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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

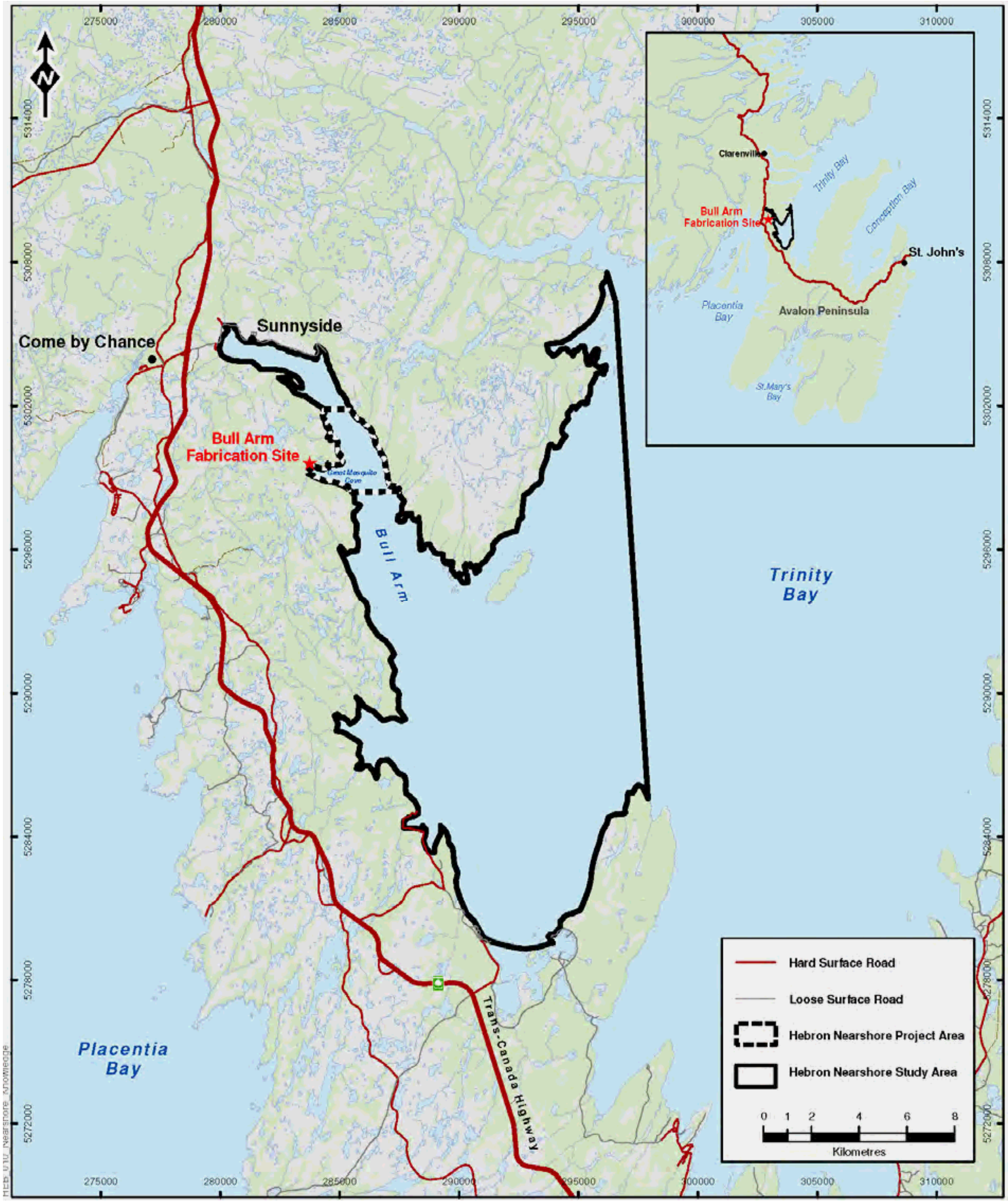


Figure 10-1 Nearshore Study and Project Areas

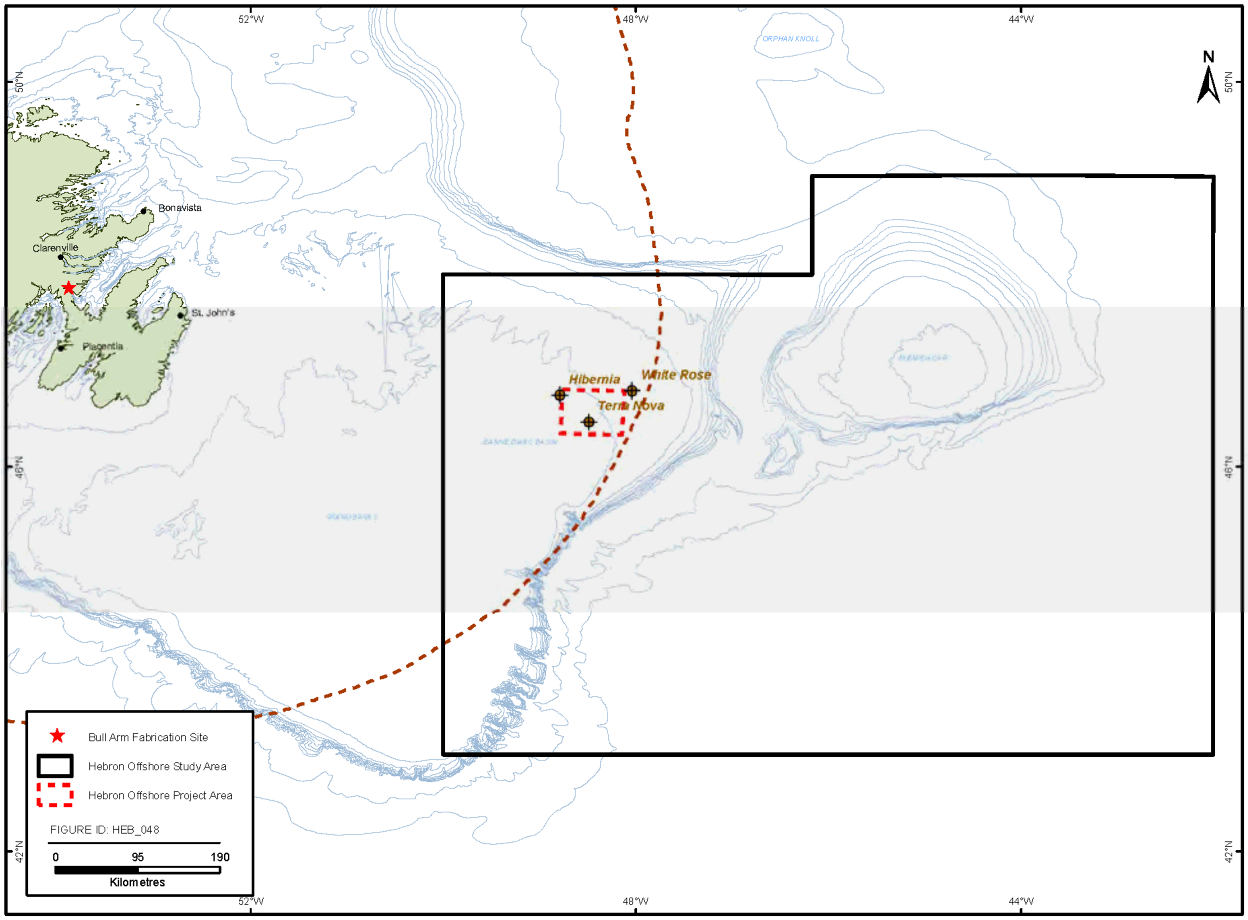


Figure 10-2 Offshore Study and Project Areas

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.

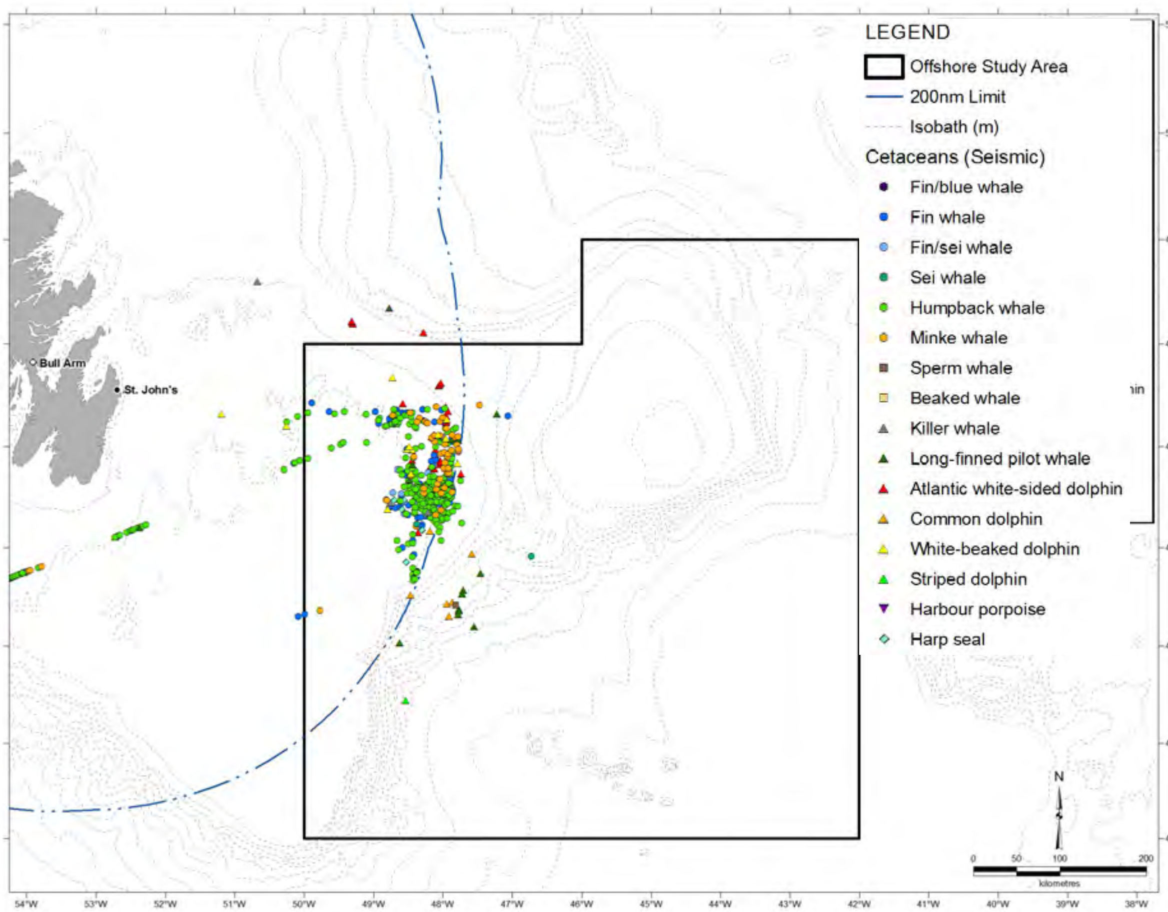


Figure 10-3 Locations of Marine Mammal Sightings Observed during Jeanne d'Arc Basin Seismic Surveys (2005 to 2008), Relative to the Offshore Study Area

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).

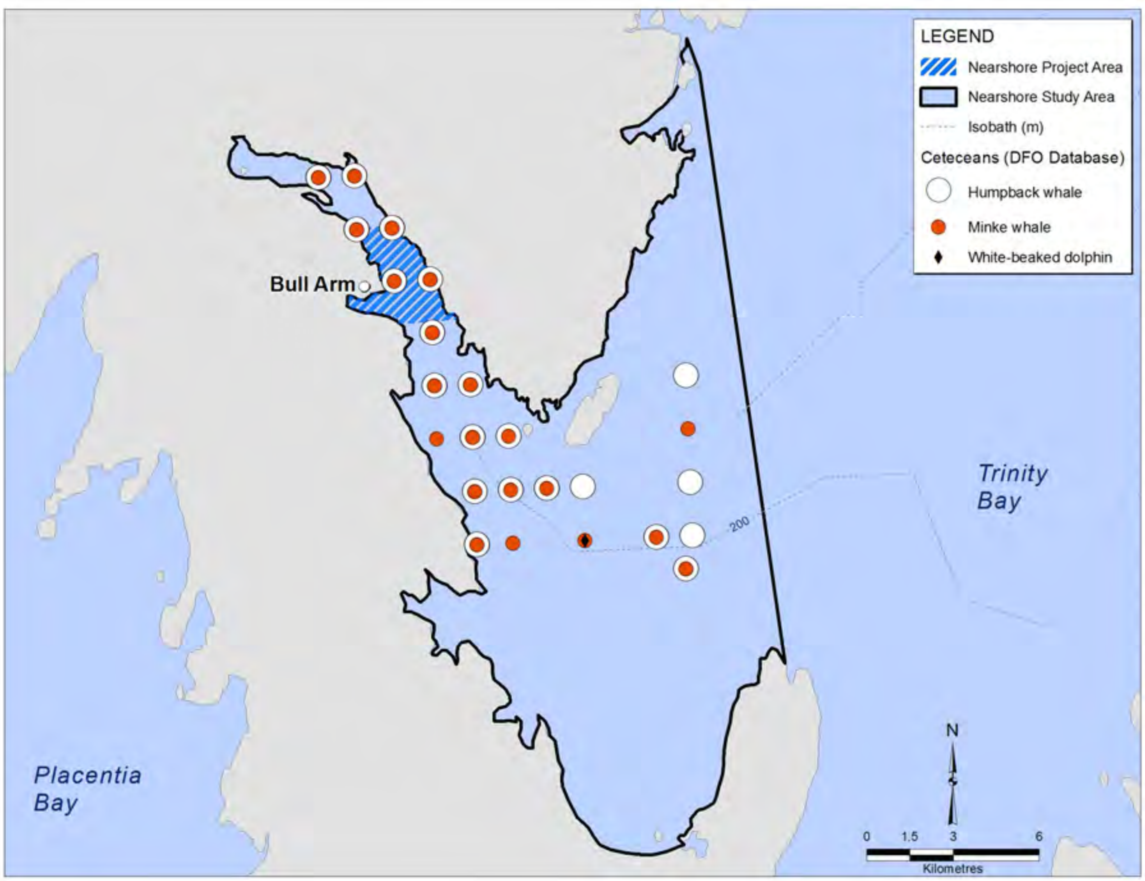


Figure 10-4 Sightings of Cetaceans within the Nearshore Study Area, Based on DFO Cetacean Sighting Database (1945 to 2007)

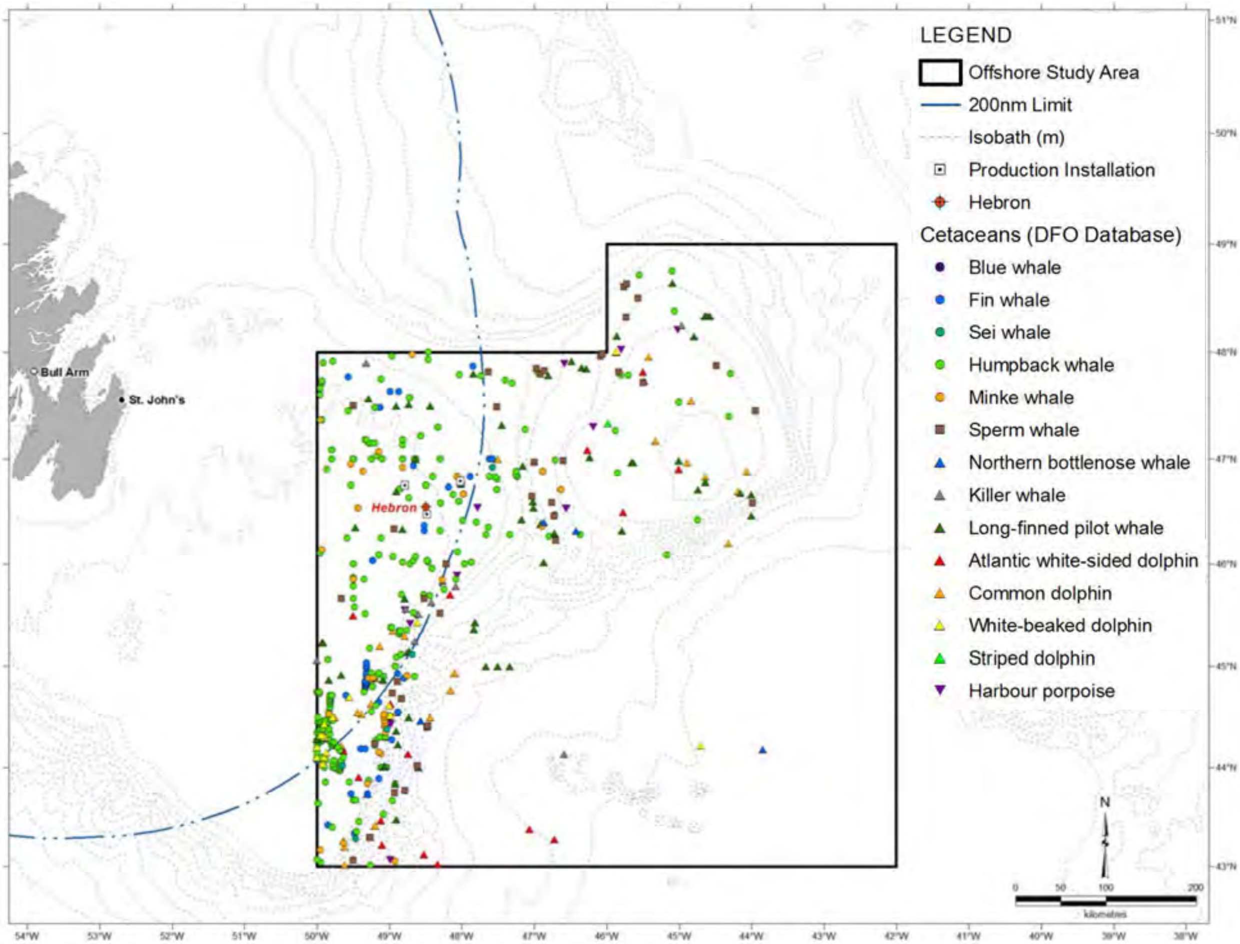


Figure 10-5 Sightings of Cetaceans within the Offshore Study Area, based on DFO Cetacean Sighting Database (1945 to 2007)

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.

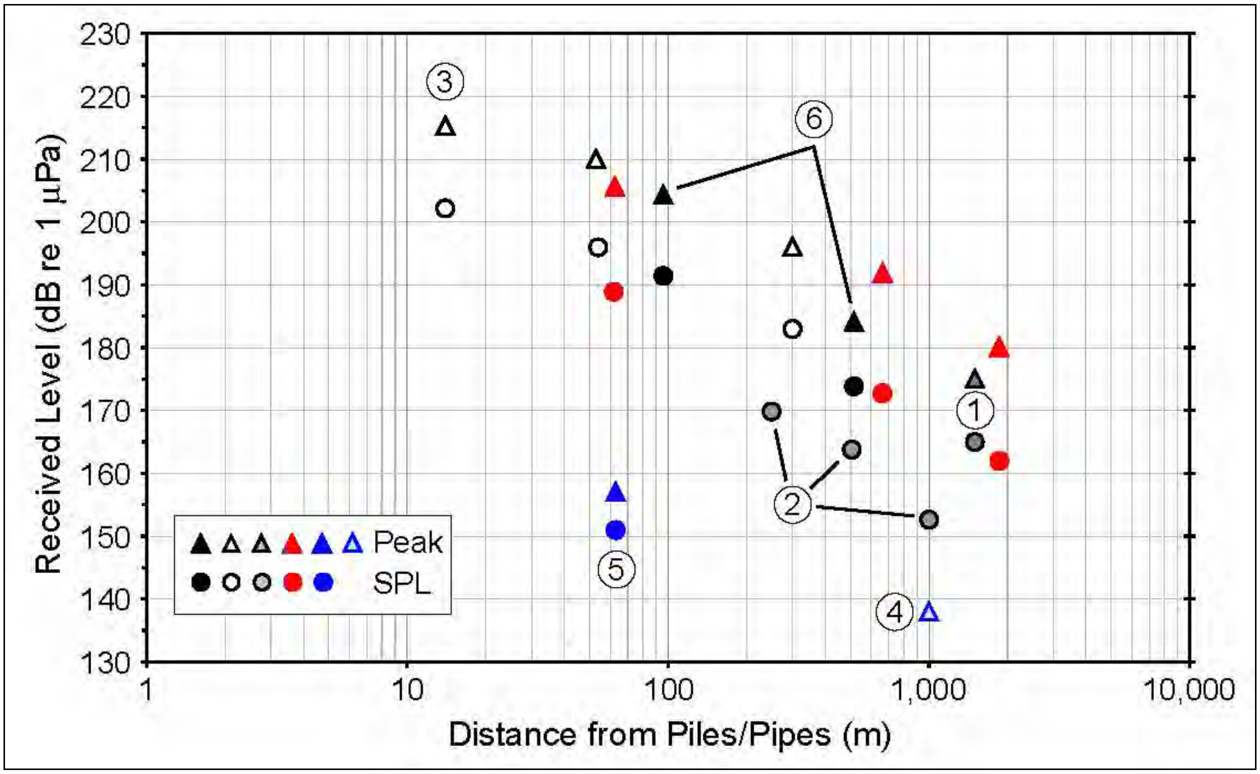
Pile driving produces impulsive sound levels high enough to cause hearing impairment effects, which may result in a change in habitat quality for marine mammals and sea turtles. Sound levels high enough to cause a change in habitat quality typically occur very close to the source.

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 nonresponsive. 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

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Frequency:
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Reversibility:
R = Reversible
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Ecological / Socio-economic Context:
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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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Frequency:
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Reversibility:
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Ecological / Socio-economic Context:
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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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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:	Level of Confidence in the Effect Rating:	Probability of Occurrence of Significant Environmental Effect:
S = Significant Adverse Environmental Effect NS = Not Significant Adverse Environmental Effect	1 = Low level of Confidence 2 = Medium Level of Confidence 3 = High level of Confidence	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.