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Distribution and Acoustic Backscatter of Herring in NAFO Divisions 4T and 4Vn, November-December 1988

by

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ABSTRACT

The fifth annual acoustic survey for herring in the southern Gulf of St. Lawrence and Sydney Bight was conducted in November-December 1988. Acoustic backscatter estimates were made for the Bay of Chaleur area from a November survey which began 10 days after its planned start date. Estimates for Sydney Bight were derived from a survey conducted in December. Estimates totaled 240294 and 172886 tonnes for the two areas, respectively. These estimates were 64% lower than those of 1987. Backscatter conversion factors, migration biases, completeness of survey coverage, identification of insonified fish, effect of groundfish on herring backscatter, day-night effects, and mixing of 4T and 4WX herring are discussed as possible sources of error in the estimation of 4T herring stock size from acoustic surveys.

RESUME

Le cinquième relevé acoustique du hareng du sud du Golfe Saint-Laurent et dans l'Anse de Sydney a été mené en novembre et décembre 1988. Les coefficients d'écho ont été estimés pour la région de Chaleur à partir d'un relevé fait en novembre qui a débuté 10 jours plus tard que prévu. Les estimés pour l'Anse de Sydney étaient basés sur un relevé mené en décembre. La biomasse était estimée à 240294 et 172886 tonnes pour les deux régions, respectivement. Les estimés ont subi une baisse de 64% par rapport à ceux de 1987. Les facteurs de conversion des coefficients d'écho, les biais dus à la migration, l'envergure des relevés, l'identification des poissons repérés par sondeur, les effets des poissons de fond sur les coefficients d'écho des harengs, les effets jour-nuit, et le mélange des poissons provenant des districts 4T et 4WX ont été discutés comme sources possibles d'erreur dans l'estimation de l'importance du stock du hareng du 4T à partir des relevés acoustiques.

INTRODUCTION

Since 1984, the Department of Fisheries and Oceans has conducted acoustic surveys of late fall concentrations of herring (*Clupea harengus*) belonging to the southern Gulf of St. Lawrence stock complex (Shotton 1986, Shotton et al. 1987 a and b, Cairns et al. 1988). Survey effort has concentrated in the Bay of Chaleur area, where 4T herring congregate in the late fall, and the Sydney Bight area of Cape Breton Island, which is the wintering ground for many, and possibly all, 4T herring (W.T. Stobo, in prep.). Both of these areas are subject to important purse seine fisheries in November.

The long-term objective of these surveys is to obtain an independent index of stock abundance for 4T herring which could be used as a means of calibrating virtual population analysis. This report presents acoustic backscatter estimates for herring in the Chaleur and Sydney Bight areas. We also present maps showing the distribution of herring and other acoustic targets within the areas surveyed.

SURVEY AREA AND METHODS

The 1988 acoustic survey was delayed from its planned start date of 2 November by gearbox troubles with the survey vessel (the *Alfred Needler*). Surveys began in the Bay of Chaleur area on 12 November, and continued to 18 November (Tables 1-2). Surveys began in Sydney Bight on 20 November, but work there was suspended the following day because of bad weather. Because of the difficulties in completing the November surveys, additional vessel time was obtained on the *E. E. Prince*. We used this vessel for additional acoustic surveys in the Bay of Chaleur on 1-3 December, and in Sydney Bight from 9-13 December (Table 2).

Acoustic surveys were conducted according to a stratified design, using random parallel transects within strata. The use of random parallel transects was recommended by CAFSAC following the special meeting of its Pelagic Subcommittee in August 1988 on acoustic survey design. This design represents a departure from that used in previous years, when random zigzag transects were used. Transect lines were established by drawing perpendiculars from points chosen randomly along a straight line drawn along the seaward boundary of a stratum. Transect lines ran from the seaward stratum boundary to approximately the 10 fathom line. Random start points within 200 m of a pre-existing point were rejected.

Strata are mapped in Figs. 1-11. Strata and their boundaries were the same as those used in 1987, except that three new strata were added in the Bay of Chaleur (Central Chaleur, East Central Chaleur and Maisonnette; Fig. 2), and the Northeast Prince Edward Island stratum was not surveyed.

Survey time was allocated among strata on the basis of the amount of herring backscatter recorded in each stratum in previous surveys. Three categories were established, with densities of transects within strata assigned in a 1:2:3 ratio. Highest-density strata were Grande Rivière, Newport, Shigawake, Maisonnette, West Miscou, Neil Harbour, Wreck Cove and New Waterford. Intermediate strata were Anse-à-Beaufils, St. Ann's Bay, Sydney and Donkin. Low-density strata were Cap Bon Ami, Baie de Gaspé, Gaspé Offshore, American Bank, New Carlisle, New Richmond, North Miscou, East Miscou, Aspy Bay and Haddock Bank.

Because survey time may be unexpectedly restricted by bad weather, we prepared two series of transect lines. Start points were chosen independently in the two series, so that the 200 m minimum inter-transect distance does not apply to lines of different series. In the A series, the number of lines per stratum was calculated so that cruising transects would completely use up the planned survey period. This assumes that no time would be lost to weather. The number of lines per stratum in the B series was 60% that of the A series.

Transects were run 24 hours a day at 10 knots, except in poor weather when speed was reduced to 8-9 knots.

With the exception of the change to random parallel transects, acoustic estimates used the same equipment, procedures, and algorithms as in previous years. Acoustic equipment was calibrated by R. Dowd by the method of narrow/wide beam axis comparison (Dickie and Boudreau 1987).

To select acoustic targets for integration, we examined paper sounder traces and identified marks as adult herring, small targets, or groundfish. Solid black marks rising in pyramids or plumes in the water column were considered to be adult herring. Light speckles were taken as small targets, and heavy speckles, sometimes merging into nearly solid black, were taken as groundfish. We matched marks identified as adult herring schools with corresponding echo measurements recorded by the sounder on computer tape.

Echo strengths of selected schools were integrated on the Cyber at the Bedford Institute of Oceanography using software written by R. Shotton. This software rejects any voltage samples within 30 cm of the bottom (R. Shotton, pers. comm.) This software gives both edited and unedited integrations. Edited integrations are necessary in cases where herring schools are sufficiently dense that conventional integration mistakes the surface of the fish school for the bottom. The editing integrator evaluates the steepness of the gradient of the apparent bottom to identify likely fish schools, and calculates echo strengths of these schools. Once schools were integrated by both methods, we again examined the sounder paper and made a visual judgement as to whether a sharply rising bottom was likely a herring school. In most cases we accepted the edited integration where this differed from the unedited integration.

Calculation of mean and variance of acoustic and biomass estimates follows Jolly and Hampton (in press) and Jolly and Smith (1989). Foote's (1987) formula was used to calculate target strength from data on length and weight of sampled fish (Table 1). Data presentation conforms to the format established at the CAFSAC Pelagic Subcommittee meeting of May 1989. Formulas are given in Appendix 1.

In December 1988, we measured temperature profiles with expendable bathythermographs (XBT's). Cast locations are given in Figs. 2 and 3. Acoustic targets were sampled by sets made at locations given in Figs. 2 and 3. An IYGPT trawl was used on the *Alfred Needler*, and an Engel trawl was used on the *E. E. Prince*. Both trawls were equipped with headline transducers. All sets were made at night, when herring appear to be easier to catch by trawl.

Acoustic surveys in the western Bay of Chaleur were done in conjunction with surveys for juvenile herring (Figs. 6, 13). Juvenile survey dates were 14-15 November and 2-7 December. Although these surveys were not designed to provide quantitative estimates of adult herring backscatter, they allowed us to evaluate the extent to which adult herring are distributed outside regular strata in the western Bay of Chaleur.

RESULTS

Distribution and backscattering of adult herring

Chaleur

The distribution of adult herring encountered during surveys in the Bay of Chaleur is mapped in Figs. 4-8, and total backscattering estimates are presented in Tables 2 and 3. In November, the bulk of insonified herring was in the Shigawake stratum on the north side of the Bay, where total backscattering accounted for 75% of the total for the Chaleur area. Most of the remainder (19%) was found in the Maisonnette stratum on the south side. Small quantities of herring were found in the western Bay in the New Richmond and New Carlisle strata. No measurable herring was found in eight of the 16 strata in the Chaleur area, and none was located during the juvenile surveys in the western Bay.

Although the December survey of the Chaleur area included most of the strata where fish were found in November, only a small quantity of herring was located. Total backscattering for December was 5% of the November total. Most of the fish encountered were in the East Central Chaleur stratum, which accounted for 85% of the December total. Some fish were found in Newport and Shigawake, and two small schools were encountered during juvenile surveys in the western Bay (Fig. 6).

Sydney Bight

The November survey in Sydney Bight covered only two strata before it was abandoned to inclement weather. A substantial quantity of herring was found in Aspy Bay (8899 m^2 sr^{-1}, Table 3). Only 30 of 35 planned transects were completed in Neil Harbour, resulting in incomplete coverage of the southern end of the stratum (Fig. 9). These transects produced a total backscattering estimate of 4015 m^2 sr^{-1} (Table 2).

In December, no herring were found in Aspy Bay, but major concentrations were located in Neil Harbour and Wreck Cove (Figs. 10-11). These fish appeared as bands in a trench of deep water about 4-5 km from the coast. Except for a small school in the Sydney stratum (Fig. 11), no herring were found in the southern part of Sydney Bight.

Because of the large aggregations of herring encountered in the western part of the Bight, we attempted to intensify coverage by conducting a second survey in the Neil Harbour stratum. The first survey of this stratum did a complete set of B transects. For the second, we randomly chose 16 of the 35 transects in the A series. However, we completed only 13 of these due to bad weather. Total backscattering in Neil Harbour was 16122 m^2 sr^{-1} in the first survey, and 66319 in the incomplete second survey (Table 3). Herring encountered in the Wreck Cove stratum produced an estimate of 32994 m^2 sr^{-1}.

Distribution of juvenile herring or other small targets

We were unable to distinguish sounder traces of juvenile herring from those made from capelin (*Mallotus villosus*) and smelt (*Osmerus mordax*). Locations where small acoustic targets were encountered are shown in Figs. 12-16. In November, small targets were found mainly in the western Bay of Chaleur and in the Newport stratum (Figs. 12 and 13). A small quantity was also located on American Bank (Fig. 16). In December, small targets were widely distributed throughout the Bay of Chaleur (Figs. 14-15). No small targets were found in either month in Sydney Bight.

Distribution of groundfish

Distribution of groundfish is given in Figs. 17-22. In the Chaleur area in November groundfish were widespread throughout the eastern part of the Bay, and scattered groups were found in the open Gulf to the east (Figs. 17-19). Density of sounder marks was generally low. No groundfish were found on juvenile or acoustic surveys in the Chaleur area in December.

Very high densities of groundfish were found in northwestern Sydney Bight in both November and December (Figs. 20-22). These fish formed a continuous band along the deep trench that runs parallel to the coast. Judging from the intensity of the paper sounder marks, schools were very dense. In general, herring schools in this area occurred completely within the range of the band of groundfish (Figs. 9-11, 20-22). Some concentrations of groundfish occurred in southern Sydney Bight in December, but their densities appeared to be much lower than those of groundfish in western Sydney Bight.

Temperature profiles

Temperature profiles as revealed by XBT casts made during December are presented in Figs. 23 and 24. In the Bay of Chaleur, surface waters were 1°-2.2°C. Below this surface layer, temperatures rose by ca. 1°-2°C in a thermocline at 15-35 m depth. In the western extremity of the Bay, the layer of constant temperature reached the bottom and there was no thermocline.

In Sydney Bight, surface waters ranged from 1.7° to 3.6°C. (Fig. 24). The row of casts in northern Neil Harbour (Fig. 3) revealed a well-mixed surface layer above a thermocline at ca. 40 m. Vertical structure was less developed elsewhere in Sydney Bight, although deep waters tended to be warmer than surface waters.

Size and spawning affinity of herring samples

Length frequency profiles of herring taken in sets are presented in Figs. 25 and 26, and set locations are given in Figs. 2 and 3. The three sets made in the Shigawake stratum and the single set in Maisonnette took mixtures of adult and juvenile herring. These two strata accounted for 94% of total backscattering recorded in the Chaleur area in November. Sets made in the western Bay of Chaleur consisted primarily of juvenile herring and smelt, and included no adult herring. Percent by weight of spring spawners is given below.

Set	Percent by weight, spring spawners	Mean length (cm)	Weight (g) at mean length	Regression equation
Chaleur, November				
N1	71.3	26.4		
N2	80.7	27.2		
N3	62.4	31.2		
N4	62.7	24.6		
Sum	68.2	28.7	197.5	$0.00400\ wt^{3.219}$
Sydney Bight, November				
N8	20.0	32.4	264.2	$0.00989\ wt^{2.930}$
Sydney Bight, December				
P18	26.4	30.7		
P19	16.0	30.7		
P20	35.2	27.3		
Sum	27.5	28.7	184.3	$0.00771\ wt^{3.002}$

All sets in Sydney Bight were made in the Neil Harbour and Wreck Cove strata (Fig. 3), which together accounted for 98% of total backscattering estimated for Sydney Bight in the December survey. Three of these sets (N8, P18, P19) consisted primarily of adult herring, with a small quantity of juveniles (Fig. 25). Set P20 took juvenile and adult herring in roughly equivalent numbers. Most herring taken in sets were fall spawners (see text table above).

Biomass estimates

Using Foote's (1987) formula for target strength, we estimated biomass of herring schools encountered in Chaleur and Sydney Bight (Tables 2-6). Because few herring were found in the December cruise to Chaleur, we used data from the November cruise to estimate biomass from that area. For Sydney Bight, we used data from the December cruise because the November cruise was incomplete.

Biomass estimates for Chaleur were 163881 tonnes of spring spawners and 76413 tonnes of fall spawners, for a total of 240294 tonnes. Estimates for Sydney Bight were 47544 tonnes of spring spawners and 125342 tonnes of fall spawners, for a total of 172886 tonnes.

DISCUSSION

Estimates of herring biomass generated by acoustic surveys in 4T and 4VN showed a stable or increasing trend in 1984-1986, followed by a dramatic rise in 1987 (Table 6, Fig. 27). Estimates for 1988 are higher than those for the first three years of surveys, but only 36% of the value for 1987.

Acoustic biomass estimates for 4T herring must be viewed in the context of potential errors and biases which may affect results. Principal sources of uncertainty are reviewed below.

Backscatter conversions

Calculation of biomass from acoustic backscatter requires the use of conversion factors. These factors are difficult to measure, and may be influenced by uncontrolled variables such as attitude of fish in the water. Problems in determining reliable conversion factors have been extensively discussed elsewhere, and will not be further dealt with here.

Identification of insonified fish

Adult herring in late fall concentrations can be readily identified by the distinct marks they make on sounder paper. Correspondence between these marks and adult herring schools has been confirmed by many trawl sets over the years. We do not consider identification of adult herring a problem except where sounder marks are small and faint. Such schools constitute a negligible fraction of total backscattering. However, mis-identification of small marks could cause errors in the mapping of fish distribution.

Groundfish show as heavy black speckles on sounder paper. This has been confirmed by trawl sets over the years. It was further confirmed by sets P16 and P17, in which cod were caught after heavy black speckles appeared on the sounder.

Although adult herring make distinctive sounder marks, schools containing adult herring only cannot be separated from those which also contain juveniles. Schools containing heavy concentrations of juveniles (e.g. Sets N2 and P20, Fig. 25) look like typical adult schools on the sounder. In both Chaleur and Sydney Bight, there is a purse seine fishery operating at the same time as our surveys. Skippers of these vessels are unable to distinguish schools of pure adults from those containing a proportion of juveniles high enough to prevent the fish from being marketable.

Our integrated backscatter estimates therefore include juvenile herring where they mix with adults, although the survey is intended as an adult survey. This may upwardly bias biomass estimates in a way which is likely to vary in time and place.

Backscatter of herring in the presence of groundfish

Nearly all herring encountered in Sydney Bight in November and December were associated with a dense band of groundfish that ran along the coast from St. Ann's Bay stratum to the northern end of Neil Harbour stratum (Figs. 20-22). Sounder traces of herring in this area looked like a black mountain rising in a sea of heavy black speckles. It is likely that some echoes from these groundfish were included in acoustic backscatter attributed to the herring schools. However, we are unable to judge how important a bias this likely produced.

An additional problem in this area was the presence of herring and groundfish below 100 m depth. One hundred meters was the bandwidth of our sounder paper, so we were unable to maintain a paper record of fish below this depth while simultaneously recording the upper 100 m. In some cases, the lack of a paper record of fish below 100 m compromised our ability to evaluate edited and unedited backscatter integrations.

Day-night effects

Cairns et al. (1988) found limited evidence suggesting diel behaviour cycles of herring in the Bay of Chaleur. In this survey, transects were run night and day because of limitations of ship time. If the availability of herring to insonification changes systematically between day and night, survey results may be biased according to whether major aggregation areas are covered in the day or at night.

Completeness of spatial coverage

When 4T-4VN acoustic surveys began in 1984, survey tracks covered a very wide area to ensure that all suspected areas for herring aggregations were covered (Shotton et al. 1987a). In 1985 and 1986, survey effort in the Chaleur area was restricted to a small subset of the original survey zone, in order to concentrate on important aggregating areas. In 1987 and again in 1988, coverage in the Chaleur area expanded to include new strata. In Sydney Bight, the area covered by surveys has been fairly constant since 1984, although important strata have been missed in some years (Table 5).

We feel that our coverage in both Chaleur and Sydney Bight is likely to be fairly complete. Extensive juvenile surveys in the western Bay of Chaleur in 1988 showed few or no adult herring, so it is unlikely that we are missing important aggregations there. However, our strata do not cover all parts of the eastern Bay, and it is possible that herring concentrate in places not covered by our strata. The case of Maisonnette stratum illustrates the potential effect of incomplete survey coverage. If we had not introduced this as a new stratum in 1988, we would have missed 12,290 m^2 sr^{-1}, and the total Chaleur estimate would have been lower by 19% (Table 5).

The 1984 survey found a major concentration of herring along the coast of northwest Cape Breton Island, and fish there accounted for 17% of all backscatter observed in that year. This area has not been surveyed since. We intended to cover it in 1988, but were prevented from doing so by weather and limited ship time. If herring still concentrate in this area, lack of coverage in 1985-1988 may downwardly bias total backscattering estimates for 4T-4VN.

Migration bias

Acoustic biomass estimates of 4T herring depend on the assumption that all or nearly all fish of the 4T stock complex are located within survey strata at the time that the survey is conducted. Tagging data (W.T. Stobo in prep.) indicate that adult herring move out of the Gulf to winter in the Sydney Bight area. Since the Gulf is mostly ice-covered in winter, it is difficult to determine with certainty whether some adult herring remain in the Gulf for the winter. However, the surveys we conducted in late fall 1988, which showed that parts of the Bay of Chaleur which were heavily populated with herring in November were nearly devoid of fish in December, suggest that Chaleur fish may leave the area some time in late November. Because no other concentrations of herring are known in the southern Gulf at this time of the year (except West Cape Breton; see above), we assume that these Chaleur fish leave the Gulf, and that their probable destination is Sydney Bight.

If the pattern of migration proposed above is correct, there are main two ways in which incorrect acoustic estimates could be generated. Firstly, some fish might be missed because they are migrating between Chaleur and Sydney Bight during the time of the surveys. Most of the route between the Bay of Chaleur and Sydney Bight is outside survey strata, so fish would not be encountered during their migration. Even if strata were laid down to cover possible migration routes, we are uncertain of what migrating herring would look like on the sounder and whether valid backscatter measurements could be made.

The second type of error could occur if there is a substantial delay between Chaleur and Sydney Bight surveys, so that migrating fish were counted in both surveys. Our biomass estimates for 1988 are based on surveys conducted 13-18 November in Chaleur and 9-13 December in Sydney Bight. We did not use the December Chaleur survey because we found few fish or the November Sydney Bight survey because it did not cover most strata. During the 3-4 week interval between the two surveys that were accepted as biomass estimators, it is possible that fish that were counted in Chaleur migrated to Sydney Bight, where they were counted again.

The 1988 survey was unusual in the time elapsed between the Chaleur and Sydney Bight surveys, which are normally separated by only a few days. However, it is possible that migration may produce under-counting or double-counting of fish even when the Sydney Bight survey closely follows that of Chaleur. Ideally, surveys in the two areas should be done simultaneously on different vessels. This would ensure that fish were not counted twice, but some fish could still be missed during migration.

If fish movements and survey schedules remained constant from year to year, bias due to migration would be constant and resulting acoustic estimates would form a valid index of stock size. However, survey dates may vary due to ship availability and weather, and migration phenology is unlikely to be identical from year to year. For example, substantial quantities of herring were found on the north side of the Bay of Chaleur in early December 1987 in an area where few fish were found in early December 1988. Errors due to undercounting and overcounting of migrating fish could differ substantially among years if either survey or migration schedules vary by several days.

Separation of 4T fish from 4WX fish

Sydney Bight is an overwintering site for herring from both the 4T and 4WX stock complexes. Use of acoustic surveys in Sydney Bight for estimating 4T stock abundance requires knowledge of the importance of 4WX fish among fish insonified in Sydney Bight. In general, tagging results (W.T. Stobo, in prep.) indicate that herring in the northern part of Sydney Bight tend to belong to the 4T stock, whereas fish in the southern part of Sydney Bight tend to originate in 4WX.

This suggests that a biomass estimate that combines Chaleur results with those from northern Sydney Bight might reflect 4T stock size with only a small error due to inclusion of 4WX fish. However, this conclusion depends on migration patterns being the same from year to year. In 1988, virtually no herring were found in southern Sydney Bight. This contrasts to substantial concentrations found there in the two previous years for which complete surveys were available (1985 and 1987, Table 4). The most likely explanation for the paucity of herring in southern Sydney Bight is that 4WX fish did not migrate as far in 1988 as in previous years, and remained outside our survey strata. However, the possibility cannot be excluded that 4WX fish migrated further in 1988 than usual, and reached overwintering destinations in the northern part of Sydney Bight.

A further uncertainty in the migration patterns of 4T and 4WX herring arises from the results of an acoustic survey of the herring survey conducted in Sydney Bight in late January 1989 (Buerckle in prep.). No herring were located during this survey, which covered all of the Sydney Bight strata except Aspy Bay and the northern two thirds of Neil Harbour.

Confidence limits of estimates

The introduction of random parallel transects in the 1988 survey has put backscatter estimates on firmer statistical footing. Because of the change in survey design, it is not appropriate to calculate significance levels of differences in acoustic estimates among years.

Standard errors calculated for survey estimates apply to one place and one time, and do not reflect error and bias due to the factors considered above. The effects of short term variation are illustrated by two surveys of Neil Harbour in December 1988. The first of these surveys generated an estimate of 16122 m^2 sr^{-1}, and the second produced an estimate of 66319 m^2 sr^{-1} (Table 2). Because the second survey included only 13 of 16 planned transects, its sampling intensity could not be considered random. However, even if the unfinished transects in the second survey had contained no fish at all, its total backscattering estimate would have exceeded that of the first survey by a factor of at least three. Such a result would have doubled the total acoustic estimate for Sydney Bight.

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Table 1. Lengths, weights, and spawning affinity of herring from sets made during acoustic cruises, 1984-1988. 1988 data are from the November cruise to Chaleur and the December cruise to Sydney Bight.

Year	Chaleur				Sydney Bight			
	Mean length (cm)	Weight at mean length (g)	Weight formula	Percent spring spawners	Mean length (cm)	Weight at mean length (g)	Weight formula	Percent spring spawners
1984	28.0	184.7	a		27.7	168.1	b	
1985	29.4	215.6	a		28.3	178.9	b	
1986	31.4	265.8	a	56.0	31.7	249.2	b	
1987	29.3	213.3	$0.00468 \times len^{3.176}$	21.4	28.5	182.7	$0.01035 \times len^{2.919}$	43.3
1988	28.7	197.2	$0.00400 \times len^{3.219}$	68.2	28.7	184.3	$0.00771 \times len^{3.002}$	27.5

[a] Weight formula from Chaleur 1987

[b] Weight formula from Sydney Bight 1987

Table 2. Estimates of total backscatter and biomass of herring encountered in acoustic transects in the Chaleur and Sydney Bight areas, November-December 1988.

Stratum	Transect no.	Transect length (km)	Transect area (m^2)	Target strength (dB kg^{-1})	Sa (Area scattering coefficient (sr^{-1}))	Total backscattering (m^2 sr^{-1})	Biomass density (kg m^{-2})	Total biomass (t $transect^{-1}$)	Set number	Number of fish sampled
Bay of Chaleur, November										
Cap Bon Ami	A1	7.062	1412420	-35.698	.00000000	.000000	.00000	.00		
	A2	7.927	1585484	-35.698	.00000000	.000000	.00000	.00		
	A3	9.496	1899153	-35.698	.00000000	.000000	.00000	.00		
Baie de Gaspé	A1	5.844	1168759	-35.698	.00000000	.000000	.00000	.00		
	A2	6.246	1249287	-35.698	.00000000	.000000	.00000	.00		
	A3	3.985	796986	-35.698	.00000000	.000000	.00000	.00		
Gaspé Offshore	A1	6.750	1349957	-35.698	.00000000	.000000	.00000	.00		
	A2	12.809	2561890	-35.698	.00000000	.000000	.00000	.00		
	A3	11.922	2384445	-35.698	.00000000	.000000	.00000	.00		
	A4	11.050	2209906	-35.698	.00000000	.000000	.00000	.00		
American Bank	A1	6.796	1359219	-35.698	.00000000	.000000	.00000	.00		
	A2	8.714	1742743	-35.698	.00000000	.000000	.00000	.00		
	A3	8.635	1727054	-35.698	.00000000	.000000	.00000	.00		
	A4	6.255	1251006	-35.698	.00000000	.000000	.00000	.00		
La Malbaie	A1	9.147	1829305	-35.698	.00000000	.000000	.00000	.00		
	A2	14.965	2992995	-35.698	.00000000	.000000	.00000	.00		
	A3	15.327	3065469	-35.698	.00000000	.000000	.00000	.00		
	A4	14.394	2878859	-35.698	.00000000	.000000	.00000	.00		
Anse-à-Beaufils	A1	10.136	2027255	-35.698	.00000000	.000000	.00000	.00		
	A2	10.805	2161012	-35.698	.00000000	.000000	.00000	.00		
	A3	9.220	1843997	-35.698	.00000000	.000000	.00000	.00		
	A4	10.104	2020723	-35.698	.00000000	.000000	.00000	.00		
	A5	5.674	1134798	-35.698	.00000000	.000000	.00000	.00		
	A6	6.541	1308113	-35.698	.00000000	.000000	.00000	.00		
Grande Rivière	A1	4.971	994202	-35.698	.00000000	.000000	.00000	.00		
	A2	5.636	1127193	-35.698	.00000000	.000000	.00000	.00		
	A3	5.622	1124300	-35.698	.00000000	.000000	.00000	.00		
	A4	5.994	1198756	-35.698	.00000094	1.129944	.00350	4.20		
	A5	5.995	1198965	-35.698	.00000058	.694892	.00215	2.58		
	A6	6.462	1292459	-35.698	.00000090	1.158779	.00333	4.30		
	A7	7.074	1414805	-35.698	.00000131	1.857243	.00487	6.90		
	A8	5.132	1026387	-35.698	.00000000	.000000	.00000	.00		
	A9	6.733	1346572	-35.698	.00000050	.666804	.00184	2.48		
	A10	6.162	1232314	-35.698	.00000000	.000000	.00000	.00		
	A11	4.755	950918	-35.698	.00000221	2.097864	.00819	7.79		
	A12	4.762	952302	-35.698	.00000051	.482553	.00188	1.79		
Newport	A1	4.648	929675	-35.698	.00000000	.000000	.00000	.00		
	A2	6.790	1357978	-35.698	.00000000	.000000	.00000	.00		
	A3	6.744	1348741	-35.698	.00000000	.000000	.00000	.00		
	A4	7.564	1512711	-35.698	.00000000	.000000	.00000	.00		
	A5	7.838	1567619	-35.698	.00000000	.000000	.00000	.00		
	A6	7.530	1506038	-35.698	.00000000	.000000	.00000	.00		
	A7	8.184	1636786	-35.698	.00000000	.000000	.00000	.00		
	A8	7.640	1528046	-35.698	.00000000	.000000	.00000	.00		
	A9	6.948	1389554	-35.698	.00000000	.000000	.00000	.00		
	A10	6.555	1310921	-35.698	.00000000	.000000	.00000	.00		
	A11	6.375	1274983	-35.698	.00000000	.000000	.00000	.00		
	A12	5.410	1081939	-35.698	.00000000	.000000	.00000	.00		
	A13	3.509	701884	-35.698	.00000000	.000000	.00000	.00		
Shigawake	A1	6.252	1250400	-35.698	.00000000	.000000	.00000	.00		
	A2	6.925	1384986	-35.698	.00000000	.000000	.00000	.00		
	A3	7.560	1512023	-35.698	.00005361	81.054791	.19908	301.01		
	A4	8.784	1756812	-35.698	.00029457	517.499772	1.09392	1921.81		
	A5	8.815	1762957	-35.698	.00011026	194.381480	.40946	721.86		
	A6	8.792	1758427	-35.698	.00037596	661.096172	1.39618	2455.07		
	A7	7.451	1490120	-35.698	.00039405	587.188098	1.46338	2180.61	N1,N2	245
	A8	7.080	1415905	-35.698	.00036729	520.040536	1.36396	1931.24		
	A9	7.255	1451054	-35.698	.00023187	336.450687	.86107	1249.46		
	A10	7.490	1498047	-35.698	.00018514	277.343186	.68753	1029.95		
	A11	6.514	1302838	-35.698	.00027029	352.146385	1.00377	1307.75	N3	190
	A12	6.915	1382959	-35.698	.00033904	468.875795	1.25907	1741.24		
	A13	6.099	1219747	-35.698	.00037877	462.003889	1.40662	1715.72		
	A14	5.571	1114243	-35.698	.00000000	.000000	.00000	.00		
	A15	5.317	1063441	-35.698	.00000000	.000000	.00000	.00		
	A16	5.118	1023673	-35.698	.00000000	.000000	.00000	.00		
	A17	4.918	983514	-35.698	.00000000	.000000	.00000	.00		

Table 2 (con't)

Stratum	Transect no.	Transect length (km)	Transect area (m^2)	Target strength (dB kg^{-1})	Sa (Area scattering coefficient (sr^{-1}))	Total back-scattering (m^2 sr^{-1})	Biomass density (kg m^{-2})	Total biomass (t $transect^{-1}$)	Set number	Number of fish sampled
Shigawake (con't)	A18	5.192	1038375	-35.698	.00000000	.000000	.00000	.00		
	A19	5.145	1029060	-35.698	.00000000	.000000	.00000	.00		
	A20	4.947	989424	-35.698	.00000000	.000000	.00000	.00		
	A21	5.493	1098658	-35.698	.00000000	.000000	.00000	.00		
	A22	5.733	1146515	-35.698	.00000000	.000000	.00000	.00		
	A23	5.922	1184487	-35.698	.00000000	.000000	.00000	.00		
New Carlisle	A1	4.809	961798	-35.698	.00000748	7.190577	.02776	26.70		
	A2	5.416	1083194	-35.698	.00000000	.000000	.00000	.00		
	A3	5.816	1163215	-35.698	.00000000	.000000	.00000	.00		
	A4	5.831	1166156	-35.698	.00000000	.000000	.00000	.00		
	A5	5.723	1144681	-35.698	.00000000	.000000	.00000	.00		
New Richmond	A1	4.500	899978	-35.698	.00005450	49.051440	.20240	182.16		
	A2	5.632	1126307	-35.698	.00000000	.000000	.00000	.00		
	A3	3.931	786261	-35.698	.00000000	.000000	.00000	.00		
	A4	5.707	1141445	-35.698	.00005106	58.284889	.18963	216.45		
	A5	5.943	1188676	-35.698	.00006314	75.052688	.23448	278.72		
	A6	5.576	1115183	-35.698	.00000000	.000000	.00000	.00		
	A7	4.482	896371	-35.698	.00000000	.000000	.00000	.00		
	A8	5.403	1080634	-35.698	.00000000	.000000	.00000	.00		
	A9	5.430	1085940	-35.698	.00000000	.000000	.00000	.00		
	A10	5.301	1060209	-35.698	.00000000	.000000	.00000	.00		
	A11	5.985	1196901	-35.698	.00000000	.000000	.00000	.00		
	A12	7.666	1533193	-35.698	.00000000	.000000	.00000	.00		
	A13	3.159	631875	-35.698	.00000000	.000000	.00000	.00		
	A14	3.355	670906	-35.698	.00000000	.000000	.00000	.00		
Central Chaleur	A1	11.242	2248470	-35.698	.00000000	.000000	.00000	.00		
	A2	10.308	2061611	-35.698	.00000000	.000000	.00000	.00		
	A3	10.172	2034372	-35.698	.00000000	.000000	.00000	.00		
	A4	9.758	1951618	-35.698	.00000000	.000000	.00000	.00		
	A5	9.061	1812253	-35.698	.00000000	.000000	.00000	.00		
	A6	8.734	1746861	-35.698	.00000265	4.635741	.00986	17.22		
	A7	9.027	1805340	-35.698	.00000000	.000000	.00000	.00		
	A8	9.174	1834858	-35.698	.00000000	.000000	.00000	.00		
	A9	8.934	1786839	-35.698	.00000000	.000000	.00000	.00		
	A10	9.864	1972743	-35.698	.00000072	1.414717	.00266	5.25		
	A11	10.435	2087005	-35.698	.00000000	.000000	.00000	.00		
	A12	10.566	2113167	-35.698	.00000000	.000000	.00000	.00		
Maisonnette	A1	4.297	859413	-35.698	.00000263	2.256885	.00975	8.38		
	A2	4.362	872356	-35.698	.00000000	.000000	.00000	.00		
	A3	5.146	1029124	-35.698	.00000328	3.375693	.01218	12.54		
	A4	5.073	1014622	-35.698	.00017793	180.534970	.66078	670.44		
	A5	2.058	411627	-35.698	.00002524	10.387490	.09371	38.58		
	A6	4.252	850437	-35.698	.00016734	142.313173	.62145	528.50		
	A7	4.089	817843	-35.698	.00005625	46.001969	.20888	170.83		
	A8	3.938	787536	-35.698	.00000000	.000000	.00000	.00		
	A9	4.582	916493	-35.698	.00000000	.000000	.00000	.00		
	A10	3.872	774412	-35.698	.00000000	.000000	.00000	.00		
	A11	4.222	844444	-35.698	.00001592	13.443449	.05912	49.92		
	A12	5.005	1001052	-35.698	.00049479	495.307465	1.83746	1839.39	N4	11
West Miscou	A1	9.078	1815651	-35.698	.00000000	.000000	.00000	.00		
	A2	10.067	2013344	-35.698	.00000000	.000000	.00000	.00		
	A3	9.628	1925607	-35.698	.00000000	.000000	.00000	.00		
	A4	9.563	1912592	-35.698	.00000000	.000000	.00000	.00		
	A5	8.956	1791147	-35.698	.00001489	26.674664	.05531	99.06		
	A6	8.194	1638745	-35.698	.00000000	.000000	.00000	.00		
	A7	8.146	1629146	-35.698	.00000000	.000000	.00000	.00		
	A8	8.163	1632682	-35.698	.00001094	17.864808	.04063	66.34		
	A9	8.433	1686557	-35.698	.00000000	.000000	.00000	.00		
	A10	8.602	1720357	-35.698	.00000000	.000000	.00000	.00		
	A11	10.205	2041050	-35.698	.00000000	.000000	.00000	.00		
	A12	11.353	2270520	-35.698	.00000000	.000000	.00000	.00		
	A13	12.633	2526683	-35.698	.00000000	.000000	.00000	.00		
	A14	12.092	2418468	-35.698	.00000000	.000000	.00000	.00		
	A15	13.371	2674118	-35.698	.00000000	.000000	.00000	.00		
	A16	13.645	2728984	-35.698	.00000000	.000000	.00000	.00		
	A17	12.900	2579993	-35.698	.00000000	.000000	.00000	.00		
	A18	7.682	1536492	-35.698	.00000000	.000000	.00000	.00		
	A19	7.607	1521392	-35.698	.00000000	.000000	.00000	.00		
	A20	6.391	1278120	-35.698	.00001058	13.519315	.03928	50.21		
North Miscou	A1	13.466	2693200	-35.698	.00000000	.000000	.00000	.00		
	A2	11.027	2205312	-35.698	.00000000	.000000	.00000	.00		
	A3	11.257	2251319	-35.698	.00000000	.000000	.00000	.00		

Table 2 (con't)

Stratum	Transect no.	Transect length (km)	Transect area (m^2)	Target strength (dB kg^{-1})	Sa (Area scattering coefficient (sr^{-1})	Total backscattering (m^2 sr^{-1})	Biomass density (kg m^{-2})	Total biomass (t transect^{-1})	Set number	Number of fish sampled
North Miscou (con't)	A4	6.684	1336742	-35.698	.00000000	.000000	.00000	.00		
East Miscou	A1	30.476	6095265	-35.698	.00000000	.000000	.00000	.00		
	A2	24.844	4968798	-35.698	.00000053	2.637606	.00197	9.80		
	A3	25.140	5027902	-35.698	.00000000	.000000	.00000	.00		
	A4	24.389	4877712	-35.698	.00000000	.000000	.00000	.00		
	A5	24.114	4822716	-35.698	.00000000	.000000	.00000	.00		
	A6	23.153	4630562	-35.698	.00000000	.000000	.00000	.00		
	A7	23.835	4766907	-35.698	.00000000	.000000	.00000	.00		
	A8	24.392	4878468	-35.698	.00000000	.000000	.00000	.00		
	A9	23.714	4742831	-35.698	.00000000	.000000	.00000	.00		
	A10	23.706	4741216	-35.698	.00000000	.000000	.00000	.00		
	A12	24.238	4847510	-35.698	.00000000	.000000	.00000	.00		
	A13	24.226	4845108	-35.698	.00000000	.000000	.00000	.00		
	A14	23.980	4795993	-35.698	.00000000	.000000	.00000	.00		
	A15	20.114	4022800	-35.698	.00000000	.000000	.00000	.00		
<u>Sydney Bight, November</u>										
Aspy Bay	A1	1.782	356449	-35.908	.00000000	.000000	.00000	.00		
	A2	7.900	1580004	-35.908	.00000258	4.074821	.01005	15.88		
	A3	8.646	1729224	-35.908	.00000158	2.735033	.00617	10.66		
	A4	8.505	1701065	-35.908	.00000119	2.023071	.00464	7.89		
	A5	9.358	1871572	-35.908	.00001561	29.219801	.06086	113.90		
	A6	9.057	1811315	-35.908	.00002555	46.278281	.09959	180.39		
	A7	4.107	821429	-35.908	.00006858	56.331391	.26731	219.58		
	A8	3.883	776503	-35.908	.00010228	79.421893	.39869	309.59		
	A9	2.579	515824	-35.908	.00071764	370.177304	2.79736	1442.95		
Neil Harbour[a]	A1	4.082	816432	-35.908	.00010742	87.699637	.41871	341.85		
	A2	3.581	716104	-35.908	.00000000	.000000	.00000	.00		
	A3	3.852	770485	-35.908	.00000000	.000000	.00000	.00		
	A4	4.425	885068	-35.908	.00000000	.000000	.00000	.00		
	A5	4.853	970563	-35.908	.00000000	.000000	.00000	.00		
	A6	5.256	1051146	-35.908	.00000000	.000000	.00000	.00		
	A7	5.176	1035104	-35.908	.00000000	.000000	.00000	.00		
	A8	5.780	1155961	-35.908	.00000000	.000000	.00000	.00		
	A9	5.203	1040600	-35.908	.00000000	.000000	.00000	.00		
	A10	3.577	715492	-35.908	.00000000	.000000	.00000	.00		
	A11	3.588	717559	-35.908	.00000000	.000000	.00000	.00		
	A12	4.242	848445	-35.908	.00000000	.000000	.00000	.00		
	A13	4.089	817746	-35.908	.00000000	.000000	.00000	.00		
	A14	8.677	1735357	-35.908	.00000000	.000000	.00000	.00		
	A15	8.961	1792191	-35.908	.00000000	.000000	.00000	.00		
	A16	8.979	1795892	-35.908	.00000000	.000000	.00000	.00		
	A17	8.794	1758857	-35.908	.00000000	.000000	.00000	.00		
	A18	8.943	1788625	-35.908	.00000000	.000000	.00000	.00		
	A19	9.129	1825731	-35.908	.00000000	.000000	.00000	.00		
	A20	9.517	1903338	-35.908	.00000426	8.114092	.01662	31.63		
	A21	9.118	1823538	-35.908	.00000000	.000000	.00000	.00		
	A22	9.429	1885881	-35.908	.00001834	34.579342	.07147	134.79	N8	315
	A23	10.207	2041438	-35.908	.00008721	178.030510	.33994	693.96		
	A24	10.589	2117806	-35.908	.00005201	110.147994	.20274	429.36		
	A25	10.607	2121332	-35.908	.00003703	78.553151	.14434	306.20		
	A26	10.493	2098650	-35.908	.00002289	48.042936	.08923	187.27		
	A27	13.195	2638917	-35.908	.00002444	64.488732	.09526	251.38		
	A28	12.909	2581724	-35.908	.00002132	55.033807	.08309	214.52		
	A29	12.995	2599086	-35.908	.00001207	31.377470	.04706	122.31		
	A30	4.708	941531	-35.908	.00000000	.000000	.00000	.00		
<u>Bay of Chaleur, December</u>										
Maisonnette	B1	5.174	1034889	-35.698	.00000000	.000000	.00000	.00		
	B2	4.387	877400	-35.698	.00000000	.000000	.00000	.00		
	B3	4.120	824047	-35.698	.00000000	.000000	.00000	.00		
	B4	3.766	753132	-35.698	.00000000	.000000	.00000	.00		
	B5	3.123	624595	-35.698	.00000000	.000000	.00000	.00		
	B6	2.504	500811	-35.698	.00000000	.000000	.00000	.00		
	B7	3.727	745400	-35.698	.00000000	.000000	.00000	.00		
Newport	B1	7.347	1469332	-35.698	.00000904	13.289061	.03359	49.35		
	B2	8.621	1724101	-35.698	.00000430	7.408480	.01596	27.51		
	B3	7.498	1499641	-35.698	.00000000	.000000	.00000	.00		
	B4	8.418	1683652	-35.698	.00000000	.000000	.00000	.00		
	B5	6.951	1390265	-35.698	.00000000	.000000	.00000	.00		
	B6	7.680	1536009	-35.698	.00000000	.000000	.00000	.00		
	B7	6.306	1261147	-35.698	.00000000	.000000	.00000	.00		
	B8	3.292	658343	-35.698	.00000000	.000000	.00000	.00		
Shigawake	B1	5.345	1068940	-35.698	.00000000	.000000	.00000	.00		
	B2	8.315	1663033	-35.698	.00000139	2.315284	.00517	8.60		
	B3	9.400	1879982	-35.698	.00000000	.000000	.00000	.00		
	B4	8.419	1683779	-35.698	.00000000	.000000	.00000	.00		

Table 2 (con't)

Stratum	Transect no.	Transect length (km)	Transect area (m^2)	Target strength (dB kg^{-1})	Sa (Area scattering coefficient (sr^{-1}))	Total backscattering (m^2 sr^{-1})	Biomass density (kg m^{-2})	Total biomass (t $transect^{-1}$)	Set number	Number of fish sampled
Shigawake (con't)	B5	6.476	1295269	-35.698	.00000000	.000000	.00000	.00		
	B6	7.300	1460022	-35.698	.00000000	.000000	.00000	.00		
	B7	6.912	1382405	-35.698	.00000044	.614873	.00165	2.28		
	B8	6.575	1315000	-35.698	.00000000	.000000	.00000	.00		
	B9	6.280	1255929	-35.698	.00000172	2.154418	.00637	8.00		
	B10	6.875	1375073	-35.698	.00000055	.755449	.00204	2.81		
	B11	6.375	1274989	-35.698	.00000000	.000000	.00000	.00		
	B12	7.005	1400955	-35.698	.00000000	.000000	.00000	.00		
	B13	6.825	1365099	-35.698	.00000000	.000000	.00000	.00		
Central Chaleur	B1	11.548	2309633	-35.698	.00000000	.000000	.00000	.00		
	B2	11.304	2260705	-35.698	.00000000	.000000	.00000	.00		
	B3	8.715	1743077	-35.698	.00000000	.000000	.00000	.00		
	B4	9.373	1874662	-35.698	.00000000	.000000	.00000	.00		
	B5	10.257	2051377	-35.698	.00000000	.000000	.00000	.00		
	B6	10.816	2163217	-35.698	.00000000	.000000	.00000	.00		
	B7	8.981	1796160	-35.698	.00000000	.000000	.00000	.00		
East Central Chaleur	A1	7.042	1408392	-35.698	.00000000	.000000	.00000	.00		
	A2	19.310	3861983	-35.698	.00000011	.408646	.00039	1.52		
	A3	19.841	3968295	-35.698	.00000000	.000000	.00000	.00		
	A4	14.896	2979155	-35.698	.00004208	125.366157	.15627	465.56		
<u>Sydney Bight, December</u>										
Sydney	B1	5.645	1128939	-35.384	.00000000	.000000	.00000	.00		
	B2	8.288	1657642	-35.384	.00000000	.000000	.00000	.00		
	B3	10.513	2102524	-35.384	.00000000	.000000	.00000	.00		
	B4	12.449	2489750	-35.384	.00000000	.000000	.00000	.00		
	B5	12.187	2437448	-35.384	.00000000	.000000	.00000	.00		
	B6	12.118	2423675	-35.384	.00000376	9.108851	.01298	31.46		
	B7	12.229	2445748	-35.384	.00000000	.000000	.00000	.00		
	B8	12.740	2547905	-35.384	.00000000	.000000	.00000	.00		
	B9	12.440	2487995	-35.384	.00000000	.000000	.00000	.00		
Haddock Bank	B1	7.625	1524914	-35.384	.00000000	.000000	.00000	.00		
	B2	5.892	1178443	-35.384	.00000000	.000000	.00000	.00		
St. Ann's Bay	B1	7.929	1585829	-35.384	.00005412	85.828814	.18695	296.47		
	B2	8.168	1633544	-35.384	.00000326	5.332747	.01128	18.42		
	B3	7.266	1453207	-35.384	.00000000	.000000	.00000	.00		
	B4	8.544	1708900	-35.384	.00000000	.000000	.00000	.00		
	B5	7.860	1572023	-35.384	.00000000	.000000	.00000	.00		
	B6	7.861	1572221	-35.384	.00000000	.000000	.00000	.00		
	B7	6.344	1268776	-35.384	.00000000	.000000	.00000	.00		
	B8	6.342	1268427	-35.384	.00000000	.000000	.00000	.00		
	B9	5.961	1192119	-35.384	.00000000	.000000	.00000	.00		
	B10	5.150	1029970	-35.384	.00000000	.000000	.00000	.00		
	B11	5.235	1046985	-35.384	.00000000	.000000	.00000	.00		
	B12	.717	143475	-35.384	.00000000	.000000	.00000	.00		
	B13	4.706	941142	-35.384	.00000000	.000000	.00000	.00		
	B14	2.472	494400	-35.384	.00000000	.000000	.00000	.00		
Wreck Cove	B1	2.452	490487	-35.384	.00000000	.000000	.00000	.00		
	B2	6.017	1203390	-35.384	.00012439	149.694202	.42968	517.08		
	B3	6.616	1323142	-35.384	.00031936	422.554195	1.10313	1459.60		
	B4	5.933	1186633	-35.384	.00054581	647.671612	1.88533	2237.20		
	B5	6.916	1383274	-35.384	.00083386	1153.455917	2.88033	3984.29		
	B6	6.964	1392799	-35.384	.00095723	1333.236207	3.30650	4605.29		
	B7	7.210	1441942	-35.384	.00117356	1692.206070	4.05374	5845.25		
	B8	7.505	1500906	-35.384	.00013735	206.155454	.47445	712.11		
	B9	7.590	1518047	-35.384	.00001081	16.414412	.03735	56.70		
	B10	7.998	1599500	-35.384	.00000000	.000000	.00000	.00		
	B11	8.138	1627524	-35.384	.00013524	220.112038	.46716	760.32	P18	160
	B12	8.136	1627127	-35.384	.00001675	27.256409	.05786	94.15		
	B13	8.363	1672643	-35.384	.00000735	12.295467	.02539	42.47		
	B14	8.483	1696566	-35.384	.00001957	33.209236	.06761	114.71		
Neil Harbour	B1	5.053	1010607	-35.384	.00000232	2.348517	.00803	8.11		
	B2	5.072	1014312	-35.384	.00000000	.000000	.00000	.00		
	B3	5.239	1047713	-35.384	.00000000	.000000	.00000	.00		
	B4	5.905	1180972	-35.384	.00048145	568.579217	1.66303	1964.00		
	B5	10.216	2043157	-35.384	.00022598	461.716114	.78059	1594.87		
	B6	9.811	1962229	-35.384	.00063419	1244.428013	2.19064	4298.53	P20	355
	B7	9.607	1921496	-35.384	.00000307	5.901095	.01061	20.38		
	B8	9.852	1970398	-35.384	.00001355	26.695300	.04680	92.21		
	B9	7.962	1592403	-35.384	.00012534	199.586463	.43294	689.42	P19	87
	B10	10.625	2125086	-35.384	.00000527	11.203933	.01821	38.70		
	B11	10.958	2191575	-35.384	.00000243	5.332867	.00841	18.42		
	B12	11.453	2290607	-35.384	.00000000	.000000	.00000	.00		
	B13	9.354	1870896	-35.384	.00000000	.000000	.00000	.00		
	B14	13.885	2777006	-35.384	.00000000	.000000	.00000	.00		

Table 2 (con't)

Stratum	Transect no.	Transect length (km)	Transect area (m^2)	Target strength (dB kg^{-1})	Sa (Area scattering coefficient) (sr^{-1})	Total back-scattering (m^2 sr^{-1})	Biomass density (kg m^{-2})	Total biomass (t $transect^{-1}$)	Set number	Number of fish sampled
Neil Harbour (con't)	B15	13.681	2736268	-35.384	.00000000	.000000	.00000	.00		
	B16	11.775	2355025	-35.384	.00000000	.000000	.00000	.00		
	B17	11.452	2290468	-35.384	.00000000	.000000	.00000	.00		
	B18	11.547	2309423	-35.384	.00000000	.000000	.00000	.00		
	B19	7.673	1534519	-35.384	.00000000	.000000	.00000	.00		
	B20	14.445	2889096	-35.384	.00000000	.000000	.00000	.00		
	B21	14.362	2872468	-35.384	.00004015	115.330793	.13869	398.38		
	B22	12.377	2475349	-35.384	.00006214	153.829493	.21466	531.36		
	B23	10.541	2108143	-35.384	.00004657	98.182466	.16087	339.14		
New Waterford	B1	8.807	1761499	-35.384	.00000000	.000000	.00000	.00		
	B2	8.732	1746465	-35.384	.00000000	.000000	.00000	.00		
	B3	8.068	1613700	-35.384	.00000000	.000000	.00000	.00		
	B4	7.227	1445440	-35.384	.00000000	.000000	.00000	.00		
	B5	7.712	1542384	-35.384	.00000000	.000000	.00000	.00		
	B6	8.834	1766748	-35.384	.00000000	.000000	.00000	.00		
	B7	8.699	1739767	-35.384	.00000000	.000000	.00000	.00		
	B8	8.225	1645019	-35.384	.00000000	.000000	.00000	.00		
	B9	8.375	1675012	-35.384	.00000000	.000000	.00000	.00		
	B10	8.475	1695047	-35.384	.00000000	.000000	.00000	.00		
	B11	6.934	1386863	-35.384	.00000000	.000000	.00000	.00		
	B12	6.934	1386839	-35.384	.00000000	.000000	.00000	.00		
	B13	7.358	1471687	-35.384	.00000000	.000000	.00000	.00		
	B14	6.706	1341231	-35.384	.00000000	.000000	.00000	.00		
	B15	6.531	1306170	-35.384	.00000000	.000000	.00000	.00		
Neil Harbour[a]	A1	4.685	936959	-35.384	.00000000	.000000	.00000	.00		
	A3	4.606	921250	-35.384	.00000000	.000000	.00000	.00		
	A4	5.076	1015213	-35.384	.00000000	.000000	.00000	.00		
	A6	5.446	1089132	-35.384	.00000153	1.667637	.00529	5.76		
	A7	5.092	1018469	-35.384	.00000000	.000000	.00000	.00		
	A10	5.467	1093341	-35.384	.00065935	720.896704	2.27755	2490.14		
	A12	5.633	1126680	-35.384	.00060016	676.189479	2.07309	2335.71		
	A13	5.882	1176412	-35.384	.00074038	870.990625	2.55743	3008.59		
	A14	9.861	1972282	-35.384	.00008638	170.356439	.29836	588.45		
	A16	9.831	1966270	-35.384	.00027921	549.002339	.96445	1896.37		
	A19	10.081	2016115	-35.384	.00028785	580.337485	.99430	2004.61		
	A23	11.500	2299981	-35.384	.00036234	833.386111	1.25162	2878.70		
	A24	8.774	1754866	-35.384	.00016880	296.224947	.58308	1023.23		
Aspy Bay	B1	2.793	558663	-35.384	.00000000	.000000	.00000	.00		
	B2	3.868	773612	-35.384	.00000000	.000000	.00000	.00		
	B3	5.102	1020403	-35.384	.00000000	.000000	.00000	.00		
	B4	9.741	1948183	-35.384	.00000000	.000000	.00000	.00		
	B5	3.349	669796	-35.384	.00000000	.000000	.00000	.00		
Donkin[a]	B4	7.821	1564110	-35.384	.00000000	.000000	.00000	.00		
	B5	7.036	1407150	-35.384	.00000000	.000000	.00000	.00		
	B6	7.010	1402022	-35.384	.00000000	.000000	.00000	.00		
	B7	6.699	1339836	-35.384	.00000000	.000000	.00000	.00		

[a]Survey did not include all planned transects.

Table 3. Total backscattering and biomass estimates of herring encountered in acoustic strata in the Chaleur and Sydney Bight areas, November-December 1988.

Stratum	Target strength ($dB\ kg^{-1}$)	Stratum area (m^2)	Stratum area scattering coefficient (sr^{-1})	Total back-scattering ($m^2\ sr^{-1}$) mean	Total back-scattering ($m^2\ sr^{-1}$) SE	Statum biomass density ($kg\ m^{-2}$)	Total stratum biomass (t) mean	Total stratum biomass (t) SE
Bay of Chaleur, November								
Cap Bon Ami	-35.698	109800000	.000000000	0	0	.00000	0	0
Baie de Gaspé	-35.698	117600000	.000000000	0	0	.00000	0	0
Gaspé Offshore	-35.698	50000000	.000000000	0	0	.00000	0	0
American Bank	-35.698	187400000	.000000000	0	0	.00000	0	0
La Malbaie	-35.698	191200000	.000000000	0	0	.00000	0	0
Anse-à-Beaufils	-35.698	191900000	.000000000	0	0	.00000	0	0
Grande Rivière	-35.698	173800000	.000000584	101	32	.00217	377	118
Newport	-35.698	187000000	.000000000	0	0	.00000	0	0
Shigawake	-35.698	323300000	.000149311	48272	11069	.55449	179266	41106
New Carlisle	-35.698	167000000	.000001303	218	225	.00484	808	834
New Richmond	-35.698	253600000	.000012654	3209	1720	.04699	11917	6386
Central Chaleur	-35.698	208400000	.000000258	54	42	.00096	200	158
Maisonnette	-35.698	140000000	.000087788	12290	6716	.32601	45642	24942
West Miscou	-35.698	378000000	.000001476	558	329	.00548	2072	1220
North Miscou	-35.698	417800000	.000000000	0	0	.00000	0	0
East Miscou	-35.698	93500000	.000000039	4	4	.00014	13	13
Sydney Bight, November								
Aspy Bay	-35.908	168300000	.000052875	8899	6168	.20611	34687	24044
Neil Harbour[a]	-35.908	259500000	.000015471	4015	1240	.06031	15650	4834
Bay of Chaleur, December								
Maisonnette	-35.698	140000000	.000000000	0	0	.00000	0	0
Newport	-35.698	187000000	.000001844	345	231	.00685	1281	859
Shigawake	-35.698	323300000	.000000317	102	53	.00118	381	195
Central Chaleur	-35.698	208000000	.000000000	0	0	.00000	0	0
East Central Chaleur	-35.698	239400000	.000010294	2464	2519	.03823	9152	9355
Sydney Bight, December								
Aspy Bay	-35.384	168300000	.000000000	0	0	.00000	0	0
Neil Harbour	-35.384	259500000	.000062125	16122	7841	.21460	55687	27086
Neil Harbour[ab]	-35.384	259500000	.000255564	66319	16068	.88278	229080	55504
Wreck Cove	-35.384	109700000	.000300766	32994	12082	1.03891	113969	41735
St. Ann's Bay	-35.384	159000000	.000005391	857	787	.01862	2961	2718
Haddock Bank	-35.384	94900000	.000000000	0	0	.00000	0	0
Sydney	-35.384	168600000	.000000462	78	77	.00160	269	266
New Waterford	-35.384	141300000	.000000000	0	0	.00000	0	0
Donkina	-35.384	109200000	.000000000	0	0	.00000	0	0

[a]Survey did not include all planned transects.
[b]Not used in calculating regional area backscattering totals.

Table 4. Total backscattering, biomass, and spawning composition of herring encountered in the Chaleur and Sydney Bight areas, November-December 1988.

Survey area	Month	Number of transects	Total backscattering (m^2 sr^{-1})		Biomass (tonnes)		Percent spring spawners	Biomass (tonnes)	
			Mean	CV	Mean	CV		Spring spawners	Fall spawners
Chaleur	November	153	64706	0.202	240294	0.202	68.2	163881	76413
Chaleura	December	39	2912	0.869	10814	0.869	20.0	2163	8651
Sydney Bight[a]	November	39	12914	0.487	50337	0.487	68.2[b]	34330	16007
Sydney Bight	December	86	50051	0.288	172886	0.288	27.5	47544	125342

[a]Survey did not cover all areas which potentially contained herring.
[b]Percentage based on November Chaleur cruise.

Table 5. Total area backscatter estimates of herring surveyed in 4T and 4VN, 1984-1987. N means the number of transects run. A dash (-) indicates that the stratum was not surveyed in the indicated year. Data for 1984 from Shotton et al. 1987a, for 1985 from Shotton 1986, for 1986 from Shotton et al. 1987b, and for 1987 from Cairns et al. 1988. Data for 1988 are from the November survey of the Bay of Chaleur and the December survey of Sydney Bight (Tables 2 and 3).

Stratum	Total area backscatter (m^2 sr^{-1})									
	1984	1985		1986		1987		1988		
	Mean	Mean	N	Mean	N	Mean	N	Mean	SE	N
Chaleur										
Cap Bon Ami		0@	2	0*	3	0*	2	0*	0	3
Baie de Gaspé		0@	2	23*	3	11*	2	0*	0	3
Gaspé Offshore				0#	4	0*	3	0*	0	4
American Bank		-		-		115*	3	0*	0	4
La Malbaie		0@	3	0#	4	61*	3	0*	0	4
Anse-à-Beaufils		1807@	3	535#	7	0*	4	0*	0	6
Grande Rivière				25731*	7	3667*	9	101*	32	12
Newport		4814	2	16275*	3	2713*	8	0*	0	13
Shigawake				18600*	3	8142*	8	48272*	11069	23
New Carlisle		-		-		0*	3	218*	225	5
New Richmond		-		-		258*	3	3209*	1720	14
Central Chaleur		-		-		-		54	42	12
Maisonnette		-		-		-		12290	6716	12
West Miscou		7964*	2	59*	3	141885*	3	558*	329	20
North Miscou		0@	3	0*	3	1389*	3	0*	0	4
East Miscou		4464*	4	20*	4	28000*	2	4*	4	15
Total Chaleur	28700	19048	21	61243	44	186241	56	64706	13067	154
Prince Edward Island										
North Point	-	16	1	-		-		-		
Northeast P.E.I.	-	-		2346*	3	0*	2	-		
Beyond East Pt. (BP)	-	0	1	-		-		-		
East Point (EP)	-	0	1	-		-		-		
Cardigan Bay (CB)	-	0	1	-		-		-		
Total P.E.I.	-	16	4	2346	3	0	2	-		
West Cape Breton	10787	-		-		-		-		
Sydney Bight										
Aspy Bay		642*	1	174*	2	3484*	7	0*	0	5
Neil Harbour		3630@	1	16310*	1	54672*	8	16122*	7841	23
Wreck Cove		17246@	9	16755#	3	10066*	9	32994*	12082	14
St. Ann's Bay		-		-		3257*	7	857*	787	14
Haddock Bank		1133@	5	12*	4	412*	7	0*	0	2
Sydney		2956*	4	0*	3	3970*	7	78*	77	9
New Waterford		4572*	6	-		43268*	8	0*	0	15
Donkin		703*	4	-		8080*	7	0*	0	4
Total Sydney Bight	22318	30882	30	33251	13	127209	60	50051	14425	86
Total all areas	61805	49946	55	96840	60	313450	118	114757		240

@,#,* Years with similar symbols have the same stratum boundaries. Years with different symbols have different stratum boundaries.

Table 6. Acoustic biomass estimates for herring in the Southern Gulf of St. Lawrence and Sydney Bight, 1984-1988. All estimates are based on Foote's (1987) value for target strength. A dash (-) means that no estimate is available.

Area and spawning affinity	Biomass estimate (tonnes)				
	1984	1985	1986	1987	1988
Chaleur					
Spring	-	-	143179	153381	163881
Fall	-	-	112498	563352	76413
Total	104709	73599	255677	716733	240294
Survey dates	7-12 Nov	7-13 Nov	17-28 Nov	4-11 Nov	12-18 Nov
P.E.I.					
Total	-	62	9794	0	-
Survey dates		8-27 Nov	1-12 Dec	16-17 Nov	
West Cape Breton					
Total	36600	-	-	-	-
Survey dates	17 Nov				
Sydney Bight					
Spring	-	-	-	191844	47544
Fall	-	-	-	251214	125342
Total	75724	106865	127708	443058	172886
Survey dates	18-27 Nov	21-25 Nov	1-12 Dec	17-24 Nov	9-13 Dec
All areas					
Spring	-	-	-	345225	211424
Fall	-	-	-	814566	201756
Total	217033	180464	383385	1159791	413180
Survey dates	7-27 Nov	7-28 Nov	17 Nov-12 Dec	4-24 Nov	12 Nov-13 Dec

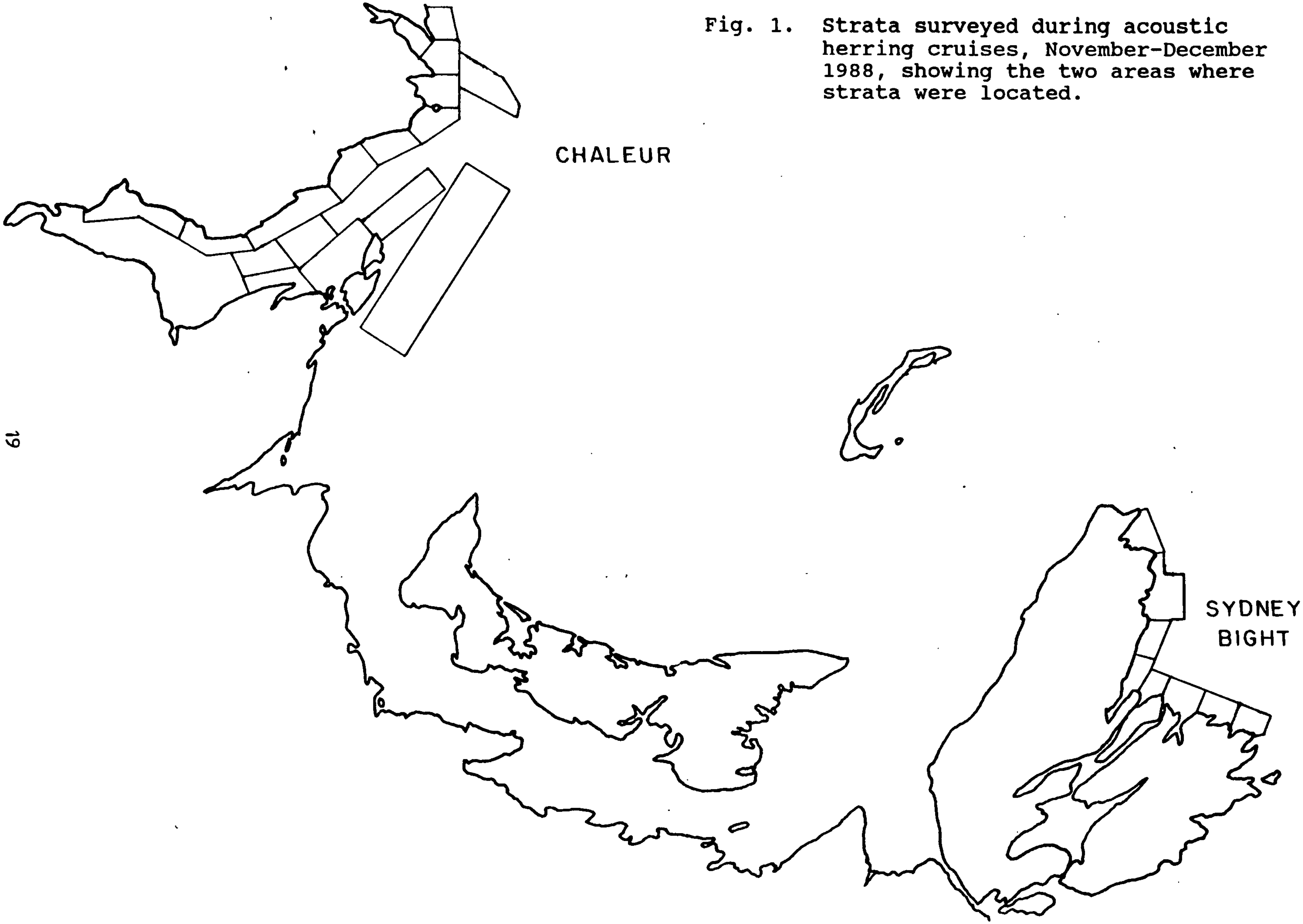
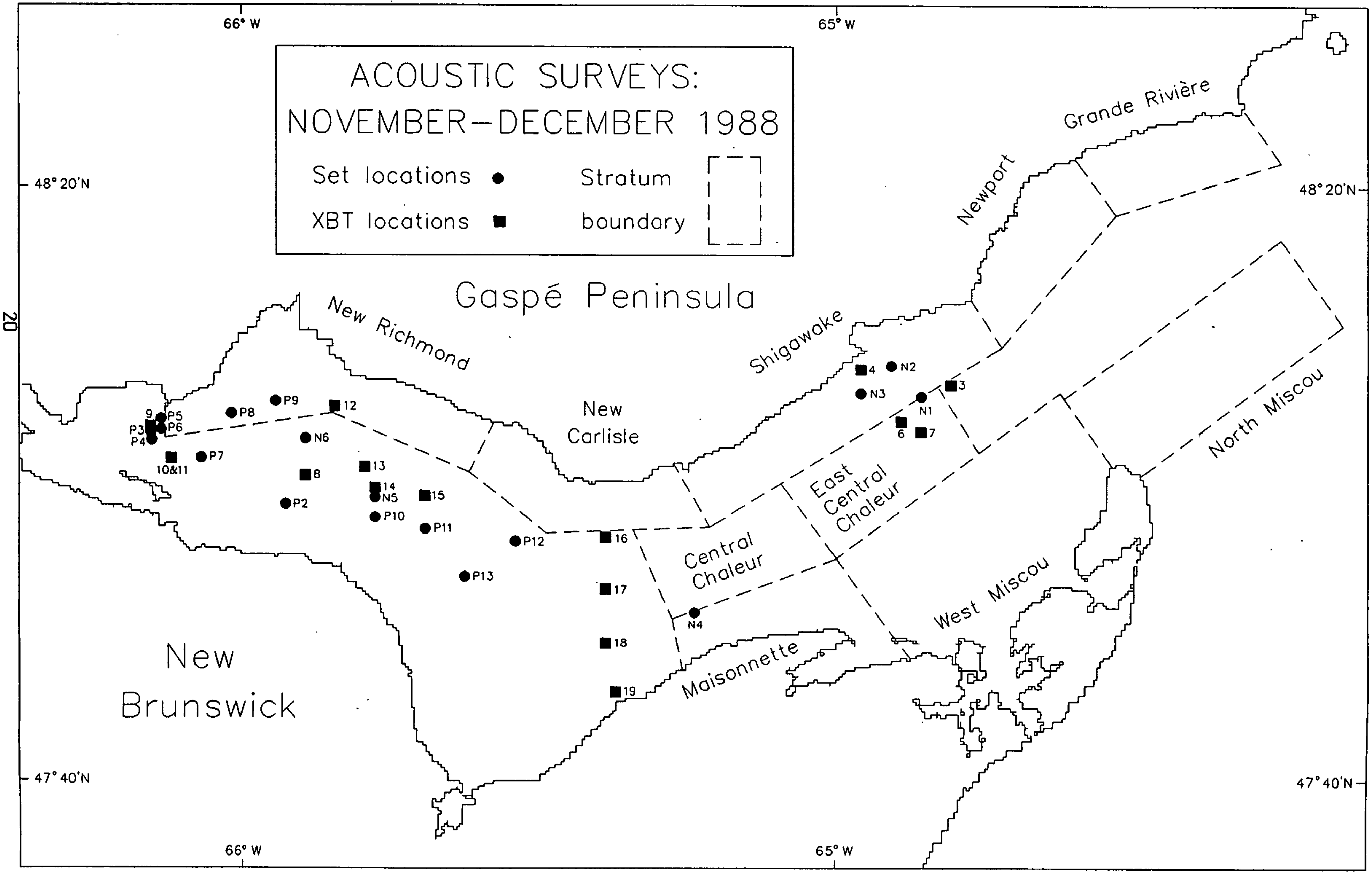


Fig. 1. Strata surveyed during acoustic herring cruises, November-December 1988, showing the two areas where strata were located.

Fig. 2. Locations of trawl sets and expendable bathythermograph (XBT) casts in the Chaleur area, fall 1988. Sets marked N were made by the <u>Alfred Needler</u> in November; those marked P were made by the <u>E. E. Prince</u> in December. XBT casts were made from the <u>E. E. Prince</u> in December.



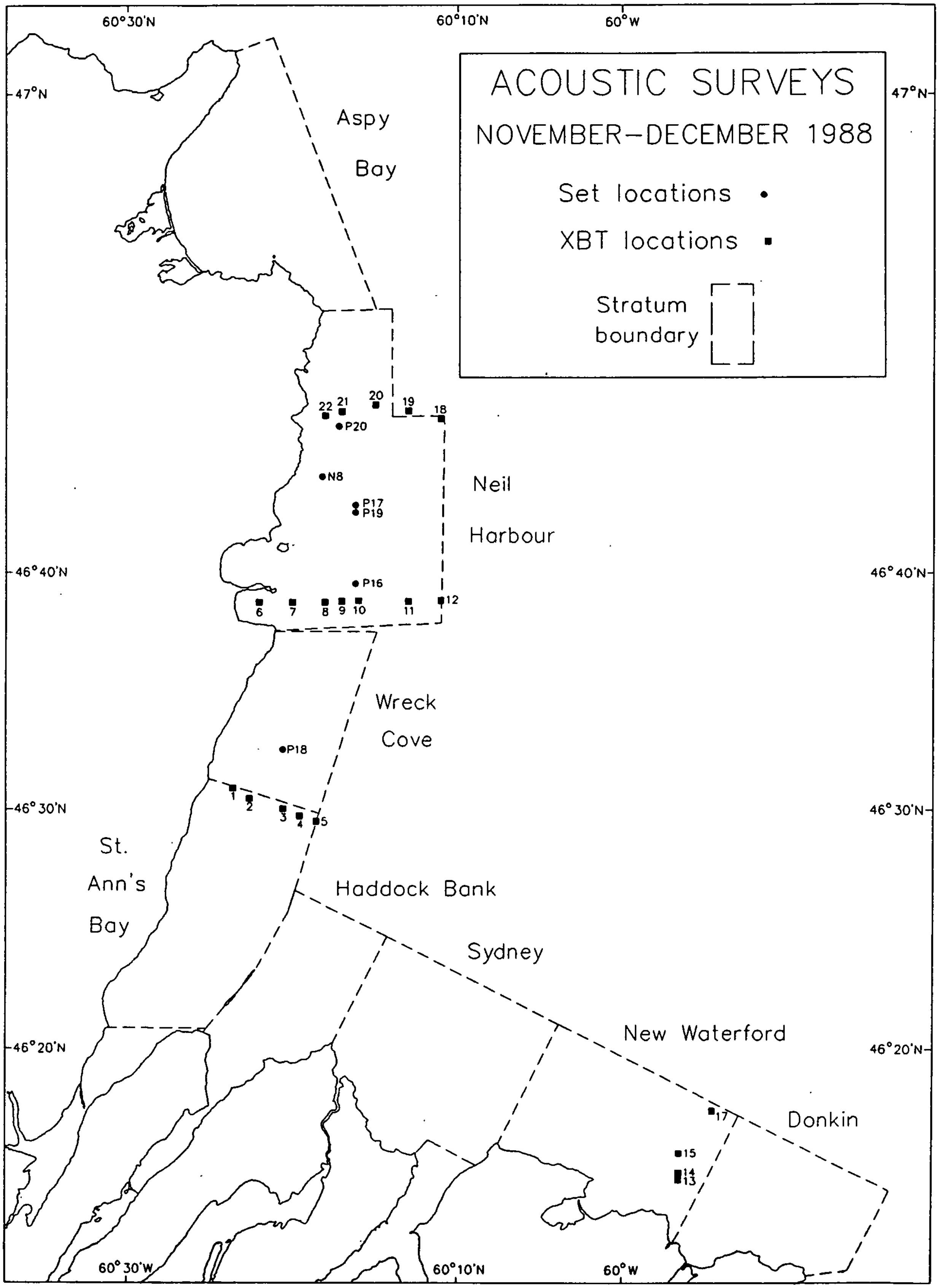


Fig. 3. Locations of trawl sets and expendable bathythermograph (XBT) casts in the Sydney Bight area, fall 1988. Sets marked N were made by the *Alfred Needler* in November; those marked P were made by the *E. E. Prince* in December. XBT casts were made from the *E. E. Prince* in December.

Fig. 4. Acoustic transects in the Bay of Chaleur, November 1988, showing locations where adult herring were observed on the sounder.

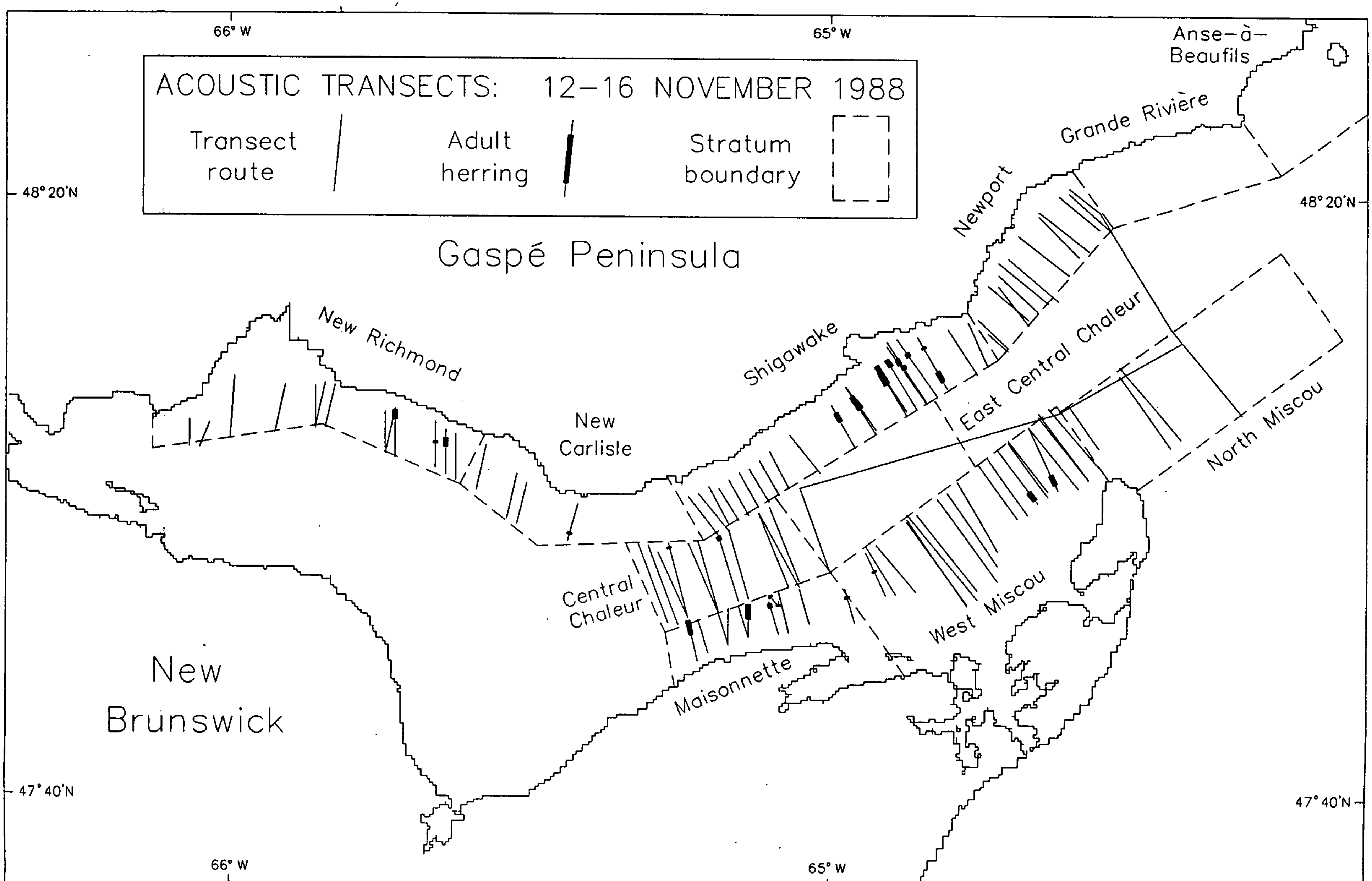


Fig. 5. Acoustic transects in the Bay of Chaleur, December 1988, showing locations where adult herring were observed on the sounder.

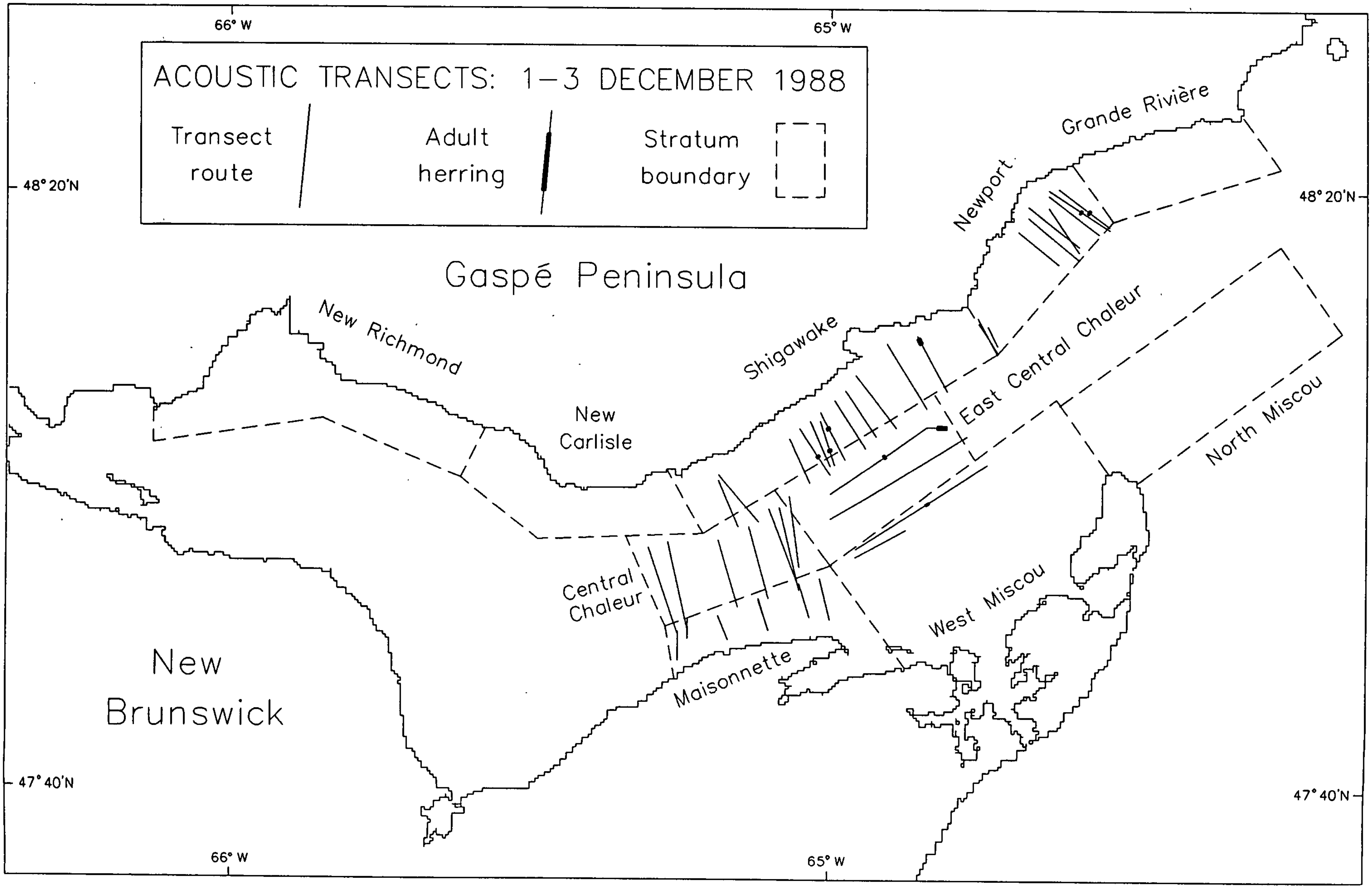
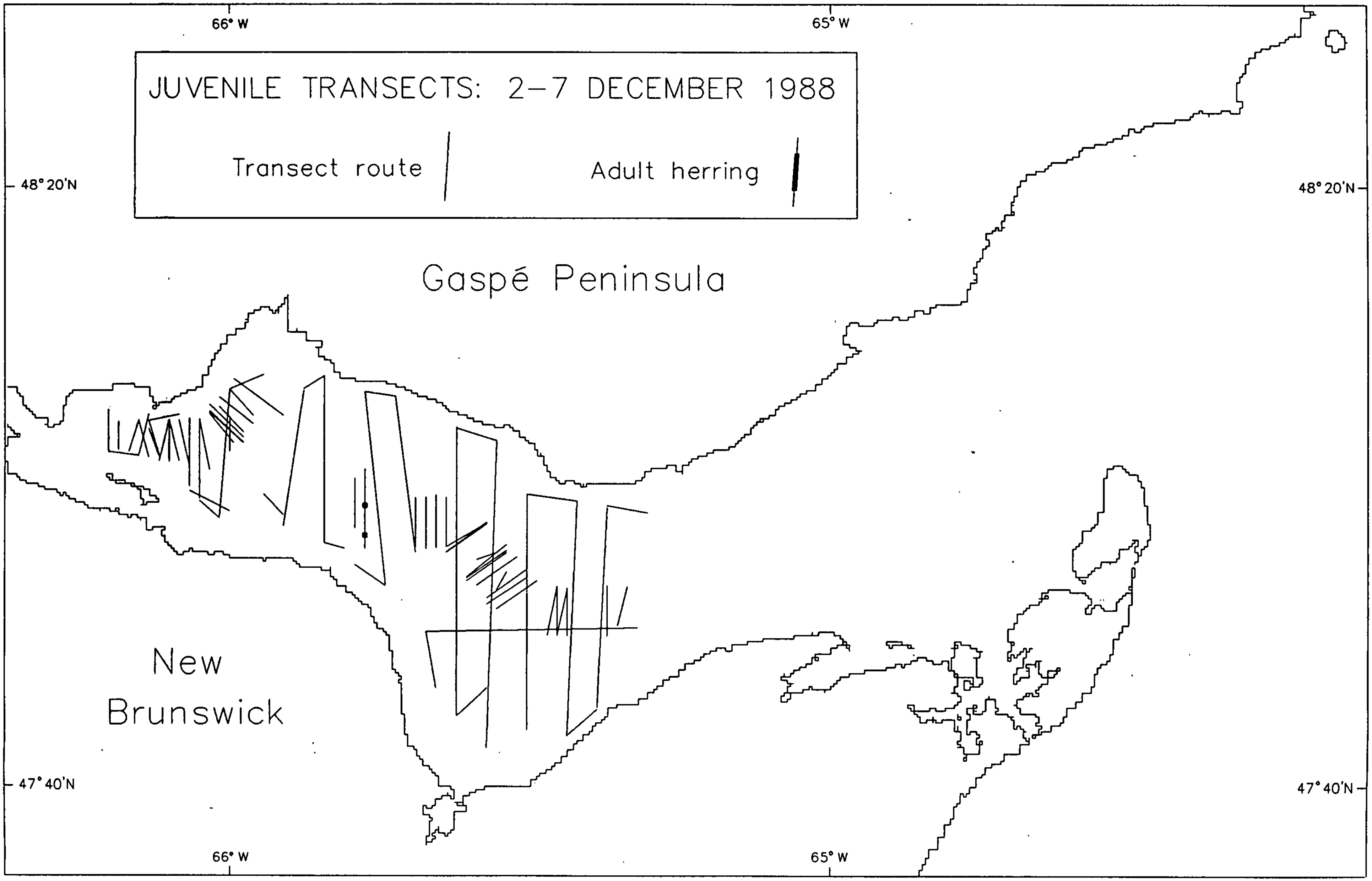


Fig. 6. Juvenile herring transects in the Bay of Chaleur, December 1988, showing locations where adult herring were observed on the sounder.



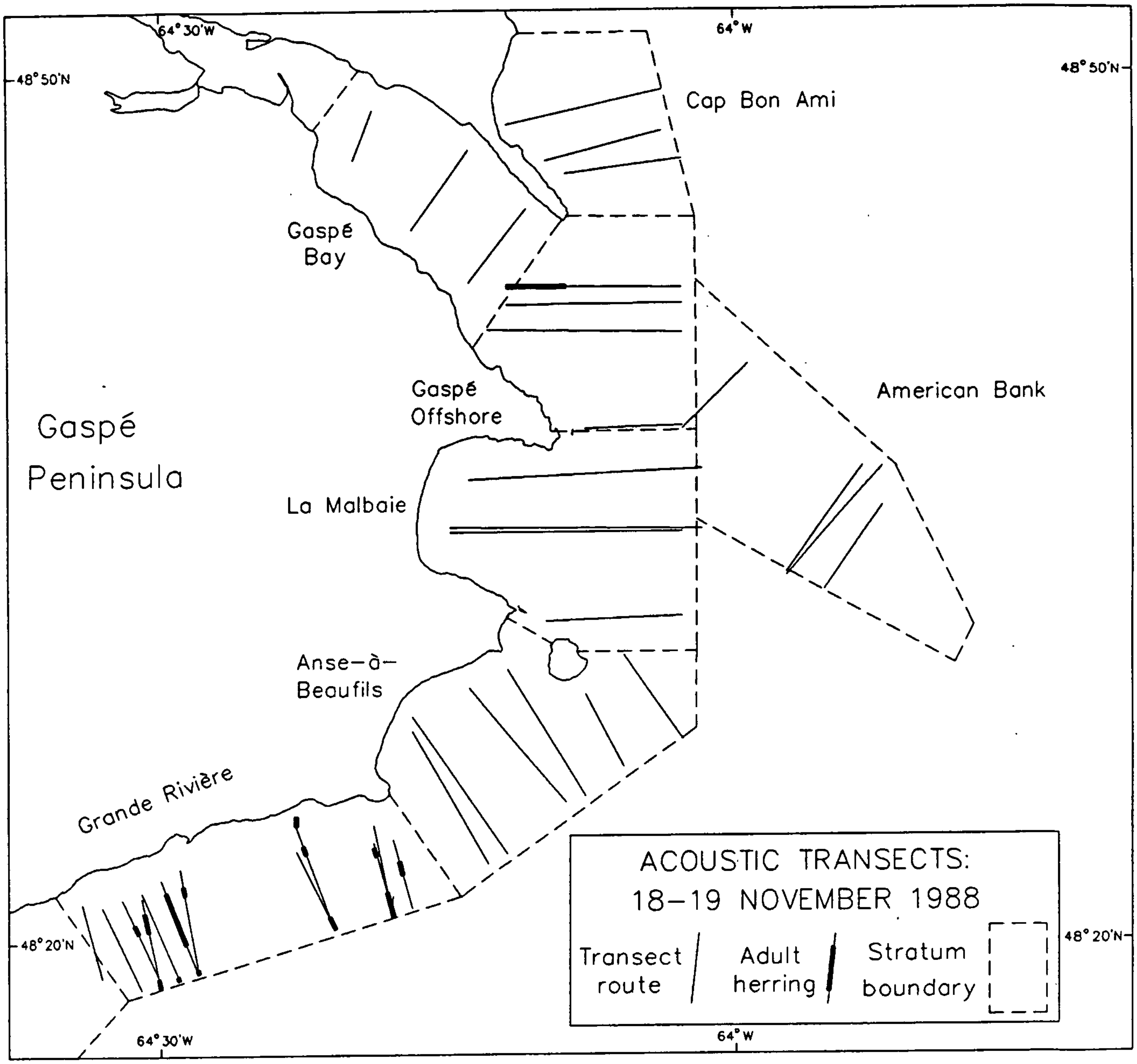


Fig. 7. Acoustic transects in the East Gaspé area, November 1988, showing locations where adult herring were observed on the sounder.

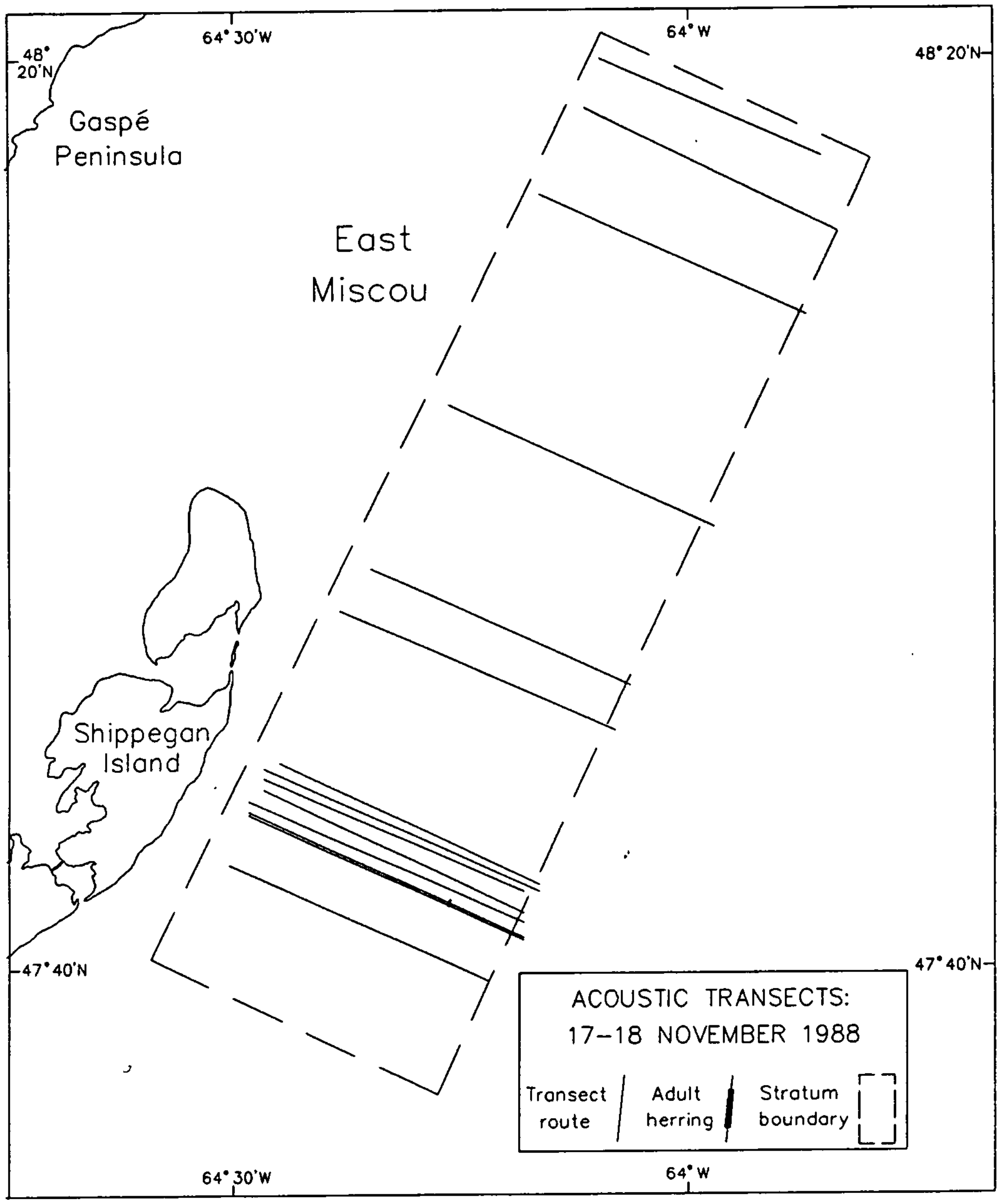


Fig. 8. Acoustic transects in the East Miscou stratum, November 1988, showing location where adult herring were observed on the sounder.

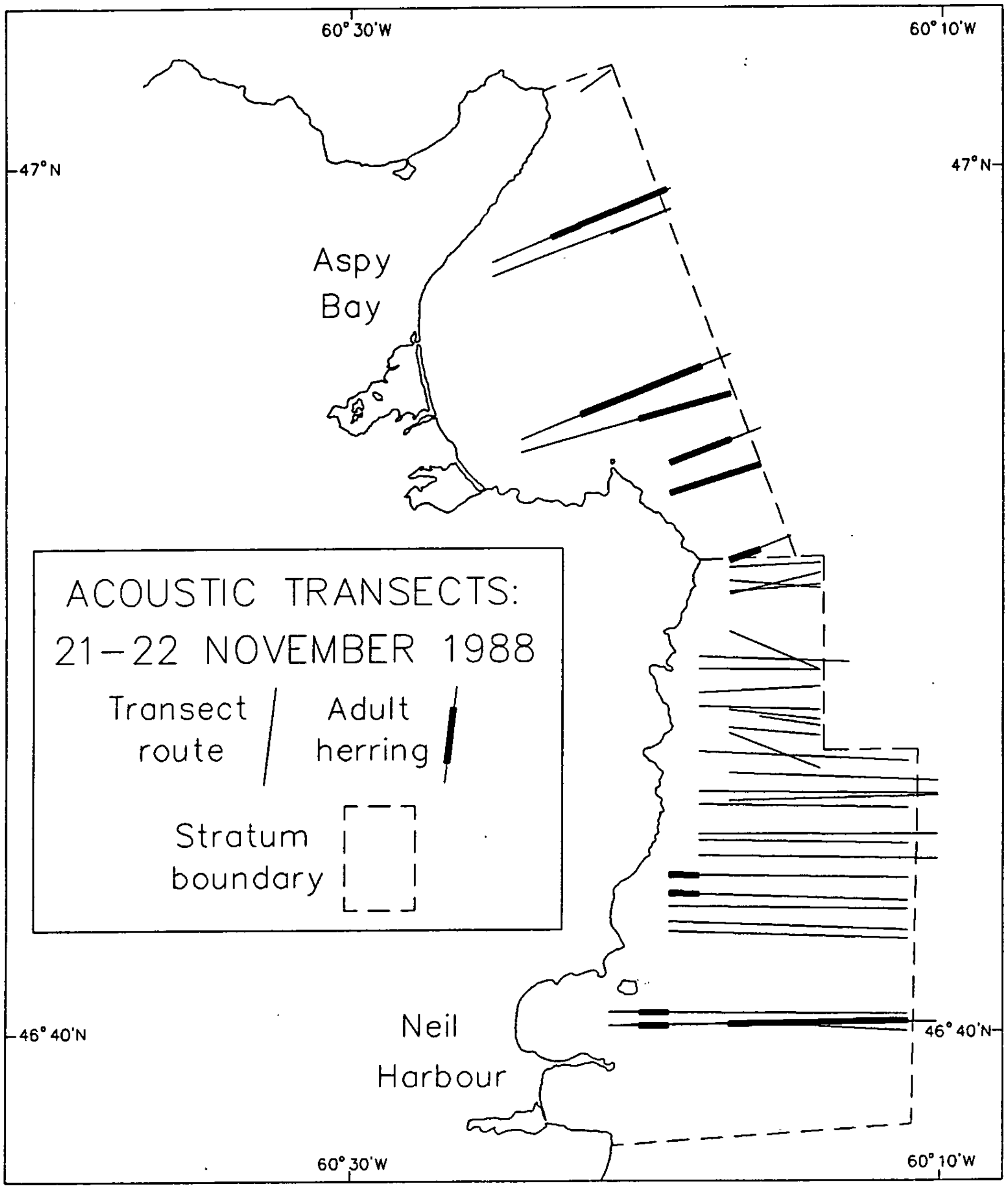


Fig. 9. **Acoustic transects in the northern Sydney Bight area, November 1988, showing locations where adult herring were observed on the sounder.**

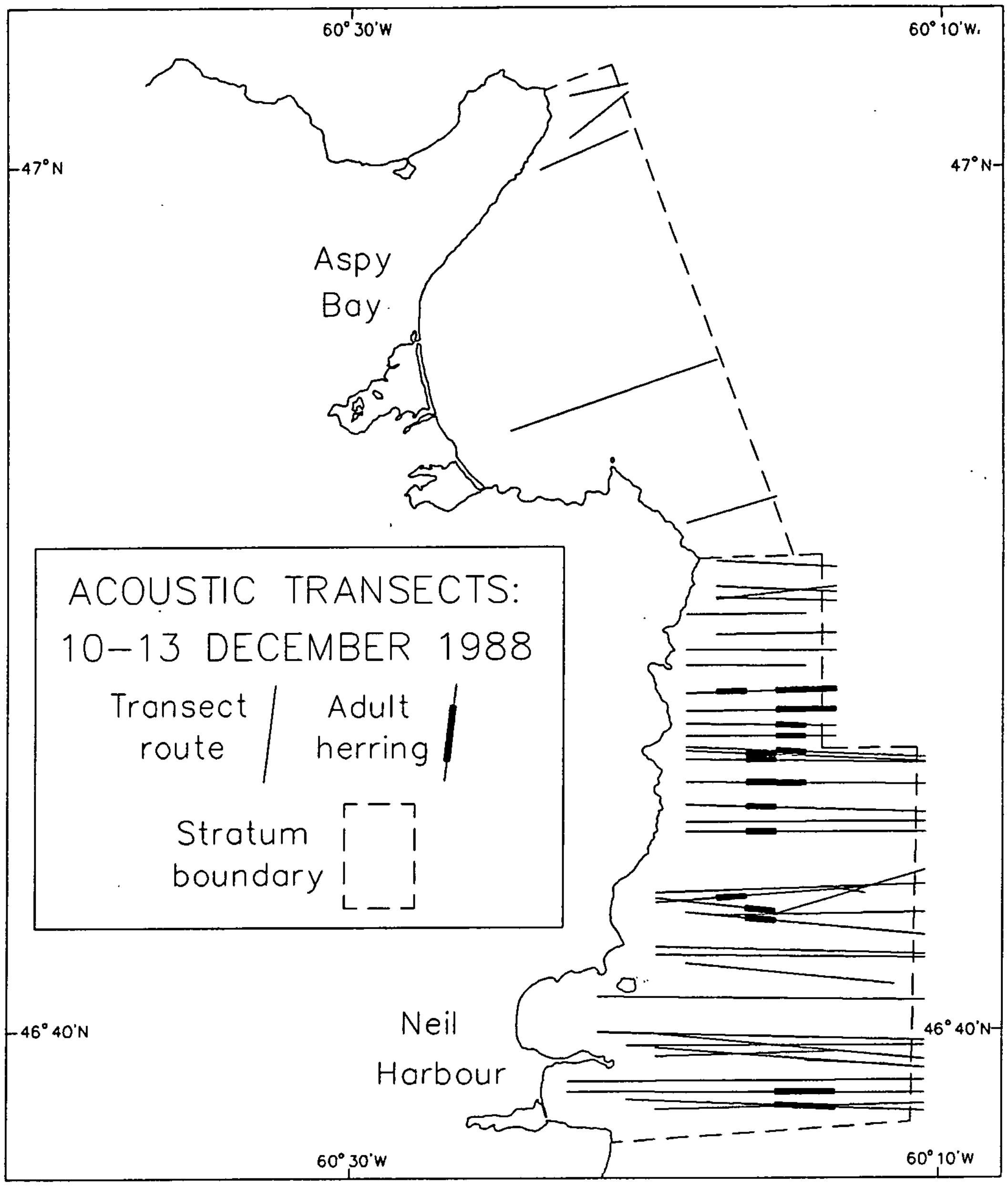


Fig. 10. Acoustic transects in the northern Sydney Bight area, December 1988, showing locations where adult herring were observed on the sounder.

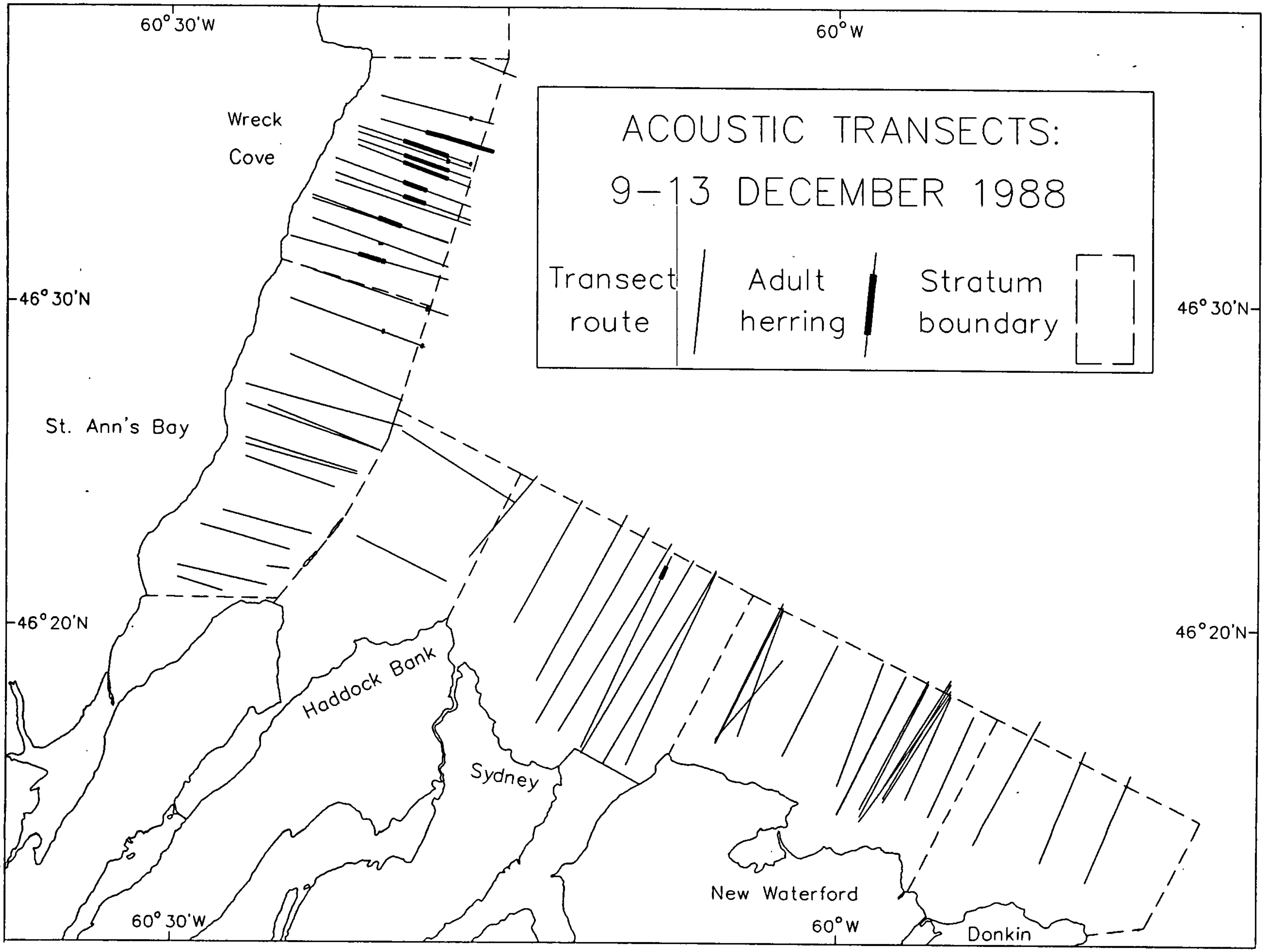


Fig. 11. **Acoustic transects in the eastern Sydney Bight area, December 1988, showing locations where adult herring were observed on the sounder.**

Fig. 12. Acoustic transects in the Bay of Chaleur, November 1988, showing locations where juvenile herring or other small targets were observed on the sounder.

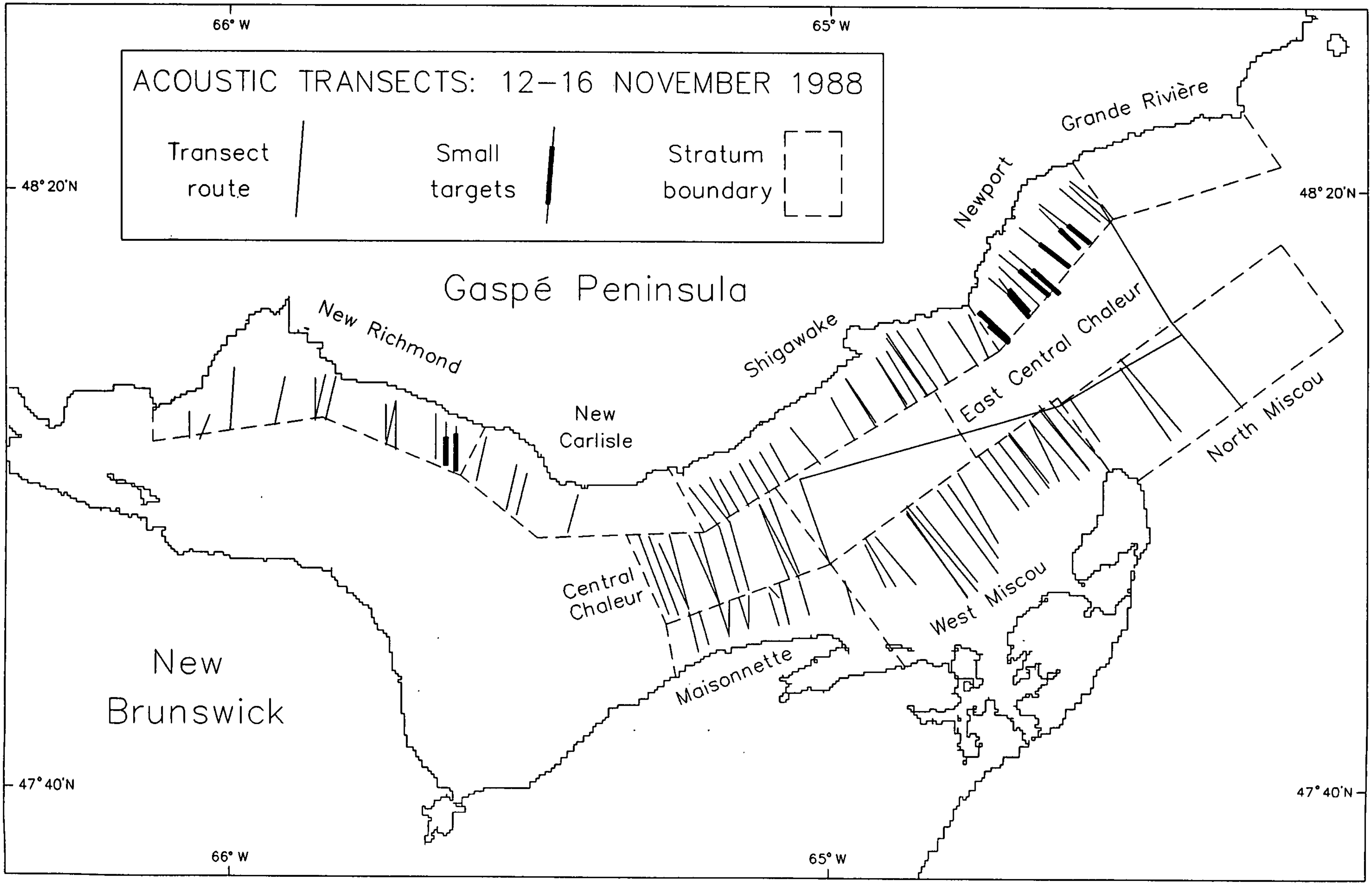


Fig. 13. Juvenile herring transects in the Bay of Chaleur, November 1988, showing locations where juvenile herring or other small targets were observed on the sounder.

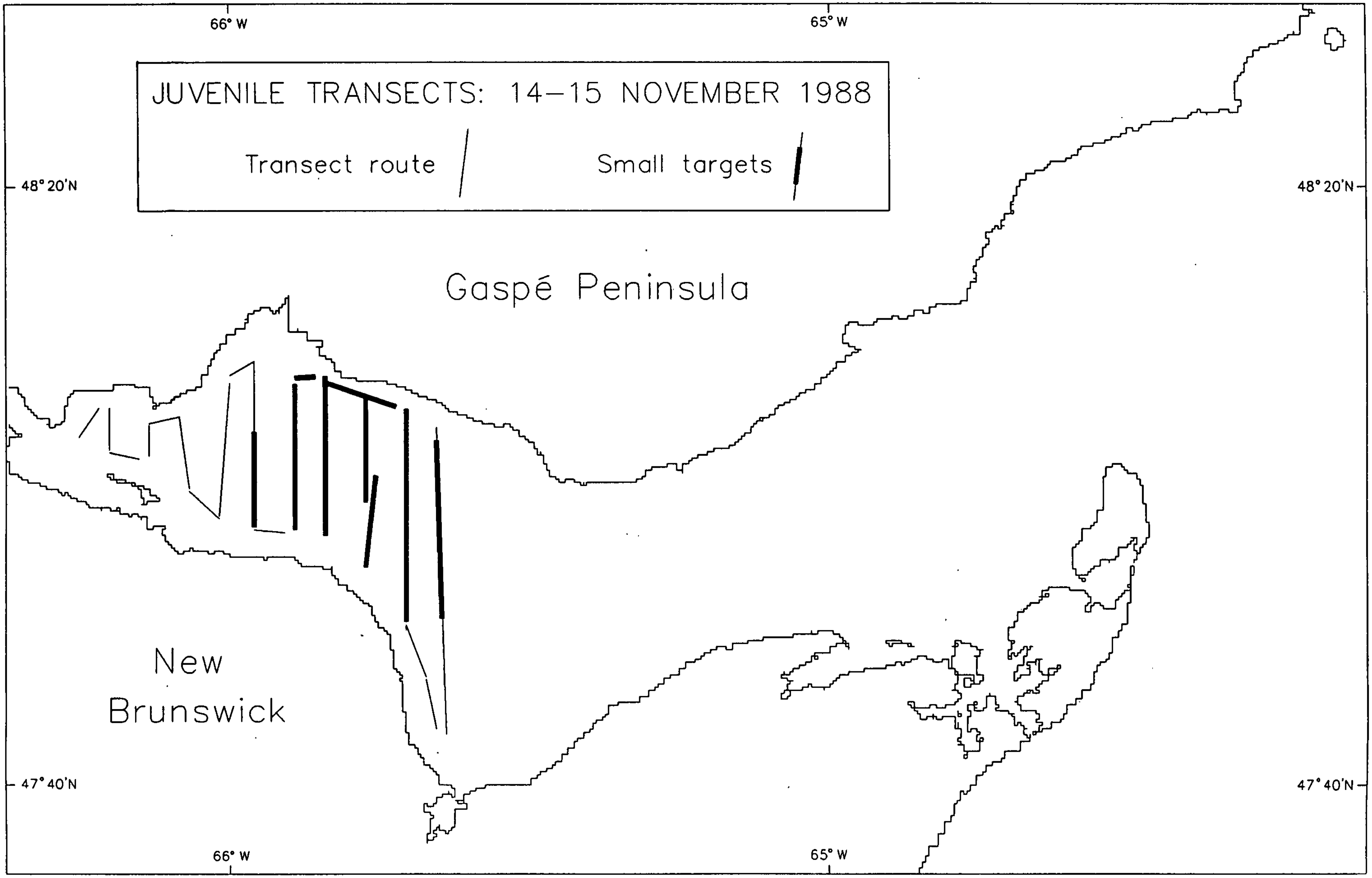


Fig. 14. Acoustic transects in the Bay of Chaleur, December 1988, showing locations where juvenile herring or other small targets were observed on the sounder.

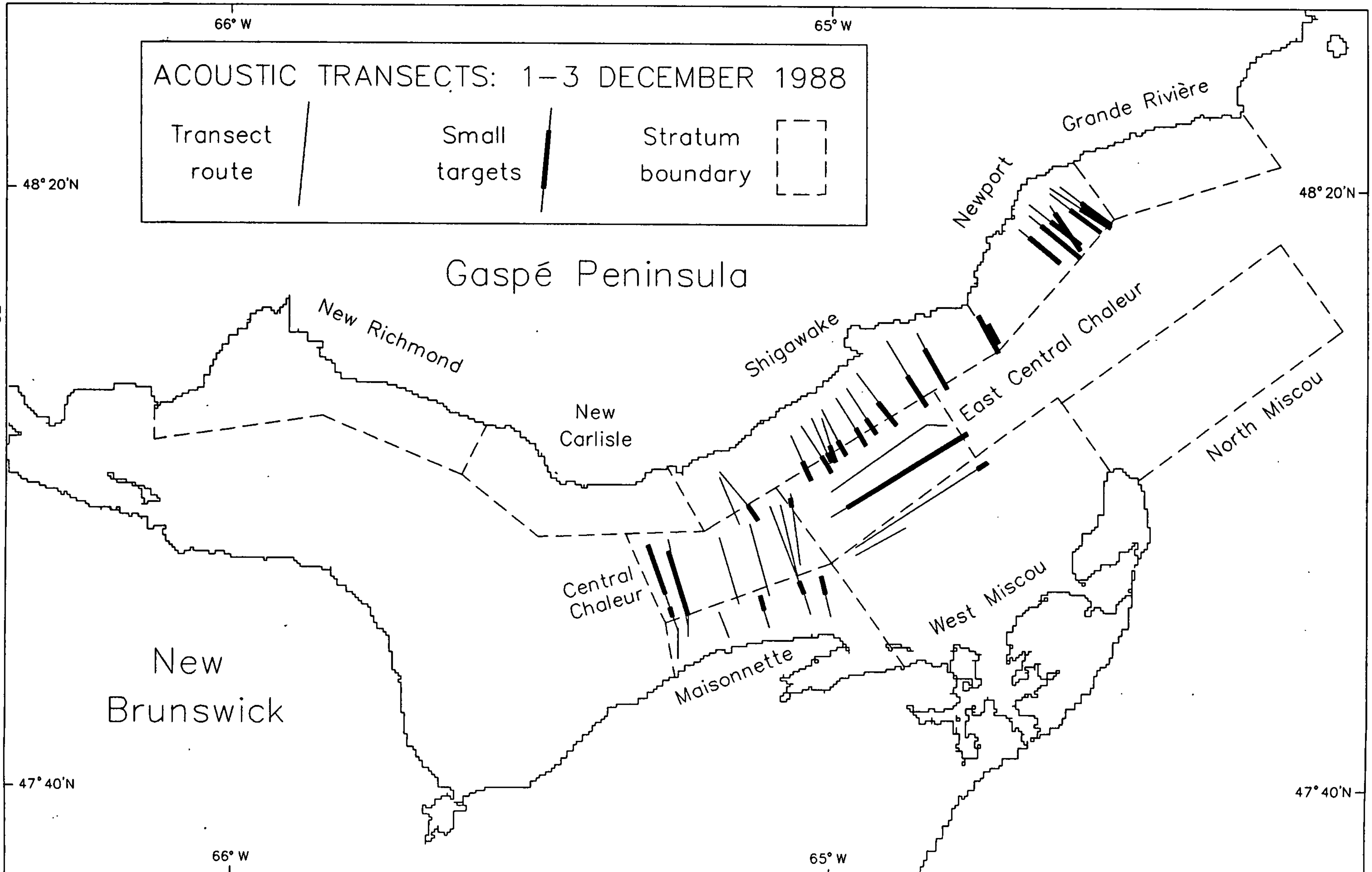
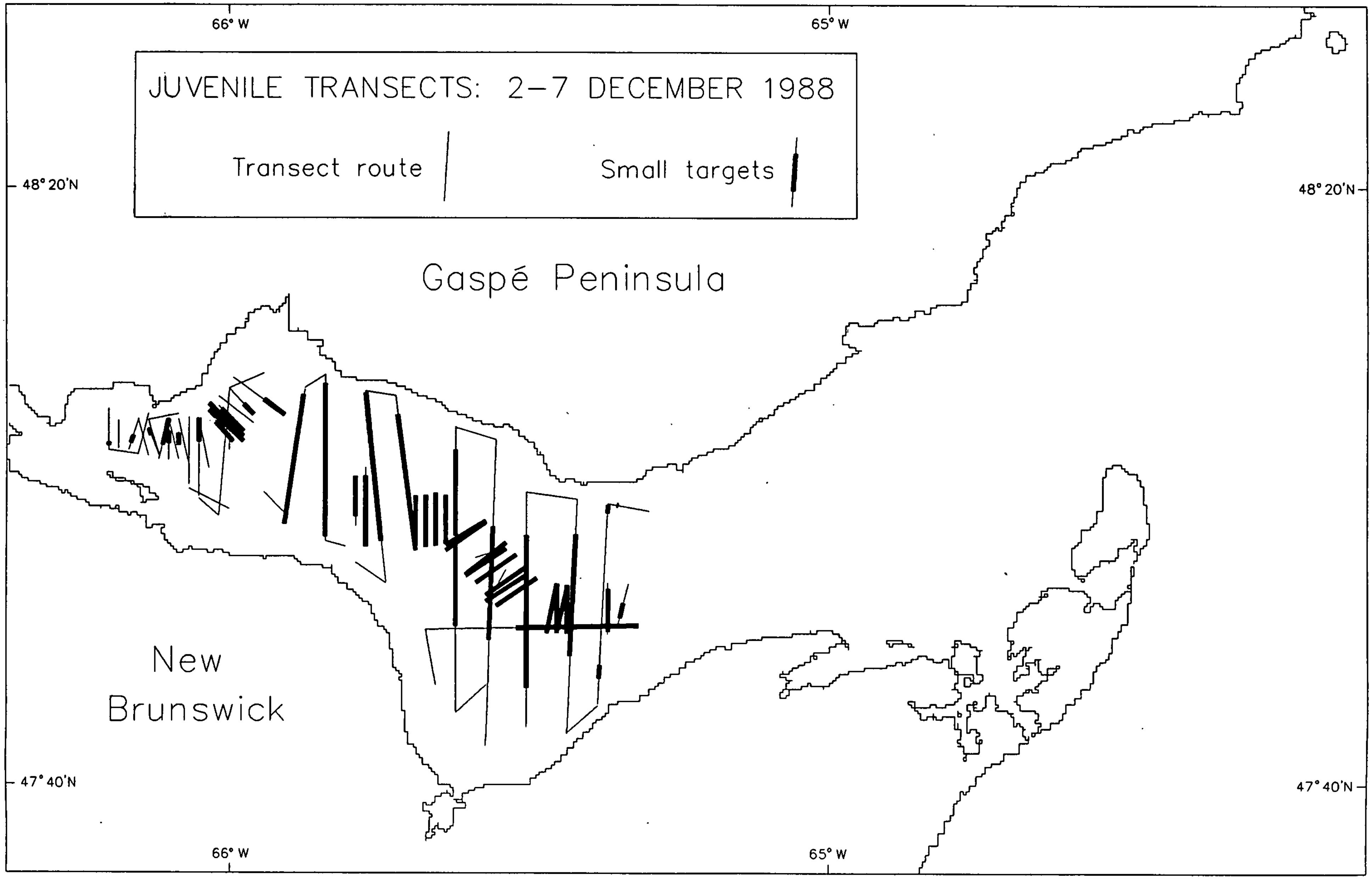


Fig. 15. Juvenile herring transects in the Bay of Chaleur, December 1988, showing locations where juvenile herring or other small targets were observed on the sounder.



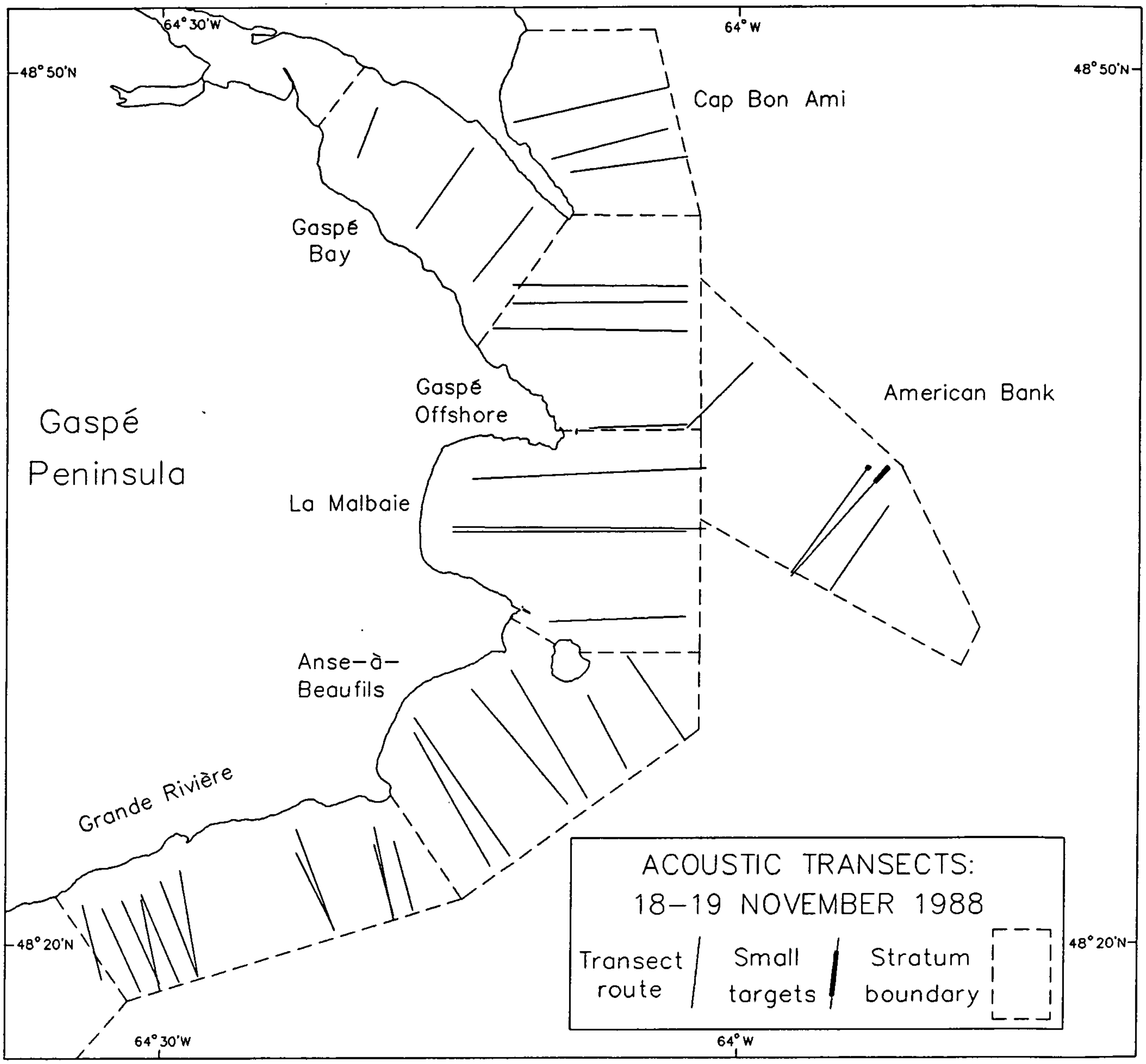
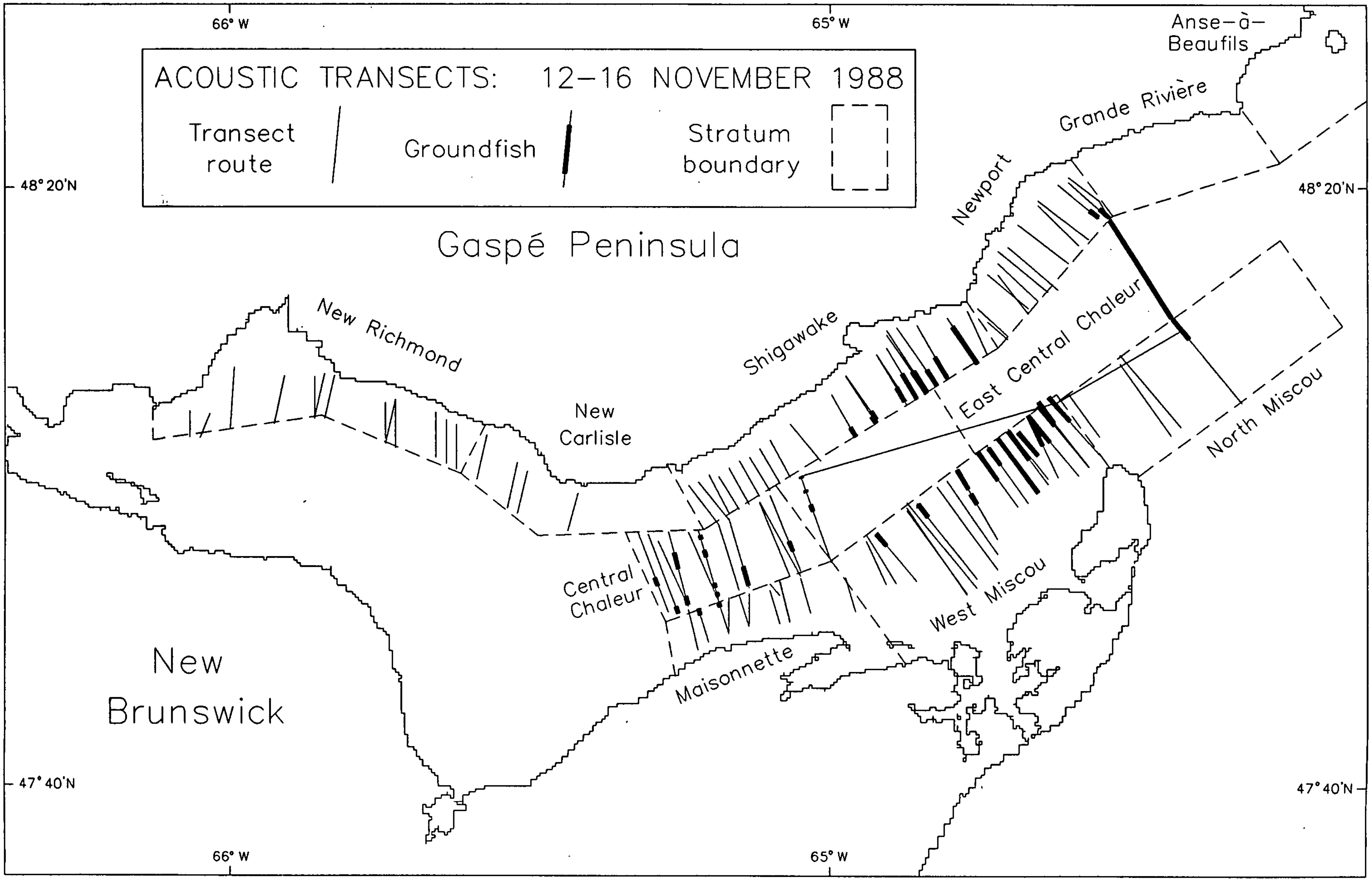


Fig. 16. Acoustic transects in the eastern Gaspé area, November 1988, showing locations where juvenile herring or other small targets were observed on the sounder.

Fig. 17. Acoustic transects in the Bay of Chaleur, November 1988, showing locations where groundfish were observed on the sounder.



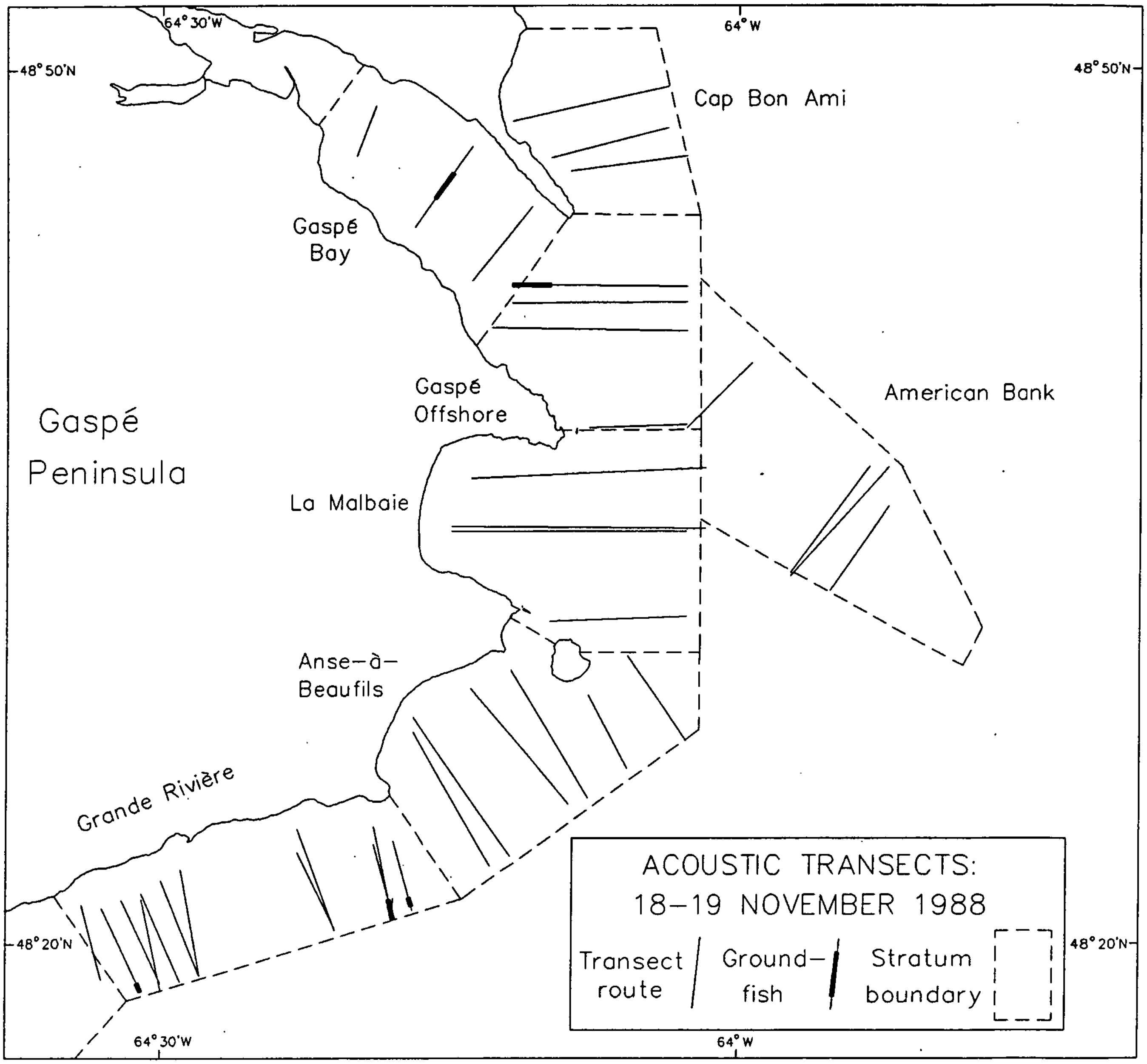


Fig. 18. Acoustic transects in the eastern Gaspé area, November 1988, showing locations where groundfish were observed on the sounder.

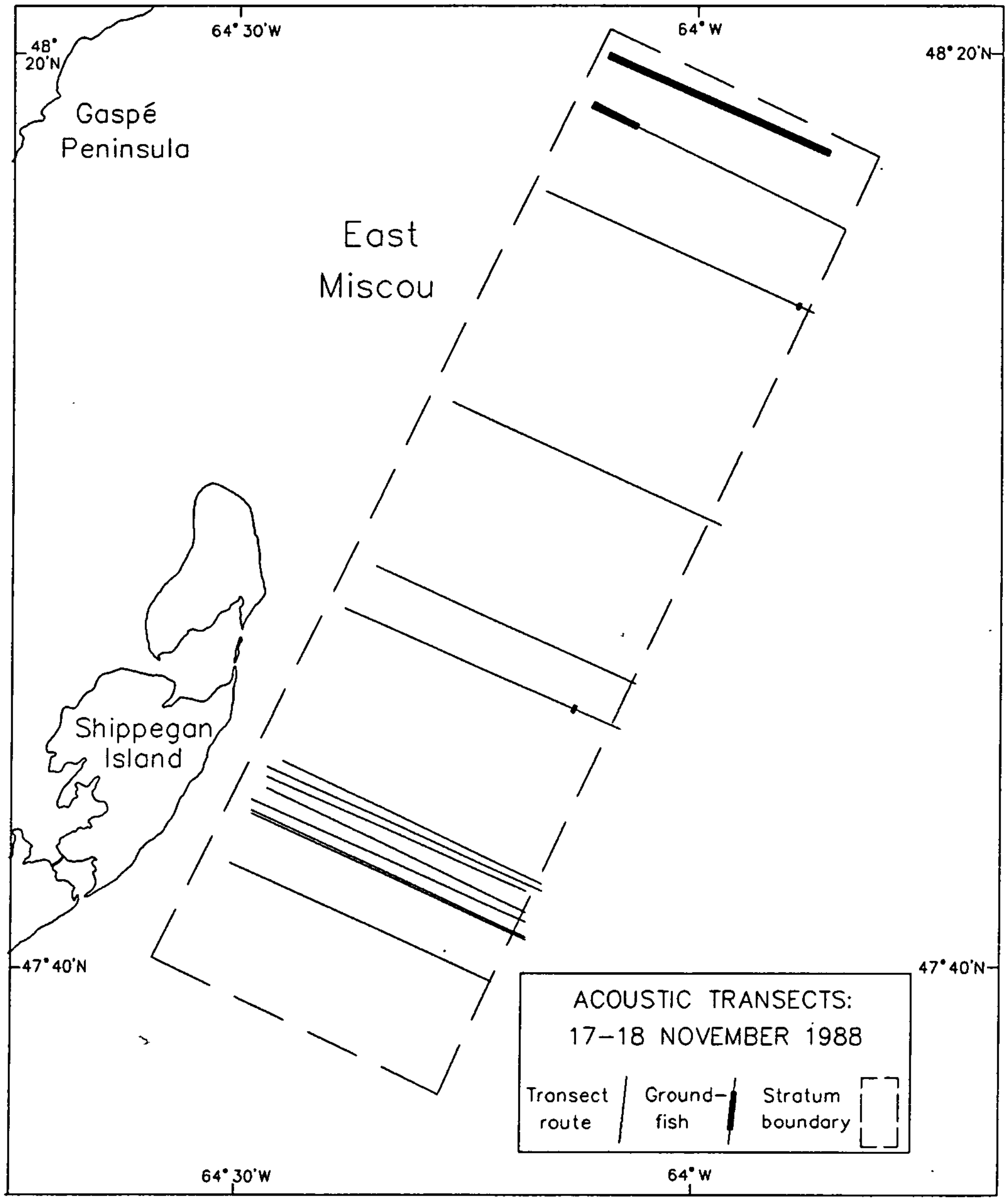


Fig. 19. Acoustic transects in the East Miscou stratum, November 1988, showing locations where groundfish were observed on the sounder.

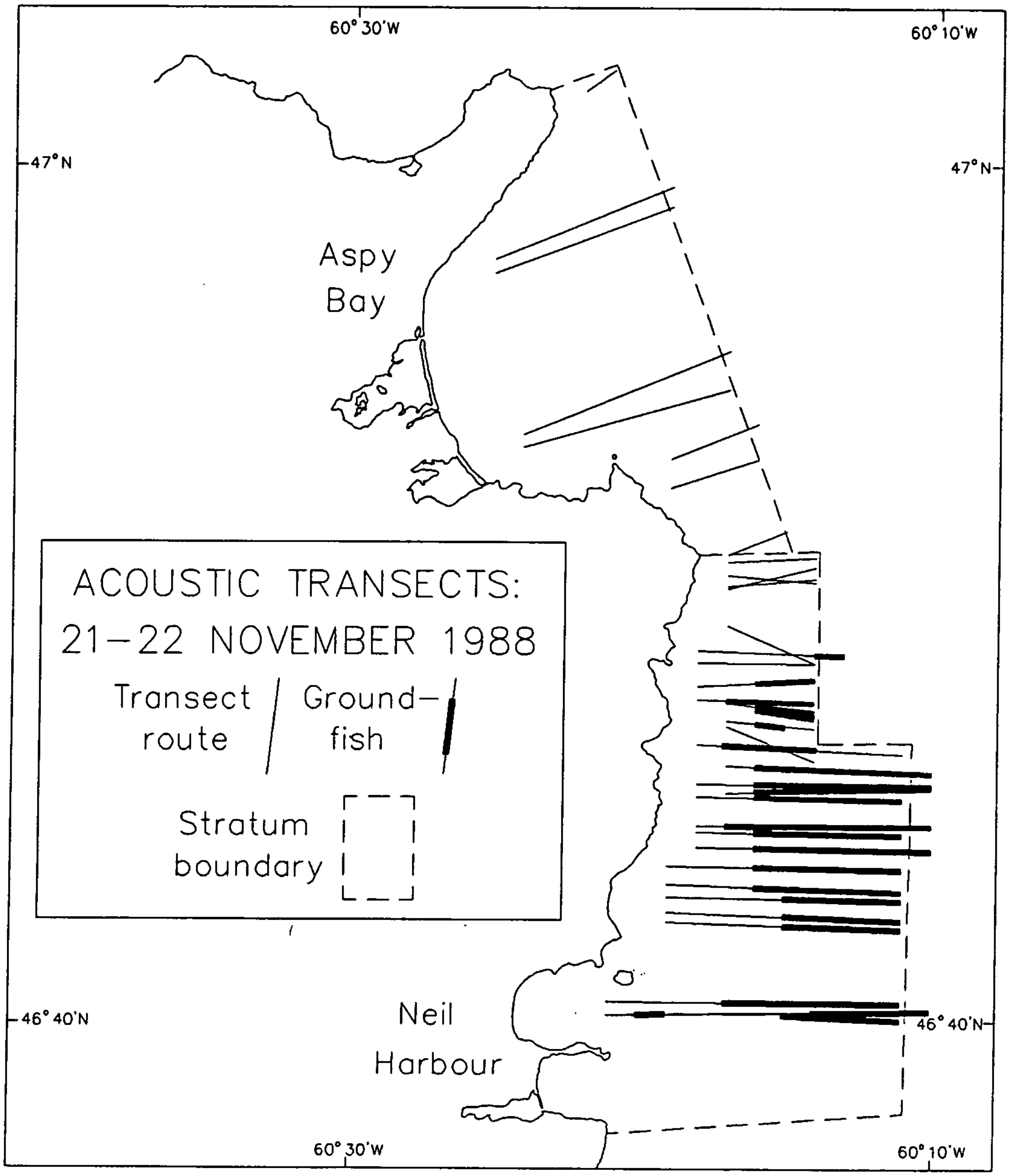


Fig. 20. Acoustic transects in the northern Sydney Bight area, November 1988, showing locations where groundfish were observed on the sounder.

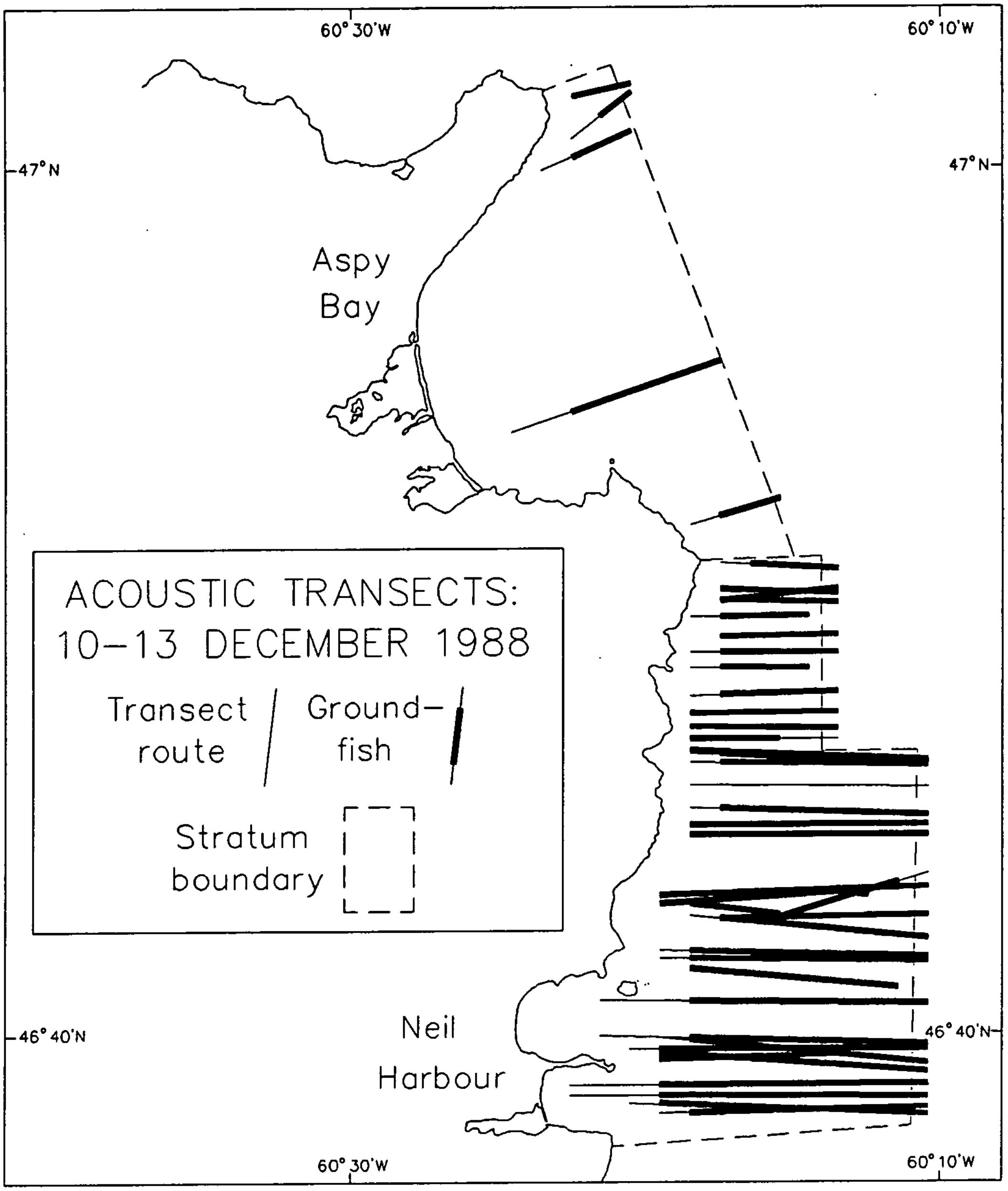


Fig. 21. Acoustic transects in northern Sydney Bight, December 1988, showing locations where groundfish were observed on the sounder.

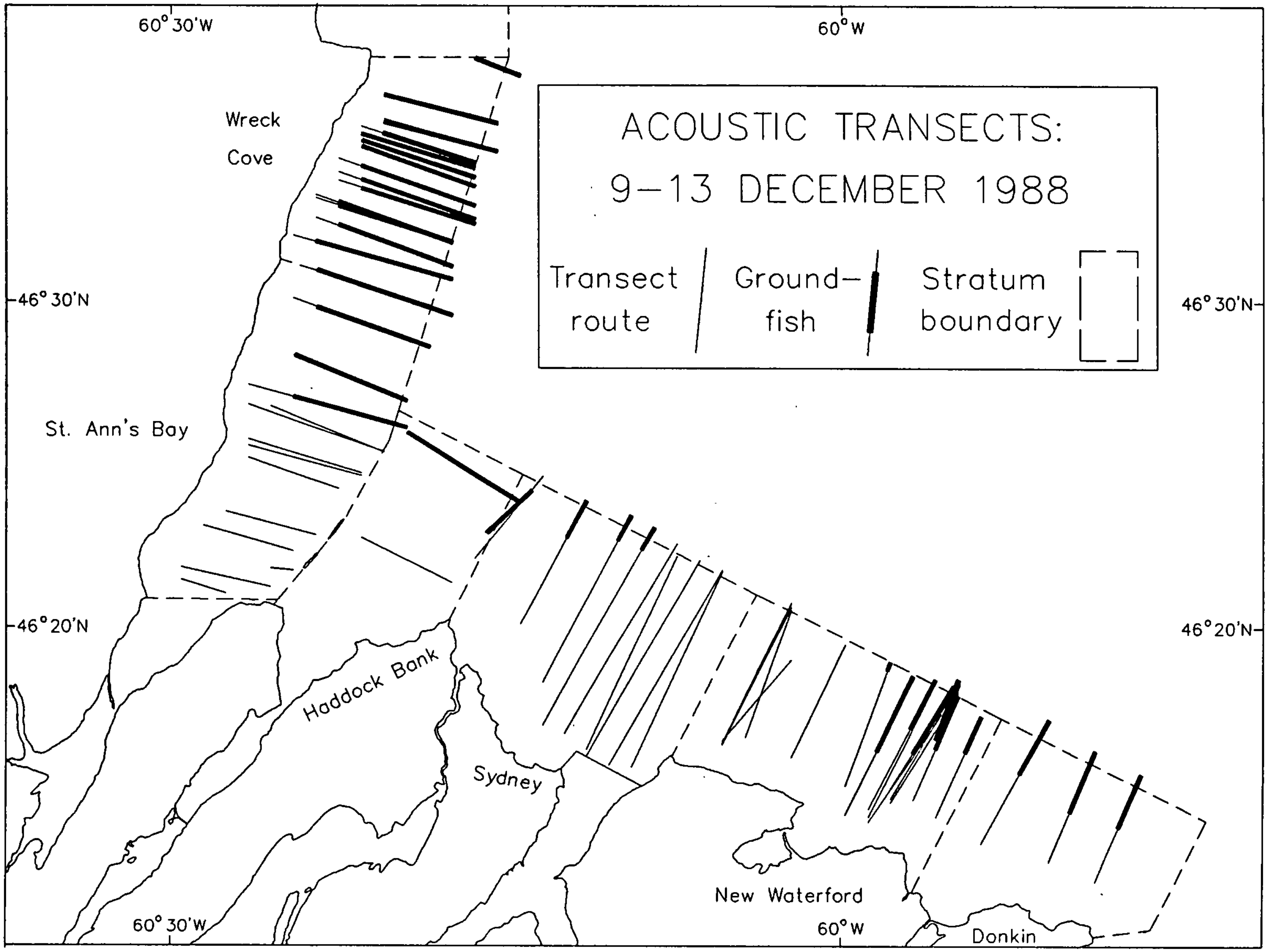


Fig. 22. Acoustic transects in eastern Sydney Bight, December 1988, showing locations where groundfish were observed on the sounder.

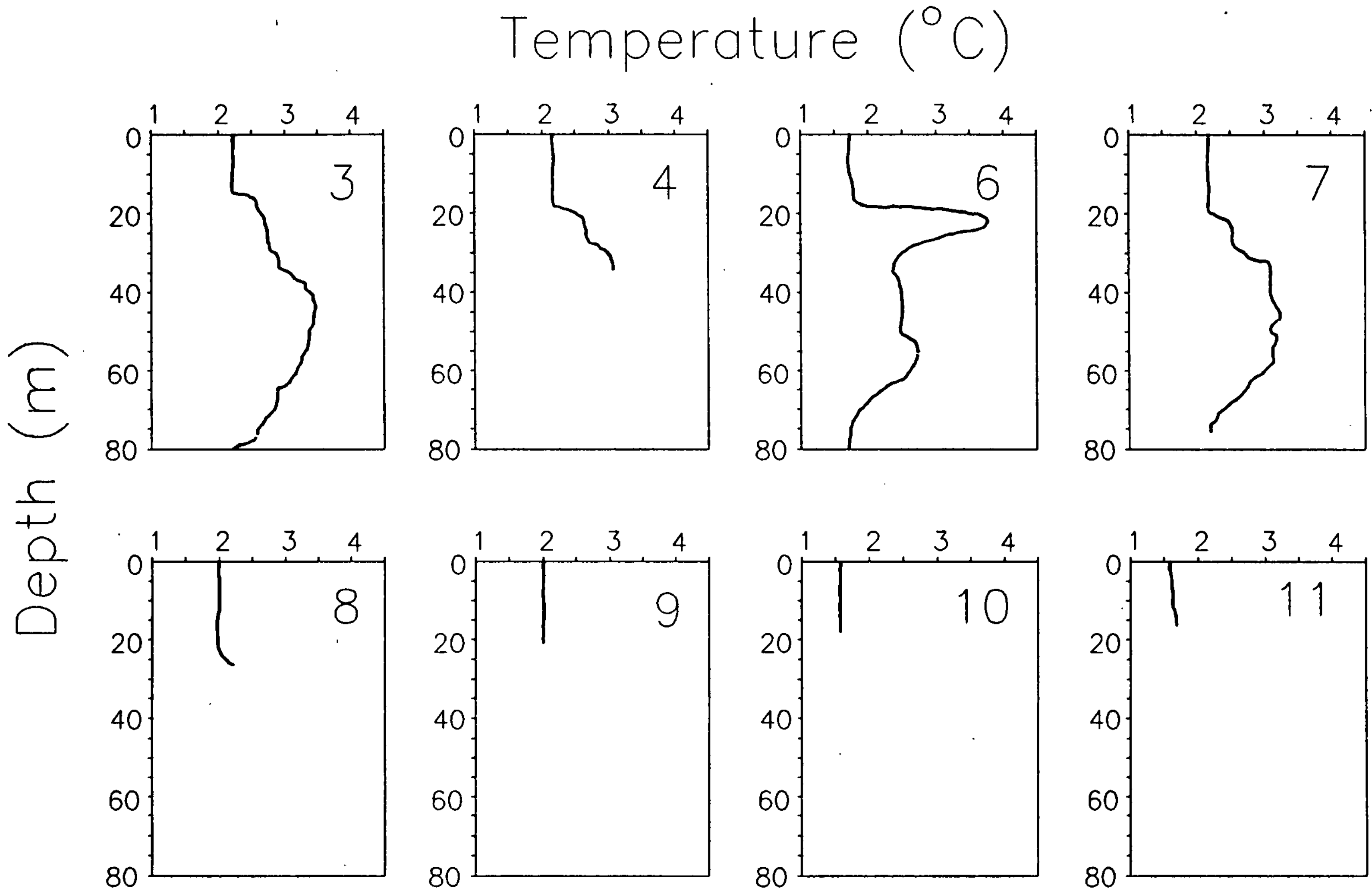


Fig. 23. Temperature profiles recorded by expendable bathythermograph (XBT) probes in the Bay of Chaleur, December 1988. Numbers on each panel refer to cast locations given in Fig. 2.

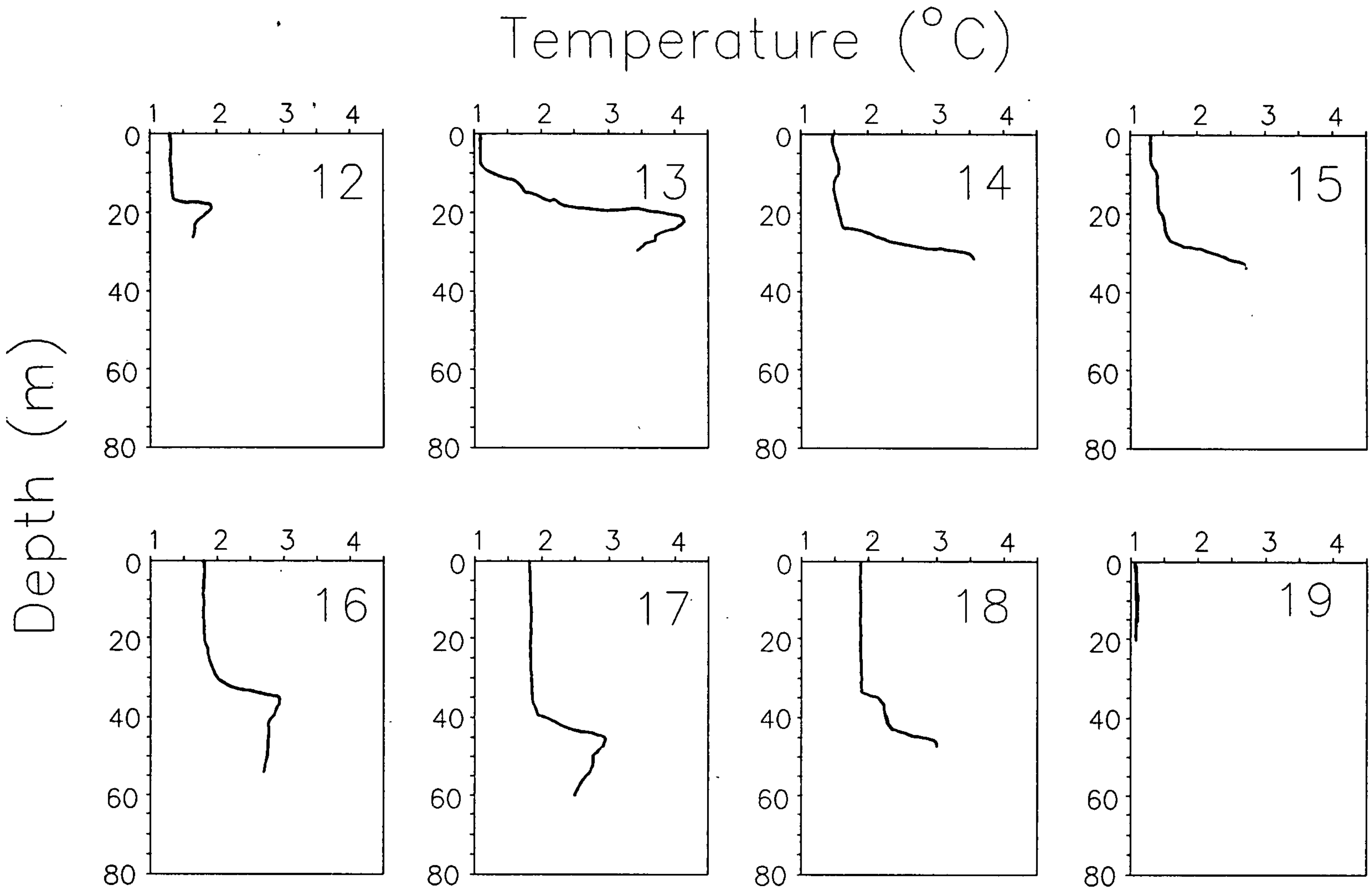


Fig. 23. (Continued)

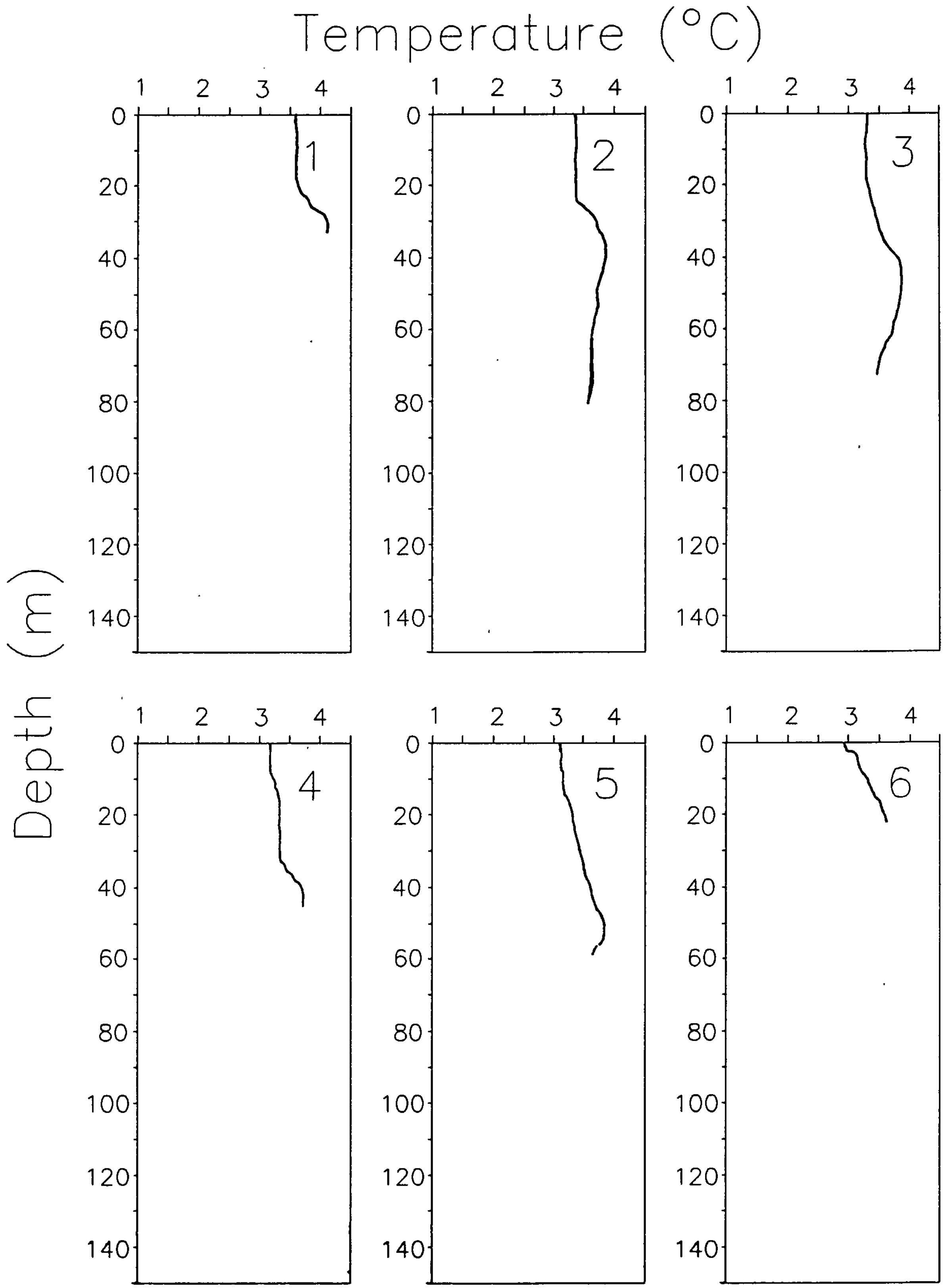


Fig. 24. Temperature profiles recorded by expendable bathythermograph (XBT) probes in Sydney Bight, December 1988. Numbers on each panel refer to cast locations given in Fig. 3.

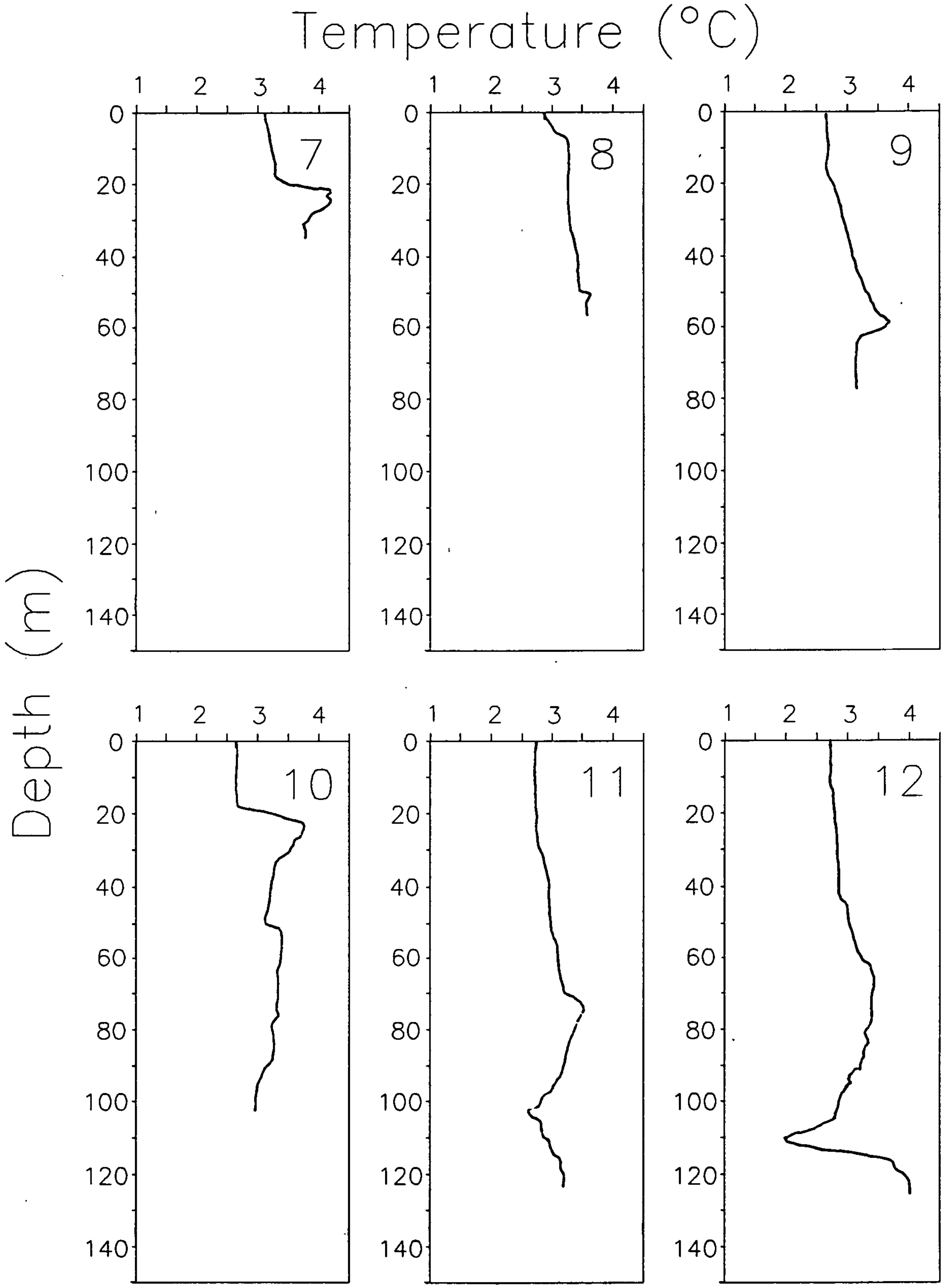


Fig. 24 (continued)

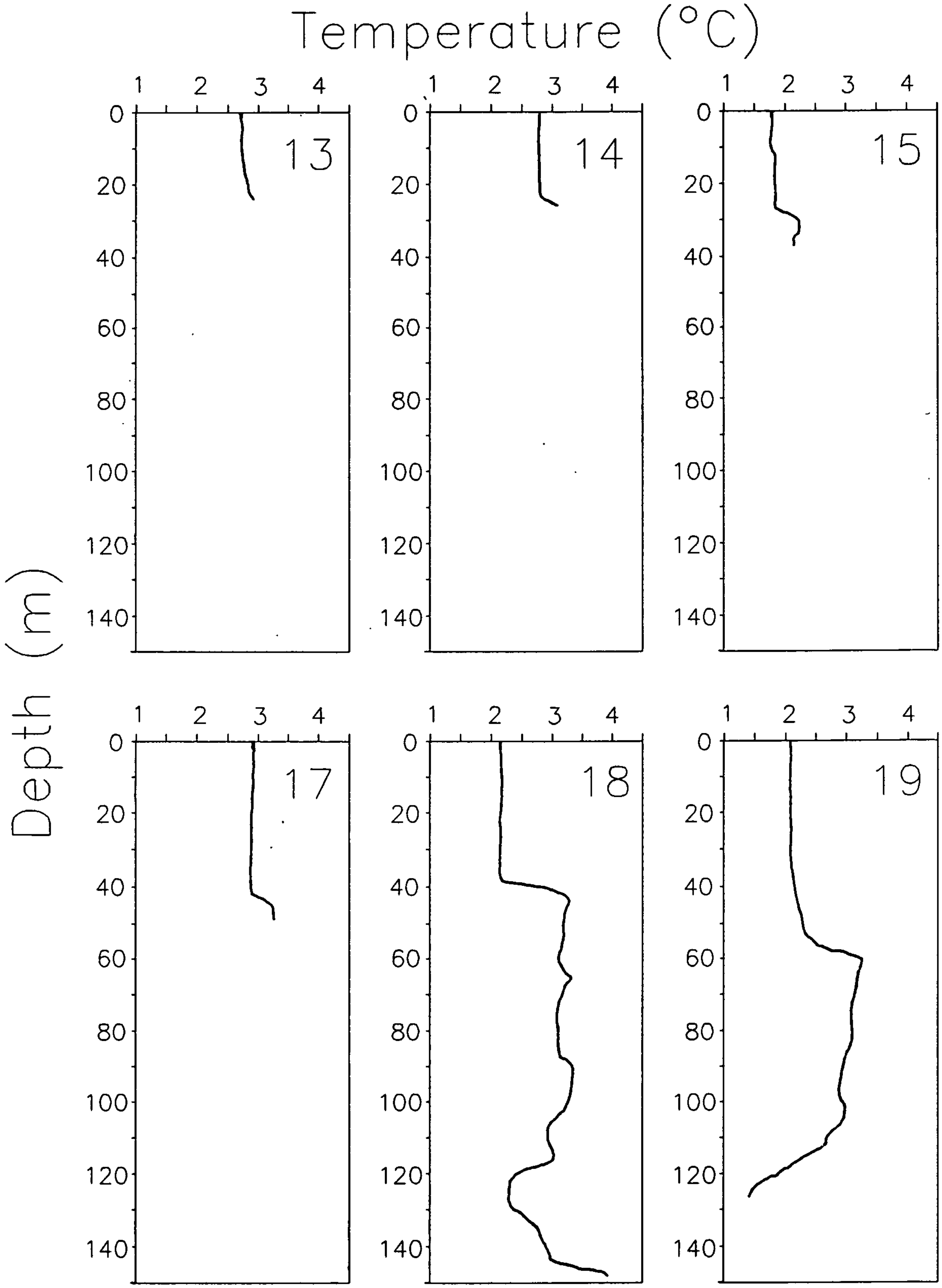


Fig. 24 (continued)

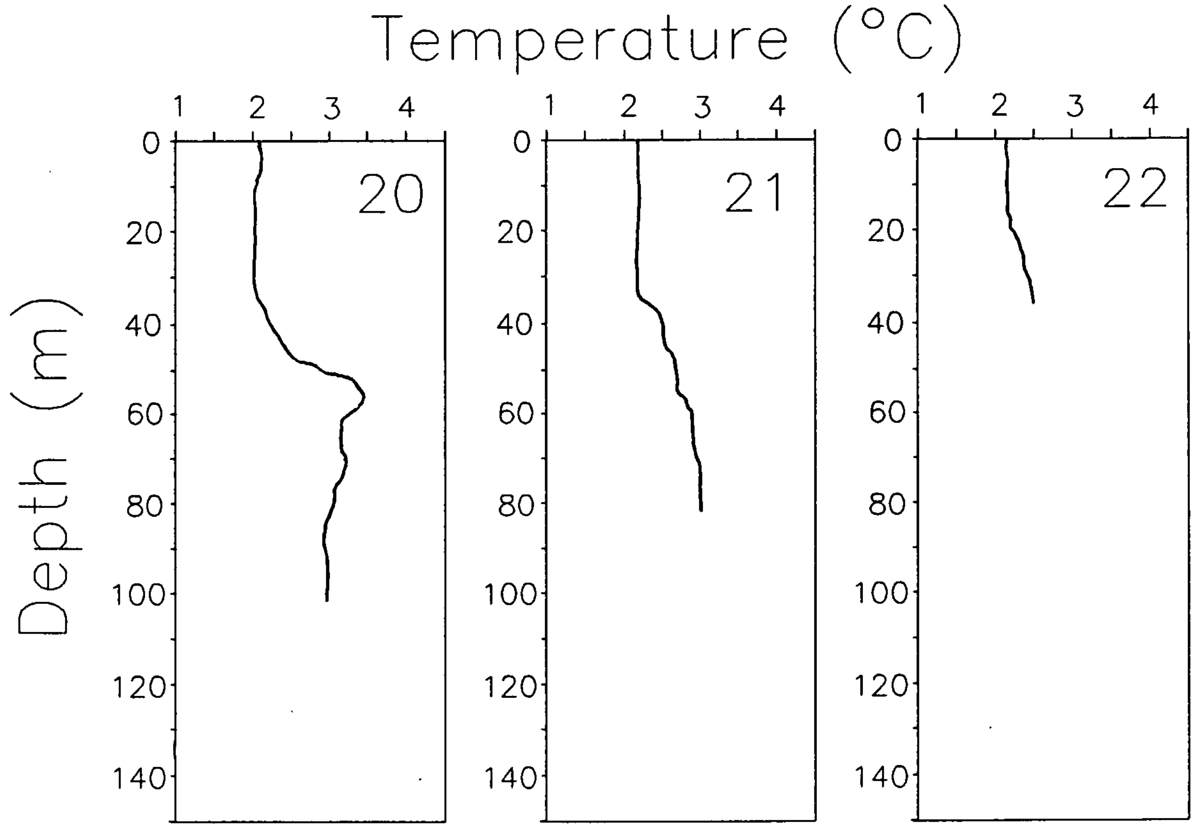


Fig. 24 (continued)

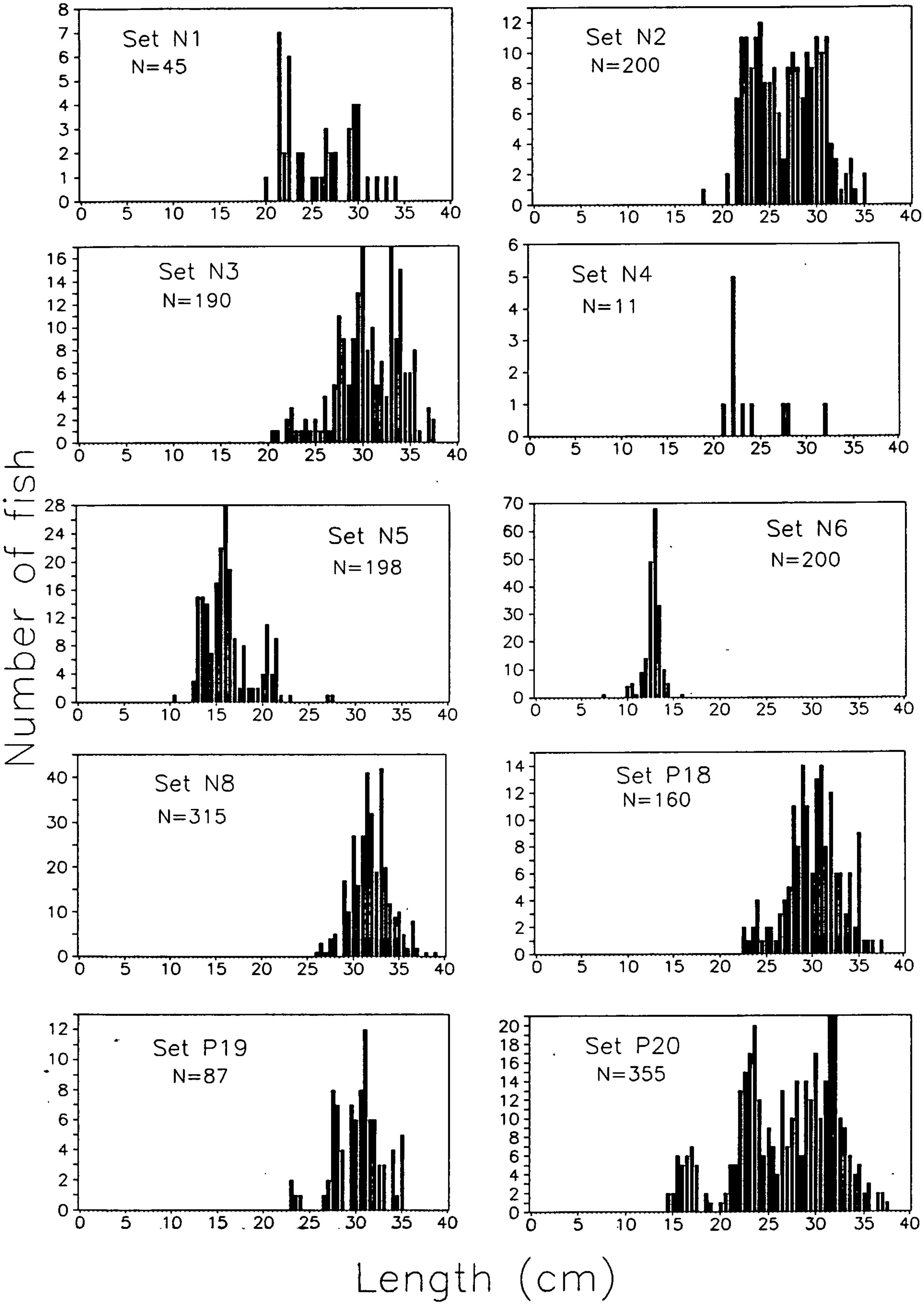


Fig. 25. Length frequency distributions of herring taken in sets during acoustic surveys in the Bay of Chaleur, November 1988 (Sets N1 - N6); Sydney Bight, November 1988 (Set N8); and Sydney Bight, December 1988 (Sets P18 - P20).

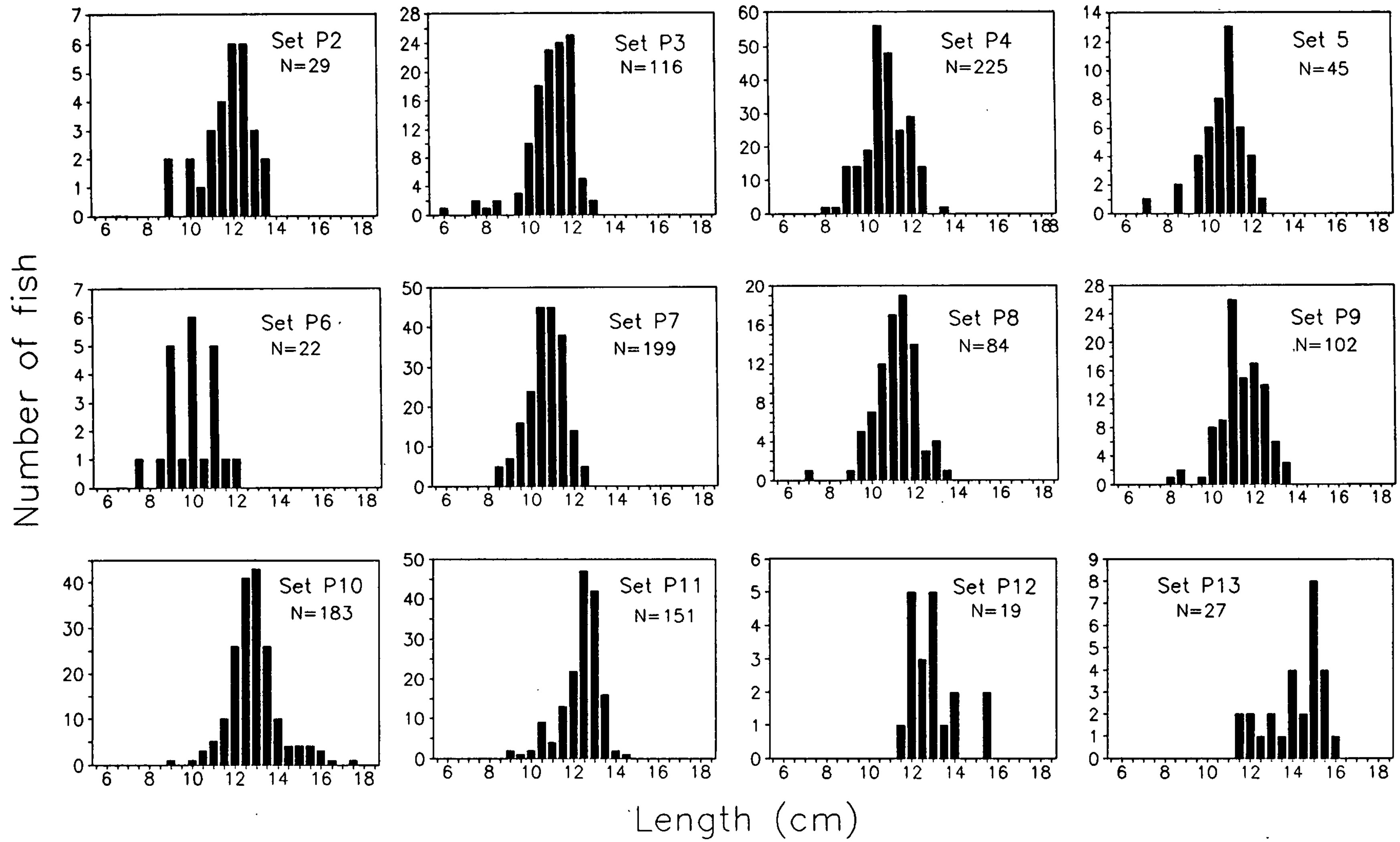


Fig. 26. Length frequency distributions of herring taken in sets during juvenile herring surveys in the Bay of Chaleur, December 1988.

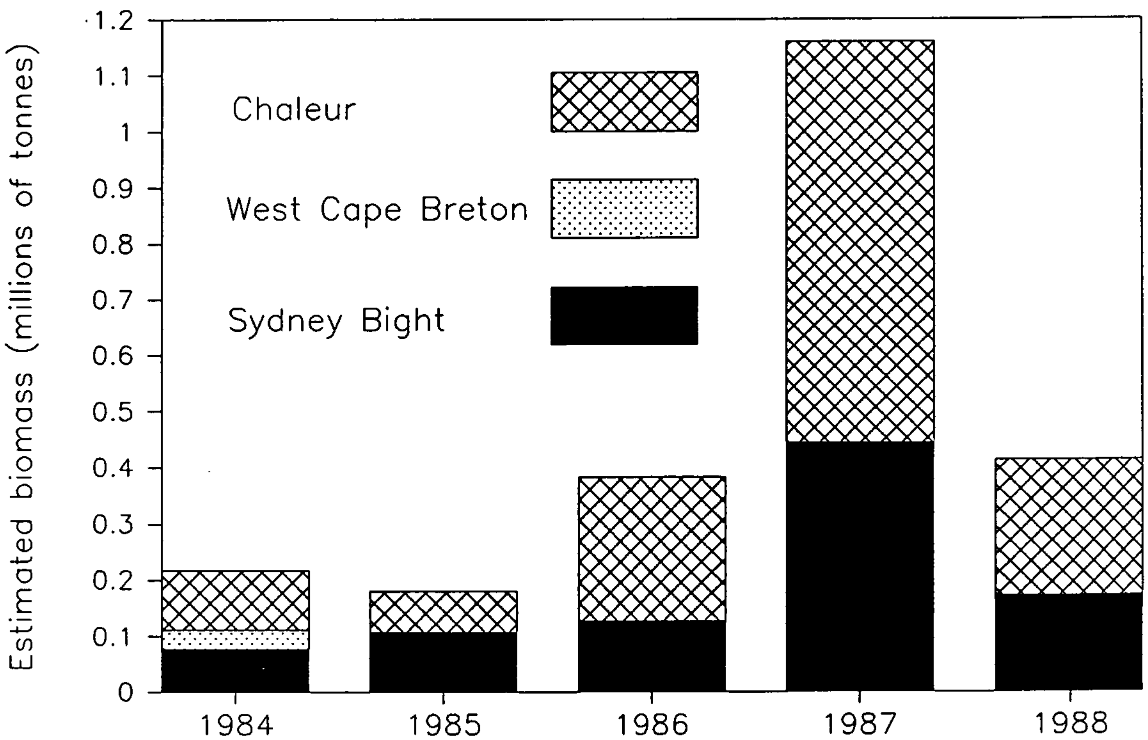


Fig. 27. Herring biomass estimates for the southern Gulf of St. Lawrence and Sydney Bight, 1984-1988. Estimates are computed using Foote's (1987) conversion factor. Note that West Cape Breton was not surveyed in 1985-1988.

Appendix 1. Formulas used in calculating values given in Tables 1-4. Unless otherwise indicated, lengths are in m, areas are in m^2, time is in hours, area scattering coefficient is in sr^{-1}, total backscattering is in $m^2\ sr^{-1}$, and mass is in tonnes.

<u>Table 2 - formulas for individual transects.</u>

Transect area = 200 x transect length

$$\text{Target strength in dB kg}^{-1} = (20 \log \text{length} - 71.9) - 10 \log \text{weight}$$

Notes: This equation is from Foote (1987). Length is mean length of fish in cm. Weight is mean weight in kg at this length.

$$\text{Sa} = \text{Area scattering coefficient} = \frac{\text{Raw total scatter} \times 0.9462}{7500 \times \text{transect duration}}$$

Note: 7500 is the number of pulses per hour

Total backscattering = transect area x area scattering coefficient

$$\text{Biomass density in kg m}^{-2} = \frac{\text{Area scattering coefficient}}{10^{\left(\frac{\text{target strength}}{10}\right)}}$$

$$\text{Total biomass in tonnes transect}^{-1} = \frac{0.001 \times \text{total backscattering}}{10^{\left(\frac{\text{target strength}}{10}\right)}}$$

<u>Table 3 - formulas for strata</u>

$$\text{Weighting factor} = \frac{\text{transect area}}{\text{mean transect area}}$$

$$\text{Stratum area scattering coefficient} = \frac{1}{\text{number of transects}} \times \sum \text{weighting factor} \times \text{area scattering coefficient for each transect}$$

$$\text{Mean total backscattering per stratum} = \text{stratum area scattering coefficient} \times \text{stratum area}$$

$$\text{Variance of area scattering coefficient} = \frac{\sum \text{weighting factor}^2 \times \left(\text{area scattering coefficient} - \text{mean of weighted area scattering coefficient}\right)^2}{\text{number of transects} \times (\text{number of transects} - 1)}$$

$$\text{Variance of total backscattering} = \left(\text{stratum area}\right)^2 \times \text{variance of area scattering coefficient}$$

$$\text{Standard error of total backscattering} = \sqrt{\text{variance of total backscattering}}$$

$$\text{Stratum biomass density in kg m}^{-2} = \frac{\text{stratum area scattering coefficient}}{10^{\left(\frac{\text{target strength}}{10}\right)}}$$

$$\text{Total stratum biomass} = 0.001 \times \text{stratum area} \times \text{stratum biomass density}$$

$$\text{Variance of biomass density} = \frac{\sum \text{weighting factor}^2 \times \left(\text{biomass density} - \text{mean of weighted biomass density}\right)^2}{\text{number of transects} \times (\text{number of transects} - 1)}$$

$$\text{Standard error of total stratum biomass} = \sqrt{0.001^2 \times \text{stratum area}^2 \times \text{variance of biomass density}}$$

Table 4 - Formulas for survey areas

$$\text{Mean total backscattering per survey area} = \sum \text{total backscattering for strata in survey area}$$

$$\text{Variance total backscattering per survey area} = \sum \text{stratum area}^2 \times \text{variance of stratum area scattering coefficient}$$

$$\text{Coefficient of variation of total backscattering per survey area} = \frac{\sqrt{\text{variance total backscattering per survey area}}}{\text{mean total backscattering per survey area}}$$

$$\text{Mean biomass per survey area} = \Sigma \text{ biomass for strata in survey area}$$

$$\text{Variance of biomass per survey area} = 0.001^2 \times \sum \text{stratum area}^2 \times \text{variance biomass density within strata}$$

$$\text{Coefficient of variation of biomass per survey area} = \frac{\sqrt{\text{variance of biomass per survey area}}}{\text{mean biomass per survey area}}$$

Table 5 - Formula for survey area

$$\text{SE total backscattering per survey area} = \sqrt{\text{variance of total backscattering per survey area}}$$