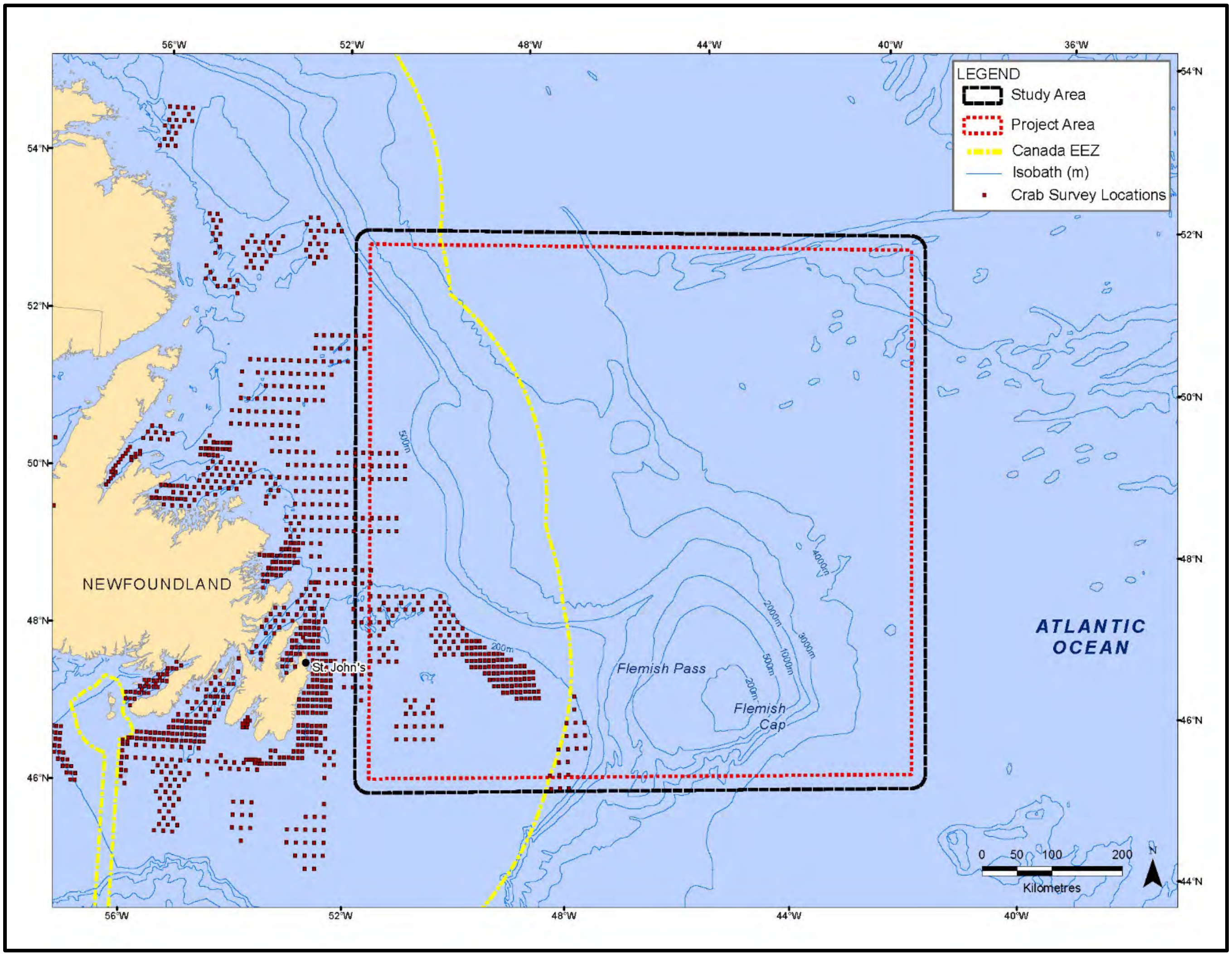



Source: DFO 2014.

**Figure 4.42 Locations of DFO-Industry Collaborative Post-season Snow Crab Trap Survey Stations in Relation to the Study Area and Project Area.**

## 4.4 Seabirds

The eastern Newfoundland offshore area is rich in seabirds year-round. The southward flowing Labrador Current interacts with the continental shelf edge, causing mixing in the water column and creating a productive environment for the growth of plankton. A mixing of currents in the Orphan Basin creates more upwellings and productive conditions for the growth of plankton, the base of a rich oceanic environment. The highly productive Grand Banks support large numbers of seabirds in all seasons (Lock et al. 1994; Fifield et al. 2009). The combination of shelf edges and the Labrador Current flowing through the Study Area create prime conditions for enhanced productivity of plankton, the basis of oceanic food chains.

### 4.4.1 Information Sources

Seabird surveys in the Study Area and surrounding areas have been conducted by the CWS and through oil industry related seabird monitoring. Prior to 2000, seabird surveys were sparse on the Orphan Basin, northern Grand Banks and Flemish Cap. Original baseline information has been collected by the CWS through PIROP (Programme intégré de recherches sur les oiseaux pélagiques). These data have been published for 1969-1983 (Brown 1986) and 1984-1992 (Lock et al. 1994). Since the late 1990s additional seabird observations have been collected on the northeast Grand Banks by the offshore oil and gas industry from drill platforms and supply vessels (Baillie et al. 2005; Burke et al. 2005; Fifield et al. 2009). Seabird surveys were also conducted from vessels conducting geophysical surveys within the Study Area from 2004-2008 as part of marine bird monitoring programs required by the C-NLOPB (Moulton et al. 2005, 2006; Lang et al. 2006; Lang 2007; Lang and Moulton 2008; Abgrall et al. 2008a,b, 2009). In addition, the CWS initiated a program called Eastern Canadian Seabirds at Sea (ECSAS). The Environmental Studies Research Funds (ESRF) combined with CWS to fund a multi-year project focused on improving the knowledge of seabirds at sea on the northern Grand Banks and other areas of oil industry activity in eastern Canada (Fifield et al. 2009). A total of 76 CWS surveys were conducted, including many from the Grand Banks and Orphan Basin. Monthly surveys were conducted in the northeast Grand Banks production area from 2006 to 2009. Survey results from 2010-2014 were not published at the time of writing this EA.

The results from all surveys indicated above were used to describe the abundance, diversity and spatial distribution of seabirds in the Study Area.

### 4.4.2 Summary of Seabirds in the Study Area

During the ECSAS surveys of Newfoundland waters, the Sackville Spur, Orphan Basin and Flemish Pass were all identified as important areas for one or more seabird species/groups during one or more seasons (Fifield et al. 2009). Northern Fulmar and gulls were found in the highest concentrations in the Newfoundland and Labrador shelves region on the Sackville Spur during spring. Significant numbers of these birds were also present in winter. Northern Fulmars, Leach's Storm-petrels and shearwaters were observed during the summer along the southern edge of the Orphan Basin. ECSAS surveys in the Flemish Pass and Flemish Cap indicated local hotspots during winter and spring for Northern Fulmar, Black-legged Kittiwake, Dovekie, gulls (spring only) and murres.

### 4.4.3 Seasonal Occurrence and Abundance

The world range, seasonal occurrence and seasonal abundance of seabirds occurring regularly in the Study Area are described below. Table 4.11 summarizes the predicted abundance status for each species by month. The following four categories that qualitatively define the relative abundance of seabirds are used.

- Common: occurring in moderate to high numbers;
- Uncommon: occurring regularly in small numbers;

- Scarce: a few individuals occurring; and
- Very Scarce: very few individuals.

A species world population estimate is taken into consideration when assessing relative abundance. For example, Great Shearwater is far more numerous on a worldwide scale compared to a predator like the Great Skua. Seasonal occurrence and abundance information was derived from Abgrall et al. (2008a,b), Baillie et al. (2005), Brown (1986), Lang et al. (2006), Lang (2007), Lock et al. (1994), Moulton et al. (2005, 2006) and Fifield et al. (2009).

The predicted monthly relative abundance for each species expected to occur regularly in the Study Area are provided in Table 4.11.

### 4.4.4 Breeding Seabirds in Eastern Newfoundland

Just over five million pairs of seabirds nest on the southeast coast of Labrador and the east coast of Newfoundland. This includes 3.7 million pairs of Leach's Storm-Petrels and 792,000 pairs of Common Murres (Table 4.12). The seabird breeding colonies on Funk Island, Baccalieu Island, the Witless Bay Islands and Cape St. Mary's are among the largest in Atlantic Canada. More than 4.8 million pairs nest at these three locations alone (Table 4.12). This includes the largest Atlantic Canadian colonies of Leach's Storm-petrel (3,336,000 pairs on Baccalieu Island), Common Murre (470,000 pairs on Funk Island), Black-legged Kittiwake (13,950 pairs on Witless Bay Islands), Thick-billed Murre (1,000 pairs at Cape St. Mary's), and Atlantic Puffin (324,650 pairs on Witless Bay Islands). Many of these breeding birds may use the western edge of the Study Area during the breeding season. After the nesting season, breeding seabirds disperse over a large area of the Newfoundland and Labrador offshore area, including the Project's Study Area.

In addition to local breeding birds, there are many non-breeding seabirds that occur within the Study Area during all seasons of the year. A significant portion of the world's population of Great Shearwater migrates to the Grand Banks and eastern Newfoundland to moult and feed during the summer months, after completion of nesting in the Southern Hemisphere (Lock et al. 1994). Depending on the species, seabirds require two to four years to become sexually mature. Many non-breeding sub-adult seabirds, notably Northern Fulmars and Black-legged Kittiwakes, are present on the Grand Banks and Flemish Cap year-round. Large numbers of Arctic-breeding Thick-billed Murre, Dovekie, Northern Fulmar, and Black-legged Kittiwake migrate to eastern Newfoundland, including the Grand Banks and Flemish Cap, to spend the winter.

## Table 4.11 Predicted Monthly Abundances of Seabird Species Occurring in the Study Area.

| Common Name | Scientific Name | Monthly Abundance | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| *Procellariidae* | | | | | | | | | | | | | |
| Northern Fulmar | *Fulmarus glacialis* | C | C | C | C | C | C | C | C | C | C | C | C |
| Great Shearwater | *Puffinus gravis* | | | | | U | C | C | C | C | C | S | |
| Sooty Shearwater | *Puffinus griseus* | | | | | S | U | U | U | U | U | S | |
| Manx Shearwater | *Puffinus puffinus* | | | | | S | S | S | S | S | S | | |
| *Hydrobatidae* | | | | | | | | | | | | | |
| Leach's Storm-Petrel | *Oceanodroma leucorhoa* | | | | U-C | C | C | C | C | C | C | S | |
| Wilson's Storm-Petrel | *Oceanites oceanicus* | | | | | | S | S | S | S | | | |
| *Sulidae* | | | | | | | | | | | | | |
| Northern Gannet | *Morus bassanus* | | | | U | U | U | U | U | U | U | | |
| *Phalaropodinae* | | | | | | | | | | | | | |
| Red Phalarope | *Phalaropus fulicarius* | | | | | S | S | S | S | S | S | | |
| Red-necked Phalarope | *Phalaropus lobatus* | | | | | S | S | S | S | S | | | |
| *Laridae* | | | | | | | | | | | | | |
| Herring Gull | *Larus argentatus* | U | U | U | U | U | S | S | S | S | S | S | S |
| Iceland Gull | *Larus glaucoides* | S | S | S | S | | | | | | S | S | S |
| Lesser Black-backed Gull | *Larus fuscus* | | | | | VS | VS | VS | VS | VS | VS | VS | VS |
| Glaucous Gull | *Larus hyperboreus* | S | S | S | S | | | | | | S | S | S |
| Great Black-backed Gull | *Larus marinus* | U | U | U | U | U | S | S | U | U | U | U | U |
| Ivory Gull | *Pagophila eburnea* | S | S | S | S | | | | | | | | |
| Black-legged Kittiwake | *Rissa tridactyla* | C | C | C | C | C | S | S | S | C | C | C | C |
| Arctic Tern | *Sterna paradisaea* | | | | | S | S | S | S | S | | | |
| *Stercorariidae* | | | | | | | | | | | | | |
| Great Skua | *Stercorarius skua* | | | | | S | S | S | S | S | S | S | |
| South Polar Skua | *Stercorarius maccormicki* | | | | | S | S | S | S | S | S | | |
| Pomarine Jaeger | *Stercorarius pomarinus* | | | | S | S | S | S | S | S | S | | |
| Parasitic Jaeger | *Stercorarius parasiticus* | | | | | S | S | S | S | S | S | | |
| Long-tailed Jaeger | *Stercorarius longicaudus* | | | | | S | S | S | S | S | | | |
| *Alcidae* | | | | | | | | | | | | | |
| Dovekie | *Alle alle* | C | C | C | C | U | VS | VS | VS | S | C | C | C |
| Common Murre | *Uria aalge* | S-U | S-U | S-U | S-U | C | C | C | C | C | C | C | U |
| Thick-billed Murre | *Uria lomvia* | C | C | C | C | C | S | S | S | U | C | C | C |
| Razorbill | *Alca torda* | | | | S | S | S | S | S | S | S | S | |
| Atlantic Puffin | *Fratercula arctica* | S | S | S | U | U | S | S | C | C | C | C | S |

Notes: C = Common, occurring in moderate to high numbers; U = Uncommon, occurring regularly in small numbers; S = Scarce, present, regular in very small numbers; VS = Very Scarce, very few individuals or absent. Blank spaces indicate not expected to occur in that month. Predicted monthly occurrences derived from 2004, 2005, 2006, 2007 and 2008 monitoring studies in the Orphan Basin and Jeanne d'Arc Basin and extrapolation of marine bird distribution at sea in eastern Canada in Brown (1986); Lock et al. (1994) and Fifield et al. (2009).

Sources: Brown (1986); Lock et al. (1994); Baillie et al. (2005); Moulton et al. (2005, 2006); Lang et al. (2006); Lang (2007); Lang and Moulton (2008); Abgrall et al. (2008a,b, 2009.)

## Table 4.12 Number of Pairs of Seabirds Nesting at Colonies in Eastern Newfoundland and Southeast Labrador.

| Species | Gannet Islands | Bird Island | Northern Groais Island | Wadham Islands | Cape Freels and Cabot Island | Funk Island | Baccalieu Island | Witless Bay Islands | Mistaken Point | Cape St. Mary's |
|---|---|---|---|---|---|---|---|---|---|---|
| Northern Fulmar | 16[a] | | | | | 13[a] | | 13[a] | | Present[c] |
| Leach's Storm-Petrel | 20[a] | Present[b] | | 6,000[a] | 250[c] | | 3,336,000 | 314,020[a,d] | | |
| Northern Gannet | | | | | | 6,075[a] | 2,564 | | | 14,789[a] |
| Herring Gull | | | | | | 150[a] | 46 | 2,045[e] | | Present[c] |
| Great Black-backed Gull | 120[a] | 20[b] | | | | 75[a] | 2 | 15[e] | | Present[c] |
| Black-legged Kittiwake | 72[a] | | 2,400[c] | | | 100[a] | 5,096 | 13,950[a] | 4,750[f] | 10,000[c] |
| Common and Arctic Tern | | | | | 250[c] | | | | | |
| Common Murre | 31,170[a] | 3,100[b] | | | 2,600[c] | 470,000[a] | 1,440 | 268,660[a] | 100[f] | 15,484[a] |
| Thick-billed Murre | 1,846[a] | Present[b] | | | | 250[a] | 73 | 240[s] | | 1,000[c] |
| Razorbill | 14,801[a] | 1,530[b] | | 30[a] | 25[c] | 200[a] | 406 | 846[a] | Present[f] | 100[c] |
| Black Guillemot | 110[a] | | | 25[a] | | | 113 | 20[c] | Present[f] | Present[c] |
| Atlantic Puffin | 38,666 | 8,070[b] | | 7,140[a] | 20[c] | 2,000[a] | 45,300 | 324,650[a,] | 50[f] | |
| Total | 86,821 | 12,720 | 2,400 | 13,195 | 3,145 | 478,863 | 3,391,040 | 924,459 | 4,900 | 41,373 |

Sources: [a] EC-CWS, unpubl.data; [b] Important Bird Areas of Canada (www.ibacanada.ca); [c] Cairns et al. (1989); [d] Wilhelm et al. submitted; [e] Bond et al. in press; [f] Parks and Natural Areas (unpubl. data)

#### 4.4.4.1 Procellariidae (Fulmars and Shearwaters)

**Northern Fulmar**

Northern Fulmar is common in the Study Area year-round. The Northern Fulmar breeds in the North Atlantic, North Pacific, and Arctic oceans. In the Atlantic, it winters south to North Carolina and southern Europe (Brown 1986; Lock et al. 1994). Through band recoveries, it is known that most individuals in Newfoundland waters are from Arctic breeding colonies. Adults and sub-adult birds are present in the winter with sub-adults remaining through the summer. About 80 pairs breed in eastern Newfoundland (Stenhouse and Montevecchi 1999; Robertson et al. 2004). During the period 1999 to 2002, fulmars were found to be most numerous on the northeast Grand Banks during spring and autumn (Baillie et al. 2005).

Results from monitoring programs in the Orphan Basin during 2004–2007 indicate that Northern Fulmar was among the top four most abundant seabird species from mid-May to September (Moulton et al. 2006; Abgrall et al. 2008b). Monthly average densities during June, July and August ranged from 1.7 birds/$km^2$ to 4.8 birds/$km^2$. Higher densities were recorded in May and September with 30.1 birds/$km^2$ in May 2005 and 16.1 birds/$km^2$ in September 2005, and 5.8 birds/$km^2$ in September 2006. Results from the Jeanne d'Arc Basin show an average of 5.1 birds/$km^2$ for July and August 2006, 1.2 birds/$km^2$ in late May to September 2008, and 14.7 birds/km in October and early November in 2005 (Abgrall et al. 2008a; Abgrall et al. 2009).

The ECSAS survey data collected in the Study Area during 2006-2009 indicate that Northern Fulmar was present during all survey seasons (spring, summer and winter; Fifield et al. 2009). Densities within the Study Area (considering 1º survey blocks) ranged from 1.0 to 22.4 birds/$km^2$ in spring to 0 to 10.7 birds/$km^2$ in summer, and 0 to 33.7 birds/$km^2$ in winter. High densities were observed along the southern edge of Orphan Basin at the Sackville Spur in winter (Fifield et al. 2009). ECSAS data collected during 2010 to 2013 were obtained from EC-CWS for the Eastern Newfoundland SEA Study Area (C-NLOPB 2014). The data were not yet ready to be used for calculating seabird densities but they do provide additional information on seasonal and spatial trends in abundance for the different seabird groups.

**Great Shearwater**

Great Shearwater migrates north from breeding islands in the South Atlantic, arriving in the Northern Hemisphere during summer. A large percentage of the world population of Great Shearwaters is thought to moult their flight feathers during the summer months while in Newfoundland waters (Brown 1986; Lock et al 1994). Great Shearwater was among the top four most abundant species observed in the Orphan Basin during June to September seismic monitoring, 2004–2007 (Abgrall et al. 2008a; Abgrall et al. 2009). Monthly average densities ranged from 2.4 to 35.4 birds/$km^2$. The highest densities were observed in July and August 2005, averaging 35.4 birds/$km^2$ and 21.2 birds/$km^2$ respectively. Great Shearwater may still be abundant in the Orphan Basin during September where an average density of 9.2 birds/$km^2$ was observed during September 2005. Seismic monitoring in the

Jeanne d'Arc Basin showed Great Shearwater was common during the summer, exhibiting a weekly average densities of 5.1 birds/km$^2$ from 9 July to 16 August 2006 (Abgrall et al. 2008a) and 11.9 birds/km$^2$ from 21 May to 29 September 2008 (Abgrall et al. 2009). The ECSAS survey data collected during 2006 to 2009 aggregate all shearwater species within the Study Area. They indicate densities per 1º survey blocks ranging from 0 to 14.1 birds/ km$^2$ during the May to August period (Fifield et al. 2009).

**Other Shearwaters**

Sooty Shearwater follows movements similar to Great Shearwater but is scarce to uncommon in the Study Area during May to early November. Hedd et al. (2012) tracked Sooty Shearwaters from the nesting colony on the Falkland Islands (south Atlantic) to eastern Newfoundland offshore waters, including the Project's Study Area. Manx Shearwater breeds in the North Atlantic in relatively small worldwide numbers compared to Great Shearwater. It is expected to be scarce in the Study Area during May to October.

#### 4.4.4.2 Hydrobatidae (Storm-petrels)

**Leach's Storm-Petrel**

Leach's Storm-Petrel is common and widespread in offshore waters of Newfoundland from April to early November. Very large numbers nest in eastern Newfoundland with more than 3,300,000 pairs breeding on Baccalieu Island (see Table 4.12). Adults range far from nesting sites on multi-day foraging trips during the breeding season. Leach's Storm-Petrels carrying geolocators were shown to travel up to 1,015±238 km during foraging trips from nesting colonies in Nova Scotia (Pollet et al. 2014). Non-breeding sub-adults remain at sea during the breeding season. Leach's Storm-petrel was among the top four most abundant species observed in the Orphan Basin during May to September seismic monitoring between 2004 and 2007 (Moulton et al. 2006; Abgrall et al. 2008b).

The average monthly density for the period of May to September 2005 was 7.43 birds/km$^2$ (Moulton et al. 2006). The average monthly density during August and September 2006 was 6.1 birds/km$^2$ (Abgrall et al. 2008a), and the average density observed per survey during the period 23 July to 6 September 2007 was 4.3 birds/km$^2$ (Abgrall et al. 2008b). Observed densities of Leach's Storm-petrels were lower during seismic surveys in the Jeanne d'Arc Basin, averaging 0.6 birds/km$^2$ during the 9 July to 16 August 2006 survey period (Abgrall et al. 2008a), and 0.9 birds/km$^2$ during the 21 May to 29 September 2008 survey period (Abgrall et al. 2009). The ECSAS survey data collected during 2006–2009 indicated Study Area storm-petrel densities per 1º survey blocks ranging from 0 to 4.2 birds/km$^2$ during the May to August period (Fifield et al. 2009).

**Wilson's Storm-Petrel**

The Wilson's Storm-petrel migrates north from breeding islands in the South Atlantic to the North Atlantic in the summer months. Newfoundland is at the northern edge of its range. It is expected to be scarce in the Study Area from June to September.

#### 4.4.4.3 Sulidae (Gannets)

**Northern Gannet**

More than 23,000 pairs of Northern Gannet nest on three colonies in eastern Newfoundland (see Table 4.12). Gannets are common near shore and scarce beyond 100 km from shore. The Study Area is beyond the range of most Northern Gannets. Very few were observed during seabird monitoring in the Orphan and Jeanne d'Arc Basins during 2004–2007 (Moulton et al. 2006; Abgrall et al. 2008a,b; Abgrall et al. 2009). This species is expected to be a scarce visitor to the Study Area during the April to October period.

#### 4.4.4.4 Phalaropodinae (Phalaropes)

**Red and Red-necked Phalarope**

The Red Phalarope and Red-necked Phalarope both breed in the Arctic to sub-Arctic regions of North America and Eurasia. They winter at sea, primarily in the Southern Hemisphere. They migrate and feed offshore, including Newfoundland waters, during their spring and autumn migrations. Phalaropes seek out areas of upwelling and convergence where rich sources of zooplankton are found. Very small numbers of migrant Red Phalaropes and Red-necked Phalaropes have been observed in the Orphan Basin and northern Grand Banks during monitoring surveys in 2005–2008 (Abgrall et al. 2008a, 2009). Phalaropes are expected to be scarce in the Study Area during May to October.

#### 4.4.4.5 Laridae (Gulls and Terns)

**Great Black-backed, Herring, Glaucous, Iceland and Lesser Black-backed Gull**

Great Black-backed, Herring, Iceland, Glaucous, and Lesser Black-backed Gulls occur in the Study Area. Great Black-backed Gull and Herring Gull are widespread nesters on the North Atlantic, including Newfoundland and Labrador. Glaucous and Iceland Gulls, which breed at Subarctic and Arctic latitudes, are winter visitors to Newfoundland. Lesser Black-backed Gull is a European gull which is increasing in abundance as a migrant and wintering species in eastern North America.

Great black-backed Gull is usually the most numerous of the large gulls found in the offshore regions of Newfoundland. The Sackville Spur has been identified as an area with a high concentration of large gulls, particularly in late winter and early spring (Fifield et al. 2009). On drilling platforms on the northeast Grand Banks during 1999 to 2002, Great Black-backed Gull was common from September to

February, and nearly absent from March to August (Baillie et al. 2005). A similar pattern was observed by environmental observers on offshore installations on the Terra Nova oil field from 1999 to 2009 (Suncor, unpubl. data). Results from seismic monitoring programs in Jeanne d'Arc Basin indicate that large gulls were most numerous from mid-August to October (Abgrall et al. 2008a; Abgrall et al. 2009). In the Orphan Basin, highest densities of Great Black-backed Gull occurred in September (Moulton et al. 2006; Abgrall et al. 2008b).

The ECSAS survey data collected during 2006–2009 indicate that 'large gulls' were present in the Study Area during all survey seasons (i.e., spring, summer, fall and winter) (Fifield et al. 2009). Densities within the Study Area (considering 1º survey blocks) were highest during the non-breeding season, ranging from 0 to 7.1 birds/km$^2$ in spring and 0 to 3.8 birds/km$^2$ in winter. Herring Gulls were present in consistent numbers throughout the year but in lower numbers than Great Black-backed Gulls. Results from seismic monitoring programs in Jeanne d'Arc Basin between May and October indicated that large gulls were most numerous from mid-August to October (Abgrall et al. 2008a; Abgrall et al. 2009).

**Black-legged Kittiwake**

Black-legged Kittiwake is an abundant species in the North Atlantic. It is a pelagic gull that occurs on land only during the nesting season. Non-breeding sub-adults remain at sea for the first year of life. Black-legged Kittiwake is expected to be present within the Study Area year-round and most numerous during the non-breeding season (August to May). Black-legged Kittiwake is present during all months of the year on the Grand Banks. Observations from the drilling platforms on the northeast Grand Banks during 1999 to 2002 indicated that Black-legged Kittiwakes were present during October to May, but were most abundant during November to December (Baillie et al. 2005). It was among the most abundant species observed by environmental observers on offshore installations on the Terra Nova oil field during the winter months (Suncor, unpubl. data).

Results from monitoring programs in the Orphan Basin during 2004–2007 indicate that Black-legged Kittiwake are uncommon from mid-May to September (Moulton et al. 2006; Abgrall et al. 2008a). The monthly average density during surveys conducted from 14 May to 24 September 2005 was 0.3 birds/km$^2$ (Moulton et al. 2006). Higher densities were recorded in August and September 2006, averaging 3.9 birds/km$^2$ (Abgrall et al. 2008b). The average density during the survey period of 23 July to 6 September 2007 was 0.01 birds/km$^2$ (Abgrall et al. 2008b). Results from monitoring programs in the Jeanne d'Arc Basin indicate an average of 0.01 birds/km$^2$ for July and August 2006, 0.02 birds/km$^2$ for late May to September 2008, and 6.6 birds/km$^2$ in October and early November 2005 (Abgrall et al. 2008a, 2009).

Based on ECSAS survey data collected within the Study Area during 2006–2009, densities of Black-legged Kittiwakes ranged from 0 to 10.2 birds/km$^2$ during the winter period (November to February), 0 to 5.8 birds/km$^2$ during the spring period (March and April), and 0 to 2.1 birds/km$^2$ during the summer period May to August (Fifield et al. 2009).

### Ivory Gull

The Ivory Gull was designated as an endangered species by COSEWIC in April 2006 and was still listed as *endangered* under *SARA* Schedule 1 (COSEWIC 2013a). The Ivory Gull likely occurs in small numbers in the portion of the Study Area north of 50°N during periods when sea ice is present (i.e., late winter and early spring). It probably occurs irregularly south of 50°N among the ice pack during heavier ice years.

### Arctic Tern

Arctic Tern is the only species of tern expected in offshore waters of Newfoundland. It breeds in sub-Arctic to Arctic regions of North America and Eurasia. It winters at sea in the Southern Hemisphere, and migrates in small numbers through the Study Area from May to September. This species is present in such low densities that it is rarely recorded during systematic surveys.

## 4.4.4.6 Stercorariidae (Skuas and Jaegers)

### Great Skua and South Polar Skua

These two skua species occur regularly but in very low densities in offshore waters of Newfoundland during the May to October period. The Great Skua breeds in the Northern Hemisphere in Iceland and northwestern Europe. The South Polar Skua breeds in the Southern Hemisphere from November to March and migrates to the Northern Hemisphere where it occurs from May to October. Identifying skuas to species is difficult at sea. They usually occur where other marine birds are numerous, particularly along shelf edges. Skuas occur in such low densities that they are infrequently recorded during systematic surveys during monitoring programs. Skuas are expected to be scarce in the Study Area from May to early November.

### Pomarine Jaeger, Parasitic Jaeger and Long-tailed Jaeger

All three species of jaeger nest in the Subarctic and Arctic in North America and Eurasia. They winter at sea in the Pacific and Atlantic Oceans. Pomarine and Parasitic Jaegers winter mainly south of 35°N, and Long-tailed Jaegers winter mainly south of the equator. Adults migrate through Newfoundland waters in spring, late summer and fall, while sub-adults migrate only part-way to the breeding grounds and are present in Newfoundland waters all summer. Because of the low densities of jaegers, they are infrequently recorded during systematic surveys. All three jaeger species were observed in low densities during recent monitoring programs in the Orphan Basin and Jeanne d'Arc Basin. Jaegers are expected to be scarce in the Study Area from May to early November.

#### 4.4.4.7 Alcidae (Dovekie, Murres, Black Guillemot, Razorbill and Atlantic Puffin)

There are six species of alcids breeding in the North Atlantic. All of these except for Dovekie nest in large numbers in eastern Newfoundland (see Table 4.12). Dovekies nest primarily in Greenland. Dovekie, Common Murre, Thick-billed Murre, and Atlantic Puffin occur in the Study Area during a large portion of the year. Black Guillemot and Razorbills are more coastal and are expected to be rare within the Study Area.

**Dovekie**

Dovekie breeds in the North Atlantic, primarily in Greenland and eastern Nova Zemlya, Jan Mayen and Franz Josef Land in northern Russia. This species winters at sea as far south as 35°N. The Dovekie is a very abundant bird, with a world population estimated at 30 million (Brown 1986). A large percentage of the Greenland-breeding Dovekies winter in the Northwest Atlantic, mainly off Newfoundland (Brown 1986). The predicted status in the Study Area is common from October to April, uncommon during the end of spring migration in May and at the beginning of fall migration in September, and very scarce during the summer months (June to August). The low numbers of Dovekies observed from the drill platforms on the northeast Grand Banks during 1999 to 2002 was attributed to the difficulty in seeing the small birds from the observation posts (Baillie et al. 2005).

Fort et al. (2013) tracked Dovekies from large breeding colonies along northwestern and east Greenland to wintering areas offshore Newfoundland, where the birds spent the period from early December through April. Some of these birds likely passed through and/or over-wintered in the Study Area.

During seismic monitoring programs in the Orphan Basin in 2005, there was an observed density of 1.3 birds/km$^2$ during the last two weeks of May (Moulton et al. 2006). These were mostly birds flying north in late spring migration. Sightings were rare on the Orphan Basin monitoring programs between mid-June and mid-September (Moulton et al. 2006; Abgrall et al. 2008b).

During seismic monitoring programs in the Jeanne d'Arc Basin in 2005, 2006 and 2008, Dovekies were most numerous in October, averaging 6.6 birds/km$^2$ during 1 October to 8 November 2005 (Abgrall et al. 2008a). Incidental observations of Dovekies during these monitoring programs suggest larger numbers were present than the systematic surveys showed. For example, approximate daily totals from incidental observations were 500 on 3 October, 2,000 on 13 October, and 2,500 on 4 November (Abgrall et al. 2008a).

The ECSAS survey data collected during 2006–2009 indicated Dovekie density ranges per 1º survey blocks within the Study Area of 0 to 22.59 birds/km$^2$ during the spring period (March and April), 0 to 5.17 birds/km$^2$ during the summer (May to August), and 0 to 11.41 birds/km$^2$ during winter (November to February) (Fifield et al. 2009).

## Murres

Since the two species of murre, Common and Thick-billed, are often difficult to differentiate with certainty at sea, they are often aggregated as "murres" during offshore seabird surveys. Common Murre is an abundant breeding species in eastern Newfoundland with just over a 750,000 pairs nesting. Most of these occur at two colonies, Funk Island (470,000 pairs) (EC-CWS, unpubl. data) and the Witless Bay Islands (268,660 pairs) (EC-CWS, unpubl. data) (see Table SB-2). They typically overwinter from eastern Newfoundland south to Massachusetts. Thick-billed Murre is an uncommon breeder in eastern Newfoundland (i.e., 1,500 pairs), with an additional 1,800 pairs breeding off southeast Labrador (Table SB-2). Most nesting by this species occurs much farther north. Newfoundland waters are an important wintering area for many of the two million pairs breeding in Arctic Canada and Greenland.

The ECSAS survey data collected during 2006–2009 indicate murre density ranges (per 1º survey blocks) within the Study Area of 0 to 6.65 birds/km$^2$ during the spring period (March and April), 0 to 6.39 birds/km$^2$ during summer (May to August), and 0 to 9.98 birds/km$^2$ during winter (November to February) (Fifield et al. 2009).

During monitoring surveys in the Orphan Basin in 2005, 2006 and 2007, murres were present in low densities during May to September (Moulton et al. 2006; Abgrall et al. 2008b). For example, during the 14 May to 24 September 2005 survey, average monthly densities for Thick-billed Murre were 0.6 birds/km$^2$ in May and 0.7 birds/km$^2$ in June, but none were observed during July to September (Moulton et al. 2006). During the same survey, observed Common Murre densities were 0.05 birds/km$^2$ in May, 0.06 birds/km$^2$ in June, and 0.14 birds/km$^2$ in July. None were observed during surveys in August and September.

In the Jeanne d'Arc Basin, murres were present in moderate densities during seismic monitoring from 1 October to 8 November 2005. The average densities for this period were 4.11 birds/km$^2$ for Thick-billed Murre, and 0.81 birds/km$^2$ for Common Murre (Abgrall et al. 2008a; Abgrall et al. 2009).

Recent tracking studies of Common and Thick-billed Murres have indicated connections between the Study Area and several murre nesting colonies along the northern and eastern coasts of Canada, including Prince Leopold I (central high arctic), Coats I and East Digges I (northern Hudson Bay), the Minarets (Baffin I), Gannet Is (Labrador), and Funk I and the Witless Bay Is (Newfoundland) (McFarlane Tranquilla et al. 2013). Common Murres spent most of the non-breeding season in or near the Study Area (Hedd et al. 2011; Montevecchi et al. 2012). Some Funk Island parental male Common Murres with fledglings swam through the Orphan Basin during August and September en route to the Southeast Shoal of the Grand Bank (Montevecchi et al. 2012).

## Other Alcids (Atlantic Puffin, Razorbill and Black Guillemot)

There are about 380,000 pairs of Atlantic Puffin nesting in eastern Newfoundland and 47,000 pairs nesting in south east Labrador (see Table 4.12). Atlantic Puffins winter off southern Newfoundland and Nova Scotia, occurring in low densities as far offshore as the Study Area. Non-breeding sub-adults occur throughout the summer whereas adults and juveniles can occur in late summer and fall. Seabird surveys conducted in the Orphan Basin and Jeanne d'Arc Basin during seismic operations in 2004-2008, (mid-May to late September period) indicated very low densities of Atlantic Puffins (Moulton et al. 2006; Abgrall et al. 2008a,b; Abgrall et al. 2009). Monitoring associated with seismic surveying in Jeanne d'Arc Basin during 1 October to 8 November 2005 indicated an average density of 1.46 birds/km$^2$ (Abgrall et al. 2008a). Atlantic Puffin is expected to be scarce in the Study Area during the breeding season (April to August), and scarce to uncommon during the post-breeding season (September to December).

About 1,600 pairs of Razorbill nest in eastern Newfoundland and 16,300 nest off south east Labrador (see Table 4.12). Razorbills tend to occur closer to shore than the murres. Very few were recorded during monitoring programs in the Orphan Basin and Jeanne d'Arc Basin during 2004–2008 between mid-May and early November (Abgrall et al. 2008a,b; Abgrall 2009; Moulton 2006). Razorbill is expected to be very scarce in the Study Area from April to November and absent from December to March.

Black Guillemot is common nearshore in Newfoundland and Labrador but would not be expected as far offshore as the Study Area.

#### 4.4.5 Prey and Foraging Habits

Seabirds in the Study Area consume a variety of prey ranging from small fishes to zooplankton. Different foraging methods include plunge diving from a height of 30 m into the water, feeding on the surface, and sitting on the water then diving. Table 4.13 summarizes the feeding habits of birds expected to occur in the Study Area.

## 4.5 Marine Mammals and Sea Turtles

### 4.5.1 Marine Mammals

Twenty-five marine mammal species are known to occur near or within the Study Area: 19 species of cetaceans (whales, dolphins, and porpoises) and six species of phocids (true seals). However, only 19 of these species (Table 4.14) are expected to regularly occur in the Study Area. Most marine mammals use the area seasonally, and the region likely represents important foraging habitat for many.

## Table 4.13 Foraging Strategy and Prey of Seabirds Likely to Occur in the Study Area.

| Species | Prey | Foraging Strategy | Time with Head Under Water | Depth (m) |
|---|---|---|---|---|
| ***Procellariidae*** | | | | |
| Northern Fulmar | Fish, cephalopods, crustaceans, zooplankton, offal | Surface feeding | Brief | 1-2 |
| Great Shearwater | Fish, cephalopods, crustaceans, zooplankton, offal | Shallow plunging, surface feeding | Brief | Usually <2, recorded maximum of 18. |
| Sooty Shearwater | Fish, cephalopods, crustaceans, zooplankton, offal | Shallow plunging, surface feeding | Brief | Usually <10, maximum recorded 60. |
| Manx Shearwater | Fish, cephalopods, crustaceans, zooplankton, offal | Shallow plunging, surface feeding | Brief | 1-10 |
| ***Hydrobatidae*** | | | | |
| Wilson's Storm-Petrel | Crustaceans, zooplankton | Surface feeding | Brief | <0.5 |
| Leach's Storm-Petrel | Crustaceans, zooplankton | Surface feeding | Brief | <0.5 |
| ***Phalaropodinae*** | | | | |
| Red Phalarope | Zooplankton, crustaceans | Surface feeding | Brief | 0 |
| Red-necked Phalarope | Zooplankton, crustaceans | Surface feeding | Brief | 0 |
| ***Laridae*** | | | | |
| Herring Gull | Fish, crustaceans, offal | Surface feeding, shallow plunging, scavenging | Brief | <0.5 |
| Iceland Gull | Fish, crustaceans, offal | Surface feeding, shallow plunging | Brief | <0.5 |
| Glaucous Gull | Fish, crustaceans, offal | Surface feeding, shallow plunging, scavenging | Brief | <0.5 |
| Great Black-backed Gull | Fish, crustaceans, offal | Surface feeding, shallow plunging, scavenging | Brief | <0.5 |
| Ivory Gull | Fish, crustaceans, offal | Surface feeding, shallow plunging, scavenging | Brief | <0.5 |
| Black-legged Kittiwake | Fish, crustaceans, offal | Surface feeding, shallow plunging | Brief | <0.5 |
| Arctic Tern | Fish, crustaceans, zooplankton | Surface feeding, shallow plunging | Brief | <0.5 |
| ***Stercorariidae*** | | | | |
| Great Skua | Fish, cephalopods, offal | Kleptoparasitism | Brief | <0.5 |
| Pomarine Jaeger | Fish | Kleptoparasitism | Brief | <0.5 |
| Parasitic Jaeger | Fish | Kleptoparasitism | Brief | <0.5 |
| Long-tailed Jaeger | Fish, crustaceans | Kleptoparasitism, surface feeding | Brief | <0.5 |
| ***Alcidae*** | | | | |
| Dovekie | Crustaceans, zooplankton, fish | Pursuit diving | Prolonged | Max 30, average is <30 |
| Common Murre | Fish, crustaceans, zooplankton | Pursuit diving | Prolonged | Max 100, average 20-50 |
| Thick-billed Murre | Fish, crustaceans, zooplankton | Pursuit diving | Prolonged | Max 100, average 20-60 |
| Razorbill | Fish, crustaceans, zooplankton | Pursuit diving | Prolonged | Max 120, average 25 |
| Atlantic Puffin | Fish, crustaceans, zooplankton | Pursuit diving | Prolonged | Max 60, average <60 |

Sources: Cramp and Simmons (1983); Nettleship and Birkhead (1985); Lock et al. (1994).

## Table 4.14 Marine Mammals with Reasonable Likelihood of Occurrence in the Study Area.

| Species | Study Area | | Habitat | *SARA* Status[a] | COSEWIC Status[b] |
|---|---|---|---|---|---|
| | Occurrence | Season | | | |
| ***Baleen Whales (Mysticetes)*** | | | | | |
| North Atlantic right whale (*Eubalaena glacialis*) | Extremely Rare | Summer | Coastal, shelf & pelagic | Schedule 1: Endangered | E |
| Humpback whale (*Megaptera novaengliae*) | Common | Year-round, but mostly May–Sept | Coastal & banks | Schedule 3: Special Concern | NAR |
| Minke whale (*Balaenoptera acutorostrata*) | Common | Year-round, but mostly May–Oct | Shelf, banks & coastal | NS | NAR |
| Sei whale (*Balaenoptera borealis*) | Uncommon | May–Nov? | Pelagic | NS | DD; HPC |
| Fin whale (*Balaenoptera physalus*) | Common | Year-round, but mostly summer | Shelf breaks, banks & pelagic | Schedule 1: Special Concern | SC |
| Blue whale (*Balaenoptera musculus*) | Rare | Year-round | Pelagic & coastal | Schedule 1: Endangered | E |
| ***Toothed Whales (Odontocetes)*** | | | | | |
| Sperm whale (*Physeter macrocephalus*) | Common | Year-round, but mostly summer | Pelagic, slope & canyons | NS | NAR; MPC |
| Northern bottlenose whale (*Hyperoodon ampullatus*) | Uncommon | Year-round | Pelagic, slope & canyons | Schedule 1: Endangered[c] / NS[d] | E[c] / SC[d] |
| Sowerby's beaked whale (*Mesoplodon bidens*) | Rare | Summer? | Pelagic, slope & canyons | Schedule 1: Special Concern | SC |
| Striped dolphin (*Stenella coeruleoalba*) | Rare | Summer? | Shelf & pelagic | NS | NAR |
| Short-beaked common dolphin (*Delphinus delphis*) | Common | Summer | Pelagic & shelf | NS | NAR |
| White-beaked dolphin (*Lagenorhynchus albirostris*) | Uncommon | Year-round, but mostly June–Sept. | Pelagic & shelf | NS | NAR |
| Atlantic white-sided dolphin (*Lagenorhynchus acutus*) | Common | Year-round, but mostly summer–fall. | Coastal & shelf | NS | NAR |
| Killer whale (*Orcinus orca*) | Uncommon | Year-round | Widely distributed | NS | SC |
| Long-finned pilot whale (*Globicephala melas*) | Common | Year-round, but mostly spring–fall | Pelagic, shelf break & slope | NS | NAR |
| Harbour porpoise (*Phocoena phocoena*) | Uncommon | Year-round, but mostly spring–fall | Shelf, coastal & pelagic | Schedule 2: Threatened | SC |
| ***True Seals (Phocids)*** | | | | | |
| Harp seal (*Pagophilus groenlandicus*) | Uncommon | Year-round, but mostly winter–spring | Pack ice & pelagic | NS | NC; HPC |
| Hooded Seal (*Cystophora cristata*) | Uncommon | Year-round, but mostly winter–spring | Pack ice & pelagic | NS | NAR; HPC |
| Grey seal (*Halichoerus grypus*) | Uncommon | Year-round, but mostly summer | Coastal & shelf | NS | NAR |

Notes: ? indicates uncertainty.

[a] Species designation under the *Species at Risk Act* (GC 2015); NS = No Status.

[b] Species designation by COSEWIC (Committee on the Status of Endangered Wildlife in Canada; COSEWIC 2015); 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] Scotian Shelf population.

[d] Davis Strait-Baffin Bay-Labrador Sea population.

Marine mammal occurrence and sightings data within and near the Study Area were described in the Eastern Newfoundland SEA (C-NLOPB 2014). Other sources of relevant marine mammal information and sightings summaries include the Orphan Basin SEA (LGL 2003), and recent geophysical and drilling EAs and associated amendments (Buchanan et al. 2004; Moulton et al. 2005; LGL 2005, 2008, 2009, 2011a,b, 2012a,b, 2013a,b, 2014b). DFO research and scientific documents and COSEWIC species assessment and status reports also served as primary sources of information on the occurrence, distribution, and abundance of marine mammals in the Study Area. Historical and more recent sightings of cetaceans within Newfoundland and Labrador waters have been compiled and made available by DFO in St. John's (see Section 4.5.1.1).

Information on the occurrence, habitat, and conservation status for each of the cetacean and pinniped species that could occur near the Study Area is presented in Table 4.14 above. Six of the marine mammals that have been recorded near or within the Study Area are unlikely to occur, and are thus only briefly mentioned here:

- The common bottlenose dolphin (*Tursiops truncatus*) ranges worldwide in tropical and temperate waters (Jefferson et al. 2008). There was a single sighting of 15 bottlenose dolphins in the Orphan Basin in September 2005 (Moulton et al. 2006).
- The beluga (*Delphinapterus leucas*) is an occasional visitor to the waters around Newfoundland and Labrador; sightings have usually been of lone juveniles, but rare groups of hundreds have also been observed (DFO 2014e). These whales may come from any of the seven distinct populations of belugas in Canada (COSEWIC 2004), but genetics testing has revealed that to date, none have come from the nearby St. Lawrence Estuary population (DFO 2014).
- Risso's dolphin (*Grampus griseus*) ranges north into southern Newfoundland and Labrador, but strongly prefers mid-temperate waters of the continental shelf and slope between 30° and 45° latitude (Jefferson et al. 2014). Risso's dolphins are considered rare in Atlantic Canada (Baird and Stacey 1991).
- The harbour seal (*Phoca vitulina*) is present in discrete pockets along the coasts of Newfoundland (Boulva and McLaren 1979; Sjare et al. 2005). Although it is widely distributed in the northern hemisphere, it is generally restricted to coastal waters (Jefferson et al. 2008).
- The ringed seal (*Pusa hispida*) is a year-round resident in the Arctic and its distribution is strongly correlated with pack and land-fast ice because it hauls out on ice to breed, moult, and rest (Jefferson et al. 2008). The southern range of the ringed seal extends to the coasts of Labrador and northern Newfoundland, where it most commonly occurs from November to January (Brattey and Stenson 1993; Stenson 1994).
- The bearded seal (*Erignathus barbatus*) has a patchy circumpolar distribution as far north as 85°N (Burns 1981). Its southern range extends south to the coasts of Labrador and northern Newfoundland, where it is solitary and thought to be relatively rare (Brattey and Stenson 1993; Stenson 1994).

#### 4.5.1.1 DFO Sightings Database

A large database of cetacean and sea turtle sightings in Newfoundland and Labrador waters has been compiled from various sources by DFO in St. John's (J. Lawson, DFO Research Scientist, pers. comm., 2015), and has been made available for the purposes of describing species sightings within the Study Area. These data have been opportunistically gathered and have no indication of survey effort. Therefore, while these data can be used to indicate what species may occur in the Study Area, they cannot be used to predict species abundance, distribution, or fine-scale habitat use in the area.

The following *caveats* should be considered when using data from the DFO sightings database:

- 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 vessel-based platforms of opportunity. The inherent problems with negative or positive reactions by cetaceans to the approach of vessels have not been factored into the data;
- Sighting effort has not been quantified (i.e., numbers cannot be used to estimate true species density or abundance for an area);
- 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);
- These data represent an amalgamation of sightings from a variety of years and seasons. Effort (and number of sightings) is not consistent among months, years, and areas; and there are some large gaps between years. Therefore, apparent patterns with season, depth, and distribution should be interpreted with caution; and
- Many sightings could not be identified to species, but are listed to the smallest taxonomic group possible.

Cetacean sightings in the Study Area compiled from the DFO sightings database are summarized in Table 4.15. Sighting dates ranged from 1947 to 2006, and sightings included baleen whales (Figure 4.43), large toothed whales (Figure 4.44), and dolphins and porpoises (Figure 4.45).

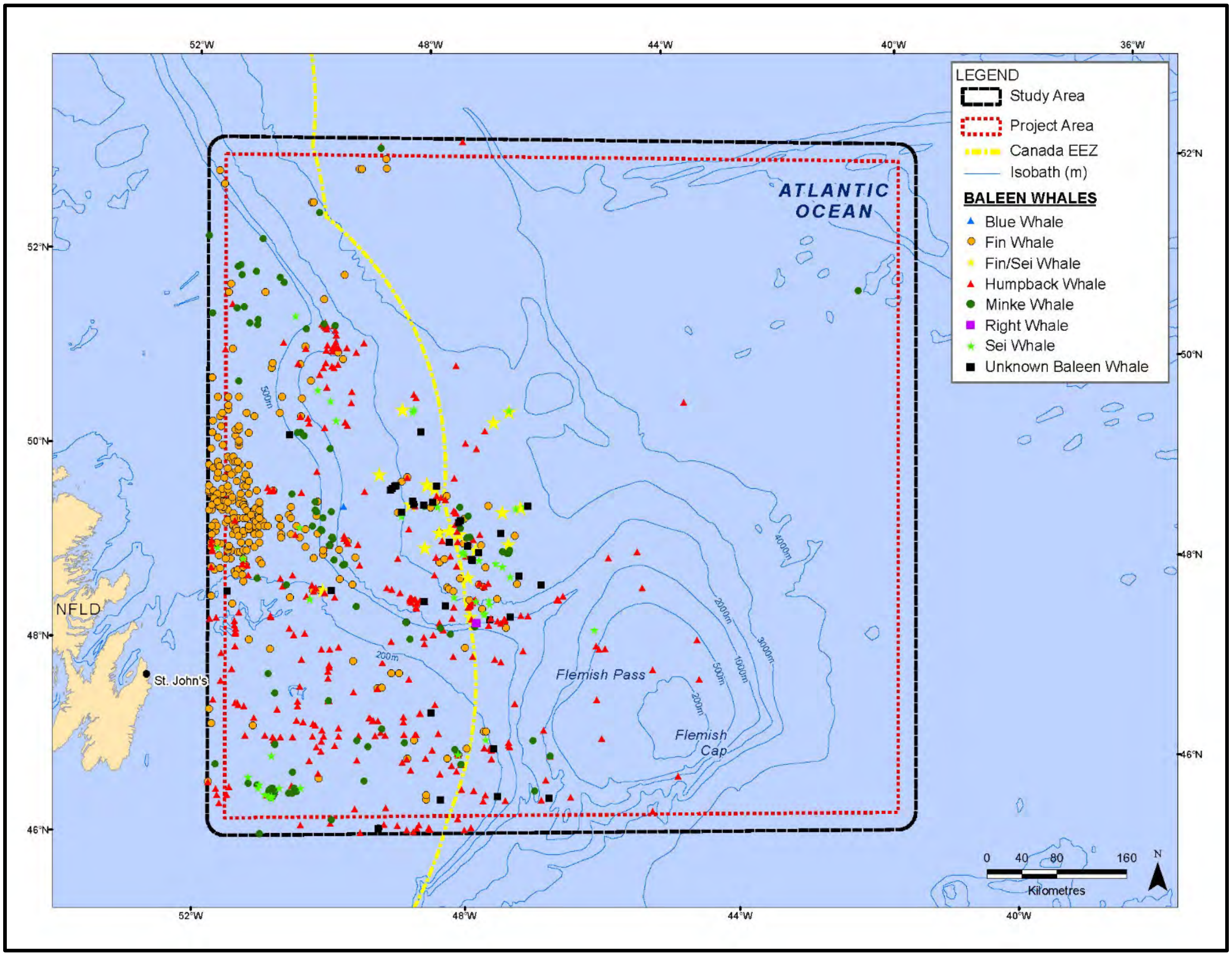
#### 4.5.1.2 Baleen Whales (Mysticetes)

Six species of baleen whales are known to occur in the Study Area, four of which occur regularly (see Table 4.13). Given that blue whales and North Atlantic right whales are listed as *endangered* on Schedule 1 of *SARA*, these species are described in the Species at Risk section (Section 4.6). Although some individual baleen whales may be present in offshore waters of Newfoundland and Labrador year-round, most baleen whale species presumably migrate to lower latitudes during winter months (references in C-NLOPB 2014).

**Table 4.15 Cetacean Sightings in the Study Area, compiled from the DFO sightings database.**

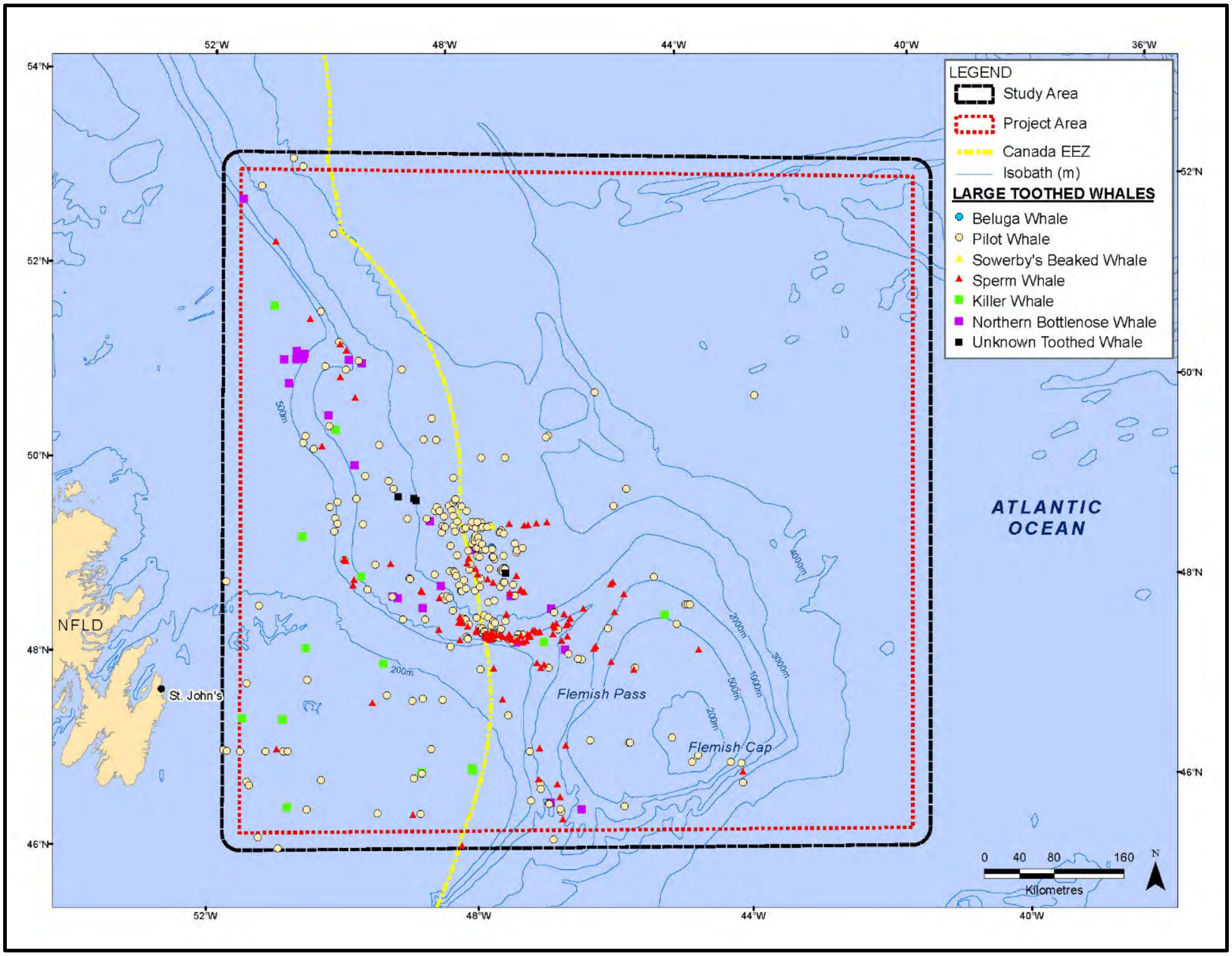
| Species | Number of Sightings | Number of Individuals | Months Sighted |
|---|---|---|---|
| **Mysticetes** | | | |
| North Atlantic Right Whale | 1 | 2 | June |
| Humpback whale | 512 | 1,659 | Jan–Dec |
| Minke whale | 191 | 373 | Jan, Mar–Dec |
| Sei whale | 49 | 87 | May–Sept, Nov |
| Fin whale | 412 | 539 | Apr–Dec |
| Sei/Fin whale | 19 | 26 | June–Sept |
| Blue whale | 1 | 1 | Apr |
| *Balaenoptera* sp. | 3 | 11 | May |
| Unidentified baleen whale | 33 | 45 | June–Oct |
| **Odontocetes** | | | |
| Sperm whale | 127 | 291 | Jan–Dec |
| Northern bottlenose whale | 26 | 84 | May–Oct |
| Sowerby's beaked whale | 1 | 4 | Sept |
| Beluga | 1 | 1 | July |
| Bottlenose dolphin | 1 | 15 | Sept |
| Striped dolphin | 4 | 19 | Aug, Sept |
| Common dolphin | 29 | 877 | Mar, July–Oct, Dec |
| White-beaked dolphin | 15 | 96 | Mar, May–Aug, Oct |
| Atlantic white-sided dolphin | 39 | 864 | Feb, Apr–Oct |
| False killer whale | 1 | 2 | June |
| Killer whale | 21 | 137 | Mar, May–Oct |
| Pilot whale | 302 | 5,532 | Jan–Dec |
| Harbour Porpoise | 38 | 381 | Feb, Mar, May–Oct |
| *Stenella* sp. | 1 | 1 | Oct |
| Unidentified dolphin | 190 | 2,679 | Jan–Dec |
| Unidentified porpoise | 4 | 12 | Feb, Mar, Sept |
| Unidentified toothed whale | 4 | 20 | July–Sept |
| **Other** | | | |
| Unidentified large whale | 123 | 260 | Jan–Dec |
| Unidentified medium whale | 2 | 3 | Aug, Oct |
| Unidentified small whale | 5 | 8 | May, June, Sept |
| Unidentified whale | 222 | 394 | Jan–Dec |
| Unidentified cetacean | 10 | 33 | May, Aug, Sept |

Note: see Section 4.3.1.1 for description of DFO sightings database and *caveats* associated with these data.



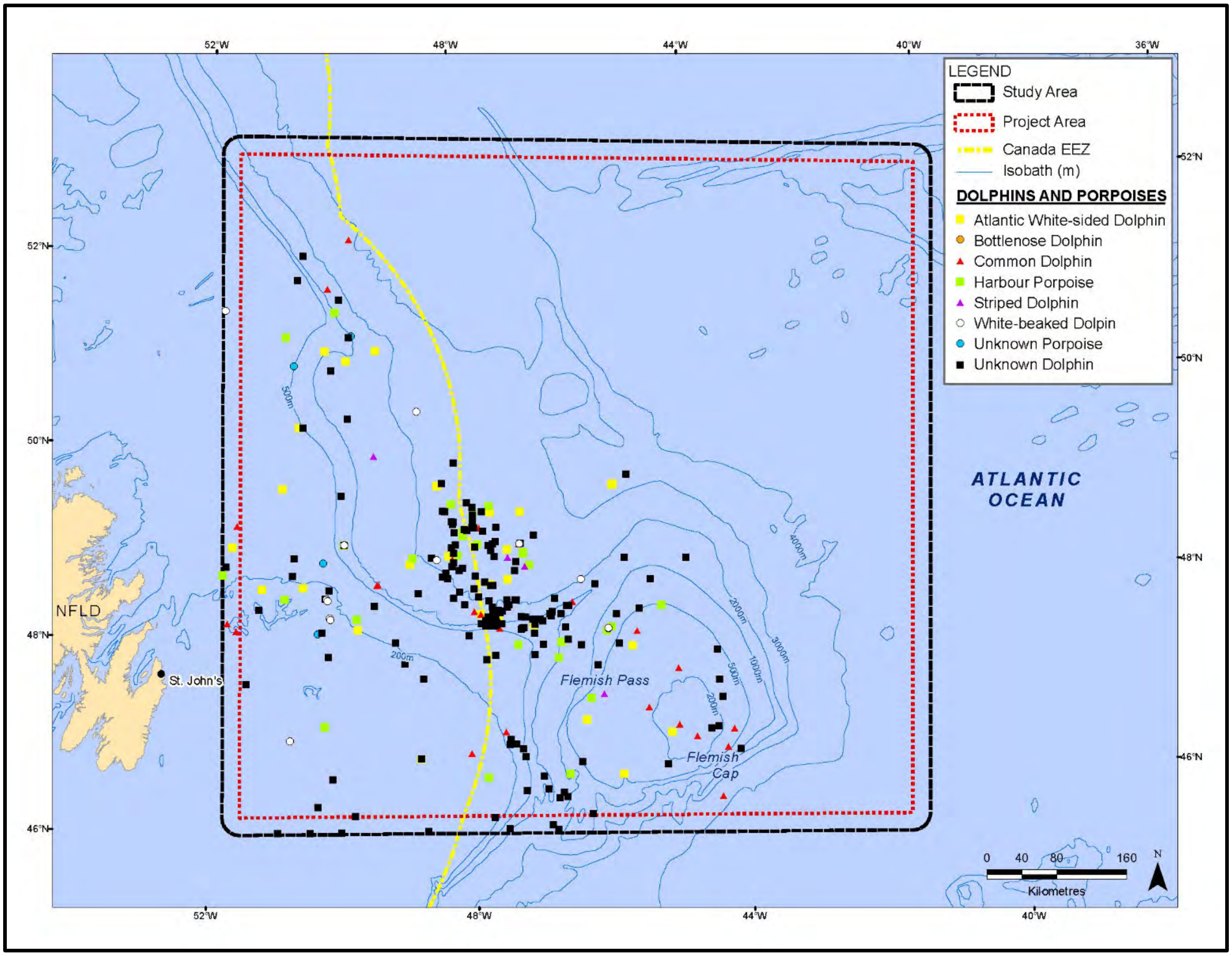

Data source: DFO cetacean sightings database, see text for description of data and *caveats* associated with these data.

**Figure 4.43 Baleen Whale Sightings in the Study Area.**




Data source: DFO cetacean sightings database, see text for description and caveats associated with these data.

**Figure 4.44 Toothed Whale Sightings in the Study Area.**




Data source: DFO cetacean sightings database, see text for description and caveats associated with these data.

**Figure 4.45 Dolphin and Porpoise Sightings in the Study Area.**

### Humpback Whale

The humpback whale is cosmopolitan in distribution and is most common over the continental shelf and in coastal areas (Jefferson et al. 2008). In the North Atlantic, humpback whales migrate annually from high-latitude foraging areas in the summer to breeding grounds in the West Indies in winter (Clapham et al. 1993; Stevick et al. 1998; Kennedy et al. 2014). Clapham et al. (1993) noted that not all individuals migrate to the tropics each year; some presumably remain near their foraging grounds in high and mid-latitudes during winter. Four feeding aggregations of North Atlantic humpbacks have been identified: the Gulf of Maine, eastern Canada, West Greenland, and the eastern North Atlantic (Stevick et al. 2006).

There are an estimated 11,570 humpback whales in the North Atlantic (Stevick et al. 2003). Lawson and Gosselin (2009) provided an abundance estimate of 1,427 humpback whales for Newfoundland based on aerial surveys conducted off the southern and eastern coast; when corrected for perception and availability biases, abundance was estimated at 3,712 whales (Lawson and Gosselin, unpublished data). The humpback whale is listed as *special concern* under *SARA* (Schedule 3; GC 2015) and in considered *not at risk* by COSEWIC (COSEWIC 2003a). Most large whale entanglements in Newfoundland and Labrador involve humpback whales (Benjamins et al. 2012).

Humpback whales are common over the banks and nearshore areas of Newfoundland and Labrador from June through September, sometimes forming large aggregations to feed primarily on spawning capelin, sand lance, and krill (Whitehead and Glass 1985; Piatt and Methven 1992; Kingsley and Reeves 1998). Davoren (2013) reported several humpback whale hotspots off northeastern Newfoundland that were associated with capelin spawning. Two humpbacks outfitted with satellite transmitters near the Dominican Republic travelled near or within the Study Area: one whale was recorded on the eastern edge of Cabot Strait in May 2011, and a second whale was recorded on the Grand Banks in June 2012 (Kennedy et al. 2014). Humpbacks are the most commonly recorded mysticete in the Study Area in the DFO sightings database, with sightings occurring year-round (see Table 4.15; Figure 4.43), but predominantly during summer. Humpback whales are likely to be common within the Study Area.

**Minke Whale**

The minke whale has a cosmopolitan distribution that spans polar, temperate, and tropical regions (Jefferson et al. 2008). Four stocks are recognized in the North Atlantic: the Canadian East Coast, west Greenland, central North Atlantic, and Northeast Atlantic (Donovan 1991). However, DNA data suggest that there may be as few as two stocks in the North Atlantic (Anderwald et al. 2011). There are an estimated 20,741 individuals (CV = 0.30) in the Canadian east coast stock, which ranges from the Gulf of Mexico to Davis Strait (Waring et al. 2013). Lawson and Gosselin (2009) provided an abundance estimate of 1,315 minke whales for Newfoundland, based on aerial surveys conducted off the southern and eastern coast; when corrected for perception and availability biases, abundance was estimated to be 4,691 whales (Lawson and Gosselin, unpublished data). The minke whale has no status under *SARA* (GC 2015) and is considered *not at risk* in Atlantic Canada by COSEWIC (COSEWIC 2015).

The minke whale is common over the banks and coastal regions of Newfoundland and Labrador from early spring to fall, arriving as early as April and remaining as late as October and November. Minke whales tend to forage in continental shelf waters on small schooling fish like capelin and sand lance, making relatively short duration dives (Stewart and Leatherwood 1985). Minke whales are the third most commonly recorded mysticete in the Study Area in the DFO sightings database, with sightings predominantly recorded during summer months (see Table 4.15; Figure 4.43). Thirty-one sightings of minke whales were recorded in Jeanne d'Arc Basin during the Statoil/Husky seismic monitoring program in 2008 (Abgrall et al. 2009). Minke whales are likely to be common, at least seasonally, within the Study Area.

**Sei Whale**

The sei whale is an oceanic species, and appears to prefer mid latitude temperate waters (Jefferson et al. 2008). Sei whales migrate to higher latitude waters in summer to forage. Satellite telemetry data has shown that sei whales migrate from the southeast North Atlantic to the Labrador Sea where they display behaviour consistent with foraging, suggesting that the Labrador Sea is an important feeding ground (Olsen et al. 2009; Prieto et al. 2010, 2014). Two stocks of sei whales are currently considered to occur in eastern Canada, on the Scotian Shelf and in the Labrador Sea, although there is limited evidence supporting the definition of the Labrador Sea stock (COSEWIC 2003b). The best estimate of abundance for the Nova Scotia stock of sei whales is 357 (CV = 0.52; Waring et al. 2013). In the Canadian Atlantic, the sei whale has no status under *SARA* (GC 2015) and is considered *data deficient* by COSEWIC (COSEWIC 2003b).

Sei whales appear to prefer offshore, pelagic, deep areas that are often associated with the shelf edge, seamounts, and canyons (Kenney and Winn 1987; Gregr and Trites 2001; COSEWIC 2003b). Sei whales were occasionally sighted in the Orphan Basin during the seismic monitoring programs in 2004 and 2005 (6 and 15 sightings, respectively; Moulton et al. 2005, 2006), and one sei whale sighting was recorded in Jeanne d'Arc Basin during the Statoil/Husky seismic monitoring program in 2008 (Abgrall et al. 2009). One of the sei whales tagged during the Prieto et al. (2010) study spent up to 96 h near the middle of the Study Area en route to the Labrador Sea. There are 49 sightings for a total of 87 sei whales in the Study Area in the DFO sightings database; sightings occurred from May to November (see Table 4.15; Figure 4.43). Sei whales are likely to be uncommon in the Study Area.

**Fin Whale**

The fin whale is distributed throughout the world's oceans, but is most common in temperate and polar waters (Jefferson et al. 2008). It was heavily targeted by commercial whalers in Newfoundland and Labrador but continues to regularly occur there, particularly during summer months. The current estimate for the western North Atlantic stock is 3,522 individuals (CV = 0.27; Waring et al. 2013). Lawson and Gosselin (2009) provided an abundance estimate of 890 fin whales for Newfoundland, based on aerial surveys conducted off the southern and eastern coast; when corrected for perception and availability biases, abundance was estimated at 1,555 fin whales (Lawson and Gosselin, unpublished data). The Atlantic fin whale population is currently designated as *special concern* under Schedule 1 of *SARA* (GC 2015) and by COSEWIC (COSEWIC 2005).

Fin whales feed on small schooling fish and krill (Borobia et al. 1995) and tend to be found in areas where these prey concentrate, such as thermal fronts, areas of upwelling, shelf breaks, and banks (Woodley and Gaskin 1996; COSEWIC 2005; Doniol-Valcroze et al. 2007). Fin whales are the second most commonly recorded mysticete in the Study Area in the DFO sightings database, with sightings predominantly recorded during summer months (see Table 4.15; Figure 4.43). Fin whales were commonly observed in Orphan Basin during the 2004 and 2005 seismic monitoring programs (Moulton et al. 2005, 2006) and were also sighted during the Statoil/Husky seismic monitoring program in Jeanne d'Arc Basin (Abgrall et al. 2009). Fin whales are likely to be common in the Study Area during late spring to fall.

#### 4.5.1.3 Toothed Whales (Odontocetes)

Ten species of toothed whales are likely to occur in the Study Area (see Table 14), ranging from the largest of all odontocetes, the sperm whale, to one of the smallest whales, the harbour porpoise. Several of these species occur in the Study Area only seasonally, but there is generally little information about the distribution and abundance of these species. Note that the species profile of the northern bottlenose whale is provided in Section 4.6 on Species at Risk.

**Sperm Whale**

The sperm whale is somewhat migratory and widely distributed, occurring from the edge of the polar pack ice to the equator; however, it is most common in tropical and temperate waters (Jefferson et al. 2008). Its distribution and relative abundance has been observed to vary in response to prey availability, most notably mesopelagic and benthic squid (Jaquet and Gendron 2002). There is currently no reliable estimate of sperm whale abundance in the entire western North Atlantic; the best recent abundance estimate, based on aerial and shipboard surveys and uncorrected for dive-time, of 2,288 (CV = 0.28) is likely an underestimate (Waring et al. 2014). Sperm whales have no status under *SARA* (GC 2015) and are designated *not at risk* but considered a by *low priority candidate* species by COSEWIC (COSEWIC 2015).

Sperm whales appear to prefer deep waters off the continental shelf, particularly areas with high secondary productivity, steep slopes, and canyons that may concentrate their primary prey of large-bodied squid (Jaquet and Whitehead 1996; Waring et al. 2001). Sperm whales were regularly sighted in the deep waters of Orphan Basin during the summers of 2004–2007 (Moulton et al. 2005, 2006; Abgrall et al. 2008b) but were not observed in the shallower waters of Jeanne d'Arc Basin in 2005–2008 (Lang et al. 2006; Lang and Moulton 2008; Abgrall et al. 2008a, 2009). There are 127 sightings for a total of 291 sperm whales in the Study Area in the DFO sightings database; sightings occurred year-round, but were greatest during March–October (see Table 4.15; Figure 4.44). Sperm whales are likely to be common in the Study Area.

**Sowerby's Beaked Whale**

Sowerby's beaked whale is the most northerly distributed mesoplodont beaked whale in the North Atlantic (Jefferson et al. 2008). It is thought to be widely distributed in Canadian Atlantic waters, and ranges offshore as far north as Davis Strait (COSEWIC 2006a). There is no population estimate for this species in Canadian waters (COSEWIC 2006a). It is designated as *special concern* under Schedule 1 of *SARA* (GC 2015) and by COSEWIC (COSEWIC 2006a).

Mesoplodont beaked whales (*Mesoplodon* spp.) are difficult to distinguish in the field, and confirmed at-sea sightings are rare (Mead 1989; Jefferson et al. 2008; Waring et al. 2014). Mesoplodonts are distributed primarily in deep waters (>2000 m) and along continental slopes at depths 200–2,000 m, and are rarely found in continental shelf waters (Pitman 2009). Based on stomach contents analysis, Sowerby's beaked whales appear to prey primarily on mid to deep-water fish, with squid making up a small portion of the diet (MacLeod et al. 2003; Pereira et al. 2011). Strandings and sightings have occurred in the Atlantic waters of Newfoundland and Labrador, primarily during June–October (COSEWIC 2006a). A single whale stranded on the southern shore of Newfoundland in February 2015 (CBC 2015). There is one sighting of four Sowerby's beaked whales in the Study Area in the DFO sightings database; the sighting occurred in September (see Table 4.15; Figure 4.44). Sowerby's beaked whale is likely to be rare in the Study Area.

**Striped Dolphin**

The striped dolphin is distributed worldwide in warm temperate to tropical waters, and ranges as far north as the Grand Banks in the western North Atlantic (Lens 1997; Baird et al. 1993b). There are an estimated 46,882 striped dolphins (CV = 0.33) from central Virginia to the lower Bay of Fundy (Waring et al. 2014), and no abundance estimate for Canadian waters. The striped dolphin has no status under *SARA* (GC 2015) and is considered *not at risk* by COSEWIC (2015).

Preferred habitat for the striped dolphin appears to be deep water along the edge and seaward of the continental shelf, particularly in areas with warm currents (Baird et al. 1993b). There are four sightings for a total of 19 striped dolphins in the Study Area in the DFO sightings database; sightings occurred in August and September (see Table 15; Figure 4.45). Striped dolphins are likely to be rare in the Study Area.

**Short-beaked Common Dolphin**

The short-beaked common dolphin is an oceanic species that is widely distributed in temperate to tropical waters of the Atlantic and Pacific Oceans (Jefferson et al. 2008). Lawson and Gosselin (2009) provided an abundance estimate of 576 common dolphins for Newfoundland based on aerial surveys conducted off the southern and eastern coasts; when corrected for perception and availability biases, abundance was estimated at 1,806 dolphins (Lawson and Gosselin, unpublished data). The short-beaked common dolphin has no status under *SARA* (GC 2015) and is considered *not at risk* by COSEWIC (COSEWIC 2015).

The distribution of the short-beaked common dolphin is often correlated with features of the Gulf Stream (Hamazaki 2002), and has been observed to coincide with peaks in prey abundance (Selzer and Payne 1988). Gaskin (1992a) indicated that common dolphins can be abundant off the coast of Nova Scotia and Newfoundland for a few months during the summer. There are 29 sightings for a total of 877 common dolphins in the Study Area in the DFO sightings database; most sightings were made during July–September (see Table 4.15; Figure 4.45). The short-beaked common dolphin is likely to be common in the Study Area.

**White-beaked Dolphin**

The white-beaked dolphin has a more northerly distribution than most dolphin species, occurring in cold temperate and sub-Arctic waters of the North Atlantic (Jefferson et al. 2008). White-beaked dolphins are thought to remain at high latitudes year-round; and are generally considered to be pelagic, but also inhabit continental shelf waters (Lien et al. 1997). Lawson and Gosselin (2009) provided an abundance estimate of 1,842 white-beaked dolphins for Newfoundland based on aerial surveys conducted off the southern and eastern coasts; when corrected for perception and availability biases, abundance was estimated at 15,625 dolphins (Lawson and Gosselin, unpublished data). This species has no status under *SARA* (GC 2015) and is considered *not at risk* by COSEWIC (COSEWIC 2015).

The abundance and distribution of white-beaked dolphins has been observed to correlate with that of its prey; white-beaked dolphin abundance has been observed to increase in the presence of spawning capelin, and to follow the northward progression of spawning concentrations (Lien et al. 1997). White-beaked dolphins are relatively uncommon in the Study Area compared to Atlantic white-sided and common dolphins. There are 15 sightings for a total of 96 dolphins in the Study Area in the DFO sightings database; sightings were made throughout the year (see Table 4.15; Figure 4.45). Year-round sightings of beaked-whales have been reported by the Newfoundland Lighthouse keepers Sighting Network (Lien et al. 1997). The white-beaked whale is likely to be uncommon in the Study Area.

**Atlantic White-sided Dolphin**

The Atlantic white-sided dolphin occurs in temperate and sub-Arctic regions of the North Atlantic (Jefferson et al. 2008). Based on the distribution of sightings, strandings, and incidental takes, Palka et al. (1997) suggested the existence of three stock units in the western North Atlantic: Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea. Lawson and Gosselin (2009) provided an abundance estimate of 1,507 white-sided dolphins for Newfoundland based on aerial surveys conducted off the southern and eastern coasts; when corrected for perception and availability biases, abundance was estimated at 3,384 dolphins (Lawson and Gosselin, unpublished data). The Atlantic white-sided dolphin has no status under *SARA* (GC 2015) and is considered *not at risk* by COSEWIC (COSEWIC 2015).

In the Northwest Atlantic, the white-sided dolphin has primarily been sighted within the 100-m depth contour and in areas of high relief (Gaskin 1992b). Stenson et al. (2011) reported bycatch records of Atlantic white-sided dolphins in the spring for the Newfoundland Basin and the southern Grand Banks. There were 39 sightings for a total of 864 white-sided dolphins in the Study Area in the DFO sightings database; sightings were primarily made in summer and fall (see Table 4.15; Figure 4.45). The Atlantic white-sided dolphin is expected to be common in the Study Area.

**Killer Whale**

The killer whale has a cosmopolitan distribution and occurs in all oceans from polar pack ice to the equator, but is most common in coastal areas of higher latitudes (Jefferson et al. 2008). Although they occur at relatively low densities, killer whales are considered year-round residents of Newfoundland and

Labrador (Lien et al. 1988; Lawson et al. 2007; Lawson and Stevens 2013). The number of killer whales in the Northwest Atlantic/Eastern Arctic population is unknown (COSEWIC 2008), but at least 67 individuals have been identified in the northwest Atlantic (Lawson and Stevens 2013). The Northwest Atlantic/Eastern Arctic population has no status under *SARA* (GC 2015) and is considered *special concern* by COSEWIC (COSEWIC 2008).

Killer whale movements are generally related to the distribution and abundance of their primary prey, which can include fish, other marine mammals, seabirds, and cephalopods (Ford et al. 2000). In Newfoundland and Labrador, killer whales have been observed approaching, attacking, and/or consuming other cetaceans, seals, seabirds, and several species of fish; however, it is not known if there is any prey specialization among killer whale groups or individuals (Lawson et al. 2007).

There are 21 sightings for a total of 137 killer whales in the Study Area in the DFO sightings database; sightings occurred in March and May to October (see Table 4.15; Figure 4.44). Four sightings of killer whales were recorded in Jeanne d'Arc Basin during the Statoil/Husky seismic monitoring program in 2008 (Abgrall et al. 2009). A killer whale outfitted with a satellite tag at Admiralty Inlet, Baffin Island, on 15 August 2009, was tracked moving into the North Atlantic in mid-November, where it traveled to just east of the Flemish Cap (Matthews et al. 2011). Killer whales are likely to be uncommon in the Study Area.

**Long-finned Pilot Whale**

The long-finned pilot whale is widespread in the North Atlantic and considered an abundant year-round resident of Newfoundland and Labrador (Nelson and Lien 1996). Waring et al. (2014) estimated an abundance of 6,124 (CV = 0.28) long-finned pilot whales in the area from northern Labrador to the Scotian Shelf in summer. Long-finned pilot whales have no status under *SARA* (GC 2015) and are considered *not at risk* by COSEWIC (COSEWIC 2015).

Pilot whales occur on the continental shelf break, in slope waters, and in areas of high topographic relief; and they exhibit seasonal inshore/offshore movements coinciding with the abundance of their prey (Jefferson et al. 2008). Short-finned squid have historically been the primary prey item in Newfoundland, but they also consume other cephalopods and fish (Nelson and Lien 1996). Long-finned pilot whales are the most commonly recorded odontocete in the Study Area in the DFO sightings database, with sightings occurring year-round (see Table 4.15; Figure 4.44), but predominantly during spring to fall. Stenson et al. (2011) reported bycatch records of long-finned pilot whales in the spring for the Newfoundland Basin and the southern Grand Banks. Long-finned pilot whales are likely to be common in the Study Area.

**Harbour Porpoise**

The harbour porpoise occurs in continental shelf regions of the northern hemisphere, and ranges from Baffin Island to New England in the Northwest Atlantic (Jefferson et al. 2008). There are at least three populations recognized in the Northwest Atlantic: eastern Newfoundland and Labrador, the Gulf of

St. Lawrence, and the Gulf of Maine/Bay of Fundy (Palka et al. 1996). Lawson and Gosselin (2009) provided an abundance estimate of 1,195 harbour porpoises for Newfoundland based on aerial surveys conducted off the southern and eastern coasts; when corrected for perception and availability biases, abundance was estimated to be 3,326 porpoises (Lawson and Gosselin, unpublished data). The Northwest Atlantic harbour porpoise is listed as *threatened* under Schedule 2 of *SARA* (GC 2015), and is designated *special concern* by COSEWIC (COSEWIC 2006b).

Data on harbour porpoises incidentally caught in groundfish gillnets suggest that they occur around the entire island of Newfoundland and in southern Labrador (Lawson et al. 2004). Bycatch data also indicate that harbour porpoises occur as far north as Nain, and in deep water (>2,000 m) in the Newfoundland Basin and Labrador Sea (Stenson and Reddin 1990 *in* COSEWIC 2006b; Stenson et al. 2011). Harbour porpoises are primarily observed over continental shelves and in areas with coastal fronts or upwelling that concentrate small schooling fish, although sightings also occasionally occur in deeper waters (Read 1999). There are 38 sightings for a total of 381 harbour porpoises in the Study Area in the DFO sightings database; sightings occurred from February to October, but the majority occurred from June to September (see Table 4.15; Figure 4.45). Harbour porpoises are likely to be uncommon in the Study Area.

#### 4.5.1.4 True Seals (Phocids)

Harp, hooded, and grey seals consume a variety of fish (e.g., cod, capelin, sand lance, and halibut) and invertebrates (e.g., squid and shrimp), and their diets are known to vary considerably among years, geographic regions, and seasons (summarized in C-NLOPB 2014). None of these three species are listed under *SARA* (GC 2015); however, harp and hooded seals are currently considered *high priority candidate* species by COSEWIC (COSEWIC 2015).

**Harp Seal**

The harp seal is the most abundant seal in the North Atlantic. The total population size for the Northwest Atlantic harp seal population was estimated to be 7,411,000 in 2014 (SE = 656,000; Hammill et al. 2014a). Despite highly variable pup production among years, this population has shown little change in abundance since 2004 and is considered to be relatively stable (Hammill et al. 2014a).

The Northwest Atlantic population of harp seals whelps and moults in the Gulf of St. Lawrence and on the ice front off southern Labrador and northeastern Newfoundland from February to May. Most seals migrate north from these areas in April and May to summer in the arctic, though small numbers remain in southern waters throughout the summer (Stenson and Kavanagh 1994; references in C-NLOPB 2014). Harp seals are likely to be uncommon in the Study Area during spring through fall.

**Hooded Seal**

The hooded seal is found in the North Atlantic, and four major whelping areas have been identified: the “West Ice” near Jan Mayen Island, the pack ice “Front” northeast of Newfoundland, in the Gulf of

St. Lawrence, and in Davis Strait (Sergeant 1974). Hammill and Stenson (2006) modeled pup production data, and estimated that the total northwest Atlantic hooded seal population size was 593,500 in 2005 (SE = 67,200), and that the population size at the Front was 535,800 (SE = 93,600).

Hooded seals are typically found drifting in offshore pack ice with 25–99% ice cover (McLaren and Davis 1982), and migrate with it as it moves north in the summer and then south in the fall (Jefferson et al. 2008). By March, this highly migratory species has established three main whelping areas in the western North Atlantic Ocean (Sergeant 1976; McLaren and Davis 1982; Andersen et al. 2009); and in early April, begins its northward migration to Davis Strait and the coastal waters of southwest and central Greenland (Rasmussen and Öritsland 1964; Mansfield 1967; Kapel 1975; McLaren and Davis 1982). Small numbers of hooded seals, particularly juveniles, have been recorded in the Study Area in spring and fall (Stenson and Kavanagh 1994; Andersen et al. 2009; Andersen et al. 2013). Hooded seals are likely to be uncommon in the Study Area during spring through fall.

**Grey Seal**

The grey seal is found in cold temperate to sub-arctic waters in the North Atlantic, and occurs in Canada in the Gulf of St. Lawrence, and off the coasts of Nova Scotia, Newfoundland, and Labrador (Jefferson et al. 2008). Population sizes for 2014 were estimated to be 394,000 (95% CI 238,000-546,000); 13,800 (95% CI = 9,300–27,300); and 98,000 (95% CI = 54,000–179,000) for the Sable Island, coastal Nova Scotia and Gulf of St. Lawrence herds, respectively (Hammill et al. 2014b). The grey seal has no status under *SARA* (GC 2015) and is considered *not at risk* by COSEWIC (COSEWIC 2015).

Grey seals are present in northwestern Atlantic waters year-round, and are primarily a coastal species (Lesage and Hammill 2001). Grey seals from both the Sable Island and Gulf breeding stocks are seasonal migrants to Newfoundland and Labrador, where they are most common during the summer (Stenson 1994; Lesage and Hammill 2001). Given their preference for coastal waters and low numbers in Newfoundland in general, grey seals are likely to be uncommon in the Study Area.

### 4.5.2 Sea Turtles

Four species of sea turtles have been reported in Newfoundland waters, but only three species are likely to occur in the Study Area. Information on the occurrence, habitat, and conservation status for the three sea turtle species that may occur in the Study Area is presented in Table 4.16. The Kemp's ridley sea turtle (*Lepidochelys kempii*) is extremely unlikely to occur in the Study Area, and is therefore only briefly described here. It has no status under *SARA* (GC 2015), and is considered a *low priority candidate* by COSEWIC (COSEWIC 2015). The Kemp's ridley has a more restricted distribution than other sea turtles: adults primarily occur in the Gulf of Mexico, and some juveniles feed along the U.S. east coast and sometimes range into the Canadian Atlantic (Spotila 2004). There are records of Kemp's ridley turtle for Nova Scotia, but the presence of this turtle off Newfoundland has not been confirmed (McAlpine et al. 2007). Note that the species profile for the leatherback sea turtle is provided in Section 4.6 on Species at Risk.

**Table 4.16 Sea Turtles with Reasonable Likelihood of Occurrence in the Study Area.**

| Species | Study Area | | Habitat | *SARA* Status[a] | COSEWIC Status[b] |
|---|---|---|---|---|---|
| | Occurrence | Season | | | |
| Leatherback sea turtle (*Dermochelys coriacea*) | Rare | April to December | Pelagic & Shelf | Schedule 1: Endangered | E |
| Loggerhead sea turtle (*Caretta caretta*) | Rare | Summer and fall | Pelagic | NS | E |
| Green sea turtle (*Chelonia mydas*) | Extremely rare | Summer | Pelagic | NS | NC; LPC |

Notes:
[a] Species designation under the *Species at Risk Act* (GC 2015); NS = No Status.
[b] Species designation by COSEWIC (Committee on the Status of Endangered Wildlife in Canada; COSEWIC 2015); E = Endangered, NC = Not Considered, LPC = Low-priority Candidate

### 4.5.2.1 Loggerhead Sea Turtle

The loggerhead turtle is the most common sea turtle in North American waters (Spotila 2004), and its distribution is largely constrained by water temperature. It does not generally occur in waters with temperatures below 15°C (O'Boyle 2001; Brazner and McMillan 2008), but rather prefers temperatures between 20–25°C (DFO 2010c). Loggerheads may be seen in the open seas during migration and foraging (e.g., Mansfield et al. 2009). While foraging at sea, loggerheads likely consume gelatinous zooplankton and squid (Spotila 2004).

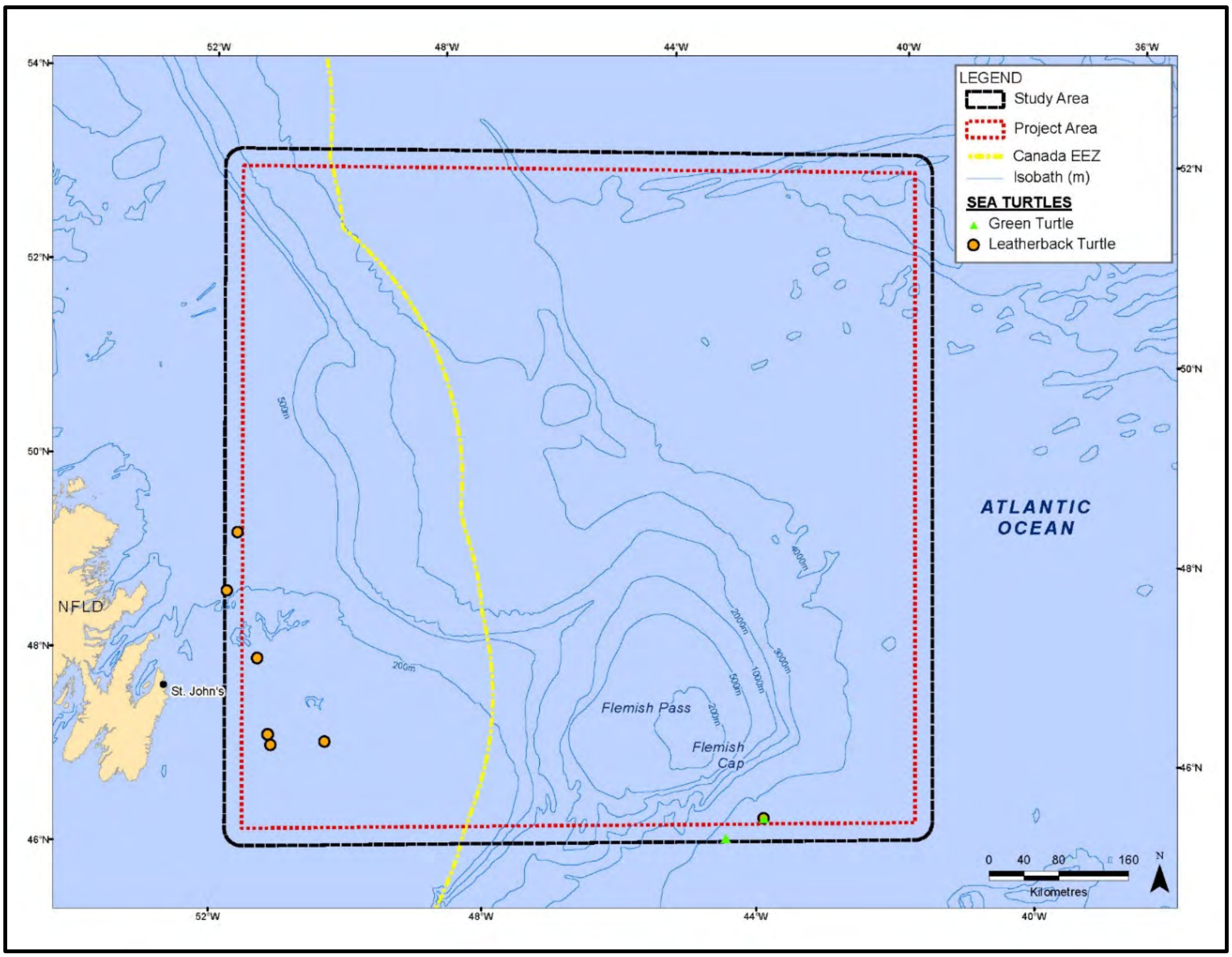
A seasonal population of juvenile loggerhead turtles occurs in Atlantic Canada (COSEWIC 2010b). Loggerheads migrate considerable distances between near-equatorial nesting areas and temperate foraging areas, and some move with the Gulf Stream into eastern Canadian waters during the summer (Hawkes et al. 2007); waters off the Scotian Shelf, Georges Bank, and Grand Banks are occupied by foraging loggerheads from July through October (Smith 2001, 2002 *in* Brazner and McMillan 2008; Javitech 2002, 2003 *in* Brazner and McMillan 2008). The adult female population in the western North Atlantic is estimated at 38,334 individuals (Richards et al. 2011). There are no current population estimates for loggerhead turtles in Atlantic Canada (DFO 2010c). The loggerhead sea turtle has no status under *SARA* (GC 2015) and has been designated *endangered* by COSEWIC (COSEWIC 2010b).

Thousands of mostly immature loggerheads have been bycaught in the Canadian pelagic longline fishery off the east coast since 1999 (Brazner and McMillan 2008; Paul et al. 2010). Most loggerhead records offshore Newfoundland have occurred in deeper waters south of the Grand Banks, and sightings have extended as far east as the Flemish Cap (Figures 6 and 7 *in* COSEWIC 2010b). Some juvenile loggerhead turtles tagged in U.S. waters with satellite transmitters were tracked near or within the southern edge of the Study Area in summer and fall (Mansfield et al. 2009). Loggerhead turtles are likely to be rare in the Study Area.

### 4.5.2.2 Green Sea Turtle

The green sea turtle is widely distributed in tropical and subtropical waters near continental coasts and around islands, although it has been recorded 500–800 miles from shore in some regions (Eckert 1993 *in* NMFS 2002). The most important nesting beaches in the northern Atlantic are in Costa Rica, the Yucatan Peninsula, Surinam, and southeast Florida; nesting primarily occurs between May and August (Thompson 1988; Spotila 2004). Juvenile and sub-adult green sea turtles may travel thousands of kilometers before returning to their breeding and nesting grounds (Carr et al. 1978). The green sea turtle has no status under *SARA* (GC 2015), and has not assessed by COSEWIC but is currently listed as a *high priority candidate* species (COSEWIC 2015).

Green sea turtles are expected to be very rare in the Study Area. Nonetheless, there are two records of green turtles in the Study Area in July in the DFO sightings database (see Section 4.5.1.1 for caveats). Both sightings were in the southeastern part of the Study Area where water depth >4,000 m (Figure 4.46).




Data source: DFO cetacean sightings database, see text for description of data and *caveats* associated with these data.

**Figure 4.46 Sea Turtle Sightings in the Study Area.**

## 4.6 Species at Risk

The *SARA* was assented to in December 2002 with certain provisions coming into force in June 2003 (e.g., independent assessments of species by COSEWIC) and June 2004 (e.g., prohibitions against harming or harassing listed *endangered* and *threatened* species or damaging or destroying their critical habitat). Species are listed under *SARA* on Schedules 1 to 3, with only those designated as *endangered* or *threatened* on Schedule 1 having immediate legal implications. Schedule 1 is the official list of wildlife species at risk in Canada. Once a species/population is designated, the measures to protect and recover that species/population are implemented. Three cetacean species/populations, one sea turtle species, one seabird species, and three fish species/populations that have the potential to occur in the Study Area are legally protected under *SARA* (Table 4.17). In addition, Sowerby's beaked whale, the Atlantic population of fin whale, and the Atlantic wolfish are designated as *special concern* on Schedule 1 of *SARA*. Schedules 2 and 3 of *SARA* identify species that were designated "at risk" by COSEWIC prior to October 1999 and must be reassessed using revised criteria before they can be considered for addition to Schedule 1. Species that potentially occur in the Study Area and are considered at risk but have not received specific legal protection (i.e., prescribed penalties and legal requirement for recovery strategies and plans) under *SARA* are also listed in Table 4.17, as are species designated as *endangered*, *threatened,* or of *special concern* under COSEWIC.

Under *SARA*, a 'recovery strategy' and corresponding 'action plan' must be prepared for *endangered*, *threatened*, and *extirpated* species. A 'management plan' must be prepared for species considered as *special concern*. Final recovery strategies have been prepared for seven species currently designated as either *endangered* or *threatened* under Schedule 1 and potentially occurring in the Study Area: (1) the blue whale (Beauchamp et al. 2009); (2) the North Atlantic right whale (Brown et al. 2009); (3) the Scotian Shelf population of the northern bottlenose whale (DFO 2010d); (4) the leatherback sea turtle (ALTRT 2006); (5) the Ivory Gull (Environment Canada 2014); (6) the spotted wolffish (Kulka et al. 2007); and (7) the northern wolffish (Kulka et al. 2007). The recovery strategy for the North Atlantic right whale (Brown et al. 2009) was amended in 2014 to incorporate changes made pertaining to the critical habitat of the population (DFO 2014f). A management plan has been prepared for the Atlantic wolffish (Kulka et al. 2007), currently designated as *special concern* on Schedule 1.

WesternGeco will monitor *SARA* issues through the Canadian Association of Petroleum Producers (CAPP), the law gazettes, the Internet and communication with DFO and EC, and will adaptively manage any issues that may arise in the future. WesternGeco will comply with relevant regulations pertaining to *SARA* Recovery Strategies and Action Plans.

WesternGeco acknowledges the rarity of the Species at Risk and will continue to exercise due caution to minimize effects on them during all of its operations. WesternGeco also acknowledges the possibility of other marine species being designated as *endangered* or *threatened* on Schedule 1 during the course of the Project. Due caution will also be extended to any other species added to Schedule 1 during the life of this Project.

## Table 4.17 *SARA*- and COSEWIC-Listed Marine Species with Reasonable Liklihood of Occurrence in the Study Area.

| SPECIES | | *SARA*[a] | | | COSEWIC[b] | | |
|---|---|---|---|---|---|---|---|
| **Common Name** | **Scientific Name** | **Endangered** | **Threatened** | **Special Concern** | **Endangered** | **Threatened** | **Special Concern** |
| **Marine Mammals** | | | | | | | |
| Blue whale (Atlantic population) | *Balaenoptera musculus* | Schedule 1 | | | X | | |
| North Atlantic right whale | *Eubalaena glacialis* | Schedule 1 | | | X | | |
| Northern bottlenose whale (Scotian Shelf population) | *Hyperoodon ampullatus* | Schedule 1 | | | X | | |
| Fin whale (Atlantic population) | *Balaenoptera physalus* | | | Schedule 1 | | | X |
| Sowerby's beaked whale | *Mesoplodon bidens* | | | Schedule 1 | | | X |
| Harbour porpoise (Northwest Atlantic population) | *Phocoena phocoena* | | Schedule 2 | | | | X |
| Humpback whale (Western North Atlantic population) | *Megaptera novaeangliae* | | | Schedule 3 | | | |
| Killer whale (Northwest Atlantic/Eastern Arctic populations) | *Orcinus orca* | | | | | | X |
| Northern bottlenose whale (Davis Strait-Baffin Bay-Labrador Sea population) | *Hyperoodon ampullatus* | | | | | | X |
| **Sea Turtles** | | | | | | | |
| Leatherback sea turtle | *Dermochelys coriacea* | Schedule 1 | | | X | | |
| Loggerhead sea turtle | *Caretta caretta* | | | | X | | |
| **Marine Fish** | | | | | | | |
| White shark (Atlantic population) | *Carcharodon carcharias* | Schedule 1 | | | X | | |
| Northern wolffish | *Anarhichas denticulatus* | | Schedule 1 | | | X | |
| Spotted wolffish | *Anarhichas minor* | | Schedule 1 | | | X | |
| Atlantic wolffish | *Anarhichas lupus* | | | Schedule 1 | | | X |
| Atlantic cod | *Gadus morhua* | | | Schedule 3 | | | |
| Atlantic cod (Newfoundland and Labrador population) | *Gadus morhua* | | | | X | | |
| Atlantic bluefin tuna | *Thunnus thynnus* | | | | X | | |
| Porbeagle shark | *Lamna nasus* | | | | X | | |
| Roundnose grenadier | *Coryphaenoides rupestris* | | | | X | | |

| SPECIES | | *SARA*[a] | | | COSEWIC[b] | | |
|---|---|---|---|---|---|---|---|
| **Common Name** | **Scientific Name** | **Endangered** | **Threatened** | **Special Concern** | **Endangered** | **Threatened** | **Special Concern** |
| Cusk | *Brosme brosme* | | | | X | | |
| American eel | *Anguilla rostrata* | | | | | X | |
| Shortfin mako shark (Atlantic population) | *Isurus oxyrinchus* | | | | | X | |
| American plaice (Newfoundland and Labrador population) | *Hippoglossoides platessoides* | | | | | X | |
| Atlantic salmon (South Newfoundland population) | *Salmo salar* | | | | | X | |
| Acadian redfish (Atlantic population) | *Sebastes fasciatus* | | | | | X | |
| Deepwater redfish (Northern population) | *Sebastes mentella* | | | | | X | |
| White hake (Atlantic population) | *Urophycis tenuis* | | | | | X | |
| Blue shark (Atlantic population) | *Prionace glauca* | | | | | | X |
| Basking shark (Atlantic population) | *Cetorhinus maximus* | | | | | | X |
| Spiny dogfish (Atlantic population) | *Squalus acanthias* | | | | | | X |
| Roughhead grenadier | *Macrourus berglax* | | | | | | X |
| Thorny skate | *Amblyraja radiata* | | | | | | X |
| **Birds** | | | | | | | |
| Ivory Gull | *Pagophila eburnea* | Schedule 1 | | | X | | |

Sources: [a]*SARA* website (http://www.sararegistry.gc.ca/search/SpeciesSearch_e.cfm), accessed February 2015; [b]COSEWIC website (http://www.cosewic.gc.ca/index.htm); accessed February 2015; COSEWIC candidate species not included.

Species profiles of fishes, seabirds, marine mammals, and sea turtles listed on Schedule 1 as *endangered* or *threatened* and any related special or sensitive habitat in the Study Area are described in the following subsections.

### 4.6.1 Profiles of Marine Species Designated as Endangered or Threatened on Schedule 1 of the *SARA*

#### 4.6.1.1 Fishes

Three fish species are listed as either *endangered* or *threatened* under Schedule 1 of the *SARA*; white shark, northern wolffish and spotted wolffish. Profiles of these three species are provided in this section. Some of the other fish species/populations that are included in Table 4.17 above (i.e., Atlantic cod, roughhead grenadier, American plaice and redfishes) are profiled in Section 4.2 of this EA.

**White Shark**

Worldwide, this species is rare but does occur with some predictability in certain areas. The white shark is widely distributed in sub-polar to tropical seas of both hemispheres, but it is most frequently observed and captured in inshore waters over the continental shelves of the northwest Atlantic, Mediterranean Sea, southern Africa, southern Australia, New Zealand, and the eastern north Pacific. The species is not found in cold polar waters (*SARA* website accessed January 2015). The status of the Atlantic population of the white shark for both Schedule 1 of *SARA* and COSEWIC is *endangered*.

Off Atlantic Canada, the white shark has been recorded from the northeastern Newfoundland Shelf, the Strait of Belle Isle, the St. Pierre Bank, Placentia Bay, Sable Island Bank, the Forchu Misaine Bank, in St. Margaret's Bay, off Cape La Have, in Passamaquoddy Bay, in the Bay of Fundy, in the Northumberland Strait, and in the Laurentian Channel as far inland as the Portneuf River Estuary. In recent years, numerous white sharks have been tagged by OCEARCH, a non-profit organization devoted to global-scale research on white sharks and other large apex predators, providing open source, near-real time data (including satellite tracks) through the Global Shark Tracker (www.ocearch.org/tracker). An adult female, 'Lydia,' originally tagged in March 2013 off Jackson, Florida, was noted within and/or in the immediate vicinity of the Study Area from October 2013 through February 2014 (Global Shark Tracker accessed 26 January 2015). The species is highly mobile, and individuals in Atlantic Canada are likely seasonal migrants belonging to a widespread northwest Atlantic population. It occurs in both inshore and offshore waters, ranging in depth from just below the surface to just above the bottom, down to a depth of at least 1,280 m (*SARA* website accessed January 2015).

With respect to reproduction, the female produces eggs which remain in her body until they are ready to hatch. When the young emerge, they are born live. Gestation period is unknown, but may be about 14 months. Litter size varies, with an average of 7 pups. Length at birth is assumed to be between 109 and 165 cm. Potential white shark pupping areas on the west and east coasts of North America include off southern California and the Mid-Atlantic Bight, respectively (*SARA* website accessed January 2015).

The white shark is an apex predator with a wide prey base, feeding primarily on many types of fish, marine mammals, squid, molluscs, crustaceans, marine birds, and reptiles. There has, however, been one recorded occurrence of an orca preying on a white shark (*SARA* website accessed January 2015).

**Northern Wolffish**

The northern wolffish is a deepwater fish of cold northern seas that has been caught at depths ranging from 38 to 1,504 m, with observed densest concentrations between 500 and 1,000 m at water temperatures of 2 to 5°C. During 1980-1984, this species was most concentrated on the northeast Newfoundland and Labrador shelf and banks, the southwest and southeast slopes of the Grand Banks, and along the Laurentian Channel. Between 1995 and 2003, the area occupied and density within the area was considerably reduced compared to results of earlier surveys. Northern wolffish are known to inhabit a wide range of bottom substrate types, including mud, sand, pebbles, small rock and hard bottom, with highest concentrations observed over sand and shell hash in the fall, and coarse sand in the spring. Unlike other wolffish species, both juvenile and adult stages of this species have been found a considerable distance above the bottom, as indicated by diet (Kulka et al. 2007).

Prey of northern wolffish are primarily bathypelagic (>200 m depth) biota such as ctenophores and medusa, but also include mesopelagic biota (<200 m depth) and benthic invertebrates. Pelagic fish represent the largest percentage of stomach contents on the basis of volume. Tagging studies have suggested limited migratory behaviour by these wolffish. Northern wolffish typically spawn late in the year on rocky bottom. Cohesive masses of fertilized eggs are laid in crevices but are unattached to the substrate. Pelagic larvae hatch after an undetermined egg incubation time, and typically feed on crustaceans, fish larvae and fish eggs (Kulka et al. 2007).

During DFO RV surveys conducted in the Study Area during 2008-2012, 465 northern wolffish were caught (see Table 4.7 in Section 4.3.7). Most of the northern wolfish were caught in the western and southwestern parts of the Study Area, primarily in slope areas where water depths range from 200-1,000 m (see Figure 4.41 in Section 4.3.7).

**Spotted Wolffish**

The life history of the spotted wolffish is very similar to that of the northern wolffish except that it seldom inhabits the deepest areas used by the northern wolffish. Although spotted wolffish have been caught at depths ranging from 56 to 1,046 m, the observed densest concentrations occur between 200 and 750 m at water temperatures of 1.5 to 5°C. During 1980-1984, spotted wolffish were most concentrated on the northeast Newfoundland and Labrador shelf and banks, the southwest and southeast slopes of the Grand Banks, along the Laurentian Channel, and in the Gulf of St. Lawrence. Between 1995 and 2003, the area occupied and density within the area was considerably reduced compared to results of earlier surveys. As with northern wolffish, spotted wolffish also inhabit a wide range of bottom substrate types, including mud, sand, pebbles, small rock and hard bottom, with highest concentrations observed over sand and shell hash in the fall, and coarse sand in the spring (Kulka et al. 2007).

Prey of spotted wolffish are primarily benthic (>75%), typically including echinoderms, crustaceans, and molluscs associated with both sandy and hard bottom substrates. This species is referred to as an echinoderm specialist (i.e., benthivore) (DFO 2011d). Fish also constitutes part of the spotted wolffish diet (<25%). Tagging studies indicate the spotted wolffish migrations are local and limited. Spotted wolffish reproduction includes internal fertilization. In Newfoundland and Labrador waters, this typically occurs in July and August on stony bottom. Cohesive masses of eggs are deposited in crevices, remaining unattached to the substrate. After an undetermined incubation time, pelagic larvae hatch and start to feed on crustaceans, fish larvae and fish eggs within a few days of hatching (Kulka et al. 2007).

During DFO RV surveys conducted in the Study Area during 2008-2012, 549 spotted wolffish were caught (see Table 4.8 in Section 4.3.7). Most of the northern wolfish were caught in the western and southwestern parts of the Study Area, primarily in slope areas where water depths range from 200-1,000 m (see Figure 4.41 in Section 4.3.7).

#### 4.6.1.2 Seabirds

The Ivory Gull is the only seabird listed as either *endangered* or *threatened* under Schedule 1 of the *SARA* that could potentially occur in the Study Area.

**Ivory Gull**

The Ivory Gull has a circumpolar breeding distribution and is associated with pack ice throughout the year. In Canada, the Ivory Gull breeds exclusively in Nunavut. Breeding colonies occur on southeastern Ellesmere Island, eastern Devon Island and northern Baffin Island. In Canadian waters, Ivory Gulls occur among the pack ice of the Davis Strait, the Labrador Sea, Strait of Belle Isle, and northern Gulf of St. Lawrence. The Ivory Gull is listed as *endangered* on Schedule 1 of *SARA*, designated as *endangered* by COSEWIC, and considered *near threatened* on the Red List of Threatened Species (see Table 4.17; IUCN 2014).

In comparison to most gulls, Ivory Gulls have reduced reproductive output, in that they usually only lay one to two eggs (Haney and MacDonald 1995). They depart from colonies immediately following breeding (~mid-August) for offshore foraging areas associated with the ice edge of permanent, multi-year pack ice. At sea, the Ivory Gull is a surface-feeder where its main prey includes small fish and macro-zooplankton. It is also an opportunistic scavenger of carrion found on ice and marine mammals killed by large predators (Haney and MacDonald 1995). Currently, the Canadian breeding population is estimated at 500 to 600 individuals (COSEWIC 2006b). Surveys conducted during 2002 to 2005 indicate a total decline of 80% and an annual decline of 8.4% over the last 18 years. If this decline continues at a steady rate, the breeding population will decrease by a further 62% over the next decade, to approximately 190 individuals. A survey conducted in March 2004 within the pack ice off the coast of Newfoundland and Labrador observed a substantial decrease in Ivory Gull observations as compared to 1978 results (COSEWIC 2006b). The numbers of Ivory Gulls observed per 10-minute watch period were 0.69 and 0.02 individuals for 1978 and 2004, respectively (COSEWIC 2006b). Considering that changes to the breeding environment have been minimal, causes for the observed decline are likely related to factors occurring during migration or on the wintering grounds (Stenhouse 2004). During heavy ice winters, the Ivory Gull may occasionally reach the southern Orphan Basin and northern Grand Banks in the Study Area, late in the winter or early spring when sea ice reaches the maximum southern extremity. The thirty-year median of ice concentration shows ice extending into the northern edge of the Grand Banks east to 48°W during late February to late March. The total of 21 Ivory Gulls reported from drill platforms on the NE Grand Banks during 1999 to 2002, seems improbable, especially considering that most sightings were reported during ice-free periods. Ivory Gull is reported regularly along the coast of Labrador and the tip of the Great Northern Peninsula of Newfoundland in winter. There are occasional sightings of Ivory Gulls south along the east coast of Newfoundland. It is expected to be very rare in the Study Area.

#### 4.6.1.3 Marine Mammals

Three marine mammal species/populations with reasonable likelihood of occurrence in the Study Area are designated as either *endangered* or *threatened* under Schedule 1 of the *SARA*; blue whale, North Atlantic right whale, and the Scotian Shelf population of the northern bottlenose whale. Profiles of these three species are provided in this section. Some of the other marine mammal species/populations that are included in Table 4.16 are profiled in Section 4.5 on the Marine Mammal and Sea Turtle VEC.

**Blue Whale**

The Atlantic population of blue whales is listed as *endangered* on Schedule 1 of *SARA* (GC 2015) and by COSEWIC (COSEWIC 2002a, 2012a). Blue whales became severely depleted during industrial whaling and still occur at relatively low densities in the North Atlantic. It has been estimated that 400-600 whales may be found in the western North Atlantic (Waring et al. 2011). The recovery strategy for blue whales in the Northwest Atlantic notes a long-term recovery goal of reaching a total of 1,000 mature individuals through the achievement of three 5-year objectives (Beauchamp et al. 2009).

The blue whale has a cosmopolitan distribution, but tends to be more frequently observed in deep water than in coastal environments (Jefferson et al. 2008). Its distribution is often associated with areas of upwelling or shelf edges where its prey, primarily euphasiids, may concentrate (COSEWIC 2002a). The distribution of blue whales around Newfoundland and Labrador is poorly known: it was sighted only sporadically off the Labrador coast, was rarely caught by whalers east of Labrador or Newfoundland, and regularly strands off southwestern Newfoundland in late winter and early spring (references in COSEWIC 2002a). Clark et al. (1995 *in* Beauchamp et al. 2009) examined acoustical data and determined that blue whales occur on the Grand Banks between August and May, with peak calling activity from September through February. Two sightings of blue whales were made in the Orphan Basin in August-September 2007 (Abgrall et al. 2008b), and there is a single blue whale sighting in the Study Area in April in the DFO sightings database (see Figure 4.43). Blue whales are likely to rarely occur in the Study Area.

**North Atlantic Right Whale**

The North Atlantic right whale is listed as *endangered* on Schedule 1 of *SARA* (GC 2015) and by COSEWIC (COSEWIC 2003c, 2013). The North Atlantic right whale population was severely depleted by commercial whaling and it is considered one of the most critically endangered large whale populations (Clapham et al. 1999; IWC 2001). Based on a census of individual whales identified using photo-identification, the western North Atlantic population size is estimated to be comprised of at least 510 individuals (NARWC 2013). The lack of recovery has been attributed to direct and indirect impacts from human activities, especially collisions with ships and entanglement in fishing gear (IWC 2001; Brown et al. 2009).

Right whales migrate from northern feeding grounds to calving grounds off the southeastern U.S. in late fall to winter, and return northward in late winter to early spring. Peak sightings on Canadian feeding grounds occur from August to early October, coinciding with the abundance of their primary prey, calanoid copepods (Baumgartner et al. 2003). Research suggests the existence of six major habitats or congregation areas for North Atlantic right whales: the coastal waters of the southeastern United States; the Great South Channel; Georges Bank/Gulf of Maine; Cape Cod and Massachusetts Bays; the Bay of Fundy; and the Scotian Shelf (COSEWIC 2003c; Waring et al. 2013). Roseway Basin on the Scotian Shelf and Grand Manan Basin in the Bay of Fundy have been designated as critical habitat for right whales (Brown et al. 2009). There is a single sighting of two right whales in the Study Area in June in the DFO sightings database (see Figure 4.43). This species is likely to be extremely rare in the Study Area.

**Northern Bottlenose Whale**

There are two genetically distinct populations of northern bottlenose whales in Canada (Dalebout et al. 2006). The Scotian Shelf population is estimated to comprise 143 individuals (O'Brien and Whitehead 2013) and is designated *endangered* under Schedule 1 of *SARA* (GC 2015) and by COSEWIC (COSEWIC 2002b, 2011). The size of the Davis Strait-Baffin Bay-Labrador Sea population is uncertain, but low sighting rates suggest that it has not recovered from heavy whaling activity (Whitehead and Hooker 2012). The Davis Strait-Baffin Bay-Labrador Sea population has no status under *SARA* (GC 2015) and is considered *special concern* by COSEWIC (COSEWIC 2011). The northern bottlenose whale was extensively harvested throughout its range during industrial whaling (Jefferson et al. 2008).

The northern bottlenose whale occurs primarily in deep waters over canyons and the shelf edge, routinely dives to depths over 800 m, and may remain submerged for over an hour (Hooker and Baird 1999). Two regions of concentration have been identified in Canada: the Gully and adjacent submarine canyons on the eastern Scotian Shelf, and Davis Strait off northern Labrador (Reeves et al. 1993). Although most sightings are made during the summer, winter occurrences have been recorded, and it is presumed that the populations remain within these regions year-round (Reeves et al. 1993). It is unknown whether whales sighted between these two regions (e.g., off the Grand Banks and south of Newfoundland) belong to either the Scotian Shelf or Davis Strait-Baffin Bay-Labrador Sea populations, or form another distinct population (COSEWIC 2011). There are 26 sightings for a total of

84 bottlenose whales in the Study Area in the DFO sightings database; sightings occurred from May to October (see Table 4.15; Figure 4.44). Northern bottlenose whales are expected to be uncommon in the Study Area.

#### 4.6.1.4 Sea Turtles

The leatherback turtle is the only sea turtle with reasonable likelihood of occurrence in the Study Area designated as either *endangered* or *threatened* under Schedule 1 of the *SARA*. The other sea turtle species included in Table 4.17, the loggerhead, is profiled in Section 4.5.

**Leatherback Turtle**

The leatherback sea turtle is designated as *endangered* under *SARA* (Schedule 1; GC 2015) and by COSEWIC (COSEWIC 2012b). Globally, it is estimated to have declined by more than 70%; in the Atlantic, it is impacted by factors including fisheries bycatch, coastal and offshore development, and poaching; and in Canada, it is threatened by entanglement in fishing gear (COSEWIC 2012b). A recovery strategy for the leatherback sea turtle was published in 2006, but critical habitat was not defined (ALTRT 2006). Subsequent research, including satellite telemetry data, will be used to identify critical habitat in a forthcoming amendment to the 2006 recovery strategy (DFO 2013g).

The leatherback is the largest and most widely ranging sea turtle, and is distributed from sub-polar and cool temperate foraging grounds to tropical and sub-tropical nesting areas in all of the world's oceans (Spotila 2004). Genetic analysis of leatherback turtles captured off Nova Scotia revealed that the majority originated from natal beaches in Trinidad, followed by French Guiana, Costa Rica, St. Croix, and Florida (Stewart et al. 2013). The leatherback turtle exhibits wide-ranging oceanic movements, and occurs in pelagic regions of the North Atlantic where it forages on gelatinous zooplankton (Hays et al. 2006): it inhabits both shelf and offshore waters in Canada between April and December while foraging (COSEWIC 2012b). Leatherback sea turtles have been observed to forage on lion's mane and moon jellyfish in Atlantic Canadian waters, and it has been estimated that they consume an average of 330 kg (wet mass) of jellyfish per day (Heaslip et al. 2012). Satellite telemetry data has been used to identify three primary habitats likely used for foraging by leatherback turtles: (1) the area near Georges Bank, (2) southeastern Gulf of St. Lawrence and waters east of Cape Breton, and (3) waters south and east of Burin Peninsula, Newfoundland (DFO 2011e).

There are an estimated 34,000–94,000 adult leatherbacks in the North Atlantic (TEWG 2007). Although the size of the seasonal population of foraging leatherbacks in Canada is unknown, it is thought to number in the thousands (COSEWIC 2012b). Adult leatherbacks are considered regular summer visitors to eastern Newfoundland, with the northernmost records occurring off Labrador at nearly 54ºN; observations around Newfoundland and Labrador occur from June to November, but are most common in August and September (Goff and Lien 1988). Most sea turtles migrate southward by mid-October (Sherrill-Mix et al. 2008). James et al. (2006) noted that increasing sea surface temperatures in Canadian waters result in a significant increase in turtle sightings. Most leatherbacks that occur in

Atlantic Canadian waters are large sub adults and adults, with a female-biased sex ratio among mature turtles (James et al. 2007).

There are seven sighting records (for a total of eight individuals) of leatherback turtles within the Study Area (see Figure 4.46) in the DFO sightings database; sightings were made during July–September. There was also a sighting of a leatherback turtle in Jeanne d'Arc Basin during the Statoil/Husky seismic monitoring program in 2008 (Abgrall et al. 2009). Leatherback turtles outfitted with satellite telemetry have also been tracked near or within the Study Area (TEWG 2007). It is likely that leatherback sea turtles would rarely occur in the Study Area.

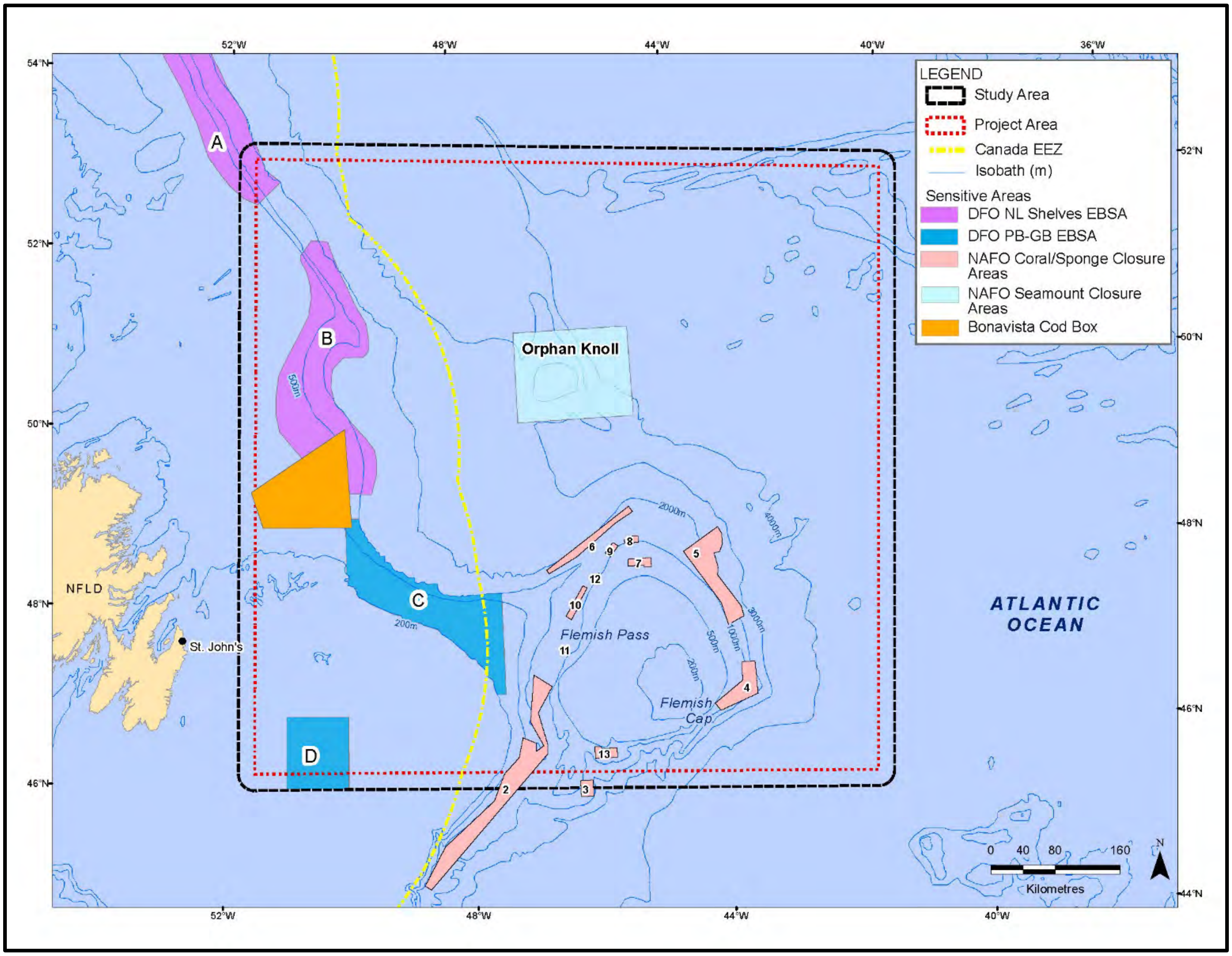
## 4.7 Sensitive Areas

There are a variety of regulatory frameworks that deal directly or indirectly with sensitive areas in Newfoundland and Labrador. Marine fisheries are administered by DFO through the federal *Fisheries Act*. Management of marine mammals, including species at risk, is controlled by DFO under the *Marine Mammals Regulations* of the *Fisheries Act*. All species at risk are administered under the *SARA* (2002), which lists the species and provides measures to protect those species. The *Oceans Act* Marine Protected Areas are established by DFO to protect and conserve important fish and marine mammal habitats, *endangered* marine species, unique features and areas of high biological productivity or biodiversity. Migratory birds, including species at risk, are solely or jointly managed (depending on the species) between Canada and the U.S. through the CWS branch of EC. Current legislation and agreements regarding migratory birds include the Convention for the Protection of Migratory Birds (1916), *Migratory Birds Convention Act*, and the North American Waterfowl Management Plan (CWS and United States Fish and Wildlife Services (USFWS) 1986; CWS, USFWS, and SEMARNAP 1998). Waterfowl are managed according to "flyways" denoting wintering and summering habitat connected by international migration corridors.

The 18 sensitive areas that occur either entirely or partially within the Study Area are listed below and discussed further in this section.

- Twelve (12) NAFO coral/sponge fishery closure areas;
- One (1) seamount fishery closure area: Orphan Knoll;
- Four (4) Ecologically and Biologically Significant Areas: Northeast Shelf and Slope, Virgin Rocks, Orphan Spur and Labrador Slope; and
- Bonavista Cod Box.

Figure 4.47 shows the locations of these 18 sensitive areas in relation to the Study Area.




Note: NL Shelves Bioregion EBSAs: (A) Labrador Slope; (B) Orphan Spur PB-GB LOMA EBSAs: (C) Northeast Shelf and Slope (D) Virgin Rocks.

**Figure 4.47 Locations of 18 Sensitive Areas that Occur Entirely or Partially within the Study Area.**

### 4.7.1 Integrated Management Areas

The Study Area includes portions of the Placentia Bay-Grand Banks (PB-GB) Large Ocean Management Area (LOMA), and the Newfoundland and Labrador Shelves Bioregion, marine regions established to form the planning basis for implementation of integrated-management plans by DFO. The LOMAs are typically thousands of square kilometres in size. Their boundaries are determined using a combination of ecological and administrative considerations. For each LOMA, all levels of government, aboriginal groups, industry organizations, environmental and community groups, and academia work together to develop a strategic, long-term plan for sustainable management of resources within its boundaries. This plan is intended to be adaptive in that strategies and plans may change as new information is obtained through ongoing monitoring and reporting (DFO 2012c). The LOMAs are delineated so that ecosystem health and economic development issues within their boundaries can be addressed and suitably managed.

This can best be accomplished using an integrated ocean management approach, an approach based on addressing the socio-economic and cultural needs of humankind while preserving the health of the marine ecosystem (DFO 2012c).

The *Oceans Act* provides the Minister of Fisheries and Oceans with a leadership role for coordinating the development and implementation of a federal network of MPAs, which can include areas within and outside of the Integrated Management (IM) area that have yet to be developed within the Region. Therefore, there remains potential for further identification of EBSAs, AOI, MPAs and other sensitive areas within the Study Area.

#### 4.7.1.1 PB-GB LOMA

The PB-GB LOMA has been recognized by DFO as one of five priority LOMAs in Canada. The PBGB LOMA Committee comprises a group of stakeholders partnering for the sustainable use and development of coastal and ocean resources within the LOMA. The designation of EBSAs is a tool to allow appropriate management of “geographically or oceanographically discrete areas that provide important services to one or more species/populations of an ecosystem or to the ecosystem as a whole, compared to other surrounding areas or areas of similar ecological characteristics” (DFO 2013a). DFO Newfoundland and Labrador Region has identified 11 EBSAs within the PB-GB LOMA as potential Areas of Interest (AOIs) for Marine Protected Area (MPA) designation, two of which occur entirely within the Study Area; the Northeast Shelf and Slope EBSA and the Virgin Rocks EBSA (see Figure 4.47). These locations encompass important spawning areas and/or locations with relatively high densities of marine flora and fauna. The Northeast Shelf and Slope has been identified as having the highest concentrations of Greenland halibut and spotted wolffish that aggregate to the area in the spring, while the Virgin Rocks EBSA is identified as having high aggregations of capelin and many groundfish such as Atlantic cod, American plaice and yellowtail flounder. The Virgin Rocks EBSA is also identified as an area of relatively high macroalgae and seaweed abundance (C-NLOPB 2014). DFO (2012c) ranked the PB-GB EBSAs in terms of significance; the Northeast Shelf and Slope EBSA ranks ninth, and the Virgin Rocks EBSA ranks eleventh.

Section 4.2.1.10 of the Eastern Newfoundland SEA (C-NLOPB 2014) provides more detailed information on these two EBSAs.

#### 4.7.1.2 Newfoundland and Labrador Shelves Bioregion

DFO has also recently identified fifteen EBSAs within the Newfoundland and Labrador Shelves Bioregion (exclusive of the PB-GB LOMA), of which 14 are spatially defined. Of these, all of the Orphan Spur EBSA occurs within the Study Area while only the southern extremity of the Labrador Slope EBSA occurs within the Study Area (see Figure 4.47; DFO 2013h). Corals occur in the Orphan Spur EBSA as do high densities of species of conservation concern (e.g., northern, spotted and Atlantic wolffish, skates, roundnose grenadier, American plaice, redfish) and sharks (C-NLOPB 2014). The Labrador Slope EBSA was designated for its biodiversity which includes corals and sponges, several species of conservation concern (e.g., northern, spotted and Atlantic wolffish, skates, roundnose grenadier), and high densities of northern shrimp, American plaice, redfish, Atlantic cod and Greenland halibut (C-NLOPB 2014).

Section 4.2.1.10 of the Eastern Newfoundland SEA (C-NLOPB 2014) provides more detailed information on these two EBSAs.

### 4.7.2 NAFO Coral and Sponge Closure Areas

In 2008 and 2009, the NAFO Scientific Council identified areas of significant coral and sponge concentrations within the NAFO Regulatory Area. Based on these identifications, 13 areas for closure to fishing with bottom contact gear have been delineated. Figure 4.47 shows the locations of 12 of these 13 areas (numbers 2 to 13) that occur either entirely or partially within the proposed Study Area. Coral/sponge closure area #1 occurs about 200 km to the south of the Study Area. No vessel shall engage in bottom fishing activities within these areas until at least 31 December 2020 (NAFO 2015a). Given the nature of seismic surveys, survey equipment is not expected to come in contact with the corals and sponges.

### 4.7.3 NAFO Seamount Closure Areas

The term ‘Vulnerable Marine Ecosystem (VME) Element’ refers to topographical, hydrophysical or geological features which potentially support VMEs including slopes, summits and flanks of seamounts and knolls, and canyons. Only one NAFO seamount closure area occurs entirely within the Study Area: the Orphan Knoll (see Figure 4.47). This area is closed to all bottom fishing activities until at least 31 December 2020 (NAFO 2015a).

### 4.7.4 Bonavista Cod Box

In March 2003, as protection for the Northern cod, the *Fisheries Resource Conservation Council (*FRCC) recommended the establishment of an experimental ‘cod box’ in the Bonavista Corridor (see Figure 4.47). The Corridor has been identified as an area important for cod spawning and juvenile cod. The FRCC recommended that this area be protected from all forms of commercial fishery (excluding snow crab trapping) and other invasive activity such as seismic exploration (see www.frcc.ccrh.ca). This ‘closure’ action was never implemented.

# 5.0 Effects Assessment

Two general types of effects are considered in this document:

1. Effects of the environment on the Project; and
2. Effects of the Project on the environment, particularly the biological environment.

Methods of effects assessment used here are comparable to those used in recent east coast offshore geophysical (e.g., LGL 2014a,b,c and drilling EAs (e.g., Christian 2008; LGL 2008). These documents conform to the (now repealed) *Canadian Environmental Assessment Act* (*CEAA*) of 1992 and its associated Responsible Authority's Guide and the CEA Agency Operational Policy Statement (OPS-EPO/5-2000; CEA Agency 2000). Cumulative effects are incorporated within the procedures in accordance with *CEAA* (CEA Agency 1994) as adapted from Barnes and Davey (1999).

## 5.1 Scoping

The C-NLOPB provided a Final Scoping Document (C-NLOPB 2015; dated 27 February 2015) for the Project which outlined the factors to be considered in the assessment. In addition, various stakeholders were contacted for input (see Section 5.1.1 below). Another aspect of scoping for the effects assessment involved reviewing relevant and recent EAs and SEAs that were prepared for areas relevant to this EA, including the Eastern Newfoundland SEA (C-NLOPB 2014). Reviews of present state of knowledge on the effects of seismic survey activities as well as the physical and biological setting of the Study Area were also conducted.

### 5.1.1 Consultations

#### 5.1.1.1 WesternGeco's Consultation Policy and Approach

WesternGeco's policy for consultation on marine seismic projects is to consult (primarily through in-person meetings) with relevant agencies, stakeholders and rights-holders (e.g., beneficiaries) during the pre-survey and survey stages. WesternGeco will initiate meetings and respond to requests for meetings with the interested groups throughout this period. After the survey is complete WesternGeco will conduct follow-up discussions. The same approach would be followed before, during and after any survey work for 2016-2024. In summary, each year WesternGeco will meet as follows:

- Before the survey is permitted to provide Project information, gather information about area fisheries, determine issues or concerns, and discuss communications and mitigations;
- After the survey is permitted and during the survey activities to report on the progress of the survey, to determine if any survey-related issues have come up, and to discuss potential solutions; and
- After the survey is completed to provide an update on the Project, to be informed of any issues that arose, and to present results of the MMO and FLO reports.

The in-person meetings included the direct participation of WesternGeco's Marine Shore Manager.

#### 5.1.1.2 Program Consultations

The program consultations were organized and coordinated by Canning & Pitt. Project information packages were sent to all relevant stakeholder groups in mid-January 2015. In addition to a representative of Canning & Pitt, representatives of WesternGeco and LGL also attended the consultation meetings. All requested face-to-face meetings were held in St. John's. Initial contact and requested face-to-face meetings were conducted between 16 January and 2 February 2015. Appendix 1 includes the full report on consultations undertaken for this EA thus far. Consultations with fishers and the FFAW are ongoing, the results of which will be included in the EA Addendum.

During each requested face-to-face meeting, a PowerPoint presentation with details regarding the proponent and the proposed Project was provided. The presentations included a map showing the Project Area and Study Area, as well as several maps (as appropriate) showing fish-harvesting locations (key species) in relation to these areas. Detailed notes were made during the meetings, documenting all comments and issues.

Stakeholder groups that were engaged include the following.

- Fisheries and Oceans Canada (DFO);
- Environment Canada (EC);
- Nature Newfoundland and Labrador (NNL) (and various member organizations);
- One Ocean;
- Fish, Food and Allied Workers Union (FFAW)/Unifor;
- Association of Seafood Producers (ASP);
- Ocean Choice International (OCI);
- Groundfish Enterprise Allocation Council (GEAC) Ottawa;
- Canadian Association of Prawn Producers;
- Clearwater Seafoods;
- Icewater Fisheries; and
- Newfound Resources Ltd. (NRL).

As has been the case for other seismic project assessments in the Newfoundland and Labrador sector, the most consistent issue raised during the consultations related to potential conflict with the commercial fisheries, specifically ensuring that the survey does not interfere with or otherwise impact harvesting success. Consequently, fish harvester groups and agencies were a key focus of the consultations.

Other topics of discussion included potential effects on marine biota and the importance of ongoing communication between the Operator and potentially affected groups.

#### 5.1.1.3 Follow-Up

As described above, WesternGeco will conduct follow-up discussions with all interested groups during and after the survey. This would include reporting on the progress of the survey, monitoring the effectiveness of the mitigations, determining if any survey-related issues had arisen, and presenting monitoring results.

## 5.2 Valued Environmental Components

The VEC approach was used to focus the assessment on those biological resources of most potential concern and value to society.

VECs include the following groups:

- rare or threatened species or habitats (as defined by the *SARA* and COSEWIC);
- species or habitats that are either unique to an area or valued for their aesthetic properties;
- marine species that are harvested by people (e.g., commercial fishery target species); and
- marine species with some potential to be affected by the Project.

The VECs were identified based on the scoping exercise as described in Section 5.1. The VECs and the associated rationale for their inclusion are as follows:

- **Fish and Fish Habitat** with emphasis on principal commercial species in the Study Area including snow crab (invertebrate species), yellowtail flounder (flatfish without swim bladder), and Atlantic cod (groundfish with swim bladder), as well as *SARA* species (e.g., wolffishes). It is recognized that there are many other fish species, commercial or prey species, that could be considered but it is LGL's professional opinion that this suite of species captures all of the relevant issues concerning the potential effects of seismic surveys on important invertebrate and fish populations of the Study Area.

- **Fisheries** (primarily commercial harvesting) were the most referenced VEC of concern during consultations. While they are directly linked to the Fish and Fish Habitat VEC above in that an impact on fish could affect fishery success for that species, the greater concern expressed was interference with fishing, either through the sound produced by the array (scaring fish from fishing gear) or interference with fixed fishing gear (caused by the ships or the seismic streamer). All fisheries are considered where relevant (i.e., commercial, subsistence, ceremonial, recreational). The commercial fishery is a universally acknowledged important element in the society, culture, economic and aesthetic environment of Newfoundland and Labrador. Also included in this VEC are research surveys conducted by both DFO and industry. This VEC is of prime concern from both a public and scientific perspective, at local, national and international scales.

- **Seabirds** with emphasis on those species most sensitive to seismic activities (e.g., deep divers such as murres) or vessel stranding (e.g., petrels). Newfoundland and Labrador waters support some of the largest seabird colonies in the world and the Study Area hosts large populations during all seasons. They are important socially, culturally, economically, aesthetically, ecologically and scientifically. This VEC is of prime concern from both a public and scientific perspective, at local, national and international scales.

- **Marine Mammals** with emphasis on those species potentially most sensitive to low frequency sound (e.g., baleen whales) and *SARA* species (e.g., blue whale). Whales and seals are key elements in the social and biological environments of Newfoundland and Labrador. The economic and aesthetic importance of whales is evidenced by the large number of tour boats that feature whale watching as part of a growing tourist industry. This VEC is also of concern from both a public and scientific perspective, at local, national and international scales.

- **Sea Turtles**, although uncommon in the Study Area, are mostly *threatened* and *endangered* on a global scale. The leatherback sea turtle that forages in eastern Canadian waters has *endangered* status under *SARA*. While they are of little or no economic, social or cultural importance to Newfoundland and Labrador, their *endangered* status warrants their inclusion as a VEC.

- **Species at Risk** are those designated as *endangered* or *threatened* on Schedule 1 of *SARA*. In addition, species listed as *special concern* have been considered here as well. All species at risk in Newfoundland and Labrador offshore waters are captured in the VECs listed above. However, because of their special status, they are also discussed separately.

- **Sensitive Areas** are areas considered to be unique due to their ecological and/or conservation sensitivities. Examples of sensitive areas in the Study Area include EBSAs and coral/sponge conservation areas.

## 5.3 Boundaries

For the purposes of this EA, the following temporal and spatial boundaries are defined.

### 5.3.1 Temporal

The temporal boundaries of the Project are 1 May to 30 November, 2015-2024.

### 5.3.2 Spatial

#### 5.3.2.1 Project Area

The 'Project Area' is defined as the area within the C-NLOPB jurisdiction where seismic data could be acquired and all vessel movements with deployed equipment will occur (see Figure 1.1). The coordinates of the Project Area (WGS84, unprojected geographic coordinates) are presented in Table 5.1.

**Table 5.1 Coordinates of the Project Area Extents (WGS84, unprojected geographic coordinates).**

| Project Area Extent | WGS84 (Decimal Degrees) | |
|---|---|---|
| | Latitude (°N) | Longitude (°W) |
| Northwest | 53.008 | -51.560 |
| Northeast | 52.436 | -40.206 |
| Southwest | 46.160 | -51.514 |
| Southeast | 45.828 | -41.566 |

#### 5.3.2.2 Affected Area

The 'Affected Area' varies according to the specific vertical and horizontal distributions and sensitivities of the VECs of interest and is defined as that area within which effects (physical or important behavioural ones) have been reported to occur.

#### 5.3.2.3 Study Area

The 'Study Area' is an area larger than the Project Area that encompasses routine potential effects reported in the literature.

#### 5.3.2.4 Regional Area

The 'Regional Area' is an area larger than the Study Area and is used when considering cumulative effects.

## 5.4 Effects Assessment Procedures

The systematic assessment of the potential effects of the Project involved three major steps:

1. preparation of interaction matrices (i.e., interactions of Project activities and the environment);
2. identification and evaluation of potential effects, including description of mitigation measures and residual effects; and
3. preparation of residual effects summary tables, including evaluation of cumulative effects.

### 5.4.1 Identification and Evaluation of Effects

Interaction matrices identifying all possible Project activities that could interact with any of the VECs were prepared. The interaction matrices are used to identify potential interactions only and they do not make any assumptions about the potential effects of the interactions.

Interactions were then evaluated for their potential to cause effects. In instances where the potential for an effect of an interaction was deemed impossible or extremely remote, these interactions were not considered further. This approach allows the assessment to focus on key issues and the more substantive environmental effects.

An interaction was considered to be a potential effect if it could change the abundance or distribution of VECs, or change the prey species or habitats used by VECs. The potential for an effect was assessed by considering:

- the location and timing of the interaction;
- the literature on similar interactions and associated effects (seismic EAs for offshore Nova Scotia and Newfoundland and Labrador);
- consultation with other experts, when necessary; and
- results of similar effects assessments, especially monitoring studies done in other areas.

When data were insufficient to allow precise effects evaluations, predictions were made based on professional judgement. In such cases, the uncertainty is documented in the EA. Effects were evaluated for the proposed seismic survey program, and included the consideration of mitigation measures that are either mandatory or have become standard operating procedure in the industry.

### 5.4.2 Classifying Anticipated Environmental Effects

The concept of classifying environmental effects simply means determining whether they are negative or positive. The following includes some of the key factors that are considered for determining negative environmental effects, most of which are included in the CEA Agency guidelines (CEA Agency 1994):

- negative effects on the health of biota;
- loss of rare or *endangered* species;
- reductions in biological diversity;
- loss or avoidance of productive habitat;
- fragmentation of habitat or interruption of movement corridors and migration routes;
- transformation of natural landscapes;
- discharge of persistent and/or toxic chemicals;
- toxicity effects on human health;

- loss of, or detrimental change in, current use of lands and resources for traditional purposes;
- foreclosure of future resource use or production; and
- negative effects on human health or well-being, including economic well-being, such as fishing income.

### 5.4.3 Mitigation

Where needed, mitigation measures appropriate for each effect predicted in the matrix were identified (see Section 5.7), and the effects of various Project activities were then evaluated assuming that appropriate mitigation measures are applied. Residual effects predictions were made taking into consideration these mitigations.

### 5.4.4 Evaluation Criteria for Assessing Environmental Effects

Several criteria were taken into account when evaluating the nature and extent of environmental effects. These criteria include (CEA Agency 1994):

- magnitude;
- geographic extent;
- duration;
- frequency;
- reversibility; and
- ecological, socio-cultural and economic context.

#### 5.4.4.1 Magnitude

Magnitude describes the nature and extent of the residual environmental effect for each activity.

Ratings for this criterion are defined as:

0 *Negligible* - An interaction that may create a measureable effect on individuals but would never approach the value of the 'low' rating.

1 *Low* - Affects >0 to 10% of individuals in the affected area (e.g., geographic extent). Effects may include acute mortality, sublethal effects or exclusion due to disturbance.

2 *Medium* - Affects >10 to 25% of individuals in the affected area (e.g., geographic extent). Effects may include acute mortality, sublethal effects or exclusion due to disturbance.

3 *High* - Affects >25% of individuals in the affected area (e.g., geographic extent). Effects may include acute mortality, sublethal effects or exclusion due to disturbance.

#### 5.4.4.2 Geographic Extent

Geographic extent refers to the specific area ($km^2$) of the residual environmental effect caused by the Project activity. Geographic extent will likely vary depending on the activity and the relevant VEC.

Ratings for this criterion are defined as:

1 = <1 $km^2$
2 = 1-10 $km^2$
3 = >10-100 $km^2$
4 = >100-1,000 $km^2$
5 = >1,000-10,000 $km^2$
6 = >10,000 $km^2$

#### 5.4.4.3 Duration

Duration describes how long a residual effect will occur.

Ratings for this criterion are defined as:

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

Short duration can be considered 12 months or less, medium duration 13 to 36 months, and long duration >36 months.

#### 5.4.4.4 Frequency

Frequency describes how often a residual effect will occur.

Ratings for this criterion are defined as:

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

#### 5.4.4.5 Reversibility

Reversibility refers to the capability of a VEC population to return to either its pre-Project or an improved condition, after the Project has ended.

Ratings for this criterion are defined as:

R = reversible
I = irreversible

#### 5.4.4.6 Ecological, Socio-cultural and Economic Context

The ecological, socio-cultural and economic context refers to the pre-Project status of the Study Area (i.e., potential affected area) in terms of existing environmental effects. The Study Area is not considered to be strongly affected by human activities.

Ratings for this criterion are defined as:

1 = Environment not negatively affected by human activity (i.e., relatively pristine area)
2 = Evidence of existing negative effects on the environment

### 5.4.5 Cumulative Effects

Projects and activities considered in the cumulative effects assessment include other human activities in Newfoundland and Labrador offshore waters, with emphasis on the Grand Banks Regional Area.

- Within-Project cumulative impacts. For the most part, and unless otherwise indicated, within-Project cumulative effects are fully integrated within this assessment;
- Existing and *in progress* offshore oil developments in Newfoundland and Labrador: Hibernia (GBS platform), Terra Nova FPSO, White Rose FPSO and associated extension, and the Hebron GBS;
- Other offshore oil exploration activity (particularly seismic surveys and exploratory drilling as outlined on the C-NLOPB website). There is some potential for several 2D/3D/4D, geohazard and VSP surveys in any given year;
- Fisheries (domestic and foreign commercial, recreational, aboriginal/subsistence);
- Marine transportation (tankers, cargo ships, supply vessels, naval vessels, fishing vessel transits, etc.); and
- Hunting activities (marine birds and seals).

### 5.4.6 Integrated Residual Environmental Effects

Upon completion of the evaluation, the residual environmental effects are assigned a rating of significance for:

- each project activity or accident scenario;
- the cumulative effects of activities within the Project; and
- the cumulative effects of combined projects in the Regional Area.

The last of these points considers all residual environmental effects, including project and other-project cumulative environmental effects. As such, this represents an integrated residual environmental effects evaluation.

The analysis and prediction of the significance of residual environmental effects, including cumulative environmental effects, encompasses the following:

- determination of the significance of residual environmental effects;
- establishment of the level of confidence for prediction; and
- evaluation of the scientific certainty and probability of occurrence of the residual impact prediction.

Ratings for level of confidence associated with each prediction are presented in the table of residual environmental effects. In the case of a significant predictive rating, ratings for probability of occurrence and determination of scientific certainty are also included in the table of residual environmental effects. The guidelines used to determine these ratings are discussed in the following sections.

#### 5.4.6.1 Significance Rating

Significant residual environmental effects are those that are considered to be of sufficient magnitude, duration, frequency, geographic extent, and/or reversibility to cause a change in the VEC that will alter its status or integrity beyond an acceptable level. Establishment of the criterion is based on professional judgment but is transparent and repeatable. In this EA, a significant residual effect is defined as:

> *Having either a high magnitude regardless of duration and geographic extent ratings, or a medium magnitude for more than one year over a geographic extent greater than 100 km$^2$*

A residual effect can be considered *significant* (S), *not significant* (NS), or *positive* (P).

#### 5.4.6.2 Level of Confidence

The significance of the residual environmental effects is based on a review of relevant literature, consultation with experts, and professional judgement. In some instances, making predictions of potential residual environmental effects are difficult due to the limitations of available data (i.e., technical boundaries). Ratings are therefore provided to qualitatively indicate the level of confidence for each prediction. The level of confidence is considered low (1), medium (2) or high (3).

#### 5.4.6.3 Probability of Occurrence

The probability of occurrence of a *significant* residual effect, based on professional judgement, is considered low (1), medium (2) or high (3).

#### 5.4.6.4 Scientific Certainty

The scientific certainty of a *significant* residual effect, based on scientific information, statistical analysis and/or professional judgement, is considered low (1), medium (2) or high (3).

### 5.4.7 Follow-up Monitoring

Since effects of the Project on the environment are predicted to be relatively short-term and transitory, follow-up monitoring is not required. However, there will be some monitoring (described below in Section 5.5 on Mitigation Measures) during the course of the Project, and if these observations indicate evidence of an anticipated effect on a VEC or an accidental release of fuel, then the need for follow-up monitoring and other actions will be assessed in consultation with the C-NLOPB.

## 5.5 Mitigation Measures

The effects assessments that follow (see Section 5.7) consider the potential effects of the eastern Newfoundland offshore seismic program in light of the specific mitigation measures that will be applied for this Project. The purpose of these measures is to eliminate or reduce the potential impacts that might affect the VECs (as identified in Section 5.4). WesternGeco recognizes that the careful and thorough implementation of, and adherence to, these measures will be critical for ensuring that the Project does not result in unacceptable environmental consequences.

This section details the various measures that will be established and applied for this Project. Collectively, they are based on several sources, including:

- Discussions and advice received during consultations for this Project (see Section 5.1.1 and Appendix 1), and for other relevant EAs;
- The C-NLOPB Scoping Document (C-NLOPB 2015), and the Environmental Planning, Mitigation and Reporting guidance in Appendix 2 of the Board's *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012);
- DFO's *Statement of Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment;*
- National and international acts, regulations or conventions, such as the *Fisheries Act* and Regulations, *International Convention for the Prevention of Pollution from Ships* (MARPOL), and International Maritime Organization (IMO) standards;

- Other standards and guidance, such as the One Ocean *Protocol for Seismic Survey Programs in Newfoundland and Labrador* (2013);
- Industry best practices; and
- Expert judgement/experience from past surveys.

The mitigation measures that follow are organized under the following categories: (1) Survey Layout and Location; (2) Communications and Liaison; (3) Fisheries Avoidance; (4) Fishing Gear Damage Program; (5) Marine Mammal, Sea Turtle, and Seabird Monitoring and Mitigation; and (6) Pollution Prevention and Emergency Response. Several of the mitigation measures listed under these categories are designed to mitigate potential effects on more than one VEC (e.g., seismic array ramp-up/soft start can deter marine mammals and fish)—Table 5.2 (at the end of this section) summarizes the measures by VEC and type of effect.

These mitigation measures will be adhered to in each survey year, with adjustments as necessary based on monitoring and follow-up.

### 5.5.1 Survey Layout and Location

The layout of WesternGecos 2D seismic surveys (that may occur in 2016-2024) will be characterized by very long and widely spaced lines, meaning that in most areas (fishing grounds and wildlife habitat) there will be only one-time close exposure to Project activities. With the seismic ship travelling at about 8-9 km/hour, the survey will be 10 to 20 km away from any given point within the survey area within a few hours. The seismic source will not return to a specific point, except for where perpendicular lines cross. These crossovers will likely occur several days or weeks after the initial exposure at a given point. Typically, only parts of a few lines would pass over any key fishing ground in any program year. The layout of 3D seismic surveys will include more narrowly spaced lines, meaning that exposures at any particular point within the survey area will occur more frequently.

### 5.5.2 Communications and Liaison

Consultations and discussions for this Project have indicated that frequent, timely and effective communications with fishing industry organizations/participants must be a central part of the fisheries mitigations for the survey. Communications and liaison will ensure that the seismic program does not operate in the area of active fisheries, and allow the survey to plan its acquisition and proceed in the most efficient way possible in light of locations being actively fished within the survey area.

#### 5.5.2.1 Information Exchange

Detailed and up-to-date information about the fisheries likely to be active in specific parts of the Project Area at specific times will be examined. Maps of past fish harvesting activities (see Section 4.3 of this EA) are a valuable planning tool, but exact times and locations change somewhat from year to year. To be accurate, the information flow about current fishing activities will need to be a continuing process that is updated as fishing seasons open and close, and as quotas are taken. This information will be accessed through continuing information exchanges with the relevant fishing organizations on a regular basis, including through the mechanisms described below, such as the FFAW Petroleum Information Liaison (PIL) person, the FLOs, direct contacts with representatives of the Newfoundland fisheries organizations, and with DFO (for fisheries survey/research information). Operational details of these communications will be finalized with the relevant organizations as the fishing season information and plans are known.

#### 5.5.2.2 Fisheries Liaison Officers (FLOs)

WesternGeco will place a FLO on board the seismic ship to communicate with fishing vessels at sea, and relay information to shore as needed. The FLOs are the primary at-sea liaison between the commercial fishing industry and the seismic survey program. In past seismic surveys, FLOs have been effective for "real time" communications, and to assist the vessel in planning activities in light of current fisheries and fishing gear locations.

As described in the document One Ocean Protocol for Seismic Survey Programs in Newfoundland and Labrador (One Ocean 2013), "the FLO is tasked with identifying potential at-sea conflicts between fishing and petroleum operations". His/her duties include radio contact with fishing boats in the area, informing fishers nearby about the seismic program (including provision of coordinates of planned survey lines), helping to identify fishing plans (i.e., when fishing a particular area) and any fishing gear in and near the seismic survey program area so it can be avoided, providing advice on the best course of action to avoid gear and/or other fishing activities, providing information about changes in relevant fisheries, and sending daily reports. The FLO roles and duties, based on past practice and the One Ocean Protocol document (Section 4.6, FLO Operational Responsibilities, Protocols and Communications *in* One Ocean 2013)**,** will include the following:

- while stationed on the seismic vessel and support vessel, observe activities which may affect the fishing industry and petroleum operations;
- initiate and maintain radio contact with fishing boats in the area and ensure all communication with fishing vessels is conducted via the FLO;
- inform fishers nearby about the seismic survey program and provide coordinates and relevant spatial and temporal details;
- help identify/locate any fishing gear in and near the seismic survey program area so it can be avoided;
- determine gear type, layout, fishing plans (when in area, when leaving);
- advise bridge about best course of action to avoid gear and/or fishing activities;
- serve as initial contact if damaged gear is encountered, verify damage, help identify owners and file an incident report;
- regularly discuss/convey fisheries related aspects including changes in relevant fisheries, status of species quotas and closures with the onboard Client Representative;
- report to and confer with the onboard Client Representative regarding operational situations;
- attend regular operations briefings;
- attend safety meetings and participate in all relevant Health Safety and Environment (HSE) initiatives and procedures as requested;

- complete and submit a daily report (electronic/hardcopy) including all observations, communications and meetings attended to the onboard Client Representative; and
- other duties as identified and approved through consultation with the Operator and Service Provider.

The One Ocean Protocol document (One Ocean 2013) also notes that the FFAW/One Ocean PIL (see below) usually prepares a Summary Report on fishing activity for the FLO, including Vessel Monitoring System (VMS) data (see below) before departure on the seismic ship, and continues to provide data to the FLO while on board the seismic vessel on an as-needed basis throughout the program. The FLO would also assist if there are any gear damage incidents, as detailed below (Fishing Gear Damage Program).

#### 5.5.2.3 Single Point of Contact (SPOC)

The role of the shore-based SPOC (as noted in the C-NLOPB Guidelines [C-NLOPB 2012]) is to facilitate communication between the Project and other marine users, particularly those involved in the fisheries. It has become a standard and effective mitigation for seismic surveys over many years. Typical services provided are as follow:

- documenting the locations of known vessels for seismic survey operators; provide current information about the locations of seismic activities and fishing activities;
- regularly update survey vessels on expected locations of fishing activities in their operating areas;
- assisting with updates to the seismic vessels about changes in relevant fisheries, the progress of species quotas and closures;
- maintaining additional contact with fishers known to be in active survey areas, directly or through the FLOs, the FFAW, other fishing organizations and One Ocean;
- providing information directly to fishers when requested via email or a toll-free phone line maintained for this purpose, based on the best-available data provided to them by the survey;
- attempting to identify (from CFV id numbers, etc.) any gear located in the water or involved in an incident, as requested by the survey operator;
- providing survey information to fisheries groups and organizations as required; and
- providing initial contacts (via email and/or the toll free phone number) for any gear damage or loss claims, for the survey's fishing gear compensation program.

SPOC contact information will be broadcast in the Coast Guard Notices to Shipping and communicated to fishers through their organizations. The SPOC will also have duties if there are any gear damage incidents, as detailed below (Fishing Gear Damage Program).

#### 5.5.2.4 FFAW/One Ocean Petroleum Industry Liaison Contacts

As an initiative of One Ocean (whose mission is to be the medium for information exchange regarding industry operational activities between the fishing and petroleum industries in Newfoundland and Labrador), an arrangement was undertaken for the employment of a PIL at the FFAW. The principle objective of the PIL is to ensure the views and concerns of fish harvesters are considered by the offshore petroleum industry and regulators during the development, review and execution of exploration, development and production activities. As such, the PIL is the main contact for petroleum related activities at the FFAW. WesternGeco will utilize the PIL as the key contact for communications between the Project and FFAW-represented fishing interests.

#### 5.5.2.5 VMS Data

WesternGeco will use VMS data (as available) to understand and help avoid fishing locations and monitor other area marine activities, for logistics and safety. The One Ocean Protocol notes that "One Ocean and Fisheries and Oceans Canada (DFO) have an arrangement to provide Vessel Monitoring System (VMS) information to petroleum company members of One Ocean. The VMS program at DFO Newfoundland Region provides a satellite based, near real time, positional tracking system of fishing vessels within the Canadian Exclusive Economic Zone (EEZ), as well as foreign and domestic vessels in the northwest Atlantic Fisheries Organization (NAFO) Regulatory Area outside the 200 nautical mile limit. The ability to access current fisheries data (location of activity) is an important component in the development of operational plans for offshore petroleum related activities. The VMS data generated by DFO consists of coordinates only and does not divulge information of a confidential or sensitive nature." WesternGeco has requested (through One Ocean) that the Project have access to these data.

#### 5.5.2.6 Notices to Shipping

As a standard procedure and requirement, WesternGeco will file and update NotShips with Canadian Coast Guard Radio/ECAREG advising marine interests of the seismic survey's general operating area for the period covered by the Notice. The Notices will include contact information (email and toll-free phone number) for the survey's Fishing Gear Damage program (see below).

#### 5.5.2.7 Survey Start-Up Sessions

WesternGeco places a strong emphasis on informing the at-sea Project personnel on each ship before the survey begins, through several presentation modules, about the environmental issues and concerns in the area in which they will be working, WesternGeco's environmental commitments and regulatory requirements, safety, emergency response, the duties and authority of the MMOs and the FLOs, and the cultural importance and legal status of Aboriginal interests in the area. These sessions will include showing the CAPP "Fishery Liaison Officer Video" about the importance of FLO participation in offshore Newfoundland and Labrador exploration activities, as recommended in the One Ocean Protocol. The FLOs, MMOs and WesternGeco Project Manager will be present at these meetings.

#### 5.5.2.8 Communications Follow-Up

As stated in the consultations section (see Section 5.1.1; Appendix 1), WesternGeco will continue to consult with fisheries groups and other groups before and during the survey. WesternGeco will also conduct follow-up discussions with all interested groups after the survey. This would include reporting on the progress of the survey, monitoring the effectiveness of the mitigations, addressing any survey-related issues that had arisen, and presenting monitoring results after completion of the survey.

#### 5.5.2.9 Other Notifications/Communication

WesternGeco will also follow several procedures/vehicles to facilitate excellent communications for the survey, including the following:

- WesternGeco will employ the latest technology in at-sea communications with and between the survey ships (VHF, HF, Satellite telephone and internet, VMS).
- WesternGeco will provide information (the NotShip text) to the CBC Fisheries Broadcast.

Further details of the communications plans will be developed during WesternGeco's continuing discussions with fisheries representatives.

### 5.5.3 Fisheries Avoidance

#### 5.5.3.1 Avoidance of Commercial Fishing Areas

To the best of its ability, WesternGeco will avoid active fishing areas during the seismic survey. Specifically, WesternGeco will monitor the location of fishing activities and make best efforts to plan its work away from those grounds where fishing is active. The communications protocols and methods described above will be the key means for WesternGeco to have the information to plan around and away from fish harvesting. Continuing contact between the Project and fishing group representatives, the onboard FLOs, the SPOC, DFO and the FFAW PIL will be essential for this process.

WesternGeco understands that fish harvesters are not required to move their vessels or gear from the seismic survey program area and will not be told to do so. This information will be clearly communicated at the start-up meetings.

#### 5.5.3.2 No Gear Deployment En Route to Survey Area

WesternGeco will not deploy its array or streamer (s) in Newfoundland and Labrador waters during transits to the survey area. All gear deployments will occur within the Project Area. In addition, the FLOs will advise the vessel en route to the survey area to ensure that fishing gear is avoided.

#### 5.5.3.3 Avoidance of Fisheries Science Surveys

As with the commercial fishery, those involved in DFO and joint DFO/Industry research surveys will need to exchange detailed locational information with those involved in the seismic surveying. For previous seismic surveys off Newfoundland and Labrador, a temporal and spatial separation plan has been implemented (on DFO advice) to ensure that seismic operations did not interfere with the research survey. The procedures, which WesternGeco will follow, involve adequate "quiet time" before the research vessel arrived at its survey location. The avoidance protocol includes a 30 km (16 nm) spatial separation and a seven day pre-research survey temporal separation.

#### 5.5.3.4 Monitoring and Follow-up

As described above, WesternGeco in discussions with relevant groups and mechanisms (such as the FLOs), will continue to monitor the effectiveness of the mitigations during the survey, and consider the results before subsequent year programs.

### 5.5.4 Fishing Gear Damage Program

#### 5.5.4.1 Fishing Gear Damage or Loss Compensation Program

A compensation Program will be made available by WesternGeco which is consistent with C-NLOPB guidelines and past practices. This program covers any damage to fishing gear (or vessels) caused by the survey vessels or survey gear, and includes the value of any harvest lost as a direct result of an incident. The Notices to Shipping filed by the vessels for survey work and for transits to and from the survey area will also inform fishers that they may contact the SPOC toll free by telephone or email if they believe that they have sustained survey-related gear damage. This information will also be communicated through other means (e.g., the Newsletter, contact through fisheries organizations).

The SPOC will follow through with any claim received, in communication with WesternGeco, the FLOs and the relevant fisheries organization. For responding to a claim, WesternGeco will follow procedures (which have been employed successfully in the past by other Operators) similar to those outlined in the One Ocean Protocol document.

#### 5.5.4.2 Damage or Loss Incident Response

The One Ocean Protocol (Sections 4.8 and 4.9 in One Ocean 2013) describes responses to be followed as a result of a gear conflict. WesternGeco will have such procedures in place and will respond to them and any subsequent compensation claim. More specifically, in case of an observed or reported incident, one of the FLOs will follow the following procedures:

- if personnel on board the seismic and/or scout vessel observe fishing gear (abandoned, adrift or active) it should be communicated to the FLO. Gear should not be touched/retrieved by project personnel as it is illegal for anyone but the gear owner to move the gear;
- if the support vessel makes the observation, personnel should record exact positions and name or Canadian Fishing Vessel (CFV) number on the gear (buoy/highflyer) and report it to the FLO;
- the FLO will communicate with fishing vessels in the vicinity in an attempt to identify the gear owner;
- if the CFV number is known, the FLO or the SPOC may be able to identify and contact the owner;

- if identification and contact with the gear owner is successful, the FLO will attempt to determine the plans/schedule of the gear owner with respect to the gear and will encourage the owner to communicate with the FLO at sea;
- if it is not possible to contact the gear owner, the survey ship should attempt to work in another area and return to the location at a later time;
- the FLO will record the information in the daily report and submit it to the on-board Client representative;
- if there is any indication a Project vessel or its equipment made contact with fishing gear it should be communicated to the FLO immediately;
- the FLO will contact the on-board Client Representative and vessel Master as soon as possible after discovery of the incident;
- the FLO will take all reasonable action to prevent any further or continuing damage;
- if possible, photograph the gear or gear debris in the water and after recovery;
- if necessary, secure and retain any of the gear debris;
- record the incident in the Daily Report;
- file a Fishing Gear Incident Report and give it to the on-board WesternGeco Client Representative; and
- any contact with fishing gear must be reported immediately even if no damage to the gear has occurred.

Appendix F of the One Ocean Protocol document (One Ocean 2013) contains an incident reporting form which meets the requirements of the C-NLOPB Guidelines in assessing a claim. WesternGeco understands that all such incidents must be reported to the C-NLOPB, which maintains a 24-hour answering service at 709-682-4426 for this purpose (709-778-1400 during working hours). Reports on contacts with fishing gear will include the exact time and location of initial contact, loss of contact and a description of any identifying markings on the gear. Incidents will be reported to WesternGeco (Project Manager and Environmental Manager) by their onboard Client Representative; WesternGeco will then report it to the C-NLOPB following the Board's incident reporting guidelines and/or any other requirements.

### 5.5.5 Marine Mammal, Sea Turtle, and Seabird Monitoring and Mitigation

The following marine mammal- and sea turtle-related measures are based on the DFO's *Statement of Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment,* which is also contained in the C-NLOPB Guidelines.

#### 5.5.5.1 Use of a Safety Zone

A circular safety zone with a radius of at least 500 m as measured from the center of the airgun array will be monitored by MMOs for the presence of marine mammals and sea turtles while the array is operating during daylight periods as well as before operations commence (i.e., during the pre-start up watch, see below).

#### 5.5.5.2 Pre-Start Up Watch

A qualified MMO will continuously observe the safety zone for a minimum period of 30 minutes before array start up. If a marine mammal or sea turtle is detected within the safety zone during this pre-start up watch, ramp up will be delayed until the marine mammal or sea turtle has been observed to leave the safety zone or 30 minutes have passed since the animal was last detected within the safety zone.

#### 5.5.5.3 Ramp-Up

If array activation is permitted (based on the pre-start up watch), a gradual ramp-up (slow increase in the number of airguns activated) of the airgun array will take place over an approximate 30-minute period, beginning with the activation of a single airgun, preferably the smallest airgun in terms of energy output, and followed by a gradual activation of additional airguns until the full array is operational.

#### 5.5.5.4 Shut-down of Array

The airgun array will be shut down immediately if any of the following is observed by the MMO in the safety zone:

a) a marine mammal or sea turtle listed as *endangered* or *threatened* on Schedule 1 of *SARA*; or
b) any other marine mammal or sea turtle that has been identified in an EA process as a species for which there could be significant adverse effects.

In addition, shut downs will be implemented if any sea turtle species is observed within the safety zone. If a shutdown occurs, the array cannot be re-activated until the marine mammal or sea turtle has been observed to leave the safety zone or 30 minutes have passed since the animal was last detected within the safety zone.

#### 5.5.5.5 Line Changes and Equipment Maintenance Shut-Downs

When seismic data acquisition along a survey line is over, the airgun array will be

a) shut down completely; or
b) reduced to a single airgun.

If the airgun array is reduced to a single airgun, visual monitoring of the safety zone and shut-down requirements will be maintained, and ramp up will be required when seismic surveying resumes.

#### 5.5.5.6 Seabird Strandings

The MMO will conduct a daily search of the seismic vessel for stranded birds. Additionally, any other project vessels will be searched by the ship's crew. Any seabirds (most likely Leach's Storm-Petrel) that become stranded on the vessels will be released using the mitigation methods consistent with *The*

*Leach's Storm-Petrel: General Information and Handling Instructions* by U. Williams (Petro-Canada) and J. Chardine (CWS) (n.d.). It is understood by WesternGeco that a CWS *Migratory Birds Permit* will be required. WesternGeco will request the ships to minimize lighting on board to the extent that it does not affect safety.

#### 5.5.5.7 Marine Mammal, Sea Turtle, and Seabird Monitoring

Marine mammal and sea turtle observations will be made during all daylight periods when airguns are active (ramp-ups, during data acquisition periods, single airgun use, and testing), during the 30-minute pre-start up watch, and during all other daylight periods when possible. This will include observations about marine mammal responses and behaviour to the seismic vessel and/or the array. Seabird surveys (i.e., standardized counts) will be conducted throughout the seismic program from the seismic vessel by MMOs experienced in the identification of seabirds at sea. Protocols modified and approved for use from ships at sea by EC as outlined in the ECSAS Standardized Protocol for Pelagic Seabird Surveys from Moving and Stationary Platforms will be utilized (Gjerdrum et al. 2012). A schedule of conducting seabird surveys (e.g., three times per day) at widely spaced intervals will be followed. Surveys can only be conducted when visibility is >300 m and adequate light conditions allow species identification. Data will be collected by qualified environmental observer(s).

#### 5.5.5.8 Reporting

A monitoring report will be submitted to the C-NLOPB following completion of the surveys as per the C-NLOPB *Guidelines*. In the unlikely event that marine mammals, sea turtles or birds are injured or killed by Project equipment or accidental spills of fuel, a report will immediately be filed with C-NLOPB and the need for follow-up monitoring assessed.

### 5.5.6 Pollution Prevention / Emergency Response

The following sections describe the various pollution prevention/emergency response mitigations.

#### 5.5.6.1 Waste Management

As indicated in Section 2.0 of this EA, wastes produced from the vessels, including hazardous and non-hazardous waste material, will be managed in accordance with MARPOL and with the vessel-specific waste management plans. All solid wastes will be sorted by type, compacted where practicable, and stored on board before disposal to an appropriate certified reception facility. Non-toxic combustible material and waste oil from the vessels will be burned on-board in approved incinerators. The shipboard incinerators will have been examined and tested in accordance with the requirements for shipboard incinerators IMO Res. MEPC 76(40) for disposing of ships-generated waste appended to the Guideline for the implementation of Annex V of MARPOL 73/78. Sufficient and adequate facilities will be available on vessels to store solid wastes generated. Any contracted vessels' policies and procedures will be reviewed against the WesternGeco waste management plan, which will be filed with the C-NLOPB. Only ports with licensed waste contractors will be used for any waste returned from offshore.

#### 5.5.6.2 Discharge Prevention and Management

Vessel discharges will not exceed those of standard vessel operations and will adhere to all applicable regulations. The main discharges include grey water (wastewater from washing, bathing, laundry, and food preparation), black water (human wastes), bilge water, deck drainage and discharges from machinery spaces. All discharges will comply with requirements in the International Convention for the Prevention of Pollution of Ships, 1973, as modified by Protocol of 1978 (MARPOL 73/78) and its annexes. Ground galley food waste can be discharged when a vessel is more than 3 miles offshore. Non-ground galley food waste can be discharged when a vessel is more than 12 miles offshore.

#### 5.5.6.3 Air Emission Control

The vessels will have an International Air Pollution Prevention Certificate issued under the provisions of the Protocol of 1997 as amended by resolution MEPC.176(58) in 2008, to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 related thereto (hereinafter referred to as the Convention). Atmospheric emissions will be those associated with standard operations for marine vessels in general, including the seismic vessel and support vessel. Vessels will only use diesel and gasoil with a sulphur content of no more than 1% (weight) following the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI, for the North American Emission Control Area, which was implemented in Canada in August 2012 (see http://www.tc.gc.ca/eng/marinesafety/bulletins-2012-03-eng.htm).

#### 5.5.6.4 Response to Accidental Events

In the unlikely event of the accidental release of hydrocarbons during the Project, WesternGeco will implement the measures outlined in the Shipboard Oil Pollution Emergency Plans (SOPEPs) which will be filed with the C-NLOPB. In addition, WesternGeco has an emergency response plan in place which bridges the emergency plans of all project entities and vessels to the local facilities and the Halifax Search and Rescue Region. The WesternGeco representative onboard will represent WesternGeco in all offshore Quality, Health, Safety & Environment (QHSE) activities. The Vessel Supervisor will represent WesternGeco onshore from an office in St. John’s.

The SOPEPs are designed to assist the ships’ personnel in dealing with an unexpected discharge of oil. The primary purpose is to set in motion the necessary actions to stop or minimize the discharge of oil and to mitigate its effects. Effective planning ensures that the necessary actions are taken in a structured, logical and timely manner. The primary objectives of this Plan are to prevent oil pollution, to stop or minimize oil outflow when damage to the ship occurs, to stop or minimize oil outflow when an operational spill occurs, and to help contain/clean-up a spill.

The ships also carry Spill Kits which typically contain such equipment as:

- air operated pump;
- polypropylene scoops;
- swabs, shovels, brooms with handle;
- bags with absorbent;
- absorbent sheets;
- absorbent bond;
- guard bond;
- plastic drums;
- plastic garbage bin;
- plastic bags;
- rubber gloves and boots; and
- chemical protective suits.

In the event of a spill, the seismic and picket vessels would work together to respond to and contain the released hydrocarbons.

#### 5.5.6.5 Use of Solid Core Streamer

WesternGeco will use a solid core streamer; this eliminates the risk of leakage associated with cables filled with floatation fluid.

#### 5.5.6.6 Use of Solid Core Streamer

Table 5.2 summarizes mitigation measures by potential effect on the VECs.

## 5.6 Effects of the Environment on the Project

The physical environment is summarized in Section 3.0 of this EA and the reader is referred to this section to assist in determining the effects of the environment on the Project. Furthermore, safety issues are assessed in detail during the permitting and program application processes established by the C-NLOPB, the regulatory authority. Nonetheless, effects on the Project are important to consider, at least on a high level, because they may sometimes cause effects on the environment. For example, accidental spills may be more likely to occur during rough weather.

Given the Project time window of May to November for seismic operations and the requirement of a seismic survey to avoid periods and locations of sea ice, sea ice should have little or no effect on the Project (see Section 3.4.1). Icebergs in the spring and early summer may cause some survey delays if tracks have to be altered to avoid them (see Section 3.4.2). Within the Project time frame, icebergs may require the vessels to detour in May and June when about one third of the yearly total of icebergs are expected to occur based on monthly iceberg distribution data (Table 3.15 in Section 3.4.2).

**Table 5.2 Summary of Mitigations Measures by Potential Effect.**

| Potential Effects | Primary Mitigations |
|---|---|
| Interference with fishing vessels/mobile and fixed gear fisheries | • Upfront communications, liaison and planning to avoid fishing activity<br>• Continuing communications throughout the program<br>• FLOs<br>• SPOC<br>• Advisories and communications<br>• VMS data<br>• Avoidance<br>• Start-up meetings on ships |
| Fishing gear damage | • Upfront communications, liaison and planning to avoid fishing gear<br>• Use of support vessel<br>• SPOC<br>• Advisories and communications<br>• FLOs<br>• Compensation program<br>• Reporting and documentation<br>• Start-up meetings on ships |
| Interference with shipping | • Advisories and at-sea communications<br>• FLOs (fishing vessels)<br>• Use of support vessel<br>• SPOC (fishing vessels)<br>• VMS data |
| Interference with DFO/FFAW research program | • Communications and scheduling<br>• Avoidance |
| Temporary or permanent hearing damage/disturbance to marine animals (marine mammals, sea turtles, seabirds, fish, invertebrates) | • Pre-watch of safety zone<br>• Delay start-up if marine mammals or sea turtles are within 500 m<br>• Ramp-up of airguns<br>• Shutdown of airgun arrays for *endangered* or *threatened* marine mammals and sea turtles within 500 m<br>• Use of qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations |
| Temporary or permanent hearing damage/ disturbance to Species at Risk or other key habitats | • Pre-watch of safety zone<br>• Delay start-up if marine mammals or sea turtles are within 500 m<br>• Ramp-up of airguns<br>• Shutdown of airgun arrays for *endangered* or *threatened* marine mammals and sea turtles within 500 m<br>• Use of qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations. [No critical habitat has been identified in or near the Study Area.] |
| Injury (mortality) to stranded seabirds | • Daily monitoring of vessel<br>• Handling and release protocols<br>• Minimize lighting if safe |
| Seabird oiling | • Adherence to MARPOL<br>• Spill contingency and response plans<br>• Use of solid streamer |

Most environmental constraints on seismic surveys on the Grand Banks are those imposed by wind and wave. If the Beaufort wind scale is six or greater, there is generally too much noise for seismic data to be of use. A Beaufort wind scale of six is equivalent to wind speeds of 22-27 knots (11.3-13.9 m/s), and is associated with wave heights ranging from 2.4-4.0 m. In the Study Area, these conditions are typically reached at a consistent level in the late autumn and winter months. Certainly, if the sea state exceeds 3.0 m or winds exceed 40 kt (20.6 m/s), then continuation/termination of seismic surveying will be evaluated. Based on multi-year data at four grid points in the Study Area (see Section 3.0), these wave limits are typically approached during the October to April period. In addition, based on multi-year data at the same four grid points in the Study Area, wind speeds of 23.2 m/s are most likely to occur during the same period indicated above for wave limits.

Poor visibility can constrain helicopter operations. It also may hinder sightings of other vessels and fishing gear. These constraints are alleviated somewhat by WesternGeco's experience in northwest Atlantic operations, state of the art forecasting, and the use of radar and FLOs to detect fishing vessels and gear.

Related to the effects of the environment on the Project, some operators have used an estimate of 25% weather-related down time for project planning purposes. If 25% is used as a guideline, then conditions in November might be considered a significant effect on project logistics and economics by some proponents although this is likely to be variable depending upon the operator.

The Project scheduling avoids most of the continuous extreme weather conditions and WesternGeco will be thoroughly familiar with East Coast operating conditions. Seismic vessels typically suspend surveys once wind and wave conditions reach certain levels because the ambient noise affects the data. They also do not want to damage towed gear which would cause costly delays.

Environmental effects on other Project vessels (e.g., picket and supply vessels) are likely less than on the seismic vessel which is constrained by safety of towed gear and data quality issues.

Effects of the biological environment on the Project are unlikely although there are anecdotal accounts of sharks attacking and damaging streamers.

The Department of National Defense (DND) records indicate that there are two shipwrecks present within the Study Area: (1) the U-658 shipwreck (50.00889N, 46.5333W); and (2) the U-520 shipwreck (47.78334N, 49.8333W).

It is understood that the proposed seismic activities to be conducted will have no interaction with the sea floor; therefore the associated unexploded ordinate (UXO) risk is negligible. Nonetheless, due to the inherent dangers associated UXO and the fact that the northwest Atlantic Ocean was exposed to many naval engagements during WWII, any suspected UXO encountered during the course of the operations will be geo-referenced, immediately reported to the Coast Guard, and left undisturbed.

Effects of the environment on the Project are predicted to be *not significant* for the reasons discussed above.

## 5.7 Effects of the Project on the Environment

This effects assessment is organized so that issues generic to any type of ship activity in the Study Area (e.g., seismic operations vessels, fisheries vessels, DFO research vessels, military ships, marine transporters) are discussed first. A detailed effects assessment then follows, which focuses on the effects of noise (primarily on marine mammals, fish and fisheries) and the towed seismic streamer array (primarily on fishing gear), which is the major distinction between the effects of seismic surveys versus those of other marine vessels. The applicable mitigation measures (detailed in Section 5.5) are also noted for the relevant activity. The detailed assessment includes the generic effects in the ratings and predictions tables but does not discuss these generic issues in any detail.

### 5.7.1 Generic Activities - Air Quality

The atmospheric emissions from Project activities will be those from the Project vessels' engines, generators, and incinerators. Project atmospheric emissions will be within the range of emissions from typical marine vessels on the east coast, such as fishing, research, or offshore supply vessels. As such, there will be no particular health or safety concerns associated with Project emissions.

Given that the Project will use low sulphur content (no more than 1%) fuel (following Canadian 2012 ECA regulations) and that it will add negligible atmospheric emissions (relative to total northwest Atlantic ship traffic) to a windy oceanic environment, there will be no measureable adverse effect on air quality or human health in the Project Area.

### 5.7.2 Generic Activities - Marine Use

Project-related traffic will include one seismic survey vessel, one picket vessel and one supply vessel. The seismic and support vessels will operate within the Project Area (see Figure 1.1), except when transiting to or from the survey area. The seismic and/or support vessel may operate occasionally to and from the Project Area for re-provisioning, re-fuelling, and crew changes.

Other ships operating in the area could include freighters, tankers, fishing vessels, research vessels, naval vessels, and private yachts. Mitigations (detailed in Section 5.5) intended to minimize potential conflicts and any adverse effects with other vessels include the following.

- At sea communications (VHF, HF, Satellite, radar etc.);
- Utilization of FLOs for advice and coordination in regard to avoiding fishing vessels and fishing gear;
- Support vessel to alert other vessels of towed gear in water;
- Posting of advisories with the Canadian Coast Guard and the CBC Fisheries Broadcast;
- Compensation program in the event any project vessels damage fishing gear; and
- Single Point of Contact.

WesternGeco will also coordinate with DFO, St. John's, to avoid any potential conflicts with research vessels that may be operating in the area. Given the expected vessel density conditions and mitigations described above, there should be *negligible* adverse effects on other marine users of the Project Area.

### 5.7.3 Generic Activities - Waste Handling

Project waste will be generated by about 50 personnel. Waste will include the following.

- Gray/black water;
- Galley waste; and
- Solid waste.

As described in Section 5.5, vessel discharges will not exceed those of standard vessel operations and will adhere as a minimum to all applicable regulations and applicable international standards. The main discharges include grey water (wastewater from washing, bathing, laundry, and food preparation), black water (human wastes), bilge water, deck drainage and discharges from machinery spaces. Wastes produced from the seismic and support vessels, including hazardous and non-hazardous waste material, will be managed in accordance with MARPOL and with the vessel specific waste management plans.

Waste produced by the Project will be handled and treated appropriately and, therefore, will have *negligible* effect on the environment in the Project Area.

### 5.7.4 Fish and Fish Habitat VEC

Although there will be interaction between Project activities and the 'fish habitat' component of the Fish and Fish Habitat VEC (i.e., water and sediment quality, phytoplankton, zooplankton, and benthos) (Table 5.3), the *negligible* residual effects are predicted to be *not significant*. The seismic program will not result in any direct physical disturbance of the bottom substrate. Also, the probability is very low of any accidental event (i.e., hydrocarbon release) being of large enough magnitude to cause a significant effect on fish habitat. Therefore, other than in Table 5.3, no further reference to the 'fish habitat' component of the Fish and Fish Habitat VEC is made in this assessment subsection. Note that ichthyoplankton, invertebrate eggs and larvae, and macrobenthos are considered as part of the 'fish' component of the Fish and Fish Habitat VEC.

#### 5.7.4.1 Underwater Sound

The potential effects of exposure to airgun sound on invertebrates and fishes can be categorized as either physical (includes both pathological and physiological) or behavioural. Pathological effects include lethal and sub-lethal damage, physiological effects include temporary primary and secondary stress responses, and behavioural effects refer to deviations from normal behavioural activity. Physical and behavioural effects are very likely related in some instances and should therefore not be considered as completely independent of one another.

### Table 5.3 Potential Interactions of the Project Activities and the Fish and Fish Habitat VEC.

| Valued Environmental Component: Fish and Fish Habitat | | | | | | | |
|---|---|---|---|---|---|---|---|
| Project Activities | Non-Biological Environment | Feeding | | Reproduction | | Adult Stage | |
| | Water and Sediment Quality | Plankton | Benthos | Eggs and Larvae | Juveniles [a] | Pelagic Fish | Groundfish |
| **Sound** | | | | | | | |
| Airgun Array (2D, 3D and 4D) | | X | X | X | X | X | X |
| Seismic Vessel | | X | X | X | X | X | X |
| Supply Vessel | | X | X | X | X | X | X |
| Picket Vessel | | X | X | X | X | X | X |
| Helicopter [b] | | | | | | | |
| Echo Sounder | | | | | | X | |
| Side Scan Sonar | | | | | | X | |
| **Vessel Lights** | | X | | | | X | |
| **Vessel Presence** | | | | | | | |
| Seismic Vessel/Gear (2D, 3D and 4D) | | | | | | | |
| Supply Vessel | | | | | | | |
| Picket Vessel | | | | | | | |
| **Sanitary/Domestic Waste** | X | X | | X | | X | |
| **Atmospheric Emissions** | X | X | | X | | X | |
| **Garbage** [c] | | | | | | | |
| **Helicopter Presence**[b] | | | | | | | |
| **Shore Facilities** [d] | | | | | | | |
| **Accidental Releases** | X | X | X | X | X | X | X |
| **Other Projects and Activities in Region of Study Area** | | | | | | | |
| Oil and Gas Activities | X | X | X | X | X | X | X |
| Fisheries | X | X | X | X | X | X | X |
| Marine Transportation | X | X | X | X | X | X | X |

[a] Juveniles are young fish that are no longer planktonic and are often closely associated with the sea bottom.
[b] No helicopter use is planned for 2015 but helicopters may be used during 2016-2024.
[c] Not applicable as garbage will be brought ashore.
[d] There will not be any new onshore facilities. Existing infrastructure will be used.

The following subsections provide an overview of available information on relationships of underwater sound to invertebrates and fishes. The overview includes discussion of sound detection, sound production, and possible effects of exposure to airgun sounds and higher frequency sounds that could be emitted from survey gear such as sonar. More details related to sound detection, sound production and potential effects of exposure to seismic airgun sound as they relate to marine invertebrates and fishes are provided in Appendices 2 and 3, respectively.

The following subsections discuss the Project activities that will interact with the Fish and Fish Habitat VEC, including the assessment of the potential effects of these interactions.

### Sound Detection

Sensory systems, like those that allow for hearing, provide information about an animal's physical, biological, and social environments, in both air and water. Extensive work has been done to understand the structures, mechanisms, and functions of animal sensory systems in aquatic environments (Atema et al. 1988; Kapoor and Hara 2001; Collin and Marshall 2003).

Underwater sound has both a pressure component and a particle displacement component associated with it. While all marine invertebrates and fishes appear to have the capability of detecting the particle displacement component of underwater sound, only certain fish species appear to be sensitive to the pressure component (Breithaupt 2002; Casper and Mann 2006; Popper and Fay 2010).

#### Invertebrates

The sound detection abilities of marine invertebrates are the subject of ongoing debate. Aquatic invertebrates (with the exception of aquatic insects) do not possess the equivalent physical structures present in fish and marine mammals that can be stimulated by the pressure component of sound. It appears that marine invertebrates respond to vibrations rather than pressure (Breithaupt 2002). Statocysts (organs of balance containing mineral grains that stimulate sensory cells as the animal moves) apparently function as a vibration detector for at least some species of marine invertebrates (Popper and Fay 1999). The statocyst is a gravity receptor and allows the swimming animal to maintain a suitable orientation.

Among the marine invertebrates, decapod crustaceans have been the most studied in regards to sound detection. Crustaceans appear to be the most sensitive to low frequency sounds (i.e., <1,000 Hz) (Budelmann 1992; Popper et al. 2001), with some species being particularly sensitive to low-frequency sound (Lovell et al. 2006). Other studies suggest that some species (such as American lobster) may also be more sensitive to high frequencies than has been previously reported (Pye and Watson III 2004).

It is likely that cephalopods also use statocysts to detect low-frequency aquatic vibrations (Budelmann and Williamson 1994). Kaifu et al. (2008) provided evidence that the cephalopod *Octopus ocellatus* detects particle motion with its statocyst. Studies by Packard et al. (1990), Rawizza (1995), Komak et al. (2005) and Mooney et al. (2010) have quantified some of the optimally detected sound frequencies for various octopus (1–100 Hz), squid (1–500 Hz), and cuttlefish (20–8,000 Hz) species. Using the auditory brainstem response approach, Hu et al. (2009) showed that auditory-evoked potentials can be obtained in the frequency ranges 400–1,500 Hz for the squid *Sepiotheutis lessoniana* and 400–1,000 Hz for the octopus *Octopus vulgaris*, higher than frequencies previously observed to be detectable by cephalopods.

A recent study concluded that planktonic coral larvae can detect and respond to sound, the first description of an auditory response in the invertebrate phylum Cnidaria (Vermeij et al. 2010). Eggleston et al. (2013) have presented results of laboratory and field experiments that suggest oyster larvae use underwater sound to optimize settlement. Similarly, in a study by Stocks et al. (2012), it was found that marine invertebrate larvae of several species responded to sound and, in some cases, appeared to distinguish between different sound frequencies.

## <u>Fishes</u>

Marine fish are known to vary widely in their ability to hear sounds. Although hearing capability data only exist for fewer than 100 of the 27,000 fish species (Hastings and Popper 2005), current data suggest that most species of fish detect sounds below 1,500 Hz (Popper and Fay 2010). Some marine species, such as shads and menhaden, can detect higher frequency sounds above 180 kHz (Mann et al. 1997, 1998, 2001). Also, at least some species are acutely sensitive to infrasound (very low frequency), down to below 1 Hz (Sand and Karlsen 2000). Reviews of fish-hearing mechanisms and capabilities can be found in Fay and Popper (2000) and Ladich and Popper (2004).

All fish species have hearing (inner ear) and skin-based mechanosensory systems (lateral lines). Amoser and Ladich (2005) hypothesized that, as species within a particular family of fish may live under different ambient sound conditions, the hearing abilities of the individual species are likely to have adapted to the dominant conditions of their specific environments. The ability of fish to hear a range of biotic and abiotic sounds may affect their survival rate, with better adapted fish having an advantage over those that cannot detect prevailing sounds (Amoser and Ladich 2005).

Fish ears are able to respond to changes in pressure and particle motion in the water (van Bergeijk 1964; Schuijf 1981; Kalmijn 1988, 1989; Shellert and Popper 1992; Hawkins 1993; Fay 2005). Two major pathways have been identified for sound transmittance: (1) the otoliths, calcium carbonate masses in the inner ear that act as accelerometers when exposed to the particle motion component of sound, which cause shearing forces that stimulate sensory hair cells; and (2) the swim bladder, which expands and contracts in a sound field, re-radiating the sound's signal within the fish and in turn stimulating the inner ear (Popper and Fay 1993).

Researchers have noted that fish without an air-filled cavity (swim bladder), or with a reduced swim bladder or limited connectivity between the swim bladder and inner ear, are limited to detecting particle motion and not pressure, and therefore have relatively poor hearing abilities (Casper and Mann 2006). These species have commonly been known as 'hearing generalists' (Popper and Fay 1999), although a recent reconsideration suggests that this classification is oversimplified (Popper and Fay 2010). Rather, there is a range of hearing capabilities across species that is more like a continuum, presumably based on the relative contributions of pressure to the overall hearing capabilities of a species (Popper and Fay 2010). Results of direct study of fish sensitivity to particle motion have been reported in numerous published papers (Horodysky et al. 2008; Wysocki et al. 2009; Kojima et al. 2010).

### Sound Production

Many invertebrates and fishes produce sounds. It is believed that these sounds are used for communication in a wide range of behavioural and environmental contexts. The behaviours most often associated with acoustic communication include territorial behaviour, mate finding, courtship and aggression. Sound production provides a means of long distance communication as well as communication when underwater visibility is poor (Zelick et al. 1999).

Invertebrate groups with species capable of producing sound include barnacles, amphipods, shrimps, crabs, and lobsters (Au and Banks 1998; Tolstoganova 2002; Pye and Watson III 2004; Henninger and Watson III 2005; Buscaino et al. 2011). Invertebrates typically produce sound by scraping or rubbing various parts of their bodies, although they also produce sound in other ways.

More than 700 fish species are known to produce sounds (Myrberg 1981, Kaatz 2002 *in* Anderson et al. 2008). Fishes produce sounds mainly by using modified muscles attached to their swim bladders (i.e., drumming) or rubbing body parts together (i.e., stridulating). Examples of 'soniferous' fishes include Atlantic cod (Finstad and Nordeide 2004; Rowe and Hutchings 2004), toadfishes (Locascio and Mann 2008; Vasconcelos and Ladich 2008), and basses (Albers 2008; Johnston et al. 2008).

**Effects of Exposure to Airgun Sound**

Most airgun sound energy is associated with frequencies <500 Hz, although there is some energy associated with higher frequencies. The following sections discuss the potential physical (i.e., pathological and physiological) and behavioural effects of exposure to airgun sound on marine invertebrates and fishes.

**<u>Physical Effects</u>**

***Invertebrates***

In a field study, Pearson et al. (1994) exposed Stage II larvae of the Dungeness crab *Cancer magister* to single discharges from a seven-airgun array and compared their mortality and development rates with those of unexposed larvae. No statistically significant differences were found in immediate survival, long-term survival, or time to moult between the exposed and unexposed larvae, even those exposed within one metre of the seismic source.

The pathological impacts of seismic survey sound on marine invertebrates were investigated in a pilot study on snow crabs *Chionoecetes opilio* (Christian et al. 2003, 2004). Under controlled field experimental conditions, captive adult male snow crabs, egg-carrying female snow crabs, and fertilized snow crab eggs were exposed to variable Sound Pressure Levels (SPLs) (191 to 221 dB re 1 $\mu Pa_{0\text{-}p}$) and sound exposure levels (SELs) (<130–187 dB re 1 $\mu Pa^2 \cdot s$). Neither acute nor chronic (12 weeks post-exposure) mortality was observed for the adult crabs. However, a significant difference in development rate was noted between the exposed and unexposed fertilized eggs/embryos. The egg mass exposed to seismic energy had a higher proportion of less-developed eggs than did the unexposed mass. It should be noted that both egg masses came from a single female and any measure of natural variability was unattainable (Christian et al. 2003, 2004).

In 2003, a collaborative study was conducted in the southern Gulf of St. Lawrence, Canada, to investigate the effects of exposure to sound from a commercial seismic survey on egg-bearing female snow crabs (DFO 2004a). This study had design problems that impacted interpretation of some of the results (DFO 2004b). Caged animals were placed on the ocean bottom at a location within the survey area and at a location outside of the survey area. The maximum received SPL was ~195 dB re 1 $\mu Pa_{0-p}$. The crabs were exposed for 132 hours of the survey, equivalent to thousands of seismic shots of varying received SPLs. The animals were retrieved and transferred to laboratories for analyses. Neither acute nor chronic lethal or sub-lethal injury to the female crabs or crab embryos was indicated. DFO (2004b) reported that some exposed individuals had short-term soiling of gills, antennules and statocysts, bruising of the hepatopancreas and ovary, and detached outer membranes of oocytes. However, these differences could not be linked conclusively to exposure to seismic survey sound. Boudreau et al. (2009) presented the proceedings of a workshop held in 2007 to evaluate the results of additional studies conducted to answer some questions arising from the original study discussed in DFO (2004b). A series of scientific papers was presented to address issues of concern, including (1) actual sound pressure levels received by the snow crab; (2) reasons for the differences in presence of foreign particles on the gills, antennules and statocysts between study group crabs; (3) effect of seismic surveys on crab distribution and abundance; (4) reasons for differences in the cellular structure of certain organs between study group crabs; (5) reasons for differences in rate of leg loss between study group crabs; and (6) effect of exposure to seismic sound on snow crab embryos (Courtenay et al. 2009). Proceedings of the workshop did not include any more definitive conclusions regarding the original results.

Payne et al. (2007) conducted a pilot study of the effects of exposure to airgun sound on various health endpoints of the American lobster. Adult lobsters were exposed either 20 to 200 times to 202 dB re $1\mu Pa_{p-p}$ or 50 times to 227 dB re $1\mu Pa_{p-p}$, and then monitored for changes in survival, food consumption, turnover rate, serum protein level, serum enzyme levels, and serum calcium level. Observations extended over a period of a few days to several months. Results showed no delayed mortality or damage to the mechanosensory systems associated with animal equilibrium and posture (as assessed by turnover rate).

McCauley et al. (2000a,b) exposed caged cephalopods to sound from a single 20 $in^3$ airgun with maximum SPLs of >200 dB re 1 $\mu Pa_{0-p}$. Statocysts were removed and preserved, but at the time of publication, results of the statocyst analyses were not available. No squid or cuttlefish mortalities were reported as a result of these exposures.

Biochemical responses by marine invertebrates to acoustic exposure have also been studied to a limited degree. Such studies of stress responses could possibly provide some indication of the physiological consequences of acoustic exposure and perhaps any subsequent chronic detrimental effects. Stress responses could potentially affect animal populations by reducing reproductive capacity and adult abundance.

Stress indicators in the haemolymph of adult male snow crabs were monitored immediately after exposure of the animals to seismic survey sound (Christian et al. 2003, 2004) and at various intervals after exposure. No significant acute or chronic differences were found between exposed and unexposed animals in which various stress indicators (e.g., proteins, enzymes, cell type count) were measured.

Payne et al. (2007), in their study of the effects of exposure of adult American lobsters to airgun sound, noted decreases in the levels of serum protein, particular serum enzymes and serum calcium, in the haemolymph of animals exposed to the sound pulses. Statistically significant differences ($p$=0.05) were noted in serum protein at 12 days post-exposure, serum enzymes at 5 days post-exposure, and serum calcium at 12 days post-exposure. During the histological analysis conducted 4 months post-exposure, Payne et al. (2007) noted more deposits of PAS-stained material, likely glycogen, in the hepatopancreas of some of the exposed lobsters. Accumulation of glycogen could be due to stress or disturbance of cellular processes.

Price (2007) found that blue mussels *Mytilus edulis* responded to a 10 kHz pure tone continuous signal by decreasing respiration. Smaller mussels did not appear to react until exposed for 30 minutes whereas larger mussels responded after 10 minutes of exposure. The oxygen uptake rate tended to be reduced to a greater degree in the larger mussels than in the smaller animals.

In general, the limited studies done to date on the effects of acoustic exposure on marine invertebrates have not demonstrated any serious pathological and physiological effects. See Appendix 2 for a more detailed review of potential physical effects of exposure to seismic airgun sound on marine invertebrates.

### *Fishes*

Review papers on the effects of anthropogenic sources of underwater sound on fishes have been published recently (Payne et al. 2008; Popper 2009; Popper et al. 2014; Popper and Hastings 2009a,b). These papers consider various sources of anthropogenic sound, including seismic airguns.

Fertilized capelin (*Mallotus villosus*) eggs and monkfish (*Lophius americanus*) larvae were exposed to seismic airgun sound and subsequently examined and monitored for possible effects of the exposure (Payne et al. 2009). The laboratory exposure studies involved a single airgun. Approximate received SPLs measured in the capelin egg and monkfish larvae exposures were 199 to 205 dB re 1 $\mu Pa_{p-p}$ and 205 dB re 1 $\mu Pa_{p-p}$, respectively. The capelin eggs were exposed to either 10 or 20 airgun discharges, and the monkfish larvae were exposed to either 10 or 30 discharges. No statistical differences in mortality/morbidity between control and exposed subjects were found at 1 to 4 days post-exposure in any of the exposure trials for either the capelin eggs or the monkfish larvae.

In uncontrolled experiments, Kostyuchenko (1973) exposed the eggs of numerous fish species (anchovy, red mullet, crucian carp, blue runner) to various sound sources, including seismic airguns. With the seismic airgun discharge as close as 0.5 m from the eggs, over 75% of them survived the exposure. Egg survival rate increased to over 90% when placed 10 m from the airgun sound source. The range of received SPLs was about 215 to 233 dB re 1 $\mu Pa_{0-p}$.

Eggs, yolk sac larvae, post-yolk sac larvae, post-larvae, and fry of various commercially important fish species (cod, saithe, herring, turbot, and plaice) were exposed to received SPLs ranging from 220 to 242 dB re 1 μPa (unspecified measure type) (Booman et al. 1996). These received levels corresponded to exposure distances ranging from 0.75 to 6 m. The authors reported some cases of injury and mortality but most of these occurred as a result of exposures at very close range (i.e., <15 m).

Saetre and Ona (1996) applied a "worst-case scenario" mathematical model to investigate the effects of seismic sound on fish eggs and larvae. They concluded that mortality rates caused by exposure to seismic airgun sound are so low compared to the natural mortality that the impact of seismic surveying on recruitment to a fish stock must be regarded as insignificant.

Evidence for airgun-induced damage to fish ears has come from studies using pink snapper *Pagrus auratus* (McCauley et al. 2000a,b, 2003). In these experiments, fish were caged and exposed to the sound of a single moving seismic airgun every 10 seconds over a period of 1 hour and 41 minutes. The source SPL at 1 m was about 223 dB re 1 μPa at 1 $m_{p\text{-}p}$, and the received SPLs ranged from 165 to 209 dB re 1 $\mu Pa_{p\text{-}p}$. The sound energy was highest over the 20 to 70 Hz frequency range. The pink snapper were exposed to more than 600 airgun discharges during the study. In some individual fish, the sensory epithelium of the inner ear sustained extensive damage as indicated by ablated hair cells. Damage was more extensive in fish examined 58 days post-exposure compared to those examined 18 hours post-exposure. There was no evidence of repair or replacement of damaged sensory cells up to 58 days post-exposure. McCauley et al. (2000a,b, 2003) included the following *caveats* in the study reports: (1) fish were caged and unable to swim away from the seismic source, (2) only one species of fish was examined, (3) the impact on the ultimate survival of the fish is unclear, and (4) airgun exposure specifics required to cause the observed damage were not obtained (i.e., a few high SPL signals or the cumulative effect of many low to moderate SPL signals).

Recently, Andrews et al. (2014) conducted functional genomic studies on the inner ear of Atlantic salmon that had been exposed to seismic airgun sound. The air guns had a maximum SPL of approximately 145 dB re 1 $\mu Pa^2$/Hz and the fish were exposed to 50 discharges per trial. The results provided evidence that fish exposed to seismic sound either increased or decreased their expressions of different genes demonstrating that seismic sound can effect fish on a genetic level.

Popper et al. (2005) tested the hearing sensitivity of three Mackenzie River fish species after exposure to five discharges from a seismic airgun. The mean received peak SPL was 205 to 209 dB re 1 μPa per discharge, and the approximate mean received SEL was 176 to 180 dB re 1 $\mu Pa^2 \cdot s$ per discharge. While the broad whitefish (*Coregonus nasus*) showed no Temporary Threshold Shift (TTS) as a result of the exposure, adult northern pike (*Esox lucius*; a *hearing generalist*), and lake chub (*Couesius plumbeus*; *a hearing specialist*) exhibited TTSs of 10 to 15 dB, followed by complete recovery within 24 hours of exposure. The same animals were also examined to determine whether there were observable effects on the sensory cells of the inner ear as a result of exposure to seismic sound (Song et al. 2008). No damage to the ears of the fishes was found, including those that exhibited TTS. TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard.

In uncontrolled experiments using a very small sample of different groups of young salmonids, including Arctic cisco (*Coregonus autumnalis*), fish were caged and exposed to various types of sound. One sound type was either a single firing or a series of four firings 10 to 15 seconds apart of a 300 $in^3$ seismic airgun at 2,000 to 2,200 psi (Falk and Lawrence 1973). Swim bladder damage was reported but no mortality was observed when fish were exposed within 1 to 2 m of an airgun source with source level ~230 dB re 1 µPa at 1 m (unspecified measure) (as estimated by Turnpenny and Nedwell 1994). Considerable uncertainty is associated with this estimation of the source level.

See Appendix 3 for a more detailed review of potential physical effects of exposure to seismic airgun sound on fishes.

**Behavioural Effects**

### *Invertebrates*

Some studies have focused on potential behavioural effects on marine invertebrates. Christian et al. (2003) investigated the behavioural effects of exposure to airgun sound on snow crabs. Eight animals were equipped with ultrasonic tags, released, and monitored for multiple days prior to exposure and after exposure. Received SPL and SEL were ~191 dB re 1 $\mu Pa_{0\text{-}p}$ and <130 dB re 1 $\mu Pa^2 \cdot s$, respectively. The crabs were exposed to 200 discharges over a 33 minute period. None of the tagged animals left the immediate area after exposure to the seismic survey sound. Five animals were captured in the snow crab commercial fishery the following year, one at the release location, one 35 km from the release location, and three at intermediate distances from the release location.

Another study approach used by Christian et al. (2003) involved monitoring snow crabs with a remote video camera during their exposure to airgun sound. The caged animals were placed on the ocean bottom at a depth of 50 m. Received SPL and SEL were ~202 dB re 1 $\mu Pa_{0\text{-}p}$ and 150 dB re 1 $\mu Pa^2 \cdot s$, respectively. The crabs were exposed to 200 discharges over a 33 minute period. They did not exhibit any overt startle response during the exposure period.

Caged female snow crabs exposed to airgun sound associated with a recent commercial seismic survey conducted in the southern Gulf of St. Lawrence, Canada, exhibited a higher rate of ‘righting’ than those crabs not exposed to seismic survey sound (J. Payne, Research Scientist, DFO, St. John’s, NL, pers. comm.). ‘Righting’ refers to a crab’s ability to return itself to an upright position after being placed on its back. Christian et al. (2003) made the same observation in their study. Payne et al. (2007), in their study of the effects of exposure to airgun sound on adult American lobsters, noted a trend for increased food consumption by the animals exposed to seismic sound.

Caged brown shrimp *Crangon crangon* reared under different acoustical conditions exhibited differences in aggressive behaviour and feeding rate (Lagardère 1982). Those exposed to a continuous sound source showed more aggression and less feeding behaviour. It should be noted that behavioural responses by caged animals may differ from behavioural responses of animals in the wild.

McCauley et al. (2000a,b) provided the first evidence of the behavioural response of southern calamari squid *Sepioteuthis australis* exposed to seismic survey sound. McCauley et al. (2000a,b) reported on the exposure of caged cephalopods (50 squid and two cuttlefish) to sound from a single 20 $in^3$ airgun. The cephalopods were exposed to both stationary and mobile sound sources. The two-run total exposure times during the three trials ranged from 69 to 119 min. at a firing rate of once every 10 to 15 seconds. The maximum SPL was >200 dB re 1 $\mu Pa_{0-p}$. Some of the squid fired their ink sacs apparently in response to the first shot of one of the trials and then moved quickly away from the airgun. In addition to the above-described startle responses, some squid also moved towards the water surface as the airgun approached. McCauley et al. (2000a,b) reported that the startle and avoidance responses occurred at a received SPL of 174 dB re 1 $\mu Pa_{rms}$. They also exposed squid to a ramped approach-depart airgun signal whereby the received SPL was gradually increased over time. No strong startle response (i.e., ink discharge) was observed, but alarm responses, including increased swimming speed and movement to the surface, were observed once the received SPL reached a level in the 156 to 161 dB re 1 $\mu Pa_{rms}$ range.

Komak et al. (2005) also reported the results of a study of cephalopod behavioural responses to local water movements. In this case, juvenile cuttlefish *Sepia officinalis* exhibited various behavioural responses to local sinusoidal water movements of different frequencies between 0.01 and 1,000 Hz. These responses included body pattern changing, movement, burrowing, reorientation, and swimming. Similarly, the behavioural responses of the octopus *Octopus ocellatus* to non-impulse sound have been investigated by Kaifu et al. (2007). The sound stimuli, reported as having levels 120 dB re 1 $\mu Pa_{rms}$, were at various frequencies: 50, 100, 150, 200 and 1,000 Hz. The respiratory activity of the octopus changed when exposed to sound in the 50–150 Hz range but not for sound at 200–1,000 Hz. Respiratory suppression by the octopus might have represented a means of escaping detection by a predator.

Low-frequency sound (<200 Hz) has also been used as a means of preventing settling/fouling by aquatic invertebrates such as zebra mussels *Dreissena polymorpha* (Donskoy and Ludyanskiy 1995) and balanoid barnacles *Balanus* sp. (Branscomb and Rittschof 1984). Price (2007) observed that blue mussels *Mytilus edulis* closed their valves upon exposure to 10 kHz pure tone continuous sound.

Although not demonstrated in the invertebrate literature, masking can be considered a potential effect of anthropogenic underwater sound on marine invertebrates. Some invertebrates are known to produce sounds (Au and Banks 1998; Tolstoganova 2002; Latha et al. 2005). The functionality and biological relevance of these sounds are not understood (Jeffs et al. 2003, 2005; Lovell et al. 2006; Radford et al. 2007). If some of the sounds are of biological significance to some invertebrates, then masking of those sounds or of sounds produced by predators, at least the particle displacement component, could potentially have adverse effects on marine invertebrates. However, even if masking does occur in some invertebrates, the intermittent nature of airgun sound is expected to result in less masking effect than would occur with continuous sound.

### *Invertebrate Fisheries*

Christian et al. (2003) investigated the pre- and post-exposure catchability of snow crabs during a commercial fishery. Received SPLs and SELs were not measured directly and likely ranged widely considering the area fished. Maximum SPL and SEL were likely similar to those measured during the telemetry study. There were seven pre-exposure and six post-exposure trap sets. Unfortunately, there was considerable variability in set duration because of poor weather. Results indicated that the catch-per-unit-effort did not decrease after the crabs were exposed to seismic survey sound.

Andriguetto-Filho et al. (2005) attempted to evaluate the impact of seismic survey sound on artisanal shrimp fisheries off Brazil. Bottom trawl yields were measured before and after multiple-day shooting of an airgun array. Water depth in the experimental area ranged between 2 and 15 m. Results of the study did not indicate any significant deleterious impact on shrimp catches. Anecdotal information from Newfoundland indicated that catch rates of snow crabs showed a significant reduction immediately following a pass by a seismic survey vessel (G. Chidley, Newfoundland fisherman, pers. comm.). Additional anecdotal information from Newfoundland indicated that an aggregation of shrimp observed with a fishing vessel sounder appeared to shift downwards and away from a nearby seismic airgun sound source (H. Thorne, Newfoundland fisherman, pers. comm.). This observed effect was temporary.

Parry and Gason (2006) statistically analyzed data related to rock lobster *Jasus edwardsii* commercial catches and seismic surveying in Australian waters from 1978 to 2004. They did not find any evidence that lobster catch rates were affected by seismic surveys. They also noted that due to natural variability and fishing pressure, a large effect on lobster would be required to make any link to effect of seismic.

See Appendix 2 for a more detailed review of potential behavioural effects of exposure to seismic airgun sound on marine invertebrates.

### *Fishes*

Pearson et al. (1992) investigated the effects of seismic airgun sound on the behaviour of captive rockfishes *Sebastes* sp. exposed to the sound of a single stationary airgun at a variety of distances. The airgun used in the study had a source SPL at 1 m of 223 dB re 1 μPa at 1 $m_{0\text{-}p}$, and measured received SPLs ranged from 137 to 206 dB re 1 $\mu Pa_{0\text{-}p}$. The authors reported that rockfishes reacted to the airgun sounds by exhibiting varying degrees of startle and alarm responses, depending on the species of rockfish and the received SPL. Startle responses were observed at a minimum received SPL of 200 dB re 1 $\mu Pa_{0\text{-}p}$, and alarm responses occurred at a minimum received SPL of 177 dB re 1 $\mu Pa_{0\text{-}p}$. Other observed behavioural changes included the tightening of schools, downward distributional shift, and random movement and orientation. Some fishes ascended in the water column and commenced to mill (i.e., "eddy") at increased speed, while others descended to the bottom of the enclosure and remained motionless. Pre-exposure behaviour was re-established from 20 to 60 minutes after cessation of seismic airgun discharge. Pearson et al. (1992) concluded that received SPL thresholds for overt rockfish behavioural response and more subtle rockfish behavioural response are 180 dB re 1 $\mu Pa_{0\text{-}p}$ and 161 dB re 1 $\mu Pa_{0\text{-}p}$, respectively.

Fish exposed to the sound from a single airgun in the study by McCauley et al. (2000a,b) exhibited startle responses to short range start up and high level airgun signals (i.e., with received SPLs of 182 to 195 dB re 1 $\mu Pa_{rms}$. Smaller fish were more likely to display a startle response. Responses were observed above received SPLs of 156 to 161 dB re 1 µ$Pa_{rms}$. The occurrence of both startle response (classic C-turn response) and alarm responses (e.g., darting movements, flash school expansion, fast swimming) decreased over time. Other observations included downward distributional shift that was restricted by the 10 m x 6 m x 3 m cages, increase in swimming speed, and the formation of denser aggregations. Fish behaviour appeared to return to pre-exposure state 15 to 30 min after cessation of seismic firing.

Using an experimental hook and line fishery approach, Skalski et al. (1992) studied the potential effects of seismic airgun sound on the distribution and catchability of rockfishes. The source SPL of the single airgun used in the study was 223 dB re 1 µPa at 1 m $_{0\text{-}p}$, and the received SPLs at the bases of the rockfish aggregations ranged from 186 to 191 dB re 1 µ$Pa_{0\text{-}p}$. Characteristics of the fish aggregations were assessed using echosounders. During long-term stationary seismic airgun discharge, there was an overall downward shift in fish distribution. The authors also observed a significant decline in total catch of rockfishes during seismic discharge. It should be noted that this experimental approach was quite different from an actual seismic survey, in that duration of exposure was much longer.

In another study, caged European sea bass *Dicentrarchus labrax* were exposed to multiple discharges from a moving seismic airgun array with a source SPL of about 256 dB re 1 µPa at 1 $m_{0\text{-}p}$ (unspecified measure type) (Santulli et al. 1999). The airguns were discharged every 25 seconds during a two hour period. The minimum distance between fish and seismic source was 180 m. The authors did not indicate any observed pathological injury to the sea bass. Blood was collected from both exposed fish (6 h post-exposure) and control fish (6 h pre-exposure) and subsequently analyzed for cortisol, glucose, and lactate levels. Levels of cortisol, glucose, and lactate were significantly higher in the sera of exposed fish compared to sera of control fish. The elevated levels of all three chemicals returned to pre-exposure levels within 72 hours of exposure (Santulli et al. 1999).

Santulli et al. (1999) also used underwater video cameras to monitor fish response to seismic airgun discharge. Resultant video indicated slight startle responses by some of the sea bass when the seismic airgun array discharged as far as 2.5 km from the cage. The proportion of sea bass that exhibited startle response increased as the airgun sound source approached the cage. Once the seismic array was within 180 m of the cage, the sea bass were densely packed at the middle of the enclosure, exhibiting random orientation, and appearing more active than they had been under pre-exposure conditions. Normal behaviour resumed about 2 hours after airgun discharge nearest the fish (Santulli et al. 1999).

Boeger et al. (2006) reported observations of coral reef fishes in field enclosures before, during and after exposure to seismic airgun sound. This Brazilian study used an array of eight airguns that was presented to the fishes as both a mobile sound source and a static sound source. Minimum distances between the sound source and the fish cage ranged from 0 to 7 m. Received sound levels were not reported by Boeger et al. (2006). Neither mortality nor external damage to the fishes was observed in any of the experimental scenarios. Most of the airgun array discharges resulted in startle responses although these behavioural changes lessened with repeated exposures, suggesting habituation.

Chapman and Hawkins (1969) investigated the reactions of free-ranging whiting (silver hake), *Merluccius bilinearis*, to an intermittently discharging stationary airgun with a source SPL of 220 dB re 1 µPa at 1 $m_{0-p}$. Received SPLs were estimated to be 178 dB re 1 $\mu Pa_{0-p}$. The whiting were monitored with an echosounder. Prior to any airgun discharge, the fish were located at a depth range of 25 to 55 m. In apparent response to the airgun sound, the fish descended, forming a compact layer at depths greater than 55 m. After an hour of exposure to the airgun sound, the fish appeared to have habituated as indicated by their return to the pre-exposure depth range, despite the continuing airgun discharge. Airgun discharge ceased for a time and upon its resumption, the fish again descended to greater depths, indicating only temporary habituation.

Hassel et al. (2003, 2004) studied the potential effects of exposure to airgun sound on the behaviour of captive lesser sandeel, *Ammodytes marinus*. Depth of the study enclosure used to hold the sandeel was about 55 m. The moving airgun array had an estimated source SPL of 256 dB re 1 µPa at 1 m (unspecified measure type). Received SPLs were not measured. Exposures were conducted over a three day period in a 10 km x 10 km area with the cage at its centre. The distance between airgun array and fish cage ranged from 55 m when the array was overhead to 7.5 km. No mortality attributable to exposure to the airgun sound was noted. Behaviour of the fish was monitored using underwater video cameras, echosounders, and commercial fishery data collected close to the Study Area. The approach of the seismic vessel appeared to cause an increase in tail-beat frequency although the sandeels still appeared to swim calmly. During seismic airgun discharge, many fish exhibited startle responses, followed by flight from the immediate area. The frequency of occurrence of startle response seemed to increase as the operating seismic array moved closer to the fish. The sandeels stopped exhibiting the startle response once the airgun discharge ceased. The sandeel tended to remain higher in the water column during the airgun discharge, and none of them were observed burying themselves in the soft substrate. The commercial fishery catch data were inconclusive with respect to behavioural effects.

Various species of demersal fishes, blue whiting, and some small pelagic fishes were exposed to a moving seismic airgun array with a source SPL of about 250 dB re 1 µPa at 1 m (unspecified measure type) (Dalen and Knutsen 1986). Received SPLs estimated using the assumption of spherical spreading ranged from 200 to 210 dB re 1 µPa (unspecified measure type). Seismic sound exposures were conducted every 10 seconds during a one week period. The authors used echosounders and sonars to assess the pre- and post-exposure fish distributions. The acoustic mapping results indicated a significant decrease in abundance of demersal fish (36%) after airgun discharge but comparative trawl catches did not support this. Non-significant reductions in the abundances of blue whiting and small pelagic fish were also indicated by post-exposure acoustic mapping.

La Bella et al. (1996) studied the effects of exposure to seismic airgun sound on fish distribution using echosounder monitoring and changes in catch rate of hake by trawl, and clupeoids by gill netting. The seismic array used was composed of 16 airguns and had a source SPL of 256 dB re 1 µPa at 1 $m_{0-p}$. The shot interval was 25 seconds, and exposure durations ranged from 4.6 to 12 hours. Horizontal distributions did not appear to change as a result of exposure to seismic discharge, but there was some indication of a downward shift in the vertical distribution. The catch rates during experimental fishing did not differ significantly between pre- and post-seismic fishing periods.

Wardle et al. (2001) used video and telemetry to make behavioural observations of marine fishes (primarily juvenile saithe (*Pollachius virens*), adult pollock (*Pollachius pollachius*), juvenile cod, and adult mackerel) inhabiting an inshore reef off Scotland before, during, and after exposure to discharges of a stationary airgun. The received SPLs ranged from about 195 to 218 dB re 1 $\mu Pa_{0-p}$. Pollock did not move away from the reef in response to the seismic airgun sound, and their diurnal rhythm did not appear to be affected. However, there was an indication of a slight effect on the long-term day-to-night movements of the pollock. Video camera observations indicated that fish exhibited startle responses ("C-starts") to all received levels. There were also indications of behavioural responses to visual stimuli. If the seismic source was visible to the fish, they fled from it. However, if the source was not visible to the fish, they often continued to move toward it.

The potential effects of exposure to seismic sound on fish abundance and distribution were also investigated by Slotte et al. (2004). Twelve days of seismic survey operations spread over a period of one month used a seismic airgun array with a source SPL of 222.6 dB re 1 µPa at 1 $m_{p-p}$. The SPLs received by the fish were not measured. Acoustic surveys of the local distributions of various kinds of pelagic fish, including herring, blue whiting (*Micromesistius poutassoa*), and mesopelagic species, were conducted during the seismic surveys. There was no strong evidence of short-term horizontal distributional effects. With respect to vertical distribution, blue whiting and mesopelagics were distributed deeper (20 to 50 m) during the seismic survey compared to pre-exposure. The average densities of fish aggregations were lower within the seismic survey area, and fish abundances appeared to increase in accordance with increasing distance from the seismic survey area.

During a Mackenzie River project, Jorgenson and Gyselman (2009) investigated the behavioural responses of Arctic riverine fishes to seismic airgun sound. The mean received peak SPL was 205 to 209 dB re 1 µPa per discharge, and the approximate mean received SEL was 176 to 180 dB re 1 $\mu Pa^2 \cdot s$ per discharge. They used hydroacoustic survey techniques to determine whether fish behaviour upon exposure to airgun sound can either mitigate or enhance the potential impact of the sound. The study indicated that fish behavioural characteristics were generally unchanged by the exposure to airgun sound. The tracked fish did not exhibit herding behaviour in front of the mobile airgun array and, therefore, were not exposed to sustained high sound levels.

Thomsen (2002) exposed rainbow trout (*Oncorhynchus mykiss*) and Atlantic salmon held in aquaculture enclosures to the sounds from a small airgun array. Received SPLs were 142 to 186 dB re 1 $\mu Pa_{p-p}$. The fish were exposed to 124 pulses over a three day period. In addition to monitoring fish behaviour with underwater video cameras, the authors also analyzed cod and haddock catch data from a longline fishing vessel operating in the immediate area. Only eight of the 124 shots appeared to evoke behavioural reactions by the salmonids, but overall impacts were minimal. No fish mortality was observed during or immediately after exposure. The author reported no significant effects on cod and haddock catch rates, and the behavioural effects were hard to differentiate from normal behaviour.

Peña et al. (2013) studied the real-time behavior of herring schools exposed to a full-scale 3D seismic survey off northern Norway using an omnidirectional fisheries sonar. The feeding herring were observed over a six-hour period as the seismic vessel and active airguns approached them from a distance of 27 km to 2 km away. The investigators observed a lack of response by the herring and concluded that this observation was likely due to a combination of factors including a strong motivation for feeding, a lack of suddenness of the airgun stimulus, and an increased level of tolerance to the seismic sound.

***Finfish Fisheries***

Early comprehensive experimentation on the effects of seismic airgun sound on catchability of fishes was conducted in the Barents Sea by Engås et al. (1993, 1996). They investigated the effects of seismic airgun sound on distributions, abundances, and catch rates of cod and haddock using acoustic mapping and experimental fishing with trawls and longlines. The maximum source SPL was about 248 dB re 1 µPa at 1 $m_{0\text{-}p}$ based on calculations using sound measurements collected by a hydrophone suspended at a depth of 80 m. No measurements of the received SPLs were made. Davis et al. (1998) estimated the received SPL at the sea bottom immediately below the array and at 18 km from the array to be 205 dB re 1 $\mu Pa_{0\text{-}p}$ and 178 dB re 1 $\mu Pa_{0\text{-}p}$, respectively. Engås et al. (1993, 1996) concluded that there were indications of distributional change during and immediately following the seismic airgun discharge (45 to 64% decrease in acoustic density according to sonar data). The lowest densities were observed within 9.3 km of the seismic discharge area. The authors indicated that trawl catches of both cod and haddock declined after the seismic operations. While longline catches of haddock also showed decline after seismic airgun discharge, those for cod increased.

Løkkeborg (1991), Løkkeborg and Soldal (1993), and Dalen and Knutsen (1986) also examined the effects of seismic airgun sound on demersal fish catches. Løkkeborg (1991) examined the effects on cod catches. The source SPL of the airgun array used in his study was 239 dB re 1 µPa at 1 m (unspecified measure type), but received SPLs were not measured. Approximately 43 hours of seismic airgun discharge occurred during an 11 day period, with a five-second interval between pulses. Catch rate decreases ranging from 55 to 80% within the seismic survey area were observed. This apparent effect persisted for at least 24 hours within about 10 km of the survey area. The effect of exposure to seismic sound on commercial demersal fishes was again studied in 2009 using gillnet and longline fishery methods off the coast of Norway (Løkkeborg et al. 2010). Study results indicated that fishes did react to airgun sound based on observed changes in catch rates during seismic shooting. Gillnet catches increased during the seismic shooting, likely a result of increased fish activity, while longline catches decreased overall.

Turnpenny et al. (1994) examined results of these studies as well as the results of other studies on rockfish. They used rough estimations of received SPLs at catch locations and concluded that catchability is reduced when received SPLs exceed 160 to 180 dB re 1 $\mu Pa_{0\text{-}p}$. They also concluded that reaction thresholds of fishes lacking a swim bladder (e.g., flatfish) would likely be about 20 dB higher. Given the considerable variability in sound transmission loss between different geographic locations, the SPLs that were assumed in these studies were likely quite inaccurate. Turnpenny and Nedwell (1994) also reported on the effects of seismic airgun discharge on inshore bass fisheries in shallow U.K. waters (5 to 30 m deep). The airgun array used had a source level of 250 dB re 1 µPa at 1 $m_{0\text{-}p}$. Received levels in the fishing areas were estimated to range between 163 and 191 dB re 1 $\mu Pa_{0\text{-}p}$. Using fish tagging and catch record methodologies, they concluded that there was not any distinguishable migration from the ensonified area, nor was there any reduction in bass catches on days when seismic airguns were discharged. The authors concluded that effects on fisheries would be smaller in shallow nearshore waters than in deep water because attenuation of sound is often more rapid in shallow water, depending on the physical characteristics of the water and substrate in the area.

Skalski et al. (1992) used a 100 $in^3$ airgun with a source level of 223 dB re 1 µPa at 1 $m_{0\text{-}p}$ to examine the potential effects of airgun sound on the catchability of rockfishes. The moving airgun was discharged along transects in the study fishing area, after which a fishing vessel deployed a set line, ran three echosounder transects, and then deployed two more set lines. Each fishing experiment lasted one hour and 25 minutes. Received SPLs at the base of the rockfish aggregations ranged from 186 to 191 dB re 1 $\mu Pa_{0\text{-}p}$. The catch-per-unit-effort (CPUE) for rockfish declined on average by 52.4% when the airguns were operating. Skalski et al. (1992) believed that the reduction in catch resulted from a change in behaviour of the fishes. The fish schools descended towards the bottom and their swimming behaviour changed during airgun discharge. Although fish dispersal was not observed, the authors hypothesized that it could have occurred at a different location with a different bottom type. Skalski et al. (1992) did not continue fishing after cessation of airgun discharge. They speculated that CPUE would quickly return to normal in the experimental area, because fish behaviour appeared to normalize within minutes of cessation of airgun discharge. However, in an area where exposure to airgun sound might have caused the fish to disperse, the authors suggested that a lower CPUE might persist for a longer period.

European sea bass were exposed to sound from seismic airgun arrays with a source SPL of 262 dB re 1 µPa at 1 $m_{0\text{-}p}$ (Pickett et al. 1994). The seismic survey was conducted over a period of 4 to 5 months. The study was intended to investigate the effects of seismic airgun discharge on inshore bass fisheries. Information was collected through a tag and release program, and from the logbooks of commercial fishermen. Most of the 152 recovered fish from the tagging program were caught within 10 km of the release site, and it was suggested that most of these bass did not leave the area for a prolonged period. With respect to the commercial fishery, no significant changes in catch rate were observed (Pickett et al. 1994).

See Appendix 3 for a more detailed review of potential behavioural effects of exposure to seismic airgun sound on fishes.

**Effects of Exposure to Marine Vessel Sound**

Studies have also been conducted that consider the effects of vessel noise on marine invertebrates. For example, Filiciotto et al. (2014) found that the locomotor activities of the Mediterranean spiny lobster increased a significant amount due to the exposure of vessel noise alone for individuals placed in aquaria tanks. The researchers also saw the increase of certain biochemical parameters, often used as stress indices, including glucose level, total protein level, and total haemocyte count. Furthermore, in a tank study examining the behavior of the common cuttlefish (*Sepia officinalis*) exposed to recorded vessel noise, Hansjoerg et al. (2014) concluded that the cuttlefish adjusted their visual displays of colour change more frequently during the playback of the vessel noise compared to before and after the playback.

Numerous papers about the behavioural responses of fishes to marine vessel sound have been published in the primary literature. They consider the responses of small pelagic fishes (e.g., Misund et al. 1996; Vabo et al. 2002; Jørgensen et al. 2004; Skaret et al. 2005; Ona et al. 2007; Sand et al. 2008), large pelagic fishes (Sarà et al. 2007), and groundfishes (Engås et al. 1998; Handegard et al. 2003; De Robertis et al. 2008). Generally, most of the papers indicate that fishes typically exhibit some level of reaction to the sound of approaching marine vessels, the degree of reaction being dependent on a variety of factors including the activity of the fish at the time of exposure (e.g., reproduction, feeding, migration), characteristics of the vessel sound, and water depth.

**Sound Exposure Effects Assessment**

The assessment in this and subsequent subsections is structured such that the reader should first refer to the interaction table (e.g., Table 5.3) to determine if there are any interactions with project activities, secondly to the assessment table (e.g., Table 5.4) which contains criteria ratings, including those for magnitude, geographic extent, and duration, and thirdly to the significance predictions table (e.g., Table 5.5).

It is not practical to assess in detail the potential effects of every type of sound on every species in the Study Area. The best approach, and common practice in EA, is to provide focus by selecting (1) the strongest sound source, in this case the airgun array, and (2) several species that are representative of the different types of sensitivities and offer a relevant literature base. Snow crab and Atlantic cod best serve this purpose.

The most notable criteria in the assessment include (1) distance between airgun array and animal under normal conditions (post-larval snow crabs remain on bottom, post-larval cod occur in the water column, and larvae of both snow crab and cod are planktonic in upper water column), (2) motility of the animal (post-larval snow crabs much less motile than post-larval cod, and larvae of both are essentially passive drifters), (3) absence or presence of a swim bladder (i.e., auditory sensitivity) (snow crabs without swimbladder and cod with swimbladder), and (4) reproductive strategy (snow crabs carry fertilized eggs at the bottom until larval hatch, and cod eggs are planktonic).

Potential impacts on other marine invertebrate and fish species are inferred from the assessment using snow crab and Atlantic cod. Potential interactions between the proposed Project activities and the Fish and Fish Habitat VEC are shown in Table 5.3.

As already indicated in this subsection, although research on the effects of exposure to airgun sound on marine invertebrates and fishes is increasing, many data gaps remain (Hawkins et al. 2014). Available experimental data suggest that there may be physical impacts on the fertilized eggs of snow crab and on the egg, larval, juvenile and adult stages of cod at very close range. Considering the typical source levels associated with commercial seismic airgun arrays, close proximity to the source would result in exposure to very high sound pressure levels. While egg and larval stages are not able to actively escape such an exposure scenario, juvenile and adult cod would most likely avoid it. Developing embryos, juvenile and adult snow crab are benthic and generally far enough from the sound source to receive energy levels well below levels that may have impact. In the case of eggs and larvae, it is likely that the numbers negatively affected by exposure to seismic sound would be negligible when compared to those succumbing to natural mortality (Saetre and Ona 1996). Atlantic cod do have swim bladders and are therefore generally more sensitive to underwater sounds than fishes without swim bladders. Spatial and temporal avoidance of critical life history times (e.g., spawning aggregations) as well as ramp-up should mitigate the effects of exposure to airgun sound.

Snow crab, sensitive to the particle displacement component of sound only, will be a considerable distance from the airguns and will not likely be affected by any particle displacement resulting from airgun discharge.

Limited data regarding physiological impacts on fish and invertebrates indicate that these impacts are both short-term and most obvious after exposure at close range.

The physical effects of exposure to sound with frequencies >500 Hz are *negligible*, based on the available information from the scientific literature. Effects of exposure to <500 Hz sound and marine vessel sound appear to be primarily behavioural and somewhat temporary.

Table 5.4 provides the details of the assessment of the effects of exposure to Project-related sound on the Fish and Fish Habitat VEC.

As indicated in Table 5.4, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual effects on the Fish and Fish Habitat VEC that are *negligible* to *medium* in magnitude for a duration of *<1 month* to *1 to 12 months* over a geographic area of *<1* to *101-1,000* $km^2$. Based on these criteria ratings, the *reversible* residual effects of sound associated with WesternGeco's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (Table 5.5). The level of confidence associated with this prediction is *medium* to *high* (Table 5.5).

#### 5.7.4.2 Other Project Activities

**Vessel Lights**

As indicated in Table 5.3, there are potential interactions between vessel lights and certain components of the Fish and Fish Habitat VEC. However, other than the relatively neutral effect of attraction of certain species/life stages to the upper water column at night, there will be *negligible* effects of vessel lights on this VEC (Table 5.4). Therefore, the residual effects of vessel lights associated with WesternGeco's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (Table 5.5). The level of confidence associated with this prediction is *high* (Table 5.5).

## Table 5.4 Assessment of Effects of Project Activities on the Fish and Fish Habitat VEC.

| Valued Environmental Component: Fish and Fish Habitat | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Project Activity | Potential Positive (P) or Negative (N) Environmental Effect | Mitigation | Evaluation Criteria for Assessing Environmental Effects | | | | | |
| | | | Magnitude | Geographic Extent | Frequency | Duration | Reversibility | Ecological/ Socio-Cultural and Economic Context |
| **Sound** | | | | | | | | |
| Airguns (2D, 3D and 4D) | Physical effects (N); Disturbance (N) | Ramp-up of array; Spatial & temporal avoidance | 1-2 | 1-4 | 6 | 1-2 | R | 2 |
| Seismic Vessel | Disturbance (N) | Spatial & temporal avoidance | 0-1 | 1-2 | 6 | 1-2 | R | 2 |
| Supply Vessel | Disturbance (N) | Spatial & temporal avoidance | 0-1 | 1-2 | 1 | 1 | R | 2 |
| Picket Vessel | Disturbance (N) | Spatial & temporal avoidance | 0-1 | 1-2 | 6 | 1-2 | R | 2 |
| Echo Sounder | Disturbance (N) | Spatial & temporal avoidance | 0-1 | 1 | 6 | 1 | R | 2 |
| Side Scan Sonar | Disturbance (N) | Spatial & temporal avoidance | 0-1 | 1 | 6 | 1 | R | 2 |
| **Vessel Lights** | Neutral effect | - | - | - | - | - | - | - |
| **Sanitary/Domestic Waste** | Pathological effects (N); Contamination (N) | Treatment | 0-1 | 1 | 4 | 1-2 | R | 2 |
| **Atmospheric Emissions** | Pathological effects (N); Contamination (N) | Equipment maintenance | 0 | 1 | 6 | 1-2 | R | 2 |
| **Accidental Releases** | Pathological effects (N); Contamination (N) | Prevention protocols; Response plan | 0-1 | 1-2 | 1 | 1 | R | 2 |

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

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

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

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

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 $km^2$

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not negatively affected by human activity
2 = Evidence of existing negative effects

**Table 5.5 Significance of Potential Residual Environmental Effects of Project Activities on the Fish and Fish Habitat VEC.**

| Valued Environmental Component: Fish and Fish Habitat | | | | |
|---|---|---|---|---|
| **Project Activity** | **Significance Rating** | **Level of Confidence** | **Likelihood[a]** | |
| | **Significance of Predicted Residual Environmental Effects** | | **Probability of Occurrence** | **Scientific Certainty** |
| **Sound** | | | | |
| Airgun Array (2D, 3D and 4D) | NS | 2-3 | - | - |
| Seismic Vessel | NS | 2-3 | - | - |
| Supply Vessel | NS | 2-3 | - | - |
| Picket Vessel | NS | 2-3 | - | - |
| Echo Sounder | NS | 2-3 | - | - |
| Side Scan Sonar | NS | 2-3 | - | - |
| **Vessel Lights** | NS | 3 | - | - |
| **Sanitary/Domestic Wastes** | NS | 3 | - | - |
| **Atmospheric Emissions** | NS | 3 | - | - |
| **Accidental Releases** | NS | 2-3 | - | - |

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 $km^2$ (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Considered only in the case where 'significant negative effect' is predicted.

## Sanitary/Domestic Waste

As indicated in Table 5.3, there are potential interactions between sanitary/domestic waste and certain components of the Fish and Fish Habitat VEC. After application of mitigation measures, including treatment of the waste, the residual effects of sanitary/domestic waste on the Fish and Fish Habitat VEC are predicted to be *negligible to low* in magnitude for a duration of *<1 to 1-12 months* over a geographic area of *<1* $km^2$ (see Table 5.4). Based on these criteria ratings, the *reversible* residual effects of exposure to sanitary/domestic waste associated with WesternGeco's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (see Table 5.5). The level of confidence associated with this prediction is *high* (see Table 5.5).

**Atmospheric Emissions**

As indicated in Table 5.3, there are potential interactions between atmospheric emissions and certain components of the Fish and Fish Habitat VEC that occur near surface. Considering that the amount of atmospheric emissions produced during the proposed seismic program will rapidly disperse to undetectable levels, the residual effects of exposure to atmospheric emissions on the Fish and Fish Habitat VEC are predicted to be *negligible* (see Table 5.4). Therefore, the *reversible* residual effects of atmospheric emissions associated with WesternGeco's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (see Table 5.5). The level of confidence associated with this prediction is *high* (see Table 5.5).

**Accidental Releases**

Planktonic invertebrate and fish eggs and larvae are less resistant to effects of contaminants than are adults because they are not physiologically equipped to detoxify them or to actively avoid them. In addition, many eggs and larvae develop at or near the surface where hydrocarbon exposure may be the greatest (Rice 1985). Generally, fish eggs appear to be highly sensitive at certain stages and then become less sensitive just prior to larval hatching (Kühnhold 1978; Rice 1985). Larval sensitivity varies with yolk sac stage and feeding conditions (Rice et al. 1986). Eggs and larvae exposed to high concentrations of hydrocarbons generally exhibit morphological malformations, genetic damage, and reduced growth. Damage to embryos may not be apparent until the larvae hatch. The natural mortality rate in fish eggs and larvae is extremely high and very large numbers would have to be destroyed by anthropogenic sources before effects would be detected in an adult population (Rice 1985).

There is an extensive body of literature regarding the effects of exposure to hydrocarbons on juvenile and adult fish. Although some of the literature describes field observations, most refers to laboratory studies. Reviews of the effects of hydrocarbons on fish have been prepared by Rice et al. 1986; Armstrong et al. (1995), Payne et al. (2003) and numerous other authors. If exposed to hydrocarbons in high enough concentrations, fish may suffer effects ranging from direct physical effects (e.g., coating of gills and suffocation) to more subtle physiological and behavioural effects. Actual effects depend on a variety of factors such as the amount and type of hydrocarbon, environmental conditions, species and life stage, lifestyle, fish condition, degree of confinement of experimental subjects, and others.

As indicated in Table 5.3, there are potential interactions of accidental releases and components of the Fish and Fish Habitat VEC that occur near surface. The effects of hydrocarbon spills on marine invertebrates and fish have been discussed and assessed in numerous recent environmental assessments of proposed offshore drilling programs and assessments have concluded that the residual effects of accidental hydrocarbon releases on the Fish and Fish Habitat VEC are predicted to be *not significant*. With proper mitigations in place, the residual effects of an accidental release associated with WesternGeco's proposed seismic program on the Fish and Fish habitat VEC would be *negligible* to *low* in magnitude for a duration of *<1 month* over an area of *<1* to *1-10* $km^2$ (see Table 5.4). Based on these criteria ratings and consideration that the probability of accidental hydrocarbon releases during the proposed seismic program are low, the *reversible* residual effects of accidental releases associated with

WesternGeco's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (see Table 5.5). The level of confidence associated with this prediction is *medium* to *high* (see Table 5.5).

### 5.7.5 Fisheries VEC

The potential interactions of Project activities and the Fisheries VEC are indicated in Table 5.6. DFO and joint DFO/Industry Research Surveys are included in the assessment of the Fisheries VEC.

**Table 5.6 Potential Interactions of Project Activities and the Fisheries VEC.**

| Valued Environmental Component: Fisheries | | | |
|---|---|---|---|
| **Project Activities** | **Mobile Invertebrates and Fishes (fixed [e.g., gillnet] and mobile gear [e.g., trawls])** | **Sedentary Benthic Invertebrates (fixed gear [e.g., crab pots])** | **Research Surveys (mobile gear-trawls; fixed gear-crab pots)** |
| **Sound** | | | |
| Airgun Array (2D, 3D and 4D) | X | X | X |
| Seismic Vessel | X | X | X |
| Supply Vessel | X | X | X |
| Picket Vessel | X | X | X |
| Helicopter[a] | | | |
| Echo Sounder | X | | |
| Side Scan Sonar | X | | X |
| **Vessel Lights** | | | |
| **Vessel Presence** | | | |
| Seismic Vessel/Gear (2D, 3D and 4D) | X | X | X |
| Supply Vessel | X | X | X |
| Picket Vessel | X | X | X |
| **Sanitary/Domestic Waste** | X | X | X |
| **Atmospheric Emissions** | | | |
| **Garbage** [b] | | | |
| **Helicopter Presence**[a] | | | |
| **Shore Facilities** [c] | | | |
| **Accidental Releases** | X | X | X |
| **Other Projects and Activities in Region of Study Area** | | | |
| Oil and Gas Activities | X | X | X |
| Marine Transportation | X | X | X |

[a] No helicopter use is planned for 2015 but helicopters may be used during 2016-2024.
[b] Not applicable as garbage will be brought ashore.
[c] There will not be any new onshore facilities. Existing infrastructure will be used.

Behavioural changes in commercial species in relation to catchability, and conflict with harvesting activities and fishing gear were raised as potential issues during the consultations and issues scoping for this assessment (see Section 5.1.1). Seismic streamers and vessels can conflict with and damage fishing gear, particularly fixed gear (i.e., snow crab pots and turbot gillnets in the Study Area). Such conflicts have occurred in Atlantic Canada in the past when seismic vessels were operating in heavily fished areas. There is also a potential for interference from seismic activities with DFO and DFO/Industry research surveys if both are being conducted in a same general area at the same time. An accidental release of petroleum hydrocarbons may result in tainting (or perceived tainting) thus affecting product quality and marketing.

The primary means of mitigating potential impacts on fishery activities is to avoid active fishing areas, particularly fixed gear zones. For the commercial fisheries, gear damage compensation provides a means of final mitigation of impacts, in case a conflict does occur with fishing gear (i.e., accidental contact of gear with the survey airgun array, streamers or seismic vessel). Section 5.5 provides a comprehensive discussion of all mitigations, including those associated with the Fisheries VEC.

The document *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012) provides guidance aimed at minimizing any impacts of petroleum industry geophysical surveys on commercial fish harvesters and other marine users. The mitigations described below are also relevant to DFO and joint DFO/Industry research surveys. Development of the guidelines was based on best practices applied during previous geophysical surveys in Atlantic Canada, as well as guidelines from other national jurisdictions. The relevant guidelines state the following (in Appendix 2 of C-NLOPB (2012) - Environmental Planning, Mitigation and Reporting – II. Interaction with Other Ocean Users).

- The operator should implement operational arrangements to ensure that the operator and/or its survey contractor and the local fishing interests are informed of each other's planned activities. Communication throughout survey operations with fishing interests in the area should be maintained.

- The operator should publish a Canadian Coast Guard "Notice to Mariners" and a "Notice to Fishers" via the CBC Radio program Fisheries Broadcast.

- Operators should implement a gear and/or vessel damage compensation program, to promptly settle claims for loss and/or damage that may be caused by survey operations. The scope of the compensation program should include replacement costs for lost or damaged gear and any additional financial loss that is demonstrated to be associated with the incident. The operator should report on the details of any compensation awarded under such a program (i.e., to the C-NLOPB).

- Procedures must be in place on the survey vessel(s) to ensure that any incidents of contact with fishing gear are clearly detected and documented (e.g., time, location of contact, loss of contact, and description of any identifying markings observed on affected gear). As per Section 4.2 of these Guidelines, any incident should be reported immediately to the 24-hour answering service at (709) 778-1400 or to the C-NLOPB Duty Officer.

- Surveys should be scheduled, to the extent possible, to reduce potential for impact or interference with DFO science surveys. Spatial and temporal logistics should be determined with DFO to reduce overlap of seismic operations with research survey areas, and to allow an adequate temporal buffer between seismic survey operations and DFO research activities.

- Seismic activities should be scheduled to avoid heavily fished areas, to the extent possible. The operator should implement operational arrangements to ensure that the operator and/or its survey contractor and local fishing interests are informed of each other's planned activities. Communication throughout survey operations with fishing interests in the area should be maintained. The use of a FLO onboard the seismic vessel is considered best practice in this respect.

- Where more than one survey operation is active in a region, the operator(s) should arrange for a 'Single Point of Contact' for marine users that may be used to facilitate communication.

The following subsections assess the potential effects of Project activities on the Fisheries VEC.

#### 5.7.5.1 Sound

The potential for impacts on fish harvesting will, therefore, depend on the location and timing of the surveying activities in relation to these fishing areas, and the type of fishing gear used in any given season. If the survey work is situated away from these fishing areas or occur at different times, the likelihood of any impacts on commercial harvesting will be greatly reduced.

The DFO and joint DFO/Industry research surveys are also conducted using fishing gear. As such, the issues related to potential interference with DFO and joint DFO/Industry research surveys are much the same as for commercial fish harvesting (i.e., potential effects on catch rates and conflicts with research vessel operations).

Potential effects on marine fish behaviour are assessed in Section 5.7.4.1. While adult fish could be injured by airgun sound if they are within a few metres of a sound source, this is less likely since fish may disperse during array ramp-up or vessel approach. Therefore, the most likely type of effect will be behavioural. Seismic surveys could cause reduced trawl and longline catches during and following a survey if the fish exhibit behavioural changes (e.g., horizontal and vertical dispersion). There are various research studies on this subject as discussed in Section 5.7.4.1. While some of the behavioural effects studies report decreases in catch rates near the seismic survey area, there is some disagreement on the duration and geographical extent of the effect.

**Mitigation Measures**

Mitigations are discussed in detail in Section 5.5. The primary measures intended to minimize the effects of Project activities on the harvesting success component of the Fisheries VEC include:

- Avoidance in time and space of concentrated fishing areas;
- Good communications, and
- Deployment of FLOs.

**Assessment of the Effects of Seismic Survey Sound**

Since commercial catches are quota based, the overlap between fishing activity and seismic activity is unknown at the moment but will be determined prior to the commencement of the seismic surveys. The best way to prevent overlap between the DFO and joint DFO/Industry research surveys is to exchange detailed locational information and establish a tailored temporal and spatial separation plan, as was implemented with DFO Newfoundland and Labrador in past seasons. With application of the mitigation measures discussed above, residual effects of Project-related sound on the Fisheries VEC are predicted to be a *negligible* to *low* magnitude for a duration of *<1* to *1-12 months* over a geographic area of *<1* to *101-1,000* $km^2$ (Table 5.7). Based on these criteria ratings, the *reversible* residual effects of sound associated with WesternGeco's proposed 2D/3D/4D seismic program on the Fisheries VEC are predicted to be *not significant* (Table 5.8). The level of confidence associated with this prediction is *medium* to *high* (Table 5.8).

#### 5.7.5.2 Vessel Presence (including towed seismic equipment)

Commercial fish harvesting activities occur throughout the May to November period being assessed. Fishing with fixed gear (e.g., pot fishery for snow crab, and to a lesser extent the Greenland halibut gillnet fishery) poses the highest potential for conflict, particularly if the gear is deployed concurrently with seismic survey operations. During 2D/3D/4D seismic surveying, operations will be conducted continuously unless weather or technical issues cause interruptions. Considering the length of the streamers being towed, the manoeuvrability of a seismic vessel is relatively restricted so that other mobile vessels must give way. As already noted in the EA, the turning radius required between each track line extends the assessment area beyond the actual survey area. It is anticipated that gear deployment will be conducted within the Project Area only. Should there be a requirement to commence gear deployment en route to the Project Area, a separate route analysis will be conducted. When gear conflict events occur that damage gear or result in gear loss due to the survey, they will be assessed and compensation will be paid for losses attributable to the seismic survey.

**Mitigation Measures**

Mitigations are discussed in detail in Section 5.5. Mitigations measures intended to minimize the conflict effects of Project activities on the fishing gear component of the Fisheries VEC include:

- Avoidance;
- Communications;
- Use of FLOs;
- Single Point of Contact; and
- Fishing Gear Compensation.

## Table 5.7 Assessment of Effects of Project Activities on the Fisheries VEC.

| Valued Environmental Component: Fisheries | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Project Activity | Potential Positive (P) or Negative (N) Environmental Effect | Mitigation | Evaluation Criteria for Assessing Environmental Effects | | | | | |
| | | | Magnitude | Geographic Extent | Frequency | Duration | Reversibility | Ecological/ Socio-Cultural and Economic Context |
| **Sound** | | | | | | | | |
| Airgun Array (2D, 3D and 4D) | Disturbance (N); Effect on catch rate (N) | Spatial & temporal avoidance; communication | 0-1 | 4 | 6 | 1-2 | R | 2 |
| Seismic Vessel | Disturbance (N); Effect on catch rate (N) | Spatial & temporal avoidance; communication | 0 | 1 | 6 | 1-2 | R | 2 |
| Supply Vessel | Disturbance (N); Effect on catch rate (N) | Spatial & temporal avoidance; communication | 0 | 1 | 1 | 1 | R | 2 |
| Picket Vessel | Disturbance (N); Effect on catch rate (N) | Spatial & temporal avoidance; communication | 0 | 1 | 6 | 1-2 | R | 2 |
| Echo Sounder | Disturbance (N); Effect on catch rate (N) | Spatial & temporal avoidance; communication | 0 | 1 | 6 | 1 | R | 2 |
| Side Scan Sonar | Disturbance (N); Effect on catch rate (N) | Spatial & temporal avoidance; communication | 0 | 1 | 6 | 1 | R | 2 |
| **Vessel Presence** | | | | | | | | |
| Seismic Vessel/Gear (2D, 3D and 4D) | Conflict with gear (N)[a] | FLO; communication | 0-1 | 1-3 | 6 | 1-2 | R | 2 |
| Supply Vessel | Conflict with gear (N)[a] | FLO; communication | 0-1 | 1-3 | 1 | 1 | R | 2 |
| Picket Vessel | Conflict with gear (N)[a] | FLO; communication | 0-1 | 1-3 | 6 | 1-2 | R | 2 |
| **Sanitary/Domestic Wastes** | Taint (N); Perceived taint (N) | Treatment | 0-1 | 1 | 4 | 2 | R | 2 |
| **Accidental Releases** | Taint (N); Perceived taint (N) | Preventative protocols; response plan; communications | 0-1 | 1-2 | 1 | 1 | R | 2 |

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

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

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

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

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$^2$

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not affected by human activity
2 = Evidence of existing effects

[a] This is considered negligible since, if a conflict occurs, compensation will eliminate any economic impact.

**Table 5.8 Significance of Potential Residual Environmental Effects on the Fisheries VEC.**

| Valued Environmental Component: Fisheries | | | | |
|---|---|---|---|---|
| Project Activity | Significance Rating | Level of Confidence | Likelihood [a] | |
| | Significance of Predicted Residual Environmental Effects | | Probability of Occurrence | Scientific Certainty |
| **Sound** | | | | |
| Airgun Array (2D, 3D and 4D) | NS | 2-3 | - | - |
| Seismic Vessel | NS | 3 | - | - |
| Supply Vessel | NS | 3 | - | - |
| Picket Vessel | NS | 3 | - | - |
| Echo Sounder | NS | 2-3 | - | - |
| Side Scan Sonar | NS | 2-3 | - | - |
| **Vessel Presence** | | | | |
| Seismic Vessel (2D, 3D and 4D) | NS | 3 | - | - |
| Supply Vessel | NS | 3 | - | - |
| Picket Vessel | NS | 3 | - | - |
| **Sanitary/Domestic Wastes** | NS | 3 | - | - |
| **Accidental Releases** | NS | 2-3 | - | - |

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 $km^2$ (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Considered only in the case where 'significant negative effect' is predicted.

### Assessment of the Effects of Vessel and Seismic Gear Presence

With application of the mitigations discussed above, effects of vessel presence, including all gear being towed by the seismic vessel, on the Fisheries VEC are predicted to be a *negligible* to *low* magnitude for a duration of *<1* to *1-12 months* over a geographic area of *<1* to *11-100* $km^2$ (see Table 5.7). Based on these criteria ratings, the *reversible* residual effects of vessel/gear presence associated with WesternGeco's proposed 2D/3D/4D seismic program on the Fisheries VEC are predicted to be *not significant* (see Table 5.8). The level of confidence associated with this prediction is *high* (see Table 5.8).

### 5.7.5.3 Sanitary/Domestic Wastes

Impacts related to physical effects on fish and invertebrates, including those potentially resulting from releases of sanitary/domestic wastes, are not discussed any further in this section because earlier assessment of the Fish and Fish Habitat VEC predicted that the residual effects of the wastes associated with WesternGeco's proposed 2D/3D/4D seismic program on that VEC would be *not significant*.

#### 5.7.5.4 Accidental Releases

In the event of an accidental release of hydrocarbons (e.g., fuel spill), there is some possibility of the perception of tainting of invertebrate and fish resources in the proximity of a release, even if there is no actual tainting. Perception alone can have economic effects if the invertebrates and fish lose marketability. Preventative measures / protocols, response plans and good communications are essential mitigations to minimize the effects of any accidental hydrocarbon release. In the event of a release, the length of time that fish are exposed is a determining factor in whether or not their health is substantially affected or if there is an actual or perceived tissue tainting. Any effect on access to fishing grounds would be of relatively short duration. In the unlikely event of a substantial hydrocarbon release, the need of compensation for commercial fishers will be determined through the C-NLOPB's guidelines.

With application of the mitigations discussed above, the effect of accidental hydrocarbon releases on the Fisheries VEC is predicted have a *negligible* to *low* magnitude for a duration of *<1 month* over a geographic area of *<1* to *1-10* $km^2$ (see Table 5.7). Based on these criteria ratings, the *reversible* residual effect of accidental releases associated with WesternGeco's proposed 2D/3D/4D seismic program on the Fisheries VEC is predicted to be *not significant* (see Table 5.8). The level of confidence associated with this prediction is *medium* to *high* (see Table 5.8).

### 5.7.6 Seabirds

There are three main sources of potential effects on seabirds during the proposed seismic program: (1) sound produced by Project activities; (2) vessel lights at night; and (3) accidental release of hydrocarbons. Potential interactions of the Project activities and the Seabird VEC are indicated in Table 5.9. A brief review of available information related to the potential effects on seabirds is provided in this section.

#### 5.7.6.1 Sound

Most of the seabird species expected to occur in the Study Area feed at either the ocean's surface or in the upper metre of the water column (Table 4.11 in Section 4.4). This includes members of *Procellariidae* (Northern Fulmar), *Hydrobatidae* (Wilson's Storm-Petrel and Leach's Storm-Petrel), *Phalaropodinae* (Red Phalarope and Red-necked Phalarope), *Stercorariidae* (Great Skua, South Polar Skua, Pomarine Jaeger, Parasitic Jaeger and Long-tailed Jaeger), and *Laridae* (Herring Gull, Iceland Gull, Glaucous Gull, Great Black-backed Gull, Ivory Gull, Black-legged Kittiwake and Arctic Tern).

Northern Gannet plunge dive to a depth of 10 m. It is below surface for a few seconds during each dive so could possibly have minimal exposure to underwater sound. Great Shearwater, Sooty Shearwater and Manx Shearwater feed mainly at the surface but may also briefly chase prey below surface down to a depth of 2-10 m (Brown et al. 1978, 1981; Ronconi 2010a, b).

## Table 5.9 Potential Interactions of the Project Activities and the Seabird VEC.

| Project Activities | Valued Environmental Component: Seabird |
|---|---|
| **Sound** | |
| Airgun Array (2D, 3D and 4D) | X |
| Seismic Vessel | X |
| Supply Vessel | X |
| Picket Vessel | X |
| Helicopter [a] | X |
| Echo Sounder | X |
| Side Scan Sonar | X |
| **Vessel Lights** | X |
| **Vessel Presence** | |
| Seismic Vessel/Gear (2D, 3D and 4D) | X |
| Supply Vessel | X |
| Picket Vessel | X |
| **Sanitary/Domestic Waste** | X |
| **Atmospheric Emissions** | X |
| **Garbage** [b] | |
| **Helicopter Presence** [a] | X |
| **Shore Facilities** [c] | |
| **Accidental Releases** | X |
| **Other Projects And Activities in Region of Study Area** | |
| Oil and Gas Activities | X |
| Fisheries | X |
| Marine Transportation | X |

[a] No helicopter use is planned for 2015 but helicopters may be used during 2016-2024.
[b] Not applicable as garbage will be brought ashore.
[c] There will not be any new onshore facilities. Existing infrastructure will be used.

One seabird group, *Alcidae* (e.g., Dovekie, Common Murre, Thick-billed Murre, Razorbill and Atlantic Puffin) that occurs regularly in the Study Area, spends a relatively longer time below the ocean's surface to secure food than do other seabirds. Alcids use their wings to propel their bodies rapidly through the water. All are capable of reaching considerable depths and spending considerable time under water (Gaston and Jones 1998). An average duration and depth of dive for the five species of *Alcidae* is 25 to 40 seconds (s) and 20-60 m, respectively. Murres are capable of diving to a 120 m depth for up to 202 s (Gaston and Jones 1998). The effects of underwater sounds on *Alcidae* are unknown. In fact, the effects of underwater sound on birds in general have not been well studied. One study of the effects of underwater seismic survey sound on moulting Long-tailed Ducks in the Beaufort Sea showed little effect on their behaviour (Lacroix et al. 2003). However, the study did not consider potential physical effects on the ducks. The authors suggested caution in interpreting the data because of their limited utility to detect subtle disturbance effects, and recommended studies on other species to better understand the effects of seismic airgun sound on seabirds. Sound is probably not important to *Alcidae* for securing food. However, all five species mentioned above are quite vocal out of water at breeding sites, suggesting that auditory capability is important during that part of the life cycle.

The sound from airguns is typically focused downward during seismic surveying. In air, airgun sound is reduced to a "muffled shot" that should have little or no effect on seabirds that either have their heads above water or are in flight. It is possible that birds on the ocean's surface and proximate to discharging airguns would be startled by the sound. However, the presence of the ship and the associated seismic equipment in the water should have already warned the bird of unnatural visual and auditory stimuli.

The potential effects of helicopters on the Seabird VEC are mainly related to the sound they generate (see a review of the effects of sound on seabirds above) and not their physical presence. However, the behavioural effects of exposure to helicopter sound would be minimal and temporary.

The effect of sound produced by Project activities on the Seabird VEC is predicted to have a *negligible* to *low* magnitude for a duration of *<1 month* to *1-12 months* over a geographic area of *<1* to *1-10 km²* (Table 5.10). Based on these criteria ratings, the *reversible* residual effect of sound associated with WesternGeco's proposed 2D/3D/4D seismic program on the Seabird VEC is predicted to be *not significant* (Table 5.11). The level of confidence associated with this prediction is *medium* to *high* (Table 5.11).

#### 5.7.6.2 Vessel Lights

Birds that spend most of their lives at sea are often influenced by artificial light (Montevecchi et al. 1999; Montevecchi 2006). Even before the era of electrical lights, humans used fires on shore to attract seabirds for food (Montevecchi 2006). Birds are more strongly attracted to lights at sea during fog and drizzly conditions. Moisture droplets in the air refract light, thereby increasing illumination and creating a glow around vessels at sea. In Newfoundland waters, the Leach's Storm-Petrel is the species most often stranded on the decks of offshore vessels after being attracted to lights at night (Moulton et al. 2005, 2006; Abgrall et al. 2008a, 2008b, 2009). Occasionally, other Newfoundland seabirds (e.g., Great Shearwater, Northern Fulmar, Thick-billed Murre and Dovekie) have stranded on vessels in Newfoundland waters at night, presumably due to the attraction to ship lights. In Alaska, a species related to the Dovekie, the Crested Auklet (*Aethia cristatella*), mass-stranded on a crab fishing boat (Dick and Donaldson 1978). An estimated 1.5 tons of the Crested Auklet either collided with or landed on the brightly lit fishing boat at night. There are not any known mass stranding events involving large numbers of Dovekies or any alcid species on vessels in Newfoundland and Labrador waters.

To date, bird strandings in the Newfoundland offshore have almost all involved Leach's Storm-Petrels. This is not surprising given the large numbers of this species in these waters coupled with their relative inability to become airborne after landing on a ship or platform. Numbers of strandings on seismic vessels have ranged from zero during the early part of the season to tens of birds, mostly late in the season after fledging has occurred. On a Grand Banks seismic vessel, the stranding of tens of birds in one night can be considered a "large scale stranding". The largest single stranding event observed by LGL biologists on seismic vessels was 46 birds, all of which were released live (LGL Limited, unpublished data). This stranding occurred in the Orphan Basin in October 2005.

## Table 5.10 Assessment of Potential Effects of Project Activities on the Seabird VEC.

| Valued Environmental Component: Seabirds | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Project Activity | Potential Positive (P) or Negative (N) Environmental Effect | Mitigation | Evaluation Criteria for Assessing Environmental Effects | | | | | |
| | | | Magnitude | Geographic Extent | Frequency | Duration | Reversibility | Ecological/ Socio-Cultural and Economic Context |
| **Sound** | | | | | | | | |
| Airgun Array (2D, 3D and 4D) | Disturbance (N) | | 0-1 | 2 | 6 | 1-2 | R | 2 |
| Seismic Vessel | Disturbance (N) | | 0-1 | 1 | 6 | 1-2 | R | 2 |
| Supply Vessel | Disturbance (N) | | 0 | 1 | 1 | 1 | R | 2 |
| Picket Vessel | Disturbance (N) | | 0 | 1 | 6 | 1-2 | R | 2 |
| Helicopter | Disturbance (N) | | 0-1 | 2 | 1 | 1 | R | 2 |
| Echosounder | Disturbance (N) | | 0-1 | 1 | 6 | 1 | R | 2 |
| Side Scan Sonar | Disturbance (N) | | 0-1 | 1 | 6 | 1 | R | 2 |
| **Vessel Lights** | Attraction (N) | Reduce lighting (if possible); Monitoring; Seabird handling and release | 1 | 1-2 | 2-3 | 1-2 | R | 2 |
| **Vessel Presence** | | | | | | | | |
| Seismic Vessel/Gear (2D, 3D and 4D) | Disturbance (N) | | 0 | 2 | 6 | 1-2 | R | 2 |
| Supply Vessel | Disturbance (N) | | 0 | 2 | 1 | 1 | R | 2 |
| Picket Vessel | Disturbance (N) | | 0 | 2 | 6 | 1-2 | R | 2 |
| **Sanitary/Domestic Waste** | Increased Food (N/P) | | 0 | 1 | 4 | 1-2 | R | 2 |
| **Atmospheric Emissions** | Air Contaminants (N) | | 0 | 2 | 6 | 1-2 | R | 2 |
| **Helicopter Presence** | Disturbance (N) | Maintain high altitude | 0-1 | 2 | 1 | 1 | R | 2 |
| **Accidental Releases** | Mortality (N) | Solid streamer; spill response | 1-2 | 1-2 | 1 | 1 | R | 2 |

Key:

Magnitude:
0 = Negligible,
1 = Low
2 = Medium
3 = High

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

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

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

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 $km^2$

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not affected by human activity
2 = Evidence of existing effects

**Table 5.11 Significance of the Potential Residual Effects of the Project Activities on the Seabird VEC.**

| Valued Environmental Component: Seabirds | | | | |
|---|---|---|---|---|
| Project Activity | Significance Rating | Level of Confidence | Likelihood [a] | |
| | Significance of Predicted Residual Environmental Effects | | Probability of Occurrence | Scientific Certainty |
| **Sound** | | | | |
| Airgun Array (2D, 3D and 4D) | NS | 2-3 | - | - |
| Seismic Vessel | NS | 3 | - | - |
| Supply Vessel | NS | 3 | - | - |
| Picket Vessel | NS | 3 | - | - |
| Helicopter | NS | 3 | - | - |
| Echosounder | NS | 3 | - | - |
| Side Scan Sonar | NS | 3 | - | - |
| **Vessel Lights** | NS | 3 | - | - |
| **Vessel Presence** | | | | |
| Seismic Vessel and Gear (2D, 3D and 4D) | NS | 3 | - | - |
| Supply Vessel | NS | 3 | - | - |
| Picket Vessel | NS | 3 | - | - |
| **Sanitary/Domestic Wastes** | NS | 3 | - | - |
| **Atmospheric Emissions** | NS | 3 | - | - |
| **Helicopter Presence** | NS | 3 | - | - |
| **Accidental Releases** | NS | 2 | - | - |

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km$^2$ (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Considered only in the case where 'significant negative effect' is predicted.

Monitoring of pelagic seabird stranding on board seismic vessels due to light attraction has been conducted by LGL biologists during numerous seismic programs conducted off Newfoundland and Labrador since 2004. While seismic programs off Newfoundland and Labrador have been initiated as early as May and terminated as late as November, most have been conducted during the June to September period. The number of nights per week with strandings and the number of individuals stranded per night have been highest from late-August to mid-October. This period coincides with the fledging of Leach's Storm-Petrels from Newfoundland colonies. Young of this species fledge from Great Island (Witless Bay), Newfoundland, as early as 10 September but the majority fledge from mid-September to late-October (Huntington et al. 1996). Juveniles constituted a large majority of stranded Leach's Storm-Petrels near a colony off Scotland (Miles et al. 2010). However, in wintering areas, adult Leach's Storm-Petrels may also strand due to attraction to light (Rodríguez and Rodríguez 2009). Visibility during nights when storm-petrels stranded on seismic vessels off Newfoundland and Labrador was typically reduced due to fog, rain or overcast conditions. This has also been documented for other seabird species (Telfer et al. 1987; Black 2005). It has also been noted that seabird strandings seem to peak around the time of the new moon when moonlight levels are lowest (Telfer et al. 1987; Rodríguez and Rodríguez 2009; Miles et al. 2010).

Birds may be attracted to light because of a preference for bioluminescent prey (Imber 1975) or that the red component of light disrupts their magnetic orientation (Poot et al. 2008). Many seabirds have great difficulty becoming airborne from flat surfaces. Once on a hard surface, stranded seabirds tend to crawl into corners or under objects to hide and may die from exposure, dehydration or starvation over hours or days. A stranded seabird's plumage is prone to oiling from residual oil that may be present on a ship's deck. The open ended structure of the stern of a typical seismic ship allows entry of seabirds to several decks. These decks are lighted to various degrees, sometimes quite brightly. This is unavoidable as seismic surveying is conducted around the clock and adequate lighting is required for safe work practices.

Fledgling Atlantic Puffins have been attracted to lighting in small coastal communities overlooking the Witless Bay Seabird Ecological Reserve in Newfoundland, Canada which hosts the two largest Atlantic Puffin colonies in North America. While the number of stranded puffins found during foggy nights and nights without fog were very similar, the majority of strandings occurred within a two week period around a new moon (Wilhelm et al. 2013). A reduction of artificial lighting during the period of fledging reduced the number of stranded puffins.

Adult and fledgling Short-tailed Shearwaters *Ardenna tenuirostris* were attracted to lights on a roadway at night near a breeding colony at Phillip Island, Australia (Rodriguez et al. 2014). The birds stranding on the road were often killed by vehicular traffic. Strandings occurred most often during moonless and windy nights. Turning off the street lights decreased the number of strandings.

The use of search lights on vessels sailing in Greenland waters during periods of darkness was found to attract seabirds, mainly Common Eider *Somateria mollissima* (Merkel and Johansen 2011). The birds were more attracted to the source of the light than to the area being lit in front of the vessel. Birds died and were injured by flying into the ship's superstructure. It was recommended shielding spot lights from the sky and sides to reduce the number of birds attracted to the source.

Mitigation measures associated with seabirds are discussed in detail in Section 5.5. The rescue of stranded storm-petrels on board the seismic vessel will be the responsibility of the MMO. The MMO will conduct daily searches of the ship and the ship's crew will also be notified to contact the MMO if a bird is found. Procedures developed by the CWS and Petro-Canada (now Suncor) will be used to handle the birds and eventually release them (Williams and Chardine, n.d.). Personnel on other vessels working on the Project will be made aware of the potential problem of storm-petrels stranding on their vessels. Each vessel will have a copy of the manual developed by CWS and Suncor on proper procedure and handling of stranded storm-petrels (Williams and Chardine, n.d.). WesternGeco acknowledges that a

CWS *Migratory Birds Permit* will be required. Deck lighting can be minimized (if it is safe and practical to do so) to reduce the likelihood of stranding. A report documenting each stranded bird will be completed and delivered to the CWS by the end of the calendar year. The report includes the date of stranding, global position of the stranding, general condition of the feathers and, if the bird is releasable, its condition upon release.

The effect of light produced by Project activities on the Seabird VEC is predicted to have a *low* magnitude for a duration of *<1 month* to *1-12 months* over a geographic area of *<1* to *1-10 km²* (see Table 5.10). Based on these criteria ratings, the *reversible* residual effect of light associated with WesternGeco's proposed 2D/3D/4D seismic program on the Seabird VEC during the seismic program is predicted to be *not significant* (see Table 5.11). The level of confidence associated with this prediction is *high* (see Table 5.11).

#### 5.7.6.3 Vessel Presence

The potential effects of the physical presence of vessels and seismic gear are likely to be minimal. Seabirds may be attracted to the seismic, picket or supply vessel while prospecting for fish wastes associated with fishing vessels. Since there is little or no food made available by these vessels, seabirds are temporarily interested in the vessels and soon move elsewhere in search of food. Seabirds sitting on the water in the path of these vessels can easily evade the vessels. Therefore, the residual effects of vessel and seismic gear presence associated with WesternGeco's proposed 2D/3D/4D seismic program on the Seabird VEC are predicted to be *not significant* (see Tables 5.10 and 5.11). The level of confidence associated with this prediction is *medium* to *high* (see Table 5.11).

#### 5.7.6.4 Sanitary/Domestic Wastes

Sanitary waste generated by the vessels will be macerated before subsurface discharge. While it is possible that seabirds, primarily gulls, may be attracted to the sewage particles, the small amount discharged below surface over a limited period of time will not likely increase the far-offshore gull populations. Thus, any increase in gull predation on Leach's Storm-Petrels, as suggested by Wiese and Montevecchi (1999), is likely to be minimal. If this event occurs, the number of smaller seabirds involved will likely be low. Therefore, the residual effects of sanitary/domestic wastes associated with WesternGeco's proposed 2D/3D/4D seismic program on the Seabird VEC are predicted to be *not significant* (see Tables 5.10 and 5.11). The level of confidence associated with this prediction is *high* (see Table 5.11).

#### 5.7.6.5 Atmospheric Emissions

Although atmospheric emissions could, in theory, affect the health of some resident seabirds, these effects will be *negligible* considering that emissions consisting of potentially harmful materials will be low and will rapidly disperse to undetectable levels. Therefore, the residual effects of atmospheric emissions associated with WesternGeco's proposed 2D/3D/4D seismic program on the Seabird VEC are predicted to be *not significant* (see Tables 5.10 and 5.11). The level of confidence associated with this prediction is *high* (see Table 5.11).

#### 5.7.6.6 Helicopter Presence

No helicopter use is planned for 2015 but helicopters may be used during 2016-2024. Personnel may be transported to and from the seismic vessel via helicopters if a survey last longer than five to six weeks. Potential effects of helicopters on the marine environment are mainly related to the sound they generate (see a review of the effects of sound on seabirds above) and not their physical presence. Therefore, the residual effects of helicopter presence associated with WesternGeco's proposed 2D/3D/4D seismic program on the Seabird VEC are predicted to be *not significant* (see Tables 5.10 and 5.11). The level of confidence associated with this prediction is *high* (see Table 5.11).

#### 5.7.6.7 Accidental Release

All seabirds expected to occur in the Study Area, except Arctic Tern, spend considerable time resting on the water. Birds that spend most of their time on water, such as the murres, Dovekie and Atlantic Puffin, are the species most likely to suffer negative effects from an accidental release of hydrocarbons. Northern Fulmar, the shearwaters and storm-petrels are attracted to sheens but would not likely confuse them with a natural oceanic "sheen" comprised of zooplankton or offal. However, flocks of seabirds resting on the water would not necessarily leave the water if they drifted into an area with hydrocarbons.

An exposure to a surface release of hydrocarbons under calm conditions may harm or kill individual birds. O' Hara and Morandin (2010) demonstrated that it requires only a small amount of oil (e.g., 10 ml) to affect the feather structure of Common Murre and Dovekie with potential to lethally reduce thermoregulation. Such modifications to feather structure cause a loss of insulation, which in turn can result in mortality. However, since the potential of accidental releases of hydrocarbons during the proposed seismic program is low and the evaporation/dispersion rate of any released hydrocarbons would be high, the residual effects of Project-related accidental releases on seabirds are predicted to have a *low* to *medium* magnitude for a duration of *<1 month* over a geographic area of *<1* to *1-10* $km^2$ (see Table 5.10). Therefore, based on these criteria ratings, the residual effects of an accidental release associated with WesternGeco's proposed 2D/3D/4D seismic program on the Seabird VEC are predicted to be *not significant* (see Table 5.11). The level of confidence associated with this prediction is *medium* (see Table 5.11).

### 5.7.7 Marine Mammals and Sea Turtles

The potential effects of seismic activities on marine mammals and sea turtles have previously been reviewed in the Eastern Newfoundland SEA (C-NLOPB 2014), previous EAs of seismic programs in the Flemish Pass, Jeanne d'Arc Basin on the Grand Banks and Orphan Basin (e.g., LGL 2013a,b, 2014a,b,c) and literature reviews (e.g., Richardson et al. 1995; Gordon et al. 2004; Stone and Tasker 2006; Nowacek et al. 2007; Southall et al. 2007; Abgrall et al. 2008b).

The assessment of impacts is based on the best available information; however, there are data gaps that limit the certainty of these impact predictions. We have discussed potential impacts separately for toothed whales, baleen whales, seals and sea turtles given their different hearing abilities and sensitivities to sound. Potential interactions between Project activities and marine mammals and sea turtles are shown in Table 5.12.

**Table 5.12 Potential Interactions between Project Activities and Marine Mammal and Sea Turtle VEC.**

| Valued Environmental Component - Marine Mammal and Sea Turtle | | | | |
|---|---|---|---|---|
| **Project Activities** | **Toothed Whales** | **Baleen Whales** | **Seals** | **Sea Turtles** |
| **Sound** | | | | |
| Airgun Array (2D, 3D and 4D) | X | X | X | X |
| Seismic Vessel | X | X | X | X |
| Supply Vessel | X | X | X | X |
| Picket Vessel | X | X | X | X |
| Helicopter [a] | X | X | X | X |
| Echo Sounder | X | X | X | X |
| Side Scan Sonar | X | X | X | X |
| **Vessel Presence** | | | | |
| Seismic Vessel/Gear (2D, 3D and 4D) | X | X | X | X |
| Supply Vessel | X | X | X | X |
| Picket Vessel | X | X | X | X |
| **Vessel Lights** | | | | |
| **Helicopter Presence** [a] | X | X | X | X |
| **Sanitary/ Domestic Wastes** | X | X | X | X |
| **Atmospheric Emissions** | X | X | X | X |
| **Accidental Releases** | X | X | X | X |
| **Garbage** [b] | | | | |
| **Shore Facilities** [c] | | | | |
| **Other Projects and Activities in Region of Study Area** | | | | |
| Oil and Gas Activities | X | X | X | X |
| Fisheries | X | X | X | X |
| Marine Transportation | X | X | X | X |

[a] No helicopter use is planned for 2015 but helicopters may be used during 2016-2024.
[b] Not applicable as garbage will be brought ashore.
[c] There will not be any new onshore facilities. Existing infrastructure will be used.

#### 5.7.7.1 Airgun Sound

The potential effects of sound from airgun arrays on marine mammals and sea turtles are a common concern associated with seismic programs. Airgun arrays used during marine seismic operations introduce strong sound pulses into the water. These sound pulses could have several types of effects on marine mammals and sea turtles and are the main issue associated with the proposed seismic surveys. The effects of human-generated noise on marine mammals are quite variable and depend on numerous factors, including species, activity of the animal when exposed to the noise, and distance of the animal from the sound source. This section includes a brief summary of the anticipated potential effects of airgun sounds on marine mammals and sea turtles. More comprehensive reviews of the relevant background information for marine mammals and sea turtles appear in Appendices 4 and 5, respectively. The characteristics of airgun sounds are also summarized in Appendix 4. Descriptions of the hearing abilities of marine mammals and sea turtles are also provided in Appendices 4 and 5, respectively.

The potential effects of airgun sounds considered in this assessment include: masking of natural sounds, behavioural disturbance, non-auditory physical or physiological effects, and at least in theory, temporary or permanent hearing impairment (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007). Although the possibility cannot be entirely excluded, it is unlikely that the program would result in any cases of permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals or sea turtles encounter the survey while it is underway, behavioural effects will likely result but effects are generally expected to be localized and short-term.

**Masking**

Masking is the obscuring of sounds of interest by interfering sounds, generally at similar frequencies. Masking can occur if the frequency of the source is close to that used as a signal by the marine mammal and if the anthropogenic sound is present for a significant fraction of time (Richardson et al. 1995; Clark et al. 2009). Conversely, masking is not expected if little or no overlap occurs between the introduced sound and the frequencies used by the species or if the introduced sound is infrequent. Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are few specific data on this (see Section 1.4 of Appendix 4 for details). Because of the intermittent nature and low duty cycle of seismic pulses, marine mammals and sea turtles can emit and receive sounds in the relatively quiet intervals between pulses. However, in exceptional situations, reverberation occurs for much or all of the interval between pulses (e.g., Simard et al. 2005; Clark and Gagnon 2006), which could mask calls. Situations with prolonged strong reverberation are infrequent. However, it is common for reverberation to cause some lesser degree of elevation of the background level between airgun pulses (e.g., Gedamke 2011; Guerra et al. 2011, 2013), and this weaker reverberation presumably reduces the detection range of calls and other natural sounds to some degree.

Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls usually can be heard between the seismic pulses. In addition, some cetaceans are known to change their calling rates, shift their peak frequencies, or otherwise modify their vocal behaviour in response to airgun sounds. The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than are the ears of the small odontocetes that have been studied directly. The sounds important to toothed whales and pinnipeds are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. Based on reviewed research, the potential for masking of marine mammal calls and/or important environmental cues is considered low from the proposed seismic program. Thus, masking is unlikely to be a significant issue for either marine mammals or sea turtles exposed to the sounds from the WesternGeco seismic survey.

**Disturbance**

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; Ellison et al. 2012). If a marine mammal or sea turtle does react briefly 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 or sea turtles 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).

Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable (see Section 1.5.1 of Appendix 4 for details). Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behaviour appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme et al. 1984; Malme and Miles 1985; Richardson et al. 1995).

Little systematic information is available on reactions of toothed whales to sound pulses. However, there are systematic studies on sperm whales, and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies (see Section 1.5.2 of Appendix 4 for details). Seismic operators and MMOs on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels. In most cases, the avoidance radii for delphinids appear to be small, on the order of 1 km or less, and some individuals show no apparent avoidance. The beluga, however, is a species that (at least at times) shows long-distance (10s of km) avoidance of seismic vessels (Miller et al. 2005). Captive bottlenose dolphins and beluga whales exhibited changes in behaviour when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys, but the animals tolerated high received levels of sound before exhibiting aversive behaviours (e.g., Finneran et al. 2000, 2002, 2005). Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes.

Pinnipeds tend to be less responsive to airgun sounds than many cetaceans and are not likely to show a strong avoidance reaction to the airgun array (see Section 1.5.3 of Appendix 4 for details). Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behaviour.

Based on available data, it is likely that sea turtles would exhibit behavioural changes and/or localized avoidance near a seismic vessel (see Appendix 5 for details). To the extent that there are any impacts on sea turtles, seismic operations in or near areas where turtles concentrate are likely to have the greatest impact. There are no specific data that demonstrate the consequences to sea turtles if seismic operations with large or small arrays of airguns occur in important areas at biologically important times of year. However, turtles are considered rare in the Study Area.

**Hearing Impairment**

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds (see Section 1.6 of Appendix 4 for details). TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (reviewed in Southall et al. 2007). However, there has been no specific documentation of TTS let alone permanent hearing damage, i.e., Permanent Threshold Shift (PTS), in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

Current U.S. National Marine Fisheries Service (NMFS) policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds ≥180 and 190 dB re 1 $\mu Pa_{rms}$, respectively (NMFS 2000). Those criteria have been used in establishing the safety (=shut-down) radii planned for numerous seismic surveys conducted under U.S. jurisdiction and in some parts of Canada. 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), for at least some species.

Recommendations for science-based noise exposure criteria for marine mammals were published quite some time ago by Southall et al. (2007). Those recommendations were never formally adopted by NMFS for use in regulatory processes and during mitigation programs associated with seismic surveys, although some aspects of the recommendations have been taken into account in certain environmental impact statements and small-take authorizations. In December 2013, NMFS proposed new noise exposure criteria taking at least some of the Southall et al. recommendations into account as well as more recent literature (NOAA 2013). The new noise exposure criteria for marine mammals account for the now-available scientific data on TTS, the expected offset between the TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive (e.g., M-weighting or generalized frequency weightings for various groups of marine mammals, allowing for their functional bandwidths), and other relevant factors. DFO has not adopted any noise exposure criteria.

At the present state of knowledge, it is necessary to assume that any impact is directly related to total received energy, although there is recent evidence that auditory effects in a given animal are not a simple function of received acoustic energy; frequency, duration of the exposure, and occurrence of gaps within the exposure can also influence the auditory effect (Mooney et al. 2009; Finneran and Schlundt 2010, 2011, 2013; Finneran et al. 2010a,b; Finneran 2012; Kastelein et al. 2012a,b, 2013a,b,c, 2014;

Ketten 2012). In addition, it is inappropriate to assume that onset of TTS occurs at similar received levels in all cetaceans (*cf.* Southall et al. 2007). TTS information for odontocetes is primarily derived from studies on the bottlenose dolphin and beluga, and that for pinnipeds has mostly been obtained from California sea lions and elephant seals (see Section 1.6 of Appendix 4 for details). However, there have been several studies on TTS which indicate that received levels that elicit onset of TTS are lower in porpoise than for other odontocetes (e.g., Lucke et al. 2009; Kastelein et al. 2012a, 2013a, 2014). Additionally, evidence from more prolonged (non-pulse and pulse) exposures suggested that harbour seals incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (e.g., Kastak et al. 1999, 2005, 2008; Ketten et al. 2001; Kastelein et al. 2013c).

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 (e.g., harbour porpoise and seals) close to an airgun array might incur at least mild TTS, there has been further speculation about the possibility that some individuals occurring very close to airguns might incur PTS (e.g., Richardson et al. 1995; Gedamke et al. 2011). Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing TTS onset might elicit PTS (e.g., Kastak and Reichmuth 2007; Kastak et al. 2008).

There is substantial overlap in the frequencies that sea turtles detect vs. the frequencies in airgun pulses. Sounds from an airgun array might cause temporary hearing impairment in sea turtles if they do not avoid the immediate area around the airguns. However, monitoring studies show that some sea turtles do show localized movement away from approaching airguns (see Appendix 5). At short distances from the source, received sound levels diminish rapidly with increasing distance. In that situation, even a small-scale avoidance response could result in a significant reduction in sound exposure.

Nowacek et al. (2013) concluded that current scientific data indicate that seismic airguns have a low probability of directly harming marine life, except at close range. Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals and sea turtles occurring near the airgun array, and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. In addition, many cetaceans and (to a limited degree) pinnipeds and sea turtles show some avoidance of the area where received levels of airgun sound are high enough such that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves will reduce the possibility of hearing impairment.

**Non-auditory Physical Effects**

Non-auditory physical effects (see Appendices 4 and 5) may also occur in marine mammals and sea turtles exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur include stress, neurological effects, and 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. However, there is no definitive evidence that any of these effects occur even for marine mammals or sea turtles in close proximity to large arrays of airguns. Such effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. Marine mammals that show behavioural avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, as well as sea turtles, are especially unlikely to incur non-auditory physical effects. The brief duration of exposure of any given animal and the planned monitoring and mitigation measures would further reduce the probability of exposure of marine mammals and sea turtles to sounds strong enough to induce non-auditory physical effects.

**Sound Criteria for Assessing Impacts**

Impact zones for marine mammals are commonly defined by the areas within which specific received sound level thresholds are exceeded. The NMFS (1995, 2000) concluded that cetaceans should not be exposed to pulsed underwater noise at received levels exceeding 180 dB re 1 $\mu Pa_{rms}$; the corresponding limit for seals was set at 190 dB re 1 $\mu Pa_{rms}$. According to NMFS, these sound levels were the received levels above which one cannot be certain that there will be no injurious effects, auditory or otherwise, to marine mammals. For over a decade, it has been common for marine seismic surveys conducted in some areas of U.S. jurisdiction and in some areas of Canada (Canadian Beaufort Sea and on the Scotian Shelf), to include a "shutdown" requirement for cetaceans based on the distance from the airgun array at which the received level of underwater sounds is expected to diminish below 180 dB re 1 $\mu Pa_{rms}$. An additional criterion that is often used in predicting "disturbance" impacts is 160 dB re 1 µPa; at this received level, some marine mammals exhibit behavioural effects. There is ongoing debate about which sound levels should be used to make impact predictions (for behavioural and hearing impairment effects) and define mitigation measure parameters (i.e., safety zones, see Appendix 4).

For marine seismic programs in Newfoundland and Labrador, the C-NLOPB (2012) requires that seismic operators follow the "*Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment*" (hereafter referred to as the *Statement*) issued by the DFO. The *Statement* does not include noise criteria as part of the recommended mitigation measures; rather it defines (see Point 6.a) a safety zone as "a circle with a radius of at least 500 metres as measured from the centre of the air source array (s)".

**Assessment of Effects of Sound on Marine Mammals**

The marine mammal effects assessment is summarized in Table 5.13 and discussed in detail below. The effects of underwater sound from vessels, the echo sounder and the side scan sonar are not further discussed as their effects are considered minimal relative to sound from airgun arrays.

***Toothed Whales***

Despite the relatively poor hearing sensitivity of toothed whales (at least the smaller species that have been studied) at the low frequencies that contribute most of the energy in seismic pulses, sounds are sufficiently strong that they remain above the hearing threshold of odontocetes at tens of kilometres from the source. Species of most concern are those that are designated under *SARA* Schedule 1 and that may occur in and near the Project Area (i.e., northern bottlenose whale and Sowerby's beaked whale).

The killer whale and harbour porpoise have special status under COSEWIC (the harbour porpoise is also listed as *threatened* under Schedule 2 of *SARA*), but are not expected to occur in large numbers in the Project Area. The received sound level of 180 dB re 1 $\mu Pa_{rms}$ criterion is accepted by NMFS as a level that below which there is no physical effect on toothed whales; however, the sound level for harbour porpoise is likely lower. It is assumed that disturbance effects for toothed whales may occur at received sound levels at or above 160 dB re 1 $\mu Pa_{rms}$. However, it is noted that there is no good scientific basis for using this 160 dB criterion for odontocetes and that 170 dB re 1 $\mu Pa_{rms}$ is likely a more realistic indicator of the area within which disturbance is possible, at least for delphinids (see Appendix 4).

***Hearing Impairment and Physical Effects***

Given that toothed whales (especially harbour porpoise) typically avoid at least the immediate area around seismic (and other strong) noise sources (see Section 1.5.2 of Appendix 4), odontocetes in and near the Project Area will likely not be exposed to levels of sound from the airgun array that are high enough to cause non-auditory physical effects or hearing impairment. Even when avoidance is limited to the area within a few hundred metres of an airgun array, that should usually be sufficient to avoid TTS based on what is currently known about thresholds for TTS onset in cetaceans. It is highly unlikely that toothed whales will experience mortality or strand as a result of Project activities. The mitigation measure of ramping-up the airgun array (over a 30 min period) should allow whales close to the airguns to move away before the sounds become sufficiently strong to have potential for hearing impairment. Also, the airgun array will not be started if a toothed whale is sighted within the 500 m safety zone. These measures reduce the potential for toothed whales to be close enough to the array to experience hearing impairment. If some whales did experience TTS, the effects would likely be quite "temporary". As per Table 5.13, WesternGeco's 2D/3D/4D seismic program is predicted to have *negligible* to *low magnitude* hearing impairment/physical effects on toothed whales for a duration of *<1 month* to *1 to 12 months* over a geographic area of *<1* $km^2$ to *1-10* $km^2$. Therefore, hearing impairment and/or physical residual effects on toothed whales are predicted to be *not significant* (Table 5.14). The level of confidence associated with this prediction is *medium* (Table 5.14).

***Disturbance***

Based on our review, there could be behavioural effects on some species of toothed whales within the Study Area. Known effects may range from changes in swimming behaviour to avoidance of the seismic vessel. A 160 dB re 1 $\mu Pa_{rms}$ sound level is used to assess disturbance effects, more specifically potential displacement from the area around the seismic source. This is likely a conservative criterion since some toothed whale species:

- have been observed in other areas relatively close to an active seismic source where received sound levels are greater than 160 dB; and
- individuals which may be temporarily displaced from an area will not be significantly impacted by this displacement.

## Table 5.13 Assessment of Effects of Project Activities on the Marine Mammal VEC.

| Valued Environmental Component: Marine Mammals | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Project Activity | Potential Positive (P) or Negative (N) Environmental Effect | Mitigation | Evaluation Criteria for Assessing Environmental Effects | | | | | |
| | | | Magnitude | Geographic Extent | Frequency | Duration | Reversibility | Ecological/ Socio-Cultural and Economic Context |
| **Sound** | | | | | | | | |
| Airgun Array (2D, 3D and 4D) | Hearing Impairment (N) Physical Effects (N) | Pre-watch; Ramp-up; Delay start[a]; Shutdown[b] | 0-1 | 1-2 | 6 | 1-2 | R | 2 |
| Airgun Array (2D, 3D and 4D) | Disturbance (N) | Pre-watch; Ramp-up; Delay start[a]; Shutdown[b] | 1-2 | 3-4 | 6 | 1-2 | R | 2 |
| Seismic Vessel | Disturbance (N) | | 0-1 | 1-2 | 6 | 1-2 | R | 2 |
| Supply Vessel | Disturbance (N) | | 0-1 | 1-2 | 1 | 1 | R | 2 |
| Picket Vessel | Disturbance (N) | | 0-1 | 1-2 | 6 | 1-2 | R | 2 |
| Helicopter | Disturbance (N) | | 0-1 | 1-2 | 1 | 1 | R | 2 |
| Echo Sounder | Disturbance (N) | | 0-1 | 1 | 6 | 1-2 | R | 2 |
| Side Scan Sonar | Disturbance (N) | | 0-1 | 1 | 6 | 1-2 | R | 2 |
| **Vessel Presence** | | | | | | | | |
| Seismic Vessel/Gear (2D, 3D and 4D) | Disturbance (N) | | 0-1 | 1 | 6 | 1-2 | R | 2 |
| Supply Vessel | Disturbance (N) | | 0-1 | 1 | 1 | 1 | R | 2 |
| Picket Vessel | Disturbance (N) | | 0-1 | 1 | 6 | 1-2 | R | 2 |
| **Helicopter Presence** | Disturbance (N) | Maintain high altitude | 0-1 | 1-2 | 1 | 1 | R | 2 |
| **Sanitary/Domestic Waste** | Increased Food (N/P) | Treatment; containment | 0-1 | 1 | 4 | 1-2 | R | 2 |
| **Atmospheric Emissions** | Surface Contaminants (N) | Low sulphur fuel | 0 | 1 | 6 | 1-2 | R | 2 |
| **Accidental Releases** | Injury/Mortality (N) | Solid streamer[c]; Spill response | 1 | 1-2 | 1 | 1 | R | 2 |

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

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

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

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

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 $km^2$

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not negatively affected by human activity
2 = Evidence of existing negative effects

[a] Ramp-up will be delayed if any marine mammal is sighted within the 500 m safety zone.
[b] The airgun arrays will be shutdown if an *endangered* (or *threatened*) marine mammal is sighted within 500 m of the array.
[c] A solid streamer will be used for all seismic surveys.

## Table 5.14 Significance of Potential Residual Environmental Effects of Proposed Activities on Marine Mammals.

| Valued Environmental Component: Marine Mammals | | | | |
|---|---|---|---|---|
| Project Activity | Residual Environmental Effect Rating | Level of Confidence | Likelihood [a] | |
| | Significance of Predicted Residual Environmental Effects | | Probability of Occurrence | Scientific Certainty |
| **Sound** | | | | |
| Airgun Array (2D, 3D and 4D) – hearing/physical effects | NS | 2 | - | - |
| Airgun Array (2D, 3D and 4D) – behavioural effects | NS | 2 | - | - |
| Seismic Vessel | NS | 3 | - | - |
| Supply Vessel | NS | 3 | - | - |
| Picket Vessel | NS | 3 | - | - |
| Helicopter | NS | 3 | - | - |
| Echo Sounder | NS | 3 | - | - |
| Side Scan Sonar | NS | 3 | - | - |
| **Vessel Presence** | | | | |
| Seismic Vessel/Gear (2D, 3D and 4D) | NS | 3 | - | - |
| Supply Vessel | NS | 3 | - | - |
| Picket Vessel | NS | 3 | - | - |
| **Helicopter Presence** | NS | 3 | - | - |
| **Sanitary/Domestic Wastes** | NS | 3 | - | - |
| **Atmospheric Emissions** | NS | 3 | - | - |
| **Accidental Releases** | NS | 2 | - | - |

Key:

Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km$^2$

Residual Environmental Effect Rating:
- S = Significant Negative Environmental Effect
- NS = Not-significant Negative Environmental Effect
- P = Positive Environmental Effect

Level of Confidence: based on professional judgment:
- 1= Low
- 2= Medium
- 3= High

Probability of Occurrence: based on professional judgment:
- 1= Low
- 2= Medium
- 3= High

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
- 1= Low
- 2= Medium
- 3= High

[a] Considered only in the case where 'significant negative effect' is predicted.

It is uncertain how many toothed whales may occur in the Study Area at various times of the year. The Study Area is not known to be an important feeding or breeding area for toothed whales (however, there has been little research to verify this). As per Table 5.13, disturbance effects from Project activity noise on toothed whales would likely be *low* to *medium* magnitude for a duration of *<1 month* to *1 to 12 months* over a geographic area of *11-100* to *101-1,000 km*$^2$. Therefore, the potential residual effects related to disturbance are predicted to be *not significant* for toothed whales (see Table 5.14). The level of confidence associated with this prediction is medium (see Table 5.14).

***Effects on Prey Species***

It is unlikely that prey species for toothed whales will be impacted by seismic activities to a degree that inhibits their foraging success. If prey species exhibit avoidance of the seismic ship it will likely be transitory in nature (see Section 5.8.4) and over a small portion of a whale's foraging range within the Project Area. Potential effects of reduced prey availability on toothed whales are predicted to be *negligible*.

***Baleen Whales***

Baleen whales are thought to be sensitive to low-frequency sounds such as those that contribute most of the energy in seismic pulses. Species of most concern are those that are designated under *SARA* Schedule 1 and that may occur in and near the Project Area (i.e., blue whale and North Atlantic right whale). As with toothed whales, the 180 dB re 1 $\mu Pa_{rms}$ criterion is used when estimating the area where hearing impairment and/or physical effects may occur for baleen whales (although there are no data to support this criterion for baleen whales). For all baleen whale species, it is assumed that disturbance effects (avoidance) may occur at sound levels greater than 160 dB re 1 $\mu Pa_{rms}$.

***Hearing Impairment and Physical Effects***

Given that baleen whales typically exhibit at least localized avoidance of seismic (and other strong) noise (see Section 1.5.1 of Appendix 4), baleen whales will likely not be exposed to levels of sound from the airgun array high enough to cause non-auditory physical effects or hearing damage. The mitigation measure of ramping-up the airgun array should allow any whales close to the airguns to move away before the sounds become sufficiently strong to have potential for hearing impairment. Also, the airgun array will not be started if a baleen whale is sighted within the 500 m safety zone. Therefore, these measures reduce the potential for baleen whales to be close enough to the array to experience hearing impairment. If some whales did experience TTS, the effects would likely be quite "temporary". As per Table 5.13, WesternGeco's 2D/3D/4D seismic program is predicted to have *negligible to low magnitude* hearing impairment effects on baleen whales for a duration of *<1 month* to *1 to 12 months* over a geographic area of *<1 km*$^2$ to *1-10 km*$^2$. Therefore, hearing impairment and/or physical residual effects on baleen whales are predicted to be *not significant* (see Table 5.14). The level of confidence associated with this prediction is *medium* (see Table 5.14).

***Disturbance***

Based on the above review and information in Section 1.5.1 of Appendix 4, there could be behavioural effects on baleen whales within and near the Project Area. Reported effects range from changes in swimming behaviour to avoidance of the seismic vessel. The area where displacement would most likely occur would have a predicted scale of impact at *11-100 km*$^2$ to *101-1,000 km*$^2$. This is likely a conservative estimate given that:

- some baleen whale species have been observed in areas relatively close to an active seismic source; and
- it is unlikely that displacement from an area constitutes a significant impact for baleen whales in the Project Area.

It is uncertain how many baleen whales may occur in the Study Area during the period when seismic activity is most likely to occur (May to November). However, as per Table 5.13, disturbance effects on species of baleen whales would likely be *low* to *medium* magnitude for a duration of *<1 month* to *1 to 12 months* over a geographic area of *11-100 km*$^2$ to *101-1,000 km*$^2$. Therefore, residual effects related to disturbance are predicted to be *not significant* for baleen whales (see Table 5.14). The level of confidence associated with this prediction is *medium* (see Table 5.14).

***Effects on Prey Species***

It is unlikely that prey species for baleen whales, particularly euphausiids, will be impacted by seismic activities to a degree that inhibits their foraging success. If prey species exhibit avoidance of the seismic ship it will likely be transitory in nature (see Section 5.8.4) and over a small portion of a whale's foraging range within the seismic area. Potential effects of reduced prey availability on baleen whales are judged to be *negligible*.

***Seals***

Seals are not expected to be abundant within the Study Area, particularly in the time period when seismic operations will likely occur. Harp and hooded seals are expected to have a more northerly distribution during the survey period, although they could be moving through the Study Area. Grey seals are likely not very abundant and would be most common in coastal areas. None of the species of seal that occur within the Study Area are considered at risk by COSEWIC or are designated on a *SARA* schedule (see Section 4.6).

***Hearing Impairment and Physical Effects***

Given that seals typically avoid the immediate area around a seismic array (see Section 5.2.3 of Appendix 4), seals are unlikely to be exposed to levels of sound from the airgun array (and other noise sources) high enough to cause non-auditory physical effects or hearing impairment. Even when avoidance is limited to the area within a few hundred metres of an airgun array, that should usually be sufficient to avoid TTS based on what is currently known about thresholds for TTS onset in most pinnipeds; an exception may be the harbour seal, for which sound levels that elicit TTS may be lower. The mitigation measure of ramping-up the airgun array will allow seals close to the airguns to move away before the sounds become sufficiently strong to have potential for hearing impairment. Also, a ramp-up will not be initiated if a seal is sighted within the 500 m safety zone. These measures reduce the potential for seals to be close enough to an array to experience hearing impairment. If some seals did experience TTS, the effects would likely be quite "temporary". As per Table 5.13, WesternGeco's 2D/3D/4D seismic program is predicted to have *negligible* to *low* magnitude hearing impairment and/or physical effects on seals for a duration of *<1 month* to *1 to 12 months* over a geographic area of *<1 km²* to *1-10 km²*. Therefore, hearing impairment and physical residual effects on seals are predicted to be *not significant* (see Table 5.14). The level of confidence associated with this prediction is *medium* (see Table 5.14).

***Disturbance***

Based on information in Section 1.5.3 of Appendix 4, there could be behavioural effects on seals within and near the Project Area. Known effects include changes in diving behaviour and localized avoidance of the seismic vessel. It is uncertain how many seals may occur in the Project Area during the period when seismic operations will occur (May to November). A 160 dB re 1 $\mu Pa_{rms}$ sound level has been conservatively used to assess disturbance effects, more specifically potential displacement from the area around the seismic source. As per Table 5.13, disturbance effects on seals would likely be *low* to *medium* magnitude for a duration of *<1 month* to *1 to 12 months* over a geographic area of *11-100 km²*. Therefore, residual effects related to disturbance are predicted to be *not significant* for seals (see Table 5.14). The level of confidence associated with this prediction is *medium* (see Table 5.14).

***Effects on Prey Species***

It is unlikely that prey species for seals will be impacted by seismic activities to a degree that inhibits their foraging success. If prey species exhibit avoidance of the seismic ship it will likely be transitory in nature (see Section 5.8.4) and over a small portion of the seal's foraging range within the seismic area. Potential effects of reduced prey availability on seals are expected to be *negligible*.

**Assessment of Effects of Sound on Sea Turtles**

The effects assessment for sea turtles is summarized in Table 5.15. The effects of underwater sound from vessels, the echo sounder and the side scan sonar are not further discussed as their impact is minimal relative to airguns.

***Hearing Impairment and Physical Effects***

Based on available data, it is possible that sea turtles might exhibit temporary hearing loss if the turtles are close to the airguns (Moulton and Richardson 2000; Appendix 5. However, there is not enough information on sea turtle temporary hearing loss and no data on permanent hearing loss to reach any definitive conclusions about received sound levels that trigger TTS. Also, it is likely that sea turtles will exhibit behavioural reactions or avoidance within an area of unknown size around a seismic vessel. The mitigation measure of ramping-up the airgun array over a 30 min period should permit sea turtles close to the airguns to move away before the sounds become sufficiently strong to have any potential for hearing impairment. Also, ramp-up will not commence if a sea turtle is sighted within the 500 m safety zone, and the airgun array will be shutdown if a sea turtle is sighted within the safety zone.

It is very unlikely that many sea turtles will occur in the Study Area. Therefore, there is likely limited potential for sea turtles to be close enough to an array to experience hearing impairment. As per Table 5.15, WesternGeco's 2D/3D/4D seismic program is predicted to have *negligible* to *low* magnitude physical effects on sea turtles for a duration of *<1 month* to *1-12 months* over a geographic area of *<1 to 1-10* $km^2$. Therefore, auditory and physical residual effects on sea turtles are predicted to be *not significant* (Table 5.16). The level of confidence associated with this prediction is *medium* (Table 5.16).

***Disturbance***

It is possible that sea turtles will occur in the Project Area, although the cooler water temperatures likely preclude some species from occurring there. If sea turtles did occur near the seismic vessel, it is likely that they would exhibit avoidance within a localized area. Based on observations of green and loggerhead sea turtles, behavioural avoidance may occur at received sound levels of 166 dB re 1 $\mu Pa_{rms}$. Based on available evidence, the area where displacement would most likely occur would have a scale of impact at *11-100* $km^2$. As per Table 5.15, WesternGeco's 2D/3D/4D seismic program is predicted to have *low* magnitude disturbance effects on sea turtles for a duration of *<1 month* to *1 to 12 months* over a geographic area of *11-100* $km^2$. Therefore, effects related to disturbance, are predicted to be *not significant* for sea turtles (Table 5.16). The level of confidence associated with this prediction is *medium* to *high* (Table 5.16).

***Prey Species***

Leatherback sea turtles are expected to feed primarily on jellyfish. It is unknown how jellyfish react to seismic sources, if these invertebrates react at all. Leatherbacks are also known to feed on sea urchins, tunicates, squid, crustaceans, fish, blue-green algae, and floating seaweed. It is possible that some prey species may exhibit localized avoidance of the seismic array but this is unlikely to impact sea turtles, which are also likely to avoid the seismic vessel and are known to search for aggregations of prey. Potential effects of reduced prey availability are predicted to be *negligible*.

## Table 5.15 Assessment of Effects of Project Activities on Sea Turtles.

| Valued Environmental Component: Sea Turtles | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Project Activity | Potential Positive (P) or Negative (N) Environmental Effect | Mitigation | Evaluation Criteria for Assessing Environmental Effects | | | | | |
| | | | Magnitude | Geographic Extent | Frequency | Duration | Reversibility | Ecological/ Socio-Cultural and Economic Context |
| **Sound** | | | | | | | | |
| Airgun Array (2D, 3D and 4D) | Hearing Impairment (N); Physical Effects (N) | Pre-watch; Ramp-up; Delay start[a]; Shutdown[b] | 0-1 | 1-2 | 6 | 1-2 | R | 2 |
| Airgun Array (2D, 3D and 4D) | Disturbance (N) | Pre-watch; Ramp-up; Delay start[a]; Shutdown[b] | 1 | 3 | 6 | 1-2 | R | 2 |
| Seismic Vessel | Disturbance (N) | | 0-1 | 1-2 | 6 | 1-2 | R | 2 |
| Supply Vessel | Disturbance (N) | | 0-1 | 1-2 | 1 | 1 | R | 2 |
| Picket Vessel | Disturbance (N) | | 0-1 | 1-2 | 6 | 1-2 | R | 2 |
| Helicopter | Disturbance (N) | | 0-1 | 1-2 | 1 | 1 | R | 2 |
| Echo Sounder | Disturbance (N) | | 0-1 | 1 | 6 | 1-2 | R | 2 |
| Side Scan Sonar | Disturbance (N) | | 0-1 | 1 | 6 | 1-2 | R | 2 |
| **Vessel Presence** | | | | | | | | |
| Seismic Vessel/Gear (2D, 3D and 4D) | Disturbance (N) | | 0-1 | 1 | 6 | 1-2 | R | 2 |
| Supply Vessel | Disturbance (N) | | 0-1 | 1 | 1 | 1 | R | 2 |
| Picket Vessel | Disturbance (N) | | 0-1 | 1 | 6 | 1-2 | R | 2 |
| **Helicopter Presence** | Disturbance (N) | Maintain high altitude | 0-1 | 1-2 | 1 | 1 | R | 2 |
| **Sanitary/Domestic Waste** | Increased Food (N/P) | Treatment; containment | 0-1 | 1 | 4 | 1-2 | R | 2 |
| **Atmospheric Emissions** | Surface Contaminants (N) | Low sulphur fuel | 0 | 1 | 6 | 1-2 | R | 2 |
| **Accidental Releases** | Injury/Mortality (N) | Solid streamer[c]; Spill response | 1 | 1-2 | 1 | 1 | R | 2 |

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

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

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

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

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$^2$

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not negatively affected by human activity
2 = Evidence of existing negative effects

[a] Ramp-up will be delayed if a sea turtle is sighted within the 500 m safety zone.
[b] The airgun arrays will be shutdown if an *endangered* (or *threatened*) sea turtle is sighted within 500 m of the array.
[c] A solid streamer will be used for all seismic surveys.

## Table 5.16 Significance of Potential Residual Environmental Effects of Proposed Activities on Sea Turtles.

| Valued Environmental Component: Sea Turtles | | | | |
|---|---|---|---|---|
| Project Activity | Residual Environmental Effect Rating | Level of Confidence | Likelihood [a] | |
| | Significance of Predicted Residual Environmental Effects | | Probability of Occurrence | Scientific Certainty |
| **Sound** | | | | |
| Airgun Array (2D, 3D and 4D) – hearing/physical effects | NS | 2 | - | - |
| Airgun Array (2D, 3D and 4D) – behavioural effects | NS | 2-3 | - | - |
| Seismic Vessel | NS | 3 | - | - |
| Supply Vessel | NS | 3 | - | - |
| Picket Vessel | NS | 3 | - | - |
| Helicopter | NS | 3 | - | - |
| Echo Sounder | NS | 3 | - | - |
| Side Scan Sonar | NS | 3 | - | - |
| **Vessel Presence** | | | | |
| Seismic Vessel/Gear (2D, 3D and 4D) | NS | 3 | - | - |
| Supply Vessel | NS | 3 | - | - |
| Picket Vessel | NS | 3 | - | - |
| **Helicopter Presence** | NS | 3 | - | - |
| **Sanitary/Domestic Wastes** | NS | 3 | - | - |
| **Atmospheric Emissions** | NS | 3 | - | - |
| **Accidental Releases** | NS | 2 | - | - |

Key:

Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 $km^2$

Residual Environmental Effect Rating:
- S = Significant Negative Environmental Effect
- NS = Not-significant Negative Environmental Effect
- P = Positive Environmental Effect

Level of Confidence: based on professional judgment:
- 1= Low
- 2= Medium
- 3= High

Probability of Occurrence: based on professional judgment:
- 1= Low
- 2= Medium
- 3= High

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
- 1= Low
- 2= Medium
- 3= High

[a] Considered only in the case where 'significant negative effect' is predicted.

#### 5.7.7.2 Helicopter Sound

Available information indicates that single or occasional aircraft overflights will cause no more than brief behavioural responses in baleen whales, toothed whales and seals (summarized in Richardson et al. 1995). As per Table 5.13, disturbance effects are assessed as *negligible* to *low* magnitude for a duration of *<1 month* over a geographic area of *<1* $km^2$ to *1-10* $km^2$. Therefore, effects related to disturbance, are predicted to be *not significant* for marine mammals (see Table 5.14). The level of confidence associated with this prediction is *high* (see Table 5.14).

To the best of our knowledge, there are no 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 in relatively shallow waters. It is unknown how sea turtles would respond, but single or occasional overflights by helicopters would likely only elicit a brief behavioural response. As per Table 5.15, disturbance impacts are assessed as *negligible* to *low* magnitude for a duration of *<1 month* over a geographic area of *<1* $km^2$ to *1-10* $km^2$. Therefore, impacts related to disturbance, are predicted to be *not significant* for sea turtles (see Table 5.16). The level of confidence associated with this prediction is *high* (see Table 5.16).

#### 5.7.7.3 Vessel Presence

During the proposed seismic program, there will be one seismic ship at all times and a picket vessel on site during most of the program. A supply vessel will also regularly be present during the program. There is some risk for collision between marine mammals and vessels, but given the slow surveying speed (~4.5 knots; 8.3 km/h) of the seismic vessel (and its support vessels), this risk is likely to be minimal (e.g., Laist et al. 2001, 2014; Vanderlaan and Taggart 2007; Gende et al. 2011; Wiley et al. 2011). Marine mammal responses to ships are presumably responses to noise (Anderwald et al. 2013; Williams et al. 2014), but visual or other cues are also likely involved as the physical presence of vessels, and not just noise, also plays a role in disturbance (Pirotta et al. 2015). Marine mammal response (or lack thereof) to ships and boats (pre-1995 studies) are summarized in Richardson et al. (1995), p. 252 to 274. Subsequent studies are described in Husky (2012) and more recent studies include Anderwald et al. (2013), Williams et al. (2014) and Pirotta et al. (2015). Marine mammal responses to the presence of vessels are variable. Seals often show considerable tolerance to vessels, but can also show signs of displacement in response to vessel traffic. Toothed whales sometimes show no avoidance reactions and occasionally approach vessels; however, some species are displaced by vessels. Baleen whales often interrupt their normal behaviour and swim rapidly away from vessels that have strong or rapidly changing noise, especially when a vessel heads directly towards a whale. Stationary vessels or slow-moving, “non-aggressive” vessels typically elicit very little response from baleen whales.

There are few systematic studies on sea turtle reactions to ships and boats but it is thought that response would be minimal relative to responses to seismic sound. Hazel et al. (2007) evaluated behavioural responses of green turtles to a research vessel approaching at slow, moderate, or fast speeds (4, 11, and 19 km/h, respectively). Proportionately fewer turtles fled from the approaching vessel as speed increased, and turtles that fled from moderate to fast approaches did so at significantly shorter distances from the vessel than those that fled from slow approaches. The authors concluded that sea turtles cannot be relied on to avoid vessels with speeds greater than 4 km/h. However, studies were conducted in a 6 m aluminum boat powered by an outboard engine, which would presumably be more challenging for a sea turtle to detect than a seismic or support vessels. Lester et al. (2012) reported variable behavioural responses of a semi-aquatic turtles to boat sounds.

Sea turtles may also become entangled with seismic gear (e.g., cables, buoys, streamers, etc.) or collide with the vessel (Pendoley 1997; Ketos Ecology 2007; Weir 2007; Hazel et al. 2007). Entanglement of sea turtles with marine debris, fishing gear, dredging operations, and equipment operations are a documented occurrence and of elevated concern for sea turtles. Turtles can become wrapped around cables, lines, nets, or other objects suspended in the water column and become injured or fatally wounded, drowned, or suffocated (e.g., Lutcavage et al. 1997; NMFS 2007). Seismic personnel have reported that sea turtles (number unspecified) became fatally entrapped between gaps in tail-buoys associated with industrial seismic vessel gear deployed off West Africa in 2003 (Weir 2007). With dedicated monitoring by trained biological observers, no incidents of entanglements of sea turtles with this gear have been documented in over 40,000 n.mi. (74,000 km) of NSF-funded seismic surveys (e.g., Smultea and Holst 2003; Haley and Koski 2004; Holst 2004; Smultea et al. 2004; Holst et al. 2005a,b; Holst and Smultea 2008). Towing of the hydrophone streamer or other equipment is not expected to significantly interfere with sea turtle movements, including migration, unless they were to become entrapped as indicated above.

However, the Project Area is not a breeding area for sea turtles and it is not known or thought to be an important feeding area. Thus, it is not expected that high concentrations of sea turtles could potentially be physically affected.

Effects of the presence of vessels on marine mammals or sea turtles, including the risk of collisions, are predicted to be *negligible to low* magnitude for a duration of *<1 month* to *1-12 months* over a geographic area of *<1* $km^2$. Therefore, residual effects related to the presence of vessels, are predicted to be *not significant* for marine mammals and sea turtles (see Tables 5.13 to 5.16). The level of confidence associated with this prediction is *high* (see Tables 5.14 and 5.16).

### 5.7.7.4 Accidental Releases

All petroleum hydrocarbon handling and reporting procedures on board will be consistent with WesternGeco's policy, and handling and reporting procedures. A fuel spill may occur from the seismic ship and/or the support vessels. Spills would likely be small and quickly dispersed by wind, wave, and ship's propeller action. The effects of hydrocarbon spills on marine mammals and sea turtles were reviewed in Section 11.4.3 of Husky (2012) and are not repeated here. Based on multiple studies, whales and seals do not exhibit large behavioural or physiological responses to limited surface oiling, incidental exposure to contaminated food, or ingestion of oil (St. Aubin 1990; Williams et al. 1994). Sea turtles are thought to be more susceptible to the effects of oiling than marine mammals but effects are primarily believed to be sublethal (Husky 2012). Camacho et al. (2013) reported that 88% of loggerhead turtles that stranded due to crude oil in the Canary Islands, Spain, survived; those that died showed signs of ingested oil and internal lesions. Lesions on the skin, carapace, and plastron tend not to be fatal (Camacho et al. 2013). Residual effects of a small accidental spill on marine mammals or sea turtles would be *low* magnitude for a duration of *<1 month* over a geographic area *<1 km² to 1-10 km²* and are predicted to be *not significant* (see Tables 5.13 to 5.16). The level of confidence associated with this prediction is *medium* (see Tables 5.14 and 5.16).

#### 5.7.7.5 Other Project Activities

There is potential for marine mammals and sea turtles to interact with domestic and sanitary wastes, and atmospheric emissions from the seismic ship and the support vessels. Any effects from these interactions are predicted to be *negligible* (see Tables 5.13 to 5.16).

### 5.7.8 Species at Risk

Biological overviews of all species designated as *endangered* or *threatened* under Schedule 1 of the *SARA* and with reasonable likelihood of occurrence in the Study Area were provided in Section 4.6. Similarly, biological overviews of all species designated as *special concern* under Schedule 1 of *SARA* and with reasonable likelihood of occurrence in the Study Area were provided in Section 4.2 on fish and fish habitat and Section 4.5 on marine mammals and sea turtles. No critical habitat for any of these species/populations has been identified in the Study Area. As indicated in Table 4.17 in Section 4.6, the eleven *SARA* Schedule 1 species/populations of relevance to the Study Area include:

- Blue whale (Atlantic population), North Atlantic right whale, northern bottlenose whale (Scotian Shelf population), fin whale (Atlantic population), and Sowerby's beaked whale;
- Leatherback sea turtle;
- White shark (Atlantic population), northern wolffish, spotted wolffish, and Atlantic wolffish; and
- Ivory Gull.

Species/populations currently without designation on Schedule 1 of *SARA* but listed on Schedule 2 or 3 or being considered for addition to Schedule 1 (as per their current COSEWIC listing of *endangered, threatened* or *special concern*), are not included in this assessment of potential effects on the Species at Risk VEC. Instead, potential effects on these species/populations have been assessed in the appropriate VEC assessment section (i.e., Section 5.7.4 (Fish and Fish Habitat), Section 5.7.6 (Seabirds) and Section 5.7.7 (Marine Mammals and Sea Turtles) of this EA. If species/populations without current designations on Schedule 1 of *SARA* do become listed during the temporal scope of the Project (2015-2024), the Proponent will re-assess these species/populations considering the prohibitions of *SARA* and any recovery strategies or action plans that may be in place. Possible mitigation measures as they relate to species at risk will be reviewed with DFO and EC. Potential interactions between Project activities and the Species at Risk VEC are indicated in Table 5.17. Only those seven species/populations that are designated as either *endangered* or *threatened* under Schedule 1 of the *SARA* (see Table 4.17) are included in the interactions table (Table 5.17).

**Table 5.17 Potential Interactions of Project Activities and the Species at Risk VEC.**

| Valued Environmental Component: Species at Risk | | | | | |
|---|---|---|---|---|---|
| **Project Activities** | **White Shark** | **Wolffishes** | **Ivory Gull** | **Blue Whale North Atlantic Right Whale Northern Bottlenose Whale** | **Leatherback Sea Turtle** |
| **Sound** | | | | | |
| Airgun Array (2D, 3D and 4D) | X | X | X | X | X |
| Seismic Vessel | X | X | X | X | X |
| Supply Vessel | X | X | X | X | X |
| Picket Vessel | X | X | X | X | X |
| Helicopter [a] | | | X | X | X |
| Echosounder | X | X | X | X | X |
| Side Scan Sonar | X | X | X | X | X |
| **Vessel Lights** | X | | X | | |
| **Vessel Presence** | | | | | |
| Seismic Vessel/Gear (2D, 3D and 4D) | | | X | X | X |
| Supply Vessel | | | X | X | X |
| Picket Vessel | | | X | X | X |
| **Sanitary/ Domestic Waste** | X | X | X | X | X |
| **Atmospheric Emissions** | X | X | X | X | X |
| **Garbage** [b] | | | | | |
| **Helicopter Presence**[a] | | | X | X | X |
| **Shore Facilities** [c] | | | | | |
| **Accidental Releases** | X | X | X | X | X |
| **Other Projects and Activities in Region of Study Area** | | | | | |
| Oil and Gas Activities | X | X | X | X | X |
| Fisheries | X | X | X | X | X |
| Marine Transportation | X | X | X | X | X |

[a] No helicopter use is planned for 2015 but helicopters may be used during 2016-2024.
[b] Not applicable as garbage will be brought ashore.
[c] There will not be any new onshore facilities. Existing infrastructure will be used.

The potential effects of activities associated with WesternGeco's proposed seismic program are not expected to contravene the prohibitions of *SARA* (Sections 32(1), 33, 58(1)).

### 5.7.8.1 Marine Mammal and Sea Turtle Species at Risk

Based on available information, blue whales, North Atlantic right whales, northern bottlenose whales and leatherback sea turtles are not expected to occur regularly in the Study Area. No critical habitat for these species/populations has been identified in the Study Area. Mitigation and monitoring designed to minimize potential effects of airgun array noise on *SARA*-listed marine mammals and sea turtles will include:

- Ramp-up of the airgun array over a 30 min period;
- Monitoring by MMO(s) (with assistance from a FLO) during daylight hours that the airgun array is active;
- Shutdown of the airgun array when an *endangered* or *threatened* marine mammal or sea turtle is sighted within the 500 m safety zone; and
- Delay of ramp-up if any marine mammal or sea turtle is sighted within the 500 m safety zone.

Section 5.5 provides more details on the relevant mitigation measures.

With these mitigation measures in place and as per the detailed effects assessment in Section 5.7.7, the predicted effects of the Project on blue whales, North Atlantic right whales, northern bottlenose whales and leatherback sea turtles will range from *negligible* to *medium* in magnitude for a duration of *<1 month* to *1-12 months* over a geographic area of *<1* to *101-1,000* $km^2$ (Table 5.18). Based on these criteria ratings, the predicted effects of activities associated with WesternGeco's proposed seismic program on blue whales, North Atlantic right whales, northern bottlenose whales and leatherback sea turtles are predicted to be *not significant* (Table 5.19). The level of confidence associated with this prediction is *medium* to *high* (Table 5.19).

#### 5.7.8.2 Fish Species at Risk

The mitigation measure of ramping up the airgun array over a 30 minute period is expected to minimize the potential effects on white sharks and wolffishes. As per the detailed effects assessment contained in Section 5.7.4, physical effects of Project activities on the various life stages of the white shark and wolffishes will have *negligible* to *low* magnitude for a duration of *<1 month* to *1-12 months* over a geographic area of *<1* $km^2$ (Table 5.18). Based on these criteria ratings, the residual physical effects of activities associated with WesternGeco's proposed seismic program on white sharks and wolffishes are predicted to be *not significant* (Table 5.19). The level of confidence associated with this prediction is *high* (Table 5.19).

Behavioural effects of Project activities on the various life stages of the white shark and wolffishes will have *negligible* to *low* magnitude for a duration of *<1 month* to *1-12 months* over a geographic area of *<1* to *11-100* $km^2$ (Table 5.18). Based on these criteria ratings, the residual behavioural effects of activities associated with WesternGeco's proposed seismic program on white sharks and wolffishes are predicted to be *not significant* (Table 5.19). The level of confidence associated with this prediction is *medium* to *high* (Table 5.19).

## Table 5.18 Assessment of Effects of Project Activities on the Species at Risk VEC.

| Valued Environmental Component: Species At Risk | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Project Activity | Potential Positive (P) or Negative (N) Environmental Effect | Mitigation | Evaluation Criteria for Assessing Environmental Effects | | | | | |
| | | | Magnitude | Geographic Extent | Frequency | Duration | Reversibility | Ecological/ Socio-Cultural and Economic Context |
| **Sound** | | | | | | | | |
| Airgun Array (2D, 3D and 4D) | Disturbance (N)<br>Hearing Impairment (N)<br>Physical Effects (N) | Ramp-up; delay start[a]; shutdown [b] | 0-2 | 1-4 | 6 | 1-2 | R | 2 |
| Seismic Vessel | Disturbance (N) | | 0-1 | 1-2 | 6 | 1-2 | R | 2 |
| Supply Vessel | Disturbance (N) | | 0-1 | 1-2 | 1 | 1 | R | 2 |
| Picket Vessel | Disturbance (N) | | 0-1 | 1-2 | 6 | 1-2 | R | 2 |
| Helicopter | Disturbance (N) | Maintain high altitude | 0-1 | 1-2 | 1 | 1 | R | 2 |
| Echosounder | Disturbance (N) | | 0-1 | 1 | 6 | 1 | R | 2 |
| Side Scan Sonar | Disturbance (N) | | 0-1 | 1 | 6 | 1 | R | 2 |
| **Vessel Lights** | Attraction (N);<br>Mortality (N) | Reduce lighting (if safe); release protocols | 0-1 | 1-2 | 2-3 | 1-2 | R | 2 |
| **Vessel Presence** | | | | | | | | |
| Seismic Vessel/Gear (2D, 3D and 4D) | Disturbance (N) | | 0-1 | 1 | 6 | 1-2 | R | 2 |
| Supply Vessel | Disturbance (N) | | 0-1 | 1 | 1 | 1 | R | 2 |
| Picket Vessel | Disturbance (N) | | 0-1 | 1 | 6 | 1-2 | R | 2 |
| **Sanitary/Domestic Waste** | Increased food (N/P) | - | 0-1 | 1 | 4 | 1-2 | R | 2 |
| **Atmospheric Emissions** | Surface contaminants (N) | - | 0 | 1 | 6 | 1-2 | R | 2 |
| **Helicopter Presence** | Disturbance (N) | Maintain high altitude | 0-1 | 1-2 | 1 | 1 | R | 2 |
| **Accidental Releases** | Injury/Mortality (N) | Solid Streamer[d]; Spill Response | 0-2 | 1-2 | 1 | 1 | R | 2 |

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

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

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

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

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 $km^2$

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not negatively affected by human activity
2 = Evidence of existing negative effects

[a] The airgun arrays will be shutdown if an *endangered* (or *threatened*) marine mammal or sea turtle is sighted within 500 m of the array.
[b] A crew change may occur via helicopter if the seismic program is longer than 5 to 6 weeks.
[c] Solid or Isopar filled streamers may be used during future surveys, depending on the seismic contractor.

**Table 5.19 Significance of Potential Residual Environmental Effects of Project Activities on the Species at Risk VEC.**

| Valued Environmental Component: Species At Risk | | | | |
|---|---|---|---|---|
| Project Activity | Significance Rating | Level of Confidence | Likelihood [a] | |
| | Significance of Predicted Residual Environmental Effects | | Probability of Occurrence | Scientific Certainty |
| **Sound** | | | | |
| Airgun Array (2D, 3D and 4D) | NS | 2-3 | - | - |
| Seismic Vessel | NS | 3 | - | - |
| Supply Vessel | NS | 3 | - | - |
| Picket Vessel | NS | 3 | - | - |
| Helicopter | NS | 3 | - | - |
| Echosounder | NS | 3 | - | - |
| Side Scan Sonar | NS | 3 | - | - |
| **Vessel Lights** | NS | 3 | - | - |
| **Vessel Presence** | | | | |
| Seismic Vessel (2D, 3D and 4D) | NS | 3 | - | - |
| Supply Vessel | NS | 3 | - | - |
| Picket Vessel | NS | 3 | - | - |
| **Sanitary/Domestic Wastes** | NS | 3 | - | - |
| **Atmospheric Emissions** | NS | 3 | - | - |
| **Helicopter Presence** | NS | 3 | - | - |
| **Accidental Releases** | NS | 2-3 | - | - |

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km$^2$ (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Considered only in the case where 'significant negative effect' is predicted.

### 5.7.8.3 Seabird Species at Risk

Ivory Gull foraging behaviour would not likely expose it to underwater sound, and this species is unlikely to occur in the Study Area, particularly during the time when seismic surveys are likely to being conducted. Furthermore, Ivory Gulls are not known to be prone to stranding on vessels. The mitigation measures of monitoring the seismic vessel, releasing stranded birds (in the unlikely event that an Ivory Gull did strand on the vessel) and ramping up the airgun array will minimize the potential effects on this seabird species at risk. As per the detailed effects assessment in Section 5.7.6, the residual effects of activities associated with WesternGeco's proposed seismic program on Ivory Gulls are predicted to be *negligible* and *not significant* (see Table 5.19). The level of confidence associated with this prediction is *medium* to *high* (see Table 5.19).

### 5.7.9 Sensitive Areas

An overview of sensitive areas either overlapping or proximate to the Study Area was provided in Section 4.7. The habitat preferences of biota potentially inhabiting these sensitive areas, including invertebrates, fishes, marine mammals, sea turtles and seabirds, were detailed in Sections 4.2 to 4.5, and species at risk were described in Section 4.6.

Based on the conclusions of Sections 5.7.4 to 5.7.8, the residual effects of activities associated with WesternGeco's proposed 2D/3D/4D seismic program on sensitive habitat and/or the species therein within the Study Area are predicted to be *not significant.* The level of confidence associated with this prediction is *medium* to *high*.

## 5.8 Cumulative Effects

This EA has assessed cumulative effects within the Project and thus, the residual effects described in preceding sections include any potential cumulative effects from the WesternGeco seismic program activities in the Project Area.

It is also necessary to assess cumulative effects from other non-Project activities that are occurring or planned for the Regional Area. These activities include:

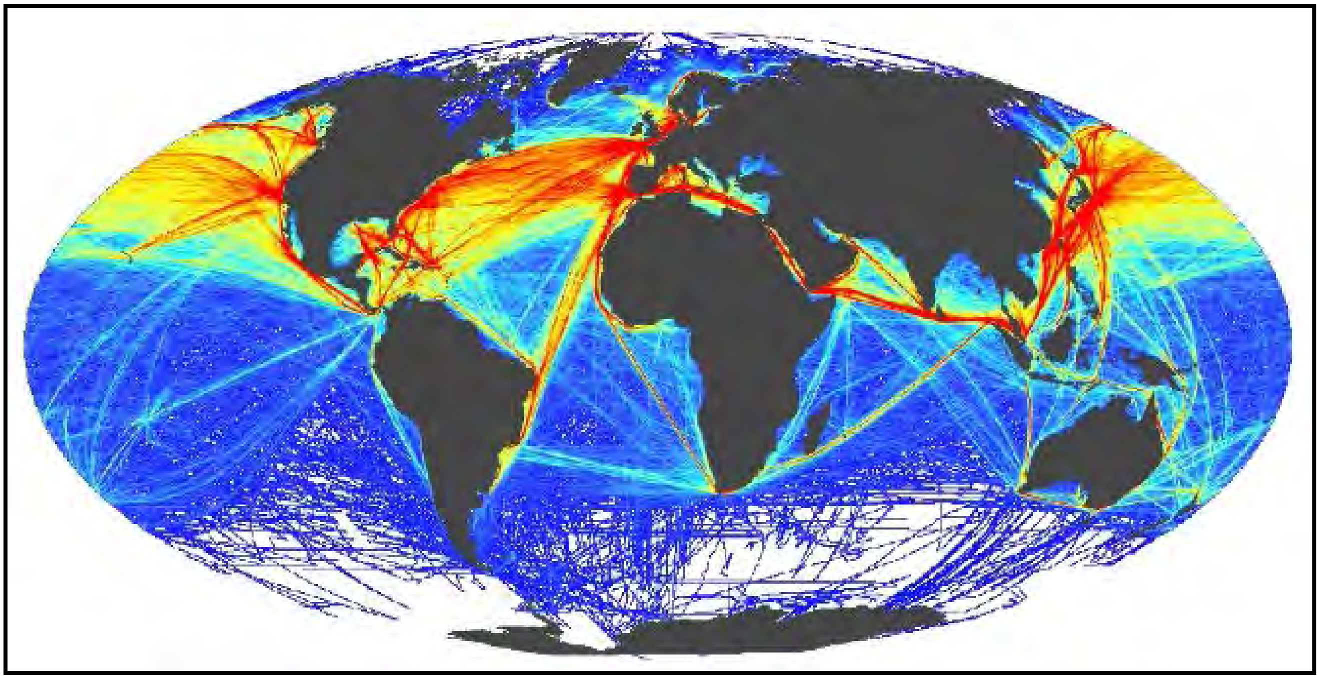
- Fisheries (commercial and research survey fishing);
- Marine transportation (e.g., cargo, defense, yachts); and
- Offshore oil and gas industry activities.

### 5.8.1 Fisheries

Fishing has been discussed and assessed in detail in Sections 4.3 and 5.6.2. Fishing activities, by their nature, cause mortality and disturbance to fish populations and may cause incidental mortalities or disturbance to seabirds, marine mammals, and sea turtles. It is predicted that the seismic surveys will not cause any mortality to these VECs (with the potential exception of small numbers of petrels) and thus, there will be either *no* or *negligible* cumulative mortality effect. There is some potential for cumulative disturbance effect (e.g., fishing vessel noise) but there will be directed attempts by both industries to mitigate such effects by avoiding each other's active areas and times as much as possible. The seismic surveying will also spatially and temporally avoid DFO research vessels during multi-species trawl surveys. Any cumulative effects (i.e., disturbance), if they occur, will be additive (not multiplicative or synergistic) and predicted to be *not significant*.

### 5.8.2 Marine Transportation

Based on voluntary reporting, extensive marine shipping occurs through and near the Project Area (Figure 5.1). The Eastern Seaboard/Europe and Halifax/Europe trade routes pass through the Project Area, primarily on a northeast-southwest orientation. In the summer, the main North Atlantic shipping lanes between Europe and North America lie to the north of the Grand Banks through the Strait of Belle Isle. However in the winter, far less traffic passes through this area as navigation can be affected by the presence of pack ice and icebergs. Accordingly, traffic shifts to the main shipping lanes along the southern Grand Banks into the Gulf of St. Lawrence (Koropatnick et al. 2012).



Source: Modified from Halpern et al. 2008.

**Figure 5.1 Frequency of Global Shipping Traffic Along Major Shipping Routes, Ranging from Low (Blue) to High (Red).**

The seismic survey vessels are not likely to add much marine traffic congestion. Ships may need to divert around the immediate seismic survey area, but this will not prevent or impede the passage of either vessel as the *Shipping Act* and standard navigation rules will apply. Thus, potential for cumulative effects with other shipping is predicted to be *low* and *not significant*.

### 5.8.3 Offshore Oil and Gas Activities

Potential offshore oil and gas industry activities in the Regional Area (as per the C-NLOPB public registry, www.cnlopb.nl.ca) include:

- Multi Klient Invest ASA (MKI) 2D/3D seismic program on Southeast Grand Banks, 2014-2018;

- Multi Klient Invest ASA (MKI) 2D/3D seismic program on Northeast Newfoundland Shelf (i.e., Labrador Basin, Orphan Basin, Flemish Pass, Jeanne d'Arc Basin), 2012-2017;
- Multi Klient Invest ASA (MKI) 2D/3D seismic program in Labrador Sea, 2014-2018;
- Electromagnetic Geoservices Canada Inc. (EMGS) controlled-source electromagnetic (CSEM) program on Eastern Newfoundland Offshore, 2014-2018;
- ExxonMobil geophysical, geochemical, environmental and geotechnical program in the eastern Newfoundland offshore, 2015-2024;
- Statoil 3D/2D geophysical program including geohazard and electromagnetic surveys in Jeanne d'Arc and Central Ridge/Flemish Pass Basins, 2011-2019;
- GXT Technology Canada Ltd.'s GrandSPAN 2D seismic, gravity and magnetic survey, 2014-2018;
- Investcan Energy Corporation 2D/3D seismic program including geohazard and VSP surveys on Labrador Shelf, 2010-2017;
- Chevron Canada Resources 3D/2D seismic program including geohazard survey in offshore Labrador, 2010-2017;
- Chevron Canada Resources 3D and/or 2D seismic program including geohazard survey in the North Grand Banks Region, 2011-2017;
- Statoil exploration, appraisal, and delineation drilling program in Jeanne d'Arc Basin area, 2008-2016;
- Suncor exploration drilling in Jeanne d'Arc Basin, 2009-2017;
- Husky White Rose new drill centre construction and operations program, 2008-2015; and
- Husky exploration and delineation drilling program in Jeanne d'Arc Basin, 2008-2017.

While the above list suggests potential for many programs to run concurrently, it should be noted that the East Coast operators tend to coordinate their logistics. As a result, based on historical levels of activities, there typically would be no more than two or three drill rigs and three or four seismic programs operating off Newfoundland and Labrador during any one season.

In addition, there are three existing offshore production developments (Hibernia, Terra Nova, and White Rose) on the northeastern part of the Grand Banks. A fourth development (Hebron) is anticipated to commence installation in the near future. These existing developments fall inside the boundaries of the WesternGeco's Study Area but do not create the same levels of underwater noise as seismic, geohazard, or VSP programs. Any cumulative effects (i.e., disturbance), if they occur, are predicted to be additive (not multiplicative or synergistic) and *not significant*.

There is potential for cumulative effects with other seismic programs proposed for 2015 (e.g., WesternGeco, MKI, Statoil, GXT). Different seismic programs could potentially be operating in relatively close proximity. During these periods, VECs may be exposed to noise from more than one of the seismic survey programs. It will be in the interests of the different parties for good coordination between programs in order to provide sufficient buffers and to minimize acoustic interference. Assuming maintenance of sufficient separation of seismic vessels operating concurrently in the Project Area, cumulative effects of seismic sound on fish and fish habitat, fisheries, seabirds, marine mammals, sea turtles, species at risk and sensitive areas are predicted to be *not significant*. However, there are uncertainties regarding this prediction—particularly regarding effects of masking on marine mammals from sound produced during multiple seismic surveys. The potential for temporal and spatial overlap of future activity of seismic programs (2016 and beyond) in the area will be assessed in the EA update process. Uncertainty due to the large identified Study Areas will be reduced as specific survey designs (covering smaller area) become available.

As discussed in this EA, negative effects (auditory, physical, and behavioural) on key sensitive VECs, such as marine mammals, appear unlikely beyond a localized area from the sound source. In addition, all programs will use mitigation measures such as ramp-ups, delayed startups, and shutdowns of the airgun arrays as well as spatial separation between seismic surveys. Thus, it seems likely that while some animals may receive sound from one or more geophysical programs, the current scientific prediction is that *no significant residual effects* will result.

## 5.9 Mitigation Measures and Follow-up

Project mitigations have been detailed in Sections 5.5 and 5.7 of this EA. They are summarized in this section, both in the text and in Table 5.20. WesternGeco will adhere to mitigations detailed in Appendix 2 of the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012) including those in the *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment*.

Fishers who may be operating in the area will be notified of the timing and location of planned activities by means of a CCG "Notice to Mariners" and a "Notice to Fishers" on the CBC Radio Fisheries Broadcast. If necessary, individual fixed gear fishers will be contacted to arrange mutual avoidance. Any contacts with fishing gear with any identifiable markings will be reported to the C-NLOPB within 24 h of the contact (in accordance with the C-NLOPB Incident Reporting and Investigation Guidelines). Fishing gear may only be retrieved from the water by the gear owner (i.e., fishing license owner). This includes buoys, radar reflectors, ropes, nets, pots, etc., associated with fishing gear and/or activity. If gear contact is made during seismic operations, it should not be retrieved or retained by the seismic vessel. There are conditions that may warrant gear being retrieved or retained if it becomes entangled with seismic gear; however, further clarification on rules and regulations regarding fishing gear should be directed to the Conservation and Protection Division of Fisheries and Oceans Canada (NL Region). WesternGeco will advise the C-NLOPB prior to compensating and settling all valid lost gear/income claims promptly and satisfactorily.

**Table 5.20 Summary of Mitigation Measures.**

| Potential Effects | Primary Mitigations |
|---|---|
| Interference with fishing vessels | • upfront planning to avoid high concentrations of fishing vessels<br>• request input from fishing captains through FFAW PIL regarding streamer deploying and testing plan.<br>• SPOC<br>• advisories and communications<br>• FLO<br>• planned transit route to and between Survey Areas (if required) |
| Fishing gear damage | • upfront planning to avoid high concentrations of fishing gear<br>• SPOC<br>• advisories and communications<br>• FLO<br>• compensation program<br>• planned transit route to and between Survey Areas (if required) |
| Interference with shipping | • SPOC<br>• advisories and communications<br>• FLO |
| Interference with DFO/FFAW research vessels | • communications and scheduling |
| Temporary or permanent hearing damage/disturbance to marine animals | • delay start-up if marine mammals or sea turtles are within 500 m.<br>• ramp-up of airguns over 30 min-period<br>• shutdown of airgun arrays for endangered or threatened marine mammals and sea turtles within 500 m<br>• use of qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations |
| Temporary or permanent hearing damage/ disturbance to Species at Risk or key habitats | • delay start-up if any marine mammals or sea turtles are within 500 m<br>• ramp-up of airguns<br>• shutdown of airgun arrays for endangered or threatened marine mammals and sea turtles<br>• use of qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations. |
| Injury (mortality) to stranded seabirds | • daily monitoring of vessel<br>• handling and release protocols<br>• minimize lighting if safe |
| Exposure to hydrocarbons | • adherence to International Convention for the Prevention of Pollution from Ships (MARPOL)<br>• spill contingency plans<br>• use of solid streamer |

Specific mitigations to minimize potential conflicts and any negative effects with other vessels include:

- Timely and clear communications (VHF, HF Satellite, etc.);
- Utilization of FLOs during 2D/3D/4D seismic programs for advice and coordination in regard to avoiding fishing vessels and fishing gear;
- MMO(s) on board;
- Posting of advisories with the Canadian Coast Guard and the CBC Fisheries Broadcast;
- Compensation program in the event any project vessels damage fishing gear; and
- Single Point of Contact (SPOC).

WesternGeco will also coordinate with the FFAW and DFO to avoid any potential conflicts with fishing and research survey vessels that may be operating in the area. WesternGeco commits to ongoing communications with other operators with active seismic programs within the general vicinity of its seismic program to minimize the potential for cumulative effects on VECs.

Mitigation measures designed to reduce the likelihood of impacts on marine mammals and sea turtles will include ramp ups, no initiation of airgun array if a marine mammal or sea turtle is sighted 30 min prior to ramp up within 500 m safety zone of the energy source, and shutdown of the energy source if an endangered (or threatened) whale or sea turtle is observed within the 500 m safety zone. Prior to the onset of the seismic survey, the airgun array will be gradually ramped up. One airgun will be activated first and then the volume of the array will be increased gradually over a recommended 30 min period. An observer (MMO) aboard the seismic ship will watch for marine mammals and sea turtles 30 min prior to ramp up. If a marine mammal or sea turtle is sighted within 500 m of the array, then ramp up will not commence until the animal has moved beyond the 500 m zone or 30 min have elapsed since the last sighting. The observers will watch for marine mammals and sea turtles when the airgun array is active (during daylight periods) and note the location and behaviour of these animals. The seismic array will be shutdown if an *endangered* or *threatened* marine mammal or sea turtle is sighted within the safety zone. The planned monitoring and mitigation measures, including ramp-ups, visual monitoring, and shutdown of the airguns when *endangered* or *threatened* marine mammals or turtles are seen within the "safety radius", will minimize the already low probability of exposure of marine animals to sounds strong enough to induce hearing impairment. Any dead or distressed marine mammals or sea turtles will be recorded and reported to the C-NLOPB.

Any seabirds that become stranded on the vessel (most likely Leach's Storm-petrel) will be released using the mitigation methods consistent with *The Leach's Storm-Petrel: General Information and Handling Instructions* by U. Williams (Petro-Canada) and J. Chardine (CWS) (n.d.). Data collection for seabirds at sea will be in accordance with Gjerdrum et al. (2012). It is understood by WesternGeco that a CWS *Migratory Birds Permit* will be required and that it will be secured as it has been in the past. WesternGeco will adhere to the conditions stipulated on the CWS permit. In the unlikely event that marine mammals, turtles or birds are injured or killed by Project equipment or accidental releases of hydrocarbons, a report will immediately be filed with the appropriate agencies (CWS, C-NLOPB) and the need for follow-up monitoring will be assessed.

Marine mammal and seabird observations will be made during ramp-ups and data acquisition periods, as well as at other times on an opportunistic basis. As per the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012), monitoring protocols for marine mammals and sea turtles will be consistent with those developed by LGL and outlined in Moulton and Mactavish (2004). Seabird data collection protocols will be consistent with those provided by CWS in Gjerdrum et al. (2012). Data will be collected and a monitoring report will be submitted to the C-NLOPB.

WesternGeco will also coordinate with DFO, St. John's, and the FFAW to avoid any potential conflicts with survey vessels that may be operating in the area. WesternGeco commits to ongoing communications with other operators with active seismic programs within the general vicinity of its seismic program to minimize the potential for cumulative effects on the VECs.

## 5.10 Assessment Summary

A summary of the significance ratings of residual effects of WesternGeco's proposed seismic program on the environment are shown in Table 5.21. The levels of confidence are also provided in the table. In summary, the residual effects of WesternGeco's proposed seismic program on the VECS are predicted to be *not significant*.

**Table 5.21 Significance of Potential Residual Environmental Effects of WesternGeco's Proposed Seismic Program on VECs in the Study Area.**

| Valued Environmental Components: Fish and Fish Habitat, Fisheries, Seabirds, Marine Mammals and Sea Turtles, Species at Risk, Sensitive Areas | | | | |
|---|---|---|---|---|
| **Project Activity** | **Significance Rating** | **Level of Confidence** | **Likelihood [a]** | |
| | **Significance of Predicted Residual Environmental Effects** | | **Probability of Occurrence** | **Scientific Certainty** |
| **Sound** | | | | |
| Airgun Array (2D, 3D and 4D) | NS | 2-3 | - | - |
| Seismic Vessel | NS | 2-3 | - | - |
| Picket vessel | NS | 2-3 | | |
| Supply Vessel | NS | 2-3 | - | - |
| Helicopter | NS | 3 | - | - |
| Echosounder | NS | 2-3 | - | - |
| Side Scan Sonar | NS | 2-3 | - | - |
| **Vessel Lights** | NS | 3 | - | - |
| **Vessel Presence** | | | | |
| Seismic Vessel/Gear (2D, 3D and 4D) | NS | 3 | - | - |
| Supply Vessel | NS | 3 | - | - |
| Picket Vessel | NS | 3 | - | - |
| **Sanitary/Domestic Wastes** | NS | 3 | - | - |
| **Atmospheric Emissions** | NS | 3 | - | - |
| **Helicopter Presence** | NS | 3 | - | - |
| **Accidental Releases** | NS | 2-3 | - | - |

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 $km^2$ (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Considered only in the case where 'significant negative effect' is predicted.

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**Personal Communication**

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# Appendices

## Appendix 1: Consultation Report

## Appendix 2: Invertebrates and Sound

## Appendix 3: Fishes and Sound

## Appendix 4: Marine Mammals and Sound

## Appendix 5: Sea Turtles and Sound