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Aerial Surveys of Seals in the Bay of Fundy and off Southwest Nova Scotia

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ABSTRACT

Stobo, W.T., and G.M. Fowler. 1994. Aerial surveys of seals in the Bay of Fundy and off southwest Nova Scotia. Can. Tech. Rep. Fish. Aquat. Sci. 1943: 57 p.

Visual counts of grey and harbor seals were made during 5 helicopter surveys in 1985-87 and 1991-92 along the coast and offshore islands of the Bay of Fundy region from Machias Seal Island to Quaco Head, New Brunswick, and from Parkers Cove to Cape Sable Island, Nova Scotia. Each survey targeted a 4-hour window centred at low tide such that any shoal areas emergent only at low tide would be censused. The survey indicated detailed haul-out site preferences for both species, and provided evidence for increasing abundance of harbor seals. The population status of grey seals in the area could not be determined. Several aspects of survey methodology are also examined.

RÉSUMÉ

Stobo, W.T., and G.M. Fowler. 1994. Aerial surveys of seals in the Bay of Fundy and off southwest Nova Scotia. Can. Tech. Rep. Fish. Aquat. Sci. 1943: 57 p.

On a procédé à des dénombrements visuels du phoque gris et du phoque commun au cours de cinq relevés par hélicoptère réalisés en 1985-87 et en 1991-92 le long de la côte et des îles du large de la baie de Fundy, depuis l'île Machias Seal jusqu'à la pointe Quaco, au Nouveau-Brunswick et depuis l'anse Parkers jusqu'à l'île Cape Sable, en Nouvelle-Écosse. Chaque relevé portait sur un créneau de quatre heures, centré sur la marée basse de sorte que tout haut-fond découvert seulement par basse mer soit englobé dans le recensement. Les relevés ont révélé des préférences nettes en matière de lieux d'atterrissage pour les deux espèces et ont apporté des preuves de l'abondance croissante du phoque commun. On n'a pu déterminer l'état de la population de phoques gris. On examine aussi plusieurs aspects de la méthodologie employée dans les relevés.

INTRODUCTION

Grey seals, *Halichoerus grypus*, and harbor seals, *Phoca vitulina*, range from Cape Cod to northern Labrador in the Northwest Atlantic Ocean. Grey seals congregate annually during January and February on Sable Island and in the southern Gulf of St. Lawrence for pupping and breeding (Mansfield and Beck, 1977; Stobo et al, 1990). Harbor seals are not found in large concentrations at any time of the year, but rather appear to form small, relatively discrete breeding groups throughout their range (Boulva and McLaren, 1979) in May and June. During the non-breeding season both species are widely distributed throughout the northwest Atlantic (Mansfield, 1966).

Known and suspected interactions between these seals and commercial fisheries on the Scotian Shelf have been a concern since the early 1900s (see Anon., 1986). Seal are primarily piscivorous and also opportunistic predators, thus they consume commercially important and commercially unimportant fish species. Both species periodically damage fishing gear (Anon., 1986), and grey seals are considered to be the prime vector for the sealworm *Pseudoterranova decipiens* (Scott and Fisher, 1958; Mansfield and Beck, 1977; Templeman, 1990).

The Canadian government first initiated action to control the seal populations in the early 1900s as a result of the fishing industry's concern about these interactions. Harbor seals were the more abundant of the two species on Canada's east coast at that time probably due to the heavy exploitation of grey seals in the 17th and 18th centuries throughout their northwest Atlantic range (Chantraine, 1980). In 1927 a bounty was placed on harbor seals with submission of the snout as proof of destruction. But due to false claims based on grey seal snouts and other material, in 1949 the snout was replaced by the lower jaw as proof of destruction; and in 1967 the bounty reward was increased in an attempt to increase the bounty return. By 1973 the northwest Atlantic harbor seal population (excluding Sable Island) had been reduced to an estimated 5500 animals (Boulva and McLaren, 1979). In 1976 the bounty was removed from harbor seals.

In 1967 the government initiated an annual program to cull grey seal breeding concentrations in the Gulf of St. Lawrence, and in 1977 established a grey seal bounty program for the entire east coast. The cull and bounty programs remained in effect until 1984 and 1987 respectively. During the 1967-87 period, the Sable Island component of the grey seal

population increased at an annual rate of over 12% and the total northwest Atlantic population also increased (Stobo and Zwanenburg, 1990; Zwanenburg and Bowen, 1990).

In 1984 a Royal Commission was established to review all aspects pertaining to seals and the sealing industry in Canada (see Anon, 1986). Among other major points, that report highlighted a lack of qualitative or quantitative information on harbor seal populations.

Since the early 1980s, Bay of Fundy fishermen and aquaculturists have reported an increasing incidence of seals disrupting their fishing operations through gear damage and pilfering. These reports, along with the Royal Commission comments, prompted us to conduct surveys for seals throughout the Bay of Fundy using a helicopter. The purpose of the surveys was i) to obtain baseline data on the distribution and abundance of the seals in the Bay of Fundy; ii) to determine if aerial surveys could be successfully used in this region to develop a time series of data to monitor population trends; and iii) based on distribution and abundance, to examine which seal species (harbor or grey) was probably responsible for the depredations in the Bay of Fundy. The last objective was set because juvenile grey seals (1-2 yrs) are the same color (mottled brown) and size as adult harbor seals; and despite fishermen reports of increasing numbers of harbor seals, only the grey seal population has been documented to be increasing (Stobo and Zwanenburg, 1990; Zwanenburg and Bowen, 1990) on the Scotian Shelf.

METHODS

Aerial surveys were conducted by helicopter in 1985, 1986, 1987, 1991, and 1992. A Messerschmidt-Blohm-Bolkow 105 was used in 1985; all subsequent surveys were conducted with a Bell 206 JetRanger. The 1985 survey was conducted in two days (May 15-16th), during the harbor seal pupping season and the beginning of the grey seal moulting season. All subsequent surveys were conducted over a period of four days during the harbor seal moulting period (July-August). In all cases the survey dates bracketed a spring tide. The surveys were generally conducted on clear days within a four-hour window centred on a mid-morning to mid-afternoon low tide. In 1985-87 however a proper window was not always achieved due to helicopter refueling requirements. Also in 1987 due to contraints on the availability of the helicopter, the survey was conducted during both early-morning and late afternoon low tides, with most of the counts being made in the early-morning.

Counts of both harbor and grey seals were made visually, taking the mean of all observations (2-3 observers) per site whenever counts differed. In order to obtain counts of large mixed species groups the helicoper had to hover and circle the concentrations. The seals would sometimes react to change in movement and/or noise and move to the water. In these cases, we concentrated on obtaining a total count; the proportion of each species in the group was then estimated by each observer and averaged. In such cases we suspect some degree of observation error was incurred due to similarities in appearance between adult harbor and juvenile grey seals (same size range), and perhaps between adult grey seals and wet adult harbor seals (from over 400 ft away both appear grey). The number of sites requiring such estimation represented less than 10% of the total number of sites.

The survey area was partitioned in Fig. 1 to provide an appropriate scale to show flight tracks, the geographic locations, and numbers of seals observed. The locations of individual seals or concentrations were recorded (Figs. 2-33) to obtain information on the permanence of haulout sites from year to year. For statistical analysis, counts from each survey were grouped into 21 areas (Fig. 34), based on the locations of major haul-out sites, clusters of sites, or regions containing low numbers of sparsely distributed seals.

The Wilcoxon matched-pairs signed-ranks test was used to examine seasonal, daily, and long-term variations in harbor and grey seal abundance. Paired t-tests were also applied to seal counts to determine the degree of correlation within haul-out areas between surveys. All tests were performed using SPSSx software. We compared spring (1985) versus summer (1986) counts, early morning (1987) versus midday (1986) counts, long-term abundance changes (1986 versus 1991 and 1992), and also did a short-term comparison of abundance changes (1991 versus 1992) to consider between-year differences that might effect contrasts of summer/afternoon 1986 counts with spring/afternoon 1985 or summer/morning 1987 counts. We use the term 'midday' to represent the local time period from 0900 to 1700 hours. An examination of repeated counts for one area in 1992 was also conducted to give some idea of the possible variance associated with a survey of this nature.

Although included in the descriptive analysis (Figs. 2-33), any count at a haul-out site made over two hours plus or minus of low tide was excluded from the area count for statistical analysis (and thus all data for that area within that year was disregarded). Four other counts were

removed prior to analysis due to confounding aspects of their component observations (ie. the 1991 Lobster Bay and Cape Sable Island counts) were accomplished by "jumping" fog patches, and the 1991 Seal Island and 1992 Lobster Bay counts were made during intense seaweed raking activity on the usual haul-out sites). Also excluded were comparisons for which both counts were zero. The number of cases (count pairs) available for analysis varied among contrasts since removal of a count for a given survey and area eliminates its comparison with that area in other years.

RESULTS and DISCUSSION

Figures 2-33 show the flight tracks and numbers of seals observed during all surveys. In 1992 the survey also included Ile Haute at the head of the Bay of Fundy. Although 51 harbor seals and 27 grey seals were counted there they are not included in the present analysis since Ile Haute was not surveyed in other years. Table 1 summarizes the observations for the subareas shown in Figure 34, and includes the date, approximate local times of observations and associated low tides. Both grey and harbor seals species have a tendency to haul-out on small isolated offshore islands and shoals rather than on the mainland coast. Due to the large tidal amplitude in and around the Bay of Fundy (up to 8 meters), the availability of haul-out space on many of these offshore islands changed dramatically during each tidal cycle, and many of the shoals were emergent for only a few hours near low tide. Harbor seals were more often observed on emergent shoals than grey seals, and commonly hauled out on rocks large enough to hold only a single, or a few seals. Harbor seals were also more often found on, or closer to, the mainland coast than grey seals. Generally, the New Brunswick side of the Bay of Fundy supported greater numbers of harbor seals (84% of the total) than the Nova Scotian side. The shoals and islands off the seaward coasts of Grand Manan accounted for 53-60% of harbor seals and 22-97% of grey seals counted during the five surveys. Off the Nova Scotia coast both species were also concentrated around the more offshore islands and shoals. In 1986 and 1992 the concentrations of grey seals off Nova Scotia were most prevalent between Gannet Rock and Seal Island . The combined counts from the offshore areas of Grand Manan and southwest Nova Scotia represent 63-70% of harbor seals and 70-100% of grey seals across all surveys.

The overall changes in abundance of harbor and grey seals in the survey area and on the two sides of the Bay of Fundy are shown in Figure 35. Harbor seals were more numerous than grey seals in all years and almost all areas. The Seal Island area off southwest Nova Scotia (see Fig. 34) was the only exception, where grey seals outnumbered harbor seals in 1986 and 1992. Over the 8-year time period of the surveys, the abundance of harbor seals increased on both sides of the Bay, the greatest increase being observed on the New Brunswick side. The grey seal numbers observed on the New Brunswick side also suggest a sustained though lower increase. But the grey seal counts on the Nova Scotia side were highly variable, such that no overall abundance trend was evident. This variability however may have been more due to confounding factors associated with the survey than changes in abundance. In 1985, the complete survey was conducted during May; the rest of the surveys were conducted in August. In 1987 part of the survey in both New Brunswick and Nova Scotia was conducted during the early morning rather than the mid-morning to mid-afternoon periods of the other surveys due to logistic problems. In 1991 fog obscured some of the area between Yarmouth and Cape Sable preventing counts being made for those areas. This area also has the most fishing boat traffic in the Bay of Fundy and intensive seaweed harvesting occurs around many of the offshore islands. Both activities could substantially increase disturbance of haul-out areas; the harvesting activities were most noticeable during the 1985 and 1991 surveys. The two highest counts of grey seals on the Nova Scotia side occurred in 1986 and 1992, the only years when these factors (fog, fishing vessel activity, seaweed raking) were comparable to the rest of the Bay of Fundy during the survey period. The counts from these two years (Fig. 35) suggest that a greater proportion of grey seals may favor the Nova Scotia side of the Bay in the summer; more research would be required to confirm this possibility.

To examine the potential effect of the timing of surveys on haulout counts, we compared our midday counts in 1986 with the morning counts in 1987 (Table 2) in the same areas (Wilcoxon matched-pairs signed-ranks test). The difference between early morning and mid-morning to mid-afternoon counts for harbour seals ($Z = -1.89$, $p = 0.059$, $n = 10$ cases) was significant at the 0.10 level, suggesting only a slight preference for mid-morning to afternoon haul-out. More intensive studies of isolated groups of harbour seals by Pauli and Terhune (1987) and Kovacs et al. (1990) have found a preference for afternoon low tides in Passamaquoddy Bay, a subsection of our study area. But the relationships can differ between geographically distant areas. For example, Olesiuk et al. (1990) found that harbor seals off the coast of British Columbia prefer to haul out

during morning low tides, and Harvey (1987) found that harbor seals off the Pacific coast of Oregon changed their preference for afternoon or morning haul-out according to proximity to the mainland. The comparison for grey seals in our study ($Z = -0.93$, $p = 0.353$, $n = 7$ cases) was not significant.

To examine the affect of season (ie. spring versus summer) on survey counts we compared the 1985 spring and the 1986 summer numbers (Table 3). The comparison for harbor seals ($Z = -1.68$, $p = 0.093$, $n = 10$ cases) was significant at the 0.10 level, suggesting only a slight preference for summer versus spring haul-out. More substantial support for a summer haul-out preference was found by Thompson and Harwood (1990) off the Orkney Islands, United Kingdom. They noted that over twice as many harbor seals hauled out during summer moulting as during the spring pupping period. This peak in haul-out abundance during the moulting period was also noted for harbor seals off California (Stewart and Yochem, 1984). The comparison for grey seals in our study ($Z = -1.36$, $p = 0.173$, $n = 6$ cases) was not significant.

Linear regression of annual counts by species was initially used to examine potential trends in overall abundance. A strong positive correlation ($r^2 = 0.863$, $p = 0.02$) with time in the harbor seal counts (Fig. 35) demonstrates a significant increase in abundance over the 8-year period of the surveys. No significant trend was found ($r^2 = 0.402$, $p = 0.25$) with the grey seal counts. But as noted above, there were confounding factors associated with the surveys. The lowest counts in the 5-year series for both species were associated with surveys conducted in 1985 (spring period) and 1987 (morning counts). Further, in 1991 fog obscured part of the southwest Nova Scotia area, thereby reducing the count of both species in that area. The counts of harbor seals would have been less affected by fog off southwest Nova Scotia than grey seal counts since harbor seals tend to be concentrated on the New Brunswick side of the Bay of Fundy. In the case of grey seals, the counts in 1985, 1987 and 1991 were the lowest of the 5 surveys (Fig. 35) and may account for the lack of a significant trend.

Due to the potential confounding effect of the 1985 (spring survey) and the 1987 (morning survey) on overall abundance estimates, we also examined long-term changes in seal abundance by comparing the 1986 counts with that of 1991 and 1992. The comparisons for harbor seals between 1986 and 1991 (Table 4; $Z = -2.67$, $p = 0.008$, $n = 15$ cases) and between 1986 and 1992 (Table 5; $Z = -3.41$, $p = 0.001$, $n = 16$ cases) were both highly significant, indicating that harbor seal abundance in the vicinity of the Bay of Fundy increased significantly during the 1986 to

1992 period. The results for the grey seal comparisons were not conclusive. The 1986 to 1991 comparison (Table 4; $Z = -2.01$, $p = 0.045$, $n = 14$ cases) indicated a significant increase in the areas compared, but contrasts with the regression analysis which indicates no change between 1986 and 1991. This difference may be explained by the confounding effects of fog and seaweed harvesting activities which would have biased 1991 counts downwards. For the Wilcoxon test, the applicable subarea count pairs were removed from both 1986 and 1991 due to this biasing, but all counts were retained in the regression analysis. The comparison for grey seals between 1986 and 1992 (Table 5; $Z = -1.18$, $p = 0.239$, $n = 12$ cases) showed no significant difference. Although other studies (Stobo and Zwanenburg, 1990; Zwanenburg and Bowen, 1990) indicate an overall increase in the northwest Atlantic grey seal population during this period, the 1986 and 1991/92 Bay of Fundy comparisons are inconclusive in demonstrating a similar increase in the Bay of Fundy area. The short-term comparison between 1991 and 1992 (Table 6) also indicates a significant increase ($Z = -2.44$, $p = 0.015$, $n = 15$ cases) for harbor seals, but no significant change ($Z = -1.35$, $p = 0.177$, $n = 14$ cases) for grey seals. The 'matched-pairs' comparison again is in apparent contradiction with the overall abundance counts for grey seals (Fig. 35) which showed an overall increase between 1991 and 1992.

The apparent contradictions between the overall grey seal abundance estimates (Fig. 35) and the 'matched pairs' comparisons may indicate a short-coming of the survey procedure for estimating grey seal abundance. Temporary disturbance of haul-out areas could have three effects: 1) seals may leave the area temporarily or permanently, 2) they may resort to an aquatic existence until the disturbance factor is removed, or 3) they may move to adjacent haulout areas. The first two effects would result in a reduced overall abundance estimate for the year in question; the third effect would inflate the counts in adjacent subareas, thereby having limited effect on the overall abundance estimate, but confounding attempts to use 'matched pairs' testing techniques. This confounding would be particularly strong in years when coupled with other factors, such as fog, which prevented counting of the disturbed areas; areas affected by fog and disturbance would be eliminated from 'matched pairs' testing while the remaining subareas (with haulout counts inflated by disturbance factors) would be compared with those same subareas in years of normal abundance conditions. The consistency in the results of the regression analysis of the harbor seal abundance trend with the 'matched pairs' comparisons suggest that the harbor seal estimates are not as susceptible to confounding influences as the grey seal estimates. The fact that only a small proportion of the overall abundance of harbor seals

are found off southwest Nova Scotia may partially explain the reduced susceptibility.

During the surveys, harbor seals and grey seals appeared to show preference for certain haulout sites or areas. Correlation coefficients (Table 7) derived from comparing the numbers of each species observed in each of the subareas (Fig. 34) between years demonstrated very consistent haul-out site preferences for harbor seals. Grey seals demonstrated no preferences in haulout sites between spring and summer or early morning and mid-morning to mid-afternoon surveys, and only a weak preference for the same sites in comparisons between 1991 and either 1986 or 1992 counts. A strong correlation for grey seal site preference was noted however when the 1986 and 1992 surveys were compared. Again, the confounding factors associated with the grey seal counts off southwest Nova Scotia may be the cause of non-conclusive results for grey seals. This leads us to believe that the offshore sites on the Nova Scotian side of the Bay of Fundy may be crucial to obtaining a reliable index of grey seal population status in the area.

An initial estimate of within-year survey variation was obtained by conducting six repeat counts of the Musquash area in 1992 during the survey period. The standard error for the harbor and grey seal counts was 6.0 (mean 140.8, range 128-168) and 3.9 (mean 11.3, range 0-25) respectively. The high coefficient of variation for the grey seal counts (0.35), if at all representative of survey counts elsewhere, would explain the lack of significance in site preference for grey seals. Conversely, the coefficient of variation for harbor seals was low (0.04), corresponding with the significant site preference shown across years and supporting our other analyses indicating the general suitability of the survey method for harbor seals.

At this time, the surveys provide evidence only of a positive increase in numbers for Bay of Fundy harbor seal populations. Given the potentially confounding factors discussed above, it would not be appropriate to make any assumptions on trends in grey seal numbers in the area. It would also be inappropriate to use the harbor seal numbers as reliable quantitative estimates of abundance, although they are most likely minimums. Although a positive trend in numbers is indicated, it would also be inappropriate to assume that the rate of increase observed could be used as a quantitative estimate. We do not have variance estimates for the study area as a whole nor variance estimates associated with individual site counts. A number of the subareas also had to be excluded from the statistical calculations due to the counts being conducted outside of the the

window around low tide and some of the seals in the area would not be hauled out at the time of the overflight, thus reducing the chances of an accurate total count being achieved Further, roughly half of the 1991 and 1992 counts used in the analysis were made on the weekend. Harvey (1987) observed that the inclination of harbor seals off Oregon to haul-out inshore was altered on the basis of weekdays (more likely) and weekends (less likely), attributing this difference to the greater probability of human disturbance on weekends. If the same bias exists with respect to the Bay of Fundy, then our 1991 and 1992 tallies and the long-term trend could be underestimated.

Two aspects of our census methods, related to haul-out behavior of seals during the four hour window centred on low tide, could not be addressed with the present data. Although only census numbers obtained during the 4-hour window were used in the statistical calculations, between years some sites were surveyed before versus after low tide or earlier or later in the time window. Olesiuk et al. (1990) found that the tendency of seals to abandon haul-out sites upon approach of an airplane was greater towards the end of the survey window, when the animals were already predisposed to return to the water, while abandonment was rare during pre-low tide counts. We perceived a similar tendency while flying the surveys, but were unable to quantify potential effects within the scope of this study. Any progressive change in the numbers of seals hauling-out as low tide approaches or recedes or any systematic difference in the number of seals hauled-out on a falling tide versus a rising tide could influence results. A detailed analysis of haul-out behavior during the 4-hour period around low tide using repeated measures of the same sites would be necessary to address these concerns.

CONCLUSIONS

An increase in the harbor seal population in and around the Bay of Fundy from 1986 to 1991 is evident, but the rate of that growth, and the current population size, remain unknown. No trend in grey seal numbers could be determined. For the purpose of deriving estimates of population growth rates the major preferred haul-out sites have been identified for both harbor and grey seals. The reliability of helicopter surveys of harbor seals in the region have been ascertained; the reliability for grey seals is not as certain, largely due to the potential effects of uncontrollable confounding factors. The location of prime haul-out site for both species deep in bays or on scattered offshore islands suggest fixed wing aircraft surveys, or transect surveys would be poor substitutes for helicopter

surveys. Future surveys should be conducted in late July-early August on sunny days between 1000 and 1600 EST, and restricted to a limited time window bracketing low tide. Following more research on haul-out behavior around low tide, reconsideration should be given to the duration and positioning of the survey window around low tide. In deference to the results of other seal census studies it may also be advisable to restrict survey flights to weekdays.

It should be emphasized that realization of the preceding survey method objectives could provide population growth rate estimates but not quantifiable abundance estimates. To obtain abundance estimates would necessitate that at least one year be surveyed extensively enough to derive a base minimum population estimate to which subsequent growth rate estimates could be applied. This survey would require within-areas count redundancy to determine sampling variance and identify outliers, and photographic truthing of visual counts to establish observation error factors. Thompson and Harwood (1990) found that visual counts accounted for only 73% of photographic counts (89% if under 100 animals, 67% if over 100), but individual observer error distributions have "unique" characteristics that should be clarified if this survey method was to be used as a monitoring tool. Repeated observations per area over several days should resolve basic concerns associated with time of day or tidal cycle, plus give the annual estimates some robustness against outliers caused by human disturbance prior to an overflight, or counts made under suboptimal weather conditions (e.g. sunny but hazy, sunny with occasional patch fog, sunny but cooler, etc.).

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Table 1a. Counts and associated data of grey and harbour seals for 1985, as summarized for analysis into the areas depicted in Figure 2. Area designations are QH_ = Quaco Head; SJH = Saint John Harbour; MUS = Musquash Head; PMQ = Passamaquoddy Bay; DCI = Deer and Campobello Islands; WQH = West Quoddy Head; WGM = Western Grand Manan; SGM = Southern Grand Manan; MSI = Machias Seal Island; GRB = Gannet Rock (New Brunswick); DN_ = Digby Neck; SMB = St. Mary's Bay; BI_ = Brier Island; SWN = Southwest Nova Scotia; GRS = Gannet Rock (Nova Scotia); SI_ = Seal Island; LB_ = Lobster Bay; CSI = Cape Sable Island; and SS_ = South Shore.

Province	General Region	Area	Date	Weekday	Time	Low Tide	Harbour	Grey
N.B.	Inner Bay of Fundy	QH_	'85 May 15	Wednesday	10:45	15:00	0	0
		SJH	'85 May 15	Wednesday	11:25	15:00	15	0
		MUS	'85 May 15	Wednesday	14:15	15:00	63	0
		Subtotal					78	0
	Passamaquoddy	MBW	'85 May 15	Wednesday	16:20	15:00	0	0
		PMQ	'85 May 15	Wednesday	17:30	15:00	0	0
		DCI	'85 May 15	Wednesday	17:10	15:00	1	0
		WQH	'85 May 15	Wednesday	17:00	15:00	51	0
		Subtotal					52	0
	Grand Manan	WGM	'85 May 15	Wednesday	14:30	15:00	12	0
		SGM	'85 May 15	Wednesday	15:15	15:00	128	11
		MSI	'85 May 15	Wednesday	14:40	15:00	88	35
		GRB	'85 May 15	Wednesday	14:55	15:00	170	27
		Subtotal					398	73
		TOTAL N.B.					528	73
N.S.	Bay of Fundy	DN_	'85 May 16	Thursday	13:05	15:00	40 (11 pups)	0
		SMB	'85 May 16	Thursday	13:30	15:00	0	0
		BI_	'85 May 16	Thursday	15:30	15:00	71	0
		SWN	'85 May 16	Thursday	13:50	14:00	0	0
		Subtotal					111	0
	Southwest Coast	GRS	'85 May 16	Thursday	14:15	14:00	0	0
		SI_	'85 May 16	Thursday	16:15	14:00	75	2
		LB_	'85 May 16	Thursday	16:45	14:00	0	0
		CSI	'85 May 16	Thursday	16:30	14:00	11	0
		SS_	'85 May 16	Thursday	18:00	14:00	6	0
		Subtotal					92	2
		TOTAL N.S.					203	2
		GRAND TOTAL FOR 1985					731	75

Table 1b. Counts and associated data of grey and harbour seals for 1986, as summarized for analysis into the areas depicted in Figure 2. Area designations are QH_ = Quaco Head; SJH = Saint John Harbour; MUS = Musquash Head; MBW = Maces Bay & Wolves; PMQ = Passamaquoddy Bay; DCI = Deer and Campobello Islands; WQH = West Quoddy Head; WGM = Western Grand Manan; SGM = Southern Grand Manan; EGM = Eastern Grand Manan, MSI = Machias Seal Island; GRB = Gannet Rock (New Brunswick); DN_ = Digby Neck; SMB = St. Mary's Bay; BI_ = Brier Island; SWN = Southwest Nova Scotia; GRS = Gannet Rock (Nova Scotia); SI_ = Seal Island; LB_ = Lobster Bay; CSI = Cape Sable Island; and SS_ = South Shore.

Province	General Region	Area	Date	Weekday	Time	Low Tide	Harbour	Grey
N.B.	Inner Bay of Fundy	QH_	'86 Aug 12	Tuesday	08:50	11:05	28	0
		SJH	'86 Aug 12	Tuesday	09:40	11:05	54	0
		MUS	'86 Aug 12	Tuesday	09:50	11:05	82	0
		MBW	'86 Aug 12	Tuesday	10:00	11:05	56	0
		Subtotal					220	0
	Passamaquoddy	PMQ	'86 Aug 13	Wednesday	10:35	12:05	46	0
		DCI	'86 Aug 13	Wednesday	11:05	12:05	63	5
		WQH	'86 Aug 13	Wednesday	11:20	12:05	151	21
		Subtotal					260	26
	Grand Manan	WGM	'86 Aug 12	Tuesday	10:50	11:05	23	0
		EGM	'86 Aug 12	Tuesday	12:15	11:05	241	35
		SGM	'86 Aug 12	Tuesday	12:15	11:05	233	36
		MSI	'86 Aug 12	Tuesday	11:05	11:05	216	24
		GRB	'86 Aug 12	Tuesday	11:15	11:05	212	31
		Subtotal					925	126
		TOTAL N.B.					1405	152
N.S.	Bay of Fundy	DN_	'86 Aug 14	Thursday	11:15	12:45	14	0
		SMB	'86 Aug 14	Thursday	11:50	12:45	3	1
		BI_	'86 Aug 14	Thursday	11:30	12:45	9	4
		SWN	'86 Aug 14	Thursday	12:15	11:40	0	0
		Subtotal					26	5
	Southwest Coast	GRS	'86 Aug 14	Thursday	12:45	11:40	105	66
		SI_	'86 Aug 15	Friday	11:15	12:20	29	220
		LB_	'86 Aug 15	Friday	12:15	12:45	2	8
		CSI	'86 Aug 15	Friday	11:45	11:50	8	87
		SS_	'86 Aug 15	Friday	13:45	11:20	0	33
		Subtotal					144	414
		TOTAL N.S.					170	419
		GRAND TOTAL FOR 1986					1575	571

Table 1c. Counts and associated data of grey and harbour seals for 1987, as summarized for analysis into the areas depicted in Figure 2. Area designations are QH_ = Quaco Head; SJH = Saint John Harbour; MUS = Musquash Head; MBW = Maces Bay & Wolves; PMQ = Passamaquoddy Bay; DCI = Deer and Campobello Islands; WQH = West Quoddy Head; WGM = Western Grand Manan; SGM = Southern Grand Manan; EGM = Eastern Grand Manan, MSI = Machias Seal Island; GRB = Gannet Rock (New Brunswick); DN_ = Digby Neck; SMB = St. Mary's Bay; BI_ = Brier Island; SWN = Southwest Nova Scotia; GRS = Gannet Rock (Nova Scotia); SI_ = Seal Island; LB_ = Lobster Bay; CSI = Cape Sable Island; and SS_ = South Shore.

Province	General Region	Area	Date	Weekday	Time	Low Tide	Harbour	Grey
N.B.	Inner Bay of Fundy	QH_	'87 Aug 10	Monday	16:45	18:00	36	0
		SJH	'87 Aug 10	Monday	17:15	18:00	22	1
		MUS	'87 Aug 11	Tuesday	06:30	07:00	45	0
		MBW	'87 Aug 11	Tuesday	06:50	07:00	12	1
		Subtotal					115	2
	Passamaquoddy	PMQ	'87 Aug 11	Tuesday	19:15	19:00	80	0
		DCI	'87 Aug 11	Tuesday	18:15	19:00	19	0
		WQH	'87 Aug 11	Tuesday	18:00	19:00	14	0
		Subtotal					113	0
	Grand Manan	WGM	'87 Aug 11	Tuesday	07:20	07:00	9	0
		EGM	'87 Aug 11	Tuesday	09:00	07:00	41	0
		SGM	'87 Aug 11	Tuesday	09:00	07:00	195	0
		MSI	'87 Aug 11	Tuesday	07:30	07:00	104	156
		GRB	'87 Aug 11	Tuesday	07:45	07:00	197	19
		Subtotal					546	175
		TOTAL N.B.					774	177
N.S.	Bay of Fundy	DN_	'87 Aug 12	Wednesday	07:00	07:00	2	0
		SMB	'87 Aug 12	Wednesday	08:00	07:00	2	0
		BI_	'87 Aug 12	Wednesday	07:30	07:00	0	0
		SWN	'87 Aug 12	Wednesday	09:00	06:00	0	0
		Subtotal					4	0
	Southwest Coast	GRS	'87 Aug 12	Wednesday	09:15	06:00	76	2
		SI_	'87 Aug 12	Wednesday	09:30	06:00	28	33
		LB_	'87 Aug 13	Thursday	06:30	07:00	8	4
		CSI	'87 Aug 13	Thursday	07:30	07:00	29	20
		SS_	'87 Aug 13	Thursday	10:00	07:00	3	0
		Subtotal					144	59
		TOTAL N.S.					148	59
		GRAND TOTAL FOR 1987					922	236

Table 1d. Counts and associated data of grey and harbour seals for 1991, as summarized for analysis into the areas depicted in Figure 2. Area designations are QH_ = Quaco Head; SJH = Saint John Harbour; MUS = Musquash Head; MBW = Maces Bay & Wolves; PMQ = Passamaquoddy Bay; DCI = Deer and Campobello Islands; WQH = West Quoddy Head; WGM = Western Grand Manan; SGM = Southern Grand Manan; EGM = Eastern Grand Manan, MSI = Machias Seal Island; GRB = Gannet Rock (New Brunswick); DN_ = Digby Neck; SMB = St. Mary's Bay; BI_ = Brier Island; SWN = Southwest Nova Scotia; GRS = Gannet Rock (Nova Scotia); SI_ = Seal Island; LB_ = Lobster Bay; CSI = Cape Sable Island.

Province	General Region	Area	Date	Weekday	Time	Low Tide	Harbour	Grey
N.B.	Inner Bay of Fundy	QH_	'91 Jul 21	Sunday	13:15	13:45	59	5
		SJH	'91 Jul 21	Sunday	13:40	13:45	104	10
		MUS	'91 Jul 21	Sunday	13:45	13:45	103	11
		MBW	'91 Jul 21	Sunday	14:00	13:45	99	11
		Subtotal					365	37
	Passamaquoddy	PMQ	'91 Jul 20	Saturday	13:30	12:50	85 (1 pup)	0
		DCI	'91 Jul 20	Saturday	13:00	12:50	85	10
		WQH	'91 Jul 20	Saturday	14:35	12:50	79	11
		Subtotal					249	21
	Grand Manan	WGM	'91 Jul 21	Sunday	14:45	13:45	58	7
		EGM	'91 Jul 22	Monday	14:30	14:40	232	41 (6 pups)
		SGM	'91 Jul 22	Monday	14:30	14:40	540	70 (3 pups)
		MSI	'91 Jul 21	Sunday	15:10	13:45	395	95
		GRB	'91 Jul 21	Sunday	15:20	13:45	324	75
		Subtotal					1549	288
		TOTAL N.B.					2163	346
N.S.	Bay of Fundy	DN_	'91 Jul 22	Monday	12:55	13:30	28	8
		SMB	'91 Jul 22	Monday	13:30	13:30	13	3
		BI_	'91 Jul 22	Monday	13:10	13:30	63	7
		SWN	'91 Jul 24	Wednesday	18:00	15:10	0	0
		Subtotal					115	18
	Southwest Coast	GRS	'91 Jul 24	Wednesday	16:45	15:10	165	15
		SI_	'91 Jul 24	Wednesday	16:00	15:10	43	9
		LB_	'91 Jul 24	Wednesday	14:00	15:10	0	0
		CSI	'91 Jul 24	Wednesday	15:45	15:10	6	6
		Subtotal					214	30
		TOTAL N.S.					329	48
		GRAND TOTAL FOR 1991					2492	394

Table 1e. Counts and associated data of grey and harbour seals for 1992, as summarized for analysis into the areas depicted in Figure 2. Area designations are QH_ = Quaco Head; SJH = Saint John Harbour; MUS = Musquash Head; MBW = Maces Bay & Wolves; PMQ = Passamaquoddy Bay; DCI = Deer and Campobello Islands; WQH = West Quoddy Head; WGM = Western Grand Manan; SGM = Southern Grand Manan; EGM = Eastern Grand Manan, MSI = Machias Seal Island; GRB = Gannet Rock (New Brunswick); DN_ = Digby Neck; SMB = St. Mary's Bay; BI_ = Brier Island; SWN = Southwest Nova Scotia; GRS = Gannet Rock (Nova Scotia); SI_ = Seal Island; LB_ = Lobster Bay; CSI = Cape Sable Island.

Province	General Region	Area	Date	Weekday	Time	Low Tide	Harbour	Grey
N.B.	Inner Bay of Fundy	QH	'92 Aug 7	Friday	15:25	13:55	57	0
		SJH	'92 Aug 6	Thursday	11:10	12:50	92	0
		MUS	'92 Aug 6	Thursday	11:15	12:50	136	0
		MBW	'92 Aug 7	Friday	13:00	13:55	152	5
		Subtotal					437	5
	Passamaquoddy	PMQ	'92 Aug 7	Friday	14:30	13:55	129	0
		DCI	'92 Aug 7	Friday	13:20	13:55	132	0
		WQH	'92 Aug 7	Friday	13:35	13:55	200	19
		Subtotal					461	19
	Grand Manan	WGM	'92 Aug 6	Thursday	13:15	12:50	36	0
		EGM	'92 Aug 6	Thursday	12:10	12:50	482	31
		SGM	'92 Aug 6	Thursday	12:40	12:50	554	48
		MSI	'92 Aug 6	Thursday	12:55	12:50	408	45
		GRB	'92 Aug 6	Thursday	12:35	12:50	535	65
		Subtotal					2015	189
		TOTAL N.B.					2813	213
N.S.	Bay of Fundy	DN_	'92 Aug 9	Sunday	14:25	14:45	90	96
		SMB	'92 Aug 9	Sunday	13:20	14:45	3	0
		BI_	'92 Aug 9	Sunday	14:05	14:45	15	5
		SWN	'92 Aug 9	Sunday	12:45	14:45	0	0
		Subtotal					108	101
	Southwest Coast	GRS	'92 Aug 8	Saturday	12:10	13:40	158	49
		SI	'92 Aug 8	Saturday	12:40	13:40	115	254
		LB_	'92 Aug 8	Saturday	14:00	13:40	16	0
		CSI	'92 Aug 8	Saturday	13:15	13:40	224	82
		Subtotal					513	385
		TOTAL N.S.					621	486
		GRAND TOTAL FOR 1992					3534	699

Table 2. Summary of contributing counts, Wilcoxon matched-pairs signed-ranks tests and site* correlation coefficients for daily contrasts of abundances of harbour and grey seals in the Bay of Fundy area.

SPECIES	CENSUS AREAS (PROVINCE)	MORNING 1987 SEAL COUNTS	MIDDAY 1986 SEAL COUNTS	NO. CASES	Z TEST	P_z	SITE CORR. COEFF.	P
	MUS (N.B.)	45	82					
	MBW (N.B.)	12	56					
	WGM (N.B.)	9	23					
HARBOUR	MSI (N.B.)	104	216					
SEALS	GRB (N.B.)	197	212					
	DN_ (N.S.)	2	14					
	SMB (N.S.)	2	3					
	BI_ (N.S.)	0	9					
	LB_ (N.S.)	8	2					
	CSI (N.S.)	29	8					
Mean		40.8	62.5	10	-1.89	0.059	0.911	0.000
Stan. Err.		20.0	26.5					
	MBW (N.B.)	1	0					
	MSI (N.B.)	156	24					
GREY	GRB (N.B.)	19	31					
SEALS	SMB (N.S.)	0	1					
	BI_ (N.S.)	0	4					
	LB_ (N.S.)	4	8					
	CSI (N.S.)	20	87					
Mean		28.6	22.1	7	-0.93	0.353	0.159	0.734
Stan. Err.		21.5	11.7					

* Site designations are MUS = Musquash Head; MBW = Maces Bay & Wolves; WGM = Western Grand Manan; MSI = Machias Seal Island; GRB = Gannet Rock (New Brunswick); DN_ = Digby Neck; SMB = St. Mary's Bay; BI_ = Brier Island; LB_ = Lobster Bay; CSI = Cape Sable Island.

Table 3. Summary of contributing counts, Wilcoxon matched-pairs signed-ranks tests and site* correlation coefficients for seasonal contrasts of abundances of harbour and grey seals in the Bay of Fundy area.

SPECIES	CENSUS AREAS (PROVINCE)	SPRING 1985 SEAL COUNTS	SUMMER 1986 SEAL COUNTS	NO. CASES	Z TEST	P_E	SITE CORR. COEFF.	P
HARBOUR SEALS	MUS (N.B.)	63	82					
	MBW (N.B.)	0	56					
	WGM (N.B.)	12	9					
	SGM (N.B.)	128	233					
	MSI (N.B.)	88	216					
	GRB (N.B.)	170	212					
	DN_ (N.S.)	40	14					
	SMB (N.S.)	0	3					
	BI_ (N.S.)	71	9					
	GRS (N.S.)	0	105					
Mean		57.2	95.3	10	-1.68	0.093	0.758	0.011
Stan. Err.		18.6	29.2					
GREY SEALS	SGM (N.B.)	11	36					
	MSI (N.B.)	35	24					
	GRB (N.B.)	27	31					
	SMB (N.S.)	0	1					
	BI_ (N.S.)	0	4					
	GRS (N.S.)	0	66					
Mean		12.2	27.0	6	-1.36	0.173	0.056	0.917
Stan. Err.		6.3	9.7					

* Site designations are MUS = Musquash Head; MBW = Maces Bay & Wolves; WGM = Western Grand Manan; SGM = Southern Grand Manan; MSI = Machias Seal Island; GRB = Gannet Rock (New Brunswick); DN_ = Digby Neck; SMB = St. Mary's Bay; BI_ = Brier Island; GRS = Gannet Rock (Nova Scotia).

Table 4. Summary of contributing counts, Wilcoxon matched-pairs signed-ranks tests and site* correlation coefficients for long-term 1986/1991 contrasts of abundances of harbour and grey seals in the Bay of Fundy area.

SPECIES	CENSUS AREAS (PROVINCE)	1986 SEAL COUNTS	1991 SEAL COUNTS	NO. CASES	Z TEST	P_z	SITE CORR. COEFF.	P
HARBOUR SEALS	SJH (N.B.)	54	104	15	-2.67	0.008	0.859	0.000
	MUS (N.B.)	82	103					
	MBW (N.B.)	56	99					
	PMQ (N.B.)	46	85					
	DCI (N.B.)	63	85					
	WQH (N.B.)	151	79					
	WGM (N.B.)	23	58					
	EGM (N.B.)	241	232					
	SGM (N.B.)	233	540					
	MSI (N.B.)	216	395					
	GRB (N.B.)	212	324					
	DN_ (N.S.)	14	28					
	SMB (N.S.)	3	13					
	BI_ (N.S.)	9	63					
	GRS (N.S.)	105	165					
Mean		100.5	158.2					
Stan. Err.		22.5	38.9					
GREY SEALS	SJH (N.B.)	0	10	14	-2.01	0.045	0.484	0.080
	MUS (N.B.)	0	11					
	MBW (N.B.)	0	11					
	DCI (N.B.)	5	10					
	WQH (N.B.)	21	11					
	WGM (N.B.)	0	7					
	EGM (N.B.)	35	41					
	SGM (N.B.)	36	70					
	MSI (N.B.)	24	95					
	GRB (N.B.)	31	75					
	DN_ (N.S.)	0	8					
	SMB (N.S.)	1	3					
	BI_ (N.S.)	4	7					
	GRS (N.S.)	66	15					
Mean		15.9	26.7					
Stan. Err.		5.4	8.2					

Site designations are SJH = Saint John Harbour; MUS = Musquash Head; MBW = Maces Bay & Wolves; PMQ = Passamaquoddy Bay; DCI = Deer and Campobello Islands; WQH = West Quoddy Head; WGM = Western Grand Manan; SGM = Southern Grand Manan; EGM = Eastern Grand Manan, MSI = Machias Seal Island; GRB = Gannet Rock (New Brunswick); DN_ = Digby Neck; SMB = St. Mary's Bay; BI_ = Brier Island; GRS = Gannet Rock (Nova Scotia).

Table 5. Summary of contributing counts, Wilcoxon matched-pairs signed-ranks tests and site* correlation coefficients for long-term 1986/1992 contrasts of abundances of harbour and grey seals in the Bay of Fundy area.

SPECIES	CENSUS AREAS (PROVINCE)	1986 SEAL COUNTS	1992 SEAL COUNTS	NO. CASES	Z TEST	P_z	SITE CORR. COEFF.	P
HARBOUR SEALS	SJH (N.B.)	54	92	16	-3.41	0.001	0.914	0.000
	MUS (N.B.)	82	136					
	MBW (N.B.)	56	152					
	PMQ (N.B.)	46	129					
	DCI (N.B.)	63	132					
	WQH (N.B.)	151	200					
	WGM (N.B.)	23	36					
	EGM (N.B.)	241	482					
	SGM (N.B.)	233	554					
	MSI (N.B.)	216	408					
	GRB (N.B.)	212	535					
	DN_ (N.S.)	14	90					
	SMB (N.S.)	3	3					
	GRS (N.S.)	105	158					
	SI_ (N.S.)	29	115					
	CSI (N.S.)	8	224					
Mean		96.0	215.4					
Stan. Err.		21.5	44.3					
GREY SEALS	MBW (N.B.)	0	5	12	-1.18	0.239	0.898	0.000
	DCI (N.B.)	5	0					
	WQH (N.B.)	21	19					
	EGM (N.B.)	35	31					
	SGM (N.B.)	36	48					
	MSI (N.B.)	24	45					
	GRB (N.B.)	31	65					
	DN_ (N.S.)	0	96					
	SMB (N.S.)	1	0					
	GRS (N.S.)	66	49					
	SI_ (N.S.)	220	254					
	CSI (N.S.)	87	82					
Mean		43.8	57.8					
Stan. Err.		17.8	20.0					

* Site designations are SJH = Saint John Harbour; MUS = Musquash Head; MBW = Maces Bay & Wolves; PMQ = Passamaquoddy Bay; DCI = Deer and Campobello Islands; WQH = West Quoddy Head; WGM = Western Grand Manan; SGM = Southern Grand Manan; EGM = Eastern Grand Manan, MSI = Machias Seal Island; GRB = Gannet Rock (New Brunswick); DN_ = Digby Neck; SMB = St. Mary's Bay; GRS = Gannet Rock (Nova Scotia); SI_ = Seal Island; CSI = Cape Sable Island.

Table 6. Summary of contributing counts, Wilcoxon matched-pairs signed-ranks tests and site* correlation coefficients for inter-annual 1991/1992 contrasts of abundances of harbour and grey seals in the Bay of Fundy area.

SPECIES	CENSUS AREAS (PROVINCE)	1991 SEAL COUNTS	1992 SEAL COUNTS	NO. CASES	Z TEST	P_z	SITE CORR. COEFF.	P
HARBOUR SEALS	QH_ (N.B.)	59	57					
	SJH (N.B.)	104	92					
	MUS (N.B.)	103	136					
	MBW (N.B.)	99	152					
	PMQ (N.B.)	85	129					
	DCI (N.B.)	85	132					
	WQH (N.B.)	79	200					
	WGM (N.B.)	58	36					
	EGM (N.B.)	232	482					
	SGM (N.B.)	540	554					
	MSI (N.B.)	395	408					
	GRB (N.B.)	324	535					
	DN_ (N.S.)	28	90					
	SMB (N.S.)	13	3					
	GRS (N.S.)	165	158					
Mean		96.0	215.4	16	-3.41	0.001	0.914	0.000
Stan. Err.		21.5	44.3					
GREY SEALS	QH_ (N.B.)	5	0					
	SJH (N.B.)	10	0					
	MUS (N.B.)	11	0					
	MBW (N.B.)	11	5					
	DCI (N.B.)	10	0					
	WQH (N.B.)	11	19					
	WGM (N.B.)	7	0					
	EGM (N.B.)	41	31					
	SGM (N.B.)	70	48					
	MSI (N.B.)	95	45					
	GRB (N.B.)	75	65					
	DN_ (N.S.)	8	96					
	SMB (N.S.)	3	0					
	GRS (N.S.)	15	49					
Mean		43.8	57.8	12	-1.18	0.239	0.898	0.000
Stan. Err.		17.8	20.0					

* Site designations are QH_ = Quaco Head; SJH = Saint John Harbour; MUS = Musquash Head; MBW = Maces Bay & Wolves; PMQ = Passamaquoddy Bay; DCI = Deer and Campobello Islands; WQH = West Quoddy Head; WGM = Western Grand Manan; SGM = Southern Grand Manan; EGM = Eastern Grand Manan, MSI = Machias Seal Island; GRB = Gannet Rock (New Brunswick); DN_ = Digby Neck; SMB = St. Mary's Bay; GRS = Gannet Rock (Nova Scotia).

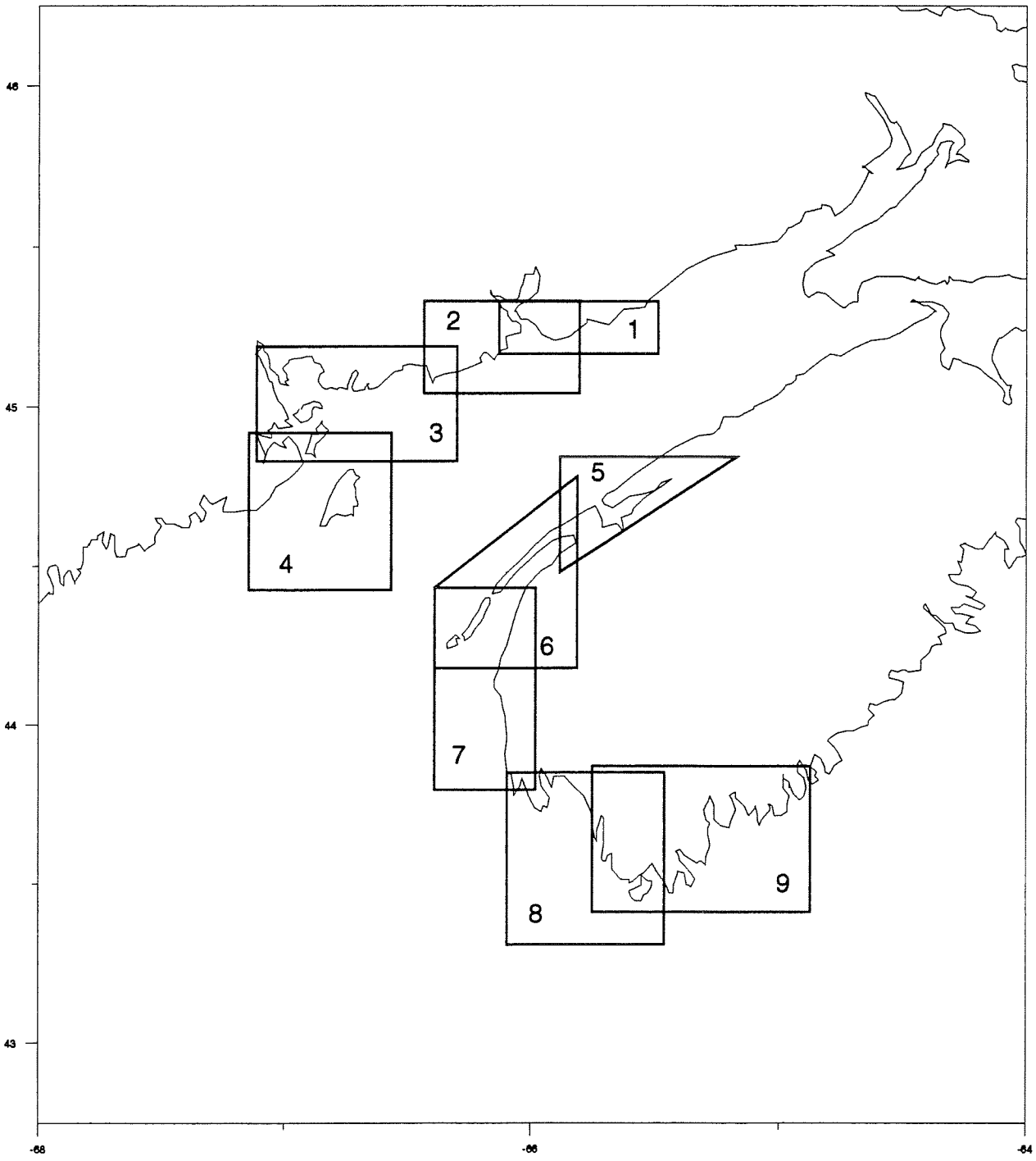

Figure 1. The Bay of Fundy and vicinity surveyed by helicopter between 1985 and 1992. The survey area was partitioned into 9 sections to portray discrete seal sightings and details of flight coverage.

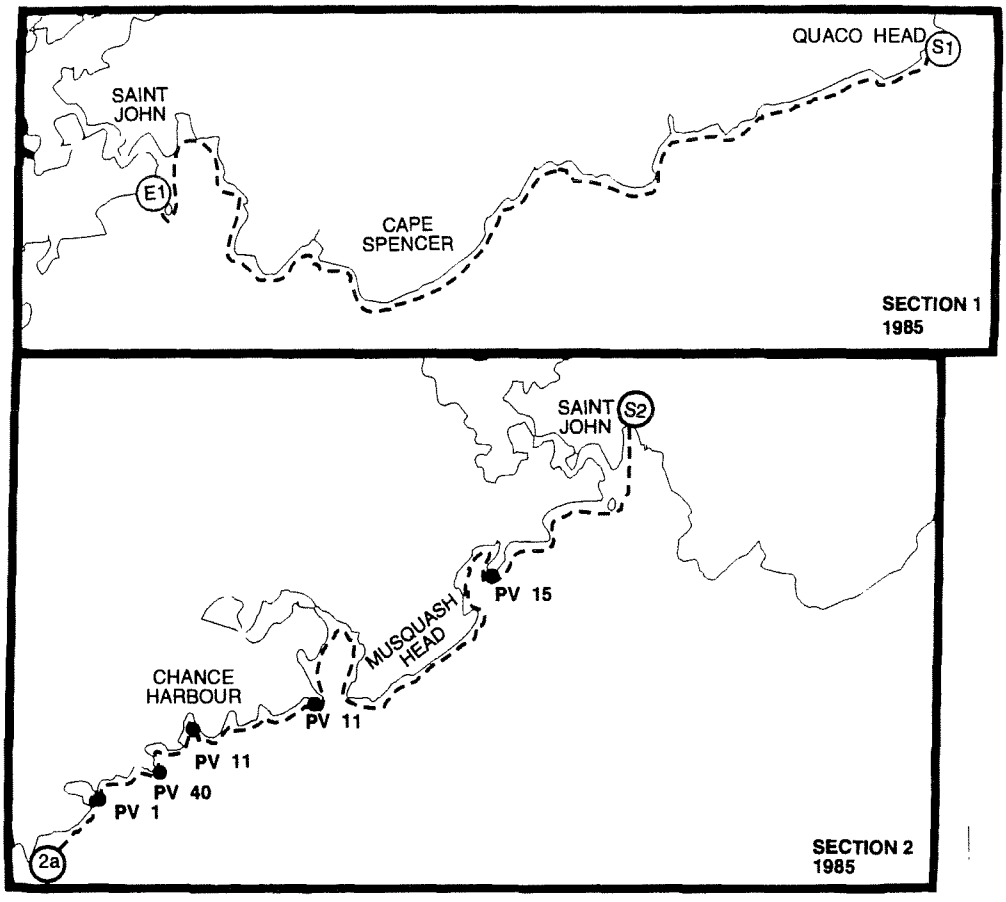

Figure 2. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1985, in sections 1 and 2 of the study area, on days 1 and 2 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbol 2a marks the point at which the track for survey day 2 is split between Figures 2 and 3 covering the first and second legs of that flight.

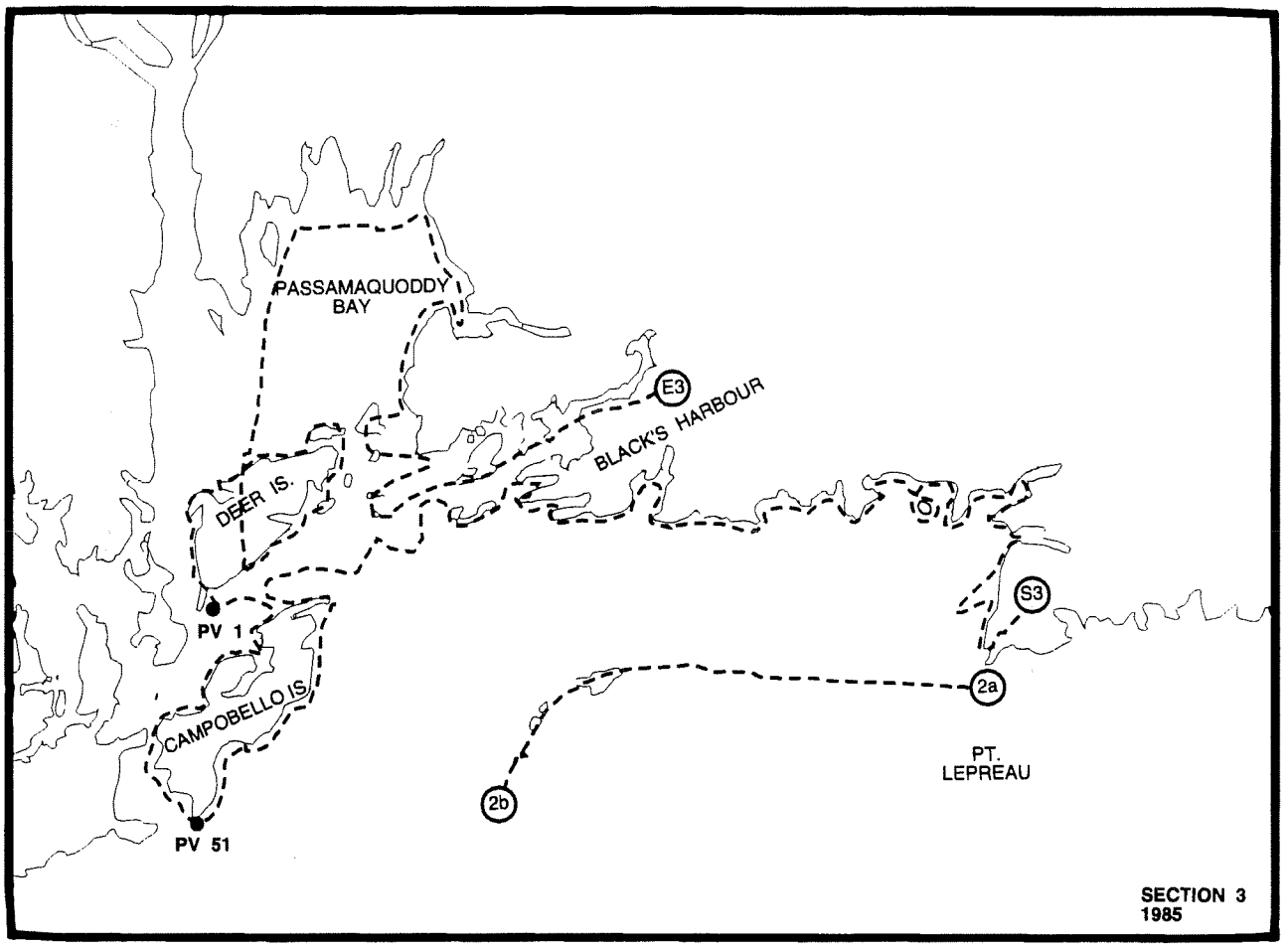

Figure 3. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1985, in section 3 of the study area, on days 2 and 3 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 2a and 2b mark the points where the track for survey day 2 is split between Figures 2, 3, and 4 covering the three legs of that flight.

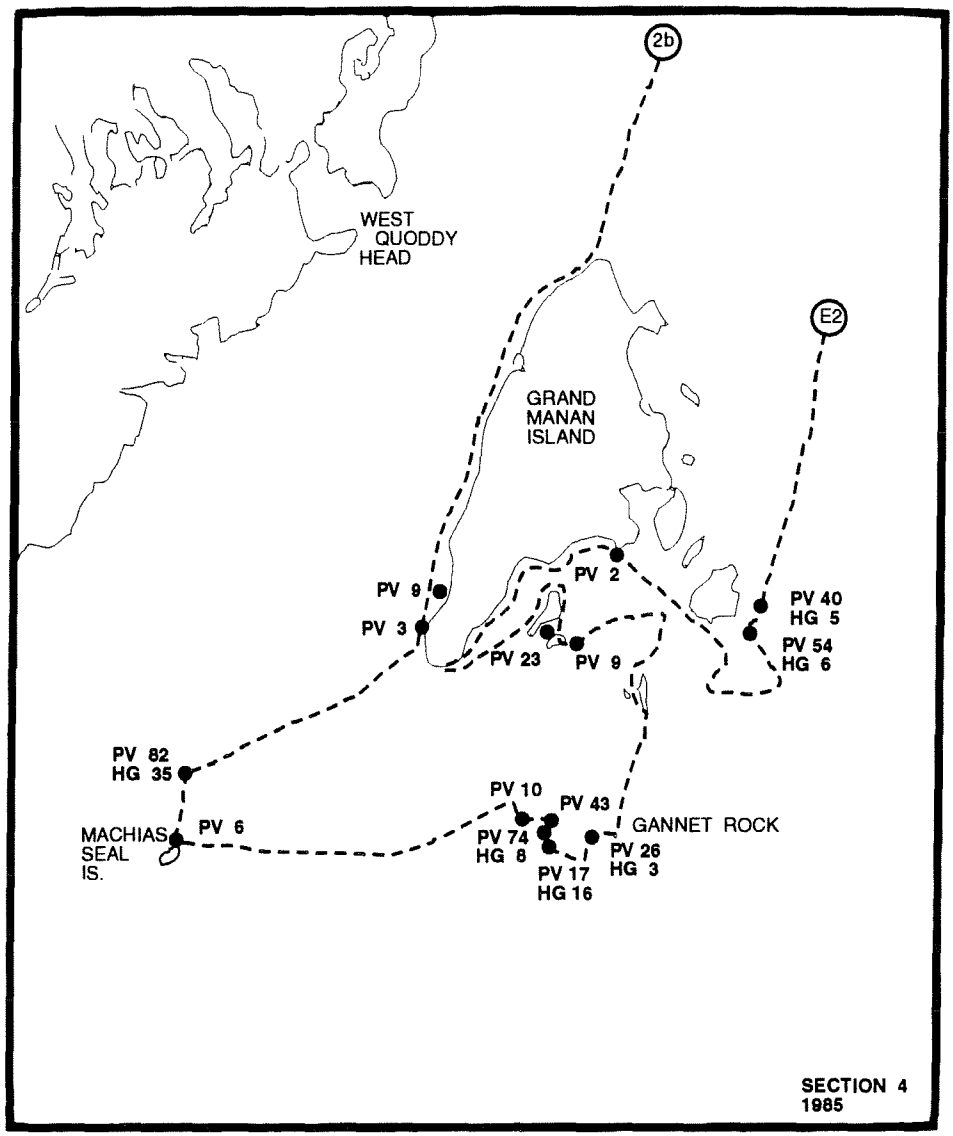

Figure 4. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1985, in section 4 of the study area, on day 2 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbol 2b marks the point where the track for survey day 2 is split between Figures 3 and 4 covering the last two legs of that flight.

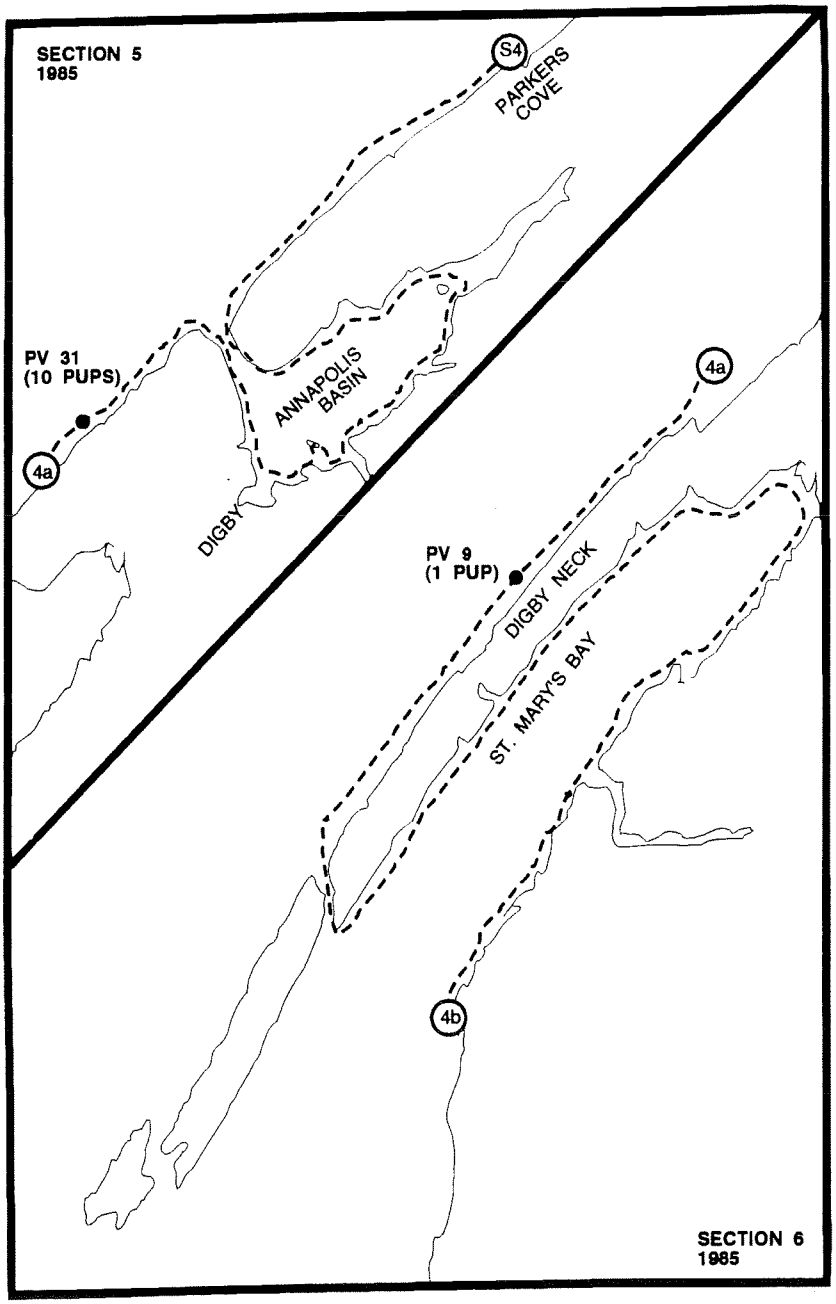

Figure 5. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1985, in sections 5 and 6 of the study area, on day 4 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 4a and 4b mark the points where the track for survey day 4 is split between sections 5 and 6, and Figures 5 and 6 respectively, covering the first three legs of that flight.

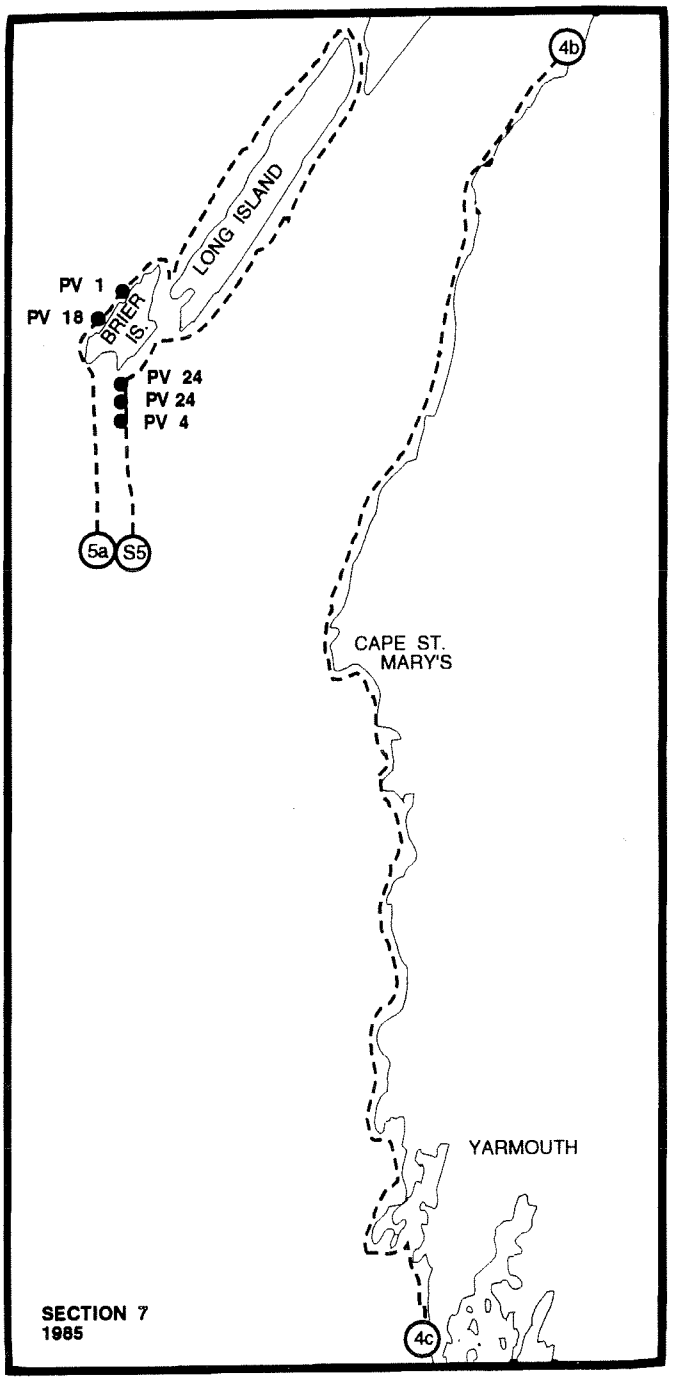

Figure 6. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1985, in section 7 of the study area, on days 4 and 5 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 4b, 4c, and 5a mark the points where the tracks for survey days 4 and 5 are split between Figures 5, 6, and 7, covering three legs of the flight on day 4 and two legs of the flight on day 5.

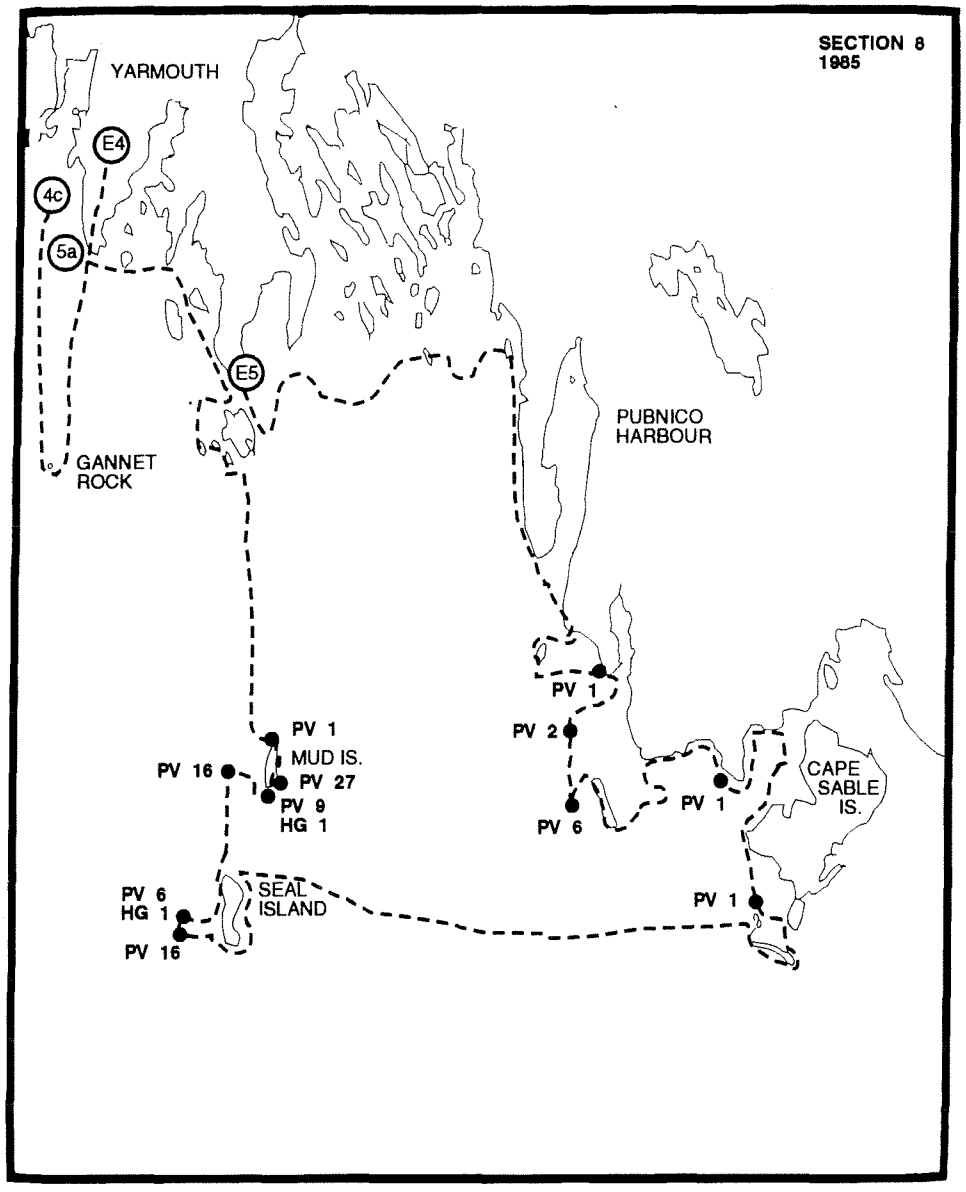

Figure 7. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1985, in section 8 of the study area, on days 4 and 5 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 4c and 5a mark the points where the track for survey days 4 and 5 are split between Figures 6 and 7, covering the last two legs of each flight.

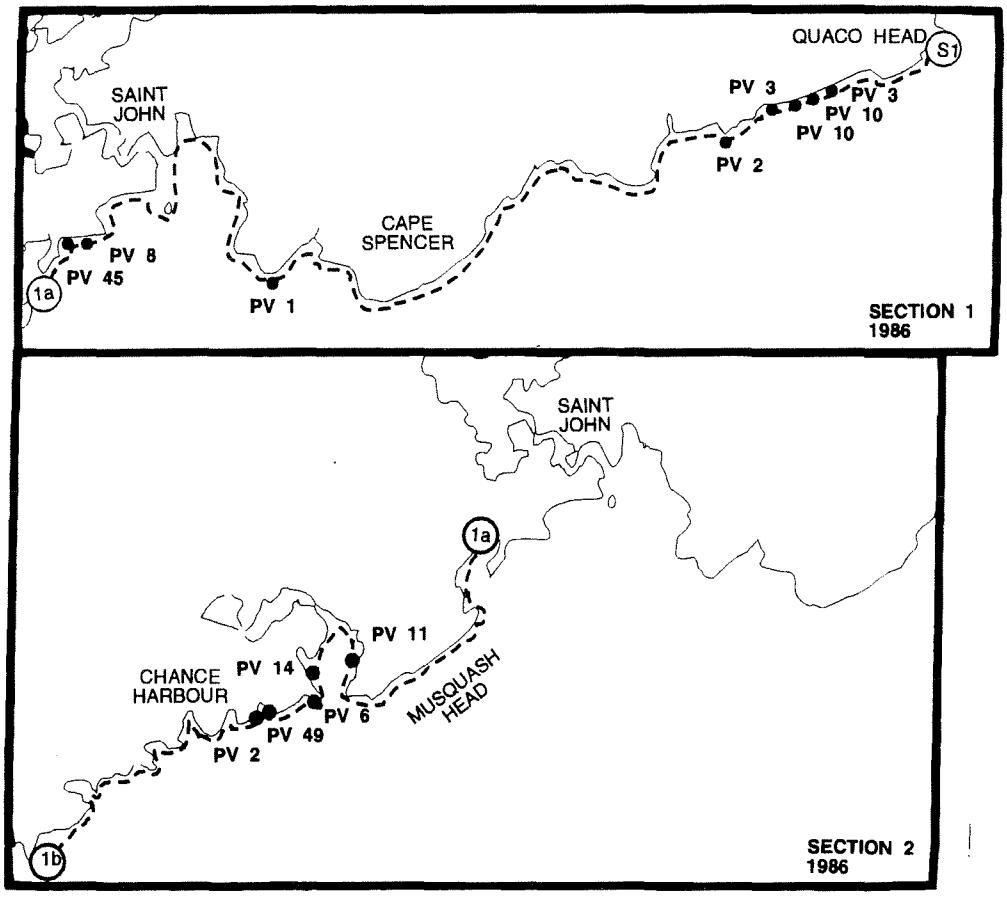

Figure 8. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1986, in sections 1 and 2 of the study area, on day 1 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 1a and 1b mark the points where the track for survey day 1 is split between sections 1 and 2, and Figures 8 and 9 respectively, covering the first three legs of that flight.

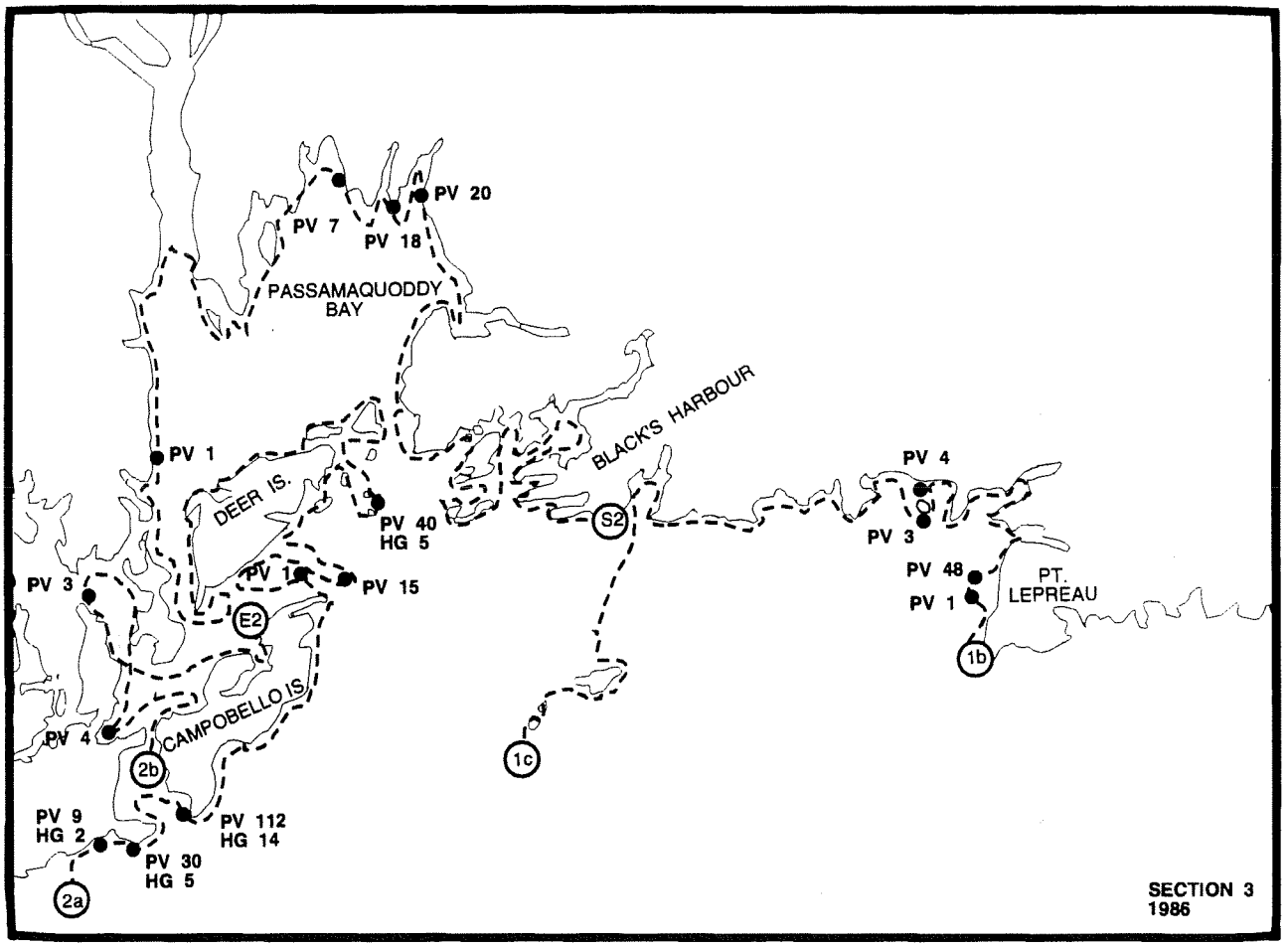

Figure 9. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1986, in section 3 of the study area, on days 1 and 2 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 1b and 1c mark the points where the track for survey day 1 is split between Figures 8, 9, and 10 covering the four legs of that flight. The symbols 2a and 2b indicate a discontinuity in the survey on day 2 due to a stop for refueling.

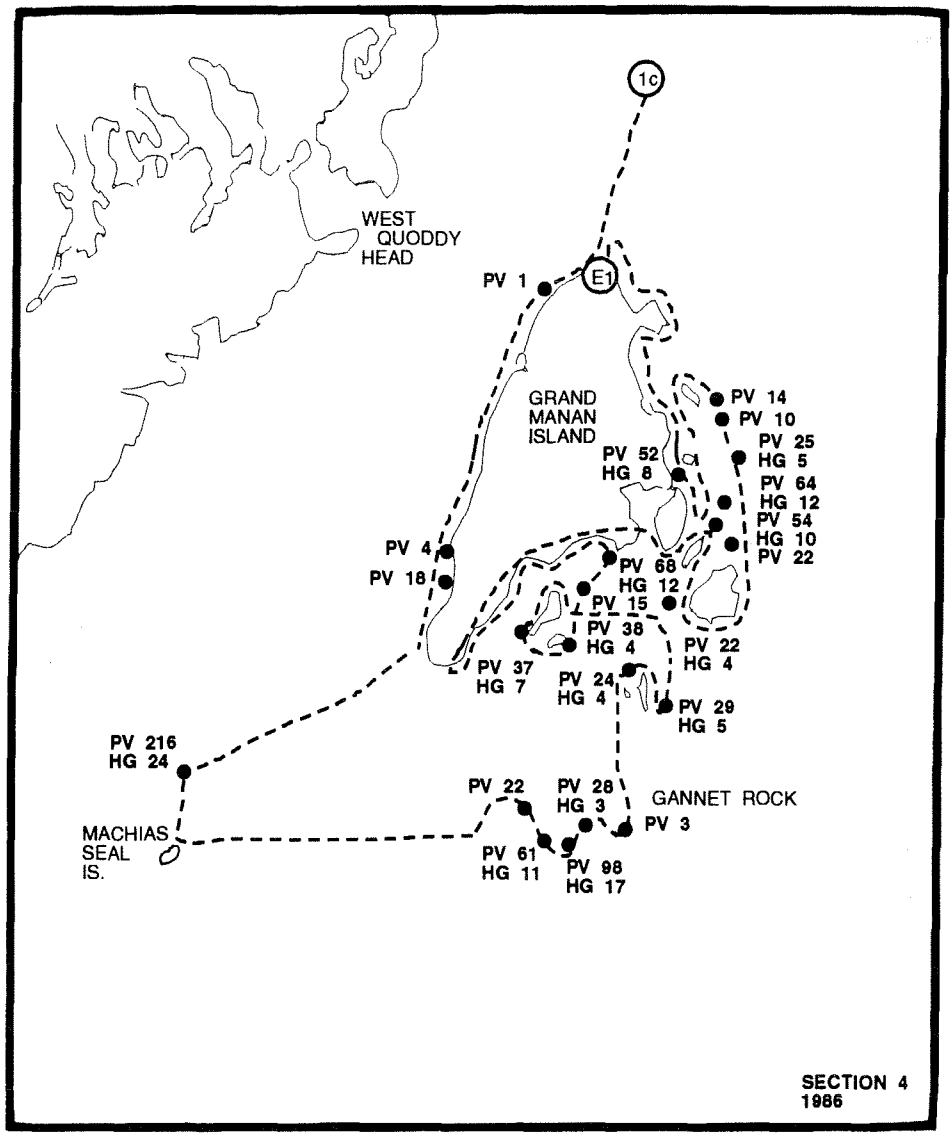

Figure 10. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1986, in section 4 of the study area, on day 1 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbol 1c marks the point where the track for survey day 1 is split between Figures 9 and 10 covering the third and fourth legs of that flight.

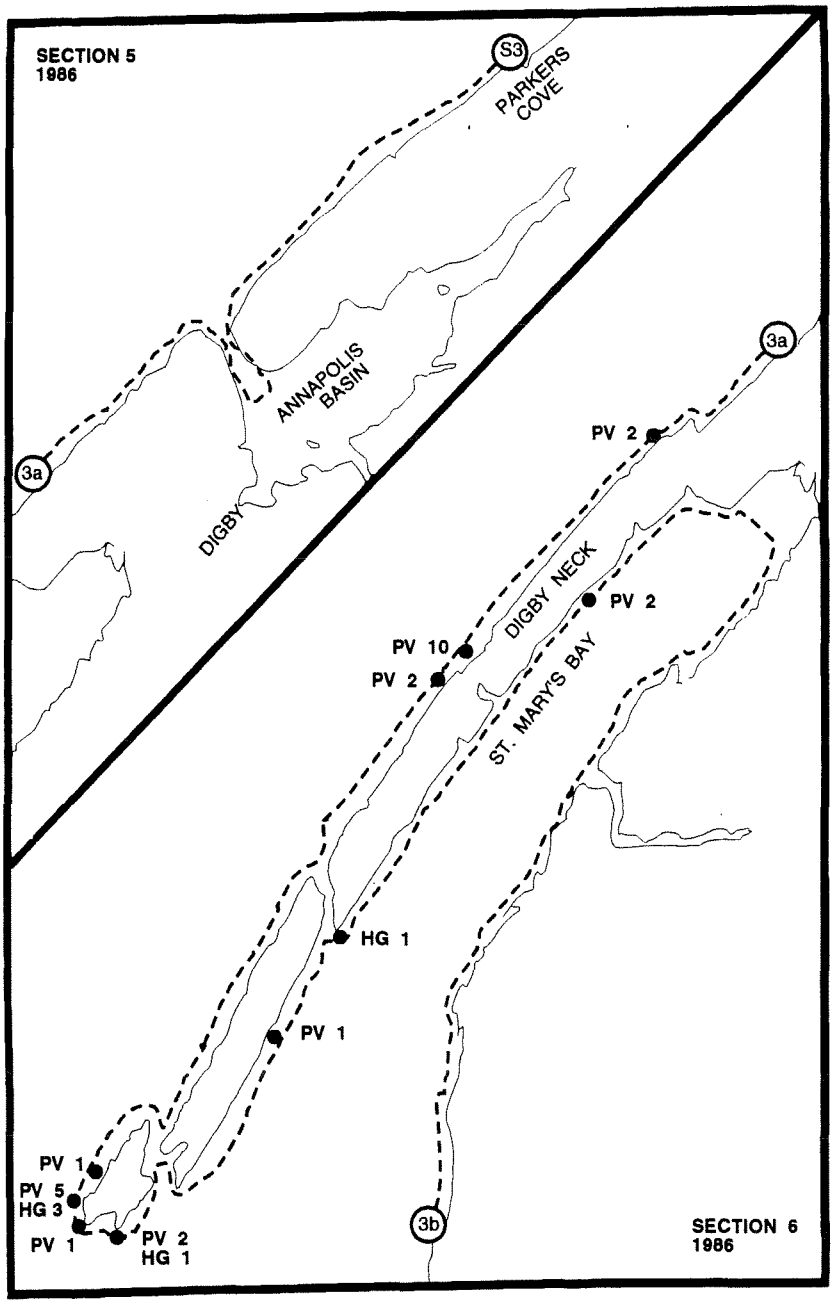

Figure 11. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1986, in sections 5 and 6 of the study area, on day 3 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 3a and 3b mark the points where the track for survey day 3 is split between sections 5 and 6, and Figures 11 and 12 respectively, covering the first three legs of that flight.

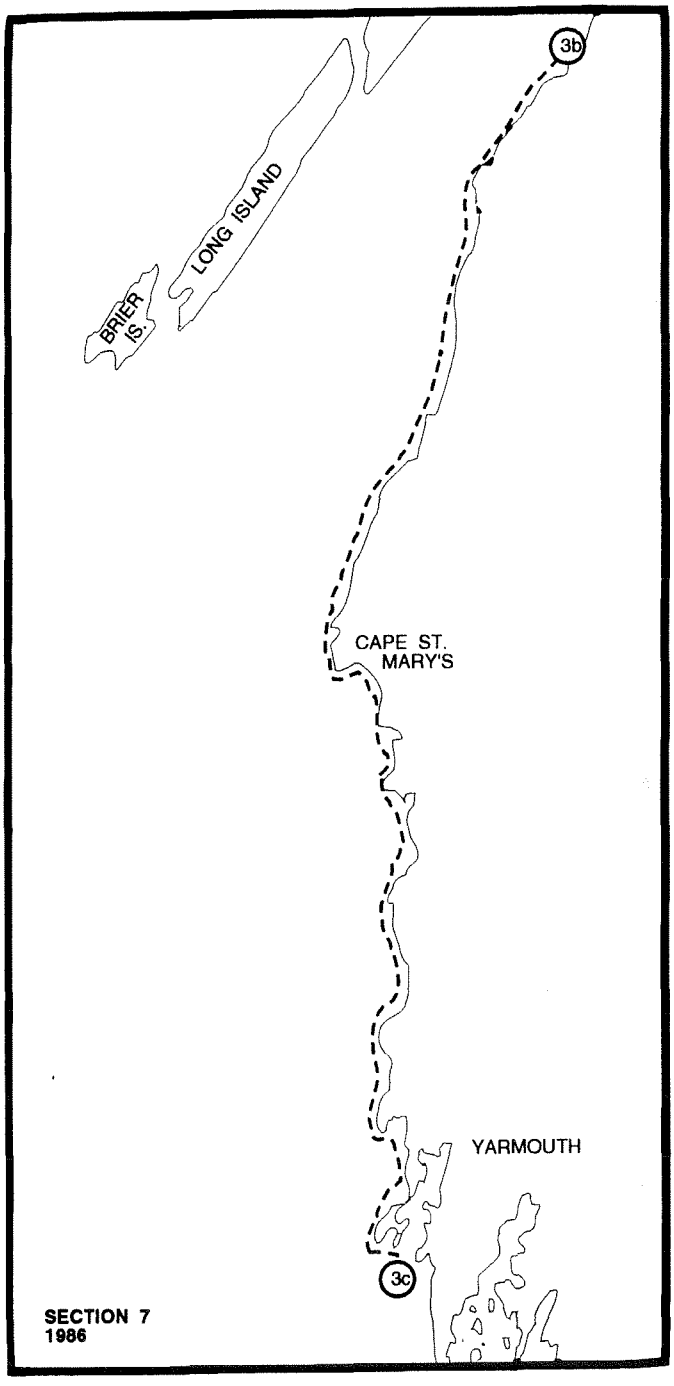

Figure 12. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1986, in section 7 of the study area, on day 3 of the survey. Continuations of a survey track (dashed line) from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 3b and 3c mark the points where the track for survey day 3 is split between Figures 11, 12, and 13 covering the last three legs of that flight.

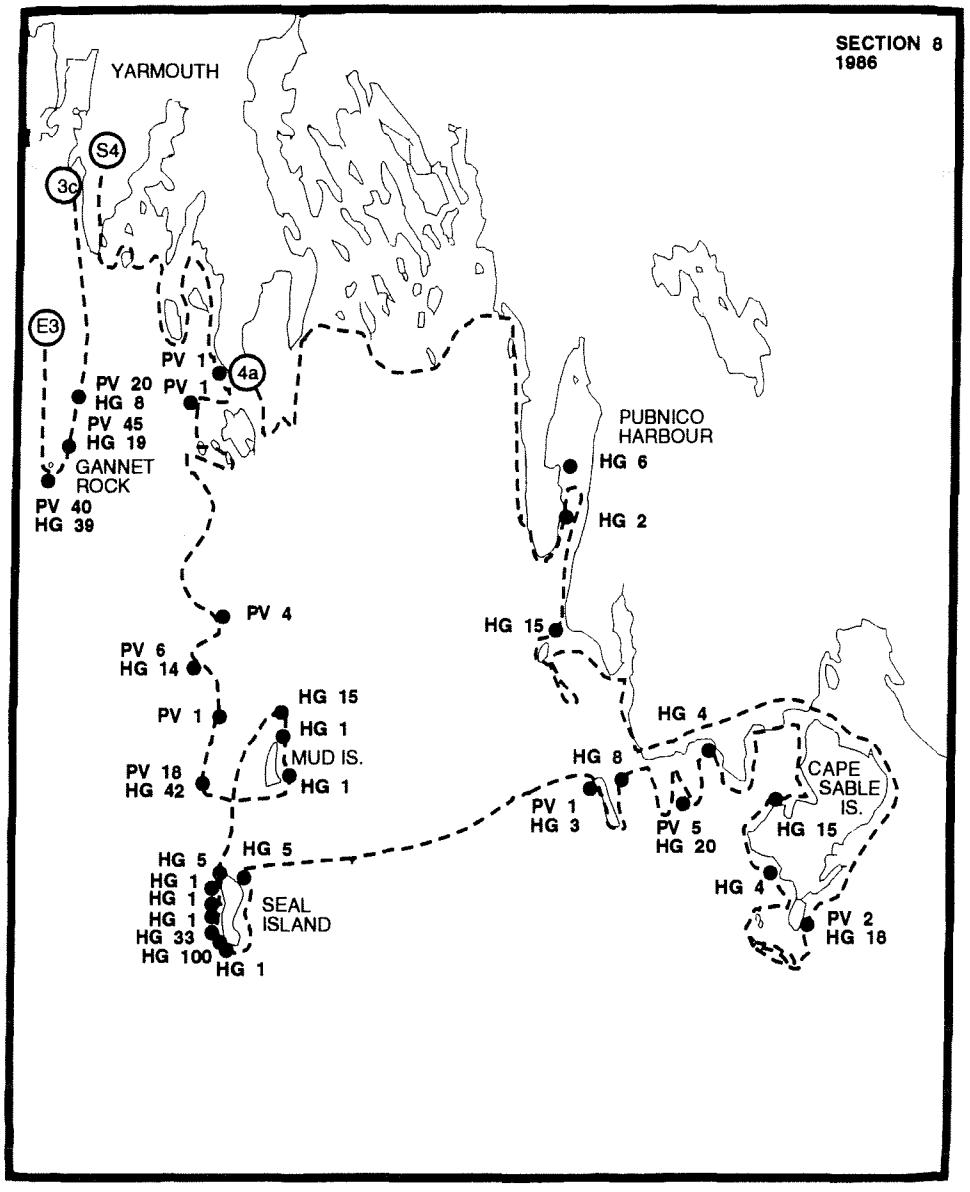

Figure 13. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1986, in section 8 of the study area, on days 3 and 4 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 3c and 4a mark the points where tracks are split between Figure 13 and Figures 12 (covering the last two legs of day 3) and 14 (covering the two legs of day 4).

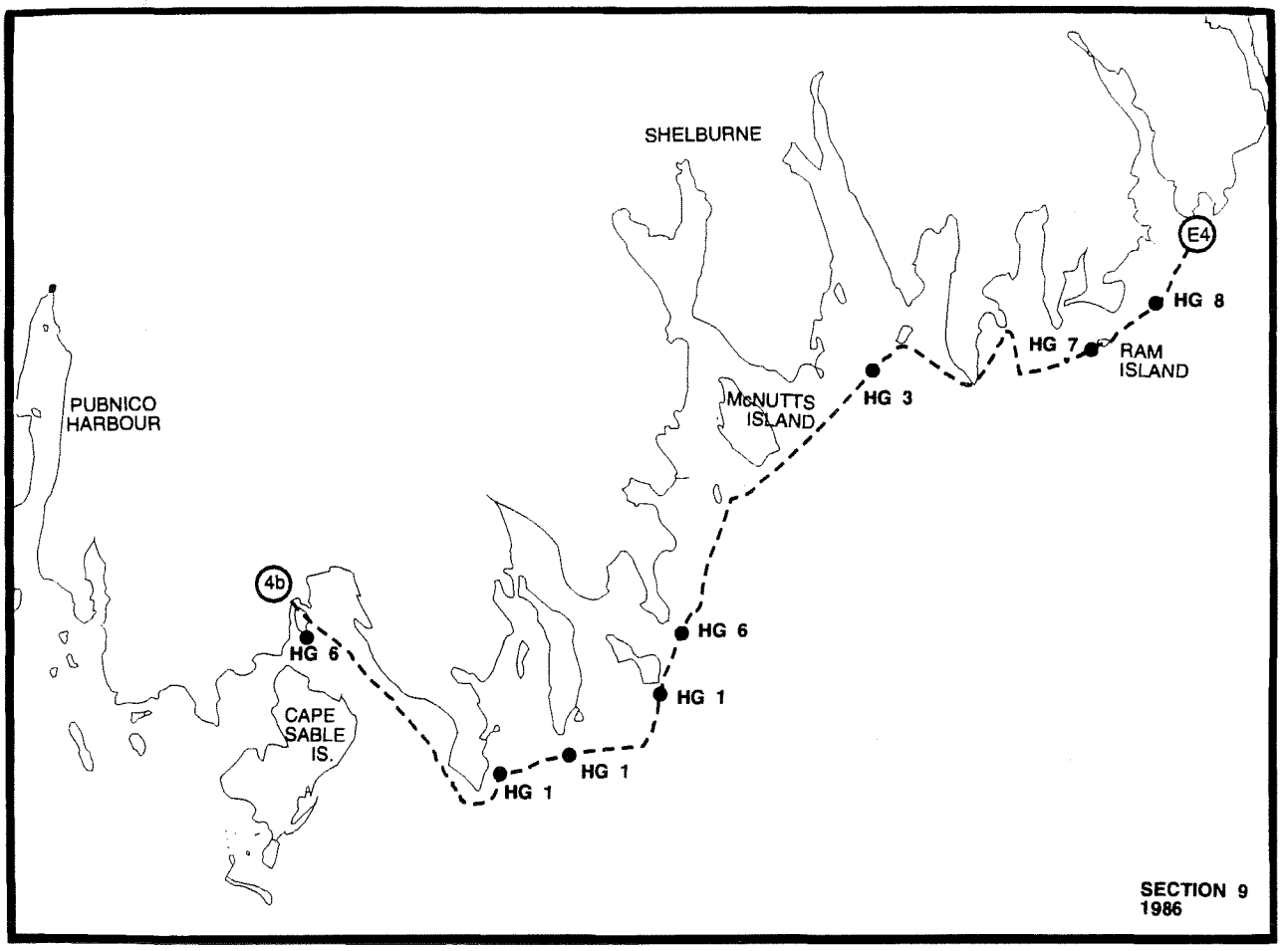

Figure 14. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1986, in section 9 of the study area, on day 4 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbol 4b marks the point where the track for survey day 4 is split between Figures 13 and 14 covering the two legs of that flight.

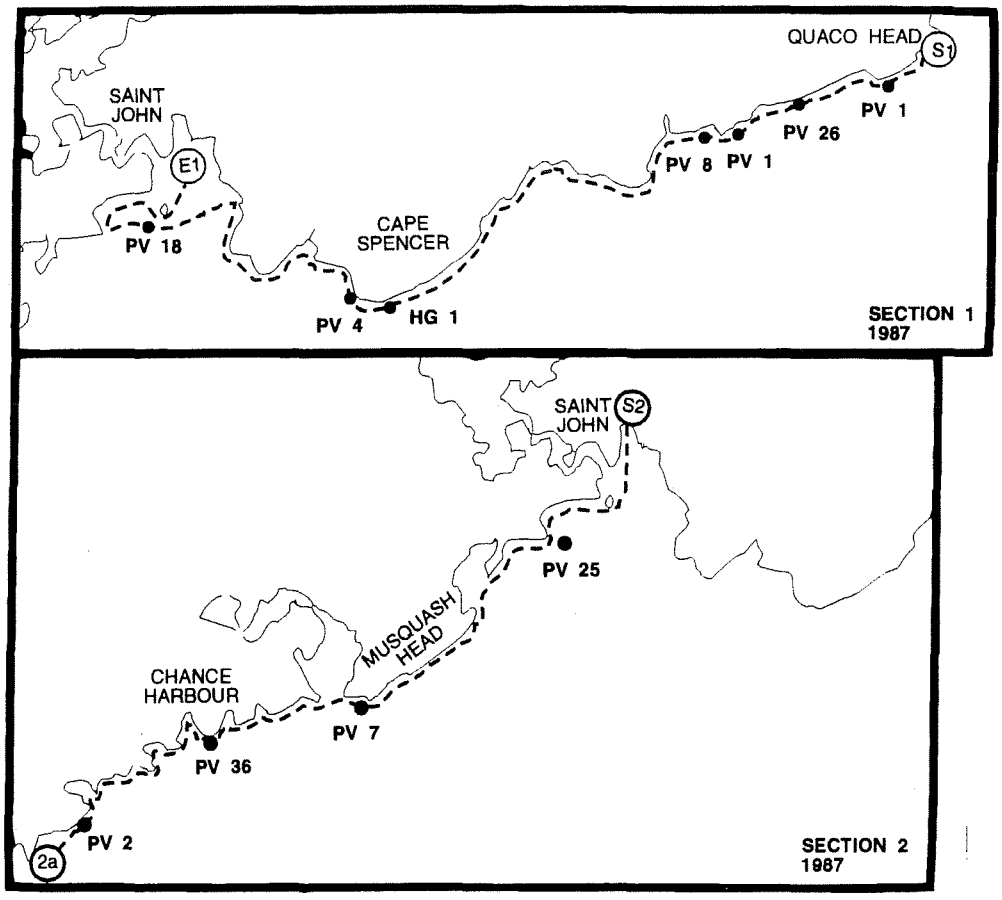

Figure 15. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1987, in sections 1 and 2 of the study area, on days 1 and 2 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbol 2a marks the point at which the track for survey day 2 is split between Figures 15 and 16 covering the first, second and fourth legs of that flight.

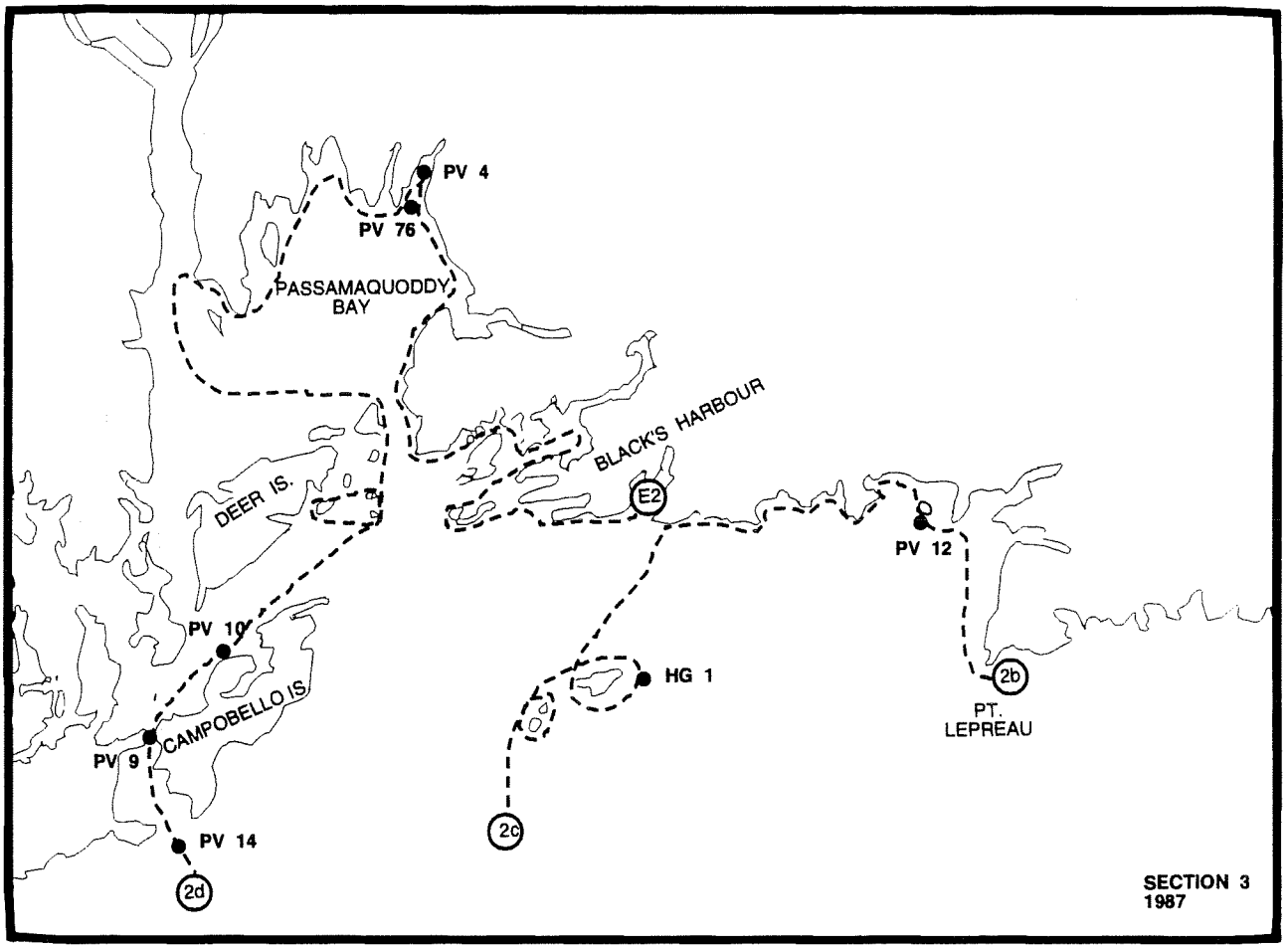

Figure 16. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1987, in section 3 of the study area, on day 2 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 2b, 2c, and 2d mark the points where the track for survey day 2 is split between Figures 15, 16, and 17, covering the four legs of that flight.

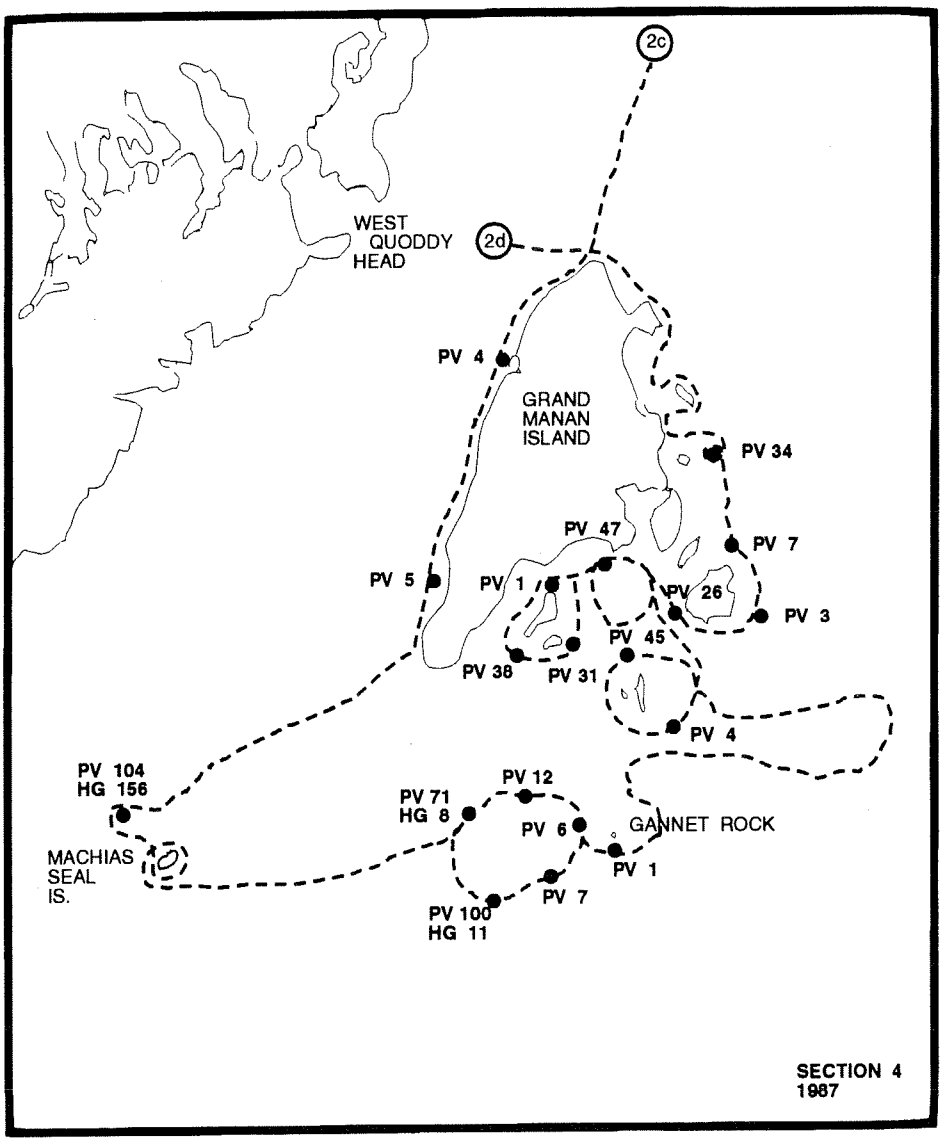

Figure 17. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1987, in section 4 of the study area, on day 2 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 2c and 2d mark the points where the track for survey day 2 is split between Figures 16 and 17 covering the last three legs of that flight.

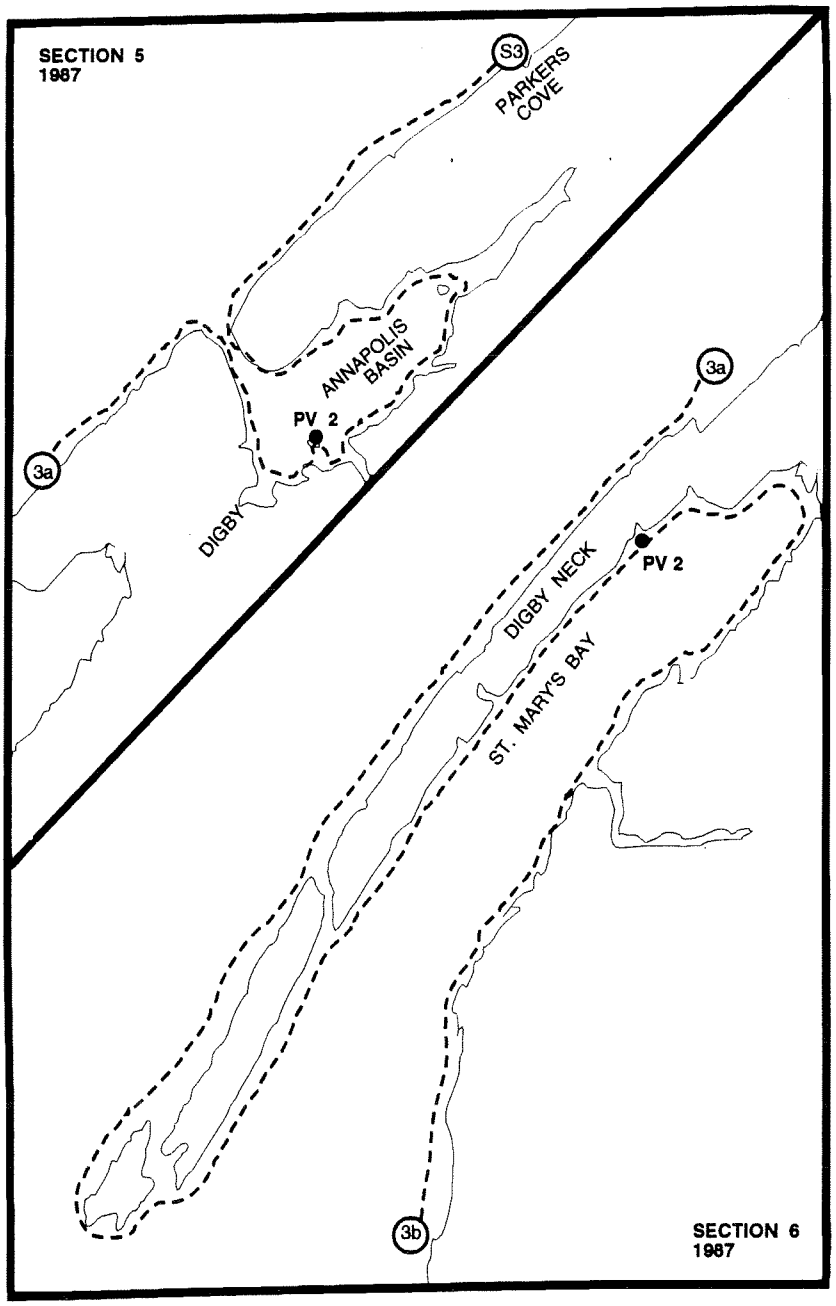

Figure 18. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1987, in sections 5 and 6 of the study area, on day 3 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 3a and 3b mark the points where the track for survey day 3 is split between sections 5 and 6, and Figures 18 and 19 respectively, covering the first three legs of that flight.

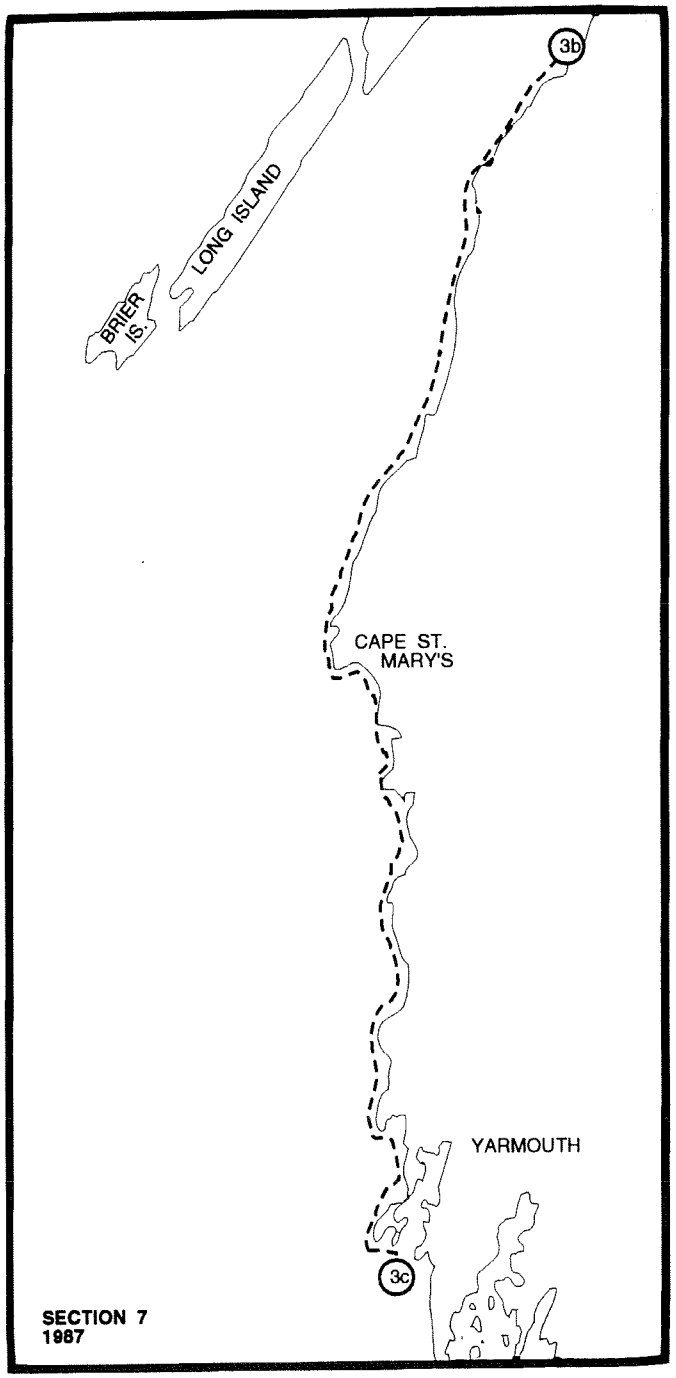

Figure 19. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1987, in section 7 of the study area, on day 3 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 3b and 3c mark the points where the track for survey day 3 is split between Figures 18, 19, and 20 covering the four legs of that flight.

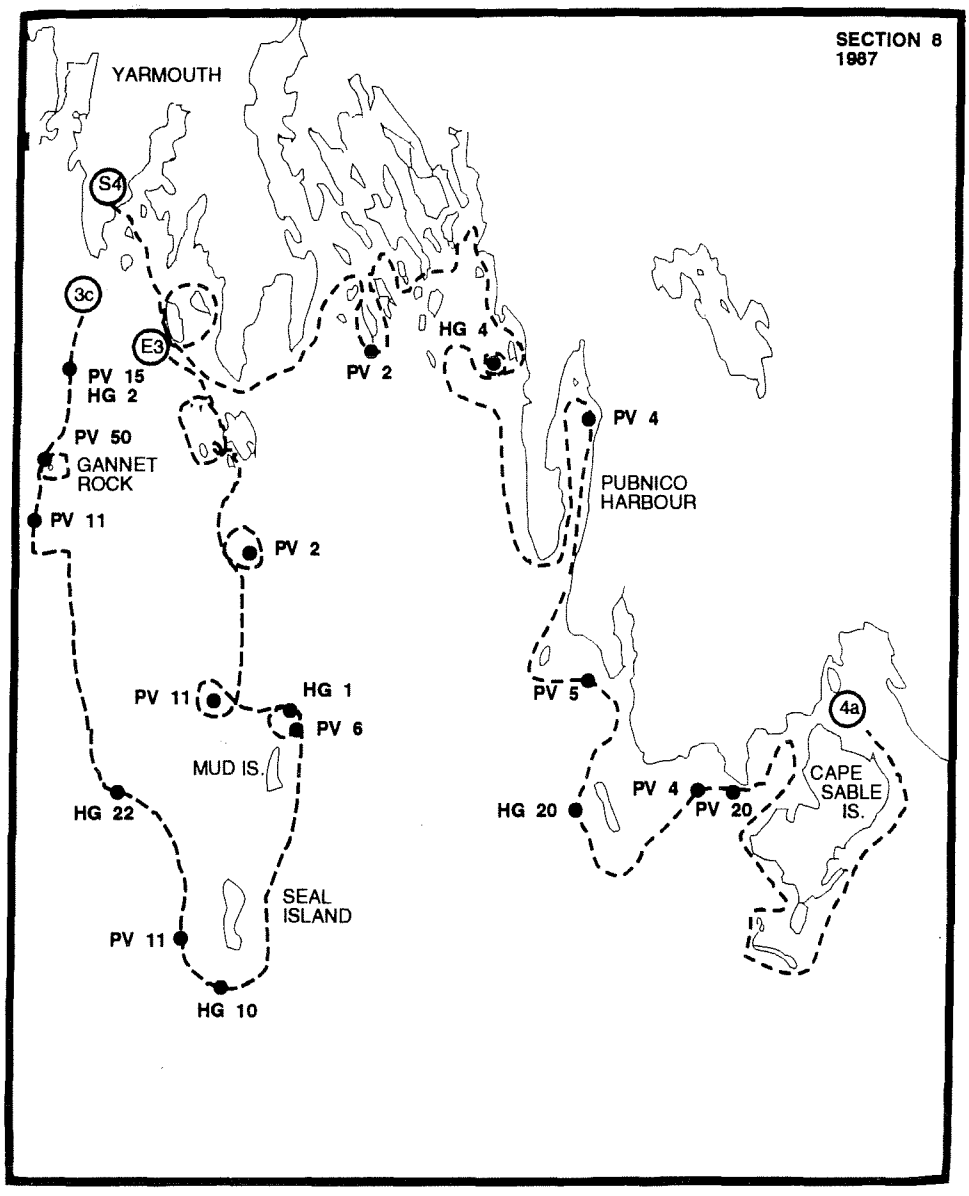

Figure 20. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1987, in section 8 of the study area, on days 3 and 4 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 3c and 4a mark the points where the track for survey days 3 and 4 are split between Figures 19 and 20 (covering the last two legs of the flight on day 3), and between Figures 20 and 21 (covering the two legs of the flight on day 4).

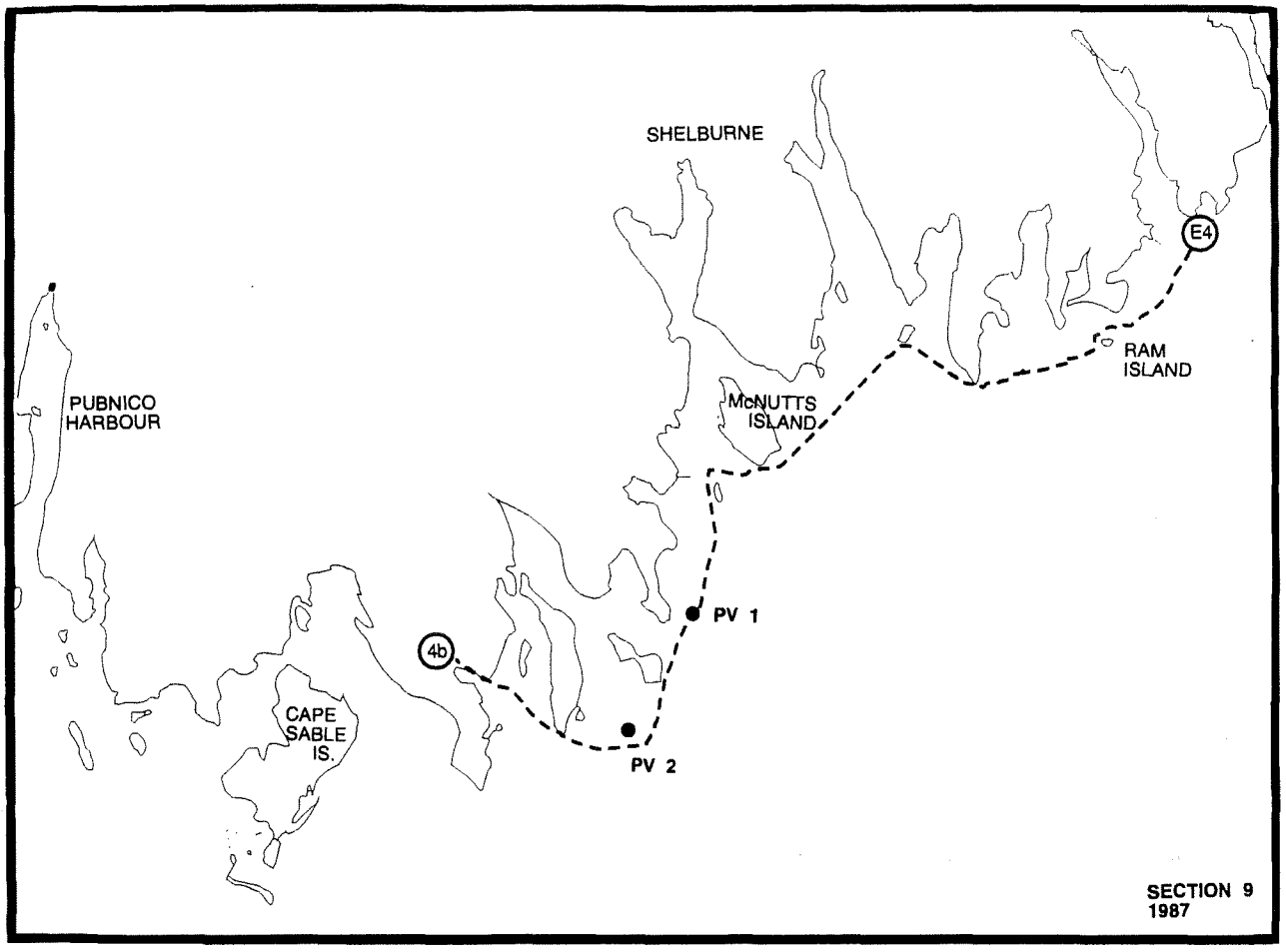

Figure 21. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1987, in section 9 of the study area, on day 4 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbol 4b marks the point where the track for survey day 4 is split between Figures 20 and 21 covering the two legs of that flight.

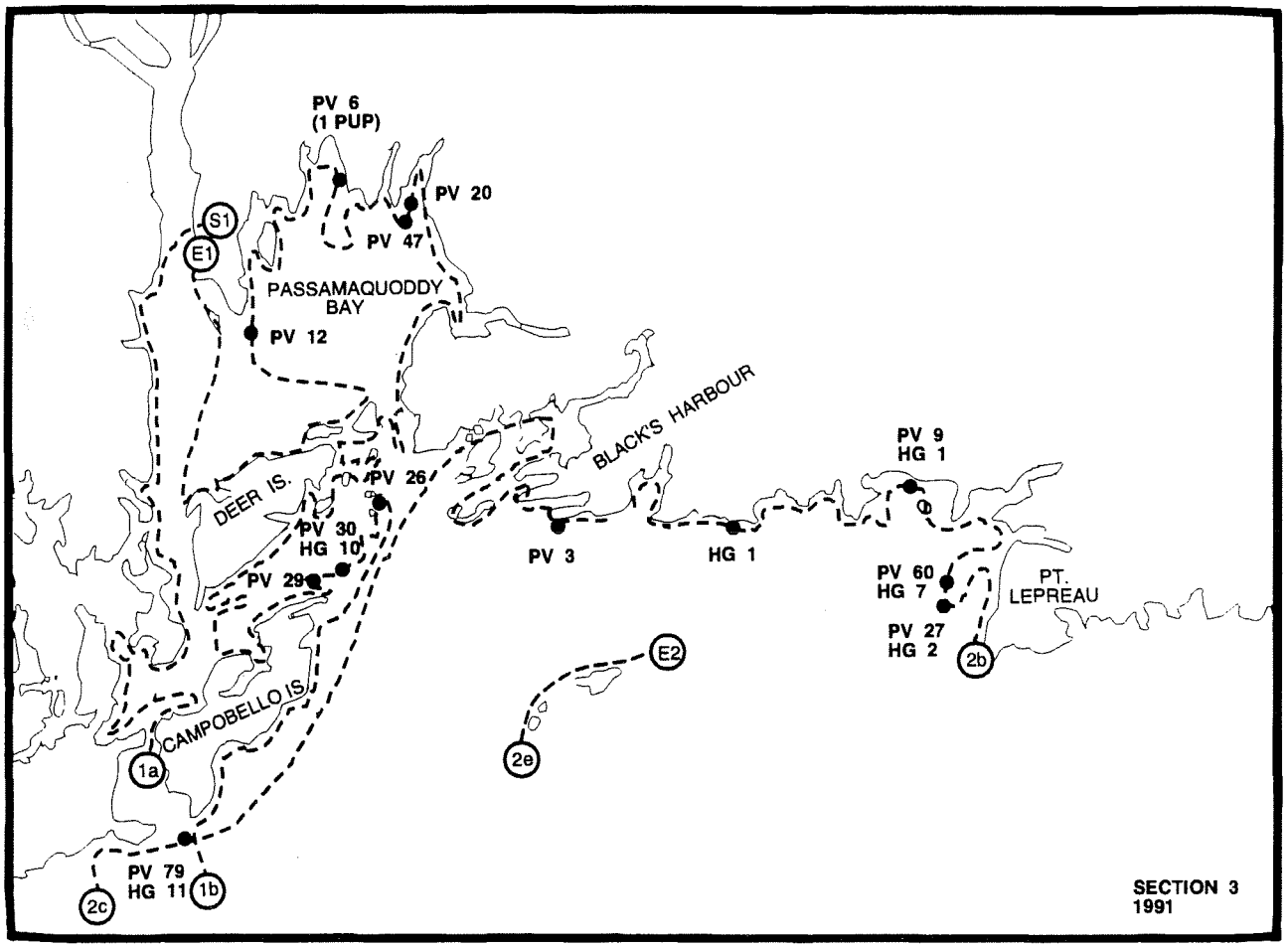

Figure 22. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1991, in section 3 of the study area, on days 2 and 3 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 1a and 1b mark the points where the track for survey day 1 is split between Figures 22 and 23 covering the three legs of that flight. The symbols 2b, 2c, and 2e mark the points where the track for survey day 2 is split between Figures 22, 23, and 24 covering the five legs of that flight.

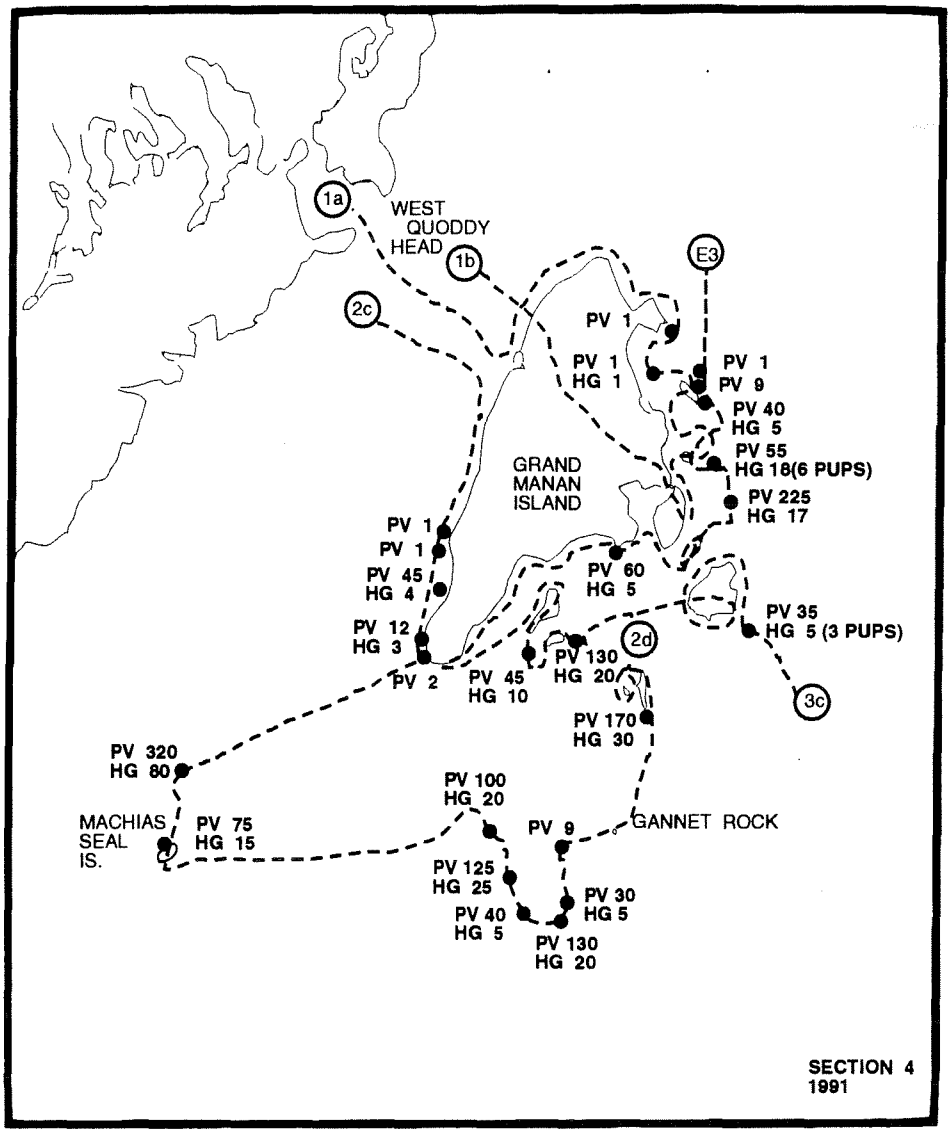

Figure 23. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1991, in section 4 of the study area, on days 1, 2, and 3 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 1a and 1b mark the points where the track for survey day 1 is split between Figures 22 and 23 covering the two legs of that flight. The symbols 2c and 2d mark the split between Figures 22 and 23 for the last three legs of the flight on day 2 (note that 2d connects with 2e, the discontinuity representing a refueling stop). The symbol 3c marks the split between Figures 23 and 25 for the three legs of the flight on survey day 3.

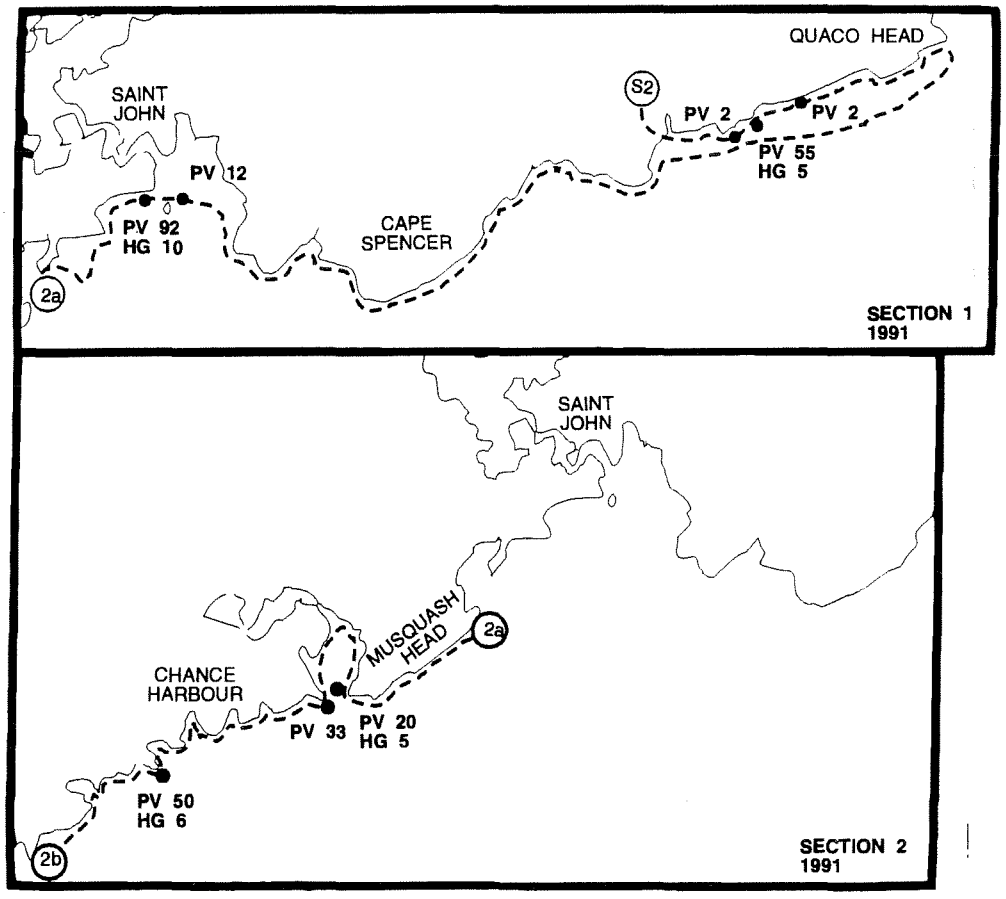

Figure 24. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1991, in sections 1 and 2 of the study area, on day 2 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 2a and 2b mark the points where the track for survey day 2 is split between sections 1 and 2, and Figures 22 and 24 respectively, covering the first three legs of that flight.

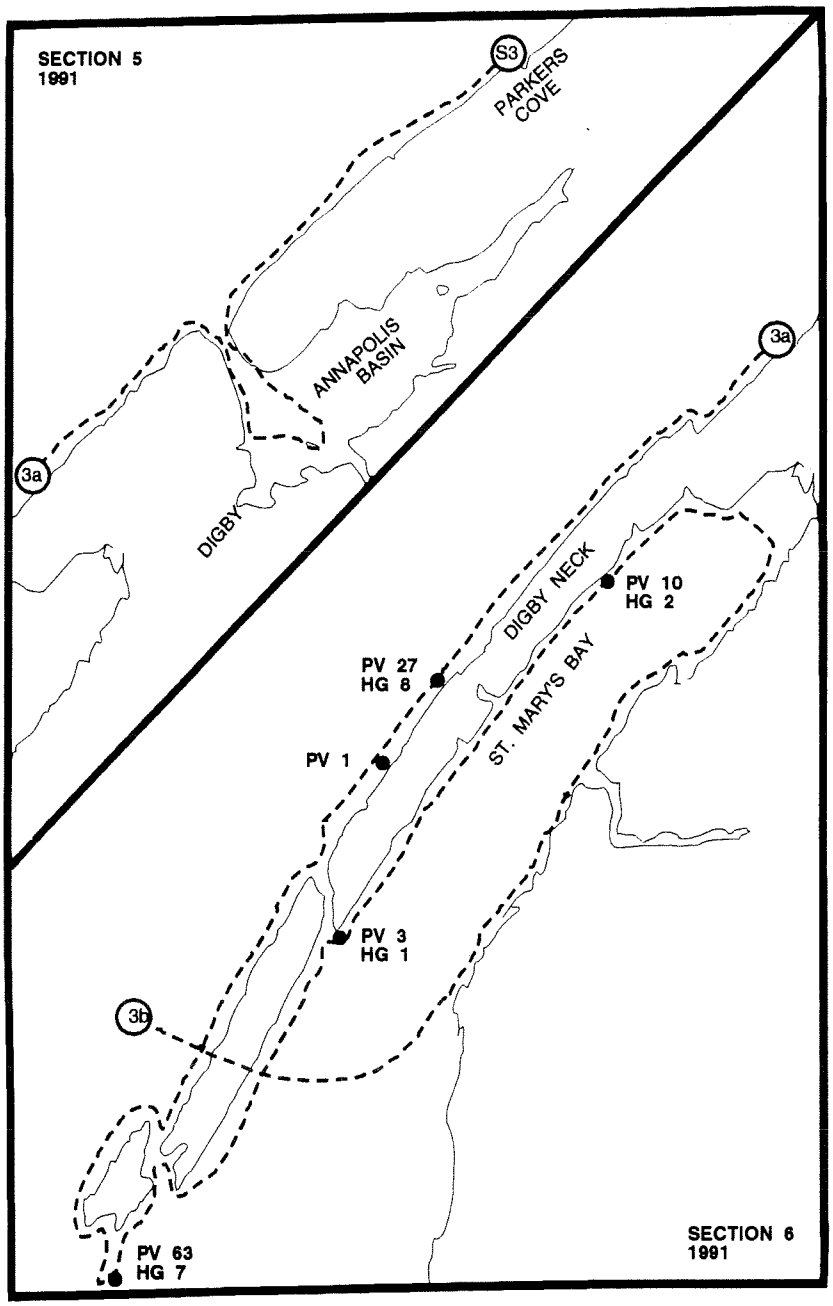

Figure 25. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1991, in sections 5 and 6 of the study area, on day 3 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 3a and 3b mark the points where the track for survey day 3 is split between sections 5 and 6, and Figures 23 and 25 respectively, covering the three legs of that flight. The discontinuity between 3b and 3c (Figure 23) reflects a refueling stop.

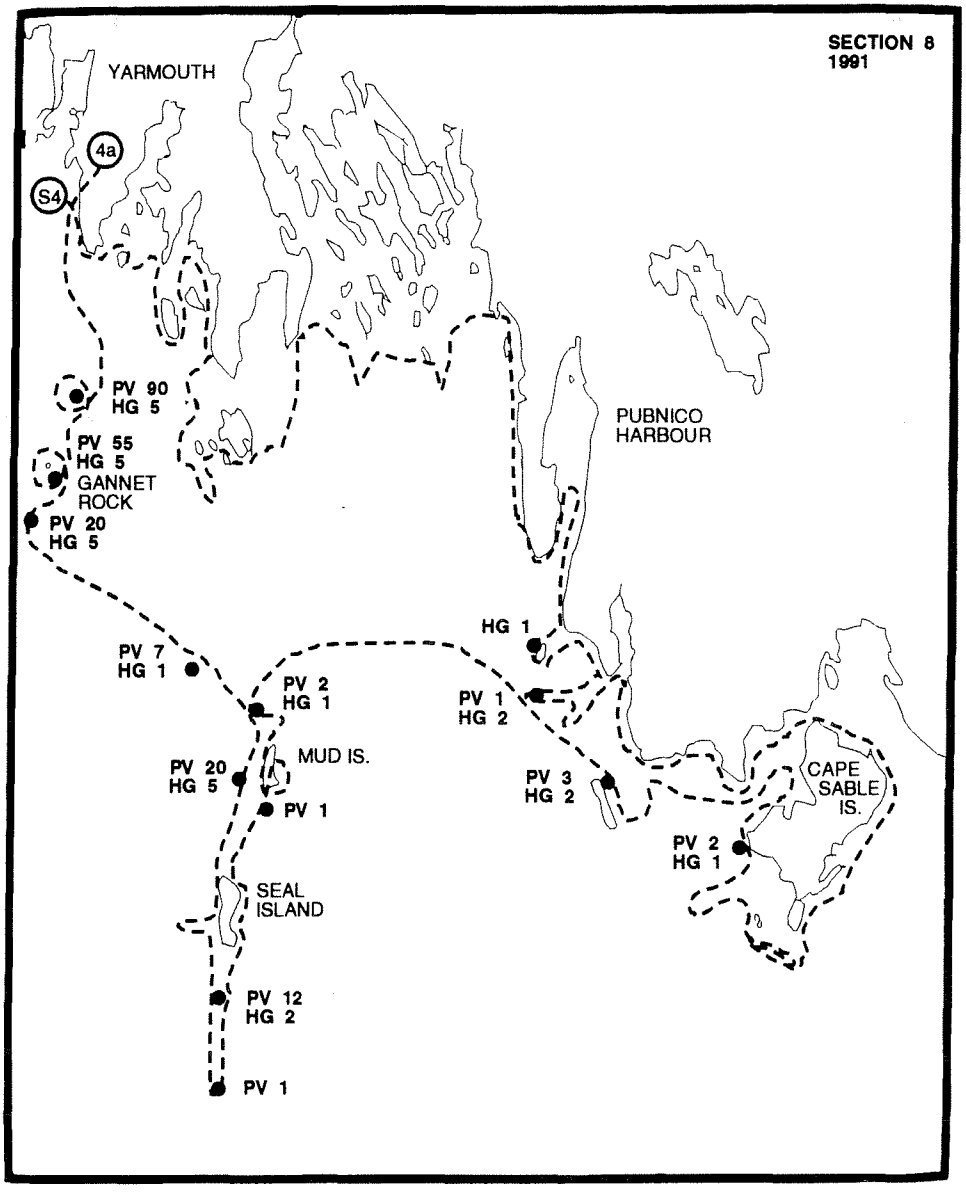

Figure 26. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1991, in section 8 of the study area, on day 4 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbol 4a marks the point where the track for survey days 4 is split between Figures 26 and 27 covering the two legs of that flight.

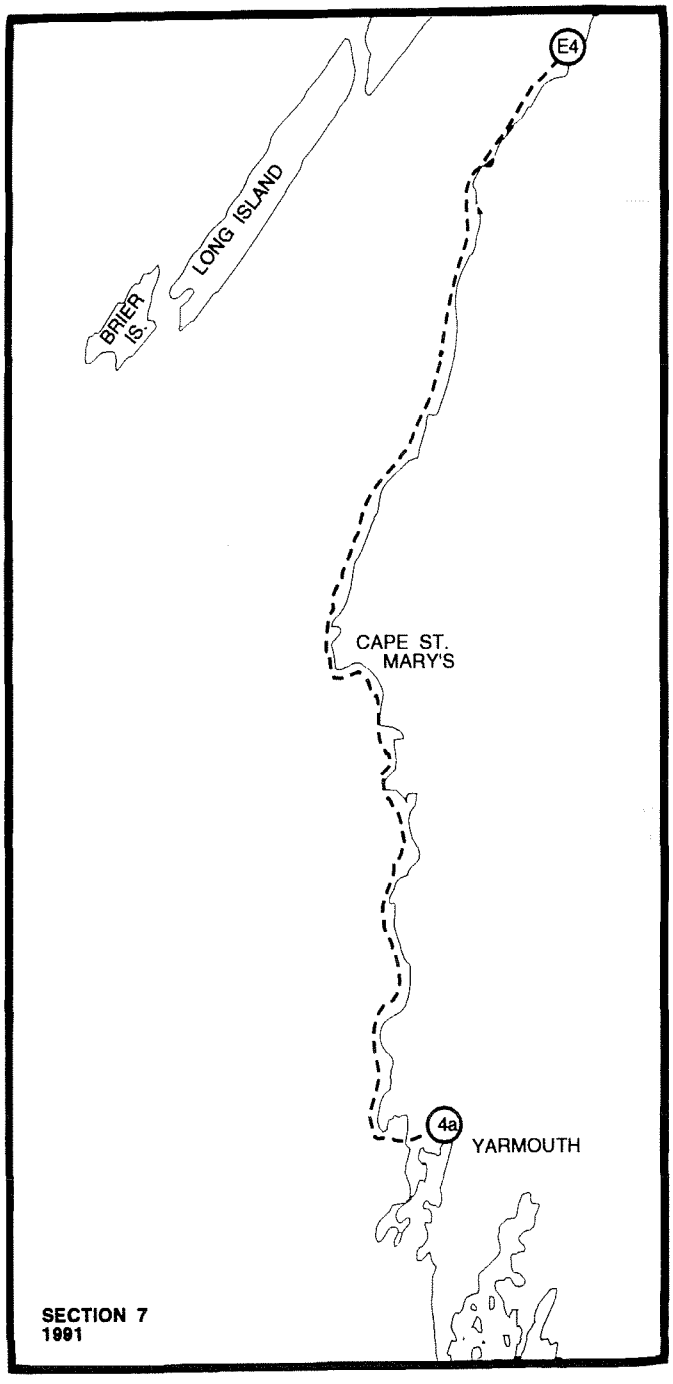

Figure 27. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1991, in section 7 of the study area, on day 4 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbol 4a marks the point where the track for survey day 4 is split between Figures 26 and 27 covering the two legs of that flight.

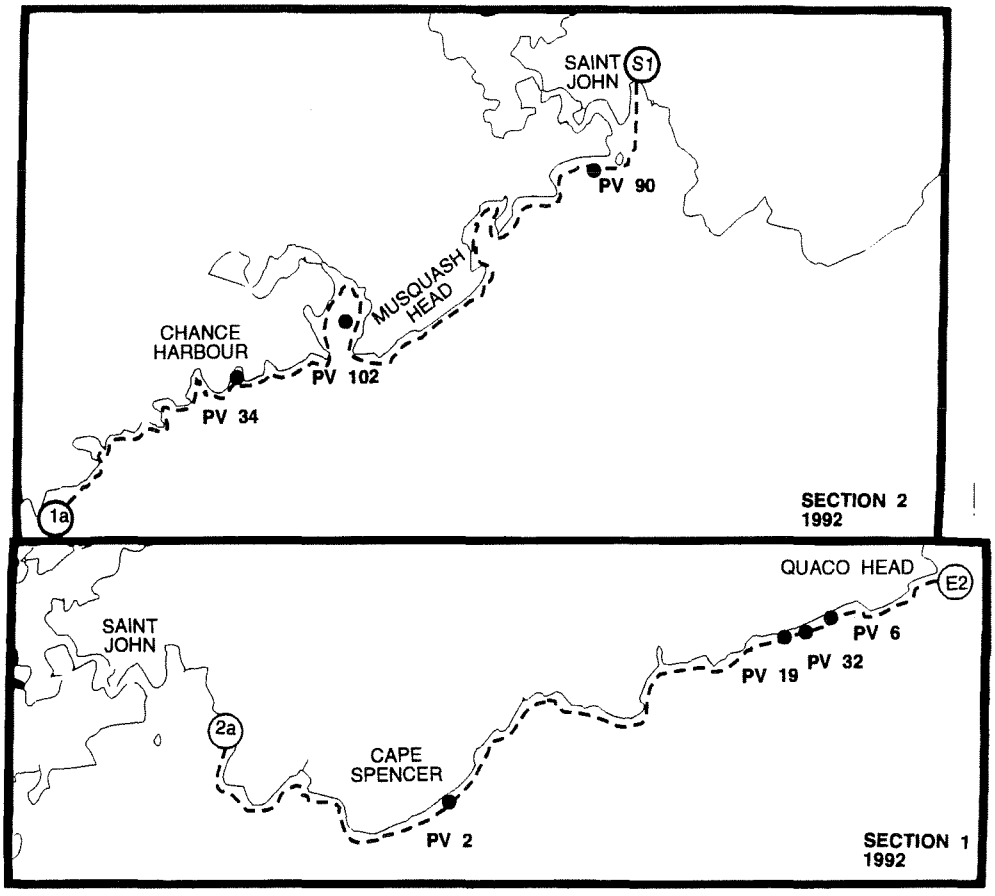

Figure 28. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1992, in sections 1 and 2 of the study area, on days 1 and 2 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 1a and 2a mark the points where the tracks for survey days 1 and 2 are split between Figure 28 and Figures 29 (day 1) and 30 (day 2) covering the first two legs of each flight.

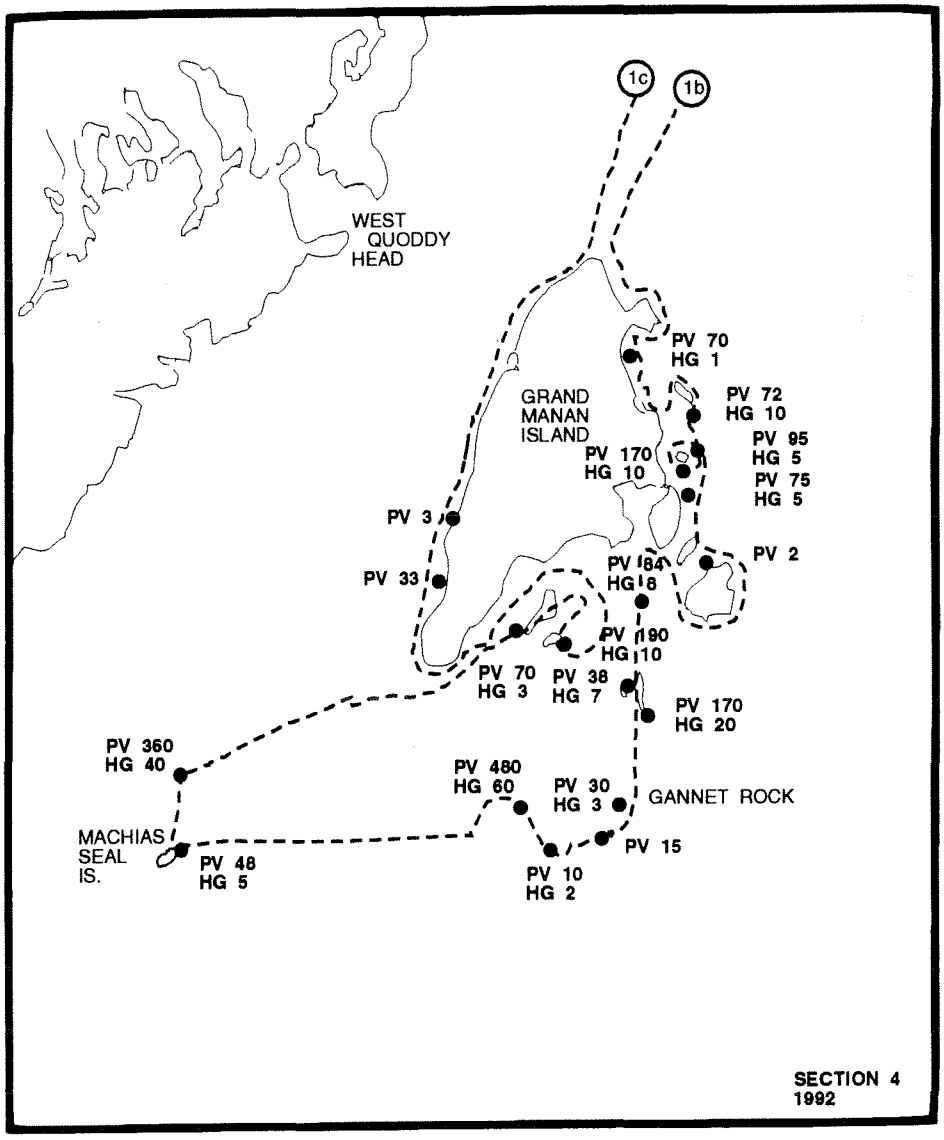

Figure 29. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1992, in section 4 of the study area, on day 1 of the survey. Continuations of a survey track (dashed line) from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 1a and 1b mark the points where the track for survey day 1 is split between Figures 22 and 23 covering the two legs of that flight. The symbols 1b and 1c mark the points where the track for survey day 1 is split between Figures 28, 29 and 30 covering the three legs of that flight.

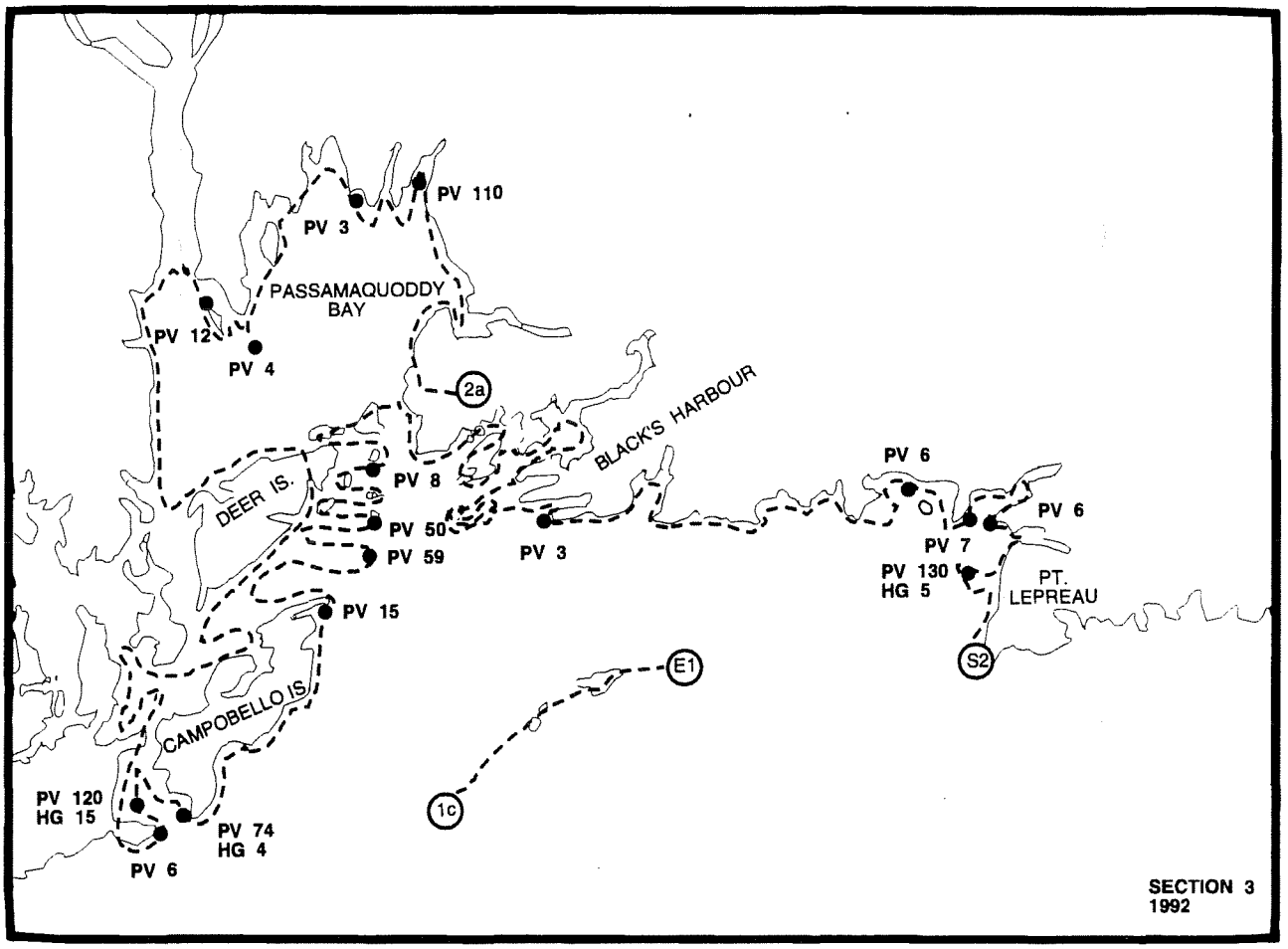

Figure 30. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1992, in section 3 of the study area, on days 1 and 2 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 1c and 2a mark the points where the tracks for survey days 1 and 2 are split between Figure 30 and Figures 29 (day 1) and 28 (day 2) covering the last two legs of day 1 and both legs of day 2.

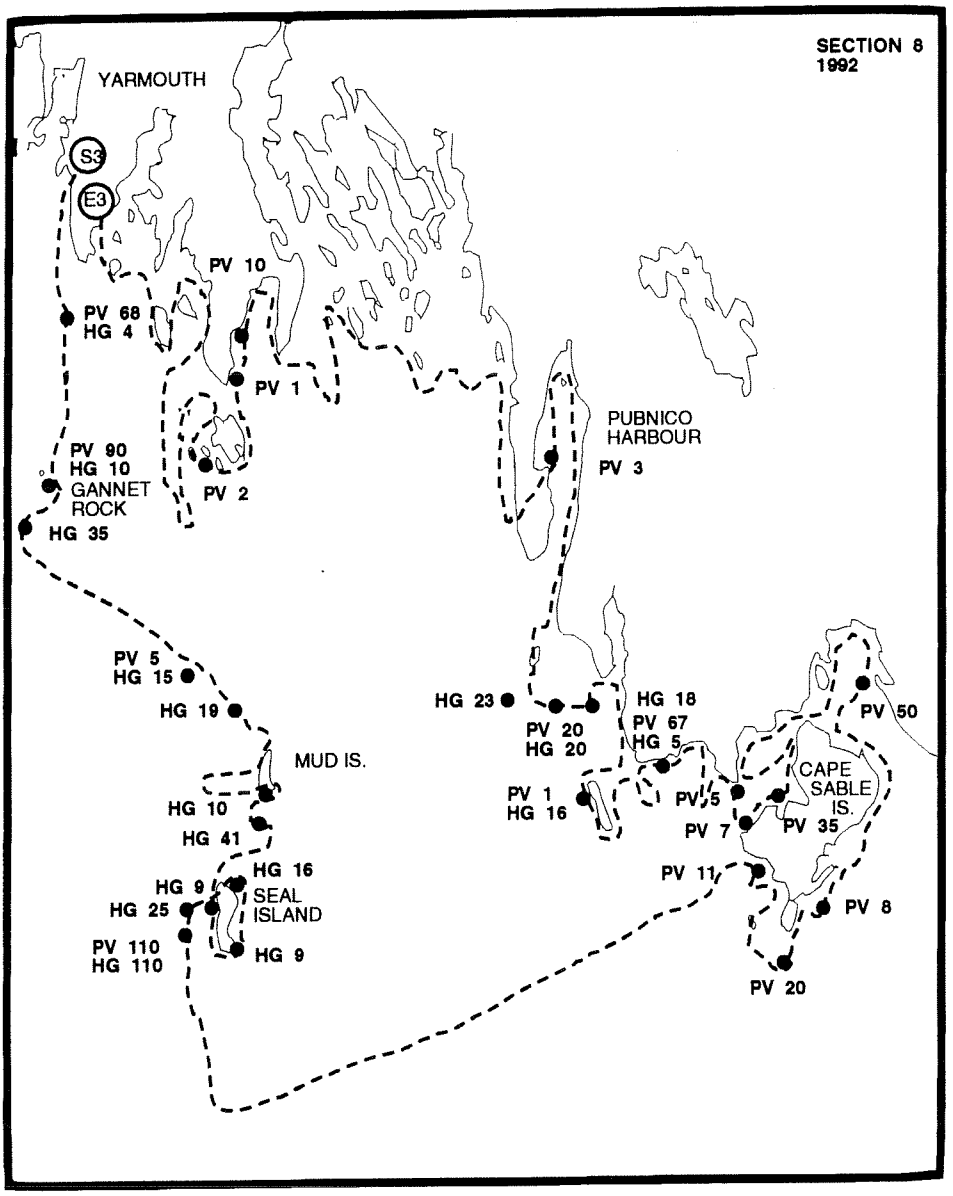

Figure 31. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1992, in section 8 of the study area, on day 3 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day.

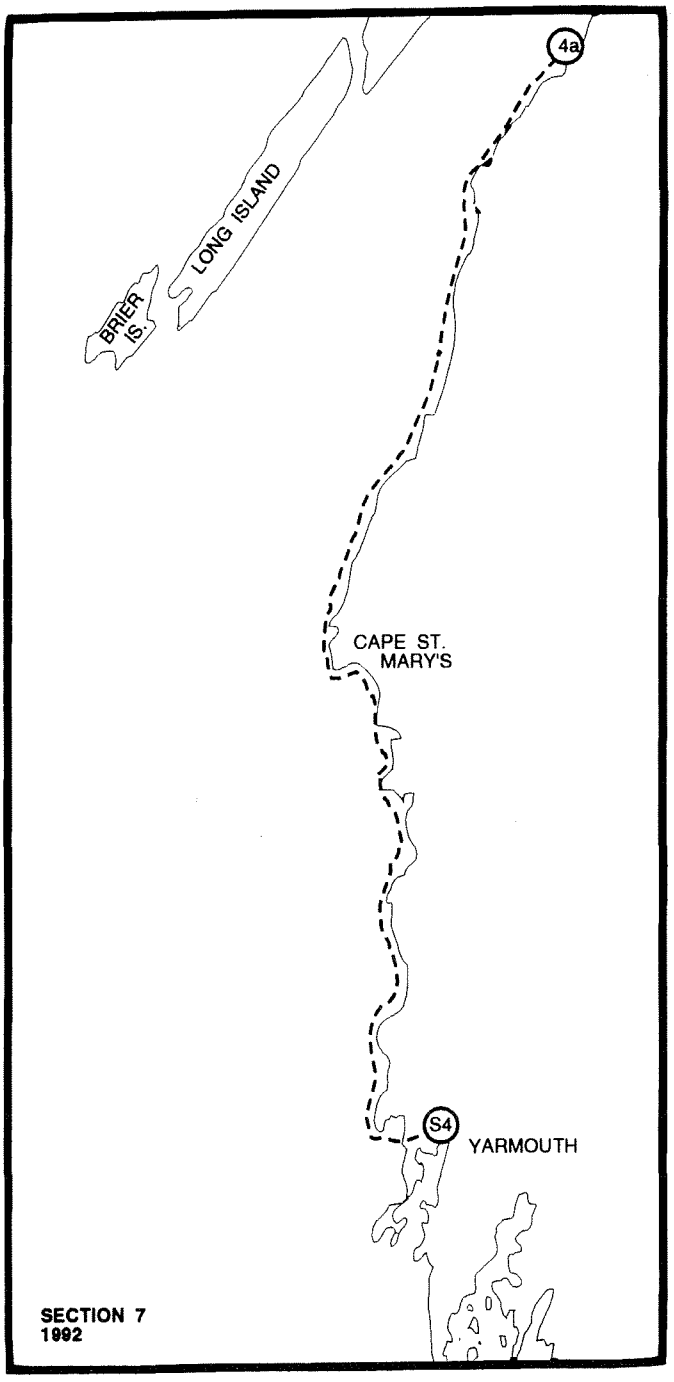

Figure 32. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1992, in section 7 of the study area, on day 4 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbol 4a marks the point where the track for survey day 4 is split between Figures 31 and 32 covering the three legs of that flight.

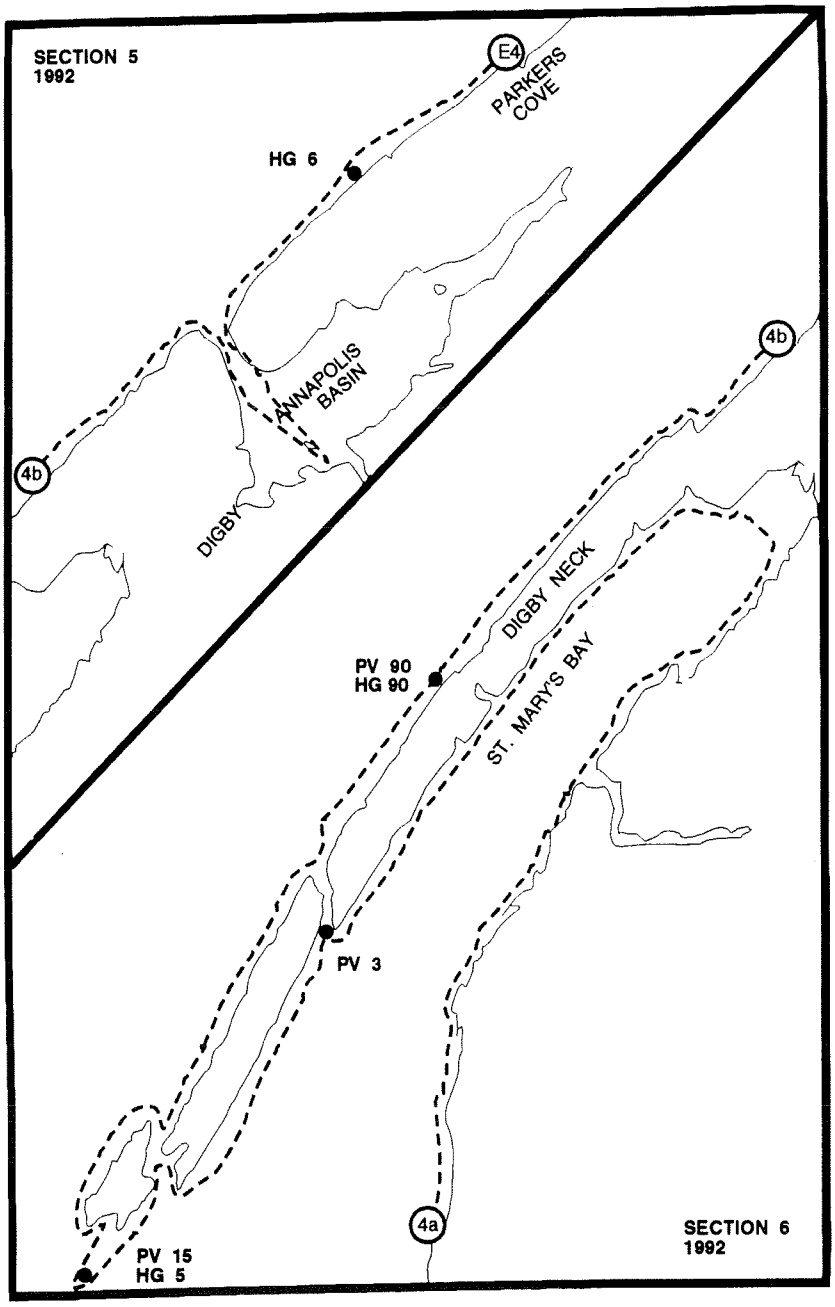

Figure 33. The locations and numbers of harbour seals (PV) and grey seals (HG) for 1992, in sections 5 and 6 of the study area, on day 4 of the survey. The start and end of a survey track (dashed line) are denoted as Sn and En respectively, with n representing the consecutive number of the survey day. Continuations from one section to another are denoted with two-character breakpoint symbols which stipulate the survey day (1,2,3,...) and sequential leg (a,b,c,...) of the flight track. The symbols 4b and 4a mark the points where the track for survey day 4 is split between sections 5 and 6, and Figures 32 and 33 respectively, covering the three legs of that flight.

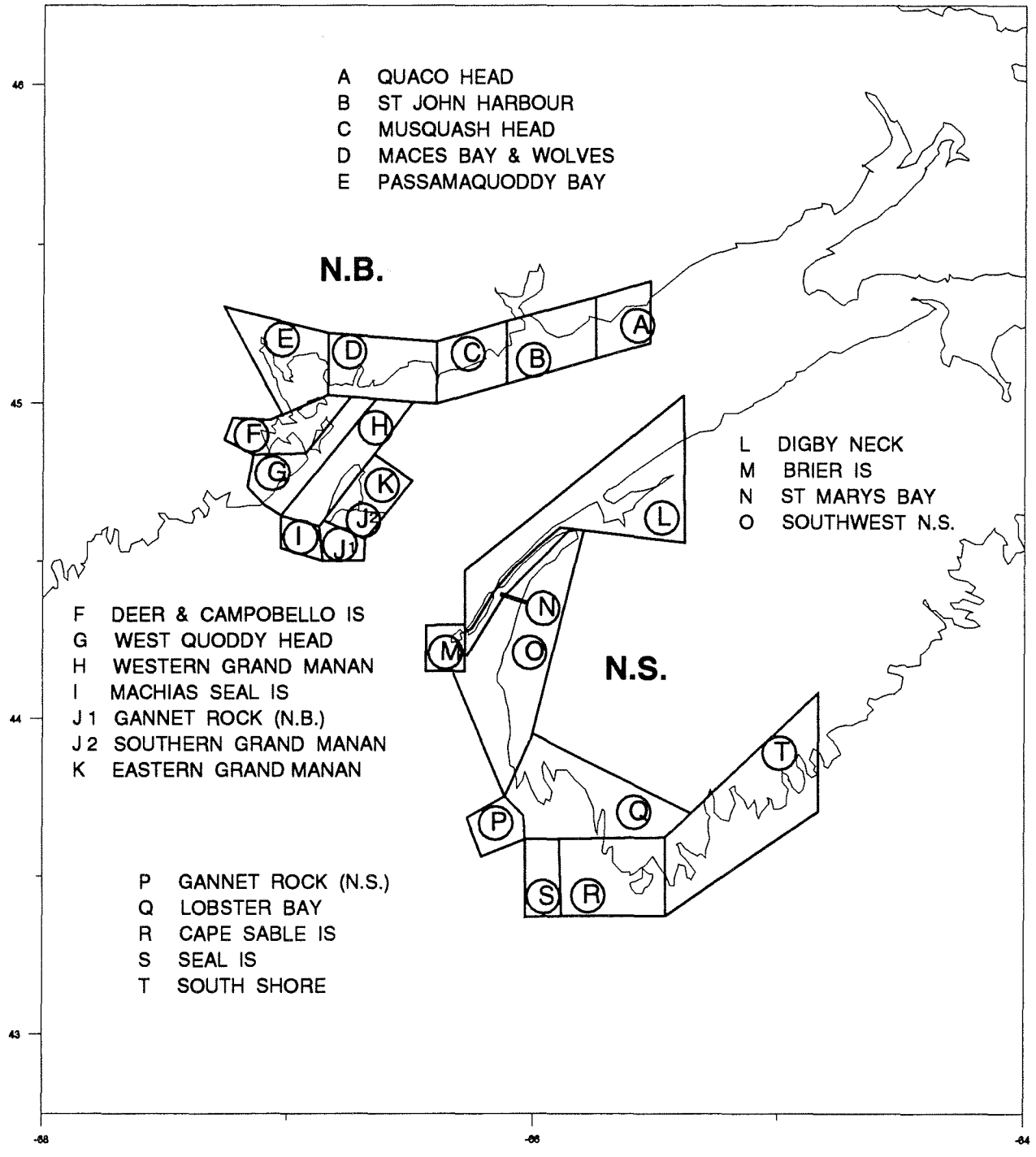

Figure 34. The 21 areas of the Bay of Fundy and vicinity into which seal counts were grouped for analysis. The locally familiar names we use in the text are associated with single letter identifiers to reduce clutter in the survey area.

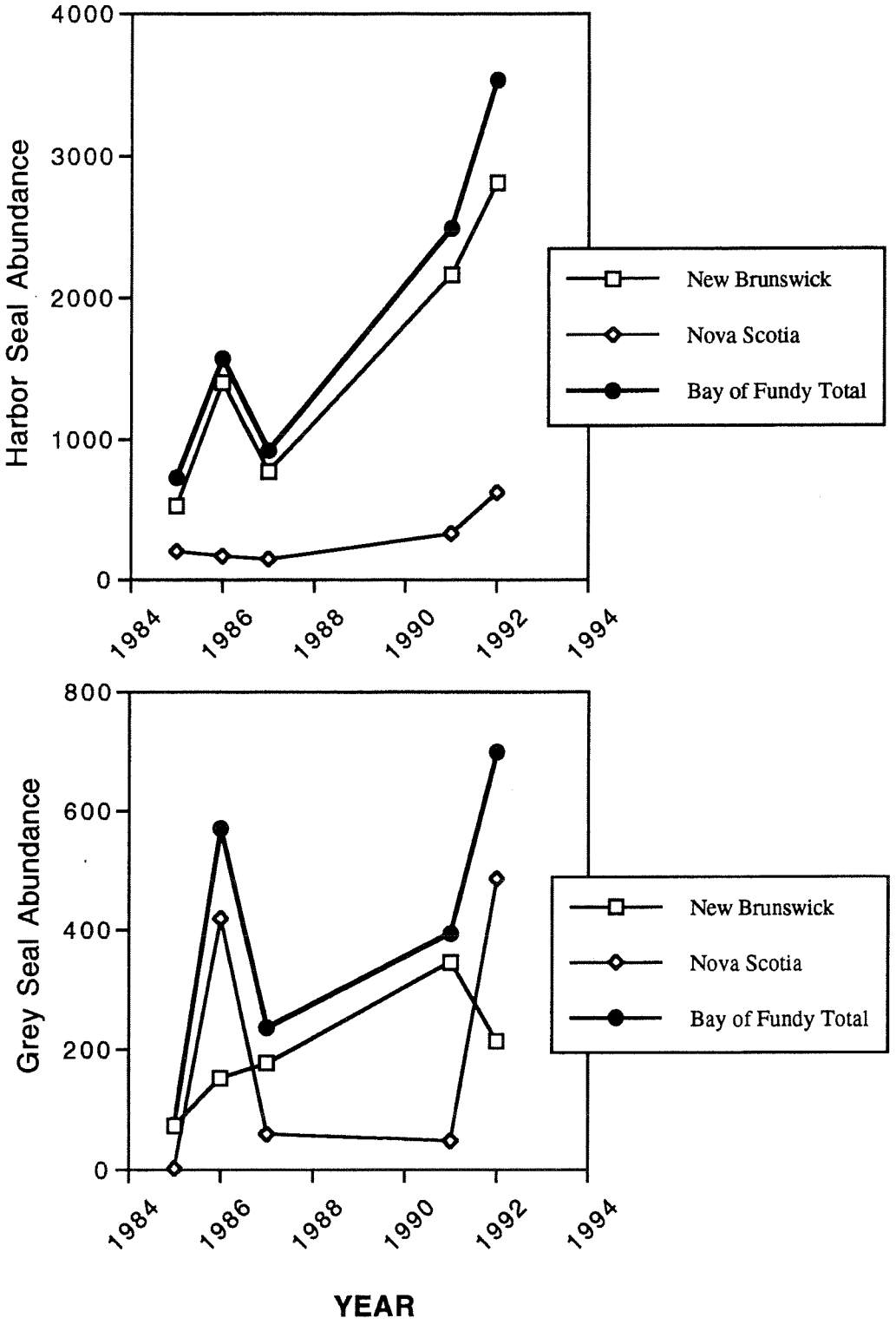

Fig. 35. Annual abundance of seals in the Bay of Fundy area, partitioned to the coastal areas of New Brunswick and Nova Scotia.