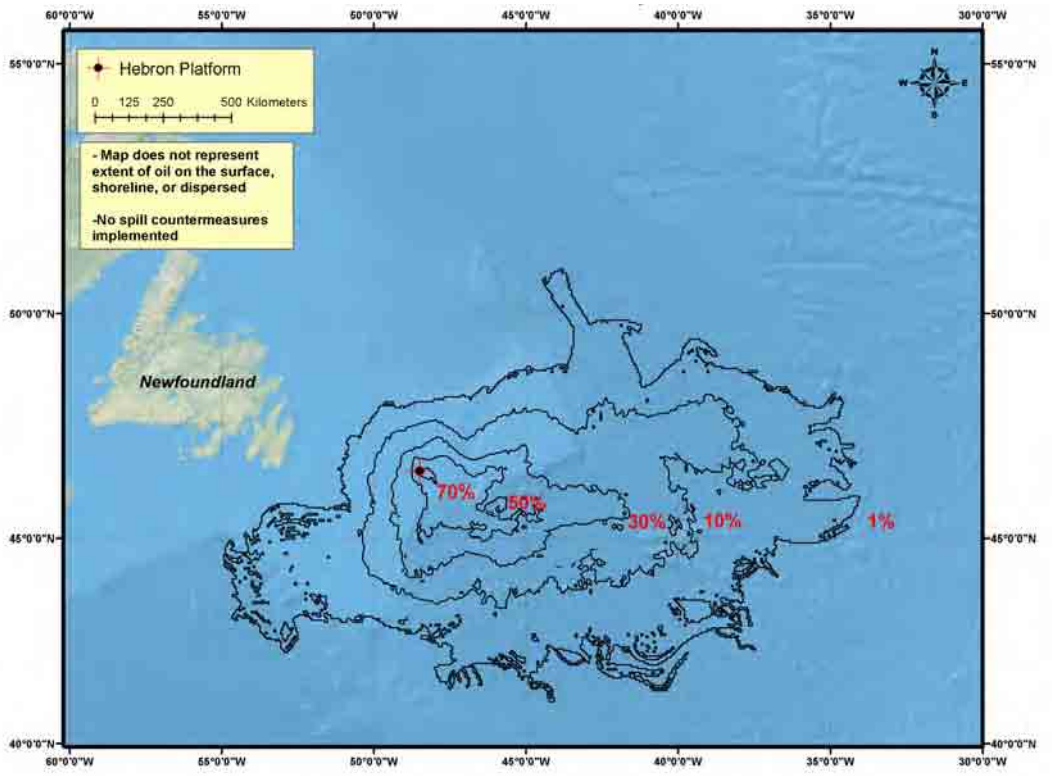


Figure 14-27 Surface Oiling Probabilities Greater than 0.01 mm for a Batch Transfer Release of 800 m^3 of Diesel during Summer

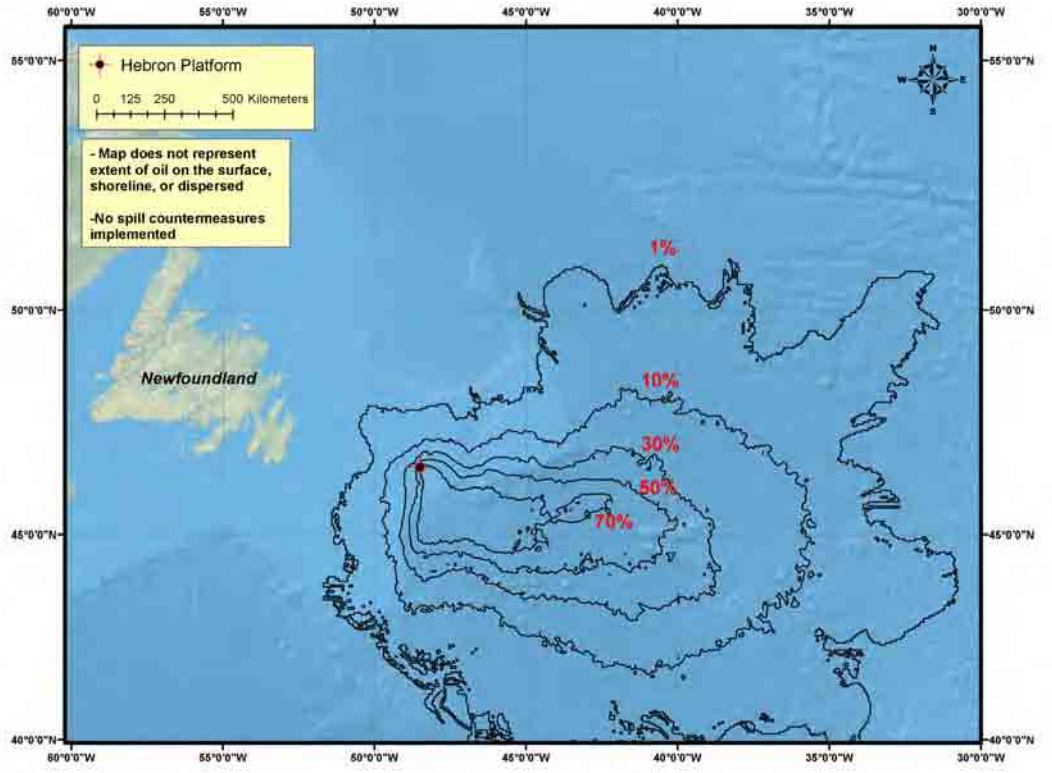


Figure 14-28 Surface Oiling Probabilities Greater than 0.01 mm for a Batch Transfer Release of 800 m^3 of Diesel during Winter

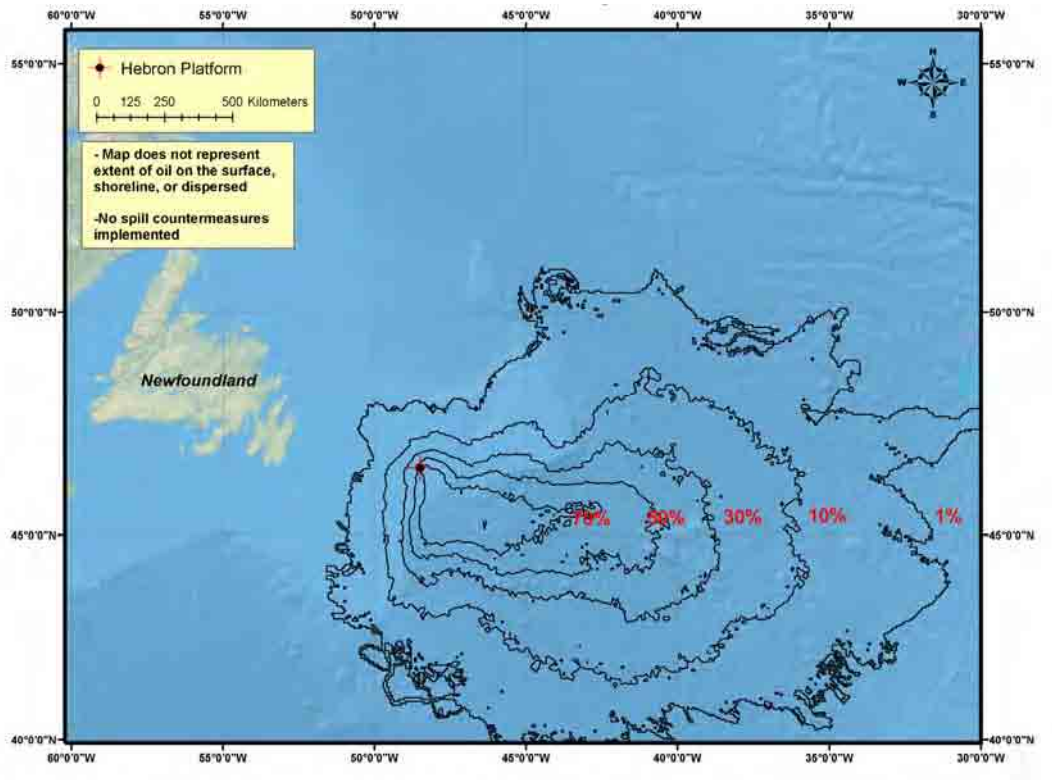


Figure 14-29 Surface Oiling Probabilities Greater than 0.01 mm for a Batch Transfer Release of 800 m^3 of Diesel during Winter (with ice present)

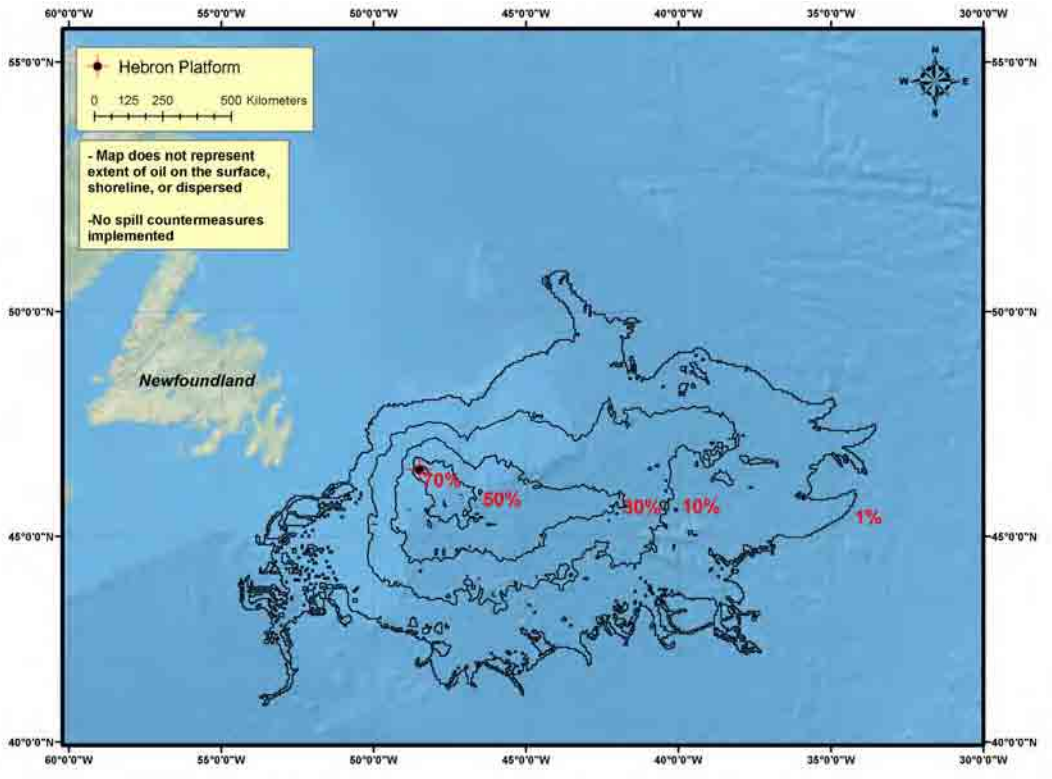


Figure 14-30 Surface Oiling Probabilities Greater than 0.01 mm for a Batch Offshore Loading System Transfer Release of 5,000 m^3 of Crude Oil during Summer

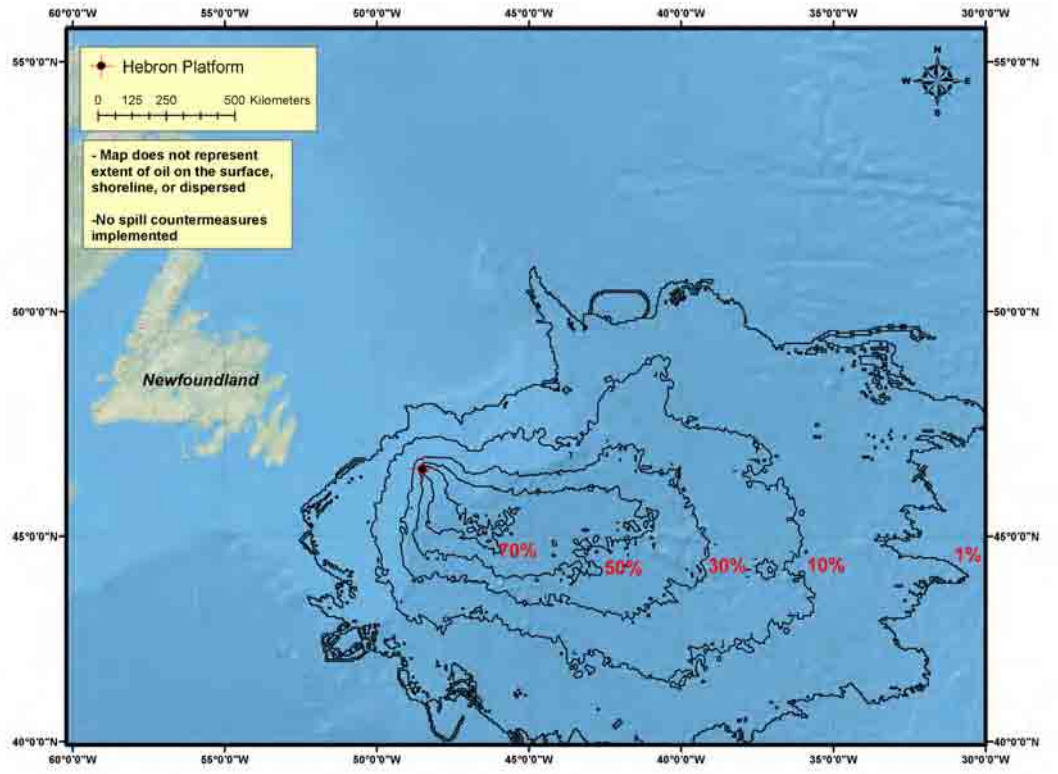


Figure 14-31 Surface Oiling Probabilities Greater than 0.01 mm for a Batch Offshore Loading System Transfer Release of 5,000 m^3 of Crude Oil during Winter

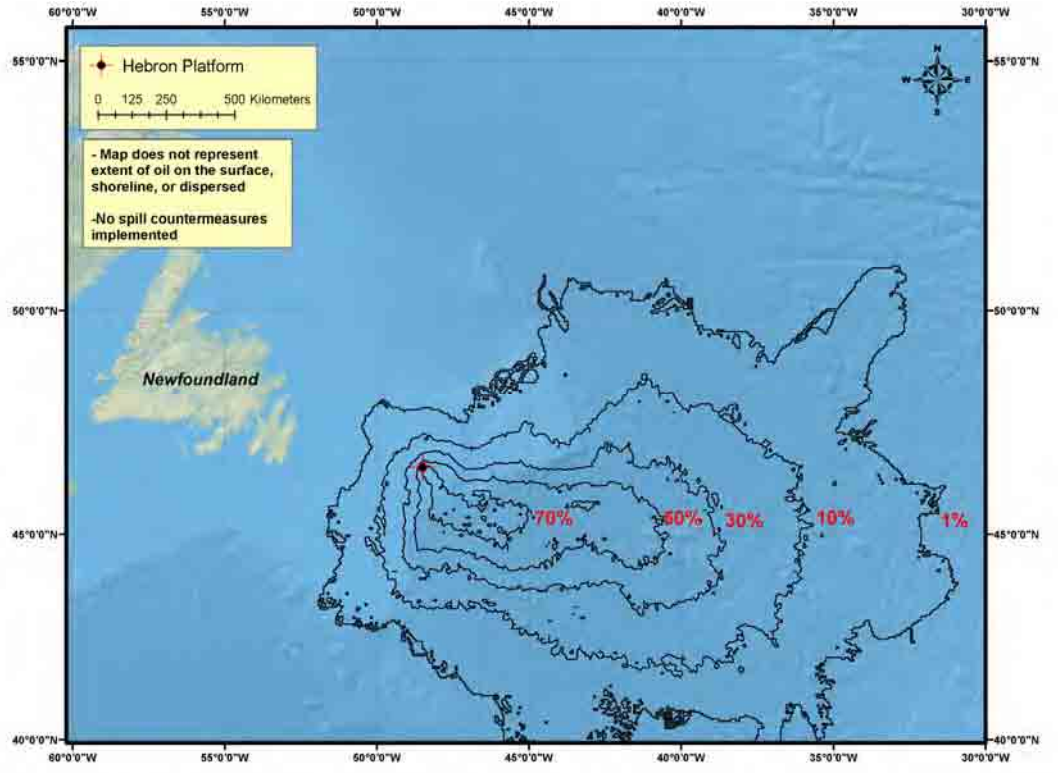


Figure 14-32 Surface Oiling Probabilities Greater than 0.01 mm for a Batch Offshore Loading System Transfer Release of 5,000 m^3 of Crude Oil during Winter (with ice present)

14.3.4 Trajectory Modelling Summary

The majority of Hebron Platform and seafloor blow-out spills at the site are predicted to travel eastward. The distance travelled is generally controlled by the blow-out duration and the season. Winter winds on average are at a higher velocity resulting in greater oil transport. A subset of the summer and winter blow-out spill simulations of greater than 30 days duration are predicted to reach segments of the Newfoundland shoreline. Similar to the blow-out releases of crude oil, marine diesel and crude oil released in batch transfer spills is predicted to travel primarily toward the east away from Newfoundland. None of the batch transfer spills are predicted to reach the Newfoundland shoreline. A summary of the trajectory modelling is provided in Table 14-22.

Table 14-22 Summary of the Stochastic Simulations of the Platform and Seafloor Blow-outs at the Hebron Well Site (values for each parameter represent the 95th percentile)

Release	Season	Sea Surface Area Oiled at >0.01 mm (km^2)	Entrained Oil Volume after 30 days (m^3)
Platform Blow-out	Summer 30/60 Day	1,383,242	501
	Winter 30/60 Day	1,901,033	573
	Winter 30/60 Day Ice	1,791,808	550
	Summer 100-Day	2,306,565	159,925
	Winter 120-Day	4,225,306	263,493
	Winter 120-Day Ice	4,841,586	263,493
Seafloor Blow-out	Summer 100-Day	2,416,717	3,706,057
	Winter 120-Day	4,415,367	4,309,446
	Winter 120-Day Ice	4,615,041	4,182,299

Note: 95^{th} percentile values are determined by ranking all 100 spills in each scenario according to the area of sea surface exposed to oil, the length of shoreline exposed to oil and the volume of entrained (naturally dispersed) oil above the stated thresholds.

Trajectory model results (ASA 2011b) demonstrate that for all blow-out scenarios very little oil becomes entrained in the water column (0.2 to 0.3 percent) or is deposited on shorelines (0 to 0.4 percent) even with a constant input of oil for extended periods of time (up to 120 days). During this period approximately 10 to 11 percent of the oil from a Platform blow-out is evaporated versus approximately 30 percent of the oil from a seafloor blow-out. Similarly approximately 32 to 37 percent of the oil from the Platform blow-out decayed versus approximately 26.5 to 30 percent for the seafloor blow-out. These differences are primarily due to the differences in the properties of the crude oils rather than other environmental factors.

Approximately 51 to 56 percent of the oil from the Platform blow-out is found on the surface of the water after 100 days of flow compared to approximately 29 to 35 percent for a seafloor blow-out. In both cases, much of this surface oil has already left the model domain after 100 days and is no longer present to further affect the VECs in the Grand Banks region. Trajectory model

results suggest that it takes about 30 days for the surface oil to approach the boundaries of the model domain and that by 60 days, it has extended beyond the model domain. This is in excellent agreement with tracker buoy data collected during the 2004 Terra Nova spill, which indicated that it took five weeks for the buoy to reach 40.00.0ºW and approximately 48.00.00ºN in November / December.

The offshore oil spill model (ASA 2011b) predicted, that without the implementation of spill countermeasures, there is <10 percent probability of oil small amounts of weathered oil reaching Newfoundland shores from a Platform spill if the oil remains on the surface for an extended period of time. The summer and winter with ice simulations indicated that no shoreline would be oiled, and approximately 143 km (428,100 m^2) of shoreline would be oiled in the winter without ice, with oil first reaching the shoreline in approximately 41 days.

In situations where a MODU would need to be internationally sourced to drill a relief well (up to approximately 165 days to stop flow in winter months), a larger volume of oil would be potentially released into the water, if no other mitigations were implemented. The potential environmental impacts to Newfoundland waters and shores, including the Grand Banks, would be similar to the cases described above. Surface oil would take approximately 30 to 60 days to approach 40.00.0^{o}W, with <10 percent probability that small amounts of weathered oil will reach Newfoundland shorelines.

14.4 Contingency Planning

ExxonMobil Canada Properties (EMCP) recognizes that prevention is the most effective way to avoid environmental effects from hydrocarbon spill events. Prior to the start of the Project, EMCP will implement the necessary policies, procedures, equipment and training programs necessary to reduce the probability of hydrocarbon spill incidents and to minimize the environmental effects of spills should they happen.

14.4.1 Scope of Planning

Prior to commencement of drilling and production operations, EMCP will develop contingency plans that will serve as the guidelines for the company's response to an emergency at the Hebron Project. Contingency plans will be developed to address emergencies that will be identified in operations-specific hazard and risk analyses. The plans will outline the necessary procedures, personnel, equipment and logistics support required to respond to an emergency incident in a safe, prompt, coordinated manner. The plans will be distributed to designated personnel who will be responsible for emergency response actions. The content of the plans will contain sufficient detail to enable personnel to respond in a coordinated and effective manner.

In this section, a general overview of the EMCP's emergency preparedness structure will be described. This chapter will briefly describe the generic EMCP emergency response process, and then focus on hydrocarbon spill

response preparedness for both the construction and the operational phases of the Project.

14.4.1.1 ExxonMobil Canada Properties Emergency Response Philosophy

EMCP, as operator of the Hebron Project, maintains a strong commitment to health, safety and environmental stewardship. The company conducts its business activities with a progressive approach and is committed to monitoring and improving its performance. Central to this commitment is a corporate Safety, Security, Health and Environment (SSH&E) management system, which governs all aspects of loss control management. EMCP's emergency response philosophy is to minimize the impact of an emergency on people, environment and the corporation. EMCP will always be prepared to act as follows:

- If responsible, react rapidly and effectively
- If the responsibility is unclear, be prepared to act and offer assistance to authorities
- If not responsible, offer technical or advisory assistance with appropriate legal safeguards
- Respond rapidly to life-threatening situations

ExxonMobil's Canada Properties Emergency Response Model is:

- Safeguard People (safety and health of the public, contractors and employees)
- Protect the Environment
- Protect Company Assets
- Protect Company Reputation

These are commonly called the "PEAR" objectives.

14.4.1.2 ExxonMobil Canada Properties Corporate Contingency Planning

As part of the corporate SSH&E management system, EMCP has developed a company-wide approach to contingency planning. All EMCP facilities are equipped with emergency response plans and procedures that share common format and content. Each plan reflects local conditions and addresses the risks to the specific facility, but is similar enough to plans for other facilities that it may be quickly supported by any trained EMCP personnel.

EMCP will use the same philosophy and approach that has been established throughout the company when developing contingency plans for the Project. In addition to environmental protection plans (EPPs) to be developed for all phases of Hebron production operations, EMCP will require a suite of operational risk management and emergency response plans for use in production operations. Facility-specific alert and emergency response procedures and vessel-specific contingency plans will be developed to cover the details of local response procedures.

14.4.1.3 Emergencies Covered by ExxonMobil Canada Properties Contingency Planning

An emergency will be defined as any unexpected occurrence resulting in or having the potential to result in:

- Death or serious injury / illness requiring hospitalization
- Environmental impact
- Major or significant damage to Operator or contractor property
- Concern for the integrity of EMCP operations in the eyes of the public or regulatory agencies

Several types of emergencies will be covered by EMCP contingency plans. The response to any the following incidents (which are not all inclusive) will require immediate action:

- Accidental injury
- Explosion or fire
- Loss of well control
- Hydrocarbon or chemical spills
- Unintentional discharge of any material at levels above those in permits
- Loss of or damage to aircraft supporting production operations
- Loss of or damage to support or standby vessels
- Loss or disablement of the Gravity Base Structure (GBS), Hebron Platform or mobile offshore drilling unit (MODU)
- Equipment damage due to equipment failure or operator error
- Imminent threat to operations posed by weather, sea ice, or icebergs
- Collision or threat of collision with an ocean-going vessel
- Gas leak
- Radioactive source
- Person overboard
- Hydrogen sulphide leak
- Loss of power
- Diving operations
- Threatened or actual damage to subsea pipelines or hardware
- Security incidents such as extortion, bomb threat, or criminal / terrorist acts

14.4.1.4 Proposed Contingency Plan Development

Contingency planning for the Project will be addressed in a number of inter-related documents that each cover a specific aspect of production operations. Overviews of the individual documents that, collectively, will dictate all emergency response operations are presented in Tables 14-23 and 14-24. At this stage of the Project, the plan names used in the tables are generic. The final structure and naming of each plan will be finalized during the development of the Project production program.

Table 14-23 Overview of ExxonMobil Canada Properties Offshore Contingency Plans

Plan	Description
Offshore Emergency Response Plan	**A plan which describes on-site response actions at the Hebron Platform:** • Provides very specific role descriptions for Hebron Platform personnel for a number of potential emergencies • Provides a link between all offshore facilities and onshore responders
Collision Avoidance Plan	**A specific plan for identifying and avoiding a potential collision with a vessel approaching a rig or platform** • Identifies potential collision situations involving the Platform or MODU • Describes communications with the threatening vessel • Lists actions to be taken on the Hebron Platform or MODU in the event that the threatening vessel does not respond • Developed specifically for offshore use and directly related to the Offshore Emergency Response Plan
Ice Management Plan	**A plan which defines how EMCP operations personnel will manage the threat of icebergs and pack ice approaching the Hebron Field:** • The plan provides a link between all ice management operations offshore and onshore • The plan describes the procedures for • Monitoring the movement of icebergs that might pose a threat to offshore activities • Determining the need for specific countermeasure operations including iceberg deflection
MedEvac Plan	**A plan which describes how ill or injured workers will be transported to shore for medical care:** • Assigns authority • Defines decision making processes • Describes logistics arrangements • Suggests onshore emergency team involvement
Spill response Plan Procedures	**Procedures developed specifically for the first response to hydrocarbon spills originating at the Hebron Platform:** • Directly related to the Offshore Emergency Response Plan and the Hebron Spill Response Plan; • Applies for both Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) and *Canada Shipping Act* (CSA) jurisdictions • Includes • Specific actions to be taken by Hebron Platform and support vessel personnel, and • Specific strategies for the response to anticipated hydrocarbon spill scenario situations
Standard Operating Procedures	**Pre-established procedures for specific technical activities undertaken by offshore emergency action teams:** • Fire • First aid • Helideck • Coxswains

Table 14-24 Overview of ExxonMobil Canada Properties Onshore Contingency Plans

Plan	Description
Onshore Emergency Response Plan	**A plan that describes actions taken onshore during an offshore emergency:** • Provides general activation and support procedures for any emergency • Directs actions of shore-based personnel • Provides the link between offshore actions (coordinated by the Hebron Platform or MODU Offshore Installation Manager (OIM)) and corporate emergency teams • Integrates response actions after the emergency phase has passed • Allows for increasing onshore and corporate responsibility as the incident escalates
Oil Spill Response Plan	**Procedures developed specifically for the response to hydrocarbon spills originating from the Hebron Platform:** • Covers situations where EMCP is the responsible party or may be required to take a responsible action • Applies for both C-NLOPB and CSA jurisdictions • Includes • Specific actions to be taken by Hebron Platform and support vessel personnel • Management or coordination actions taken by shore-based company and contractor personnel • Specific strategies for the response to anticipated hydrocarbon spill scenario situations • The plan provides a link between all spill response operations offshore and onshore • Details procedures for Incident Command System (ICS)-based spill response management when the incident escalates above Tier 1 • The plan provides a link between EMCP and other operators • Directly related to the Tier 1 Spill response Procedures, and the Onshore Emergency Response Plan
Family Support Plan	**A plan to assist family members and friends of offshore personnel during an emergency situation:** • Description of the operation of a family information service and a family support centre • Protocols for contacting family members in a constructive and proactive manner • Guidelines for volunteer family responders in how to deal with concerned relatives and friends
Emergency Communications Plan	**A comprehensive guide to all communications with affected individuals, the public and the media during an emergency response** • Description of the operation of a media response centre • News release and statement templates • Sample media questions and answers • Media information packages • Website development

14.4.1.5 Geographic Area Covered by Planning

Emergency response planning for Hebron production operations will focus on the area immediately adjacent to the production site or future excavated drill centres. The initial Safety Zone around the Hebron Platform will include an area of 500 m from the perimeter of the Platform and the OLS. This area will be defined as the Safety Zone established around the production site to ensure collision avoidance with ocean-going vessels. This is the area that will be under the jurisdiction of the *Atlantic Accord Acts* and administered by the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB).

14.4.2 Emergency Response Escalation

14.4.2.1 Phases of an Emergency Response

The response to an event will develop in phases that are based on the level of planning that is required. During the emergency phase, the situation will be dynamic and limited information will be available. The response to the actual emergency will likely be reactive and will be based on set procedures, training and contingency plans. As the situation is better understood, the response will become more proactive. The process will become strategic and be based on a regular cycle of assessment, planning and implementation, until operations are no longer necessary.

14.4.2.2 Escalation Based on Increasing Scope

Response organization will be comprised of the following components:

- At-site emergency teams
- At-site Emergency Coordination Centre
- EMCP onshore Emergency Operations Centre and
- EMCP Emergency Support Group

The role of each of these components is described in terms of scope below.

14.4.2.3 Management System Processes

Notification

Once an emergency has been declared, timely notification of response personnel, management and external agencies will be critical. In some cases, notification may include a written report. Contingency plans will include instructions for all personnel who have a notification responsibility.

On-Scene Command

All emergencies covered by this plan will take place at the Bull Arm Construction Site, offshore, or at or near the Hebron field. In most cases, regardless of the level of the emergency, the Offshore Installation Manager (OIM) on the Hebron Platform or a rig will act as On-Scene Commander (OSC) and be in command of response operations. Exceptions would be:

- Loss of the facility (OSC would shift to another platform or standby vessel)
- Search and Rescue Operations, in which case Joint Rescue Coordination Centre (at Department of National Defence - Halifax) or the Marine Rescue Sub Centre (Canadian Coast Guard (CCG) - St. John's) will take command
- Major hydrocarbon spill, in which case incident command will be based in St. John's after the initial response at site and on-scene command will transfer to a designated EMCP Representative on the lead response vessel

14.4.3 Spill Response Escalation

While many of the response management processes will be similar to those implemented in a conventional spill response, it is possible to also classify a spill response according to the level of effort required. For response planning purposes, the severity of potential hydrocarbon spills has been divided into three levels, or Tiers. This classification allows for an appropriate initial response to each level of spill, and provides for the escalation of the response should the potential impact of the spill increase. Each Tier will require a successively higher level of operational effort and management.

The parameters to be considered in selecting the appropriate level of response include:

- Size and nature of the spill
- Environmental and operational conditions at the time of the spill
- Vessel and equipment availability
- Numbers and qualifications of personnel available at site
- On-site waste hydrocarbon storage
- Corporate exposure to risk and liability as a result of the hydrocarbon spill

The three levels are defined as follows:

- A **Tier 1** spill poses the least threat of impact, and can be managed using resources available at site
- A **Tier 2** spill response requires local shore-based management support and resources in addition to those already at site
- A **Tier 3** hydrocarbon spill has the potential to affect EMCP and shareholder company business operations and may require considerable corporate and contract resources drawn from local, regional, and international sources

14.4.4 Response Organization for a Major Spill

14.4.4.1 Incident Command System

In the event of a major spill (see Section 14.1.1), the operational component of the response will be managed by using a structure based on the Incident Command System (ICS) organizational structure for emergency response management. The ICS structure has been widely adopted by emergency response agencies throughout North America as a means of sustaining a long-term response effort by adopting a function-based approach that allows personnel to rotate through positions over an extended period. Hibernia Management and Development Company Limited, Terra Nova, Husky Energy and major hydrocarbon spill response contractors have all also developed ICS-based hydrocarbon spill response procedures.

The specific tasks that individuals will be assigned in an ICS environment will be determined over time as a result of the evolution of the incident and consultation between functional groups.

Key features of this system include:

- Operational management, which is divided into five functional groups (Command, Planning, Operations, Logistics and Finance). While each group has its own responsibilities, considerable interaction between groups is necessary to ensure efficiency in the response operation
- Integrated field operations, tactical planning and logistics support through continuous situation analysis
- Information exchange through continuous interaction of supervisory personnel, scheduled review meetings, routine written reports and daily proposed action plans
- A continuing cycle of planning, prioritization and implementation, regardless of the phase of the response
- Plans developed for a defined period and focused on meeting defined objectives in consideration of environmental resources at risk, operating conditions, available resources and performance during previous operating periods
- A planning cycle that provides the basis for both tactical and strategic budgeting. When plans are authorized by EMCP, Operations receives both financial and operational authority to proceed with the next stage of the response

The roles of the five ICS functional groups are described briefly in Table 14-25.

Table 14-25 Incident Command System Section Functions

ICS Section	Focus	Duties
Command	What are the prioritized objectives	Overall vision, clarity of purpose, health and safety of all personnel
Planning	What has happened What is happening now What are the plans for the future?	Information management and action plans
Operations	What is being done to meet the planned objectives	Organize and manage all operations including: containing and recovering spilled hydrocarbon; protecting sensitive resource areas; cleaning affected areas; and disposal of waste
Logistics	What resources are needed to support operations	Provide personnel, vessels, aircraft, trucking, equipment, security and communications
Finance	Financial control	Accounts payable, insurance claims, cash flow and cost monitoring

14.4.4.2 Spill Response Contractors

In general, EMCP emergency response management personnel will be drawn from in-house resources. However, in the event of a hydrocarbon spill, the incident may require considerable resources over an extended period. In such a case, EMCP will engage the services of a response organization.

14.4.4.3 North American Regional Response Team

EMCP can also be supported by the ExxonMobil North American Regional Response Team (NARRT). NARRT is a pool of experienced responders from various business units within the ExxonMobil corporation. During a major spill, this team may be activated and mobilized in St. John's. NARRT provides oil spill experts to support the EMCP response under way at the Hebron field.

14.4.5 External Assistance

14.4.5.1 Mutual Aid with Other Operators

As with existing offshore oil and gas operations, EMCP will establish a mutual aid agreement with other Grand Banks operators. This agreement provides for the release of personnel, vessels and equipment for logistics support and exchange of operational information. Under this agreement, operators are required to provide support, if requested by a second mutual aid operator. The level of this support is limited to that effort that can be provided without jeopardizing the safe operation of the supporting operator's facilities. Mutual aid will be most evident in logistics support, ice management, and spill response efforts.

In order that mutual aid may be effective, the mechanism for interaction between operators will be clearly stated in all EMCP contingency plans.

Logistics

Other offshore platforms may be used to provide nearby staging or refuelling platforms in support of an EMCP emergency. These platforms may also provide temporary accommodation for evacuated Hebron Platform personnel.

Ice Management

The Project will require an ice management program similar to those in operation for the existing Grand Banks operators.

Relief Well Considerations

In the event of a well site loss control emergency, it may be necessary to drill a relief well. Throughout the lifetime of the Hebron production program, EMCP will maintain a listing of drilling vessels that could be brought to Hebron at short notice to drill the relief well.

ExxonMobil operates and maintains a world-wide drilling operation that encompasses a fleet of drilling units and drilling equipment inventory. Knowledge and awareness of ongoing operations is maintained company-wide. In the event a relief well is required and the required materials are not available in local stock, ExxonMobil will access this world-wide inventory to procure necessary materials to execute the required operations and/or will obtain the materials directly from vendors through our Global Procurement

organization. The time to source these materials has been considered in the oil spill scenarios described in Section 14.3.1.

14.4.5.2 Spill Response

Response Organization

The Project will be supported by a response organization contracted to provide response services as required in the event of an offshore spill event.

Canadian Coast Guard

The CCG has a Memorandum of Understanding (MOU) with the C-NLOPB. If that MOU is activated, the CCG will provide response advice to the C-NLOPB, as well as field monitoring of the response mounted by the responsible party on behalf of C-NLOPB.

Oil Spill Response

ExxonMobil is a shareholding member of Oil Spill Response (OSR). This is a large spill response cooperative that specializes in providing global spill response services from their bases in Southampton, England and Singapore. In addition to the services that OSR can provide directly, ExxonMobil also has access to other international oil spill cooperatives such as Clean Caribbean Cooperative in Miami, and Marine Spill Response Corporation throughout the United States, through OSR's participation in the Global Alliance.

14.4.5.3 Regional Environmental Emergency Team

The Regional Environmental Emergency Team (REET) is a group of environmental specialists chaired by Environment Canada that can provide knowledgeable advice to support response operations. In the event of a spill, REET may be activated either by C-NLOPB or Environment Canada.

Most REET members are government (federal and provincial) representatives and are from the local area. Private sector personnel may also be included in REET. Environment Canada may choose to draw on regional or national expertise as required to provide the best possible advice. Some REET members also have regulatory responsibilities and may be the best contact if permits are needed for operational activities.

14.4.6 Emergency Preparedness

14.4.6.1 Personnel Training

Designated EMCP personnel, including contractors, will receive directed emergency training.

All personnel will undergo an orientation to elements of emergency response planning. Offshore personnel will receive a general overview of evacuation alarms and procedures and response organization. Offshore emergency teams will receive specialized training with emphasis on hands on experience.

14.4.6.2 Response Exercises

A regular program of exercises will be instituted to ensure the readiness of all personnel. The purposes of the program exercise include:

- Continuing familiarization of all personnel with emergency procedures
- Testing of the preparedness of all personnel
- A means of developing continued improvement to emergency procedures

Exercises will be conducted in three areas:

- Communications
  - Personnel call out
  - Inter-facility communications testing
  - Media and public information training
- Table Top
  - Methodical response to an emergency scenario using established processes
  - Interaction between ERT, operational, regulatory and external personnel
- Logistics
  - Hands on training and experience for marine and technical personnel
  - Field response operations for marine crews and emergency personnel
  - Confirmation of the effectiveness of established field procedures

14.5 Spill Response at Bull Arm

The GBS will be built by a general contractor at the fabrication facility at Bull Arm.

14.5.1 Responsibility

14.5.1.1 ExxonMobil Canada Properties Responsibility

During construction, responsibility for all GBS operations will rest with primary EPC contractor for the Bull Arm facility. EMCP will require EPC contractor to meet the expectations of ExxonMobil spill response.

14.5.1.2 Contractor Responsibility

The EPC Contractor, as operator at the construction site, will be responsible for spill response under federal legislation governing marine spills and under provincial legislation for land spills, or for spills originating from shore. In the capacity of Responsible Party, EMCP's general contractor will be requested to undertake the following preventative measures:

- Identify, assess and understand the spill level of risk for land and marine spills at the Bull Arm Site
- Determine prevention barriers and measures
- Develop spill response countermeasures appropriate for the risks
- Develop a response capability for small marine and land spills
- Acquire the necessary equipment, machinery, response vessels and materials
- Provide equipment storage facilities at the Bull Arm Site
- Form on-site spill response teams for marine and land spills
- Provide adequate training for all site spill responders
- Ensure all vessels work at or visiting the site have arrangements with a Response Organization as required under the *Canada Shipping Act*
- Ensure all trucks carrying petroleum products to or from the Bull Arm Site are covered by the Canadian Petroleum Products Institute Land Spill Emergency Preparedness program
- Enter an agreement with a response organization for response to marine spills from construction

EMCP will assist its general contractor with spill response preparedness planning to ensure that:

- Spill risks are identified, understood and planned for
- Appropriate marine and land spill response capabilities are developed
- Appropriate back up resources and services are in place should they be needed

In the event of a spill, the Contractor must be prepared to undertake the following response actions:

- Report the spill to the CCG
- Respond to the spill with on-site responders
- Manage the spill response through the site emergency response structure
- Activate the appropriate spill response contractors, as required
- Monitor and document each spill response

14.5.2 Spill Prevention

Each contractor working on the Bull Arm Site will be responsible for spill prevention and proper storage and handling of the fuels and lubricants used on site, and for the collection, temporary storage, transport and disposal of all waste hydrocarbons generated. Prevention will be addressed through risk identification and assessment, good design, appropriate preparedness and training, good work practice, inspections and audits. These include:

- Inspection
- Repairs
- Prevention
- Spill clean-up / containment

14.5.3 Spill Preparedness

EMCP will periodically audit the general contractor's spill response preparedness program to ensure it meets the Hebron Project requirements.

14.5.3.1 Canada Shipping Act Requirements

Under the *Canada Shipping Act*, 2001, each vessel working at Bull Arm will be required to have a Shipboard Oil Pollution Emergency Plan and a contract with a readily available Response Organization.

14.5.3.2 On Site Capability

EMCP will have its General Contractor develop a spill response capability at Bull Arm to respond to:

- Small marine spills within a clearly defined zone around the Bull Arm facility
- Spills of any size on land within the Bull Arm facility

An appropriate land spill response capability that is suited to the spill risks at the Bull Arm Site will be available on site. The objective will be continuous improvement of awareness and understanding of spill risks, preparedness and response through the life of the construction project. Field assessments will be conducted to assess the petroleum product storage and handling to determine:

- Spill risks
- Likely pollution pathways after a spill
- Barriers needed for prevention and response
- Countermeasures strategies

The general contractor will have sufficient hydrocarbon containment boom on site to contain any marine spill arising from the work.

14.5.3.3 Storage of Petroleum Products Used during Construction

Petroleum product storage facilities will be compliant with provincial and federal legislation. Contractors will be expected to store fuels, lubricants and waste hydrocarbon in facilities constructed to provincial government standards. All vehicles carrying petroleum products into the Bull Arm Site will be required to carry a spill kit with items needed for initial spill containment in the event spills during transfer or as the result of a vehicle accident.

14.5.3.4 Training and Awareness

All construction personnel will receive orientation training in health, safety and environment objectives and issues, which will include an awareness component on hydrocarbon spill prevention and response. The Bull Arm construction site will have personnel working on-site, trained in response methods for spills on land and on the water. Refresher training will be provided.

14.5.4 Spill Response Actions

14.5.4.1 Situation Analysis and Safety Assessment

For all spills, the initial spill situation and location will be assessed to define the safety issues, the human and environmental resources at risk of being affected, and the possibility of the situation escalating into a larger incident. A disciplined approach will be used for response. The greatest priorities are:

- Protect people, property and the environment
- Stop the source of the spill
- Contain the spill

On-site security will be an important response component in achieving these objectives. All response actions will be organized as work orders assigned to teams, each having a team lead.

14.5.4.2 Net Environmental Benefit

All response actions should have a net benefit to the environment after completion. If in doubt, the OSC will consult further with the appropriate authority.

14.5.4.3 Security and Public Protection

Each major Contractor will be responsible for security and the protection of spill responders and the public. If warranted, the EPC Contractor will notify the local police detachment if assistance is required in protecting the public, or if there are security issues where assistance is required.

14.5.4.4 Spill Management for Construction-Related Spills

An OSC will be assigned by the EPC Contractor to direct the spill response effort. This person will be supported by the General Contractor's site emergency team and will be responsible for: spill site health and safety, response operations, and logistics. Generic components for each of these functions will be detailed in the General Contractor's contingency plan. The OSC will ensure that the actions taken during the spill response are documented hour by hour. Logs will be used to compile both the initial report and detailed report for a spill incident that will be submitted to authorities.

14.5.4.5 Spill Investigation

All spill incidents in the Nearshore Project Area will be investigated to determine root causes and to recommend any corrective action required to prevent similar incidents. EMCP believes that due diligence in this area will foster continuous improvement in spill prevention.

14.6 Offshore Spill Response Operations

Hydrocarbon spill prevention will be incorporated into the day-to-day operations at the Hebron Platform. All offshore systems and structures, procedures and programs will be designed with due regard to preventing the loss of any hydrocarbons. At the same time, EMCP will undertake all the necessary planning, training and exercising to ensure that the appropriate response capability is in place for all phases of the Hebron Project.

In the event of a spill, as part of its oil spill response plan, EMPC will develop a wildlife recovery plan that will identify key sensitive areas, detail what will be done to protect those areas and, in the event of oil effects upon wildlife, what they will do to recover and rehabilitate oiled wildlife.

Mitigation measures are discussed in relation to the environmental effects assessment of each VEC in the following sections:

- Fish and Fish Habitat – Section 7.5.4; Table 7-14
- Commercial Fisheries – Section 8.5.3.1; Table 8-15
- Marine Birds – Section 9.5.4; Table 9-13
- Marine Mammals and Sea Turtles – Section 10.5.4; Table 10-13
- Species at Risk – Sections 11.4.3, 11.5.3 and 11.6.3; Tables 11-7, 11-13 and 11-19
- Sensitive of Special Areas – Section 12.5.1; Table 12-3

14.6.1 Spill Risk

In Section 14.1, the risks of various levels of petroleum spill have been assessed based on worldwide historical statistics. The probability of smaller spills, especially involving fuel or crude transfers, is much higher than for large and very large spills. Even though the probability of a major spill is expected to be very low, EMCP will, nevertheless, prepare for such an incident in its oil spill response plan. Planning standards that detail the

amount of hydrocarbon spilled and operating conditions at the time of the spill will allow EMCP to ensure that the level of effort is adequate for any planning scenario. Based on probable drilling and production activities, several potential spill scenarios can be considered.

14.6.2 Spill Prevention

Standard Operating Procedures to reduce or eliminate the chance of a spill, even in the case of equipment failure, will be instituted for all hydrocarbon handling operations. Routine maintenance and testing schedules will be established for all aspects of the production program, with particular attention paid to well control, product storage and handling and fuel transfer systems. Prior to production, practices for operating in poor weather, high sea state, or sea ice or iceberg conditions will be established. Good communications and sound marine practices for all vessels will also improve the ability to prevent spills.

Proper environmental operating practices will be assured through regular inspections and audits of the Hebron Platform. The general awareness of offshore workers will be increased through training, seminars and safety meetings. Personnel will be encouraged to report potential problems and 'near miss' incidents in an attempt to avoid a re-occurrence that could result in a loss of containment or other release of petroleum or other hydrocarbons.

14.6.3 Characteristics of Spilled Crude Oil at Hebron

Previous testing of Jeanne d'Arc Basin crude oils indicate that consideration of oil characteristics and weathering properties of Hebron crude should be considered in developing specific response plans. Some characteristics that may affect response activities include:

- The potential for forming viscous emulsion
- The effects of wax on evaporation
- The effects of cold water on higher crude oil pour points

14.6.4 Spill Strategies and Technology

Strategy development should consider a range of offshore spill response options. The decision when to use each of these is based on an evaluation of operating conditions, the anticipated characteristics of the hydrocarbon, the effectiveness of the option and effects on the environment.

14.6.4.1 Response Options

While every spill response will be unique, there are a few basic options that can be practically considered (Table 14-26).

Table 14-26 Potential Response Options at Hebron

Option	Comments
Natural Dispersion / Degradation	• Weathered hydrocarbon breaks into small droplets by wave action • Droplets are naturally metabolized by micro-organisms • Effectiveness improves as wind and sea state increase • Only option when winds >25 to 30 knots, sea state >2.5 to 3.0 m
Surveillance And Monitoring	• Always necessary • Local surface surveillance using EMCP vessels and regional surveillance • Helps determine scope of problem prior to forming a strategy • Confirms effectiveness of response actions • More difficult in darkness or low visibility • Monitoring is the only response option in poor conditions • Hydrocarbon spill tracker beacons will be on EMCP supply vessels
Mechanical Dispersion	• Prop washing or high pressure water spray (Fire Monitor) • Good for small spills / thin layers of hydrocarbon, not good for crude • Quick implementation, no equipment required
Chemical Dispersion	• Authorization required from C-NLOPB before application • Use of dispersants currently being investiagted by offshore Newfoundland and Labrador operators as the next frontier of oil spill response
Containment And Recovery	• Containment and recovery through absorbent booms, Single Vessel Side Sweep and ocean-rated skimmers and booms is currently world-class • Effective but limited by sea state, encounter rate of boom system and need for high logistics support • Low recovery rates as slick spreads • Sorbent boom will be on EMCP supply vessels • Single Vessel Side Sweep system offshore • Tier 2/3 containment and recovery equipment will be available through a contracted Response Organization
Wildlife Measures	• Surveillance necessary to determine distribution of marine wildlife and potential for impact by floating hydrocarbon • Modified Candian Wildlife Service (CWS) survey techniques to determine marine bird population density • Techniques for deterring wildlife are limited to loud noise
Hydrocarbon and Wildlife (*e.g.*, marine birds, sea turtles) Sampling	• Sampling kits will be placed on EMCP supply vessels for the collection of oil and water, oil on wildlife and oiled wildlife samples • Environment Canada requires that all oiled birds collected be retained as samples for further assessment on shore • Protocols for marine bird monitoring during spill events will be established • EMCP will require a permit from CWS for collection of oiled birds

14.6.4.2 Logistics Considerations

EMCP logistics infrastructure will be employed to obtain equipment and materials specified by response managers, to transport operations personnel and equipment to and from the spill site, and to source additional operational platforms required.

The Hebron Project is at the conceptual stage of development. The Oil Spill Response Plan (OSRP) has not been developed. The Hebron crude has a lower API than the crude of existing offshore Newfoundland operations, and is therefore a heavier product. In developing the Hebron offshore OSRP, as with existing offshore oil and gas OSRPs, the OSRP will outline a tiered response to oil spills. Depending on the size and nature of the spill (*i.e.*, Tier 1, 2 or 3), the OSRP will include the type and quantity of response equipment specific for Hebron crude. In addition, it will identify equipment

that will be available within local, regional and global Response Organizations and equipment that may be available through mutual aid agreements with other operators. For a Tier 2 or Tier 3 response, Hebron can request oil spill project management support through ExxonMobil corporate response organization. Estimated response times for deployment will also be identified.

The Hebron Project is aware of the recent initiative currently being undertaken between the existing Newfoundland and Labrador operators regarding the evaluation of the level of equipment and its capability to respond to oils spills on the Grand Banks. Existing Tier 2 oil containment equipment is being upgraded and supply vessels are being configured for quick installation of the equipment. Enhanced training for vessel crews will also be provided. During the development of the Hebron OSRP, the Hebron Project will consider the response equipment available, the time it will take to deploy, if it is capable of handling Hebron crude, and determine if additional resources are required.

Tier 1 equipment will be available on-site and will be appropriate for Hebron crude.

Current Tier 2 equipment readily available onshore consists of industry and Eastern Canada Response Corporation (ECRC) equipment. In addition, and if required, the Canadian Coast Guard has an inventory of oil spill response equipment stored at their depot in Mount Pearl, some of which is suitable for offshore use.

ECMP will commit to continue working with other Grand Banks operators to enhance the existing pool of equipment based on the best available technology to support production operations.

In addition to maintaining and operating the producing operators' equipment, the Response Organization, ECRC (located in Mount Pearl) has its own open ocean containment and recovery equipment, temporary storage tankage, and oil transfer pumps.

In addition to the equipment available for a Tier 2 response, it is likely that Tier 3 resources available to Hebron production operations will be sourced from agencies outside of Newfoundland and Labrador. Principle sources include:

- The installation of diving and ROV systems to support production field maintenance programs
- ECRC equipment in other eastern Canada depots (*e.g.,* Ocean Buster high-speed boom stationed in Quebec)
- Equipment sources identified through the ExxonMobil Corporate response organization
- OSR aerial dispersant capability based in Southampton, England
- Appropriate oil spill response equipment secured from international Tier 3 response organizations by either ECRC and OSR through their membership in the Global Response Network

Estimated response times will be outlined in the Hebron OSRP. Again, depending on the nature of the spill and the required response, response times will vary.

Tier 1 resources will be available immediately at site. Sorbent boom can be deployed in less than one hour after the spill occurs. Other equipment can take up to three to six hours to deploy.

Deployment time for Tier 2 resources will depend on their location and are staged for rapid deployment. Including mobilization and delivery of gear, and activation of necessary field personnel a Tier 2 response vessel could be ready to sail from St. John's within two to three hours. Fastest transit to the spill site from St. John's would be approximately 12 to 18 hours in good conditions.

Response times for Tier 3 equipment will depend on source location.

The Hebron Project will develop synergies with the Hibernia Project and will augment the current two standby vessel, one supply vessel arrangement supporting Hibernia. It is anticipated that in order to meet production and drilling operations for Hebron, an additional standby vessel and supply vessel will be added to the pool of resources.

With regard to the availability of vessels, the industry has demonstrated that it can cope with unusual demands on vessel resources. During the spring of 2009, the core fleet was temporarily increased to a high of eighteen to meet the following demands:

- The installation of diving and ROV systems to support production field maintenance programs
- A heavy ice season that required vessels to be involved in increased ice management operations as well as unscheduled rig moves
- The grounding of all helicopter traffic to and from the Grand Banks requiring that all personnel had to travel offshore by vessel
- A high level of shipyard time for scheduled and unscheduled maintenance of vessels and platforms
- The installation of diving and ROV systems to support production field maintenance programs

To ensure that operations could continue, several additional vessels from throughout Atlantic Canada were also contracted. While not all of these vessels were capable of assuming full platform supply or standby duties, they were all useful.

Through mutual aid agreements with the Grand Banks operators, vessel assignment during an oil spill response may be similar to the spring 2009 case. Vessels of opportunity may be sourced from existing operations, where available, or sourced regionally.

14.6.4.3 Response Methods

Response methods include:

- Containment and recovery
- Emulsion breaking
- Chemical dispersion

14.6.4.4 Availability of Containment and Recovery Equipment

Even with ongoing improvements, offshore collection and recovery equipment is still limited by sea state and would be suitable for use in Grand Banks conditions for a small proportion of the year. Containment and recovery equipment must be suitable for harsh open-ocean conditions. In this section, current and proposed spill response equipment available to the Hebron Project offshore will be discussed.

For first response actions, there will be a dedicated first response capability at the Hebron facilities. EMCP's Tier 1 capability will meet or exceed the current standard for production operations.

Under mutual aid, Terra Nova, Hibernia and White Rose Tier 1 and Single Vessel Side Sweep resources may also be available. The addition of EMCP equipment will increase the pool of personnel and equipment and improve the efficiency of maintenance, spares and training. For Tier 2 and 3 response operations, larger containment and recovery systems will be mobilized onshore.

14.6.4.5 Waste Hydrocarbon – Temporary Storage and Disposal Options

The progress of any hydrocarbon spill clean-up is ultimately limited by the ability to store and dispose the collected hydrocarbon. In the field, temporary storage of hydrocarbon, oily water and emulsified oil is an important issue. Storage on the collection platform, either in portable deck tanks or permanent built-in tanks, is an easy temporary measure. As the volume of collected hydrocarbon increases with time, barges or tankers will be required to hold the hydrocarbon.

Most newly built vessels currently operating offshore Newfoundland are built to DNV oil-recovery standards. ECMP will ensure that the core vessels chartered for Hebron operations meet current pollution class standards.

Ultimately, the hydrocarbon may be disposed of in a number of ways: through re-introduction to the production stream on the Hebron Platform; as fuel in the boilers of one of an industrial steam plant; or through a refining or re-cycling process. The recovered hydrocarbon may require some level of processing to meet specifications of the disposal facility (to remove water and/or debris). The spill response plan will detail viable disposal options.

14.6.4.6 Effects Monitoring

As part of its oil spill response plan, EMCP will develop a process to implement a dedicated environmental effects monitoring (EEM) program to determine the effects of a major spill. The elements of the EEM program will be determined based on the circumstances of the spill and will consider the structure of the EEM program established for routine production activities at Hebron. The decision to implement such a program will be made after consultation between EMCP and the C-NLOPB.

14.6.5 Investing in Industry Spill Response Capability

Several recent actions indicate a more proactive approach to spill response in the Newfoundland offshore industry. This movement is similar to that undertaken in other offshore jurisdictions where operators have come to realize that there is a Tier 2 preparedness gap between measures implemented at site and membership in international spill response associations. The preferred method for filling this gap is to form some sort of cooperative between operators to develop consistency and standards on a local or regional level and to share the costs of a comprehensive oil spill program.

Since 2006, industry has been working with a local Response Organization, ECRC, to develop a more interactive relationship. As a certified Response Organization under the *Canada Shipping Act*, ECRC's primary focus has been in the general shipping and marine terminal sectors that fall under the Act. Both Suncor and Husky have an integration agreement in place with ECRC to provide Tier 1 and 2 oil spill response training for vessel crews and third-party responders. ECRC also conducts inspections and maintenance of Tier 1 and 2 oil spill response equipment as part of this contract. Industry's future relationship with a Response Organization may include a large oil spill preparedness component, which will provide for personnel training, equipment maintenance and response planning.

In 2007-2008, Grand Banks production operators cooperated in the purchase of a state-of-the-art open ocean containment and recovery equipment system consisting of:

- 400 m Norlense 1200 self-inflating boom
- Framo Transrec 150 self-contained skimmer

This investment represents the first purchase of Tier 2 equipment by the industry since 1991, and is important as it signals a more proactive approach to spill response. The system has been further enhanced by the successful demonstration of the installation of permanent deck mounts on the supply vessel *Maersk Chancellor* for the annual SYNERGY on water exercise in September 2009.

In 2009, the Canadian Association of Petroleum Producers (CAPP), on behalf of Suncor Energy, Husky Oil Operations and Hibernia Management and Development Company, as the operators of the Terra Nova, White Rose and Hibernia fields, respectively, prepared the *Marine Hydrocarbon Spill*

Response Capability Assessment Jeanne d'Arc Basin Production Operations (CAPP 2009). The report provides an evaluation of the oil spill response capability currently in place to support offshore oil and gas production operations in Newfoundland and Labrador. The report is not finalized, as the review process is ongoing. EMCP will take into consideration, and incorporate, where appropriate, recommendations regarding spill response capability that may result.

EMCP will work with other operators on continuing initiatives towards the development of consistent standards regarding spill response capability.

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15 FOLLOW-UP AND MONITORING

The follow-up and monitoring programs for this Project will be designed to meet several legislative and regulatory requirements, as well as internal corporate standards and requirements. Pursuant to the *Canadian Environmental Assessment Act* (CEAA), a follow-up program is mandatory for Projects requiring Comprehensive Studies with the purpose of "*(a) verifying the accuracy of the environmental assessment of a project, and (b) determining the effectiveness of any measures taken to mitigate the adverse environmental effects of the project.*" Follow-up programs serve as the primary means to determine and quantify change from routine operations on the receiving environment. While the Responsible Authority is responsible for the Follow-Up Program, it may also delegate any part of its design and delegation.

The Canada-Newfoundland and Labrador Offshore Petroleum Board's (C-NLOPB) Development Plan Guidelines (C-NLOPB 2006) also requires an environmental assessment to include a follow-up monitoring program which it says "*may include, but not be limited to, implementation monitoring, environmental effects monitoring, compliance monitoring, and any monitoring of identified species at risk (Species at Risk) that may be required pursuant to the Species at Risk Act*." The Development Plan Guidelines (C-NLOPB 2006) also include the requirements for the following monitoring programs to be addressed: Biological Observation Requirements, Physical Environmental Observation Program and Forecasting Programs.

There are a number of other federal and provincial regulations and guidelines are applicable to this Project including that may require monitoring to verify compliance. In addition, ExxonMobil Canada Properties (EMCP) has committed to undertake observational and monitoring programs associated with certain Project activities.

The following sections address all of the above requirements.

15.1 Environmental Effects Monitoring

A key component of monitoring the construction and operations of a project is the Environmental Effects Monitoring (EEM) program. EEM programs take repetitive measurements of environmental variables over time to detect changes caused by external influences directly or indirectly attributable to a specific anthropogenic activity or development (Duinker 1985). Ultimately, EEM programs are an assessment tool to help determine the sustainability of human activities on ecosystem health. EEM programs verify environmental effects predictions and the effectiveness of mitigative measures, as well as facilitate the identification of any unforeseen environmental problems that may arise, thereby allowing them to be addressed in a timely and effective manner.

EEM programs are designed using an iterative process that allows for opportunities to review the EEM design over the life of a project and address

project changes, as well as changing priorities in environmental management policies and practices while allowing for the incorporation of new and/or improved technologies and methodologies.

15.1.1 Proposed Offshore Environmental Effects Monitoring Program

The development and design of EEM programs in the Newfoundland and Labrador offshore oil and gas industry has built upon the considerable knowledge and experience gained from industry monitoring in the North Sea and the Gulf of Mexico. Each of the subsequent Canadian EEM programs (*i.e.*, Cohasset-Panuke, Hibernia, Sable Gas, Terra Nova and White Rose) has sought input from the regional, national and international scientific community, regulatory agencies and other stakeholders to further define expectations and goals of their EEM programs. The following describes the process that has been used to date in the development of EEM programs in the Newfoundland and Labrador offshore oil and gas industry. EMCP is proposing to use a similar process in the development of the EEM for this Project.

The initiation of the EEM process has typically consisted of the identification of the parameters to be measured, data gaps to be addressed and the overall goals and purpose of the EEM program. This step typically includes a literature and data review and identification of marine resources of interest as well as the establishment of boundaries and scale for the monitoring program. A conceptual model may also be developed at this stage, which describes the underlying cause-and-effect links of the project that may be used to generate environmental effects predications to be tested in the EEM program.

During this initial stage of the EEM process, input from the scientific community, regulatory agencies and key stakeholders groups is solicited through a series of formal and informal meetings and/or consultations. These meetings and consultations assist in developing a focused monitoring strategy by:

- Defining the purpose of the EEM Program
- Defining interactions from project discharges
- Determining the appropriate parameters to be monitored and the rationale for their inclusion / exclusion for the program
- Determining the means by which to measure environmental effects predictions
- Determining the requirement for new or additional site specific baseline data
- Determining the spatial design and statistical methodologies to be used for the various EEM components
- Reporting and incorporating information into the overall Environmental Protection Plan (EPP) to facilitate decision-making

Where an EEM program identifies unanticipated environmental effects, or where mitigation is found to be ineffective, EMCP will work with the applicable regulatory authorities to amend the EEM program and/or mitigation strategies to ensure that the Project does not result in significant adverse environmental

effects. EMCP will include the EEM program as a part of the overall Management System outlined for the Project in Chapter 16 of this Comprehensive Study Report (CSR).

As stated above, under CEAA, the Responsible Authority has overall responsibility for ensuring necessary mitigation and that a Follow-Up Program is designed and implemented in accordance with CEAA. EMCP, in consultation with the C-NLOPB, will engage the other regulatory agencies to ensure the results of the EEM program are communicated in a manner that facilitates the obligations of Responsible Authorities to report on the EEM program. Where EEM requirements are identified through the permitting stage (*i.e.,* authorizations under the *Canadian Environmental Protection Act*), these programs will be incorporated into the overall EEM program framework.

In addition to the operational EEM program, EMCP is committed to a fish habitat compensation monitoring program. The details regarding fish habitat compensation monitoring will be determined in consultation with DFO. A fish habitat compensation monitoring survey is conducted following completion of the compensation works to verify the amount and productivity of habitat created.

In addition, should an accidental release of oil occur from a spill or blow-out, a spill EEM program will be instituted.

15.1.2 Existing Offshore Environmental Effects Monitoring Programs

The three EEM programs currently approved for the Newfoundland and Labrador offshore oil and gas industry have core similarities with some differences that make each program unique (Petro-Canada 2007; HMDC 2005; Husky Energy 2007). The core components of the EEM programs are sediment, water and commercial fish analyses (Figure 15-1).

The EEM programs conducted to date offshore Newfoundland and Labrador have typically adopted a radial gradient sampling design for sediment quality monitoring; parameters are measured at increasing distances along transect radii from the drill site(s). Gradient designs have been found to provide the greatest statistical power to detect changes associated with production and drilling activities, and to provide information on the scale of disturbance effects (Ellis and Schneider 1997; Green 2003). The sediment quality monitoring program is primarily designed to detect and monitor changes associated with the release of solid discharges from the operating platforms.

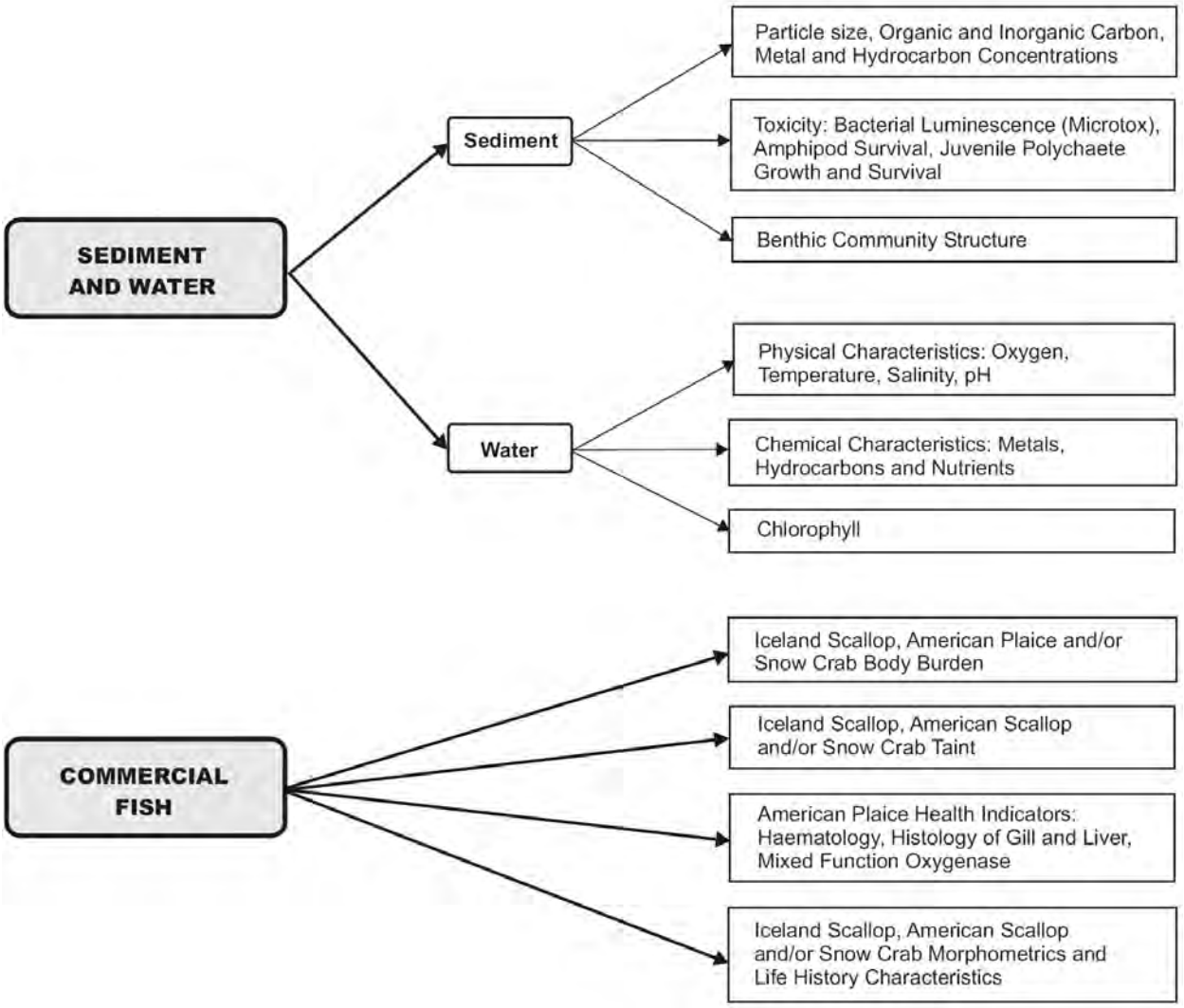


Figure 15-1 Environmental Effects Monitoring Program Components

Commercial fish parameters in Newfoundland and Labrador EEM programs have been typically examined in a control-impact design, where samples collected and parameters measured are examined from both study and control areas. The commercial fish programs are used to detect changes associated with both solid and liquid discharges.

Water sampling EEM programs have, for the most part in Newfoundland and Labrador, been based on a control-impact design or a modification of the control-impact design. These programs are designed to detect and monitor changes related to the release of liquid discharges, primarily produced water from the operating platforms.

All current EEM programs in Newfoundland and Labrador use more than one far-field reference station and have both baseline and operational EEM programs. The actual type(s) of EEM sampling design ultimately used for the Hebron Project will be chosen during the EEM design process. This process may be similar to that described above, and will build upon knowledge and data gained from existing Jeanne d'Arc Basin EEM programs. Upon

completion of a draft EEM design for the Hebron Project, the design will be formally submitted to the C-NLOPB for review and comment. Upon receipt of regulatory and other stakeholder comments, the Hebron EEM program will be finalized and implemented. Subsequent EEM programs will be reviewed and refined as necessary during the life of the project in order to ensure continual improvement.

15.1.3 Nearshore Environmental Effects Monitoring Program

EMCP will implement a nearshore EEM program to verify impact predictions in the marine environment in Bull Arm. The details of the nearshore EEM program will be developed in consultation with regulatory agencies and key stakeholders.

In addition, should an accidental release of oil occur from a spill, a spill EEM program will be determined based on criteria established with EMCP's Offshore Oil Spill Response Plan.

15.2 Environmental Compliance Monitoring

Environmental compliance monitoring (ECM) programs refers to activities used to ensure compliance with all regulatory and self-imposed environmental requirements. ECM assures regulators and the public that environmental regulations and standards are followed.

EMCP will implement a comprehensive Environmental Protection Plan (EPP) for the Nearshore Project Area and the Bull Arm Site. In addition, pursuant to the *Drilling and Production Regulations*, an EPP will be implemented for the offshore drilling and production operations.

15.2.1 Nearshore Environmental Compliance Monitoring

During construction activities at the Nearshore Project Area, as required by regulation, or as may be prescribed in the EPP and consistent with ExxonMobil standards, EMCP will implement an audit and compliance monitoring program. This program will incorporate compliance reporting requirements for applicable federal and provincial regulations governing activities at the Bull Arm Site. These regulatory instruments include, but are not limited to:

- Section 36 of the federal *Fisheries Act*, which prohibits the discharge of deleterious substances into any type of water frequented by fish
- Section 32 of the federal *Fisheries Act*, which prohibits the destruction of fish by any means other than fishing
- Section 35 of the *Migratory Birds Convention Act, 1994,* which prohibits the deposit of oil, oil wastes or any other substance harmful to migratory birds in any waters or any area frequented by migratory birds
- *Oil Pollution Prevention Regulations* of the *Canada Shipping Act*, which details how fuel transfers between ship and shore or between ships are conducted

- The *Hazardous Products Act*, which is the basis for Workplace Hazardous Materials Information System (WHMIS), which promotes proper labelling of controlled products and requires workers to receive education and training safe storage, use and handling of controlled products
- The Authorization for Works or Undertakings Affecting Fish Habitat, issued by Fisheries and Oceans Canada (DFO) under the *Fisheries Act*, and the Permit to Alter a Body of Water under the *Water Resources Act,* which details how infilling will be conducted
- Ocean disposal requirements under the *Canadian Environmental Protection Act*
- Newfoundland and Labrador Department of Environment and Conservation (NLDEC) Guidance Documents *Dredge Spoils Disposal* GD-PPD-028-1 and *Leachable Toxic Waste, Testing and Disposa*l GD-PPD-026-1, which details the testing and disposal requirements of dredged materials from marine construction activities. The removal and disposal of dredge spoils from within the marine/freshwater environment requires testing as per GD-PPD-026-1 and approval from the Government Service Centre
- *Garbage Pollution Prevention Regulations*, *Pollutant Substance Regulations*, *Pollutant Discharge Reporting Regulations* and *Oil Pollution Prevention Regulations* as required by the CSA, which will govern all vessel activities
- The NLDEC *Water and Sewer Regulations* for waste water discharge, which requires testing of the water from any on-land settling ponds prior to discharge

15.2.2 Offshore Environmental Compliance Monitoring

The ECM program requirements for the offshore oil and gas industry are detailed in the *Offshore Waste Treatment Guidelines* (OWTG) (National Energy Board (NEB) *et al.* 2010). The OWTG (NEB *et al.* 2010) outline the recommended practices and standards for the treatment and disposal of wastes and the sampling and analysis of waste streams. All operations will adhere to the most recent version of the guidelines.

The OWTG (NEB *et al.* 2010) provide minimum standards for the treatment and disposal of specific waste streams, including air emissions, produced water, drilling muds, drilling solids, storage displacement water, bilge and ballast water, deck drainage, produced sand, well treatment fluids, cooling water, desalination brine, sewage and food wastes, water for testing fire control systems, monoethylene glycol, naturally-occurring radioactive material and other substances, wastes and resides. For further information with respect to the standards for the treatment, disposal and monitoring of waste streams listed above, the reader is referred to the OWTG (NEB *et al.* 2010).

An Authorization for Works or Undertakings Affecting Fish Habitat will also be issued under the *Fisheries Act* for Project components occurring at the Offshore Project Area.

EMCP will adhere to ocean disposal requirements under the *Canadian Environmental Protection Act* for disposal of dredge spoil from any potential future excavated drill centres.

15.3 Other Required Programs

EMCP has committed to undertaking monitoring and reporting of various VECs during certain activities associated with the Hebron Project. In addition, pursuant to C-NLOPB guidelines and regulatory requirements, EMCP may have to undertake monitoring programs associated with the issuance of permits / authorizations. These may include, but are not limited to:

- Collection of data on marine mammals, sea turtles and marine birds during blasting programs at Bull Arm
- Collection of data on marine mammals and marine birds during geophysical programs. Marine mammal and sea turtle monitoring and observation protocols will be consistent with the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011). Marine bird observations will be undertaken, where applicable, as per the pelagic marine bird monitoring protocol developed by the Canadian Wildlife Service
- Compliance monitoring to ensure that the *Navigable Waters Protection Act* Conditions of Approval are implemented as outlined by Navigable Waters Protection Program of Transport Canada
- Collection and reporting of physical environmental data
- Project activities affecting fish habitat evaluated as part of the fish habitat compensation program. All fish habitat compensation measures will be monitored to ensure no net loss of productive capacity in fish habitat. A fish habitat compensation monitoring survey is conducted following completion of the compensation works to verify the amount and productivity of habitat created. In addition, compensation monitoring to determine the continued functioning of the habitat will be conducted for a period of time and at intervals agreed upon by DFO and EMCP. The timelines for monitoring will be included in the Fish Habitat Compensation Plan, which will be provided as a condition of Section 35(2) of the *Fisheries Act*

15.4 Environmental Assessment Validation

Various program activities during the life of the Hebron Project will require authorization under the Atlantic Accord Acts *(e.g.*, drilling, dredging, geotechnical, geohazard and seismic surveys). Authorizations may be valid for one to five years at the discretion of the C-NLOPB. The schedule of Project activities outlined in this environmental assessment is based on the best available knowledge at this time. EMCP recognizes the requirement to ensure that the environmental assessment is kept current and valid to support the renewal of any applicable authorizations and/or any important changes in environment or resource use in the Project Areas during that time. Therefore, during the life of the Project, as authorizations are renewed or new ones are

required, EMCP will submit documentation to the C-NLOPB and federal regulatory authorities to confirm that:

- The scope and nature of activities planned and addressed under this environmental assessment have not changed
- The nature of the species at risk in the Project and Study Areas have been validated and have not changed (including review of Recovery Strategies and Management Plans)
- The nature and extent of the fishing activities in the Project Area have been validated and have not changed
- The mitigation measures defined and committed to in the environmental assessment are still valid

As part of its continuous improvement and stakeholder engagement, EMCP will consult with stakeholders, including fishers, regarding ongoing operations, as necessary.

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16 ENVIRONMENTAL MANAGEMENT

Environmental leadership and performance for the Hebron Project will be managed by taking a sound science, risk-based, life cycle approach. Environmental management is an evergreen process that is continuously monitored and enhanced throughout Project life.

ExxonMobil Canada Properties (EMCP) recognizes that important environmental-related decisions are often made during initial planning and concept selection. In many cases, these early decisions can effectively reduce environmental effects without measurably affecting a project's cost or schedule. Early identification of potential environmental effects can help narrow the scope of concept alternatives, develop appropriate environmental mitigation approaches and optimize a project's environmental footprint by addressing energy needs, water usage, land use, air emissions, effects on sensitive environments and effects on local communities.

For the Hebron Project, EMCP will use an established ExxonMobil Corporation (ExxonMobil) Environmental Management Process that covers the complete life cycle of a new development (facility design, construction, operation and decommissioning). A number of planning and decision-making tools and processes are used to address identified environmental challenges and to ensure that the desired level of environmental performance is achieved. Environmental risk assessments, alternatives analyses and adherence to internal environmental standards will guide the Project throughout this planning and construction process.

This Comprehensive Study Report (CSR), as well as the Socio-economic Impact Statement (SEIS), was prepared after the concept was selected and approved. An Environmental Management Plan (EMP) or Environmental Protection Plan (EPP) (as required by Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) for operations) will also be prepared to document environmental impact avoidance and/or mitigation measures. This EMP will include a description of the roles and responsibilities of Project-associated personnel, environmental-related regulatory requirements and environmental performance expectations.

During the operations stage, Project personnel will track environmental measurements to ensure that the required level of environmental performance is obtained. Facilities will be dismantled and reclaimed at the end of the Project's life per C-NLOPB requirements. A life cycle approach, from initial project concept to final decommissioning, will ensure the proper stewardship of the environmental aspects for the Hebron Project.

Environmental management for the Hebron Project will be guided by ExxonMobil's Environment Policy, expectations from the "Protect Tomorrow. Today." initiative and management systems. These systems provide a systematic, structured and disciplined approach to environmental management.

16.1 ExxonMobil Corporation Environment Policy

The Board of Directors of ExxonMobil have adopted and oversee the administration of ExxonMobil's Standards of Business Conduct, which include the foundation policies of ExxonMobil. ExxonMobil's approach to environmental protection is guided by the ExxonMobil's Environment Policy, as shown in Figure 16-1.

It is ExxonMobil Corporation's policy to conduct its business in a manner that is compatible with the balanced environmental and economic needs of the communities in which it operates. The Corporation is committed to continuous efforts to improve environmental performance throughout its operations.

Accordingly, the Corporation's policy is to:

- comply with all applicable environmental laws and regulations and apply responsible standards where laws and regulations do not exist;
- encourage concern and respect for the environment, emphasize every employee's responsibility in environmental performance, and foster appropriate operating practices and training;
- work with government and industry groups to foster timely development of effective environmental laws and regulations based on sound science and considering risks, costs, and benefits, including effects on energy and product supply;
- manage its business with the goal of preventing incidents and of controlling emissions and wastes to below harmful levels; design, operate, and maintain facilities to this end;
- respond quickly and effectively to incidents resulting from its operations, in cooperation with industry organizations and authorized government agencies;
- conduct and support research to improve understanding of the impact of its business on the environment, to improve methods of environmental protection and to enhance its capability to make operations and products compatible with the environment;
- communicate with the public on environmental matters and share its experience with others to facilitate improvements in industry performance;
- undertake appropriate reviews and evaluations of its operations to measure progress and to foster compliance with this policy.

Figure 16-1 ExxonMobil Corporation Environment Policy

16.2 Corporate Environmental Initiative

ExxonMobil senior management has reinforced environmental performance expectations to all ExxonMobil's business lines in order to achieve superior performance. This leadership-driven initiative is called "Protect Tomorrow. Today." (Figure 16-2).

ExxonMobil seeks to deliver superior environmental performance, and in this spirit, an Environmental Management Process has been developed, which is integrated with project design and operations processes and procedures and has been deployed consistently around the world. This process allows ExxonMobil to conduct its business in a manner that is compatible with the balanced environmental and economic needs of the communities in which it operates. ExxonMobil is committed to continuous efforts to improve environmental performance.

"Protect Tomorrow. Today."

- Deliver superior environmental performance, leading to competitive advantage.
- Drive environmental incidents with real impact to zero, through a process of continuous improvement.
- Achieve industry leadership in key environmental areas relevant to each business.

Figure 16-2 "Protect Tomorrow. Today." Principles

16.3 Management Systems

Long-term sustainable performance will be established through use of the ExxonMobil management systems, including operations integrity, controls integrity, reliability and capital projects management. The Environmental Management Process is integrated into two of these management systems: the Operations Integrity Management System (OIMS) and the ExxonMobil Capital Projects Management System (EMCAPS).

16.3.1 Operations Integrity Management System

ExxonMobil's OIMS Framework establishes common worldwide expectations for addressing risks inherent in its business. The term “operations integrity” is used by ExxonMobil to address all aspects of its business that can affect personnel and process safety, security, health and environmental performance at ExxonMobil facilities worldwide.

OIMS is a framework of management systems designed to identify hazards and manage the associated risks. It provides a systematic, structured and disciplined approach across businesses and facilities worldwide and enables ExxonMobil to measure progress and ensure management accountability in these areas. OIMS also ensures that ExxonMobil appropriately engages with the communities in which it operates. Business-line managers are expected to adhere to all OIMS requirements, from project inception to ongoing operations, and conduct OIMS assessments on a frequent basis.

OIMS is embedded into ExxonMobil's day-to-day work processes to establish common worldwide expectations that every operating unit must fulfill to proactively manage risk globally. Over time, it has become a part of ExxonMobil's culture and the way it does business, improving operations reliability, and reducing safety, security, health and environmental risks and effects.

The overall effectiveness of OIMS is reviewed every five years and the system is adjusted accordingly. As a result, OIMS has been continuously

improved to include behaviour-based safety, security, environmental matters and enhanced community involvement.

In 2007, Lloyd's Register Quality Assurance, Inc. (LRQA) attested that OIMS meets the requirements of the ISO 14001 standard for environmental management systems. Furthermore, LRQA recognized that OIMS also meets all the requirements of the Occupational Health and Safety Assessment Series for health and safety management systems (OHSAS 18001).

EMCP is establishing the management systems, including the Environmental Management System, to address the requirements and expectations of the OIMS framework. These systems incorporate five essential characteristics:

- **Scope and Objectives:** scope defines the system's boundaries and interfaces with other systems, organizations and facilities. Objectives clearly define the system's purpose and expected results
- **Processes and Procedures:** processes address the steps that describe what the system does and how it functions. Procedures address the key tasks within a process
- **Responsible and Accountable Resources:** the approval authority, experience and training necessary for specific roles and responsibilities in implementation and execution of the system are specified
- **Verification and Measurement:** a system must be checked to see whether it is functioning as designed and is achieving its stated purpose
- **Feedback and Improvement Mechanisms:** these mechanisms help ensure actions are taken to continuously improve a system's suitability, capability and effectiveness

The OIMS framework has 11 elements (Figure 16-3), each with clearly defined expectations that every operation must fulfill. Environmental aspects are integrated throughout OIMS. The specific basis for the Environmental Management System is within Element 6, Operations and Maintenance.

16.3.2 ExxonMobil Capital Projects Management System

The EMCAPS provides a framework for guiding project development and execution. This system requires several deliverables to be completed by specific decision points in the life of a project. Two key EMCAPS deliverables related to the Environmental Management Process are the EMP and the Regulatory Compliance Plan.

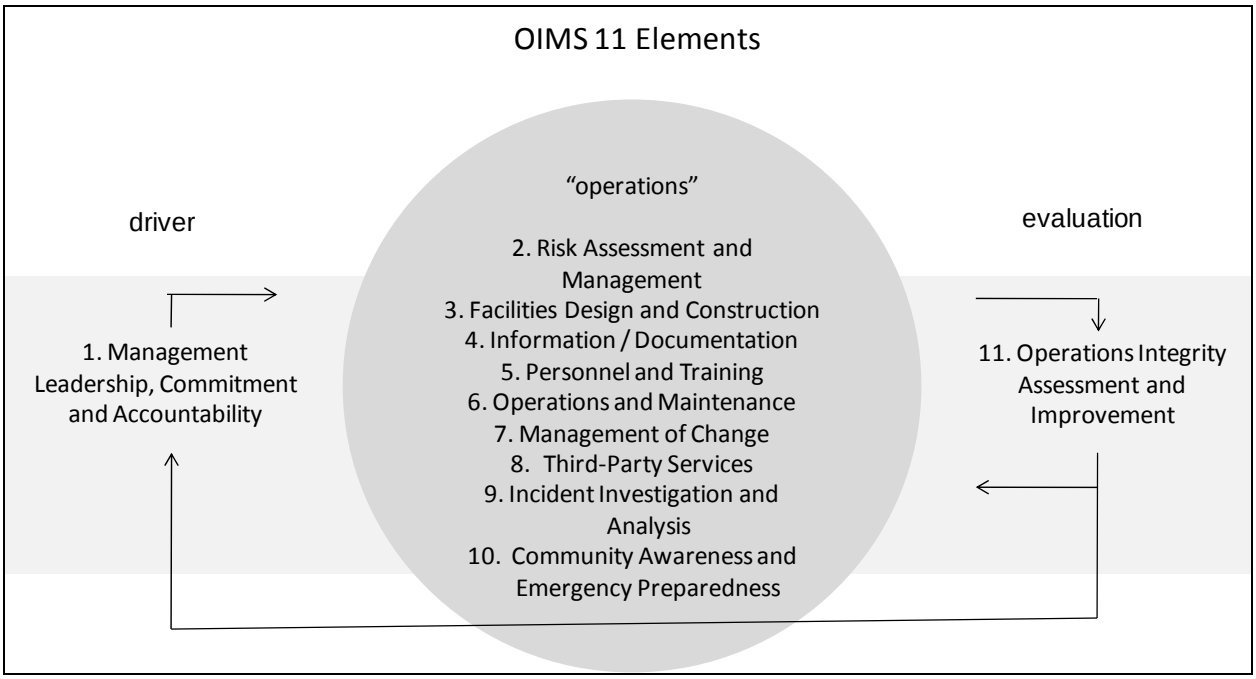


Figure 16-3 OIMS 11 Elements

16.4 Environmental Management Process

ExxonMobil's structured Environmental Management Process ensures that a variety of tools, plans and processes are in place to safeguard the environment - its biodiversity, cultural heritage and value. These features are a priority in business planning throughout a project's life cycle. The Environmental Management Process requires an early engagement approach to identifying environmental issues and alternatives, even before the project concept is determined. In the project's early stages, alternatives analyses guide project concepts and decisions as more knowledge about site characteristics and facility designs become known. Decisions early in a Project's life can lead to an overall reduced environmental footprint.

The Environmental Management Process for the Hebron Project has been broken down into five stages of activity that follow the timeline for developing and operating a project (Figure 16-4).

Implementation of a structured Environmental Management Process with organized and well-defined associated systems, tools and processes is the key to managing the environmental, socio-economic and health challenges of the Hebron Project.

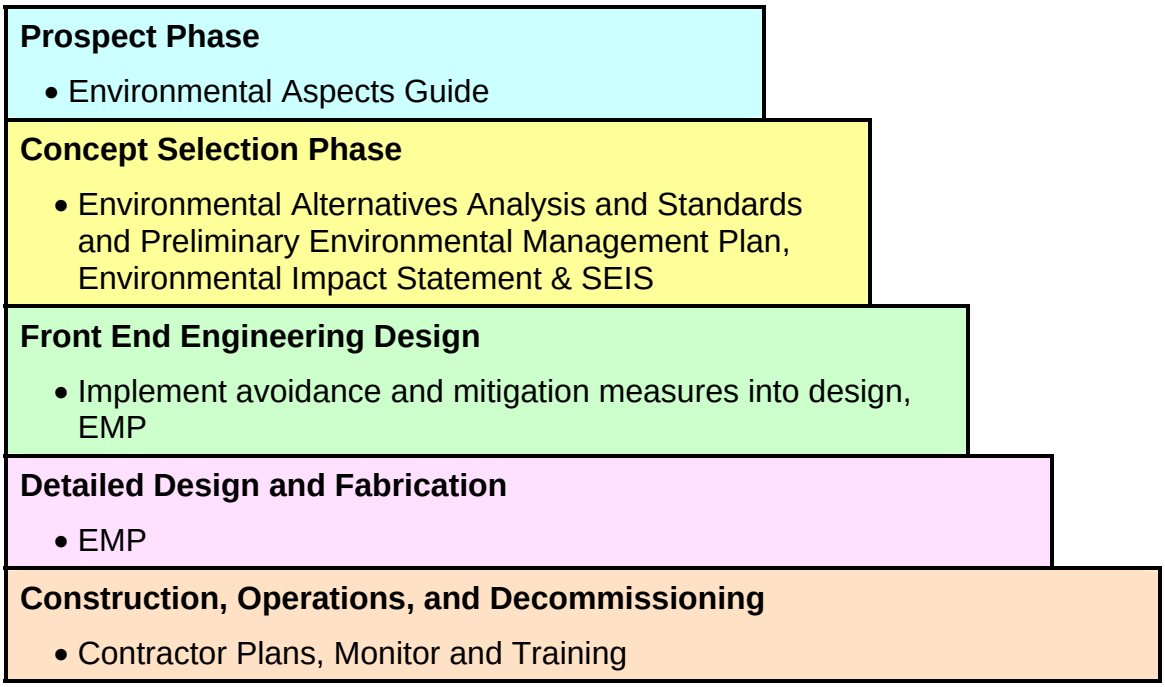


Figure 16-4 The Five Project Stages and Related Environmental Tools and Processes

16.4.1 Prospect Phase

The tool developed to guide this process and ensure that a wide range of potential environmental sensitivities are considered is the ExxonMobil Environmental Aspects Guide. This Guide provides a comprehensive list of environmental sensitivities for consideration and a systematic process for the initial assessment of activities, products and services that interact with the environment. The Guide promotes early engagement with the applicable engineering, geoscience and management teams and straightforward high-level mitigation approaches in order to reduce environmental effects. This Guide was used to steer Hebron Project environmental and regulatory planning, as well as development of the environmental assessment and Preliminary Environmental Management Plans (PEMP).

This phase of the Environmental Management Process usually involves the environmental and regulatory evaluation of various Project alternatives or concepts. The environmental risks associated with the alternative modes of development for the Hebron Project were evaluated and a preferred concept was selected prior to ExxonMobil becoming the operator (as described in Section 2.4).

From the earliest stages of the Project, the management team has actively promoted a safety, security, health and environment (SSH&E) culture, to both those working on the Project and to the public. EMCP is committed to working with the provincial government, the Workplace Health, Safety and Compensation Commission, the Building Trades Council and others toward improved safety in the province. EMCP hosted an initial contractor SSH&E Forum in June 2009 and has carried its message of safety ("Nobody Gets

Hurt."), security ("Security is everybody's business.") and environment ("Protect Tomorrow. Today.") to the public through presentations at Open Houses, in schools and at conferences. The Open Houses in the fall of 2009 were one means of bringing the information about the Project and the environmental assessment to the interested public.

16.4.2 Concept Selection Phase

In the normal process, once a new hydrocarbon resource has been determined to represent a viable development opportunity, several concepts for developing the resource are contemplated. For each of these concepts, a more detailed level of environmental alternative analysis is conducted. These analyses consider the various environmental impacts associated with each of the different design concepts and technologies being considered.

16.4.2.1 Alternatives Analyses

During the concept selection phase, the tool that is used to manage environmental reviews is the Early Project Environmental Alternatives Analysis. This tool focuses on select environmental aspects that can be reasonably evaluated at an early stage, allowing for practical decisions to be made. Another tool, developed to enhance early project decisions, is a series of ExxonMobil Environmental Standards that address aspects related to air, water, land and local communities.

16.4.2.2 Environmental Standards

EMCP is committed to meeting provincial and federal regulations for environmental performance and, where no local regulations exist, to operate to standards that are protective of the environment. These standards were developed by ExxonMobil and are based on sound science and comprehensive risk assessments. They provide an additional layer of environmental protection assurance, especially in regions where environmental requirements are not comprehensive. The existing environmental standards include nitrogen oxides emissions, offshore drill cutting discharges, flare and venting reduction, water management, waste management, land use, energy efficiency and greenhouse gases, socio-economic management, air emissions and marine geophysical operations. These standards assist in identifying environmental improvement opportunities early in project planning when they can be implemented most effectively.

16.4.2.3 Environmental and Socioeconomic Impact Statements

An Environmental Impact Statement (EIS) is required by Canadian and Newfoundland and Labrador legislation. Pursuant to the *Canadian Environmental Assessment Act*, the EIS is a CSR. Per these requirements, the scope and detail of the CSR and SEIS for the Hebron Project are based on the conceptual level of engineering design, the Project environment's sensitivity, existing socio-economic conditions, the scope of the Project and

the nature of anticipated environmental issues / effects. These tools are valuable to many Project team members, since decisions made by Project personnel will be influenced by its findings and recommendations.

The CSR and SEIS processes are detailed and rigorous, and ensure that a project is appropriately designed, constructed and operated in an environmentally responsible manner. The results of these assessments lead to the development of environmental effects avoidance and mitigation plans. These avoidance and mitigation measures, as well as specific monitoring and measuring procedures, are documented in subsequent project documents and plans, starting with the PEMP.

16.4.2.4 Preliminary Environmental Management Plan

During this phase, a PEMP was prepared to describe the process for managing its associated environmental-related issues in view of the Project schedule and other needs. This plan identified and organized the key issues and processes necessary for managing the Project's environmental aspects, including applicable environmental-related regulatory requirements, external financing-related environmental requirements (if applicable), roles and responsibilities of specific project personnel and environmental-related requirements for Project engineering and construction contracts and contractors. The PEMP provides a roadmap of environmental-related expectations as the details of the Project design and construction plans continue to be defined.

16.4.3 Front End Engineering Design

The results of the CSR, SEIS and PEMP prepared during the Concept Selection Stage, including recommended environmental issues / effects avoidance, mitigation and monitoring measures, will be integrated into the Project design during FEED. The appropriate environmental standards will be used to evaluate design changes as necessary. As design progresses during this stage, the PEMP will be updated and results documented as an EMP.

16.4.3.1 Environmental Management Plan

The EMP for the Hebron Project will integrate the environmental and socio-economic issues / effects avoidance, mitigation and monitoring measures, identified in the CSR and SEIS, into the Project's activities and operations. This includes integrating them into the overall Project schedule and in the supporting engineering and contractor plans and contracts. Deviations from agreed-upon strategies require a stringent, documented review and approval process. Any approved changes are incorporated into the Project schedule and documentation. The EMP includes plans for public consultation, environmental training of project personnel, waste management and other specific plans as appropriate. Depending on the environmental, socio-economic and health challenges associated with each Project phase, other specific plans may be needed to support the EMP.

The Hebron Project EMP will provide the basis for the EPP that will be submitted to the C-NLOPB for approval.

16.4.4 Detailed Design and Fabrication

When the Project's designs become finalized and fabrication begins, the EMP will help guide Project activities at various contractor sites. Prior to beginning significant onsite construction and installation activities, the environmental advisors will conduct a series of assessments with each major segment of the Project, such as the installation, logistics, procurement coordinators and production operations personnel to review the Project's environmental-related requirements and commitments. These assessments are documented and reviewed for endorsement by key Project managers. During this stage, the EMP will continue to be updated as the Project matures.

16.4.5 Construction, Operations and Decommissioning

The above-mentioned systems, tools and standards are primarily used for Project geophysical, planning, engineering, fabrication, construction and drilling activities. A plan will be developed to transition the EMP to the production operations group several months prior to anticipated "start-up". The plan includes the identification and documentation of key activities and responsibilities. During this commissioning process, it is optimal for construction and operations EMP implementation and compliance monitoring personnel to overlap in order to ensure a smooth transition. The development phase tools, plans and standards continue to be applicable during the production phase. At the end of Project life the Project facilities will be decommissioned.

16.4.5.1 Environmental Effects Monitoring

Throughout the construction and operations phases, the work is monitored in view of the applicable environmental and regulatory obligations and requirements. Tools such as a proprietary menu-driven database are used by ExxonMobil to track the completion of these obligations and requirements. This database is available continuously and globally so that all project team members have access to it when needed. Since it is a "live" database, updates and changes made are viewable at all times.

Regulatory Compliance Assessments are also conducted to review the various aspects of the project, including its environmental requirements, and highlights areas for improvement. Follow-up actions are monitored to ensure closure.

16.4.5.2 Contractor Requirements

Contractual requirements for each of the Project contractors will require them to develop their own EMP and Regulatory Compliance Plan specific to their scope of work. These plans are reviewed and endorsed by the Project team to ensure that the contractor will meet ExxonMobil's environmental and regulatory expectations and requirements. Project team members are

assigned to each contractor to monitor their work throughout the construction phase.

16.4.5.3 Management of Change Process

The systems and processes used to develop and construct a project include a Management of Change (MOC) Process. The MOC Process provides a means to ensure that changes are reviewed and endorsed regarding their health, safety, environmental, regulatory, security and operational implications, and any other requirements before they are endorsed.

16.5 Capacity Building

16.5.1 Training

In order to ensure that the Environmental Management Process is consistently implemented, ExxonMobil has developed a training curriculum for its environmental advisors (Figure 16-5). These sessions are taught by experts and are designed to build technical capacity and share information on ExxonMobil's environmental, socio-economic and health management philosophy and approach. Project studies are shared and problems are worked in groups to provide instruction regarding how to approach the types of decisions and issues related to environmental matters arise when undertaking major projects.



Figure 16-5 Example Training Sessions

16.5.2 Environmental Management Process Workshops

In addition to project host-country employment and business use opportunities, ExxonMobil provides workshops to explain its Environmental Management Process, how it works and ExxonMobil's overall environmental expectations and requirements. Recent workshops have included a wide range of audience, including Project teams, contractors and key government agency representatives.

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17 SUMMARY AND CONCLUSIONS

17.1 Summary of Proposed Activities

The Hebron Project is a proposed oil and gas development located offshore Newfoundland, approximately 340 km east of St. John's. Forecasted cumulative oil recovery for the initial development phase after 30 years of producing life ranges from 87 Mm^3 (548 MBO) to 140 Mm^3 (883 MBO) from an anticipated 41 wells The Ben Nevis Pool within the Hebron Field is the core of the Hebron Project, and is anticipated to produce approximately 80 percent of the Hebron Project's crude oil.

The intent is to develop the Hebron oil field using a concrete Gravity Base Structure (GBS) with an integrated Topsides facility. The GBS will be a reinforced concrete structure designed to withstand impacts from sea ice and icebergs and the meteorological and oceanographic conditions at the Hebron Field. It will accommodate up to 52 well slots with J-tubes connected to the base of the GBS for potential expansion opportunities. An Offshore Loading System (OLS) will be installed to off-load crude oil from the platform to tankers.

Potential expansion opportunities may include subsea tieback to the Hebron Platform from excavated drill centres.

The scope of the Hebron Project includes GBS construction activities at the Nalcor Energy-Bull Arm Fabrication site in Trinity Bay, Newfoundland, which are scheduled to begin in 2011, and the installation, operation and future decommissioning activities of the Project offshore, with first oil targeted for 2017. The environmental assessment is therefore focused on activities in both the Nearshore and Offshore Project Areas.

17.2 Summary of Assessment Findings

Under the *Canadian Environmental Assessment Act* (CEAA), the Hebron Project requires environmental assessment at a comprehensive study-level of assessment. The Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) and other federal Responsible Authorities (RAs) have set out the required scope of this environmental assessment in a Scoping Document (C-NLOPB 2009). This Comprehensive Study Report (CSR) meets these requirements, as well as meeting the requirements of the C-NLOPB *Development Plan Guidelines* (C-NLOPB 2006).

The potential environmental effects of each Project phase have been evaluated for each of the selected Valued Ecosystem Components (VECs) (*i.e.*, those components of the environment that are valued socially, economically, culturally and/or scientifically and are of interest when considering the potential environmental effects of the Project). The VECs selected for this environmental assessment reflect the issues raised by stakeholders and include Air Quality (air quality and greenhouse gas (GHG)

emissions), Marine Fish and Fish Habitat, Commercial Fisheries, Marine Birds, Marine Mammals and Sea Turtles, Marine Species at Risk (SAR) (marine fish species SAR, marine mammal and sea turtle SAR and bird SAR) and Sensitive or Special Areas.

17.2.1 Summary of Residual Effects

A summary of the residual environmental effects assessment for each of the identified VECs is provided in Table 17-1. The only potential for significant residual adverse environmental effects as a result of the Hebron Project is in association with an accidental event. In such an unlikely event, significant adverse environmental effects have been predicted for Marine Birds, bird SAR and the Sensitive or Special Areas located in the Nearshore Project Area, however, the likelihood of this occurring is considered very low. Emphasis on both pollution prevention and effective response planning will further reduce the potential for these unlikely significant environmental effects to occur.

Table 17-1 Significant and Not Significant Residual Environmental Effects on Valued Ecosystem Components

VEC	Significance of Residual Environmental Effect					
	Construction / Installation	Operation and Maintenance	Decommissioning and Abandonment	Accidents, Malfunctions and Unplanned Events	Project Overall	Cumulative Environmental Effects
Air Quality	NS	NS	NS	NS	NS	NS
Fish and Fish Habitat	NS	NS	NS	NS	NS	NS
Commercial Fisheries	NS	NS	NS	NS	NS	NS
Marine Birds	NS	NS	NS	S	NS	NS
Marine Mammals and Sea Turtles	NS	NS	NS	NS	NS	NS
Species at Risk: Marine Fish	NS	NS	NS	NS	NS	NS
Species at Risk: Marine Mammals and Sea Turtles	NS	NS	NS	NS	NS	NS
Species at Risk: Birds	NS	NS	NS	S	NS	NS
Sensitive or Special Areas	NS	NS	NS	S	NS	NS
S = Significant residual environmental effects NS = Not significant residual environmental effect						

17.2.2 Summary of Proposed Mitigation Measures

The proposed mitigation measures identified in association with each of the VECs is outlined in Table 17-2 for the following phases: nearshore construction activities, offshore construction and installation, potential expansion opportunities, offshore operations and maintenance, potential expansion opportunities, decommissioning and abandonment and accidental events.

Table 17-2 Proposed Mitigation by Project Phase and Valued Ecosystem Component

Applicable VECs	Mitigation
Construction	
Nearshore Construction	
• Air Quality and GHG Emissions	• Limited periods when vessels are idling • Vessel maintenance and inspection
• Fish and Fish Habitat • Marine Birds • Marine Mammals and Sea Turtles • Species at Risk (Marine Fish, Marine Mammals and Sea Turtles and Birds)	• During blasting use of bubble curtains, if required • Harmful alteration, disruption or destruction (HADD) authorization and compensation • Use of sediment control measures • Adherence to the *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* (Wright and Hopky 1998) • During blasting, monitor appropriate safety zone for diving birds, marine mammals and sea turtles • Compliance with terms of Section 32 *Fisheries Act* Authorization (if required) • Washwater from the cleaning of mixers, mixer trucks and concrete delivery systems directed to a settling basin • Proper release of stranded birds per Canadian Wildlife Service (CWS) protocol • For deepwater site moorings, restrict disturbance to mooring sites • Vessels to maintain steady course and speed and to avoid concentrations of marine birds and marine mammals • Vessels to deviate course to avoid concentrations of marine mammals • Use of best practices, continuous improvement programs and best available technology
• Commercial Fisheries	• Fisheries liaison committee • Safety zone • Timing • Vessel traffic management plan • Fisheries compensation plan • Notification and communication • Fisheries Liaison Officer (FLO) • Single point of contact (SPOC)
Offshore Construction and Installation	
• Air Quality and GHG Emissions	• Ensure the use of properly maintained and functioning equipment • Limited periods when vessels and helicopters are idling • Vessel and helicopter maintenance
• Fish and Fish Habitat • Marine Birds • Marine Mammals and Sea Turtles • Species at Risk (Marine Fish, Marine Mammals and Sea Turtles and Birds)	• Use of best practices, continuous improvement programs and best available technology • Survey vessels and equipment will only use the power required to attain the data, thereby minimizing noise • Proper release of stranded birds per CWS protocol • Helicopters to avoid active marine bird colonies, including Witless Bay Ecological Reserve, and to avoid flying at low altitudes, where possible • Vessels to maintain minimum distance of 2 km from active marine bird colonies, maintain steady course and speed and avoid concentrations of marine birds or marine mammals • Vessels to deviate course to avoid concentrations of marine mammals • Adherence to the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011) • Adherence the Section 35(2) *Fisheries Act* Authorization and completion of associated fish habitat compensation and related monitoring

Applicable VECs	Mitigation
• Commercial Fisheries	• Notification and communication • FLO • SPOC • Safety Zone • Operational Protocols • Fishing Gear Compensation Program • Compliance with *Navigable Waters Protection Act* – Conditions of Approval
Potential Expansion Opportunities	
• Fish and Fish Habitat • Marine Birds • Marine Mammals and Sea Turtles • Species at Risk (Marine Fish and Marine Mammals and Sea Turtles)	• Fish habitat compensation • Efficient Installation with minimal seabed disturbance • Use of best practices, continuous improvement programs and best available technology • Proper release of stranded birds per CWS protocol • Adherence the Section 35(2) *Fisheries Act* Authorization and completion of associated fish habitat compensation and related monitoring
• Commercial Fisheries	• Notification and communication • SPOC • Safety Zone • Operational Protocols • Fishing Gear Compensation Program
Offshore Operations and Maintenance	
• Air Quality and GHG Emissions	• Investigate the use of efficient / reduced emission technology, where appropriate, and where technologically sound and economically justifiable incorporate into the design • Monitor the number of flaring events • Develop and implement standard operating procedures (SOPs) for all chemical handling operations • Vessel and helicopter maintenance
• Fish and Fish Habitat • Marine Birds • Marine Mammals and Sea Turtles • Species at Risk (Marine Fish, Marine Mammals and Sea Turtles and Marine Birds)	• Use of best practices, continuous improvement programs and best available technology • Synthetic-based mud (SBM) reinjection • Adherence to the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011) • Subsurface discharge of wastewater and water-based mud (WBM) cuttings • Proper release of stranded birds per CWS protocol • Helicopters to avoid active marine bird colonies, including Witless Bay Ecological Reserve, and to avoid flying at low altitudes, where possible • Vessels to maintain minimum distance of 2 km from active marine bird colonies, maintain steady course and speed and avoid concentrations of marine birds • Vessels to deviate course to avoid concentrations of marine mammals
• Commercial Fisheries	• Notification and communication • FLO • SPOC • Safety Zone • Operational Protocols • Fishing Gear Compensation Program
Potential Expansion Opportunities	
• Fish and Fish Habitat • Marine Birds • Marine Mammals and	• Use of best practices, continuous improvement programs and best available technology • Adherence to the *Geophysical, Geological, Environmental and*

Applicable VECs	Mitigation
Sea Turtles • Species at Risk (Marine Fish, Marine Mammals and Sea Turtles and Marine Birds)	*Geotechnical Program Guidelines* (C-NLOPB 2011) • Plan surveys to avoid concentrations of members of Alcidae • Proper release of stranded birds per CWS protocol • Subsurface discharge of WBM and SBM cuttings • Temporal avoidance of marine mammals • For seismic surveys minimize sound levels
• Commercial Fisheries	• Notification and communication • FLO • SPOC • Safety Zone • Operational Protocols • Fishing Gear Compensation Program
Decommissioning and Abandonment	
• Air Quality and GHG Emissions	• Vessel and helicopter maintenance
• Fish and Fish Habitat • Marine Birds • Marine Mammals and Sea Turtles • Species at Risk (Marine Fish, Marine Mammals and Sea Turtles and Marine Birds)	• Use of best practices, continuous improvement programs and best available technology • Proper release of stranded birds per CWS protocol • Helicopters to avoid active marine bird colonies, including Witless Bay Ecological Reserve, and to avoid flying at low altitudes, where possible • Vessels to maintain minimum distance of 2 km from active marine bird colonies, maintain steady course and speed and avoid concentrations of marine birds • Helicopters to avoid low overflights when possible • Vessels to avoid animal concentrations when possible and deviate course to avoid animals • Vessels to maintain steady speed and course • Adherence to the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2011)
• Commercial Fisheries	• Notification and communication • FLO • SPOC • Safety Zone • Operational Protocols • Fishing Gear Compensation Program
Accidents, Malfunctions and Unplanned Events	
• Air Quality and GHG Emissions • Fish and Fish Habitat • Marine Birds • Marine Mammals and Sea Turtles • Species at Risk (Marine Fish, Marine Mammals and Sea Turtles and Birds) • Sensitive or Special Areas • Commercial Fisheries	• Train staff in spill prevention and awareness • Spill response equipment • Blowout prevention design • Alert / Emergency Response Contingency Plan • SOPs for oil handling operations • SOPs for chemical handling and storage • Prevention through design standards and maintenance • Oil Spill Response Plan • Adherence with all standard navigation procedures, Transport Canada requirements, Coast Guard requirements and navigation systems • Risk awareness and training, preparation, equipment inventory, prevention, and emergency response drills • Fisheries Compensation Plan • Control and containment of debris

A Project-specific Environmental Management Plan will be developed for the Hebron Project for the Nearshore and Offshore phases.

During construction, ExxonMobil Canada Properties (EMCP) will implement an Environmental Protection Plan (EPP) for all activities at the Bull Arm Site. This EPP will be developed in consultation with regulators and area residents, in particular the commercial fish harvesters.

For offshore drilling and production operations, EMCP will comply with all regulatory requirements respecting environmental protection in accordance with the *Drilling and Production Regulations*, Operations will adhere to C-NLOPB guidance (*e.g.*, *Offshore Waste Treatment Guidelines* (National Energy Board (NEB) *et al.* 2010), *Offshore Chemical Selection Drilling and Production Guidelines* (C-NLOPB and CNSOPB 2011), *Environmental Protection Plan Guidelines* (NEB *et al.* 2011), *Offshore Physical Environmental Guidelines* (NEB *et al.* 2008),).

Prior to commencement of Project activities, EMCP will develop contingency plans that will serve as the guidelines for EMCP's response to an emergency at the Hebron Project. EMCP's emergency response philosophy is to minimize the effect of an emergency on people, environment and the corporation.

Throughout all phases of the Project, EMCP will actively engage stakeholders and community representatives regarding Hebron Project activities.

17.3 Summary of Monitoring and Follow-Up

EMCP will develop and implement environmental effects monitoring (EEM) programs for Nearshore and Offshore activities. These EEM programs will build on the previous Bull Arm (Hibernia) EEM program and the experience of the other three existing offshore production EEM programs. The programs for both nearshore and offshore Project activities will be developed in discussion with federal and provincial regulators, as well as the area fish harvesters, and will be closely linked to the EPP.

EMCP will undertake a fish habitat compensation monitoring program for habitat compensation works offshore and nearshore.

EMCP will use environmental observers to collect data on marine mammals, and possibly marine bird occurrences, as well as to record weather and ice conditions and oversee mitigations such as proper marine bird handling procedures and documentation. An oceanographic monitoring program will also be conducted.

17.4 Conclusions

The Project will benefit from the experience of the existing production projects offshore Newfoundland and Labrador, with respect to many key items, including reducing resource conflicts with commercial fishers, development of effective monitoring programs and effective emergency response planning.

Ecological processes will not be disturbed outside natural variability, and ecosystem structure and function will not be critically affected by the Hebron Project. Most environmental effects are reversible, and of limited duration, magnitude and geographic extent. While significant adverse environmental effects have been predicted for Marine Birds, bird SAR and Sensitive or Special Areas (those located in the nearshore only) in the case of an accidental event, the likelihood of this occurring is considered very low. EMCP will have pollution prevention measures and emergency response procedures in place.

The various routine components and activities associated with the proposed Project are predicted to result in not significant residual adverse environmental effects on Air Quality, Fish and Fish Habitat, Commercial Fisheries, Marine Birds, Marine Mammals and Sea Turtles, Marine SAR and Sensitive or Special Areas.

EMCP acknowledges that the scope of the Project being assessed in this CSR extends over several decades, during which time the regulatory and biophysical environment may change from that assessed in this report. EMCP recognizes the requirement to ensure that the environmental assessment is kept current and valid to support the renewal of any applicable authorizations and/or any important changes in environment or resource use in the Project Areas during that time. During the life of the Project, as authorizations are renewed or new ones are required, EMCP will submit documentation to the C-NLOPB and federal regulatory authorities to confirm that proposed activities are captured within the scope of the Project and that environmental assessment predictions remain valid, including those for Species at Risk.

EMCP is committed to maintaining open communication with regulators and stakeholders and to an adaptive management approach with respect to environmental management of the Hebron Project.

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19 GLOSSARY, ACRONYMS AND ABBREVIATIONS

19.1 Glossary

Word	Definition
Abandonment	The decommissioning of facilities, including the plugging of wells and removal of offshore structures following production of **reserves**
Abiotic	Non-biological; a process not mediated or resulting from the activity of organisms. Ocean currents and weather are examples of abiotic processes
Advection	The process of, or referring to the transport of one fluid mass (air, water) by the movement of another
Aerobic	A process requiring the presence of air or oxygen
Alcids	A group of shorebirds, predominantly of northern coasts, including auks, puffins, murres and guillemots
Anomaly	A geological feature, especially in the subsurface, distinguished by geological, geophysical or geochemical means, that is different from the general surroundings and is often of potential economic value, (*e.g.*, a magnetic anomaly)
Anoxic	Deficient in oxygen
Anthropogenic	Derived or resulting from human activity
Artificial Reef	An underwater artificial structure that provides habitat similar to that provided by a natural reef
Artificial Reef Effect	The effect generated by the placement of an undersea structure in an area where previously there were no similar habitats. Benthic organisms colonize the structure and, subsequently, fish and other organisms are attracted to it in search of food
Astronomical Tides	The alternate rise and fall of the surface of oceans, seas and the bays, rivers, connected with them, caused by the gravitational attraction of the sun and moon
Baleen	Comb-like semi-rigid plates with frayed edges that hang from the roof of a baleen whale's mouth; used when feeding to filter prey from the water
Ballast	(a) A relatively heavy material, such as lead, iron or water, placed in a ship to ensure stability or to maintain the proper draft or trim; (b) To pump seawater into empty fuel tanks of a ship to ensure its stability or suitable draft and trim for seaworthiness
Ballast Water	Water carried in tanks on a vessel (*e.g.*, tanker) to maintain sea-going stability
Barite	A mineral (barium sulphate); used as a weighting material for drilling because of its high specific gravity
Bathymetry	The measurement of depths of water in oceans, seas and lakes; also the information derived from such measurements
Bedrock	A general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material

Word	Definition
Benthos	Marine plants and animals that live on, in, or attached to the ocean bottom
Bentonite	A clay formed from volcanic ash decomposition
Bergy Bit	A piece of floating glacier having a sail greater than 1.5 m but less than 5 m and a water plane area greater than 20 m^2 but less than 300 m^2. Size approximates that of a small house and mass is between 120 and 5,400 t
Bilge	The nearly horizontal part of a ship's bottom
Biocide	A chemical agent that destroys bacteria
Biofouling	The encrustation of submerged structures by barnacles and **molluscs**, seaweeds and other marine life; also known as marine fouling
Biomass	The amount of living matter of a specified type given as a concentration per unit area or volume
Biota	The flora and fauna of a region
Bioturbation	The churning and stirring of a sediment by organisms
Bloom	Rapid growth of a population of **plankton**ic organisms
Blowout	A change in the gas or oil pressure of the well, that cannot be handled by the well's control system, resulting in uncontrolled flow
Blowout Preventer (BOP)	A stack or an assembly of heavy duty valves attached to the top of the casing to control well pressure
Borehole	The hole in the earth made by the drill; the uncased drill hole from the surface to the bottom of the well
By-catch	Organisms that are caught commercially but are not the target species, (*e.g.*, haddock is often a by-catch of the cod fishery)
Caisson	A large-diameter pipe that houses a submudline **wellhead**
Chlorophyll	A green pigment found in all algae and higher plants. Responsible for light capture in **photosynthesis**
Climax	A community that has reached a steady-state under a particular set of environmental conditions
Cobble	A rounded rock fragment between 64 and 256 mm in diameter
Comprehensive Study Report (CSR)	A level of environmental assessment required pursuant to CEAA Sections 16(1)(2)
Continental Shelf	Gently sloping, shallowly submerged marginal zone of the continents extending from the shore to an abrupt increase in bottom inclination; greatest average depth less than 183 m, slope generally less than 1 to 1,000, local relief less than 18.3 m, width ranging from very narrow to more than 320 km
Crude Oil	Unrefined petroleum
Delineation Wells	Wells drilled after the initial exploration well to give a better understanding of the extent and performance of the **reservoir**
Demersal	Referring to animals, usually fish, associated with, but not living on, the sea bottom

Word	Definition
Detrital	Particles occurring in sedimentary rocks that were derived from pre-existing igneous, sedimentary or metamorphic rocks, or other pre-existing material
Detritus	Dead or decaying organic matter, and associated microorganisms that are responsible for its decomposition
Development Application	The official title of all the documentation submitted in support of the development of Hebron Project
Diatoms	Microscopic algae characterized by "pill-box like" cell walls containing silica
Dinoflagellate	A chiefly marine one-celled organism with resemblances to both plants and animals. Hard parts preserved as microfossils are important for dating and correlating Mesozoic and Cenozoic deposits
Drilling Mud	A special mixture of clay, water and chemical additives pumped down the wellbore through the drill pipe and drill bit to cool the rapidly rotating bit, lubricate the drill pipe as it turns in the wellbore, and carry rock cuttings to the surface; may have a **water base** or a **synthetic oil base** fluid
Ecosystem	The complex of a community and its environment functioning as an ecological unit in nature
Endangered	Descriptive of a species that is in danger of extinction within all or part of its range (the region to which it is native)
Environmental Impact Statement (EIS)	A document that attempts to predict the environmental effects a major development might have on the human and natural environments of a given geographic area. An EIS is prepared to enable industry, government and the public to consider the environmental and socio-economic costs and benefits of a development project. Based on the information in the EIS, decisions can be made on whether to proceed with the development project
Epifauna	Benthic animals living attached to or crawling over the bottom
Fault	A fracture or fracture zone along which there has been displacement of the sides relative to each other parallel to the fracture. The displacement may be a few millimetres or many kilometres
Fecundity	Potential reproductive capacity of an organism or population. In fish, fecundity is measured by the number of eggs
Flare	An arrangement of piping and burners used to burn combustible vapours - a part of emergency pressure relief system
Flaring	Disposal of surplus combustible vapours by burning at the discharge of the **flare** tower
Flatfish	Fish with a flattened body and both eyes on one side of the head. Includes plaice, flounder and halibut
Flowline	(a) A pipeline that takes fluids from a single well or a series of wells to a gathering centre. (b) Seabed piping that connects field components such as wells, **manifolds** and **riser** bases
Formation Water	See **produced water**
Geology	The study of the structure, origin, history and development of the Earth
Geostrophic	Pertaining to deflecting force resulting from the Earth's rotation

Word	Definition
Grain	A general term for sedimentary particles of all sizes (from clay to boulders), as used in the expressions “grain size”, “fine-grained” and “coarse-grained”
Gravity Base Structure (GBS)	The base of an offshore drilling and production platform, usually made of concrete, and of such weight that it is held securely on the ocean bottom without the need for piling or anchors
Grey Water	Water that has been used for washing, showers, laundry, or in the galley and contains no hydrocarbons or high concentrations of chemicals
Groundfish	Species of fish that are collected by bottom gear trawls (*e.g.*, cod, haddock and flounder)
Growler	The smallest category of iceberg size, with a sail extending less than 1.5 m above sea level and a water plane area of approximately 20 m^2. Comparable in size to a car and having a mass of less than 120 t
Gyre	Circular movement of water masses
Habitat	The place where an animal or plant lives, often characterized by some physical condition (*e.g.*, stream habitat)
HADD	Harmful alteration, disruption or destruction (of fish habitat)
Hebron Unit	Comprises the four Hebron **Significant Discovery Licences** (SDL 1006, SDL 1007, SDL 1009 and SDL 1010)
Hertz (Hz)	Unit of sound frequency equal to one cycle per second
Heterotrophs	Organisms that receive nourishment by ingesting and breaking down organic matter from the surrounding water
Hurricane	A tropical cyclone with sustained wind speeds over 118 km/h, usually accompanied by rain, thunder and lightning
Hydroids	Typical colonial polyps with variously branched bushy or feathery growths. Each polyp has a crown of tentacles around the mouth
Ichthyoplankton	Collective term for fish eggs and **larvae** when **plankton**ic
ICOADS	International Comprehensive Ocean-Atmosphere Data Set
Inhibitor	A substance that is capable of stopping or retarding a chemical reaction
Injection Water	Water pumped into the formation to maintain **reservoir** pressure (secondary recovery technique); offshore, injection water is filtered seawater treated with **biocides**, an oxygen scavenger and scale **inhibitor**
Interannual	Year-to-year
Isobath	A line on a map or chart connecting points of equal water depth
Isopods	A group of crustaceans
Juvenile	Fish past the larval stage of development, but not yet large enough to be caught in the commercial fishery (*e.g.*, cod remains juvenile for approximately four years)
Larvae	The first immature phases of many animals after hatching of eggs and before assuming the adult form and habit
Manifolds	A piece of equipment where the fluids from several wells are received and combined

Word	Definition
Megaripple	A large, gentle, ripple-like feature composed of sand in subaqueous environments having a wavelength grreater than 1 m or a ripple height greater than 10 cm. Wavelengths reach 100 m and amplitude approximately 0.5 m; may be formed by tidal currents
Mitigation	A procedure designed to reduce or negate the possible harmful effects of a substance or process on a species, habitat or environment
Mollusc	An animal possessing an external or vestigial calcium carbonate shell; including clams, snails and squid
Nursery Area	An area that supports fish during their first year of life
Operations Phase	The period following First Oil until cessation of all oil production from the Hebron Field, includes post-First Oil development drilling, offshore installation activities, production, operations, maintenance, well **abandonment**, decommissioning and removal from the Hebron Field of all facilities, equipment and vessels used in the production system
Operator	When capitalized in this document, refers to ExxonMobil Canada Properties (EMCP)
Pack Ice	Any area of sea ice, except fast ice, composed of a heterogeneous mixture of ice of varying ages and sizes and formed by the packing together of pieces of floating ice
Pebbles	Smooth rounded stones ranging in diameter from 2 to 64 mm
Pelagic Species	Animals which live or feed within the water column
Petroleum	Oil and natural gas
Photosynthesis	The use of the sun by plants to combine water and carbon dioxide into simple sugars
Phytoplankton	**Planktoni**c (*i.e.*, floating or swimming) photosynthesizing organisms that are mostly single-celled, although some are colonial; some are capable of swimming, while others are incapable of independent motion
Plankton	Plant (**phytoplankton**) and animal (invertebrate (**zooplankton**) and fish eggs and **larvae** (**ichthyoplankton**)) organisms that drift with ocean currents
Platform	A large structure used during the development and production phases to support such facilities as the drilling rigs, living quarters, production equipment and helipads
Plume	a column of one fluid or gas moving through another
Polychaete	A marine worm with true body segments and hard spines
Pool	A unique accumulation of **petroleum** whose limits are established by subsurface **geologic** factors
Porosity	The volume of the pore space expressed as a percentage of the total volume of the rock mass
Primary Production	Carbon fixation during **photosynthesis** by plants including **phytoplankton**
Produced Water	Water brought up from hydrocarbon bearing strata during the extraction of oil and/or gas and can include formation water, **injection water**, small volumes of condensed water and trace amounts of treatment chemicals

Word	Definition
Production Platform	An offshore structure equipped to receive oil or gas from offshore wells where primary processing, compression and pumping are carried out before transportation of the oil or gas to shore
Productivity	(a) Production rate of oil, gas or water per unit differential pressure; (b) The rate of production of new **biomass** by populations of organisms
Recruitment	The addition of individuals to a population through reproduction and immigration
Reserves	That part of an identified **resource** from which a usable mineral or energy commodity can be economically and legally extracted at the time of determination
Reservoir	A subsurface rock body in which gas or oil has accumulated; most reservoir rocks are porous and permeable, usually limestones, sandstones or dolomites (or a combination)
Residual Environmental Effect	Those environmental effects remaining after enhancement and **mitigation** measures have been applied
Resource	An initial volume of oil and gas that is estimated to be contained in a **reservoir**
Rig	Refers to the combination of equipment used to drill wells
Riser	A section of pipe involving vertical or near-vertical flow
Satellite	In this document, satellite refers to a remote facility or installation that cannot operate entirely independently of a central facility
Scour	(a) Seafloor trench caused by the ploughing motion of an iceberg grounding on the ocean floor. (b) Seafloor erosion caused by strong currents, resulting in the redeployment of bottom sediments and formation of holes and channels
Sea Ice	Any ice floating in the sea
Sediment	Solid material, both mineral and organic, that is being or has been transported from its site of origin by air, water or ice, and has come to rest on the Earth's surface either above or below sea level
Seismic	Pertaining to, characteristic of or produced by earthquakes or Earth’s vibration
Seismicity	The phenomenon of Earth’s movements; **seismic** activity
Sessile	Organisms that are fixed to substrate
Shuttle Tanker	A ship with large tanks in the hull for carrying oil or water back and forth over a short route
Significant Discovery License (SDL)	The document of title by which lands are held within a Significant Discovery Area. Ownership of a Significant Discovery License must be homogeneous; therefore, there may be several Significant Discovery Licenses comprising a Significant Discovery Area if ownership of the Significant Discovery Area is multi-partied
Silt	A **detrital** particle smaller than a very fine sand grain and larger than coarse clay, having a diameter in the range of 0.004 to 0.0625 mm

Word	Definition
Stock	A species, group or population that maintains and sustains itself over time in a definable area. A stock is characterized by constancy of the genetic information in the gene pool, and constancy of expression of particular characters controlled either genetically or environmentally. Examples include maintenance of colour variations or particular growth rates
Storm Surge	A rise above normal water level due to the action of wind on the water surface and the rise in level because of atmospheric pressure reduction
Stratification	Division of the water column into layers, or strata, because of differences in water density, structure or temperature
Surficial	Characteristic of, pertaining to, formed on, situated at, or occurring on the Earth's surface; especially, consisting of unconsolidated residual, alluvial or glacial deposits lying on the **bedrock**
Tectonic	Of, or relating to the deformation of the Earth's crust; the forces involved in or producing such deformation, and the resulting forms
Template	Template in this context refers to the subsea structure designed to support a collection of wells
Thermocline	A temperature gradient as in a layer of sea water, in which the temperature decrease with depth is greater than that of the overlying and underlying water
Threatened Species	In Canada, an indigenous species that is likely to become endangered if the factors affecting its vulnerability are not reversed
Topside Facilities	All the oil and gas separation, treatment and production equipment and related equipment such as compressors, **flares** and accommodations located on top of an offshore facility
Transshipment Facility	An intermediate onshore facility that receives and stores crude oil from oilfield **shuttle tankers** and subsequently transfers the oil to market via tanker
Tree	a) An arrangement of valves placed on top of a well to control flow from the well b) An arrangement of valves and fittings attached to the tubing head to control flow and provide access to the tubing string (also referred to a an Christmas tree)
Trophic Level	The position an organism occupies in the food web, determined by the number of energy transfer steps needed to get to that point
Tropical Storm	A tropical cyclone with sustained wind speeds from 61 to 118 km/h
Tsunami	A long-period sea wave produced by a submarine earthquake, also known as a **seismic** sea wave. It may travel for thousands of kilometres
Upwelling	Light surface water transported away from a coast (by action of winds parallel to it) and replaced near the coast by heavier subsurface water
Viscosity	The measure of the resistance of a fluid to flow; the lower the viscosity number, the more readily the fluid will flow
Water-based Mud (WBM)	A **drilling mud** in which the continuous phase is water
Water Column	The vertical dimension of a body of water (*i.e.*, the water between a reference point or area on the surface and one located directly below it on the bottom)
Wave Hindcasting	Prediction of waves based on past meteorological conditions

Word	Definition
Well Completion	The final sealing-off of a drilled well from the **borehole** with valving and safety and flow-control devices, following final cementing and perforation of the casing at the production zone and removal of the drilling apparatus from the **borehole**
Wellhead	The equipment installed at the top of the wellbore used to support the casing strings and upon which the **tree** is installed; it controls the rate of flow of liquid and gas from the well
Zooplankton	The animal component of those organisms drifting or weakly swimming in the ocean, largely at the mercy of prevailing currents

Note: Bolded **words within a definition are themselves defined**

19.2 Acronyms

Acronym	Definition
ACAP	Atlantic Coastal Action Program
API	American Petroleum Institute
asl	Above sea level
BIO	Bedford Institute of Oceanography
BOEMRE	US Bureau of Ocean Energy Management, Regulation and Enforcement
BTEX	Benzene, toluene, ethylbenzene, xylene
CAC	Criteria air contaminants
CAPP	Canadian Association of Petroleum Producers
CCG	Canadian Coast Guard
CCME	Canadian Council of Minsters of the Environment
CEAA	*Canadian Environmental Assessment Act*
CEA Agency	Canadian Environmental Assessment Agency
CFU	Compact Flotation Unit
CH_4	Methane
CHS	Canadian Hysrographic Service
CIS	Canadian Ice Service
C-NLOPB	Canada-Newfoundland and Labrador Offshore Petroleum Board
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalents
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPA	Closest Point of Approach
CPAWS	Canadian Parks and Wilderness Society
CSA	*Canada Shipping Act*
CWS	Canadian Wildlife Society
DFO	Fisheries and Oceans Canada

Acronym	Definition
DSM	Drilling Support Module
EBSA	Ecologically and Biological Significant Area
ECM	Environmental Compliance Monitoring
ECRC	Eastern Canada Response Corporation
EEM	Environmental Effects Monitoring
EEZ	Exclusive Economic Zone
EL	Exploration Licence
ENGO	Environmental Non-Governmental Organization
EOC	Emergency Operations Centre
EPP	Environmental Protection Plan
FEED	Front-end Engineering and Design
FFAW	Fish, Food and Allied Workers Union
FGCP	Fishing Gear Compensation Program
FLO	Fisheries Liaison Officer (on-board)
FPSO	Floating Production, Storage and Offloading (facility)
FRCC	Fisheries Resources Conservation Council
GHGs	Greenhouse ggases
GLC	Ground-level concentration
H_2S	Hydrohen sulphide
Hmax	Maximum individual wave height
Hs	Significant Wave Height
HSE	Hibernia South Extension
HUC	Hookup and Commissioning
IBA	Important Bird Area
ICOADS	International Comprehensive Ocean-Atmosphere Data Set
ICS	Incident Command System
IIP	International Ice Patrol
IPCC	Intergovernmental Panel on Climate Change
MANMAR	Manual of Marine Observations
MCP	Marine Code of Practice
MMS	US Minerals Management Service
MODU	Mobile Offshore Drilling Unit
MOU	Memorandum of Understanding
MP / HP	Medium pressure / high pressure
MSL	Mean Sea Level
N_2O	Nitrous oxide
N&C	Notification and Communications
NAAQ	National Ambient Air Quality
NAF	Non-Aqueous Fluid used for drilling (*e.g.*, **SBM**)

Acronym	Definition
NAFO	Northwest Atlantic Fisheries Organization
NAO	North Atlantic Oscillation
NARRT	North American Regional Response Team
NEB	National Energy Board
NLDEC	Newfoundland and Labrador Department of Environment and Conservation
NMCA	National Marine Conservation Area
NMFS	US National Marine Fisheries Service
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
NOAA	US National Oceanic and Atmospheric Administration
NPRI	National Pollutant Release Inventory
OIM	Offshore Installation Manager
OLS	Offshore Loading System
OSC	On-Scene Commander
OSP	Oil Spill Response
OSRP	Oil Spill Response Plan
OWTG	Offshore Waste Treatment Guidelines
PAH	Polycyclic Aromatic Hydrocarbon
PAL	Provincial Aerospace Ltd.
PBGB LOMA	Placentia Bay-Grand Banks (PBGB) Large Ocean Management Area (LOMA)
PM	Particulate Matter
PTS	Permanent Threshold Shift
PWRI	Produced water re-injection
RA	Responsible Authority
REET	Regional Environmental Emergency Team
ROV	Remote Operated Vehicle
RV	Research Vessel
SAR	Species at Risk
SARA	*Species at Risk Act*
SBM	Synthetic-based mud
SO_2	Sulphur dioxide
SOP	Standard Operating Procedure
SPOC	Single Point of Contact
SSH&E	Safety, Security, Health and Environment
THmax	Wave period associated with **Hmax**
Tp	Peak wave period
TPH	Total Petroleum Hydrocarbons
TPM	Total Particulate Matter

Acronym	Definition
TSP	Total Suspended Particulate
TSS	Total Suspended Solids
TTS	Temporary Threshold Shift
UPM	Utilities and Processing Module (Integrated Deck)
VDS	Volatile Deposited Solids
VEC	Valued Ecosystem Component
VFA	Volatile Fatty Acid
VME	Vulnerable Marine Ecosystem
VOC	Volatile Organic Compund
VSP	Vertical Seismic Profile
VTMP	Vessel Traffic Management Plan
WHGBS	Wellhead Gravity-base Structure
WHMIS	Workplace Hazardous Management Information System

19.3 Abbreviations (units of measure)

Abbreviation	Definition
bbl	Barrel (approximately 159 L)
BF	Beaufort Force
cm	centimetre
dB	Decibel
h	Hour
Hz	Hertz
kbd	Thousand barrels per day
kHz	Kilohertz
km	Kilometre
km^2	Square kilometre
km^3	Cubic kilometre
L	Litre
m	Metre
m^3	Cubic metre
m^3/day	Cubic metre per day
Mbbl	Thousand barrels
MBO	Million barrels of oil
mg	Milligram
mg/L	Milligram per Litre
mm	Millimetre
MSCFD	Thousand Standard Cubic Feet Per Day
MW	Megawatt

Abbreviation	Definition
nm	nautical mile
ppb	Parts per billion
ppm	Parts per million
s	Second
t	Metric tonne
µg	Microgram
µm	Micrometre