8.0 Pelagic Seabirds

A. R. Lock
Canadian Wildlife Service
Environment Canada (Atlantic Region)
Dartmouth, NS

8.0.1 The Scotian Shelf

The continental shelf to the east of Nova Scotia is about 200 km wide, with several shallow areas less than 200 m deep. These banks, which have supported highly productive fisheries, are separated from the coast by trough of deeper water. Sable Island lies at the edge of one of the largest of these banks, and the Gully is a deep submarine trough penetrating the edge of the bank some 30 km to the east of Sable Island. The edge of the continental shelf is influenced by the warm, north-easterly flow of the Gulf Stream and the south-westerly flow of the Nova Scotia current mixing with residual Labrador current waters. The inshore area of the shelf is dominated by the cool, south-westerly Nova Scotia Current, which flows out of the Gulf of St. Lawrence and down to the Bay of Fundy and Gulf of Maine. A large, anti-clockwise gyre, roughly centered on Sable Island forms as a result of interactions of these shelf currents (Fig. 8.0.1).

8.0.2 Marine Birds

Marine birds can be broadly categorised into coastal birds (gulls, terns, cormorants, waterfowl), and pelagic birds, those which remain at sea all year, coming ashore only to breed. Coastal birds, living in a mechanically complex environment generally have higher rates of mortality than pelagic birds which live for most of the year in a simpler and less dangerous environment. To compensate for this higher mortality coastal birds tend to have larger clutches and earlier ages of first breeding. Pelagic birds usually have single-egg clutches, delayed maturity and low adult mortality rates.

Seabirds have not been dealt with seriously by oceanographers until very recently. The correlation of seabirds with schools of fish, upwellings and distinct water bodies was part of the traditional knowledge of navigators and fishermen, but a rigorous synthesis of ornithology and oceanography has been made only in the last half century (Brown, 1980 and Batty, 1989). It is a fair generalisation that seabirds are where they are for very good reasons, usually concerned with food abundance. Recognition of that fact allows us to infer a great deal about the structure of the ocean otherwise only detectable by oceanographic instruments.

The community of marine pelagic birds on the Scotian Shelf contains very few species and this community does not breed locally; at all times of year the majority of birds present in the offshore are Arctic or southern hemisphere breeders. Interestingly, the pattern of distribution of the summer and winter avian communities is similar even though totally different species are involved. The winter avifauna consists of auks, fulmars and

kittiwakes while in summer shearwaters and storm-petrels and immature gannets predominate. The species making up the western Atlantic marine avifauna are identified below.

Tubenoses are relatives of the albatrosses, and five species are common on the Scotian Shelf Northern Fulmars *(Fulmarus glacialis)* are Arctic-breeding birds about the size of a Herring Gull. In the last few decades fulmars have increased throughout the Atlantic and extended their breeding range southwards to Labrador and insular Newfoundland. They are widespread at temperate latitudes in winter, retreating northward in spring as shearwaters move in. Greater and Sooty Shearwaters (*Puffinus gravis* and *P. griseus*) breed in the southern hemisphere, then migrate to moult in the northern hemisphere's summer. In early May, large numbers reach the Scotian Shelf on a clockwise circuit of the Atlantic Ocean. It is likely that most of the world population of Greater Shearwaters (5–10 million) pass over the Scotian Shelf to "winter" in the North Atlantic. Storm-Petrels are, starling-sized birds which pick small fish and zooplankton from the ocean surface. Leach's Storm-Petrels (*Oceanodroma leucorhoa*) breed in burrows on coastal islands from southern Labrador to Maine. Wilson's Storm-Petrels (*Oceanites oceanicus*) breed in the South Atlantic, arriving here at the same time as the shearwaters, and remaining until late summer.

Northern Gannets (*Sula bassanus*) are relatives of pelicans which catch fish near the surface by plunge diving. In eastern North America they breed at only six sites, three in eastern Newfoundland and three in the Gulf of St. Lawrence, and on the Scotian Shelf they are abundant only during migration.

Auks are compact, fast-flying birds which capture small fish by pursuit diving. Five species are common in North Atlantic pelagic waters. Two species of murres inhabit shelf waters in winter: Arctic-breeding Thick-billed Murres (*Uria lomvia)*, and Common Murres (*U. aalge*) which breed as far south as the Bay of Fundy. In summer they are to be found close to their colonies; in winter they are dispersed, with Atlantic Puffins (*Fratercula arctica*) and Razorbills (A*lca torda*) over the continental shelf off eastern Canada. Dovekies (*Alle alle*) are robin-sized auks that breed in Greenland and the European High Arctic. In summertime they are found on their breeding range, but in winter they are widely dispersed over the North Atlantic.

Gulls are not usually pelagic in habit, but Black-legged Kittiwakes (*Rissa tridactyla*) are pelagic gulls which breed mainly in the Arctic, though they have extended their breeding range south of Newfoundland to Nova Scotia around 1970, and began breeding in the Bay of Fundy in 1992. This species is a notable scavenger at fishing fleets and is increasing in numbers on both sides of the Atlantic.

8.0.3 Pelagic Distributions

Data on pelagic seabird distributions are derived from the Programme Intégré de Recherches sur les Oiseaux Pélagiques (PIROP) database maintained by the Canadian

Wildlife Service. This database stores counts of seabirds made from ships over a 25 year period, but unfortunately the data are not comprehensive, and only a few observations have been made near the Gully. A detailed examination of seabird distributions by month has shown that while the species present change throughout the year, there appear to be no major systematic changes in their distribution over the shelf with time. All observations made on the Scotian Shelf were combined and mapped in Fig. 8.0.1. This shows the mean numbers of pelagic seabirds seen in sample quadrats on the Scotian Shelf throughout the year. Seabird distributions are mapped as mean numbers of birds seen per kilometre of ship's track, the data accumulated in survey blocks covering 1/2° of longitude and 1/4° latitude. Areas in which no observations have been made are left white. Detailed mapping of individual species distributions on the Scotian Shelf is presented in Lock *et al*. (1994.)

The winter shelf avifauna is dominated by auks, fulmars and kittiwakes. Common Murres are the most common of the large auks, though significant numbers of the more northerly Thick-billed Murres are also present. By May most of the auks have withdrawn northwards to their breeding range, but a few stragglers, presumably non-breeders, linger into June. Northern Fulmars also withdraw to their Arctic breeding range as the shelf waters begin to warm and Shearwaters arrive in large numbers from their breeding range in the southern hemisphere. A few non-breeding fulmars remain on the shelf throughout the summer.

In summer shearwaters and storm-petrels are the dominant species. The shearwaters sweep north on an clockwise migration around the north Atlantic before returning south in November to breed. The majority moult and feed on the Grand Banks of Newfoundland to recover weight lost on their northern migration, but significant numbers linger on the Scotian Shelf reaching their greatest densities in July. The path of their migration through the Scotian shelf is primarily along the shelf edge where primary productivity, and concomitantly zooplankton stocks, are enhanced, (Fournier *et al.* 1979 and Brown, 1988). The shearwater migration parallels a migration of Wilson’s Storm-Petrels, also sub-Antarctic breeders. These birds, and Leach's Storm Petrels which breed on coastal islands from Maine to Newfoundland, are abundant on the shelf in summer feeding on zooplankton and ichthyoplankton, with greatest densities on the shelf edge and fishing banks. By October most have left on their southward migration to their breeding range.

Gannets are present only on their migrations to and from their breeding range in the Gulf of St Lawrence and Newfoundland, being most abundant in April and September. Small numbers of non-breeders may linger on the shelf throughout summer but after November they on their winter range in US. waters.

Very few of the pelagic seabird species on the Scotian Shelf at any time of year breed locally. Of the summering community only Leach's Storm Petrels breed in the region. The majority of the birds are Shearwaters and Wilson's Storm Petrels from the Southern Atlantic and smaller numbers of non-breeding Arctic species such as fulmars and kittiwakes. The wintering pelagic community is made up of primarily Arctic-breeding

species. The coastal seabird community, in contrast, is made up primarily of locally breeding species in winter and summer.

8.0.4 Conclusions

The high variability of seabird distributional data make it difficult, with the data available, to detect small, local anomalies of distribution. Highest concentrations of pelagic birds are found along the shelf edge and in the turbulence and mixing as currents round major headlands: East Point in P.E.I. and Cape North in Cabot Strait for instance. High seabird numbers also occur predictably in the area of mixing between Sable Island and the mainland generated by the Sable Island gyre.

The PIROP database unfortunately contains few observations made in the area of the Gully, but the few data that are available do not show any unusual enhancement of seabird numbers in the area. Weatherbee (1997) conducted a series of summertime seabird surveys at the Gully and noted that when compared with the rest of the Scotian Shelf some species appeared less abundant, and others: Greater Shearwaters and petrels for instance, appeared to be slightly more abundant. However the data available for comparison were PIROP data gathered more than a decade previously and inter-year variations in the numbers of these southern migrants may well account for the small differences observed. Furthermore his comparison was with data for the shelf as a whole rather than the adjacent shelf edge, and pelagic seabirds are generally more abundant near the shelf edge.

Yeats (Section 6.2) mapped nutrients, nitrate and phosphate, and found the Gully indistinguishable from the rest of the near-by continental shelf. Head and Harrison (Section 6.3) examined phytoplankton and zooplankton distributions in the region and did not detect any anomaly in the area around the Gully. The distributions of tuna and swordfish are determined, to some extent by the presence of small fish and invertebrates which are also the food of pelagic seabirds. Stone (Appendix 13.2) found no increase in abundance of tuna and Swordfish at the Gully.

The Gully does not appear based on the limited data available to cause upwelling or local enhancement of productivity greater than that which occurs elsewhere at the shelf edge, nor is there evidence, based on a wider view of pelagic seabird distributions off eastern Canada, that submarine canyons have any major effect on seabird distributions at the surface. Because of the poor spatial/temporal resolution of available data on pelagic seabird distributions off eastern Canada, there is not enough evidence to assess whether submarine canyons *per se* have any major effect on seabird distributions at the surface. To document small differences between seabird abundance at the Gully and elsewhere on the shelf, a series of contemporaneous observations at the Gully and over adjacent shelf areas at all seasons would be required.

8.0.5 References

Batty, L. 1989. Birds as monitors of marine environments. *Biologist.* 36:151-154.

Brown, R.G.B. 1980. Seabirds as Marine Animals. In. *Behaviour of Marine Animals*. J. Burger, B.L. Olla, and H.W. Winn (eds.). Vol. 4. Plenum Publishing, New York, pp. 1-39.

Brown, R.G.B. 1988. Zooplankton patchiness and seabird distributions. In. *ACTA XIX Congressus Internationalis Ornithologici* (H. Ouellet ed.) National Museum of Natural Sciences: Ottawa, pp. 1001-1016.

Fournier, R.O., M. van Det, J.S. Wilson and N.B. Hargraves, 1979. Influence of the Shelf-Break Front off Nova Scotia on Phytoplankton Standing Stock in Winter. *J. Fish. Res. Board Can.* 36, pp. 1228-1237.

Lock, A. R., R. G. B. Brown and S. H. Gerriets, 1994. *Gazetteer of Marine Birds in Atlantic Canada.* Canadian Wildlife Service, Atlantic Region. 137 pp.

Weatherbee, R.A. 1997. The Distribution and Abundance of Pelagic Birds in 'the Gully'. B.Sc. Thesis, Dalhousie University 59pp.

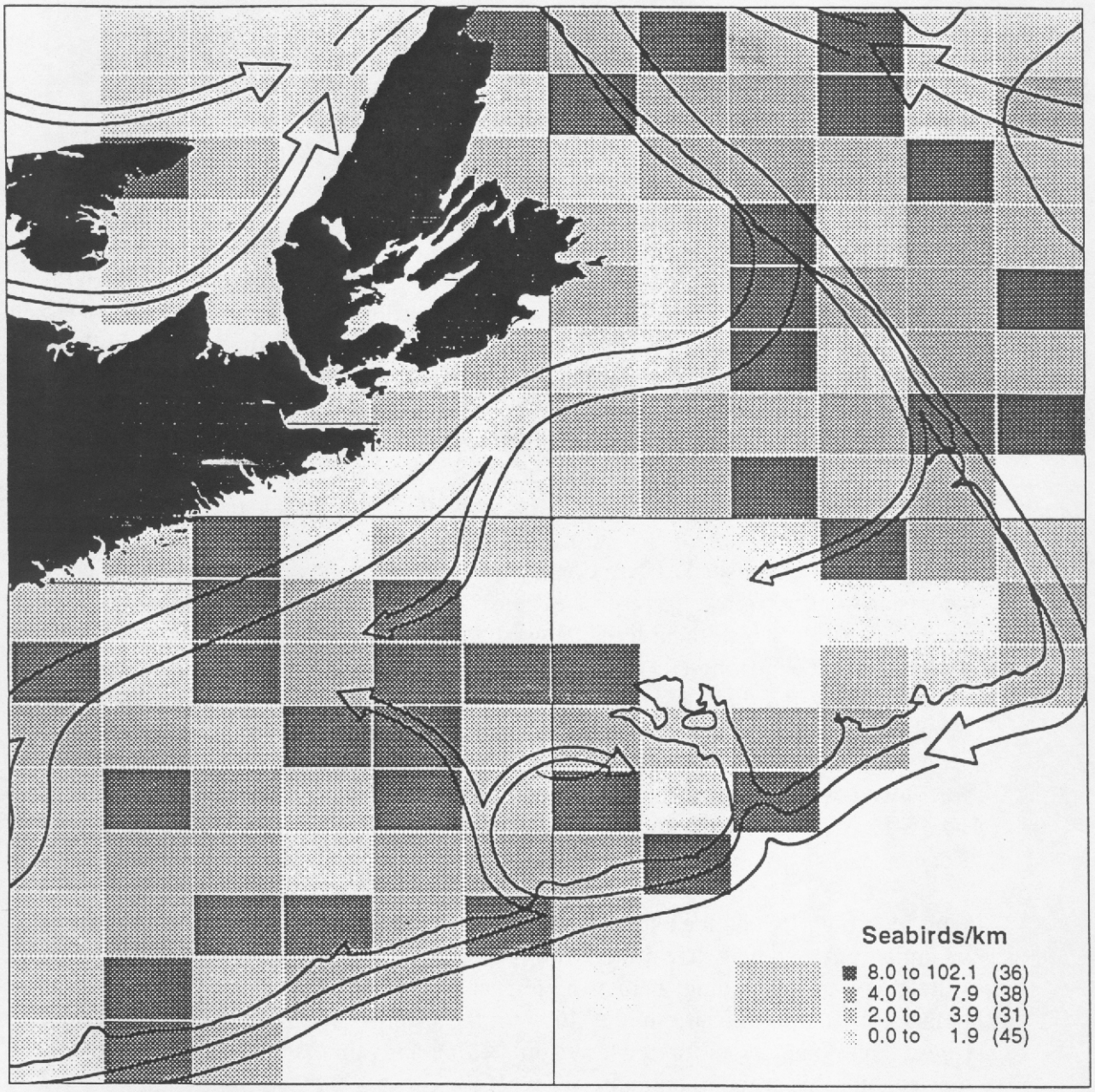


Fig. 8.0.1. Mean annual abundance of pelagic seabirds on the Scotian Shelf. The 200m isobath and major currents are also identified.

9.0 Marine Mammals

Hal Whitehead[1], W. Don Bowen[2], Sascha K. Hooker[1] and Shannon Gowans[1]
[1] Department of Biology, Dalhousie University, Halifax, NS
[2] Marine Fish Division, Bedford Institute of Oceanography, Dartmouth, NS

9.0.1 Introduction

The two principal orders of marine mammals, and the only two found on the Scotian Shelf, are the whales and dolphins, order Cetacea, and the seals, order Pinnipedia. The waters in and near the Gully and Sable Island have been identified as significant for marine mammals several times in the scientific literature. For instance, Sergeant *et al.* (1970) noted that "the waters around Sable Island evidently have the most diverse cetacean fauna of the region [eastern Canada]." Amirault (1995) summarized more recent findings: "The diversity and density of marine mammals occurring in the area indicate that it is one of the most important habitats on the east coast of Canada, and possibly of global significance."

Two of the most established eastern Canadian field studies of marine mammals occur in the Sable Island/Gully region: the research on grey (*Halichoerus grypus*) and harbour (*Phoca vitulina*) seals on Sable Island by D. Bowen and colleagues (*e.g.* Bowen *et al.,* 1992a,b; Iverson *et al.* 1993; Boness *et al.,* 1994); and the studies of northern bottlenose whales (*Hyperoodon ampullatus*) and other cetaceans in the Gully canyon by H. Whitehead and colleagues (*e.g.* Gowans and Whitehead 1995 and Whitehead *et al.,* 1992, 1997a) (Fig. 9.0.1). Thus there is comparatively good information on marine mammal species in this area. However the data base contains significant temporal and geographical biases and gaps. There is also a lack of good comparable data for other areas of the Scotian Shelf, in particular its edge.

In this report, we first define our study area, indicate our data sources, outline their strengths and limitations, and then give a short report on each species known (or suspected) to occur in the study area including: habitat preferences, temporal use of the area, approximate numbers, and the significance of the Gully for the species. We then use this information to suggest some boundaries for conservation area(s), and summarize the importance of the study area for this group of animals.

9.0.2 Data Sources and Methods

For this summary, we adopt the following study area: 43° 30' - 44° 30' N and 58° 20' - 60° 10' W (Fig. 9.0.1). This includes the deep canyon of the Gully, the basin in the northern part of the Gully, the shallow waters around Sable Island, and slope waters to the southeast.

Data on the two orders of marine mammals were collected very differently, emphasize distinct areas of biology, and are strongly biased towards different parts of the study area. Pinniped studies, carried out on Sable Island, emphasize population biology, reproduction, and breeding behaviour. There is comparatively little information on at-sea distribution and feeding behaviour, although recent satellite tagging studies are beginning to fill these gaps.

In contrast, our knowledge of the population and reproductive biology of cetaceans in the area is weak to non-existent. However, there is useful quantitative information on at-sea distribution, but this was collected principally in the vicinity of the Gully canyon, and during the summer months.

9.0.2.1 Pinniped studies

Although five species of seals are known to occur in the study area, only the harbour seal and grey seal are common to abundant. For this reason, virtually all of the seal research has been conducted on these two species. Most of this research has been carried out on Sable Island during the breeding (May-June for harbour seals, December-January for grey seals) and summer moulting seasons for both species, although spring and fall research has also been conducted over the past decade. Grey seal and harbour seal population research began on Sable Island in the early 1960's and early 1970's, respectively, and continues annually. Diets were estimated from analysis of stomach contents in the 1970s and 1980s, and examination of fecal samples since 1990. The foraging behaviour of different age and sex classes of harbour seals has been studied periodically during the breeding season since 1989 using a combination of stable isotopes, time-depth recorders and VHF telemetry. Between 1992 and 1997, both time-depth recorders and satellite tags have been used to study the spatial and seasonal characteristics of at-sea foraging in adult male and female grey seals. Annual reproductive performance and survivorship have been studied since the mid 1970's in over 2000 individually branded grey seals ranging in age from 4 to 32 years.

9.0.2.2 Cetacean studies

Most of our information on cetaceans in the study area comes from studies of northern bottlenose whales and sperm whales (*Physeter macrocephalus*) by H. Whitehead and colleagues. Each summer (June-August) between 1988-1997 (except 1991 and 1992) researchers spent periods of between 2-66 days in the region of the Gully canyon observing cetaceans aboard 10m (1988-1990) or 12m (1993-1997) auxiliary sailing vessels (Table 9.0.1). Except in 1988 and 1989 when sperm whales received considerable attention, the focus of these studies was on northern bottlenose whales. However, sightings of all other cetaceans were recorded in a systematic manner and environmental data (including position, depth and sea temperature) were collected regularly (every hour for position, every 3 hours for other variables).

Hooker *et al.* (submitted m/s) have compiled the sightings data from 1988-1996 into a Geographic Information System data base, along with regular environmental and position records, for the geographic area bounded by 43° 38' - 44° 17' N and 58° 44' - 59° 31' W (Fig. 9.0.1), where there was a reasonable amount of effort. This data base contains 1885 hours of daylight effort in this study area. The sightings and effort data permit the construction of effort-corrected images of the geographic distribution of each species, along with analyses of how abundance varies with environmental variables (such as date, sea temperature and depth). The displays and analyses of Hooker *et al.* form the bulk of our presentation about cetaceans.

Table 9.0.1. Trip dates of cetacean fieldwork in the Gully.

Year	Trip Dates	Daylight hours spent in Gully
1988	July 8 - 21, July 25 - Aug 6	213
1989	July 16 - 30, Aug 1 - 15	215
1990	June 14 - 28, July 2 - 18, July 25 - Aug 12	399
1993	July 10 - 23	153
1994	July 31 - Aug 18	170
1995	Aug 20 - Sept 2	80
1996	June 7 - 25, July 4 - 21, July 27 - Aug 12, Aug 19 - Sept 2	667

Taken from Hooker *et al.* are the following summaries of the data:

a) Summary of effort (Table 9.0.1);

b) Sightings of different cetacean species by year with mean group sizes (Table 9.0.2);

Table 9.0.2. Cetacean species sighted in the Gully by year

Species	No. of sightings	'88	'89	'90	'93	'94	'95	'96	group size mean (± SD)
blue whale	8	-	-	-	-	-	3	5	1.38 (± 0.52)
fin whale	32	6	4	6	5	1	-	10	1.31 (± 0.78)
sei whale	3	-	-	-	-	-	-	3	1 (± 0)
minke whale	8	4	-	-	1	-	-	3	1.25 (± 0.46)
humpback whale	38	2	15	1	2	12	-	6	1.47 (± 1.13)
sperm whale	92	65	5	1	1	3	1	16	1.09 (± 0.32)
northern bottlenose whale	577	11	58	180	70	39	12	207	3.29 (± 2.21)
long-finned pilot whale	54	9	9	7	2	8	8	11	11.44 (± 13.41)
striped dolphin	29	-	5	3	10	7	3	1	13.42 (± 2.49)
Atlantic white-sided dolphin	148	11	15	53	17	7	-	45	8.80 (± 8.39)
short-beaked common dolphin	104	7	25	11	18	21	-	22	15.60 (± 25.94)
bottlenose dolphin	7	-	-	2	1	-	1	3	11.29 (± 13.28)
TOTALS	1100	115	136	264	127	98	28	332	

c) Mean water depth, sea floor slope, sea-surface temperature, and calendar month for sightings of cetacean species as well as for regularly-collected environmental data (effort) (Table 9.0.3);

d) Distribution of cetacean sightings with depth and calendar month as sightings per hour of effort (Hooker *et al.* found that, of those environmental parameters that were considered, these two variables explained almost all the dependence of cetacean abundance) (Fig. 9.0.2);

e) Distribution of cetacean sightings by geographic area (Fig. 9.0.3). The small study area is divided into regions based on depth regimes, such that effort was similar in each region, and the rate of sighting each species in each region is plotted in sightings per hour of effort.

Table 9.0.3. Depth, slope, SST and calendar month sighting values (mean and standard deviation) for each cetacean species.

Species	Depth (m)	Slope ( )	SST (C)	Month
blue whale	919 (561)	14 (9)	18.0 (1.8)	8 (0)
fin whale	923 (469)	10 (6)	16.6 (3.2)	7.53 (0.51)
minke whale	166 (89)	3 (2)	13.1 (3.5)	6.75 (0.46)
humpback whale	1012 (456)	12 (9)	17.3 (3.2)	7.61 (0.59)
sperm whale	731 (428)	9 (7)	15.4 (2.2)	7.24 (0.62)
northern bottlenose whale	1196 (291)	14 (8)	14.5 (3.9)	7.11 (0.77)
long-finned pilot whale	946 (549)	11 (7)	17.3 (3.1)	7.65 (0.59)
striped dolphin	1378 (382)	13 (8)	16.8 (3.0)	7.55 (0.51)
Atlantic white-sided dolphin	1171 (411)	13 (7)	13.5 (3.6)	6.88 (0.70)
short-beaked common dolphin	1097 (479)	12 (7)	16.5 (2.9)	7.49 (0.54)
bottlenose dolphin	949 (487)	16 (8)	16.0 (2.1)	7.86 (0.38)
EFFORT (n = 1885, 1885, 703, 703)	1025 (497)	11 (8)	15.2 (3.7)	7.27 (0.73)

This analysis is augmented with:

- sightings from cetacean surveys of the area outside the June-August period by members of the Dalhousie cetacean research group (A. Faucher in September-October 1989 and February 1990; P. Simard in April 1997);

- distribution charts of catches of large whales from the Blandford, Nova Scotia, whaling station between 1966-1972 as plotted by Sutcliffe and Brodie (1977);

- distribution charts of marine mammals on and near the Scotian Shelf prepared by Kenney (1994) for the period 1966-1992 based on: shipboard and airplane sightings by U.S. researchers; Blandford whaling station records of catches and sightings (1966-1972); and incidental sightings and catches recorded by the Department of Fisheries and Oceans. This extensive data base has no measure of effort and is clearly biased against the Gully area, which was less frequently visited by whalers working from Blandford, Nova Scotia and US research cruises than the waters of the western Scotian Shelf.

- sightings from shipboard and aerial surveys carried out by Parsons (1995) in November 1994 in conjunction with Canadian Naval Patrol Frigate Shock Trials;

- information on cetacean strandings on Sable Island (Sergeant *et al.,* 1970, pre 1970; Lucas and Hooker, 1997 for 1990-1996). This information is particularly useful for the winter months (especially January and February) when pinniped scientists and other researchers identified and recorded cetacean strandings on Sable Island, but when ship sighting data from the study area are very scarce.

- from these data sources, we have a good picture of cetacean distribution and abundance in the deep canyon of the Gully during the summer months, but data become much more sparse and inferential as we move away from the deep canyon and the summer season.

9.0.3 Species Accounts: Cetaceans

In this section we give separate accounts for each species found in the study area. We first briefly describe the species and its usual habitat. We then provide information on its temporal and spatial use of the study area, the approximate numbers that might be found in the study area at any time, the likely identity of the population to which the Gully animals belong, the status of the population, and the significance of the study area for members of this population.

9.0.3.1 Blue whale (*Balaenoptera musculus*)

The blue whale, the largest animal on Earth, reaches to 30m, although North Atlantic animals tend to be smaller. Blue whales feed by engulfing large schools of zooplankton, especially euphausiids (krill).

Use of Gully area: A few blue whales are consistently found in and near the deep canyon of the Gully in mid and late August, but not earlier in the summer (Beck 1996; Hooker *et al.* Submitted m/s; Fig. 9.0.2b). A stranding on Sable Island in February 1958 suggests that these animals may use the Gully at other times of year (Sergeant *et al.*, 1970), and Kenney (1994) and Parsons (1995) data show that blues were sighted on the western and central Scotian Shelf quite often between May-November. No more than four members of this very conspicuous species have been seen at any time in the Gully. Therefore, we suspect that maximum numbers in the study area at any time are of the order of ten.

Stock identity and status: Stock relationships of blue whales in the western North Atlantic are unclear. One photographically identified animal from the Gully had been previously seen in the Gulf of St. Lawrence (R. Sears pers. comm.), and there are matches between the Gulf of St. Lawrence and Gulf of Maine (Sears *et al.*, 1990). Northwest Atlantic blues probably number a few hundred (Reeves and Brown, 1994) and are classified as "Vulnerable" by the Committee on the Status on Endangered Wildlife in Canada (COSEWIC).

Significance of study area: The consistency with which blue whales are sighted in and near the deep canyon suggests that the area has some importance to them, perhaps especially in late summer. Although numbers in the study area are generally small, this is the only known area on the Scotian Shelf where blues are consistently found.

9.0.3.2 Fin whale (*Balaenoptera physalus*)

The fin whale, second largest of all whales, reaches to 24m in the northern hemisphere. Bulk feeders, fin whales take schooling fish, zooplankton and squid.

Use of Gully area: Fin whales are sighted quite consistently in the Gully in July and August (Fig. 9.0.2b). Within Hooker *et al.*'s study area, there was no statistically significant preference for any depth regime. Kenney (1994) shows sightings and catches in the Gully region during all months from May to August, as part of a widespread distribution on the Scotian Shelf throughout most of the year. Parsons (1995) saw fin whales near the shelf break southwest of Sable Island in November 1994 . Fin whales generally seem to prefer the deeper waters of the Scotian Shelf (Kenney, 1994). Acoustic monitoring by US Navy hydrophone systems indicates that fin whales are the most common baleen whale species in the deep waters off the Shelf, and that they are present in these waters from late August, through the winter, until late spring when vocal activity stops (Clark, 1994). Sightings of this species in the study area have never been very numerous at any time, so we think it unlikely that there are ever many more than a few tens of animals in the study area.

Stock identity and status: The International Whaling Commission is unsure whether the fin whales found off Labrador/Newfoundland and on the Scotian Shelf are a single stock or separate stocks; together they probably number at least a few thousand animals (International Whaling Commission, 1992). The general seasonal migrations of fin whales in the western North Atlantic (Mitchell, 1974) may mean that a substantial number of animals pass through the Gully area in any year. None of the identification photographs taken in the Gully match any of the 800 animals catalogued from the Gulf of St Lawrence and the Gulf of Maine (Beck, 1996). Fin whales are classified as "Vulnerable" by COSEWIC.

Significance of study area: Although fin whales are quite widespread on the Scotian Shelf (Kenney, 1994), the Gully seems to be a particular (although not very emphatic) area of concentration.

9.0.3.3 Sei whale (*Balaenoptera borealis*)

The sei whale, a slim baleen whale which principally feeds by skimming copepods and other zooplankton, reaches about 18m in the northern hemisphere. Sei whales are quite difficult to identify definitively (Leatherwood and Reeves, 1983) and so sightings of this species are likely to be under-represented in many data bases.

Use of Gully area: Definitive identifications of sei whales are rare in Hooker *et al.*'s data base (Table 9.0.2), no sei whales are shown within our study area in Kenney's plots (although the species was commonly sighted and caught on the western Scotian Shelf), and no sei whales are reported as having stranded on Sable Island (Lucas and Hooker, 1997; Sergeant *et al*., 1970). Although our study area would seem to be crossed by Mitchell's (1974) assumed seasonal migration of seis along the Scotian Shelf, there is no evidence that they linger long within it.

Stock identity and status: Mitchell and Chapman (1977) suggest that the sei whales

migrating along the Scotian Shelf form a distinct stock numbering in the low thousands. The status of sei whales has not been considered by COSEWIC.

Significance of study area: The study area appears to have little importance to sei whales.

9.0.3.4 Minke whales (*Balaenoptera acutorostrata*)

Minke whales, the smallest of the balaenopterids (about 9m), are often seen alone and have a wide distribution which sometimes includes waters very close to shore. They feed on schools of fish and plankton, and are not conspicuous.

Use of Gully area: There have been a few sightings of minke whales in the study area (Table 9.0.2; Kenney, 1994; Parsons, 1995), but generally in shallow water (Figs. 9.0.2a and 9.0.3). Their migrations are unknown, although it is likely that some animals remain on or near the Scotian Shelf in winter while others migrate to warmer waters (*e.g.* Reeves and Brown, 1994). It is probable that a maximum of a few tens of animals are in the study area at any time.

Stock identity and status: The International Whaling Commission assumes an "eastern Canadian stock" (Donovan, 1991) whose numbers have never been assessed but probably are in the thousands (*e.g.* Reeves and Brown, 1994). The status of minke whales has not been considered by COSEWIC.

Significance of study area: The study area seems to have no more significance to minke whales than many other parts of the Scotian Shelf. In fact, this is the only species of Cetacea sighted at a significantly higher rate outside Hooker *et al.*'s study area compared with inside it (see Table 9.0.4).

9.0.3.5 Humpback whale (*Megaptera novaeangliae*)

The 14m humpback whale is the world's best known baleen whale. Like the fin whale, the humpback feeds on euphausiids, fish and squid. It is distinctive for its stocky body, long white (in the N. Atlantic) flippers, pronounced seasonal migrations, bubble-net feeding techniques, and the songs sung by males on the wintering grounds (*e.g.* Winn and Reichly, 1985).

Use of Gully area: Humpback whales are regularly sighted in the Gully during the summer months (Table 9.0.2). Kenney (1994) also shows sightings of humpbacks in or near the study area in May and September, and Parsons (1995) observed 7 animals in the Gully in November 1994. In Hooker *et al.*'s data set, they show no particular depth preference (Fig. 9.0.2a), but their abundance increases through the summer months (Fig. 9.0.2b). As most humpbacks migrate to warm waters in winter (Winn and Reichly, 1985), numbers are likely reduced between November and May. Like fin whales, sightings of this species have never been very numerous at any time, so we think it unlikely that there would ever be more than a few tens of animals in the study area at a time.

Table 9.0.4. Sighting rates of groups of cetaceans inside Hooker *et al.*'s Gully study area

and elsewhere on the Scotian Shelf, per hour searching.

Species	in Hooker *et al.*'s area	outside Hooker *et al.*'s area	rate in Hooker *et al.*'s area	rate outside Hooker *et al.*'s area
blue whale	8	0	0.0042	0
fin whale	32	1	0.0170	0.0009
sei whale	3	1	0.0016	0.0009
minke whale	8	16	0.0042	0.0142
humpback whale	38	0	0.0202	0
sperm whale*	92	6	0.0488	0.0054
northern bottlenose whale*	577	0	0.3061	0
long-finned pilot whale	54	11	0.0286	0.0098
striped dolphin	29	0	0.0154	0
Atlantic white-sided dolphin	148	19	0.0785	0.0169
short-beaked common dolphin	104	23	0.0552	0.0205
bottlenose dolphin	7	0	0.0037	0
white-beaked dolphin	0	1	0	0.0009
harbor porpoise	0	1	0	0.0009

Effort: in core = 1885 hours, outside core = 1121 hours
* comparison unreliable as these species were sought out in the Hooker *et al.* area.

Stock identity and status: The stock structure of humpback whales in the western North Atlantic is well known by means of photographic identifications. Almost distinct feeding aggregations (animals usually adopt their mother's aggregation) from the Gulf of Maine (ca. 240 animals), Gulf of St. Lawrence (ca. 150), Newfoundland/Labrador (ca. 2,310), Greenland and Iceland mingle on winter breeding grounds near the West Indies (Katona and Beard, 1990). Our study area is in an interesting position, roughly equidistant between the Gulf of St. Lawrence, Gulf of Maine and Newfoundland/Labrador aggregations. Three humpbacks photo-identified in the Gully had been seen earlier in other parts of the western North Atlantic: one in the Great South Channel (Gulf of Maine); one off Newfoundland; and one on the Grand Banks as well as off the Dominican Republic, West Indies (Beck, 1996). These limited data suggest that members of at least two feeding aggregations are found in the Gully. The western North Atlantic humpback whales are classified as "Vulnerable" by COSEWIC.

Significance of study area: Although only a few humpback whales are seen in the study area at any time, and it does not compare with other centres of humpback abundance in the western North Atlantic (such as the Southeast Shoal of the Grand Bank and Stellwagen Bank in the Gulf of Maine), the Gully is the only place on the Scotian Shelf where humpbacks are sighted with reasonable consistency.

9.0.3.6 Sperm whale (*Physeter macrocephalus*)

The sperm whale, the largest of the toothed whales, is generally an animal of deep waters where it feeds on mesopelagic and benthic squids and fishes. The two sexes have quite different distributions: females (about 10-11m long) and young are usually restricted to waters warmer than about 15° C and latitudes less than about 40° , whereas the much larger males (up to about 18m) are found in temperate and polar waters, with larger, and older, males generally reaching waters furthest from the equator (Rice, 1989).

Use of Gully area: Male sperm whales are an important feature of the biota of the Gully. Although sperms can be found in any water deeper than 200m, there is a particular concentration in the basin at the northern end of the Gully where water depths are between 200-400m (Fig. 9.0.3; Whitehead *et al.,* 1992). Sperm whales can be consistently found there during the summer months, and probably during much or all of the rest of the year (as there have been strandings on Sable Island in October, January and February and sightings in the Gully in November (Parsons, 1995; Reeves and Whitehead, 1997; Sergeant *et al.,* 1970; R.W. Baird pers. comm.). In these northern Gully waters their distinctive clicks can be heard much of the time through a hydrophone (Whitehead *et al.*, 1992). Individual males have been photographed in the Gully over periods of several years (J. Christal, unpublished) indicating long-term fidelity or regular return to the area. These Gully sperms are mostly maturing males of about 12.5-15.5m, although groups of females have been observed to enter the Gully briefly on two occasions (Reeves and Whitehead, 1997; Whitehead *et al.,* 1992). From the rate at which Whitehead *et al.* (1992) re-identified individual males, we suggest that the population size in the study area at any time might number of the order of 10-30 animals.

Stock identity and status: The sperm whales in the North Atlantic are assumed by the International Whaling Commission to form a single stock (Donovan, 1991), partly on the basis of a male which was tagged on the Scotian Shelf and caught off Spain (Mitchell, 1975). There is no credible estimate of the size of this population, but it probably numbers at least in the thousands (see Reeves and Whitehead, 1997). Sperm whales are not considered at risk by COSEWIC.

Significance of study area: Eastern Canadian waters rarely contain female sperm whales, but they seem to be important feeding grounds for males (Reeves and Whitehead, 1997). The northern portion of the Gully is one of two areas noted for sperm whale abundance off eastern Canada, the other being the entrance of the Hudson Strait (Reeves and Whitehead, 1997). The Gully may be the most important habitat for sperm whales on the Scotian Shelf, and it may contain long-term residents.

9.0.3.7 Northern bottlenose whale (*Hyperoodon ampullatus*)

The northern bottlenose whale, a 7-9m member of the beaked whale family, is only found in the northern North Atlantic, and is the animal most identified with the Gully. These are deep-diving animals which mostly eat squid (Mead, 1989).

Use of Gully area: Northern bottlenose whales are consistently present in those waters of the Gully canyon deeper than about 500m (Whitehead *et al.,* 1997b; Figs 9.0.2a and 9.0.3). Females are present throughout the year: they have been sighted in every survey of the Gully of which we are aware (in which there were good sighting conditions for more than a few hours), in the months of February, May, June, July, August, October and November. The females are accompanied by young animals which are thought to be born during the summer months (Whitehead *et al.,* 1997a). The same individuals have been identified in the Gully in both summer and winter (Whitehead *et al.*, 1997a). Mature males are rare in early summer, but are commonly sighted in August. Animals enter and leave the Gully at an unknown rate, but very approximately half the population of approximately 230 animals is in the Gully at any time (Whitehead *et al.,* 1997b). Time-depth recorders attached to northern bottlenose whales in the Gully indicate that they are consistently diving to beneath 1000 m, near or to the bottom of the canyon (S.K. Hooker and R.W. Baird, unpublished data). These are the deepest known modal dives of any mammal.

Stock identity and status: There are indications (smaller size, apparently different breeding seasonality, and lack of substantial migration) that the northern bottlenose whales found in the Gully are partially or wholly distinct from those off northern Labrador, the nearest other population concentration (Whitehead *et al.,* 1997a). As there are sightings in other deep waters off the Scotian Shelf (Kenney, 1994; Parsons, 1995; Whitehead *et al.,* 1997b), it is thought that the Gully bottlenose whales may spend the part of the year when they are not in the canyon south of the Scotian Shelf. The population of northern bottlenose whales that uses the Gully is classified as "Vulnerable" by COSEWIC.

Significance of study area: The Gully canyon is likely to be very important for this population, as it contains about half the population at any time. The study of these animals in the Gully is the only long-term research on living beaked whales of any species anywhere in the world (there are two recently initiated studies of *Mesoplodon densirostris* off the Bahamas and *Ziphius cavirostris* off Greece). Therefore most of what will be discovered in the next five years about some aspects of the biology of beaked whales (especially social organization) will likely come from the Gully.

9.0.3.8 Beaked whales of the genus *Mesoplodon*

The 13 or so beaked whales of the genus *Mesoplodon* are the least known of marine mammals. They are deep-diving, elusive, small (4-6m) whales which are hard to sight and identify at sea.

Use of Gully area: *Mesoplodon* have been sighted several times in the deep waters of the Gully. Sowerby's beaked whale (*Mesoplodon bidens*) has been identified positively, and Blainville's beaked whale (*Mesoplodon densirostris*) tentatively. There has also been a single stranding of Sowerby's beaked whale on Sable Island (preliminary identification by I.A. McLaren). The difficulties in sighting and identifying these animals mean that information is very sketchy and estimates of numbers impossible.

Stock identity and status: Nothing is known about the stock identity or status of these animals, although there has been a substantial by-catch of *Mesoplodon* in the US east-coast pelagic drift-net fishery, principally in and near shelf-edge canyons to the southwest of the Gully (Read, 1994 and 1996). Sowerby's beaked whale is considered "Vulnerable" by COSEWIC.

Significance of study area: Canyons are thought to be important habitat for *Mesoplodon* (*e.g.* Read, 1996) but the significance of the Gully for these animals is unknown.

9.0.3.9 Long-finned pilot whale (*Globicephala melas*)

The long-finned pilot whale is a moderate-sized (5-6m) highly social and vocal odontocete which principally feeds on squid. Pilot whales are common over the Scotian Shelf, and especially along its edge (Kenney, 1994).

Use of Gully area: Pilot whales are common in the study area in all summer months, although densities rise during August (Gowans and Whitehead, 1995). Sightings plotted by Kenney (1994) show a distribution along the edge of the shelf during springtime, and there have been strandings on Sable Island in January and February (Sergeant *et al.,* 1970) as well as sightings off the shelf in November (Parsons, 1995), suggesting that pilot whales are in the study area through much of the year. During the summer months they show no particular depth preference within Hooker *et al.*'s study area (Figs 9.0.2a and 9.0.3). Pilot whales often occur in large schools of tens of animals, so that, given the density of schools throughout the study area, it would not be surprising if there were, on occasion, more than one thousand animals in the area.

Stock identity and status: Stock distinctions among western North Atlantic long-finned pilot whales are unclear, as are population sizes, although Hay (1982) estimated 13,000 for the waters off Newfoundland and Labrador. Although the pilot whales in the Newfoundland area are likely to be still substantially

depleted following a very intense drive fishery from 1947-1971 (Nelson and Lien, 1996) long-finned pilot whales are not considered at risk by COSEWIC.

Significance of study area: The waters in our study often contain many long-finned pilot whales, but densities are probably not much higher than in other outer waters of the Scotian Shelf (Table 9.0.4).

9.0.3.10 Striped dolphin (*Stenella coeruleoalba*)

Striped dolphins are small (2.5m), social and lively dolphins which are found in temperate and tropical waters around the world. They eat squid and fish.

Use of Gully area: Striped dolphins are common in the study area in late summer when water temperatures reach above about 15° C (Fig. 9.0.2b). Within the study area, their habitat is the deeper waters in the southern part of the Gully canyon, and south of the shelf break (Fig. 9.0.3). Strandings in autumn and early winter on Sable Island (Baird *et al.,* 1993a) suggest that they may stay in the area after the water has cooled. Given the quite large schools sometimes seen, it is probable that numbers in the study area may sometimes exceed 1,000.

Stock identity and status: In the western North Atlantic, stock distinctions and population sizes are unknown for this species. It is not considered at risk by COSEWIC.

Significance of study area: The great majority of Canadian striped dolphin sightings have been made in the Gully (Baird *et al.,* 1993a; Kenney, 1994). The study area seems to be the most significant habitat for this species in Canadian waters.

9.0.3.11 Short-beaked common dolphin (*Delphinus delphis*)

The common dolphin is a very cosmopolitan species of tropical and temperate waters. Like the striped dolphin, these animals are small (2m) and gregarious, eating schooling fish and squid.

Use of Gully area: Short-beaked common dolphins are very abundant in the southern half of the study area in the later part of the summer (Figs 9.0.3 and 9.0.2b). They were frequently observed both on and off the Scotian Shelf during the November shipboard surveys reported by Parsons (1995). They have large group sizes (Table 9.0.2). Atlantic white-sided dolphins, the only small cetacean species with a higher sighting rate, live in much smaller groups. Therefore, in July and August common dolphins are probably the most abundant cetacean species in the study area, with numbers likely to be well into the thousands.

Stock identity and status: Stock distinctions and sizes in the western North Atlantic are

unknown for this species. It is classified as not at risk by COSEWIC.

Significance of study area: Although common dolphins are seen all along the edge of the Scotian Shelf in late summer (Kenney, 1994), their very high abundance in the Gully suggests that this area is of particular importance for them, perhaps the most significant habitat in Canadian waters.

9.0.3.12 Atlantic white-sided dolphin (*Lagenorhynchus acutus*)

The Atlantic white-sided dolphin (ca 2.5m), with its colourful flank markings, is perhaps the most characteristic cetacean of the Scotian Shelf. These animals eat squid and small fish.

Use of Gully area: White-sided dolphins are found in substantial numbers in the study area throughout the summer (although less in August; Fig. 9.0.2b), and there are strandings on Sable Island during the winter months (Sergeant *et al.*, 1970). They seem to prefer the deeper waters in and near the canyon (Fig. 9.0.3). Numbers in the study area throughout the summer are likely to be well into the thousands.

Stock identity and status: Stock distinctions and population sizes in the western North Atlantic are unknown for this species, although its range is from about Cape Hatteras to Greenland and it seems to be quite numerous (Gaskin, 1992). It is classified as not at risk by COSEWIC.

Significance of study area: The deeper waters of the Gully are clearly important for members of this species.

9.0.3.13 Bottlenose dolphin (*Tursiops truncatus*)

The well-known bottlenose dolphin (2-3m) has a tangled taxonomy, possibly consisting of more than one species. They eat fish and squid.

Use of Gully area: Bottlenose dolphins are occasionally sighted in the study area in late summer (Fig. 9.0.2b), often in mixed schools with striped or common dolphins. It is unlikely that more than a few hundred would be in the study area at one time.

Stock identity and status: The Gully would seem to be at almost the extreme northeast limit of the bottlenose dolphin's range in the western North Atlantic (Baird *et al.,* 1993b). Animals that visit the Gully are likely part of the "offshore form" stock which is found near the edge of the continental shelf east of the U.S. (Baird *et al.,* 1993b). It is classified as not at risk by COSEWIC.

Significance of study area: The Scotian Shelf is likely of marginal importance for these animals (Reeves and Brown, 1994).

9.0.3.14 Other species

There are several cetacean species which have been sighted only very rarely in the Gully area, or for which we have no reliable records, but are likely occasional visitors:

Right whale (*Eubalaena glacialis*): The endangered 15m northern right whale has important habitat on the western Scotian Shelf, although it is occasionally sighted further east (Kenney, 1994). We know of no sightings in the study area, although Kenney shows one sighting in August just off the Scotian Shelf south of Sable Island, about 20km south of the study area.

Pygmy sperm whale (*Kogia breviceps*) and dwarf sperm whale (*Kogia simus*): There are records of strandings of three pygmy sperm whales and one dwarf sperm whale on Sable Island (Sergeant *et al.,* 1970; Lucas and Hooker, 1997). These small (2-3m) members of the sperm whale family are difficult to sight at sea.

Harbour porpoise (*Phocoena phocoena*): This small (1.5m), and generally inshore, odontocete was sighted once in the Gully canyon, and twice off Sable Island during the summer of 1997 (S. Hooker, unpublished), and there are two January strandings on Sable Island (Lucas and Hooker, 1997), but the study area is likely to have little significance for this species.

White-beaked dolphin (*Lagenorynchus albirostris*): At about 3m, the white-beaked dolphin is the largest dolphin to be found on the Scotian Shelf. It is very common off Newfoundland, and is sighted frequently in inshore Nova Scotian waters. We know of no sightings for the study area (except for some poorly authenticated skulls from Sable Island: Sergeant *et al.,* 1970), although it is likely to be present, at least occasionally, in winter.

Killer whale (*Orcinus orca*): Killer whales (7-9m) are occasionally sighted on the Scotian Shelf (Mitchell and Reeves, 1988). There have been no sightings during recent Gully research but Blandford whalers took one male from the Gully in 1964 (Mitchell and Reeves, 1988).

Risso's dolphin (*Grampus griseus*): There have been a few sightings of this large (4m) deep-water dolphin off the Scotian Shelf (Baird and Stacey, 1991 and Parsons, 1995) but none in the Gully.

Fraser's dolphin (*Lagenodelphis hosei*): This 2.5m tropical dolphin has been tentatively sighted in the Gully on two occasions, but identifications were not confirmed.

9.0.4 Species Accounts: Pinnipeds

9.0.4.1 Grey seal (*Halichoerus grypus*)

This is a medium-sized (2-3m) member of the Family Phocidae inhabiting continental shelf waters throughout the year in eastern Canada and in the northeastern Atlantic. It is the most abundant pinniped on the Scotian Shelf. Diet varies seasonally and geographically, but in the vicinity of Sable Island sandlance (*Ammodytes* sp.), flatfishes, Atlantic cod (*Gadus morhua*), and squid (*Illex illecebrosus*) are commonly eaten (Benoit and Bowen, 1990; Bowen *et al.,* 1993; and Bowen and Harrison, 1994).

Use of the Gully area: Approximately 70% of grey seal pup production in eastern Canada is associated with Sable Island breeding colonies (Mohn and Bowen, 1996). All age and sex classes of grey seals forage in the waters of the Gully area throughout much of the year. However, grey seals are known to disperse widely throughout their range during the non-breeding season (Stobo *et al.,* 1990; Beck, Bowen, and McMillan unpublished data). Thus, it is not currently possible to estimate with any degree of confidence what fraction of the grey seal population uses the Gully area seasonally. Such estimates will be possible once the satellite tagging study has been completed. A preliminary estimate based on population size would suggest thousands of grey seals use the Gully area.

Stock identity and status: Grey seals in Eastern Canada all belong to one interbreeding population. This conclusion is based on mitochondrial DNA studies (M. Hammill, pers. comm.) and the intermixing of breeding adults from grey seals branded at weaning in both the Gulf of St. Lawrence and Sable Island (Zwanenburg and Bowen, 1991; and Bowen unpublished data). The Sable population of grey seals has been increasing at about 12% per year and was estimated at about 150,000 animals in 1994 (Mohn and Bowen, 1996).

Significance of the study area: The area is part of the core range of the grey seal on the Scotian Shelf. Sable Island supports the largest breeding colony of grey seals in the world.

9.0.4.2 Harbour seal (*Phoca vitulina*)

This is a small (1.7 m) coastal species of the Family Phocidae that inhabits temperate waters of the northern hemisphere. Diet varies seasonally and geographically (Bowen and Harrison, 1996), but around Sable Island sandlance appears to be the dominant prey (W. D. Bowen, unpublished data).

Use of the Gully area: Harbour seals breed on Sable Island and forage in the Gully area throughout the year. However, like the grey seal, harbour seals disperse widely throughout eastern Canada during the non-breeding season and thus it is not currently possible to reliably estimate the number of seals that use the

area seasonally. However, given the size of the population, it is likely that no more than hundreds of harbour seals use the Gully area.

Stock identity and status: Based on pelage colouration and dentition, Boulva and McLaren (1979) suggested that the Sable harbour seals were a distinct population within eastern Canada. However, microsatellite data (Coltman, Bowen, and Wright, unpublished data) and annual changes in pup production of greater than 20% indicate periods of genetic mixing with mainland populations. During the late 1980's, annual pup production on Sable Island (about 600 pups) made this colony the largest in eastern Canada. However, since 1992 pup production has plummeted to only 31 in 1997 (W. D. Bowen, unpublished data). The causes of this decline are uncertain, but are known to include increased shark predation on juveniles, reduced female fertility, and lack of female recruitment.

Significance of the study area: The Sable Island population is unique in that it is the only truly offshore breeding population of this species in eastern Canada, if not the world.

9.0.4.3 Other species

Harp seal (*Phoca groenlandica*). This is a highly migratory phocid species, slightly larger than the harbour seal (at 1.7m), that breeds on the pack ice off Labrador and in the Gulf of St. Lawrence in March (Sergeant, 1991). Although considered rare on the Scotian Shelf a decade ago, juvenile harp seals are now common (dozens of sightings) on Sable Island. This increase on the Scotian Shelf, and further south, is roughly correlated with an increase in population size, but changes in ocean climate may also have played a role. Recent population estimates indicate about 4.3 million harp seals in the northwest Atlantic (Anon. 1995).

Hooded seal (*Cystophora cristata*). This is another highly migratory phocid species that breeds mainly on the pack ice off southern Labrador, although there is also a small (several thousand) population in the Gulf of St. Lawrence. Hooded seals are a medium-sized species (3m). Like harp seals, hooded seals were rare on the Scotian Shelf until the last few years; recently dozens of juveniles have been routinely sighted on Sable Island. The hooded seal population has increased over the past decade and recent estimates indicate that there are about 500,000 hooded seals in the northwest Atlantic (Stenson *et al.*, 1997).

Ringed seal (*Phoca hispida*). This small (1.4m) arctic phocid is very occasionally sighted on Sable Island.

Atlantic walrus (*Odobenus rosmarus rosmarus*). The walrus (3m) used to breed on Sable Island but was extirpated in the 18th Century. Very occasional migrants from arctic populations are seen off Nova Scotia (Katona *et al.*, 1983), but we know of no reports from the study area.

9.0.5 Significance of the Gully for Marine Mammals

9.0.5.1 Diversity

In the study area there are:

- 8 frequently sighted cetacean species (those with 25 or more sightings in Hooker *et al.*'s data base: fin, humpback, sperm, northern bottlenose, and pilot whales, and striped, Atlantic white-sided and short-beaked common dolphins);
- 5 cetacean species which are sighted quite often, but which have problems of identification (Sowerby's beaked whale, sei whale), a restricted temporal presence (bottlenose dolphins, blue whales) or a distribution distinct from the northern bottlenose whale, which determined much of the distribution of effort (the minke whale);
- 7 cetacean species which are known to be, or are very likely to be, rare visitors (right whale, harbour porpoise, killer whale, white-beaked dolphin, Risso's dolphin, pygmy sperm whale, dwarf sperm whale);
- 2 cetacean species whose presence is suspected but which have not been positively identified (Blainville's beaked whale, Fraser's dolphin);
- 2 abundant or common breeding pinniped species (grey and harbour seals);
- 2 fairly commonly sighted migratory pinniped species (harp and hooded seals);
- 1 rarely observed migrant pinniped (the ringed seal).

It is impossible to compare diversity in the study area with other regions in a rigorous manner, but the Gully seems to have a higher cetacean diversity than other areas, even much larger ones, in the northwest Atlantic (using definitions of "common" of scientists in different regions):

- Gully area: 8-13 common species (depending on how many of category B are included)
- Scotian Shelf (excluding Hooker *et al.*'s study area): 5 species sighted more than once during 1,121 daylight hours of transit to and from the Gully (Table 9.0.4)
- Gulf of Maine: 6 "common" species (Katona *et al.,* 1983)
- Bay of Fundy: 6 "common" species (Gaskin, 1983)
- Shelf-edge (91-2000m) region from Cape Hatteras to George's Bank (62,100km): 12 "common" species (Hain *et al.,* 1985)

- Newfoundland-Labrador (inshore and offshore waters): 9 "commonly sighted" species (Lien *et al.,* 1985)

Pinniped diversity (with 2 breeding species, 2 regularly sighted migrants, and one rare migrant) is no different to that of other parts of the eastern Scotian Shelf, and similar to other eastern Canadian waters.

9.0.5.2 Density

The study area contains the world's largest breeding colony of grey seals, and a large proportion of the Canadian population of this species. In the study of Whitehead *et al.* (1993) sperm whales were heard much more frequently (per monitoring session) in the northern part of the Gully than elsewhere on the Scotian Shelf. The sighting rates of cetaceans in Hooker *et al.*'s study area are compared to those on other parts of the eastern Scotian Shelf in Table 9.0.4. Data for species which were the objects of study in the Gully but not outside (sperm and northern bottlenose whales) cannot be compared legitimately in this way. Differences between sighting rates inside and outside Hooker et al.'s study area were significant ($P<0.05$) for all the other species with sufficient data to make a likelihood ratio G-test valid (fin whale, humpback whale, minke whale, pilot whale, striped dolphin, white-sided dolphin, and common dolphin). All of these species, except the minke whale, were sighted more frequently inside Hooker et al.'s study area than elsewhere on the Scotian Shelf. There may be a bias towards the Gully because of generally better sighting conditions, although this is unlikely to be large (probably less than a factor of 1.5). Even with these provisos considered, it is clear from Table 9.0.4, that the density of most species of cetaceans in the Gully area is substantially higher than on other parts of the Shelf.

We were able to make a quantitative comparison of the density of large whales in the Gully with that on other parts of the edge of the Scotian Shelf using the data of the Blandford whalers summarized by Sutcliffe and Brodie (1977). We divided the shelf edge region up into contiguous areas each roughly the size of the Hooker *et al.* study area (as shown in Fig. 9.0.4). For each area we calculated the distance to the whaling station at Blandford, and the number of whales killed. These are plotted against one another in Fig. 9.0.5. As noted by Mitchell (1974), the whalers concentrated their attentions on sea areas within about 150 nautical miles from the whaling station, and the catch of whales (logged) falls roughly linearly with the log of the distance from Blandford (Fig. 9.0.5; the power relationship has exponent -2.31). The catch of whales in the Gully is approximately twice what would be expected from this relationship (Fig. 9.0.5), and significantly higher than in the other shelf edge areas, accounting for distance from Blandford (Analysis of Covariance, one-tailed $P=0.045$). Thus large whales seem to have been more available to the Blandford whalers in the Gully than in other similar-sized areas along the edge of the Scotian Shelf (including the entrance of the Fundian Channel). It can be seen, in Fig. 9.0.6, that catches in the overall Gully region are concentrated within the deep canyon and northern basin of the Gully, mostly over depths greater than 200m and that the high abundance of whales in the Gully area indicated in Fig. 9.0.5 is not an artifact of where the boundary lines (indicated in Fig. 9.0.4) were

drawn.

Other measures of the high density of cetaceans in the Gully area include:

- the almost 100% record of sighting northern bottlenose whales in the deep canyon on any survey of a few hours or more in good sighting conditions;

- the high rate (50-100% of listening stations depending on area) at which sperm whales are heard through hydrophones in the northern part of the Gully (Whitehead *et al.,* 1992);

- the high sighting rates of Atlantic white-sided and short-beaked common dolphins (Gowans and Whitehead, 1995).

9.0.5.3 Significance for particular species

The significance of the study area for different marine mammal populations can be tentatively classified as follows:

Species with populations which breed in the study area, and seem very dependent on habitat within it:

- Grey seal
- Harbor seal
- Northern bottlenose whale

Species for which the Gully is the most important habitat so far identified on the Scotian Shelf and one of the most significant areas in Canadian waters:

- Sperm whale
- Short-beaked common dolphin
- Striped dolphin

Species for which the Gully is important habitat on the Scotian Shelf:

- Fin whale
- Humpback whale
- Atlantic white-sided dolphin

Common species for which the study area does not seem to contain particularly important habitat:

- Pilot whale
- Minke whale
- Harp seal
- Hood seal

Unknown significance of study area:

- Beaked whales of genus *Mesoplodon*

9.0.6 Implications of marine mammal presence for other parts of the Gully biota

The distribution of marine mammals correlates very well with that of their important resources. The large number of pinnipeds in the study area is directly related to the presence of suitable breeding areas on Sable Island. Similarly, the presence of cetaceans implies an important resource which is almost certainly food. In most cases we know little about the diets of the cetaceans that use the Gully. However a few species are sufficiently stenophagous that their presence in the Gully allows inferences about the increased availability of certain organisms. For instance, that blue whales are found in the Gully in August implies that there are concentrated schools of euphasiids in the area at that time. The consistent presence of northern bottlenose whales in the deep waters of the Gully throughout the year is particularly interesting as it suggests a substantial biomass of the deep-water squid *Gonatus fabricius*, which seems to be their predominant prey in the region (S. Hooker et al., unpublished data). Overall, the large numbers of cetaceans of many trophic habits found in the Gully indicates enhanced biomass of many types.

9.0.7 Cetaceans in canyons, large and small

Kenney and Winn (1987) tested the hypothesis that canyons are good cetacean habitat using data from the 'CETAP' surveys of the edge of the US east coast continental shelf. They found, contrary to expectation, that cetacean biomass was significantly less in areas containing canyons than adjacent parts of the shelf. Kenney and Winn (1987) caution that the biological significance of their result may be relatively minor, as there was no significant difference between canyons and non-canyon areas for any species (except *Stenella* spp. which were more abundant in canyon areas), and no significant differences for any separate season. However, their findings seem in conflict with our result that large cetaceans were about twice as available to Nova Scotian whalers in the Gully than along other parts of the edge of the continental shelf, as well as suggestions that other submarine canyons and their environs support increased numbers of cetaceans: Kaikoura Canyon, New Zealand (Donoghue, 1996); Trincomalee Canyon, Sri Lanka (Alling, 1986 and Gordon, 1991); and Monterey Canyon, California (Advanced Research Projects Agency, 1994).

We suspect that some of this apparent contradiction may be due to the different sizes of canyons. Therefore we compared dimensions of the canyons used by Kenney and Winn (1987) as well as the Gully, and Kaikoura, Trincomalee and Monterey canyons, as defined by the 200 m and 1000 m contours (Table 9.0.5).

The Gully is the largest of the measured canyons in three of the four measured dimensions, and is particularly prominent when defined by the length of the 200 m indentation, which, at 70.7 km, is over twice that for any of the other canyons. Its breadth is only rivaled by Trincomalee canyon. Although longest according to the 1000

m contour, it is closely rivaled by Hudson canyon. The Gully's width when defined by the 1000 m contour, is not unusual among these canyons.

The Monterey, Trincomalee and Kaikoura Canyons do not appear obviously different in dimension from those measured by Kenney and Winn. However unlike the US east coast canyons and the Gully, these are adjacent to land, and so in very different physical settings. Thus it is probably unwise to extrapolate results from the US east coast canyons to the Gully, because of its much greater size, and to Kaikoura, Trincomalee and Monterey canyons because of their proximity to shore. Both size and distance from shore will affect physical oceanography, and thus potentially the resources available to cetaceans.

9.0.8 Biological Boundaries

In considering boundaries our goal was to suggest parts of the study area that seemed most important for pinnipeds and for cetaceans, and whose degradation would have the most severe consequences. Two such areas stand out:

Sable Island and adjacent waters: The island and its surrounding waters are vital habitat for the two species of breeding pinniped.

The Gully canyon and northern basin: All cetacean species for which the study area is prime breeding habitat (northern bottlenose whale), or the most important habitat so far identified on the Scotian Shelf (sperm whale, short-beaked common dolphin, striped dolphin) have primarily deep water distributions. In the case of sperm whales, waters greater than about 200m deep seem to be important. All cetacean species that have been seen in Hooker *et al.*'s study area, including those without clear depth preferences, are sighted in these deep waters. The catches of large cetaceans in the study area were also concentrated in the deeper waters of the canyon and the northern basin (Fig. 9.0.6).

Therefore, if the goal is to protect vital cetacean habitat, we suggest the following boundaries (Fig. 9.0.1):

- A core area of those waters deeper than 200m with latitudes greater than 43° 40' N and longitudes between 58° 30' N - 59° 30' W;

- A buffer zone around this core area to protect it from threats which act at long ranges (such as noise, chemical pollutants). The width of the buffer zone would depend on the range of the threats.

We recognize that boundaries must consider other aspects of the natural system as well as human activities, and it may be more practical to have straight boundaries.

Table 9.0.5. Dimensions of submarine canyons used in the analysis of Kenney and Winn (1987), together with Monterey, Kaikoura, Trincomalee canyons and the Gully. Dimensions (in km) are approximate landward indentations of 200 m and 1000 m contours from general shelf-edge trend ("length", as in Kenney and Winn),

and breadth of canyon, as defined by the 200 m or 1000 m contour, half way into the indentation ("breadth"). Measurements were made from nautical charts by S. Dufault.

	200 m contour		1000 m contour	
Canyon	**Length**	**Breadth**	**Length**	**Breadth**
Norfolk, US	15.2	2.9	6.9	1.3
Washington, US	8.8	4.5	10.2	2.6
Baltimore, US	13.7	4.2	10.5	1.7
Wilmington, US	12.2	8.5	10.7	2.2
Hudson, US	31.2	5.0	25.2	6.0
Veatch, US	8.7	5.3	6.8	2.3
Hydrographer, US	17.0	2.4	11.2	2.8
Welker, US	9.2	7.0	8.4	2.3
Oceanographer, US	21.8	4.2	18.3	2.8
Gilbert, US	11.2	6.0	13.0	3.3
Lydonia, US	18.0	4.0	10.0	3.1
Powell, US	8.7	5.2	6.8	2.0
Corsair, US	12.3	3.3	5.8	4.4
Monterey, US	24.8	8.1	16.9	3.0
Trincomalee, Sri Lanka	13.5	3.0	4.5	4.5
Kaikoura, New Zealand	13.0	15.0	15.8	3.5
The Gully, Canada	**70.7**	**16.4**	**28.4**	**2.4**

9.0.9 Data Deficiencies

Our review of the marine mammals of the Gully area is hampered by deficiencies, of which we think the following are most significant:

Lack of data on at-sea distribution of pinnipeds: Although recent studies on adult grey seals have begun to address this deficiency, there is a nearly complete lack of information on the at-sea distribution of harbour seals. Such studies could be important in understanding the causes of the dramatic population decline in this species.

Lack of data on cetacean distribution outside the summer months: Aerial surveys would be a good way to get such information. Parsons (1995) showed how valuable a short aerial survey of the Gully with experienced observers can be. Records collected by experienced and interested fishermen could also help fill this gap.

Lack of information on how cetaceans use the Gully area: For instance, which species breed there? For most species we do not know how individuals use the Gully. Are the humpback whales observed in the Gully passing through or resident for much of their summer feeding season? Do they return in subsequent years? Additional photo-identifications should help address these issues.

9.0.10 Acknowledgments

We thank Robert Kenney for sending us data, and Susan Dufault who checked the manuscript.

9.0.11 Summary

- Available evidence strongly suggests that the Gully/Sable Island area is the most important habitat for both cetaceans and pinnipeds on the Scotian Shelf.

- The area contains one of the longest and most productive pinniped research programmes anywhere in the world, as well as the only long-term study of any beaked whale species.

- The area is notable for:
  - ⇒ a high diversity of cetaceans (8-13 common species)
  - ⇒ a high density of cetaceans in the Gully canyon. Densities of most species of Cetacea are considerably higher in the Gully than on other parts of the eastern Scotian Shelf, and large whale density is higher in the Gully than elsewhere along the edge of the Scotian Shelf (including the entrance of the Fundian Channel).
  - ⇒ a high density of grey seals breeding on Sable Island
  - ⇒ particular significance (within a Canadian context) for:
    - Grey seals
    - Harbour seals
    - Northern bottlenose whales
    - Sperm whales
    - Striped dolphins
    - Atlantic white-sided dolphins
    - Short-beaked common dolphins

- The most significant marine mammal habitat within the area is:
  - ⇒ for pinnipeds: Sable Island and surrounding waters
  - ⇒ for cetaceans: the deep canyon and northern basin of the Gully (>200m in depth)

9.0.12 References

Advanced Research Projects Agency. 1994. Draft Environmental Impact Statement/Environmental Impact Report for the California Acoustic Thermometry of Ocean Climate Project.

Alling, A. 1986. Records of odontocetes in the northern Indian Ocean (1981-82) and off the coast of Sri Lanka (1982-84). *J. Bombay Nat. Hist. Soc.* 83:376-394.

Amirault, D.L. 1995. Towards a conservation strategy for the Gully, near Sable Island, Nova Scotia. Discussion Paper, Canadian Wildlife Service, Atlantic Region, P.O. Box 1590, Sackville, New Brunswick E0A 3C0. 8pp.

Anon 1995. Report on the status of harp seals in the northwest Atlantic. Department of Fisheries and Oceans, Canada Stock Status Report 95/7.

Baird, R.W., and Stacey, P.J. 1991. Status of Risso's dolphin, *Grampus griseus*, in Canada. *Can. Field Nat.* 105: 233-242.

Baird, R.W., Stacey, P.J., and Whitehead, H. 1993a. Status of the striped dolphin, *Stenella coeruleoalba* in Canada. *Can. Field Nat.* 107: 455-465.

Baird, R.W., Walters, E.L., and Stacey, P.J. 1993b. Status of the bottlenose dolphin, *Tursiops truncatus*, in Canada. *Can. Field Nat*. 107: 466-480.

Beck, C.A. 1996. The distribution, habitat partitioning and movements of baleen whales in the Gully, a submarine canyon on the Scotian Shelf. Honours BSC Thesis, Dalhousie University, Halifax, Nova Scotia.

Benoit, D., and Bowen, W.D. 1990. Summer diet of grey seals (*Halicheorus grypus*) at Anticosti Island, Gulf of St. Lawrence, Canada. Pages 227-242. Bowen, W. D., ed. Population biology of sealworm (*Psuedoterranova decipiens*) in relation to its intermediate and seal hosts. *Can. Bull. J. Fish. Aquat. Sci.*

Boness, D. J., Bowen, W.D., and Oftedal, O.T. 1994. Evidence of a maternal foraging cycle resembling that of otariid seals in a small phocid, the harbor seal. *Behav. Ecol. Sociobiol.* 34:95-104.

Boulva, J., and McLaren, I.A. 1979. Biology of the harbour seal, *Phoca vitulina*, in eastern Canada. *Bull. Fish. Res. Bd.,* Can. 200:1-24.

Bowen, W. D., and Harrison, G. 1994. Offshore diet of grey seals *Halicoeres gryphus* near Sable Island, Canada. *Mar. Ecol. Prag. Ser.* 112:1-11.

Bowen, W. D., and Harrison, G.D. 1996. Comparison of harbor seal diets in two habitats in Atlantic Canada. *Can. J. Zool.* 74:125-135.

Bowen, W. D., Lawson, J.W., and Beck, B. 1993. Seasonal and geographic variation in the species composition and size of prey consumed by grey seals (*Halicoeres gryphus*) on the Scotian shelf. *Can. J. Fish. Aquat. Sci.* 50:1768-1778.

Bowen, W. D., Oftedal, O.T., and Boness, D.J.. 1992a. Mass and energy transfer during lactation in a small phocid, the harbor seal (*Phoca vitulina*). Physiol. Zool. 65:844-866.

Bowen, W. D., Stobo, W.T., and Smith, S.J. 1992b. Mass changes of grey seal (*Halicoeres gryphus*) pups on Sable Island: differential maternal investment reconsidered. *J. Zool., Lond.* 227:607-622.

Clark, C.W. 1994. Note on acoustic activity of whales near the Scotian Shelf. Appendix 5 of "Marine mammals and the Canadian Patrol Frigate Shock trials: a literature review and recommendations for mitigating the impacts." by R.R Reeves and M.W. Brown. Prepared for National Defence Headquarters, Ottawa. pp 104-105.

Donoghue, M. 1996. The New Zealand experience--one country's response to cetacean conservation. In *The conservation of whales and dolphins: science and practice*, ed. M. P. Simmonds, and J. Hutchinson. Chichester, U.K.: Wiley.

Donovan, G.P. 1991. A review of IWC stock boundaries. Rep. int. Whal. Commn *(special issue)* 13: 39-68.

Gaskin, D.E. 1983. The marine mammal community. In. *Marine and coastal systems of the Quoddy region, New Brunswick.* Edited by M.L.H. Thomas. Canadian Special Publication of Fisheries and Aquatic Sciences 64. Department of Fisheries and Oceans, Ottawa. pp. 245-268.

Gaskin, D.E. 1992. Status of the Atlantic white-sided dolphin, *Lagenorhynchus acutus*, in Canada. *Can.Field Nat.* 106: 64-72.

Gordon, J. C. D. 1991. The World Wildlife Fund's Indian Ocean Sperm Whale Project: an example of cetacean research within the Indian Ocean Sanctuary. In *Cetaceans and cetacean research in the Indian Ocean Sanctuary*, ed. S. Leatherwood, and G. P. Donovan. Nairobi, Kenya: UNEP Technical Report Number 3.

Gowans, S., and Whitehead, H. 1995. Distribution and habitat partitioning by small odontocetes in the Gully, a submarine canyon on the Scotian Shelf. *Can. J. Zool.* 73: 1599-1608.

Hain, J.H.W., Hyman, M.A.M., Kenney, R.D., and Winn, H.E. 1985. The role of cetaceans in the shelf-edge region of the northeastern United States. *Mar. Fish. Rev.* 47: 13-17.

Hay, K. 1982. Aerial line-transect estimates of abundance of humpback, fin, and long-finned pilot whales in the Newfoundland-Labrador area. *Rep. Int. Whal. Commn*

32: 475-486.

Hooker, S.K., Whitehead, H., and Gowans, S. Submitted m/s. Spatial, temporal and environmental correlates of cetacean distribution in a submarine canyon--implications for the design of a marine protected area. *Conserv. Biol.*

International Whaling Commission 1992. Report of the Comprehensive Assessment Special Meeting on North Atlantic Fin Whales, Reykjavik, 25 February - 1 March 1991. *Rep. Int. Whal. Commn* 42: 595-644.

Iverson, S. J., Bowen, W.D., Boness, D.J., and Oftedal, O.T. 1993. The effect of maternal size and milk output on pup growth in grey seals (*Halicoeres gryphus*). *Physiol. Zool.* 66:61-88.

Katona, S.K., and Beard, J.A. 1990. Population size, migrations and feeding aggregations of the humpback whale (*Megaptera novaeangliae*) in the western North Atlantic Ocean. *Rep. Int. Whal. Comm (special issue)* 12: 295-305.

Katona, S.K., Rough, V., and Richardson, D.T. 1983. *A field guide to the whales, porpoises and seals of the Gulf of Maine and eastern Canada.* 3rd ed. Charles Scribner's, New York.

Kenney, R.D. 1994. Distribution charts of marine mammals on the Scotian Shelf, 1966 through 1992. Appendix 2 of "Marine mammals and the Canadian Patrol Frigate Shock trials: a literature review and recommendations for mitigating the impacts." by R.R Reeves and M.W. Brown. Prepared for National Defence Headquarters, Ottawa. pp 44-89.

Kenney, R. D., and H. E. Winn. 1987. Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas. *Cont. Shelf Res.* 7:107-114.

Leatherwood, S., and Reeves, R.R. 1983. *The Sierra Club handbook of whales and dolphins*. Sierra Club Books, San Francisco.

Lien, J., Fawcett, L., and Staniforth, S. 1985. *Wet and fat: whales and seals of Newfoundland and Labrador.* Breakwater, St John's, Newfoundland.

Lucas, Z.N., and Hooker, S.K. 1997. Cetacean strandings on Sable Island, Nova Scotia. International Whaling Commission, *Scientific Committee Document* SC/49/O 6.

Mead, J.G. 1989. Bottlenose whales *Hyperoodon ampullatus* (Forster, 1770) and *Hyperoodon planifrons* Flower, 1882. In. *Handbook of Marine Mammals*. Vol. 4. Edited by S.H. Ridgway and R. Harrison. Academic Press, London. pp. 321-348.

Mitchell, E. 1974. Present status of northwest Atlantic fin and other whale stocks. In. *The Whale Problem.* Edited by W.E. Schevill. Harvard University Press, Cambridge, Massachusetts. pp. 108-169.

Mitchell, E. 1975. Report of the Scientific Committee, Annex U. Preliminary report on Nova Scotian fishery for sperm whales (*Physeter catodon*). *Rep. Int. Whal. Commn* 25: 226-235.

Mitchell, E., and Chapman, D.G. 1977. Preliminary assessment of stocks of northwest Atlantic sei whales (*Balaenoptera borealis*). *Rep. Int. Whal. Commn (special issue)* 1: 117-120.

Mitchell, E., and Reeves, R.R. 1988. Records of killer whales in the western North Atlantic, with emphasis on eastern Canadian waters. *Rit Fisk.* 11: 170-183.

Mohn, R., and Bowen, W.D. 1996. Grey seal predation on the eastern Scotian Shelf: modelling the impact on Atlantic cod. *Can. J. Fish. Aquat. Sci.* 53:2722-2738.

Nelson, D., and Lien, J. 1996. The status of the long-finned pilot whale, *Globicephala melas*, in Canada. *Can. Field Nat.* 110: 511-524.

Parsons, J. 1995. Marine Mammal Monitoring Program--Canadian Patrol Frigate Shock Trials, November 8-21, 1994. Final report to Department of National Defence, Ottawa by John Parsons & Associates, Dartmouth, Nova Scotia.

Read, A.J. 1994. Interactions between cetaceans and gillnet and trap fisheries in the Northwest Atlantic. *Rep. Int. Whal. Commn (special issue)* 15: 133-147.

Read, A.J. 1996. Incidental catches of small cetaceans. In. *The conservation of whales and dolphins: science and practice*. *Edited by* M.P. Simmonds and J. Hutchinson. Wiley, Chichester, U.K. pp. 89-128.

Reeves, R.R., and Brown, M.W. 1994. Marine mammals and the Canadian Patrol Frigate Shock trials: a literature review and recommendations for mitigating the impacts. Prepared for National Defence Headquarters, Ottawa. 105 pp.

Reeves, R.R., and Whitehead, H. 1997. Status of the sperm whale (*Physeter macrocephalus*) in Canada. *Can. Field Nat.* 111: 293-307.

Rice, D.W. 1989. Sperm whale. *Physeter macrocephalus* Linnaeus, 1758. In. *Handbook of marine mammals*. Vol. 4. Edited by S.H. Ridgway and R. Harrison. Academic Press, London. pp. 177-233.

Sears, R., Williamson, J.M., Wenzel, F.W., Bérubé, M., Gendron, D., and Jones, P. 1990. Photographic identification of the blue whale (*Balaenoptera musculus*) in the Gulf of St. Lawrence, Canada. *Rep. Int. Whal. Commn (special issue)* 12: 335-342.

Sergeant, D.E. 1991. Harp seals, man, and ice. *Can. Spec. Publ. Fish. Aquat. Sci*. 114:153p.

Sergeant, D.E., Mansfield, A.W., and Beck, B. 1970. Inshore records of Cetacea for eastern Canada 1949-68. *J. Fish. Res. Board Can.* 27: 1903-1915.

Stenson, G.B., Myers, R.A., Ni, I., and Warren, W.G. 1997. Pup production and population growth of hooded seals (*Cystophora cristata*) near Newfoundland, Canada. *Can. J. Fish. Aquat. Sci.* 54 (Suppl.1):209-216.

Stobo, W.T., Beck,B., and Horne,J.K. 1990. Seasonal movements of grey seals (*Halicoeres gryphus*) in the Northwest Atlantic. Edited by Bowen, W. D., Population biology of sealworm (*Psuedoterranova decipiens*) in relation to its intermediate and seal hosts. *Can. Bull. J. Fish. Aquat. Sci.* pp. 199-213.

Sutcliffe,W.H., and Brodie, P.F. 1977. Whale distributions in Nova Scotia waters. *Fisheries and Marine Service Technical Report.* No. 722.

Whitehead, H., Brennan, S., and Grover, D. 1992. Distribution and behaviour of male sperm whales on the Scotian Shelf, Canada. *Can. J. Zool.* 70: 912-918.

Whitehead, H., Gowans, S., Faucher, A., and McCarrey, S. 1997a. Population of northern bottlenose whales in the Gully, Nova Scotia. *Mar. Mammal Sci*. 13: 173-185.

Whitehead, H., Faucher, A., Gowans, S., and McCarrey, S. 1997b. Status of the northern bottlenose whale, *Hyperoodon ampullatus*, in the Gully, Nova Scotia. *Can. Field Nat*. 111: 287-292.

Winn, H.E., and Reichly, N.E. 1985. Humpback whale *Megaptera novaeangliae* (Borowski 1781). In. *Handbook of marine mammals*. Vol. 3. Edited by S.H. Ridgway and R. Harrison. Academic Press, London. pp. 241-273.

Zwanenburg, K.C.T., and Bowen, W.D. 1990. Population trends of the grey seal (*Halicoeres gryphus*) in eastern Canada. Pages 185-197. Bowen, W. D., ed. Population biology of sealworm (*Psuedoterranova decipiens*) in relation to its intermediate and seal hosts. *Can. Bull. J. Fish. Aquat. Sci.*

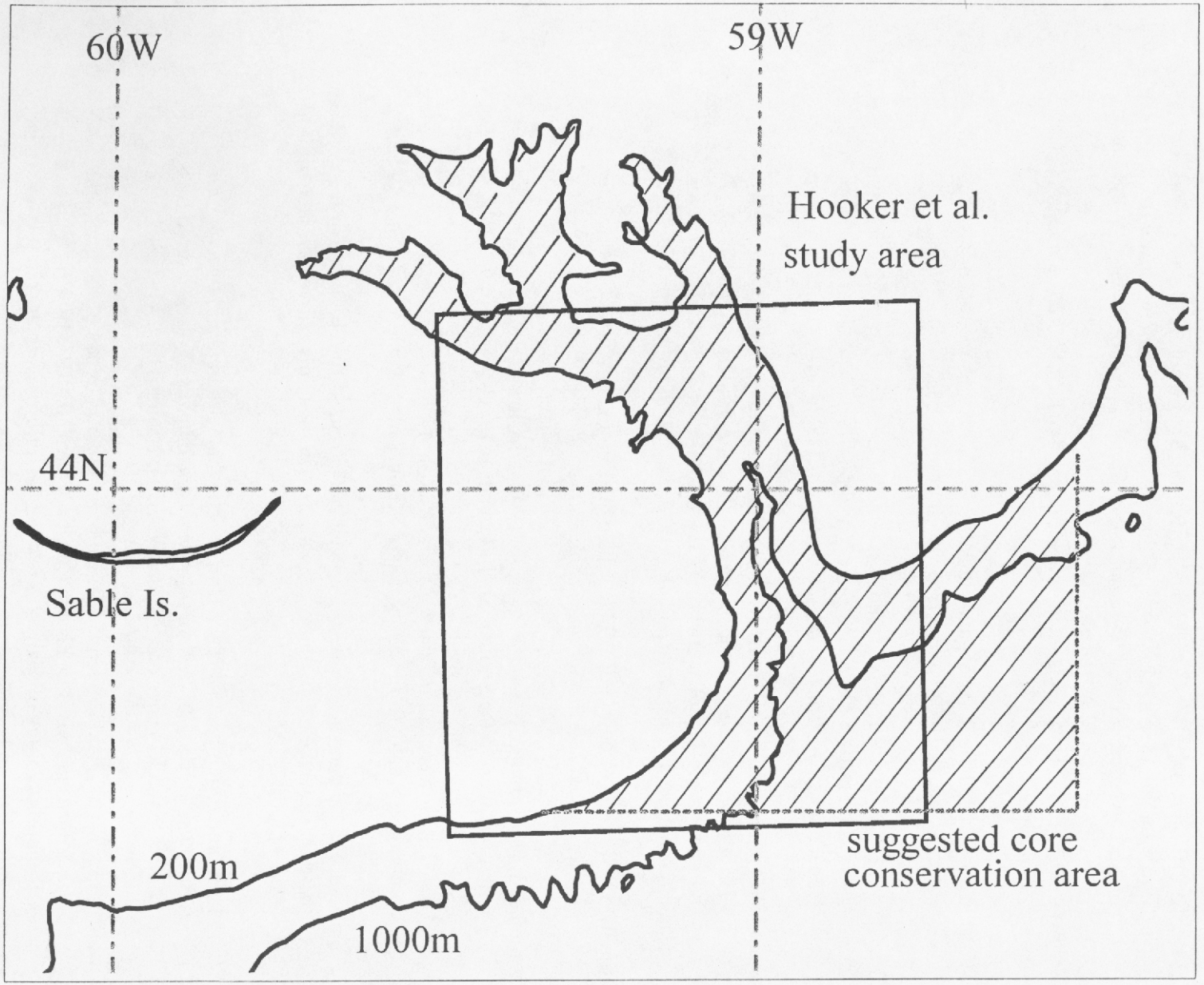


Fig. 9.0.1. Study area, showing Sable Island, 200m and 1,000m contours, the Gully Canyon, Hooker *et al.*'s (Submitted m/s) study area, and a suggested boundary for a core conservation area for cetaceans.

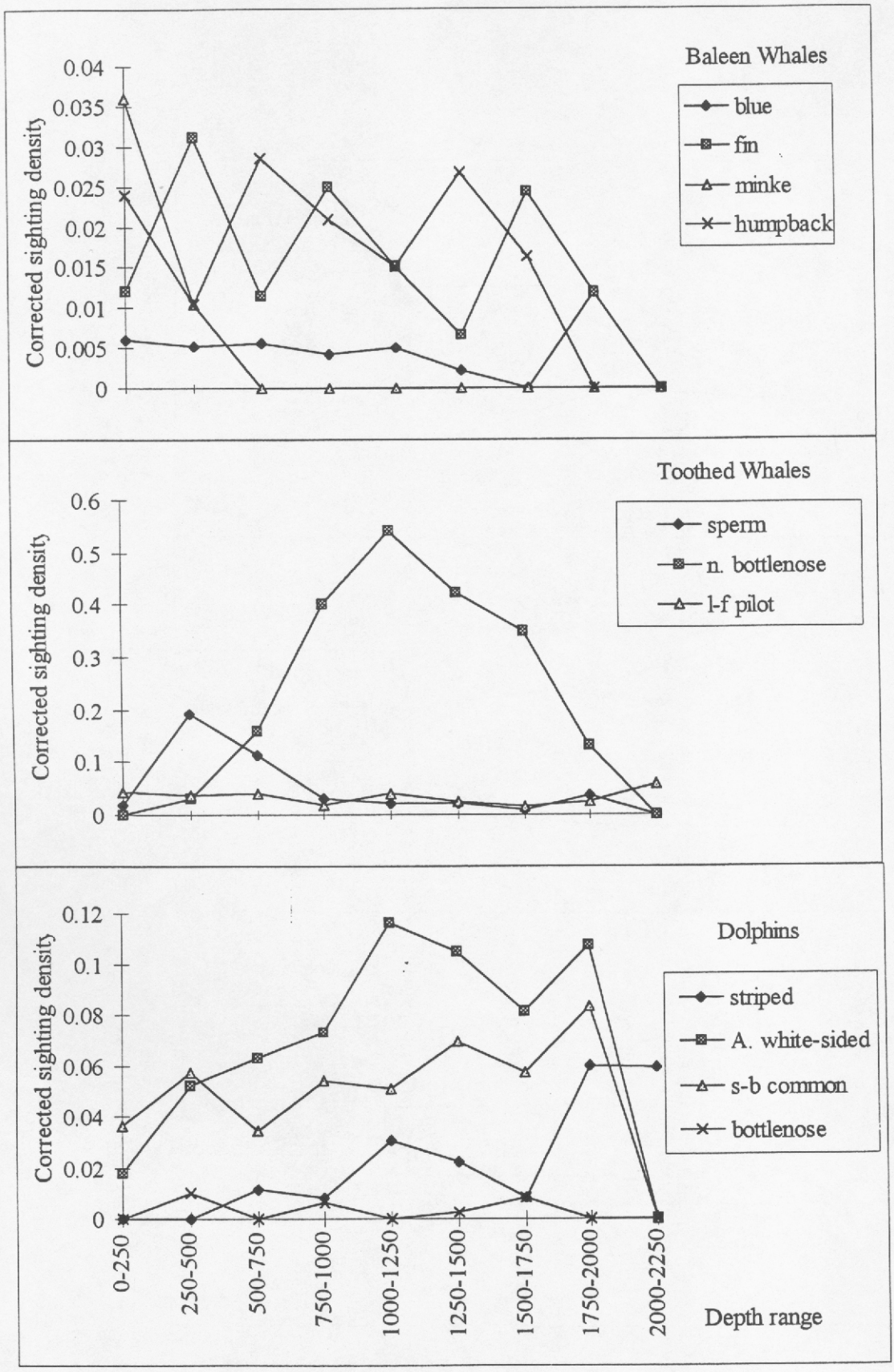


Fig. 9.0.2. Sighting rates of cetacean species (in sightings of groups per hour of effort) in Hooker *et al.*'s study area with water depth (Fig. 9.0.2a) and calendar month (Fig. 9.0.2b).

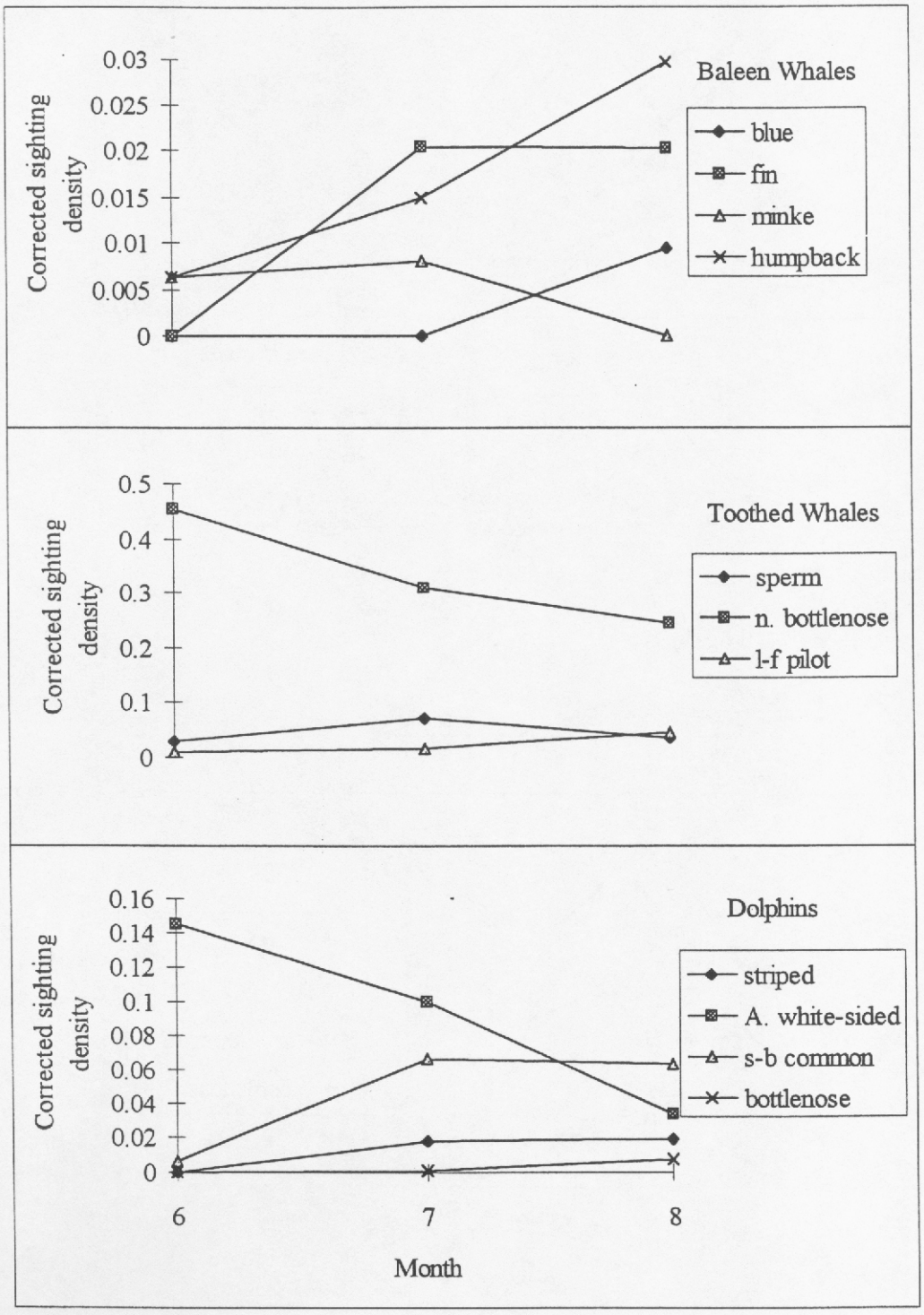
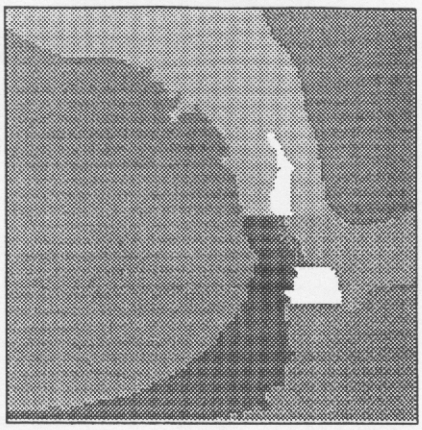
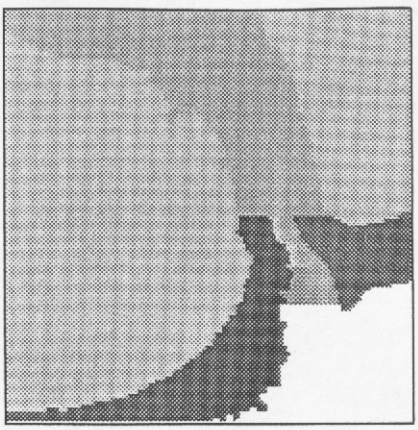


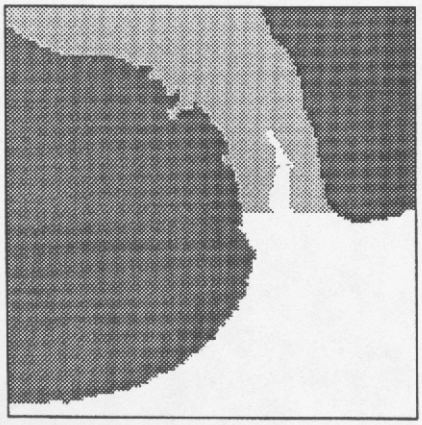
Fig. 9.0.2. (Continued)



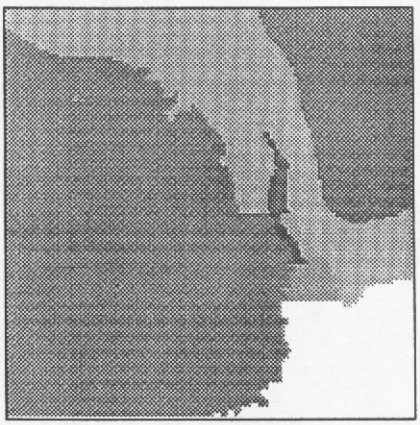
blue whale (n = 8)



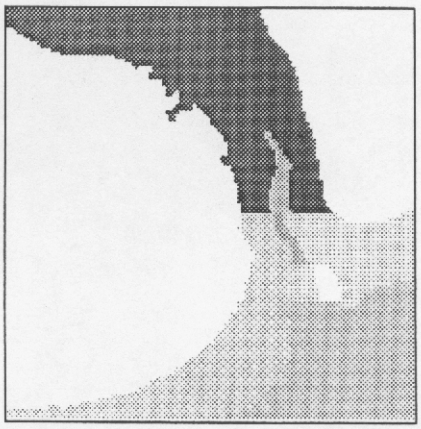
fin whale (n = 32)



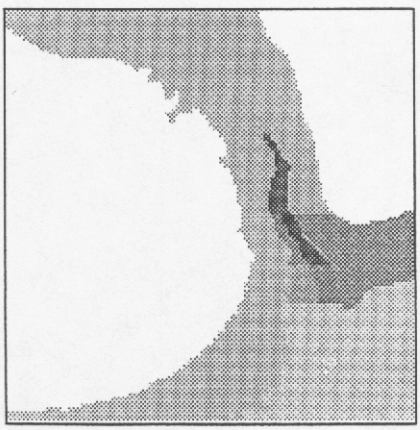
minke whale (n = 8)



humpback whale (n = 38)

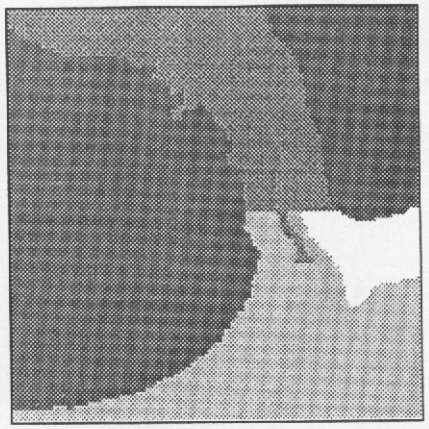


sperm whale (n = 92)

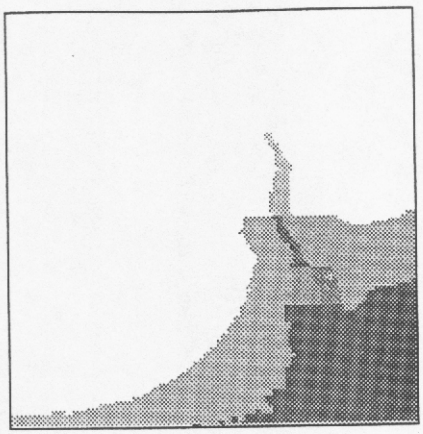


northern bottlenose whale (n = 577)

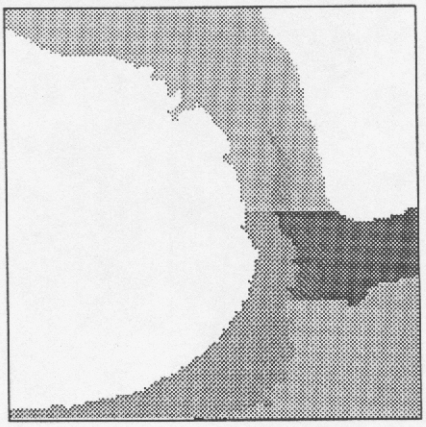
Fig. 9.0.3. Maps of distributions of cetacean species in Hooker *et al.* study area using regions defined by depth (0-200m, 200-1,000m, >1,000m), and north-south and east-west boundaries in the centre of the Gully canyon. For each species, shading ranges from black for the region of highest sightings per hour of effort to white for regions without sightings of the species.



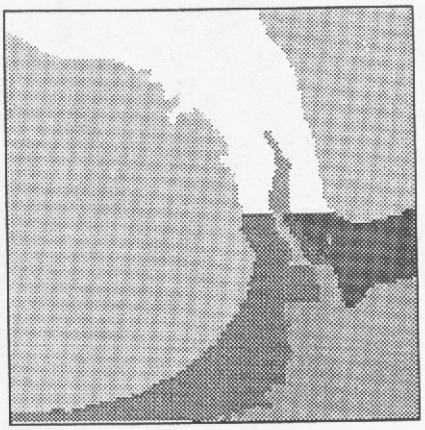
long-finned pilot whale (n = 54)



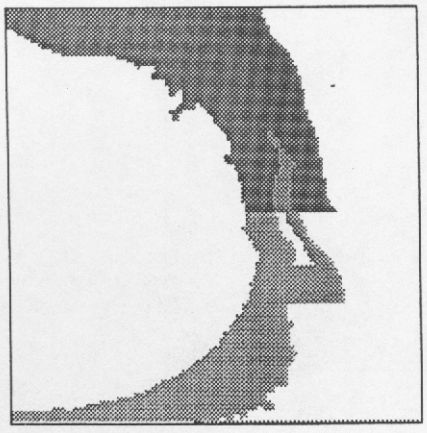
striped dolphin (n = 29)



Atlantic white-sided dolphin (n = 148)



short-beaked common dolphin (n = 104)



bottlenose dolphin (n = 7)

Fig. 9.0.3. (Continued)

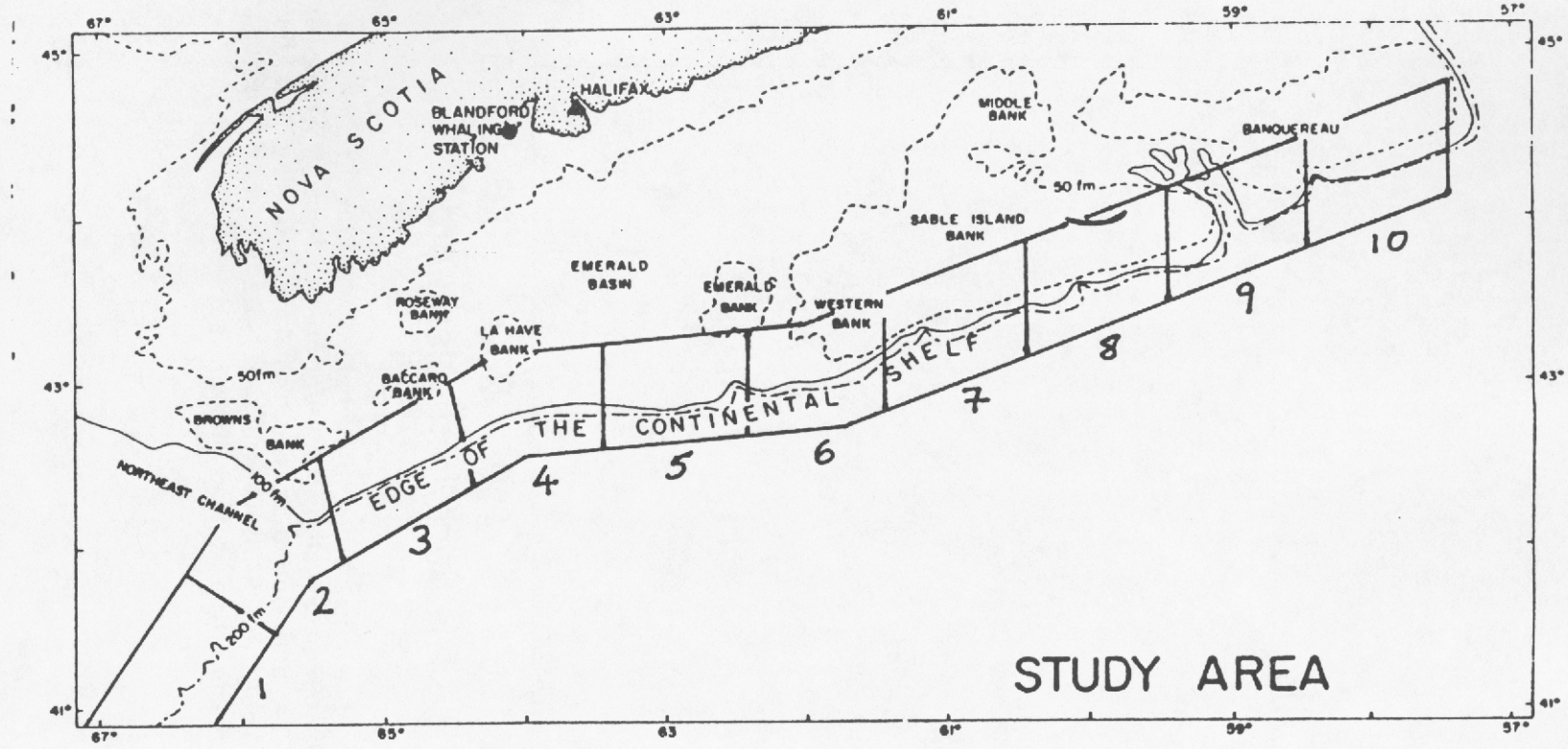


Fig. 9.0.4. Map of Scotian Shelf showing Blandford whaling station and areas used (marked by integers 1-10) for comparison of numbers of whale kills along the edge of Shelf (see Fig. 9.0.5).

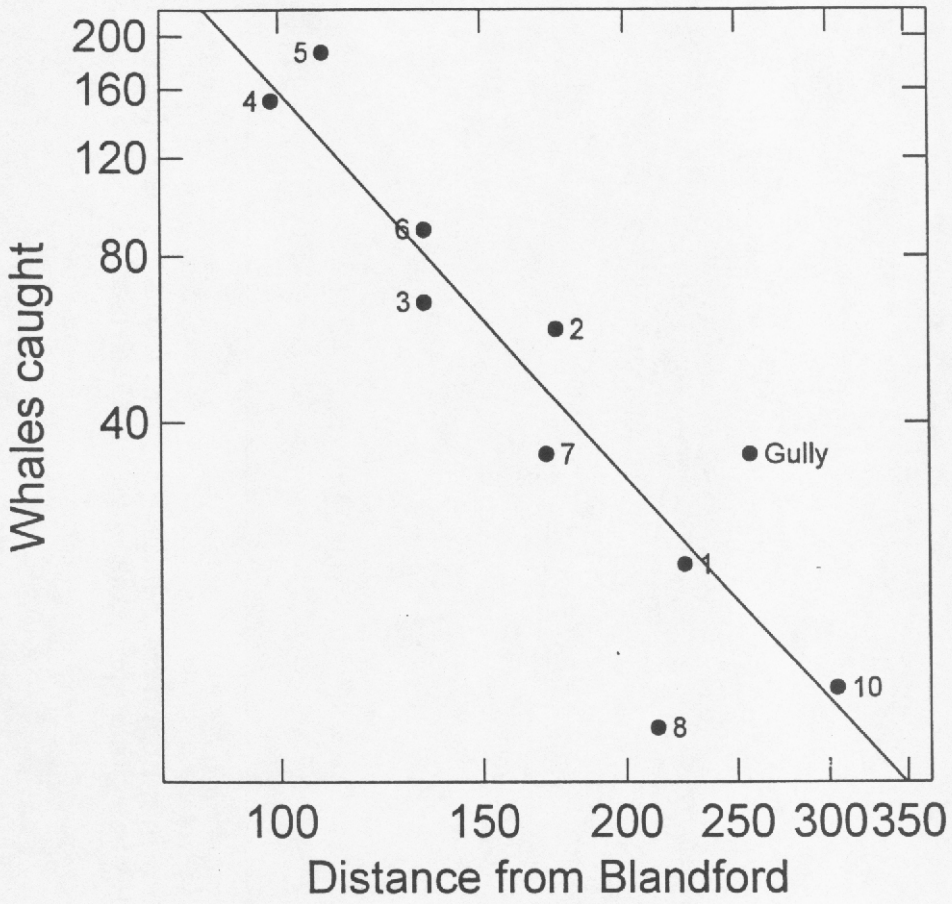


Fig. 9.0.5. Number of whales killed by whalers working from Blandford, Nova Scotia, in ten areas along the edge of the Scotian Shelf (marked by integers 1-10, and shown in Fig. 9.0.4) plotted against distance, in nautical miles, from Blandford (from Sutcliffe and Brodie 1977). A log-log regression line is also shown.

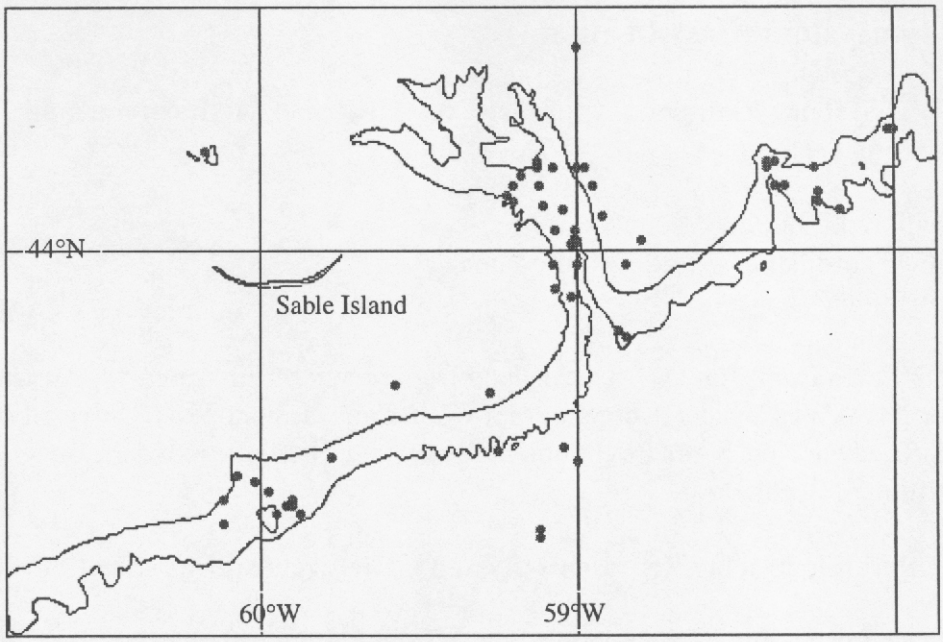


Fig. 9.0.6. Distribution of Blandford Whaling Station catches around the Gully area (1966-1972).