An Aerial Survey Estimate of 1989 Grey Seal *(Halichoerus grypus)* Pup Production in St George's Bay, Nova Scotia

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Abstract

Grey seal pup production in the St. George's Bay, Nova Scotia was estimated for 1989 season using aerial surveys. Surveys were flown 23, 30 January and 2 February 1989 resulting in pup production estimates of 4,208 (±1,515), 3,038 (±2,365) and 2,219 (±1,609) respectively. The decline in pup production estimates with succeeding surveys covering a larger area, albeit of lower survey fraction indicates that pups were likely missed due to the low survey intensity or emigration of animals from the study area. An aerial survey estimate for pup production obtained by combining transects from the high intensity survey of the northern half of St. George's Bay flown 23 January, with the lower intensity survey of the southern half of St. George's Bay flown 30 January results in a pup production estimate of 6,607 (±2,657).

Résumé

La production de jeunes phoques gris dans la Baie de St-George, Nouvelle-Ecosse, a été estimée par recensements aériens en 1989. A partir des relevés aériens effectués le 23, le 30 janvier, et le 2 février 1989, la production de jeunes a été estimée à 4,208 (±1,515) , 3,038 (±2,365) et 2,219 (±1,609), respectivement. La diminution de la production de jeunes estimée au cours des relevés successifs, qui couvraient une plus grande surface malgré le plus faible taux d'échantillonage, indique que des chiots ont échappé à l'observation dû à l'intensité plus faible de recensement ou qu'il y a eu émigration des animaux de l'aire d'étude. En combinant les recensements ayant les taux d'échantillonnage les plus élevés, effectués dans la portion nord de la Baie de St-Georges le 23 janvier, à ceux ayant les taux les moins élevés, effectués dans la portion sud de la Baie de St-George le 30 janvier, on obtient une production de jeunes estimée à 6,607 (±2,657).

Introduction

The grey seal (*Halichoerus grypus)* is one of two species of phocid seals found year round in eastern Canadian waters. Sexually dimorphic, males weigh up to 350 kg, and reach a length of 2.4 m. Females are approximately 20% smaller in size, weighing up to 250 kg and reaching 2.0 m in length (Murie and Lavigne 1992). Grey seals have been identified as a major host of the anisakid parasite, *Pseudoterranova decipens*, which infects commercial fish species, and must be removed during processing (Templeman 1990). Recent diet information indicates that they consume commercially important fish, placing them in potential competition with fishermen (Benoit and Bowen 1990a,b; Murie and Lavigne 1992).

In Canada, there are two large breeding concentrations. The largest and most intensively studied breeds on Sable Island off the Nova Scotia coast (Mansfield 1966; Mansfield and Beck 1977; Stobo and Zwanenburg 1990; Zwanenburg and Bowen 1990). A second large concentration breeds on the pack ice in the southern Gulf of St. Lawrence, in Northumberland Strait and St. George's Bay (Mansfield 1966). Small groups of whelping animals are also found on Bowen's Ledge and Big White Island off eastern Nova Scotia, and on Amet Island and Deadman Island in the Gulf of St. Lawrence (Mansfield and Beck 1977).

All pups born on Sable Island between 1977 and 1990 have been tagged. Based on complete enumeration of pups during this time the Sable Island grey seal population is increasing at an annual rate of 12.5%. Pup production in 1989 was 9,712 (Stobo and Zwanenburg 1990).

Less is known about pup production in the Gulf of St. Lawrence. Mark-recapture estimates indicate that pup production during 1984-1986 was around 6,500 (Hammill et al. 1992). More recent estimates of pup production in 1989 and 1990 from a mark-recapture experiment of pups tagged in the Gulf, but later recaptured live on Sable Island, and the development of a new mark-recapture model conducted during the birthing season (January-February), which incorporates into the model corrections for the birthing ogive and emigration (Myers et al. 1992) indicate that pup production had increased to between 8,316 ($\pm$1,705) to 12,349 ($\pm$4,454) animals.

Here we present the results from an aerial survey corrected for the temporal distribution of births to estimate 1990 pup production in St. George's Bay, Nova Scotia.

Materials and Methods

Systematic, photographic aerial surveys were flown in January and February 1989. Transects were oriented east-west along the Cape Breton coast between Low Point (45°40'N) and Cheticamp (46°31'N)(Fig. 1). Navigation was by Loran-C. All surveys were flown at an altitude of 305 m. Photographs were taken using Kodak 2405 Double X, 70 mm film, and a Vinten 70 mm camera, equipped with a 76 mm quartz lens and a Wratten 18A ultra-violet filter to aid in detecting pups (Lavigne & Øritsland 1974; Ni et al. 1988). Photographs were non-overlapping. Strip width at the survey altitude of 305 m was 228.6 m.

The position of each seal identified on each frame was marked on a clear acetate sheet placed over the negative. All frames were counted at least twice. After the second readings had been completed, the acetates were placed on the photograph, and a third examination undertaken to ensure that all seals present were correctly identified.

Survey analysis was based on a systematic sampling design with, in effect, a single random start. Pup production was determined by multiplying pup density by a weighting factor, and then summing over all transects (Kingsley et al. 1985). Estimates of error variance were based on serial differences between transects (Kingsley et al. 1985). Confidence limits were calculated using 95% C.I. = $\pm$ 1.96 (Var (N)).

Birth ogive

The change in the proportion of pups in different age dependent stages was obtained repeatedly throughout the pupping season and used to model the distribution of births throughout time. Pups were assigned to one of 5 age related developmental categories based on morphology and pelage changes. Stage charateristics and stage durations are described in detail by Myers et al. (In press). The model output was then used to correct the aerial survey data for pups not yet born or pups that had entered the water before the survey took place (Bowen et al. 1987; Stenson et al. 1991; Myers et al. 1992).

Results

Photographic surveys were flown 23 January, 30 January and 2 February. In the 23 January survey (Table 1), east-west running transects spaced 1.9 km apart, were flown from north to south in St. George's Bay beginning at 46°01'N and ending at 45°52'N. Photographic coverage was 7.7% of a total area of 690 km^2. The clump factors, a measure of seal distribution across the stratum (C_1) and between transects (C_2) were relatively high (Table 2), indicating that the seals tended to be found in clumps. The C_1/C_2 ratio was 0.69 indicating large variability in pup counts between adjacent transect lines. A total of 223 animals were counted on the photographs resulting in a mean density estimate of 4.2 (SE=1.2) and a total population estimate of 2,735 ($\pm$1,515) animals.

Surveys were again flown 28 January and 30 January, providing complete coverage of St. George's Bay. The survey flown 28 January consisted of a single line flown along 45°43'N. Since ice drift in this area was very slow based on the movement of marked pupping concentrations in the area, we included this line as the southern limit for the survey flown 30 January. In this survey, transects were spaced 3.7 km apart resulting in survey coverage of only 4.2% of 907 km^2. Results from the 30 January survey were less precise than the 23 January survey as shown by a higher coefficient of variation of 0.44 (Table 2). The distribution of pups was slightly more clumped than in the 23 January survey but C_1/C_2 ratios increased to 0.8 indicating a reduction in between transect variability. A total of 120 animals were counted for a mean density of 3.0 pups km$_2$ (SE=1.3) and an estimate for the number of animals present at the time of the survey of 2,734 ($\pm$2,365).

The transect lines flown during the 28-30 January survey of St. George's Bay were again flown on 2 February. Transects spaced 3.7 km apart were flown between 45°43'N and

46°01'N. Survey fraction was 4.2% of a total stratum area of 1013.2 km^2. Clump factors remained high, but the differences between C_1 and C_2 continued to decline. Only 92 animals were counted on transect resulting in a population estimate of 2,220 ($\pm$1,609) pups present in area 1 at the time of the survey (Table 1).

Distribution of Births

Modelling the distribution of births over time indicated that pupping on the ice had begun around the 9 January in St. George's Bay and continued until the first week in February. The buildup in births was rapid with an estimated 63% of the births occurring by 23 January, 82% by 30 January and 84% by the time of the 2 February survey (Myers et al. 1992). Correcting for the birth ogive and the loss of pups from St. George's Bay due to ice drift (Myers et al. 1992) results in a population estimate of 4,341 pups for the 23 January survey, 3,705 pups on 30 January and 2,643 on 2 February.

Surveys flown 30 January, and 2 February covered the same areas and therefore pup production estimates from these surveys should have been similar. Also these estimates were similar or lower than estimates obtained from the 23 January survey, which covered a smaller area and was flown at a time when a lower proportion of pups were present on the ice. During the 23 January survey 143 pups were counted on 5 transect lines. Correcting for unborn pups this number would increase to 227 animals. During the 30 January survey only 66 pups were counted on photographs taken along the same lines. Correcting for unborn pups this number increases to 80 animals. On 2 February the number of pups found on the same lines had declined to 38 animals, which would increase to 45 pups after correcting for pups not present on the ice at the time of the survey. Pup counts recorded along the same transects during the 3 surveys were compared and were found not to be independent of the survey (X^2= 35.5, df=2, $p<0.05$ for uncorrected counts and X^2=39.0, df=2, $p<0.05$ for corrected counts). This comparison indicates that a large number of pups surveyed on 23 January were missed during the low intensity surveys flown 30 January and 2 February.

Discussion

Aerial survey techniques have been used in several studies to census pinniped populations (Stirling et al. 1977; Kingsley et al. 1985; Bowen et al. 1987; Erickson et al. 1989). Conceptually, they are simple to complete. Myers and Bowen (1989) examined some of the difficulties associated with photographic aerial surveys of harp seals, another pack ice species that whelps in very large concentrations over a short season of 3-4 weeks. They concluded that the most important source of bias was failure to count all whelping concentrations. Ice breeding grey seals present an interesting suite of problems in trying to estimate pup production using aerial surveys. Presently, pupping is limited to Northumberland Strait and the west coast of Cape Breton Island including St. George's Bay, which is much smaller and appears to drift at a slower rate than the 'Front' area used by harp or hooded seals off the east Newfoundland coast. However, surveys of grey seals are complicated by shorter daylight hours in which to complete a survey. Although animals whelp in concentrations these patches are not evenly distributed throughout the study area.

Often these groups number only 200-500 animals, making them small enough to be easily missed, but large enough to have a major impact on the final estimates of pup production.

In our surveys, the photographs were of good quality. A survey altitude of 305 m resulted in an image size of approximately 0.2 mm for pups, 0.4 mm for females and 0.5 mm for males. At this altitude younger pups were difficult to detect. As a result some pups on the negatives may have been missed. We suggest that future surveys be flown at a lower altitude.

The low estimates of pup production obtained from the 30 January and 2 February surveys compared to the 23 January survey are surprising, especially considering that only an estimated 63% of the pups were present on the ice at the time of the 23 January survey compared to >80 % at the time of the later surveys (Myers et al. 1992). These lower estimates may have resulted from pups being missed due to a combination of the clumped distribution of whelping females and the wide transect spacing-low survey intensity of the subsequent surveys. Alternatively, they may also have resulted from a greater than expected emigration of pups out of St. George's Bay due to ice drift. To test this hypothesis we examined the movments of groups tagged prior to the 23 January survey, that were resighted at a later date. Mean drift rates were 1.3 km d^{-1} (SE=0.2, N=30). At this rate of drift, seals photographed between transect lines 46°55'N and 46°00' N, could have drifted out of St. George's Bay between the 23 January and 30 January surveys.

Because some pups may have been missed in surveys flown after 23 January, we believe a more realistic estimate of pup production would be obtained using a combination of the high intensity 23 January survey of the northern half of the bay and counts from the 30 January survey of the southern half of the bay. Combining these surveys and correcting for pups not present on the ice at the time of the survey results in a pup production estimate of 6,607 (±2,657). This estimate is similar to the estimate of 7,155 (±784) animals obtained from the within season mark-recapture experiment for pup production in St. George's Bay (Myers et al. 1992).

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Literature cited

Benoit, D. and W.D. Bowen. 1990a. Seasonal and geographical variation in the diet of grey seals (*Halichoerus grypus*) in eastern Canada, p. 215-226. *In* W.D. Bowen (ed.) Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts. Can. Bull. Fish. Aquat. Sci. 222: 306 p.

Benoit, D. and W.D. Bowen. 1990b. Summer diet of grey seals (*Halichoerus grypus*) at Anticosti Island, Gulf of St. Lawrence, Canada, p. 227-242. *In* W.D. Bowen (ed.) Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts. Can. Bull. Fish. Aquat. Sci. 222: 306 p.

Bowen, W.D., R.A. Myers and K. Hay. 1987. Abundance estimation of a dispersed, dynamic population: hooded seals (*Cystophora cristata*) in the Northwestern Atlantic. Can. J. Fish. and Aquat. Sci. 44:282-295.

Erickson, A.W., L.J. Bledsoe and M.B. Hanson. 1989. Bootstrap correction for diurnal activity cycle in census data for Antarctic seals. Marine Mammal Science 5:29-56.

Hammill, M.O., G. Stenson, R.A. Myers and W. Stobo. 1992. Mark-recapture estimates of non-Sable Island grey seal (*Halichoerus grypus*) pup production. CAFSAC Res. Doc. 92/91: 15p.

Kingsley, M.C.S.K., I. Stirling, and W. Calvert. 1985. The distribution and abundance of seals in the Canadian high Arctic, 1980-82. Can. J. Fish. Aquat. Sci. 42:1189-1210.

Lavigne, D.M. and N.A. Øritsland. 1974. Black polar bears. Nature 251 (5472): 218-219.

Mansfield, A.W. 1966. The grey seal in eastern Canadian waters. Can. Audubon Magazine 28:161-166.

Mansfield, A.W. and B. Beck. 1977. The grey seal in eastern Canada. Fish. Mar. Ser. Tech. Rep. No. 704. 81 p.

Murie, D.J. and D.M. Lavigne. 1992. Growth and feeding habits of grey seals (*Halichoerus grypus*) in the northwestern Gulf of St. Lawrence, Canada. Can. J. Zool. 70:1604-1613.

Myers, R.A. and W.D. Bowen. 1989. Estimating bias in aerial surveys of harp seal pup production. J.Wildl. Manage. 53:361-372.

Myers, R.A., W.D. Bowen, and W.T. Stobo. In Press. Duration of pelage stages of grey seal (*Halichoerus grypus*) pups. Mar. Mamm. Sci. 00:00-00.

Myers, R.A., M.O. Hammill, and G. Stenson.1992. Estimating abundance for grey seals using mark-recapture in the presence of migration.

Ni, I-H., G.B. Stenson, and H. Ripley. 1988. Evaluation of ultraviolet photography in the detection of seals. p 96-107 *In* I. Ohnuki and V. Zsilinszky (ed). Proceedings of the joint and special sessions on the Review of Advances in Remote Sensing Technology for Forestry.

Stenson, G.B., I-H. Ni, R.A. Myers, M.O. Hammill, W.G. Warren, and M.C.S. Kingsley.1991. Aerial survey estimates of pup production of Harp seals (*Phoca groenlandica*) in the Gulf of St. Lawrence and off Newfoundland during March 1990. CAFSAC Res. Doc. 91/83. 38pp.

Stirling, I., W.R. Archibald, and D.P. DeMaster. 1977. Distribution and abundance of seals in the eastern Beaufort Sea. Can. J. Zool. 34:976-9

Stobo, W.T. and K.C.T. Zwanenberg. 1990. Grey seal (*Halichoerus grypus*) pup production on Sable Island and estimates of recent production in the Northwest Atlantic, p 171-184. *In* W.D. Bowen (ed.) Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts. Can. Bull. Fish. Aquat. Sci. 222: 306 p.

Templeman, W. 1990. Historical background to the sealworm problem in eastern Canadian waters, p. 1-16. *In* W.D. Bowen (ed.) Population biology of sealworm (Pseudoterranova decipiens) in relation to its intermediate and seal hosts. Can. Bull. Fish. Aquat. Sci. 222: 306 p.

Zwanenberg, K.C.T. and W.D. Bowen. 1990. Population trends of the grey seal (*Halichoerus grypus*) in eastern Canada, p 185-197. *In* W.D. Bowen (ed.) Population biology of sealworm (*Pseudoterranova decipiens*) in relation to its intermediate and seal hosts. Can. Bull. Fish. Aquat. Sci. 222: 306 p.

Table 1 : Location of transect lines, total number of photos and number of pups counted on photos during grey seal aerial surveys flown 1989.

January 23, 1989

Latitude	Longitude		Total # frames	Total pups
	Begin	End		
45° 52'	61° 30'	61° 51.6'	109	21
45° 53'	61° 30'	62° 0.0'	121	25
45° 54'	61° 30'	62° 5.0'	145	35
45° 55'	61° 31.5'	62° 1.0'	122	53
45° 56'	61° 32.0'	62° 4.0'	128	4
45° 57'	61° 32.0'	61° 59.8'	96	50
45° 58'	61° 36.0'	62° 7.9'	132	17
45° 59'	61° 32.5'	62° 6.0'	37	6
46° 0'	61° 32.0'	61° 48.0'	65	1
46° 1'	61° 35.0'	61° 54.0'	72	7

January 30, 1989

Latitude	Longitude		Total # frames	Total pups
	Begin	End		
45° 43'	61° 28.0'	61° 45.0'	36	0
45° 45'	61° 29.0'	61° 51.0'	85	8
45° 47'	61° 29.0'	61° 49.0'	86	14
45° 49'	61° 30.5'	61° 48.6'	73	6
45° 51'	61° 30.0'	61° 46.0'	65	26
45° 53'	61° 30.0'	61° 43.0'	55	3
45° 55'	61° 31.5'	61° 59.7'	113	9
45° 57'	61° 32.0'	61° 58.0'	102	53
45° 59'	61° 32.0'	61° 43.5'	47	1
46° 1'	61° 33.0'	61° 41.7'	28	0

Table 1 (cont'd)

February 2, 1989

Latitude	Longitude		Total # frames	Total pups
	Begin	End		
45° 43'	61° 27.0'	61° 47.0'	80	0
45° 45'	61° 28.0'	61° 47.6'	80	0
45° 47'	61° 29.0'	61° 50.0'	87	12
45° 49'	61° 30.0'	62° 54.0'	94	17
45° 51'	61° 30.0'	62° 54.8'	99	30
45° 53'	61° 30.0'	61° 54.0'	99	0
45° 55'	61° 31.0'	62° 51.0'	53	5
45° 57'	61° 32.0'	62° 52.7'	82	5
46° 59'	61° 32.0'	61° 52.0'	72	23
46° 01'	61° 35.0'	61° 53.0'	70	0

Table 2. Summary of systematic photographic surveys of St. George's Bay, Nova Scotia.

DATE	TRANSECT SPACING (km)	NUMBER OF TRANSECTS	AREA SURVEYED (km^2)	STRATUM AREA	PUPS COUNTED	MEAN DENSITY	SE	C_1	C_2	E	ESTIMATED PUPS	95% C.I. (±1.96 SE)
23 JAN	1.85	11	56	690	223	3.96	1.12	12.2	17.8	0.28	2735	± 1515
30 JAN	3.7	11	38	907	120	3.01	1.33	18.8	23.3	0.44	2734	± 2365
2 FEB	3.7	10	43	1013	92	2.19	0.81	11.2	12.5	0.37	2220	± 1609

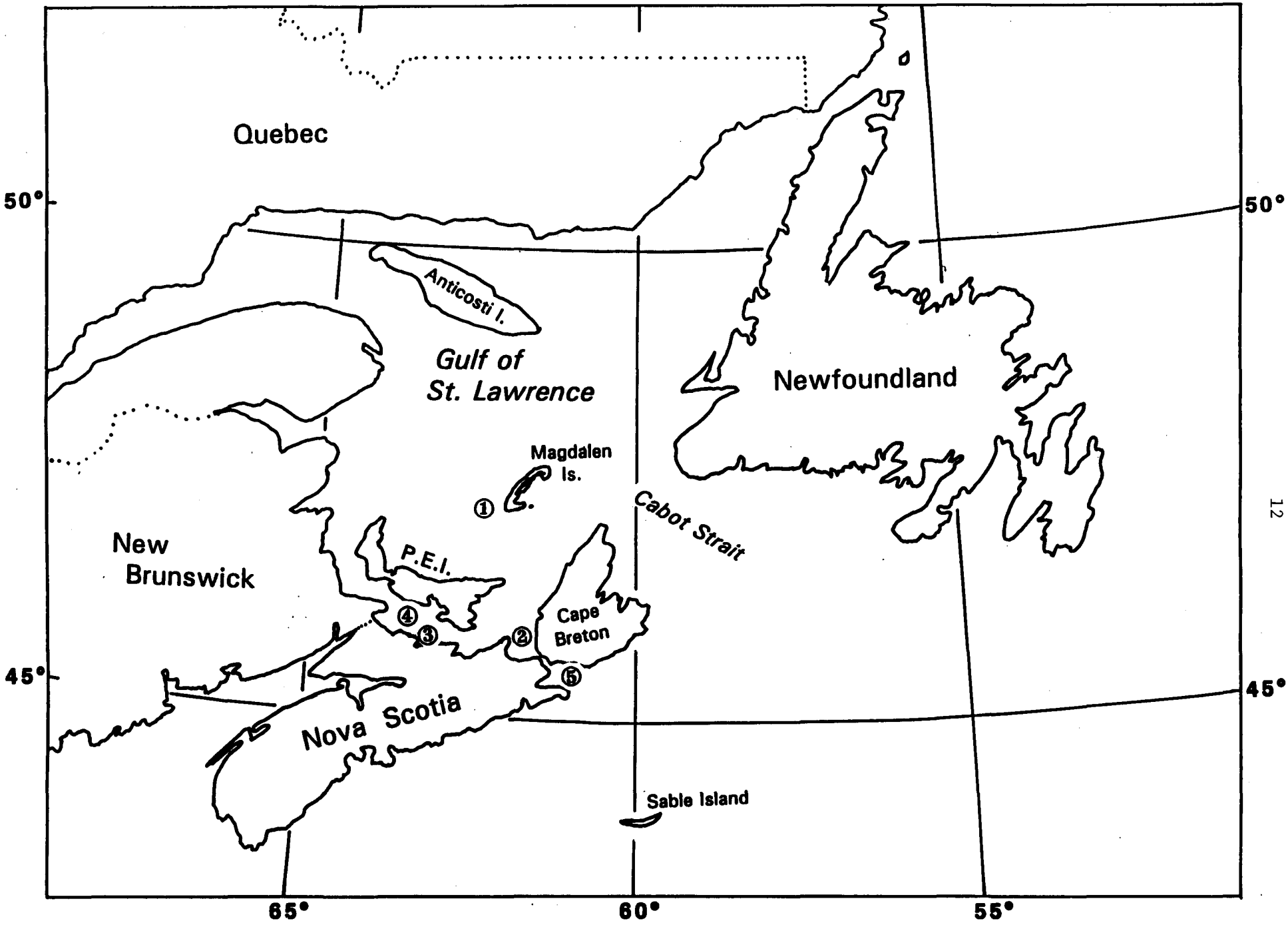

Fig. 1. Map of eastern Canada showing major grey seal pupping sites in the southern Gulf of St. Lawrence and on Sable Island, located 160 km to the east of Nova Scotia. 1= Deadman Island; 2= St. Georges Bay; 3= Amet Island; 4= Northumberland Strait; 5= Bowen's Ledge & Big White Island