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Oil and Gas Exploration in the Southeastern Gulf of St. Lawrence: A Review of Information on Pinnipeds and Cetaceans in the Area

by

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Abstract

Information on pinnipeds (seals) and cetaceans (whales) in the proposed region of oil and gas exploration in the southeastern Gulf of St. Lawrence were summarized. Cabot Strait is an important migratory corridor for marine mammals moving in and out of the Gulf of St. Lawrence. Other major features of the area include seasonal ice cover which provides a platform for pinniped reproduction and limits access of marine mammals (primarily cetaceans) to the Gulf of St. Lawrence during winter months. The presence of large canyons in the Gulf, and particularly the Cape Breton Trough near Cheticamp are important foraging areas for cetaceans.

Four pinniped species are common to the area: harp, hooded, grey and harbour seals. General knowledge on population abundance, whelping areas, distribution, and diet are available for these animals, but specific (local) at sea distribution, relative abundance and local diet information in the area are needed. Harbour seals form the basis of a seal-watching industry on the east coast of Prince Edward Island.

At least 15 whale species may occur or pass through Cabot Strait. Six are abundant regular visitors. Fin, Minke, Humpback, and Pilot whales, White-sided dolphins, and Harbour porpoise are seen regularly, while low numbers of Right whales regularly transit the area. The area appears to be particularly important for Pilot Whales and this species forms the basis of whale-watching activities on western Cape Breton Island. Overall, a major knowledge gap is a lack of information on species present, abundance, seasonal occupation, seasonal movements and diet of whales in the southeastern Gulf of St. Lawrence.

Seismic activity could cause physical damage to hearing, result in distribution changes due to noise or changes in food distribution. Increases in strandings have been linked to increases in man-made noise production. Pilot whales, a species that often strands in the area would appear to be particularly vulnerable.

Résumé

Cette étude présente un sommaire de l'information disponible sur les pinnipèdes (phoques) et les cétacés (baleines) de la région du sud-est du golfe du Saint-Laurent qui est visée par le projet d'exploration pétrolière et gazéifère. Le Détroit de Cabot constitue une importante route migratoire pour les mammifères marins visitant le golfe du Saint-Laurent. Un couvert de glace saisonnier qui procure aux pinnipèdes une plate-forme pour la reproduction et qui réduit durant l'hiver l'accessibilité du golfe du Saint-Laurent aux mammifères marins (principalement les cétacés) sont d'importantes caractéristiques de cette région. De grands canyons dans le Golfe, principalement celui situé près de Cheticamp à l'île du Cap-Breton, sont d'importants habitats d'alimentation pour les cétacés.

Quatre espèces de pinnipèdes se retrouvent communément dans cette région : les phoques du Groenland, à capuchon, gris et communs. Des connaissances générales de l'abondance, des aires de mise bas, de distribution, et du régime alimentaire existent pour ces animaux, mais leur distribution, abondance et régime alimentaire au niveau local sont mal connus. L'industrie de l'observation des mammifères marins de la côte est de l'Île-du-Prince-Édouard repose sur les phoques communs.

Au moins 15 espèces de baleines sons susceptibles d'occuper ou traverser le Détroit de Cabot. Six sont des visiteurs réguliers et abondants. Les rorquals communs, petits rorquals, rorquals à bosse, globicéphales, dauphins à flancs blancs et marsouins communs sont observés régulièrement, alors qu`un faibles nombres de baleines franches noires transitent régulièrement dans cette région. Cette dernière semble être particulièrement importante pour les globicéphales, l'industrie de l'observation des mammifères marins reposant sur cette espèce le long de la côte ouest de l'île du Cap-Breton. Globalement, il existe un manque flagrant d'information concernant l'abondance relative, l'occupation et les mouvements saisonniers et sur le régime alimentaire des espèces de cétacés présentes dans le sud-est du golfe du Saint-Laurent.

L'exploration séismique est susceptible de causer des dommages physiques à l'appareil auditif, de résulter en des changements de distribution par le bruit sous-marin et les changements de distribution de la nourriture qu'elle cause. Des augmentations du nombre d'échouages de mammifères marins ont été attribuées à une augmentation de la production de bruit sous-marin par l'humain. Le globicéphale, une espèce qui s'échoue souvent dans cette région, semble particulièrement vulnérable à ces activités.

Introduction

The Gulf of St. Lawrence (Gulf) is an important region for marine mammals. The combination of concentration of food resources, sheltered haul-out regions, and stable ice provides the necessary conditions leading to seasonal aggregations of animals belonging to the order Cetacea (dolphins and whales) and the order Pinnipedia (seals). Working in concert with these biological features, the relative proximity to human centres has provided the necessary conditions favouring the development of seasonal commercial hunting of pinnipeds and multimillion dollar seal and whale observation industries centred near Tadoussac in the upper estuary, Gaspé, the Mingan Islands, southeast Prince Edward Island, the Magdalen Islands, and Cheticamp.

Key features concerning the Gulf of St. Lawrence include the presence of large canyons the extend through the centre of the Gulf from Cabot Strait to as far west as Tadoussac in the St. Lawrence Estuary. Branches also lead off into the northern Gulf of St. Lawrence, and into the southern Gulf of St. Lawrence near Cheticamp, and near Gaspé. These canyons appear to be areas of relatively high productivity leading to high concentrations of food for marine mammals, particularly large cetaceans. A second major characteristic is the seasonal presence of ice cover during the winter months, which limits access of marine mammals to certain areas, but also provides a platform for pinnipeds to haul out on for reproduction and moulting. Three marine mammal species (beluga, *Delphinapterus leucas,* harbour seal *Phoca vitulina*, grey seal *Halichoerus grypus*) remain in the St. Lawrence Estuary or Gulf of St. Lawrence year round. Other pinniped species are known to occur in the Gulf of St. Lawrence as seasonal visitors, the seasonal movements and distribution of most cetacean species cannot be ruled out with such certainty, and likely depends on yearly and seasonal changes in ice cover.

In this report, we outline our study area, provide an overview of the existing information, including a brief outline of species that are in the area or may be in the area and comment on the strengths and weaknesses in our information.

The main area of concern in the southeastern Gulf of St. Lawrence, extends from roughly Cheticamp in the north to Port Hood in the south on the Cape Breton coast, and extending about halfway across the strait to Prince Edward Island. However, owing to the mobility of marine mammals and the presence of key sites adjacent to the main area of concern, we have defined the study area as lying between Judique (45° 50’ N, 61° 30’W) and St. Paul Island along the Cape Breton Island side (47° 10’ N, 60° 00’ W), and between the Magdalen Islands (47° 10’N, 63° 20’W), and Tatamagouche, Nova Scotia (45° 48’N 63° 15’W) in Northumberland Strait (Figure 1).

Data concerning the two marine mammal groups differ markedly in the types of information that have been collected, the amount of detail and areas where

studies have been based. Research on seals has been based in the Magdalen Islands, and in the southeastern Gulf of St. Lawrence near St. George's Bay since the late 1970's and early 1980's. Studies have been directed primarily towards estimating population size, diet composition, and reproductive behaviour (Asselin *et al*. 1993; Sergeant 1991; Kovacs *et al*. 1991; Kovacs and Lavigne 1992; Baker *et al.* 1995; Hammill *et al*. 1998; Lydersen *et al*.1997; Stewart and Murie 1986; Stewart and Lavigne 1984). Information concerning at sea movements of pinnipeds for the area is much more limited. Very little in the way of directed research has been undertaken on cetaceans in the area. Kingsley and Reeves (1998) conducted aerial surveys to estimate abundance and distribution. Quantitative information on seasonal distribution and movements, diet composition, and reproductive biology is weak to non-existent. The information presented here on cetaceans essentially comes from one aerial survey, seasonal observations made by whale-watching tour companies based in Cheticamp, and from stranding reports at Prince Edward Island in that area since 1988. Cetaceans that are known to occur in the Estuary or Gulf of St. Lawrence, along the Labrador and Eastern coast of Newfoundland, in Bay of Fundy, the Gully or elsewhere along the Scotian Shelf are presented here as potential visitors to the study area. The likelihood of their presence is discussed, based on the observations made in the study area, and their biological and ecological requirements. There is also no information on contaminant levels for cetaceans in the study area.

Pinniped studies

Seven species of seals are known to occur in the Gulf of St. Lawrence, but only five of these species are observed in the southern Gulf of St. Lawrence. Ringed (*Phoca hispida*) and bearded (*Erignathus barbatus*) seals are occasional visitors to the northern Gulf, and only rarely occur in the southern Gulf of St. Lawrence. Colonies of walrus were found in the southern Gulf, but the last walrus was exterminated from the Magdalen Islands in the 1700's. Occasional sightings of walrus are still reported, but these are likely vagrants (Kingsley 1998). Harp (*Phoca groenlandica*) and hooded (*Cystophora cristata*) seals move into the southern Gulf in January, and leave in April. Grey seals are primarily summer residents of the area, but some animals occupy the study region year round. Harbour seals also reside in the study area throughout the year. Contaminant levels have been examined in ice-breeding pinnipeds (harp, grey and hooded seals) from the Gulf of St. Lawrence and in summer residents (harbour and grey seals) in the St. Lawrence Estuary. Harbour seals in the estuary have the highest PCB and organochlorinated pesticide levels (Hobbs *et al.* In press).

Species Accounts

Here we provide separate accounts for each species found in the study area. We provide a brief description of the species and its usual habitat, information on

the temporal and spatial use of the study area, approximate numbers, and the likely population to which the animals belong.

Grey seal (*Halichoerus grypus*)

The grey seal is a medium sized phocid (length: 2-2.5 m; weight: 200-400 kg). They inhabit continental shelf waters throughout the year in eastern Canada and in the northeast Atlantic. It is the second most abundant pinniped in the study area. The grey seal diet composition varies seasonally and geographically within the southern Gulf. In samples collected during the 1950's and 1970's, which included some animals from the study area and animals from the Miramichi area, cod, herring, flatfish and skate were the most important prey (Benoit and Bowen 1990). More recent samples indicate that winter flounder, Cunner, white hake, cod, herring, and sandlance are the most important prey consumed (Table 1). A bounty kill for grey seals was in place from 1978 until 1990 and animals were culled on the whelping patch under Department of Fisheries and Oceans supervision between 1967 and 1984 (Hammill *et al*. 1998). This species is currently hunted on a limited basis.

Stock identity, status and use of the southeast Gulf

Mitochondrial DNA studies indicate that grey seals in eastern Canada form a single interbreeding stock (Boskovic *et al*. 1996). There is movement of tagged and branded animals between breeding colonies, but the extent of this annual exchange has not been quantified (Stobo *et al.* 1990; Lavigueur and Hammill 1993). In the Gulf whelping occurs on Deadman Island, Amet Island and on the pack ice between Prince Edward Island and Cape Breton Island (Figure 2). Gulf pup production estimated using mark-recapture techniques was around 10,000 and increasing at an annual rate of 9% in the early 1990's (Hammill *et al*. 1998). However, aerial surveys flown during 1997 and 1999 in the Gulf suggest that the Gulf population is currently declining (Hammill and Gosselin unpublished data). Incorporating pup production estimates from surveys conducted in 1996 into the population model developed by Mohn and Bowen (1996) results in an eastern Canadian grey seal population of about 200,000 animals in 1996 (Hammill unpublished data). About 2/3 of the pup production occurs on Sable Island, while about a third of the 1996 pup production occurs in the study area. Unfortunately, no information is available on Sable Island pup production since 1996, therefore it is not possible to comment on current Atlantic grey seal abundance or trend. Northwest Atlantic grey seals are not assigned to any particular status by COSEWIC. After breeding most grey seals are thought to leave the Gulf via Cabot Strait onto the Scotian Shelf. Movement data during the spring is limited because animal transmitters normally fall off between April and June as the animals go through their annual moult. Many are thought to moult on Sable Island, but the fraction of animals moulting outside of the Gulf is not known. A few may remain in the study area throughout the winter in the loose ice between Miramichi and Cabot Strait (Goulet *et al*. 2001). Once the moult has complete

animals return to the Gulf where they distribute throughout the Gulf of St. Lawrence and St. Lawrence Estuary. By late October or early November animals in the northern portions of the Gulf begin to migrate to the southern Gulf or to move out onto the Scotian shelf (Stobo *et al.* 1990; Lavigueur and Hammill 1993; Goulet *et al*. 2001). No quantitative information is available concerning the fraction of the Sable Island population that moves into the Gulf outside of the breeding season nor for the fraction of the Gulf population that remains on the Scotian Shelf outside of the breeding season. Deployment of satellite tags on animals in the Gulf on Anticosti Island (N=8), Kouchibouguac National Park (N=10), Amet Island (N=3) and on the whelping ice indicate that animals tagged as far away as Amet Island and the National Park will forage as far as the east coast of Prince Edward Island during early fall (Figure 3). Other data concerning relative distribution is available from four surveys flown during the 1983 (Clay and Nielsen 1983). These surveys, consisting of one flight flown in each of May, August, November, and January did not observe any grey seals in the study area in May, observed 4% of the surveyed population (N=984) in the study area in August, 9% of the population in November (N=1280), and 99% of the surveyed population (N=802) in January in the study area. This contrasts with a more recent survey around Prince Edward Island flown in early June 2001, when 130 grey seals were observed in Northumberland Strait.

Significance of the Study area

This area is part of the core area of grey seals in the southern Gulf. It is particularly important from late fall until early spring as a staging area and as a whelping area for the Gulf component of the Atlantic grey seal population. Aerial surveys flown during the spring and early summer are unlikely to be reliable indicators of abundance because more than 80% of the animals may be in the water at that time (Hammill unpublished data).

Harbour seal (*Phoca vitulina*)

The harbour seal is a small (length=1.5 m, weight=100-120kg) coastal phocid that inhabits temperate and Arctic waters of the northern hemisphere (Mansfield 1967; Boulva and McLaren 1979). They were hunted for a bounty from 1927 until 1977, but today this species is protected from harvesting. Research on this species in the study area has been limited to a questionnaire sent to fisheries agents during the 1970's to obtain information on abundance (Boulva and McLaren 1979) and to recent work on diet composition and abundance around Prince Edward Island (Robillard, Lesage and Hammill unpublished data). Harbour seals are relatively sedentary and remain within the study area year round. In a small sample of 10 animals, Cunner, Flounder and Sculpins were the most important prey, while off the east coast of Cape Breton island and Eastern Shore (N=85)(Bowen and Harrison 1996), harbour seals fed primarily on Herring, Cod, Mackerel and Pollock (Table 3).

Stock identity, status and use of the southeast Gulf

No status has been assigned to Atlantic harbour seals by COSEWIC owing to insufficient data. The genetic relationships of harbour seals in Atlantic Canada have not been examined in detail. Although this species is capable of undertaking long distance movements, it is generally considered to be a sedentary, species preferring areas of moderate water depths over the continental shelf (Lesage, Hammill and Kovacs unpublished data). Harbour seal abundance has not been evaluated throughout its range in Atlantic Canada. However, a series of surveys have been conducted over different time periods in several areas (Stobo and Fowler 1994; Robillard, Lesage and Hammill unpublished). Combining these surveys and extrapolating to non-surveyed areas suggests that the Atlantic Canadian harbour seal population lies between 15,000 and 24,000 animals excluding the east coast of Newfoundland. Approximately 30% of the estimated 2,600 animals in the Gulf of St. Lawrence and St. Lawrence Estuary occur in the study area. Use of the study area by harbour seals is not known. In some locales, harbour seals often forage $\leq$ 50 km from their haulout sites (Lesage 1999) but seasonal movements with foraging at greater distances (> 100 km) from their summer haulout regions are known to occur (Lesage 1999). No studies have examined harbour seal reproduction in the area. Presumably, pupping occurs at the same period as in harbour seal colonies on Sable Island and in the St. Lawrence Estuary, which is during May-June. Lactation lasts for an average of 24 days (Bowen *et al.* 2001). Unlike most pinnipeds, harbour seal pups enter the water and follow the female during lactation. At this time disturbance could disrupt the female-pup bond leading to increased juvenile mortality (Henry and Hammill 2001).

Significance of the study area.

Little is known about harbour seal abundance, seasonal movements or diet composition in the study area. Aerial surveys conducted in the Gulf and St. Lawrence Estuary indicates that a significant proportion of the harbour population is found within the study area (Robillard, Lesage and Hammill In prep).

Harp seals (*Pagophilus groenlandicus*)

The harp seal is slightly larger than the harbour seal (length=1.7 m; weight=150kg) (Hammill *et al.* 1995). It is a highly migratory phocid that summers in the Arctic, but returns to the study area in December (Hammill and Stenson 2000). Animals whelp on the pack ice during March near the Magdalen Islands and Prince Edward Island and normally leave the Gulf by the end of May (Sergeant 1976,1991) (Figure 2). Diet studies in the area have been limited primarily to the breeding season, a period when animals feed little (Beck *et al*. 1993b; Hammill *et al*. 1999; Hammill unpublished data). Major prey items include yellow-tailed flounder, windowpane, and euphausids (Table 2).

Stock identity, status and use of the southeast Gulf

The harp seal whelps in the study area, the northern gulf of St.Lawrence and off the northeast Newfoundland coast (Sergeant 1991). Tagging, electrophoretic and genetic studies indicate that the northwest Atlantic harp seal forms a single population (Sergeant 1991). They are seen around the Magdalen Islands, on the ice off Cheticamp and down into the eastern Northumberland Strait beginning in January through to April (Hammill unpublished data). The harp seal is the most abundant pinniped in Atlantic Canada with an estimated population of 5.2 million animals (Stenson *et al.* 2000). COSEWIC has not assigned harp seals to any particular status. The most recent assessment of this population was completed in 1999. Estimated pup production in the study area was 176,000 (SE=25,000) (Stenson *et al.* 2000), or just under 20% of the total pup production. Harp seals are hunted commercially and harvests in recent years have varied between 6,000 and 18,000 animals in the study area. Under current harvests the population is thought to be stable (Healey and Stenson 2000). Movements within the study area are governed primarily by patterns of ice drift. Normally the whelping patch forms 50 miles northwest of the Magdalen Islands. A combination of ice conditions, wind and currents move the patch down the west side of the Magdalen Islands. Depending on where the patch is pushed to, it may become fixed within a local gyre where it remains for several weeks. The stability of the ice is important for females to successfully rear their young, since suckling occurs only on the ice. The pups are weaned after 12-14 days, after which the pups remain on the ice for a further two to three weeks (Sergeant 1991). Stable ice is also required during the post weaning fast and as a resting platform while the pups learn to forage for food. Without access to ice to rest, the pups quickly tire and often drown or die from hypothermia. In recent years (since 1998), mild winters have resulted in lighter ice conditions. This has resulted in the whelping patch being pushed farther south to lie just to the north of Prince Edward Island. Higher than normal pup mortality has been expected but has not been possible to estimate. Although somewhat unusual, similar mild winters and light ice conditions also occurred during 1969, the 1970's, and 1981 (Sergeant 1991). The pups appear to follow the ice as it leaves the Gulf through Cabot Strait. Once the ice enters Cabot Strait some pups may remain with the ice, while others move north along the west Newfoundland coast exiting via the Strait of Belle Isle in June. After weaning the females undergo a brief period of intensive feeding in the study area or in the St. Lawrence Estuary (Sergeant 1991; Beck *et al*. 1993b). Males remain with the whelping patch throughout the whelping and breeding period. Once breeding has ended then animals haul out on the ice to moult. In normal years seals moult on ice around the Magdalen Islands or in the northern Gulf of St. Lawrence (Sergeant 1991).

Significance of the Study area

The area forms part of the core winter range of the harp seal. It is an important early winter staging area, whelping area in March and post-breeding site particularly to young of the year.

Hooded seal (*Cystophora cristata*)

The hooded seal is slightly larger than the grey seal (length 2.5m, weight=300-450 kg). Like the harp seal it is a highly migratory pelagic phocid often associated with the continental shelf edge. Hooded seals are protected from hunting in the Gulf of St. Lawrence. No diet information is available for hooded seals in the study area. Off the northeastern Newfoundland coast hooded seals feed primarily on Greenland halibut, witch flounder, redfish, Atlantic cod, herring and arctic cod (Hammill and Stenson 2000).

Stock identity, status and use of the southeast Gulf

COSEWIC evaluated the status of hooded seals in 1987. It considered Northwest Atlantic hooded seals as forming a single stock and concluded that no status needed to be assigned. However, three main whelping concentrations of hooded seals occur in the Northwest Atlantic (Sergeant 1976). These are located in Davis Strait, off the northeastern Newfoundland coast and in the Gulf of St. Lawrence (Sergeant 1976). The largest concentration occurs off Newfoundland with a pup production of around 80,000 animals (Stenson *et al*. 1997). The smallest group occurs in the Gulf, with pup production of around 2,000 animals (Hammill *et al*. 1992). Tag resightings indicate that some adults return to the Gulf in subsequent years (Hammill, Kovacs and Lydersen unpublished data), but the genetic relationships of animals from the three areas have never been examined. Information on hooded seal movements has been gathered from tag resightings, observations and deployment of satellite transmitters (Sergeant 1976; Hammill 1993; Stenson and Hammill unpublished data). Hooded seals move into the Gulf of St. Lawrence in fall and remain until early April. They are seen in the study area in December. Pupping occurs on the pack ice during mid-March. The pups are weaned after only a 4-day lactation period (Kovacs and Lavigne 1992). Females leave the study area once the pups are weaned and move to the northern slope of the Laurentian Channel where they remain until early April at which time they exit the Gulf via Cabot Strait along the south coast of Newfoundland and migrate to Greenland. Males remain associated with the whelping patch until breeding ceases and like the female move to the north slope of the Laurentian Channel for a period of about 4 weeks before leaving the Gulf for Greenland (Stenson and Hammill unpublished data). The pups remain with the ice as it drifts north from the Prince Edward Island coast towards Cabot Strait. The direction of the drift varies with local wind conditions. In some years the patch may be found off Cheticamp (Hammill *et al*. 1992).

Significance of the study area.

The study area is an important staging area for a small persistent herd of hooded seal. The stock relationships of this herd to other groups in the Northwest Atlantic are not understood. Resightings of tagged animals on the whelping patch and different postbreeding behaviour of satellite tagged animals compared to animals from northeast Newfoundland indicate that further insights into the stock relationships are required (Stenson and Hammill unpublished data). After pupping, the adults move to the northern slope of the Laurentian Channel in the northern Gulf of St. Lawrence, while the pups remain with the ice as it drifts north along the Cape Breton Island coast and through Cabot Strait.

Diversity of pinniped species

In the study area, there are:

- 4 abundant or commonly breeding species of pinniped (harp, hooded, grey and harbour seals);
- 3 rarely observed pinnipeds (ringed seal, bearded seal, walrus).

Density of pinniped species

The study area is the breeding location of about 20% of the Northwest Atlantic harp seal population and 30% of the grey seal population. Harbour seals are not abundant in Atlantic Canada. Within the southern Gulf of St. Lawrence, the most important colonies occur within the study area.

Significance for particular species

Species with populations that breed in the study area: harp, hooded, grey and harbour seals.
Species that seem very dependent on the habitat within the study area: harbour and grey seals.
Species for which the study area is important habitat (excluding breeding) within the Gulf of St. Lawrence: grey and harbour seals.

Research needs:

The major importance of the central part of the study area to harp and hooded seals is as a staging area prior to whelping in March, and for the particular conditions, which favour pup development. Little is known of harp and hooded seal use, and diet composition of these species in the Cabot Strait and Sydney Bight area, where large numbers are seen prior to pupping.

The study area is used only by a small population of hooded seals. However, there is some evidence to suggest that these animals may form part of an

identifiable population. A greater understanding of the stock relationships between Gulf and Newfoundland hooded seals is needed.

At sea distribution information for grey seals is based on satellite transmitters deployed on adult seals captured at Anticosti Island, in the St. Lawrence Estuary, near Amet Island and Kouchibouguac National Park. These data indicate that the study area is important to grey seals as a foraging area, but more information is needed on at sea occupation and use of the study area by juveniles and animals resident in the area.

More information is needed on harbour seal abundance, diet composition and at sea use of the study area. Unlike other pinnipeds in Atlantic Canada, this species does not appear to be increasing and in some colonies important declines in abundance have been noted e.g. Sable Island. Harbour seals are relatively sedentary. A greater understanding of stock relationships among harbour seal colonies in Atlantic Canada is needed.

Cetacean studies

Fifteen species of cetaceans are known to occur with more or less regularity in the Gulf of St. Lawrence or surrounding waters (Table 4). Based on one aerial survey conducted in August 1995, on observations made from whale-watching tour boats during May–October 2000, and on stranding records at Prince Edward Island (P.-Y. Daoust unpublished data), at least six of these species are regular visitors to the study area. The other 9 species are either known as occasional visitors to the study area, or are species that do occur in surrounding waters, and represent potential users.

Species Accounts

In the following section, we provide a brief description of the available information on each of the six species known to visit either regularly or sporadically the study area. The descriptions include information on the annual distribution and movement patterns of the species and preferred habitats, diet, population structure, size and status, and known or potential use of the southern Gulf of St. Lawrence and study area. A general description of the remaining 9 species that might occur in the study area can be found in Ridgway and Harrison (1999). For these species, the information available on their distribution patterns and abundance in the Gulf of St. Lawrence or the study area is extremely scarce, precluding any prediction of the degree of importance of this area for these species.

Long-finned pilot whales (*Globicephala melas*)

The long-finned pilot whale is a medium sized odontocete (3.6–8 m) from cold temperate waters from the North Atlantic and southern oceans. A closely related

species, the short-finned pilot whale (*G. macrorhynchus*), overlaps to some extent in distribution with the long finned pilot whale, and can easily be confounded with it. In western North Atlantic, the long finned pilot whale appears to spend the winter at lower latitudes, along the continental shelf edge off the northeast U.S. coast. The species moves north in late spring where it spends the summer through late fall in areas of high topographic relief or submerged banks (Kingsley and Reeves 1998; Waring *et al*. 2000). During that period, the species is known to occur on the Georges and Grand Banks, along the Scotian Shelf, and into the Gulf of Maine, and Gulf of St. Lawrence (Payne and Heinemann 1993; Kingsley and Reeves 1998; Waring *et al*. 2000). The distribution of the species suggests some affinity with thermal fronts and other oceanographic features (*e.g.* Gulf Stream north wall) (Waring *et al*. 1992). Its diet is poorly known, but may include squid, Atlantic mackerel, Greenland turbot, spiny dogfish, Atlantic cod, Atlantic herring, silver, red and white hake depending on areas and period of the year (Sergeant 1962; Mercer 1967; 1975; Overholtz and Waring 1991; Payne and Heinemann 1993; Gannon *et al*. 1997).

Stock identity, status and use of the southeast Gulf

It is not known whether the long-finned pilot whale from the western North Atlantic forms one or several separate stocks owing to a lack of genetic information or detailed data on movement patterns and distribution. Commercial hunting considerably reduced the abundance of the long-finned pilot whales in Northwest Atlantic. Although the species has not recovered to pre-whaling numbers, it is not considered at risk by COSEWIC. Data is insufficient to determine the current size or trend of the Northwest Atlantic population of long-finned pilot whales. A minimum population for the short- and long-finned pilot whales together was proposed to be around 11,000 individuals (Waring *et al*. 2000). Long-finned pilot whales were historically known to occur throughout the Gulf of St. Lawrence, and occasionally in the St. Lawrence Estuary, although the southern Gulf is recognised as its main area of concentration (Sergeant and Fisher 1957; Sergeant *et al*. 1970; Kingsley and Reeves 1998). Long-finned pilot whales represents nearly 20% of the strandings at Prince Edward Island since 1988, supporting their current presence in the southern Gulf of St. Lawrence (P.-Y. Daoust, unpublished data). A recent aerial survey conducted during August indicates that the trough located on the western side of Cape Breton Island is one of a few areas of concentration of long-finned pilot whales in the Gulf of St. Lawrence (Kingsley and Reeves 1998). Although sightings were too few during this survey to provide a reliable estimate of the abundance of the species in the Gulf, 166 individuals were observed in southern Gulf, of which 92 (55%) were counted near the trough off Cheticamp. The observation of pilot whales by whale-watching companies based in or near Cheticamp on 71–99% of days between June and October 2000 confirms the importance of the area for this species. On the basis of the number of observations recorded during these cruises, pilot whales appear in the study area at least by early June. Their numbers increase progressively through June, and remain high from July through at least early

October. No observations are available after this date owing to the cessation of whale-watching activity. Sightings of over 100 whales (and at least one observation of 200+ whales) were regularly reported in the study area in 2000.

Significance of the Study area

The study area is not only part of the core distribution area of long-finned pilot whales in Gulf of St. Lawrence, but the through appears to represent one of the very few habitats used by this species in this area. The study area is particularly important from June through at least October, and likely fulfils several critical needs of this species such as feeding, and possibly calving (Sergeant 1962). The lack of information on the distribution of pilot whales outside of the summer-fall period prevents us to determine whether this species occur in the study area at other times of the year. Ice cover, which might vary from year to year, is known to influence the distribution patterns of seals and whales in the Estuary and Gulf of St. Lawrence. Pilot whales are not expected to occur in areas of heavy ice cover, but they may well vary their distribution patterns in years of lighter ice cover.

Minke whale (*Balaenoptera acutorostrata*)

The minke whale is a small mysticete whale (8–10 m). They are relatively ubiquitous in polar, temperate and tropical waters, and are generally observed as singletons (Edds and Macfarlane 1987; Kingsley and Reeves 1998). Their seasonal movement patterns and distribution is poorly understood. This species appears to prefer shallow waters (less than 200 m) and may be observed very close to shore (Piatt *et al*. 1989; Kingsley and Reeves 1998; Hooker *et al*. 1999). Minke whales are known to prey on euphausids and a wide variety of schooling fish in the North Atlantic, including capelin, herring, cod, and probably sandlance (Mitchell 1974a; Lynas and Sylvestre 1988; Haug *et al*. 1996). Little is known about their feeding habits in the Gulf of St. Lawrence.

Stock identity, status and use of the southeast Gulf

Based on sex and length segregation, catch distribution, sightings, marking data, and existing ICES boundaries, Canadian east coast minke whales are considered as one of four separate populations, the other three being west Greenland, central north-Atlantic, and northeastern North Atlantic (Donovan 1991). Minke whales that occur along the eastern coast of the US would belong to the Canadian east coast stock (Waring *et al*. 2000). Little information is available on this particular stock, and its status has never been examined by COSEWIC. The size of the Canadian east coast population has never been assessed, but minimum abundance was estimated at around 3,000 individuals in 2000 (Waring *et al*. 2000). In the Gulf of St. Lawrence, minke whales are ubiquitous, but more common in northern Gulf (Kingsley and Reeves 1998).

Aerial surveys yielded uncorrected estimates of about 1,000 individuals for the entire Gulf in 1995, of which approximately 75% were in the northern Gulf, and 600 individuals for the northern Gulf in 1996 (Kingsley and Reeves 1998). Minke whales were observed by whale-watching companies based in or near Cheticamp on more than 50% of days between May and October 2000, indicating that the study area is used on a regular basis by this species. Although the few data available confirms the presence of minke whales in the study area at certain times of the year, information on their distribution or numbers within the study area, or their distribution patterns outside of the summer-early fall seasons are lacking.

Significance of the Study area

The study area is regularly used by an unknown number of minke whales, and probably represents a foraging area for this species. It appears of particular importance for minke whales from at least May through October, which might continue to frequent the area during late fall, winter and spring when ice cover is permitting.

Fin whale (*Balaenoptera physalus*)

The fin whale represents the second largest (20–25 m) mysticete species. This species is widely distributed in most if not all of the world's oceans. The seasonal distribution and migration patterns of the different sub-populations of fin whales are not well understood, although whales appear to change their distribution during winter, moving to warmer or ice-free waters (reviewed in Meredith and Campbell 1988; see also Mitchell 1974b; Hain *et al*. 1992). Movement patterns likely differ among sub-populations according to local environmental conditions. As with several other cetacean species, their migration patterns might include a deep ocean component during the winter months (Clark 1995). Fin whales are typically observed in relatively shallow waters (< 200 m) in several parts of their range, and have been observed associated with shelf edges and deep channel margins in the Estuary and Gulf of St. Lawrence (Sergeant 1977; Kingsley and Reeves 1998; Fisheries and Oceans Canada, unpublished data). Fin whales are known to prey on euphausids, copepods and squid, and on a variety of schooling fish, including capelin, herring, and probably sandlance (Mitchell 1975; Brodie *et al*. 1978; Edds and Macfarlane 1987; Borobia *et al*. 1995).

Stock identity, status and use of the southeast Gulf

The Scientific Committee of the International Whaling Commission has proposed the existence of 11 stocks of fin whales in the North Atlantic (IWC 1992). According to this scheme, whales found in the Gulf of St. Lawrence and off Nova Scotia, Labrador, and Newfoundland would belong to the same stock. However,

recent genetic studies indicate that some sub-populations with limited gene flow among them might exist within the stocks defined by the IWC (Bérubé *et al*. 1998). Fin whales stocks found in Canadian waters have been afforded a status of 'species of special concern' by COSEWIC. Their abundance in western North Atlantic was estimated at 2,200 individuals in 1995 (Waring *et al*. 2000). During aerial surveys conducted in August–September 1995 and 1996, 16–17 fin whales were observed in the Gulf of St. Lawrence, but no fin whales were observed in southern Gulf (Kingsley and Reeves 1998). However, observations of fin whales by whale-watching companies based in or near Cheticamp on more than a third of the days between May and October 2000 indicates that this species occurs on a regular basis in the southern Gulf, at least in the study area. The sighting reports suggest a decrease in abundance of fin whales in July and August, but more systematic data are necessary to validate this possible trend. As is the case for the other cetaceans, information is lacking on the distribution patterns and presence of fin whales in the study area or the Gulf during the winter and spring.

Significance of the Study area

The study area is part of the core distribution area of fin whales in the Gulf of St. Lawrence, but the number of individuals using it is unknown. As with the other cetacean species present in that area during the summer and fall, the presence of fin whales in western Cape Breton waters is likely associated with foraging activities. The study area appears particularly important for this species from at least May through October, and potentially outside of this period when ice cover is permitting.

Humpback whale (*Megaptera novaeangliae*)

The humpback whale is a large mysticete (12–14 m) that is widely distributed in all of the world's oceans. Humpback whales in the North Atlantic range from tropical to cold arctic waters (Whitehead and Moore 1982; Katona and Beard 1990; see also Smith *et al*. 1999). They apparently gather in the warm waters of the West Indies to mate and calve during winter, and then move northward towards different summer feeding areas. A certain number of humpback whales are known to remain in higher latitudes during winter (Whitehead 1982). The relationships among whales using different feeding grounds are uncertain, but strong site fidelity has been observed for particular feeding grounds (Palsbøll *et al*. 1997). The characteristics of humpback whale feeding areas largely depend on the distribution of their prey. Diets of humpback whales vary depending on season and areas, and may include euphausids, and schooling fish or invertebrates such as squid, herring, capelin, or sandlance (Mitchell 1973; Payne *et al*. 1986; Paquet *et al*. 1997; Waring *et al*. 2000). Their habitat may range from steep slopes of underwater canyons, sandy banks where sandlance occur, to bays where capelin congregate for spawning (Hay 1985).

Stock identity, status and use of the southeast Gulf

In the North Atlantic, humpback whales are considered as part of a unique population, and are viewed as a 'species of special concern' by COSEWIC (Hay 1985; Whitehead 1987). A recent, ocean-basin wide mark-recapture study indicates that approximately 11,000 humpback whales would constitute the North Atlantic population (Smith *et al*. 1999). The small number of humpback whale sightings during the recent aerial surveys in the Gulf of St. Lawrence did not provide reliable abundance estimates, but provided some information on the distribution patterns of the species during August (Kingsley and Reeves 1998). During these surveys, the 18 humpback whales observed during these surveys were distributed along the northern shelf of the Gulf. However, sighting statistics collected by whale-watching companies indicates that some humpback whales occur in southern Gulf of St. Lawrence, and in the study area at least on a seasonal basis. In 2000, some humpback whales were observed in the study area between the end of August and mid-September. Since most humpback whales move to warmer waters during winter, their numbers are probably reduced in the study area at that time.

Significance of the Study area

The information on the seasonal distribution patterns of humpback whales in the Gulf of St. Lawrence and in the study is currently too scarce to determine with any certainty the importance of the study area for the humpback whale. Sightings of humpback whales in the study area during August-September indicate that some attributes of this area, probably its food resources, might be of some interest to the species. This species being known to vary their patterns of distribution and diet according to available resources (reviewed in Waring *et al*. 2000), longer-term information is needed to clearly determine the importance of this area for humpback whales.

Harbour porpoise (*Phocoena phocoena*)

The harbour porpoise is the smallest odontocete (1.5 m) that occurs in the Eastern Canadian waters. The species has a nearly circumpolar distribution in the temperate waters of the northern hemisphere (Gaskin 1984; 1992a). Incidental by-catch in fishing gear and satellite telemetry indicates that harbour porpoise generally prefer shallow waters (< 200 m), but may at times occur in deeper waters (Fontaine and Barrette 1994; Westgate *et al*. 1995; Larrivée 1996; Read and Westgate 1997; Westgate *et al*. 1998). During summer, harbour porpoise in western North Atlantic are widely spread in the waters of the Estuary and Gulf of St. Lawrence, and along the coasts of Labrador, Newfoundland, Nova Scotia, Baie of Fundy, and the U.S. During the fall and winter, harbour porpoise appear to move away from shores, probably to avoid ice-infested waters, but their exact route or movement patterns and distribution is not well known (Gaskin 1984; Waring *et al*. 2000). Harbour porpoise that occur in the

Estuary and Gulf of St. Lawrence during summer are thought to leave the Gulf during winter (Gaskin 1984). However, there is little data to confirm that this is the case. The harbour porpoise is largely piscivorous, consuming fish from several schooling species such as herring, capelin, mackerel, pollock, redfish, sandlance, squid and cod (Gaskin *et al*. 1974; Gaskin 1984; Fontaine *et al*. 1994).

Stock identity, status and use of the southeast Gulf

Gaskin (1984; 1992a) proposed the existence of four different stocks in Northwest Atlantic. Recent studies using genetic and contaminant approaches tend to support this suggestion. Harbour porpoise from the Bay of Fundy/Gulf of Maine would constitute a separate population from those found in the Gulf of St. Lawrence, Eastern Newfoundland and Labrador, or Greenland waters (Rosel *et al*. 1999; Wang *et al*. 1996; Westgate *et al*. 1997; Westgate and Tolley 1999). However, more genetic studies allowing for a better coverage of some areas are currently underway to clarify the boundaries of the Gulf of St. Lawrence, Greenland, and Newfoundland populations. Harbour porpoises from these four populations were considered as an entity by COSEWIC and were afforded a status of threatened in 1990 that was reaffirmed in 1991 (Gaskin 1992a). Aerial surveys conducted in 1995 and 1996 provided abundance estimates (uncorrected for animal visibility) of 12,000 and 21,000 individuals for the Gulf of St. Lawrence (Kingsley and Reeves 1998). Based on these surveys, the northern Gulf of St. Lawrence would yield greater numbers of harbour porpoise than the southern Gulf, although appreciable numbers of harbour porpoises were also observed in that area. A total of five harbour porpoise were sighted in the trough area during the 1995 August survey. Harbour porpoise were also occasionally observed in that area during whale-watching tours. The small size of the species makes it difficulty to observe in moderate weather conditions (Gaskin 1984), and may result in an underestimation of their abundance (Gaskin 1984). The relatively large proportion of harbour porpoise in the stranding reports at Prince Edward Island (33%) supports the latter (P.-Y. Daoust, unpublished data).

Significance of the Study area

As with humback whales, the information on the seasonal distribution patterns of harbour porpoise in the Gulf of St. Lawrence, and in the study is currently too scarce to determine with any certainty the importance of the study area for this species.

Atlantic white-sided dolphin (*Lagenorhynchus acutus*)

The white-sided dolphin is a small odontocete (2.0–2.5 m), which distributes in cool temperate waters of the northern hemisphere. In western North Atlantic, white-sided dolphins occur in waters of the continental shelf from Greenland,

south to North Carolina (Gaskin 1992b; Palka *et al*. 1997). This species can occur in waters more than 2,000 m deep, but appears to prefer shallow waters (< 200 m), with a certain affinity for areas with steep slopes and sea floor relief (Winn 1982 in Gaskin 1992b; Selzer and Payne 1988; Hooker *et al*. 1999). Insights into the seasonal distribution patterns of white-sided dolphins have been gained from stranding dates and locations, from anecdotal sightings, and a few summer, dedicated surveys in the U.S. (Palka *et al*. 1997; Waring *et al*. 2000). Some seasonal changes in distribution seem to occur, but overall, migration patterns of white-sided dolphins remain a mystery. The diet of white-sided dolphin is not well known, but appears to vary according to geographical areas and seasons (Palka *et al*. 1997). Known prey includes herring, squid, smelt, silver hake, and possibly sandlance (Schevill 1956; Katona *et al*. 1978; Sergeant *et al*. 1980; Selzer and Payne 1988).

Stock identity, status and use of the southeast Gulf

A three-stock structure was proposed for white-sided dolphins in Western North Atlantic on the basis of distributions of stranding, sighting, and incidental take reports, and on a hiatus of such reports between the three regions: Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea (Palka *et al*. 1997). Some genetic studies are currently underway to verify the proposed structure. There is currently no reliable estimate of the abundance of white-sided dolphins in western North Atlantic, but some estimates exist for the Gulf of Maine and Gulf of St. Lawrence components. In 1995, there would have been approximately 27,000 white-sided dolphins in the Gulf of Maine, and another 12,000 individuals (estimate uncorrected for visibility biases) of this species in the Gulf of St. Lawrence (Kingsley and Reeves 1998; Waring *et al*. 2000). The abundance estimate obtained in 1996 at a slightly earlier date for the northern Gulf differed markedly (500) from the estimate obtained the previous year (5,400), suggesting some drastic changes in distribution between seasons or years (Kingsley and Reeves 1998). Based on these surveys, the steep slopes of the Laurentian Channel, and the through along the northwestern coast of Cape Breton would represent important habitats of the white-sided dolphin from the Gulf of St. Lawrence. Two white-sided dophins were observed in the study area in late August, while the species was also occasionally observed in the study area during whale-watching tours, principally in July and September. The relatively large proportion of white-sided dolphins in the stranding reports at Prince Edward Island (37%) suggests that this species does occur in significant numbers in the southern Gulf of St. Lawrence (P.-Y. Daoust, unpublished data).

Significance of the Study area

White-sided dolphins visit the study area, at least sporadically, during July–September. However, the information available on this species is currently too scarce to determine with any certainty the extent of their seasonal use of this area, and its importance for this species.

Overall significance of the study area for marine mammals

There is very little information on the seasonal distribution patterns and abundance of the different marine mammal species in the study area, particularly the cetaceans. Nevertheless, the available information indicates that it is an important whelping area for three species of pinnipeds in winter, and one species during the spring. The presence of several marine mammal species over relatively prolonged periods, at least during the summer and fall is likely related to foraging activities, and indicates a somewhat high marine productivity of this area, particularly the trough located on the northwestern side of Cape Breton Island, and Cabot Strait.

Potential impacts of oil and gas exploration on marine mammals

Oil and gas exploration is conducted in three main steps. Seismic exploration using airguns or other types of seismic survey sources is first performed to locate geological structures (porous rocks) that might yield hydrocarbons. Geophysical surveys consist in emitting high-energy, low frequency pulses underwater, creating seismic waves in the earth's crust beneath the sea. Seismic vessels usually tow an array of airguns a few meters below the surface and fire the array of airguns every few seconds. Signals returned from the sea-bottom are received by an array of hydrophones towed behind the airgun array, and analysed to determine the subsurface geological structures. Once a potential source of hydrocarbon is located, rock drilling activities take place to confirm its presence, and spatially delimit the deposits. Finally comes the exploitation phase of the resource (which will not be discussed here). Seismic exploration and drilling require the presence of survey vessels and drillships or platforms, and supporting vessels and helicopters, all contributing to ensonify the underwater environment. By-products of this activity also include an increase in aerial and boat traffic for re-supplies and crew changes, and may result in accidental discharges of contaminants in the environment (oil spills, drillmud, etc.).

Sound pulses from airgun arrays usually have a source level exceeding or approaching 250 dB re 1 μPa at 1 meter, and are often detectable over tens or hundreds of kilometres from the source (Greene and Richardson 1988; Bowles *et al*. 1994). Although most emitted energy is at low frequencies, some is emitted at higher frequencies and exceeds ambient noise levels at frequencies > 5,000 Hz (Richardson *et al*. 1995: Figure 6.20).

Noise associated with drilling operations usually includes strong tonal components at low frequencies, and in some cases, some infrasonic frequencies. Noise levels emitted by drillships are lower than those produced by airgun seismic exploration, but still high relative to ambient noise levels over ranges of several kilometres (Richardson *et al*. 1995: Figure 6.18).

The effects of noise on marine mammals depend on several factors including hearing capacities and activity of the animals, the characteristics of noise sources in terms of frequency spectrum, source levels, and duration, and propagation characteristics of the environment (reviewed in Richardson *et al*. 1995). The distance over which a noise can be heard largely depends on its intensity, frequency spectral characteristics, and on bottom type, and topographical relief of the sea bottom. Temperature and salinity profiles of the water columns are other factors that will influence the propagation of sounds (reviewed in Richardson *et al*. 1995). Although some tests are necessary to determine the actual range of propagation of different types of noises in a given environment, airgun arrays are usually audible over 50–75 km when used in water 25–50 m deep. Detection range can increase to over 100 km in deeper water or when propagation conditions are efficient (Greene and Richardson 1988). Noise levels are generally attenuated near the surface compared to deeper depths due to reverberation by the water surface, commonly known as the Lloyd mirror effect.

Masking will depend on noise levels at the frequencies where it is emitted, direction of the two noise sources, and the hearing threshold of the animal at those frequencies. No interference will arise unless the two noises overlap in frequencies (critical ratios and masking bands). Audiograms (hearing thresholds for a range of frequencies) have been produced for several pinnipeds and smaller odontocetes (reviewed in Richardson *et al*. 1995). However, they often lack the low frequency components (< 1,000 Hz) due to technical limitations during experiments in captivity (*e.g.* reverberation in tanks, etc.). In mysticetes, hearing capacities are poorly known given their large size, and the associated difficulties for captive work. In this group, hearing capacities have been inferred through indirect evidence such as reaction to conspecific calls or man-made noises at particular frequencies (reviewed in Richardson *et al*. 1995). Hearing capacities can also be inferred, to some extent, from the frequency range that a species uses to emit calls. Although some species such as some frogs appear to not have the ability to hear some of the calls they are emitting, we will assume for the purpose of this study that marine mammals do so.

The hearing sensitivity of odontocetes peaks above ca. 10,000 Hz, decreases progressively below this frequency, and appears relatively poor below 1,000 Hz. However, most communication-associated calls are emitted at frequencies less than 10,000 Hz and regularly at less than 1,000 Hz, suggesting good hearing capability at those frequencies. Pinnipeds usually have a slightly lower hearing capability than odontocetes at frequencies higher than 1,000 Hz, but better sensitivity at frequencies lower than 1,000 Hz. The greater dependence of mysticetes on low to moderate frequency calls suggests good hearing capacities at these frequencies. Some mysticetes such as fin whales are known to emit sounds at frequencies of about 20 Hz that can propagate over several hundreds of kilometres (Watkins 1981; Watkins *et al*. 1987). The function of these calls is

unclear, but may play a role in the social organisation of the species or may serve some navigational purposes.

Audiograms, inferences from vocal repertoire, and indirect evidences from reactions to conspecific calls or man-made noises indicate that marine mammals hear or emit sounds in the frequency range of those emanating from airguns, drilling activities, ships, and helicopters (reviewed in Richardson *et al*. 1995). Noise related to oil and gas exploration activities not only has the potential to cause hearing discomfort or longer-term damage to the ear, but also might interfere with calls emitted by marine mammals. Depending on the purpose of the calls they emit, marine mammal activities that might be affected could be foraging, communication, or navigation. The degree of reaction of marine mammals to man-made noise and activity will be influenced by several factors including the type of human activity and noise characteristics, the marine mammal species involved, previous experience and exposition of the animal to similar sources of disturbance (habituation). Reactions may be limited or may be linked to an increase in stranding activities (Malakoff 2001). Marine mammal reactions will also vary according to their behavioural activity at the time of disturbance, and availability of alternative habitats to fulfil their biological requirements. A lack of reaction from a marine mammal does not necessarily imply a lack of effect, but may reflect a lack of alternative habitat, causing the animal to tolerate higher levels of stress than if similar habitats existed elsewhere.

Richardson *et al*. (1995) provides an extensive review of the documented reactions of marine mammals to different types of noise. This review clearly highlights that reactions to a same noise source varies between species, and even within species according to seasons and geographical areas (see also Lesage *et al*. 1999). Few detailed controlled studies have been conducted to examine impacts of oil and gas exploration activities on marine mammals. Therefore, in many cases we must deal with anecdotal accounts, inferences, and try to transfer observations from one species and apply them to another. The few data available suggests that activities associated with seismic exploration have a greater potential of impacts on marine mammals than drilling activities, although the latter still may cause some reactions from a range of marine mammals (reviewed in Richardson *et al*. 1995). The effects of open-water seismic exploration activity on pinnipeds and odontocetes have not been documented systematically. The few studies that investigated the effect of seismic exploration using airguns on mysticetes indicate that such activity may cause strong avoidance reactions in some species while still several kilometres away from seismic survey ships (reviewed in Richardson *et al*. 1995).

Boat traffic also represents an activity that might cause different behavioural or physiological reactions from a variety of marine mammal species. Noise generated by vessels or helicopters might have diverse impacts on marine mammals ranging from disruption of the mother-pup bond, disruption of potential

food resources, temporary or permanent desertion of a region, or hearing damage (*e.g.* threshold shifts) (reviewed in Richardson *et al*. 1995; see also Lesage *et al*. 1999; Finneran *et al*. 2000a, b; Harris *et al*. 2001; Nowacek *et al*. 2001; Henry and Hammill 2001; Morton and Symonds In press).

Summary and research needs

Several studies on pinnipeds and to a much lesser extent on cetaceans indicate that a wide variety of marine mammals occur in the study area. The regularity of sightings of long-finned pilot whales, pinnipeds, minke whales, fin whales, harbour porpoise and dolphins in the region of the trough along western Cape Breton Island indicates that this area is probably a very productive, and important habitat. A greater understanding of the seasonal distribution patterns, relative abundance and type of activities (reproduction vs intensive feeding) in this area is needed to assess more fully its importance for marine mammals, and the possible consequences of industrial activity.

There is currently little information available on the impacts of seismic exploration and drilling activities on marine mammals in open-water areas, nor with respect to underwater canyons, which act as important habitat features to cetaceans. A characterisation of the noise levels generated by airguns and drillings and propagation characteristics of underwater and trough areas are needed to determine the zones of influence of the noise, and species or habitats that might be affected.

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Table 1. Diet composition (% energy) of grey seals in 4T. 'Am' = Amet Island (Northumberland Strait), 'Mi' = Miramichi River area, 'CB' = west Cape Breton Island near Margaree Island (Hammill unpublished).

	Mag. Is.	Amet			Am/Mi	Am/Mi/CB		Average (sd)
	1992	1994	1995	1997	1998	1999	2000	
Cod	17.89	0.06	0.01	0.03	0.00	12.27	0.72	4.43 (7.56)
Herring	12.84	1.39	0.00	0.98	20.65	0.21	2.81	5.56 (8.02)
Capelin	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01 (0.02)
Mackerel	0.00	0.00	0.00	0.00	0.00	1.42	0.22	0.23 (0.53)
Lycod	3.45	0.00	0.00	0.00	0.00	0.00	0.00	0.49 (1.30)
Sandlance	0.18	0.00	0.00	0.00	29.35	6.39	3.98	5.70 (10.73)
Yt flounder	0.79	1.62	4.29	0.54	0.00	1.05	0.00	1.18 (1.48)
Winterflounder	0.00	73.84	83.98	49.95	3.71	2.87	0.55	30.70 (37.47)
Plaice	52.08	0.00	0.00	0.00	0.00	2.56	0.00	7.81 (19.55)
Smelt	0.00	0.05	0.00	0.08	0.11	0.05	0.02	0.04 (0.04)
Cunner	0.00	5.03	5.63	9.55	41.88	2.98	76.05	20.16 (28.43)
Salmon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 (0.00)
Ocean pout	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.02 (0.06)
Flatfish	0.00	0.65	1.25	1.30	0.58	2.47	2.57	1.26 (0.97)
Wh hake	0.00	0.00	0.02	0.01	1.70	58.14	6.23	9.44 (21.59)
Other fish	12.72	17.21	4.82	37.56	2.02	9.59	6.87	12.97 (11.96)
Mean energy (kjoules/g)	4.45	3.85	3.76	4.20	5.88	5.49	6.28	4.84 (1.02)
# samples	6	12	4	14	19	70	31	156

Table 2. Composition of harp seal diet (% Energy) in NAFO Division 4T.

Species	Les Escoumins		Godbout	Magdalen Islands		Average	SD
	1983	1989	1996	1989	1996		
Am. Plaice	0.00	0.00	0.00	0.00	1.90	0.38	0.85
Arctic cod	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Atlantic cod	0.30	0.00	0.06	0.00	0.00	0.07	0.13
Herring	0.00	0.00	0.15	0.00	0.00	0.03	0.07
Capelin	86.00	98.52	33.95	0.00	0.20	43.73	46.61
Hake	5.00	0.00	0.00	0.00	0.00	1.00	2.24
Redfish	6.00	0.00	0.00	0.00	0.00	1.20	2.68
Salmonid	0.00	1.48	0.00	0.00	0.00	0.30	0.66
Sand lance	0.00	0.00	0.09	0.00	0.00	0.02	0.04
Sculpin	0.00	0.00	0.00	4.76	0.00	0.95	2.13
Smelt	0.05	0.00	0.01	0.00	0.00	0.01	0.02
Yellow tail flounder	0.00	0.00	0.00	56.30	0.00	11.26	25.18
Windowpane	0.00	0.00	0.00	12.62	0.00	2.52	5.64
Stichaeidae	0.00	0.00	0.00	0.00	32.10	6.42	14.36
Other fish	2.65	0.00	0.28	2.78	22.30	5.60	9.42
Euphausiids	0.00	0.00	38.60	0.00	7.00	9.12	16.76
Snow crab	0.00	0.00	0.00	1.20	0.30	0.30	0.52
Other invert	0.00	0.00	26.85	22.33	36.20	17.32	16.37
Total	100.00	100.00	100.00	100.00	100.00	100.00	
Mean Energy (kj/g)	9.00	6.21	5.14	4.98	5.01	6.07	1.72
# of samples	25	9	35	62	17		

Table 3. Diet composition of harbour seals (Hammill unpublished, Bowen and Harrison 1996).

Prey	S. Gulf N=10		Cape Breton N=85	
	Wt %	Energy %	Wt %	Energy %
Herring	0.7%	0.8%	30.2	42.8
Wrymouth	1.7%	1.3%		
Eelpout	3.4%	2.8%		
Gadidae sp	0.2%	0.2%		
Cod	0.1%	0.1%	11.1	7.9
Ocean Pout	0.1%	0.1%	0	0
Sculpin	2.1%	2.1%		
Smelt	0.1%	0.1%		
Pleuronectidae sp	0.6%	0.4%		
Winter flounder	0.2%	0.2%	0.4	0.3
Mackerel	0.1%	0.1%	3.3	3.9
Windowpane	0.1%	0.1%		
Cunner	3.3%	4.1%		
Unidentified	87.2%	87.8%		
White hake	0.1%	0.1%	0.5	0.4
Silver hake			0.4	0.3
Redfish			0.1	<0.1
Haddock			0.1	<0.1
Capelin			2.3	2.9
Alewife			0.8	1
Pollock			32.8	27.6
Amphipodes	0.0%	0%		
Decapodes	0.1%	0%	18.1	12.8
Total	100%	100%	100%	100%

Table 4. Cetacean species and frequency of occurrence ('Reg' = Regular, 'Spo' = Sporadic, 'Occ' = Occasional, 'Rar' = Rare, 'Abs' = Absent, '?' = Insufficient data) in waters from different regions of Eastern Canada. Code of probable occurrence, based on the few available data is indicated in parentheses.

Species	St. Lawrence Estuary	Gulf of St. Lawrence	Bay of Fundy or the Gully	Nfld and Labrador	Study area
Fin whale *Balaenoptera physalus*	Reg	Reg	Reg	Reg	? (Reg)
Minke whale *Balaenoptera acutorostrata*	Reg	Rég	Reg	Reg	? (Reg)
Humpback whale *Megaptera novaeangliae*	Occ	Reg	Reg	Reg	? (Occ)
Long-finned pilot whale *Globicephala melas*	Rar	Reg	Reg	Reg	? (Reg)
White-sided dolphin *Lagenorhynchus acutus*	Occ	Rég	Reg	Reg	? (Occ)
Harbour porpoise *Phocoena phocoena*	Reg	Reg	Reg	Reg	? (Reg)
Blue whale *Balaenoptera musculus*	Reg	Reg	Spo	Reg	? (Occ)
Killer whale *Orcinus orca*	Rar	? (Spo)	?(Occ)	? (Spo)	? (Occ)
Sperm whale *Physeter macrocephalus*	Occ	?(Spo)	Reg	?(Spo)	? (Occ)
Northern right whale *Eubalaena glacialis*	Abs	Occ	Reg	?(Occ)	? (Occ)
Short-beaked common dolphin *Delphinus delphis*	Rar	?(Spo)	Spo	Spo	?(Occ)
Northern bottlenose whale *Hyperodon ampullatus*	?	?(Reg)	Reg	?(Reg)	?(Occ)
Bowhead whale *Balaena mysticetus*	Abs	Abs	Abs	?(Rar)	Abs
Pygmy sperm whale *Kogia breviceps*	Abs	Rar	?(Spo)	Rar	?(Rar)

Table 4. Continued

Species	St. Lawrence Estuary	Gulf of St. Lawrence	Bay of Fundy or the Gully	Nfld and Labrador	Study area
True's beaked whale *Mesoplodon mirus*	Abs	?	?	?	?(Rar)
White-beaked dolphin *Lagenorhynchus albirostris*	Occ	Reg	Reg	Reg	?(Occ)
Beluga whale *Delphinapterus leucas*	Reg	Spo	Abs	Occ	Abs
Striped dolphin *Stenella coeruleoalba*	Abs	?(Occ)	Spo	?(Occ)	? (Abs)
Blainville's beaked whale *Mesoplodon densirostris*	Abs	?	?(Spo)	?	?
Sowerby' beaked whale *Mesoplodon bidens*	Abs	?	?(Spo)	?	?
Bottlenose dolphin *Tursiops truncatus*	Abs	?Rar	Occ	?Rar	?(Rar)

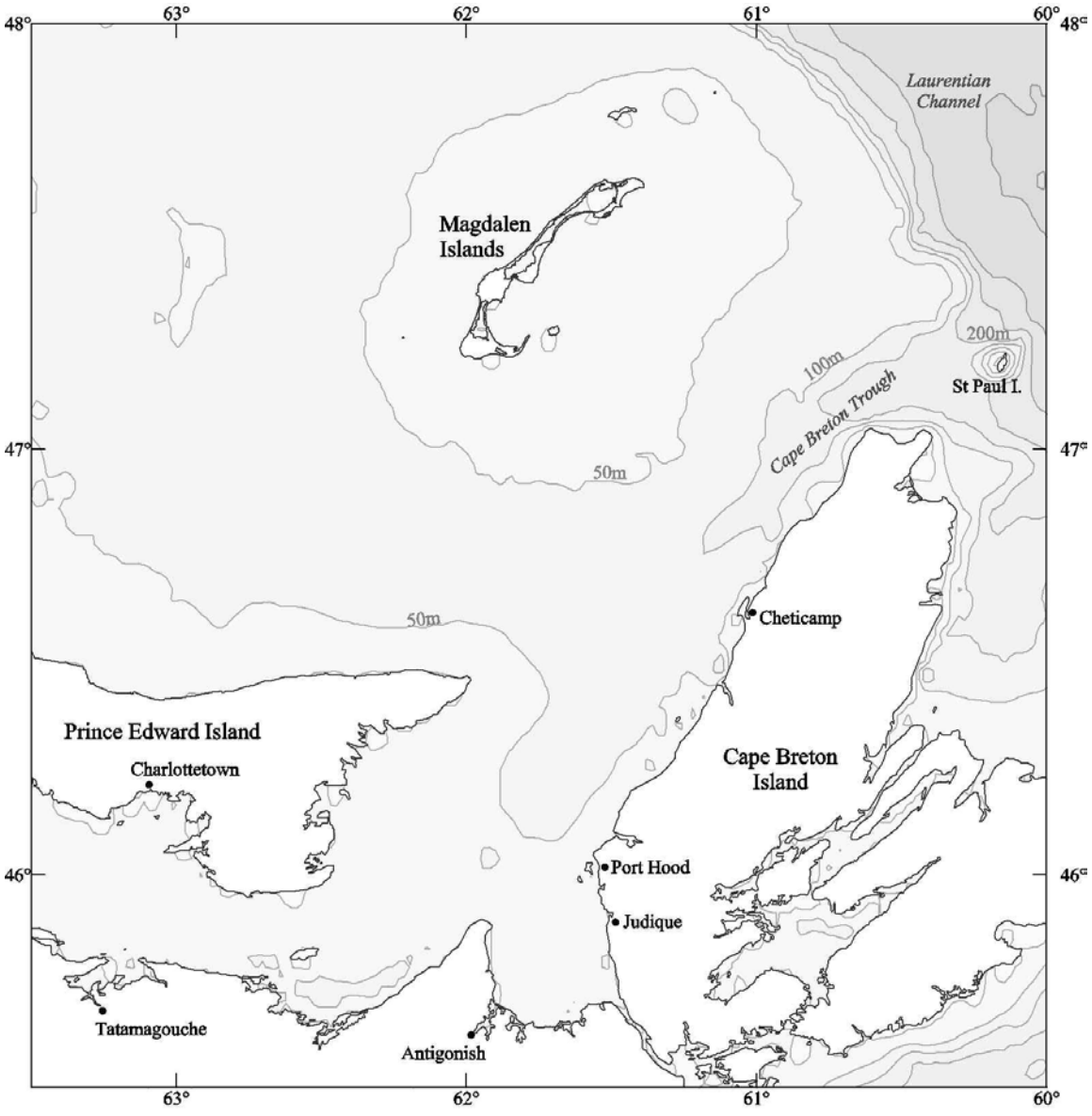

Figure 1. Southeastern Gulf considered as study area.

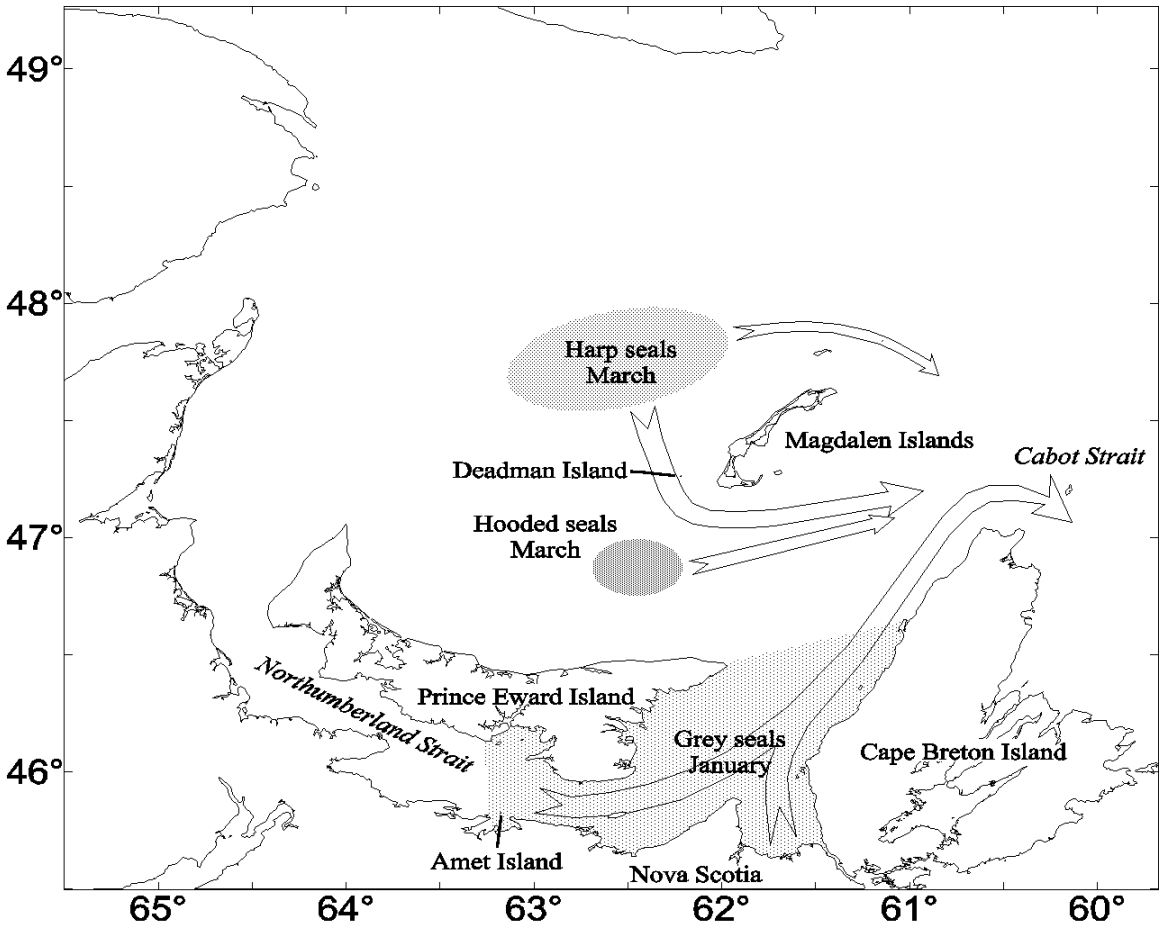

Figure 2. General location of Harp, Hooded and Grey seal whelping patches in the southern Gulf of St. Lawrence and general direction of the drift of these patches as the season progresses.

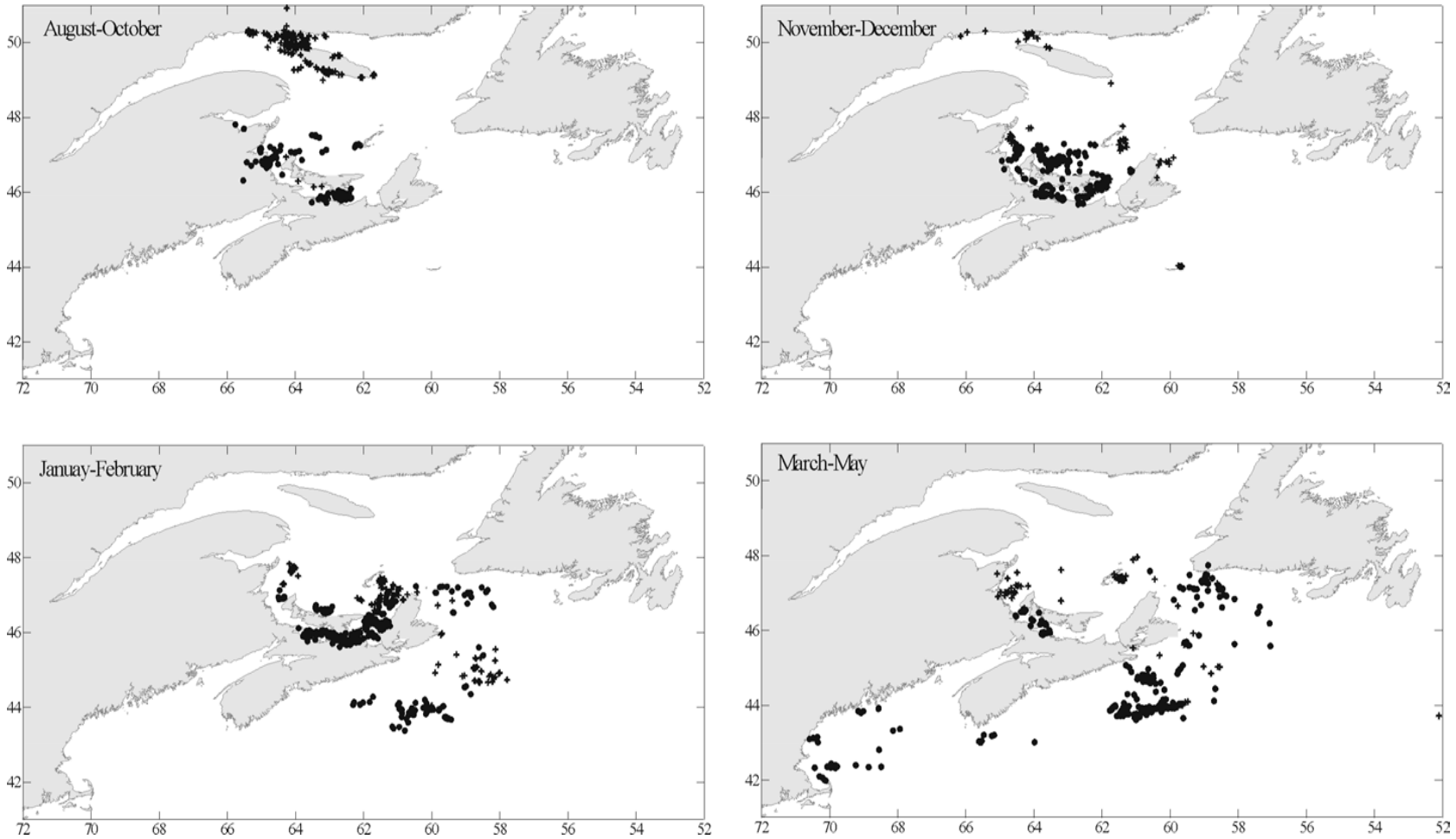

Figure 3. Bimonthly positions of 12 adult grey seals equipped with satellite transmitters in January 1993, August and September 1993 to 1999. Similar symbols within a figure indicate positions obtained from the same individual.