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Results of the Acoustic Survey of Herring Stocks in NAFO Divisions 4T and 4Vn November 1986

by

R. Shotton
Economics Branch
Scotia-Fundy Region
P.O. Box 550,Halifax, NS B3J 2S7

and

M. Chadwick and J. Wright
Department of Fisheries & Oceans
Science Branch, Gulf Region
Marine & Anadromous Fish Division
P.O. Box 5030,Moncton, NB E1C 9B6

ABSTRACT

The third acoustic survey of herring in the Southern Gulf of St. Lawrence was conducted in November, 1986. The estimated total area backscattering coefficient for Chaleur Bay was 61,243 m^2 sr^{-1}, which was more than twice the estimates made in 1984 and 1985. The coefficient of variation of this estimate was 37%. The largest herring schools were encountered in the Grande Rivière - Newport area.

In the waters off Cape Breton the total area backscattering coefficient was 33,251 m^2 sr^{-1} which was not very different form the values estimated in 1984 and 1985. Poor weather conditions off Cape Breton in 1986 resulted in fewer transects being done compared to 1984 and 1985 with the result that the variance is high, thus the estimate is probably imprecise. The coefficient of variation was 61%. In terms of biomass, using the backscattering cross-section area/biomass relation of Halldorson and Reynisson (1983), the survey estimate of herring biomass is 430,000 tonnes of which approximately two-thirds were in the Chaleur Bay Region.

RESUME

Le troisième dénombrement acoustique du hareng dans le sud du golfe du Saint-Laurent a été effectué en novembre 1986. Le coefficient de rétrodiffusion total pour la baie des Chaleurs a été estimé à 61 243 m^2/sr^{-1}, soit plus du double des valeurs obtenues en 1984 et 1985. Le coefficient de variation de cette estimation était de 37 %. Les plus gros bancs de harengs ont été observés dans la région de Grande-Rivière-Newport.

Le coefficient de rétrodiffusion total pour la région du Cap-Breton était de 33 251 m^2/sr^{-1}, soit à peu près la même valeur qu'en 1984 et 1985. A cause de conditions climatiques défavorables au large du Cap-Breton en 1986, on a effectué un plus petit nombre de transects qu'en 1984 et 1985. Par conséquent, la variance est élevée et l'estimation manque probablement de précision. Le coefficient de variation était de 61 %. En utilisant la relation aire de la section efficace de rétrodiffusion/biomasse, établie par Halldorson et Reynisson (1983), on a estimé la biomasse du hareng à 430 000 tonnes, dont les deux tiers se trouvent dans la région de la baie des Chaleurs.

1. INTRODUCTION

This report gives the results for the third acoustic survey of herring in the southern Gulf of St. Lawrence and Sydney Bight. Results for 1984 are given by Shotton, Ahrens and Bourque (1987) and for 1985 by Shotton (1986). The primary objective of the cruise was to obtain acoustic estimates of the abundance of herring in the areas which had been surveyed in 1984 and 1985 and to expand the survey to other areas where herring were expected to occur, in this case, northeastern Prince Edward Island. The second objective was to obtain length-frequency and sexual-maturity data from the herring that were sonified.

A long-term objective of these surveys is to obtain an independent estimate of stock abundance for 4T herring which could be used as a means of calibrating the sequential population analysis.

2. SURVEY AREA

A total of 17 strata was sampled: 11 strata were located in the Chaleur Bay area, one stratum on the north east coast of P.E.I. and five strata around the coast of Cape Breton Island. Figure 1 shows the locations of the sampling strata in the regions surveyed. Strata used in 1985 are shown in Figure 2. Generally the 1986 strata were the same as in 1985 with the following changes: the offshore limits of strata in Chaleur Bay were moved inshore as past experience showed that herring usually occurred in near shore areas; strata along the north and eastern region of PEI and eastern Cape Breton were dropped; and, a new stratum was initiated on the north east coast of PEI.

Detailed information on strata areas and sampling time is given in Table 1.

The dates that the strata were sampled were:

Gaspé-Miscou Island	November 17-28
Eastern P.E.I. and Cape Breton	December 1-12

In most strata at least three randomly selected transects were surveyed. Additional transects were completed in strata with large herring schools including, L'Anse-à-Beaufils and Grande-Rivière. The length of transects was calculated on the basis of ship time available to sample each stratum. Starting positions were randomly located on one of the stratum boundaries. The starting angle was calculated as arcsin (stratum width/transect length). The approximate location of transects for strata in Gaspé and Chaleur Bay are shown in Figs. 1 a), b), and c) and for those in the Cape Breton area in Fig. 1 d).

3. ACOUSTIC METHODS

3.1 Introduction

Acoustic data were collected using the ECOLOG system. The system was run with a pulse rate of 125/min, a pulse width of 0.4 ms and an echo sample frequency of 10 kHz. The transducer has an equivalent beam angle of 0.00640 sr for the narrow beam array. Ship speed along transects was a nominal 8 knots. Some transects ran at 10 knots. Power transmitted was 5 KW. The acoustic system was calibrated at the acoustics barge, Bedford Basin at the end of the cruise.

3.2 Calculation of the Area Backscattering Coefficient

The area scattering coefficient ($s_{v/a}$) was calculated using the conventional acoustic integration model (Forbes and Nakken 1972).

$$s_v = \frac{I_r R^2 e^{2\beta R}}{I_0 (c\tau)/2 \int^{2\pi} b(\theta)^2 \, d\Omega}$$

where I_r = echo intensity at the transducer

R = range of reverberation volume which returned the echo

β = coefficient of sound absorption in seawater

I_0 = intensity of sound transmitted from the transducer

c = speed of sound in seawater (1500 ms^{-1})

τ = pulse length

$b(\theta)$ = directivity function of the transducer

The area scattering coefficient, $s_{v/a}$, for the kth pulse was calculated by:

$$s_{u/a,k} = \sum_{j=1}^{J} 0.075\, s_{v,j}$$

where J = number of echo samples in the jth pulse. The summed area scattering for the ith transect is:

$$s_{u/a,i} = \sum_{k=1}^{K} s_{u/a,k}$$

where K = number of pulses in the ith transect.

The total area scatter for the stratum is calculated by:

$$\Sigma s_{u/a} = \frac{area}{P} \sum_{i=1}^{I} s_{u/a,i}$$

where P = total number of pulses in the stratum
I = number of transects in stratum

3.3 Estimation of Variance of Population Totals

The estimates of the standard deviation of the population totals given in the results measure only the sampling variance, i.e., they do not include the contributions from the variances of the components of the acoustic integration model (Eq. 1).

In several strata, the survey consisted of a single continuous zig-zag transect, i.e., there was no replication of sampling. In these cases the variance has not been estimated. Where transects have been replicated within a stratum, the variance of the population total has been estimated as follows:

$$Var(Y_{tot}) = \frac{1}{n-1} \frac{\Sigma P_i (Y_i - \overline{Y})^2}{\Sigma P_i}$$

where Y_{tot} = stratum total estimate

n = number of transects in the stratum

P_i = number of samples (i.e., pulses) in the stratum

Y_i = stratum total estimate derived from the ith transect

= $As_{v/a,i}$

where A = area of stratum

$s_{v/a}$ = mean area scattering coefficient

$$\overline{Y} = \frac{1}{n} \Sigma Y_i$$

This estimate of precision should be conservative, i.e., it should give large estimates for confidence intervals at given levels of type I probability. We prefer to use this larger variance estimate in the absence of a satisfactory understanding of the reliability of variance estimates which use measures of the autocorrelation of observations successively obtained along transects, and which ignore trends in the observations. This topic still remains to be further investigated.

3.4 Herring Length Frequencies

A mid water trawl equipped with a net sounder, was used to verify that the schools being sonified were in fact herring and secondly to collect samples to determine the age structure,

spawning group and size of herring. The length frequency distributions were used to convert the back scattering coefficient into biomass.

3.5 Estimation of Biomass

The estimation of the herring biomass from the summed area backscattering coefficient, $s_{v/a}$, requires use of an appropriate value for the backscattering cross section area per unit weight of herring. Determination of this value is difficult because it is hard to determine and because it is likely to change with the behavior of the herring, i.e., the daytime backscattering cross section per unit biomass may differ to that at night. The difficulties in selecting an appropriate value are discussed by Shotton (1985) and Buerkle (1985). Both authors tabulate values of backscattering cross sections per kilogram of herring cited in the literature. The value used here is that given by Halldorson and Reynisson.

$$\overline{TS}\,kg = -10.9 \log L - 20.9 \; dB,$$

where L = length in cm

or

$$\sigma_{b/kg} = 10^{-2.09} L^{-1.09}$$

4. RESULTS

In Chaleur Bay, herring schools were found concentrated in Grande Rivière, Newport and Shigawake strata; the largest concentrations were found near Grande Rivière (Table 1). By contrast, in 1985 the major concentration of herring was found in the West Miscou stratum (Table 2).

Because of poor weather condition in the Cape Breton area, strata and transects were dropped from the original survey design and there is

less confidence in the 1986 estimates for this area. Nevertheless, the summed backscattering coefficients appear to have changed little since 1984 (Table 2).

There were four successful trawl sets during the cruise: three in Chaleur Bay, and one off Cape Breton (Table 3). Herring from Chaleur Bay were larger than those sampled off Cape Breton (Figs. 3 and 4). Herring from Chaleur Bay were also larger than samples taken from the same area in 1985:

Year	mean	SD
1985	29.5	1.84
1986	31.4	4.07

Of interest was that the survey in Chaleur Bay encountered smaller herring than samples taken from the purse seine fishery in October (Fig. 5).

There were differences in stock structure among the schools sampled in Chaleur Bay. The schools sampled in the Grande Rivière and Newport strata were 65% spring spawners, whereas the school sampled in the Shigawake stratum comprised only 38% spring spawners. These differences could be a consequence of the small sample sizes; this needs further investigation.

The biomass estimates for 1984-1986 are summarized in Table 4. In 1986, about two thirds of the biomass occurred in Chaleur Bay. These estimates are not entirely comparable among years because of slight changes in survey design. In 1984, the survey had abroad coverage; in subsequent years, the sampling intensity was increased in areas where herring were presumed to be more abundant and reduced in offshore areas or strata where herring were not found. This type of modification will continue in subsequent surveys. Nevertheless, the data indicate that the biomass in Chaleur Bay increased in 1986 relative to the two previous years, but in Cape Breton no change was evident.

5. ACKNOWLEDGEMENTS

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Table 1. Summary of time, number of schools and total area of backscatter for transects and strata in the 1986 acoustic survey.

Stratum		Transect	Time (hr)	Number of schools	Backscatter (sr)	Total area backscatter (m^2sr^{-1})
Name	Area (m^2X10^6)					
Cape Bon Ami	138.6	1	1.467	0	0	0
		2	1.267	0	0	0
		3	1.700	0	0	0
Gaspé Bay	115.7	1	1.850	7	0.00141	11.742
		2	1.950	19	0.00620	49.044
		3	1.983	5	0.00108	8.419
Gaspé off shore	167.6	1	1.650	0	0	0
		2	1.400	0	0	0
		3	1.517	0	0	0
		4	1.267	0	0	0
La Malbaie	207.1	1	1.683	0	0	0
		2	1.483	0	0	0
		3	1.250	0	0	0
		4	1.017	0	0	0
L'Anse-à-Beaufils	262.0	1	1.683	6	0.00758	157.23
		2	1.883	1	0.04545	843.16
		3	1.883	1	0.06053	1122.80
		4	1.833	12	0.01504	286.67
		5	1.450	1	0.05459	1315.37
		6	1.583	0	0	0
		7	1.650	0	0	0
Grande Rivière	188.8	1	2.350	24	3.48587	37350.71
		2	1.900	9	4.25043	56329.39
		3	1.917	7	2.74809	36102.09
		4	2.600	3	0.79575	7706.51
		5	1.317	7	0.40034	7655.99
		6	0.517	0	0	0
		7	2.180	9	1.37917	15929.95
Newport	189.9	1	1.967	10	2.65981	34258.12
		2	1.933	2	0.30431	3987.22
		3	2.167	3	0.93373	10916.25

Table 1. Summary of time, number of schools and total area of backscatter for transects and strata in the 1986 acoustic survey. (Continued)

Stratum Name	Area (m^2X10^6)	Transect	Time (hr)	Number of schools	Backscatter (sr)	Total area backscatter (m^2sr^{-1})
Shigawake	332.1	1	3.783	5	2.29023	26807.62
		2	2.983	3	1.45288	21566.70
		3	3.817	42	0.70194	8144.41
West Miscou	389.1	1	2.533	43	0.00846	173.31
		2	2.333	0	0	0
		3	2.533	0	0	0
North Miscou	425.4	1	3.317	0	0	0
		2	3.183	0	0	0
		3	2.967	0	0	0
East Miscou	2020.7	1	8.350	9	0.00169	54.81
		2	8.683	0	0	0
		3	1.117	0	0	0
		4	4.317	0	0	0
P.E.I.	1011.9	1	10.933	2	0.24963	3080.50
		2	1.683	1	0.00972	778.67
		3	2.300	0	0	0
Aspy Bay	166.5	1	4.817	2	0.07132	328.64
		2	4.300	0	0	0
Neil Harbour	260.1	1	9.280	169	4.35704	16310.23
Wreck Cove	111.2	1	1.693	3	2.27205	19896.87
		2	3.250	9	5.78017	26372.90
		3	2.183	0	0	0
Haddock Bank	95.0	1	2.050	0	0	0
		2	1.450	0	0	0
		3	1.700	0	0	0
		4	1.283	19	0.00650	64.03
Sydney	170.4	1	1.817	0	0	0
		2	2.150	0	0	0
		3	1.850	0	0	0

Table 2. The summed back scattering coefficients (m^2sr^{-1}) and their standard deviations for strata surveyed, 1984-1986.

Area	Stratum	1984 Mean	1984 Standard deviation	1985 Mean	1985 Standard deviation	1986 Mean	1986 Standard deviation
Chaleur Bay	Cape Bon Ami			0		0	
	Gaspé Bay			0		23.2	18.5
	Gaspé offshore			0		0	
	La Malbaie			0		0	
	L'Anse-à-Beaufils			1807.0	1035.4	534.8	500.0
	Grande Rivière					25730.7	17975.5
	Newport			4813.6	4454.8	16275.1	12775.3
	Shigawake					18599.7	8123.2
	West Miscou			7964.3	4220.2	59.3	82.2
	North Miscou			0		0	0
	East Miscou			4463.5	2864.4	20.4	726.5
	TOTAL	28700	NA	19048.4	6223.2	61243.2	23452.1
P.E.I.	Bayfield	---		---		2345.8	1233.4
Cape Breton	Aspy Bay			641.5	-	173.6	164.1
	Neil Harbour			3629.9	-	16310.2	NA
	Wreck Cove			17245.9	-	16754.6	11425.2
	Haddock Bank			1132.9	-	12.4	25.3
	Sydney			2956.0	-	0	0
	Other areas			13293.8	-	0	0
	TOTAL	33500	NA	38900.0	NA	33250.8	20000.0

Table 3. Summary of herring captured in trawl sets from the acoustic survey, November 1986.

Set number	Stratum	Latitude and longitude	Number measured	Mean length (mm)	Standard deviation
01	Grande-Rivière	48 21 18 64 27 21	197	295	45.0
02	Newport	48 07 35 64 56 11	228	317	43.7
03	Shigawake	48 05 53 64 59 58	218	331	33.5
04	Neil Harbour	46 37 01 60 14 13	No herring, targets were cod		
05	Neil Harbour	46 37 09 60 19 15	317	301	49.8

Table 4. Comparison of biomass estimates in thousands of tonnes of herring in Chaleur Bay and off Cape Breton, November 1984-1986.

		Chaleur Bay		Cape Breton	
Year	Reference	Halldorson and Reynisson (1983)	Edwards and Armstrong (1983)	Halldorson and Reynisson (1983)	Edwards and Armstrong (1983)
1984	(Shotton et al 1987)	132	95	151	108
1985	(Shotton 1986)	87	63	174	125
1986	This study	280	201	152	109

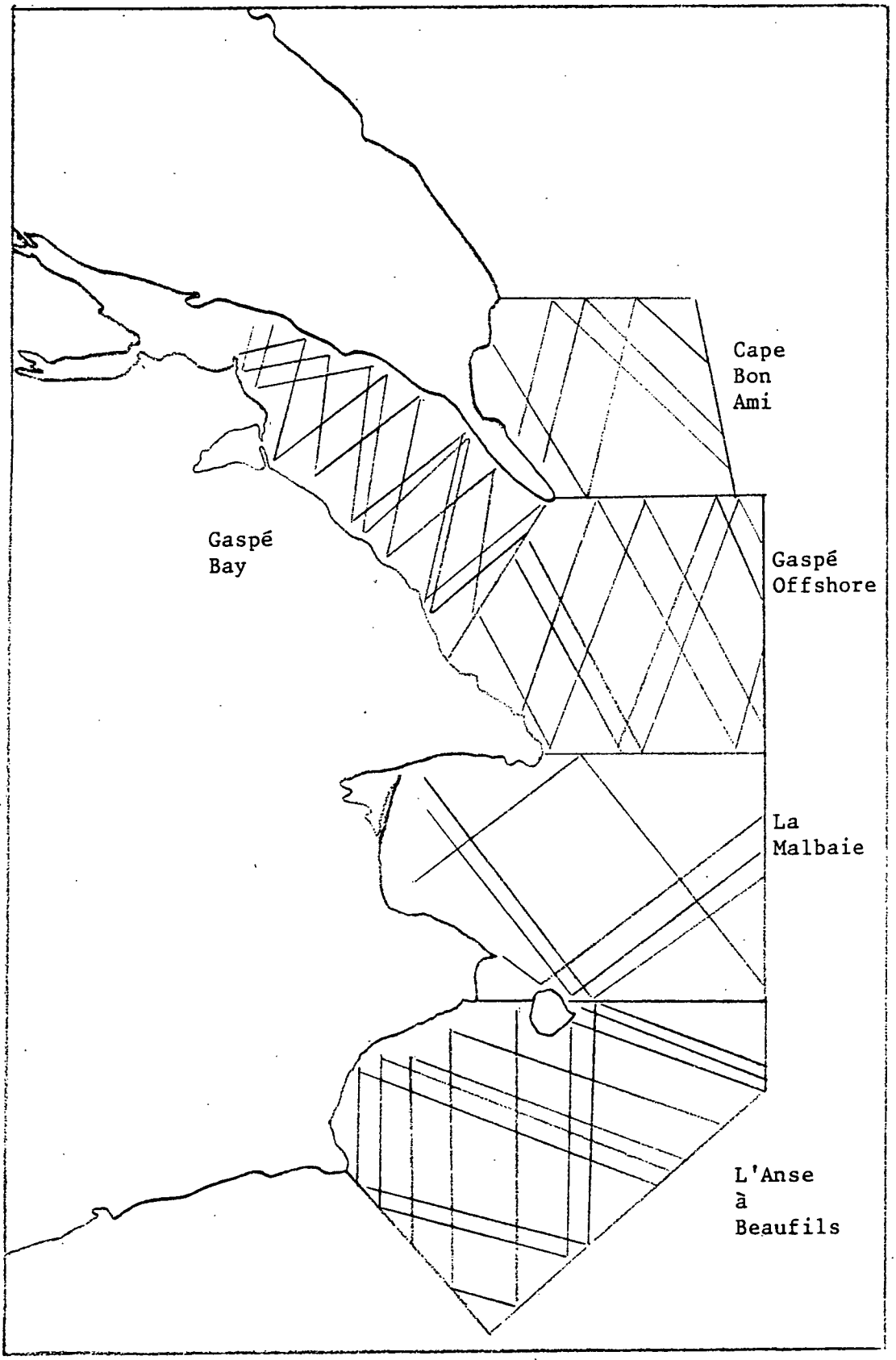


Figure 1 a) Location of strata and transects surveyed in November-December 1986: strata in Gaspé area.

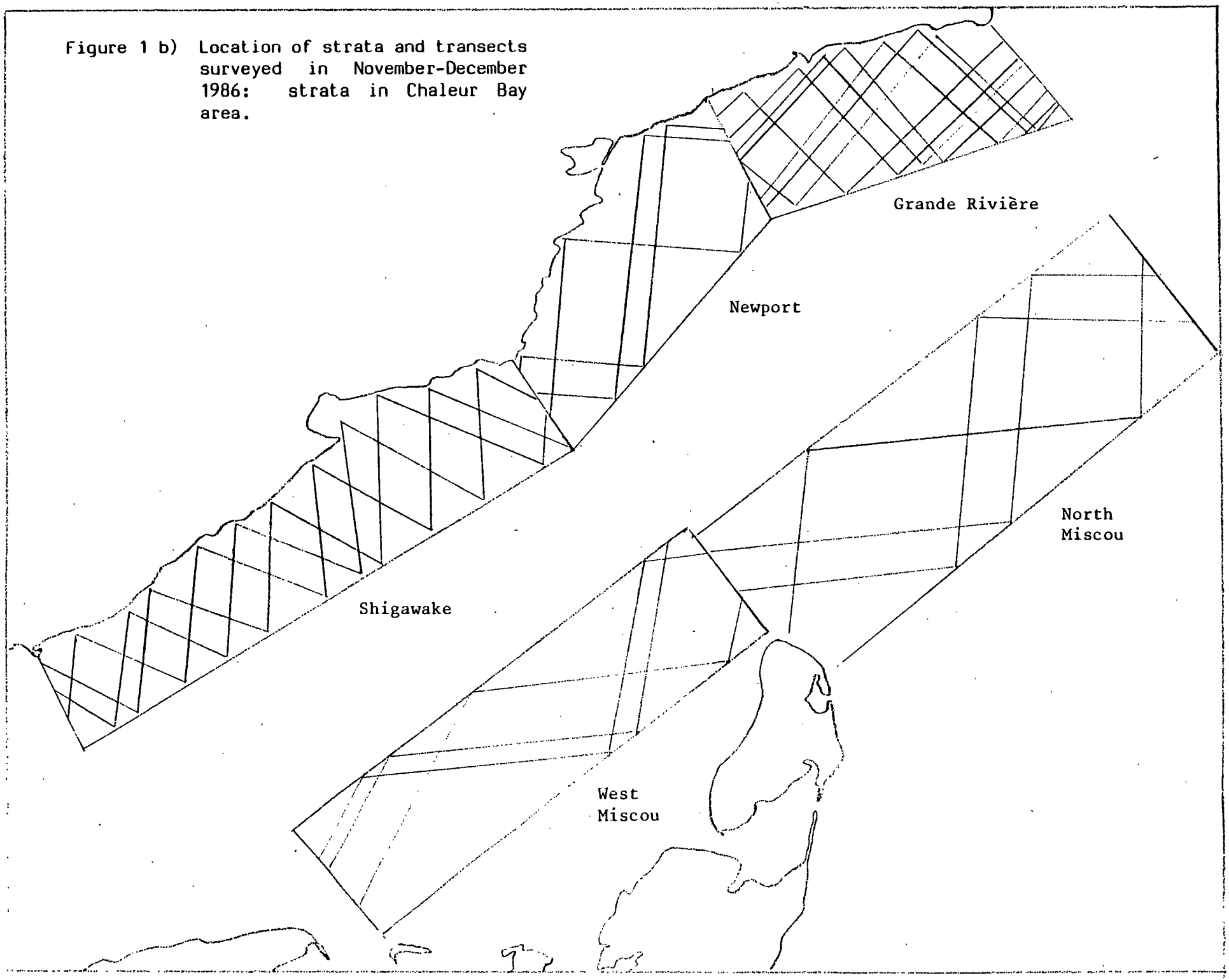


Figure 1 b) Location of strata and transects surveyed in November-December 1986: strata in Chaleur Bay area.

Figure 1 c) Location of strata and transects surveyed in November-December 1986: East Miscou stratum.

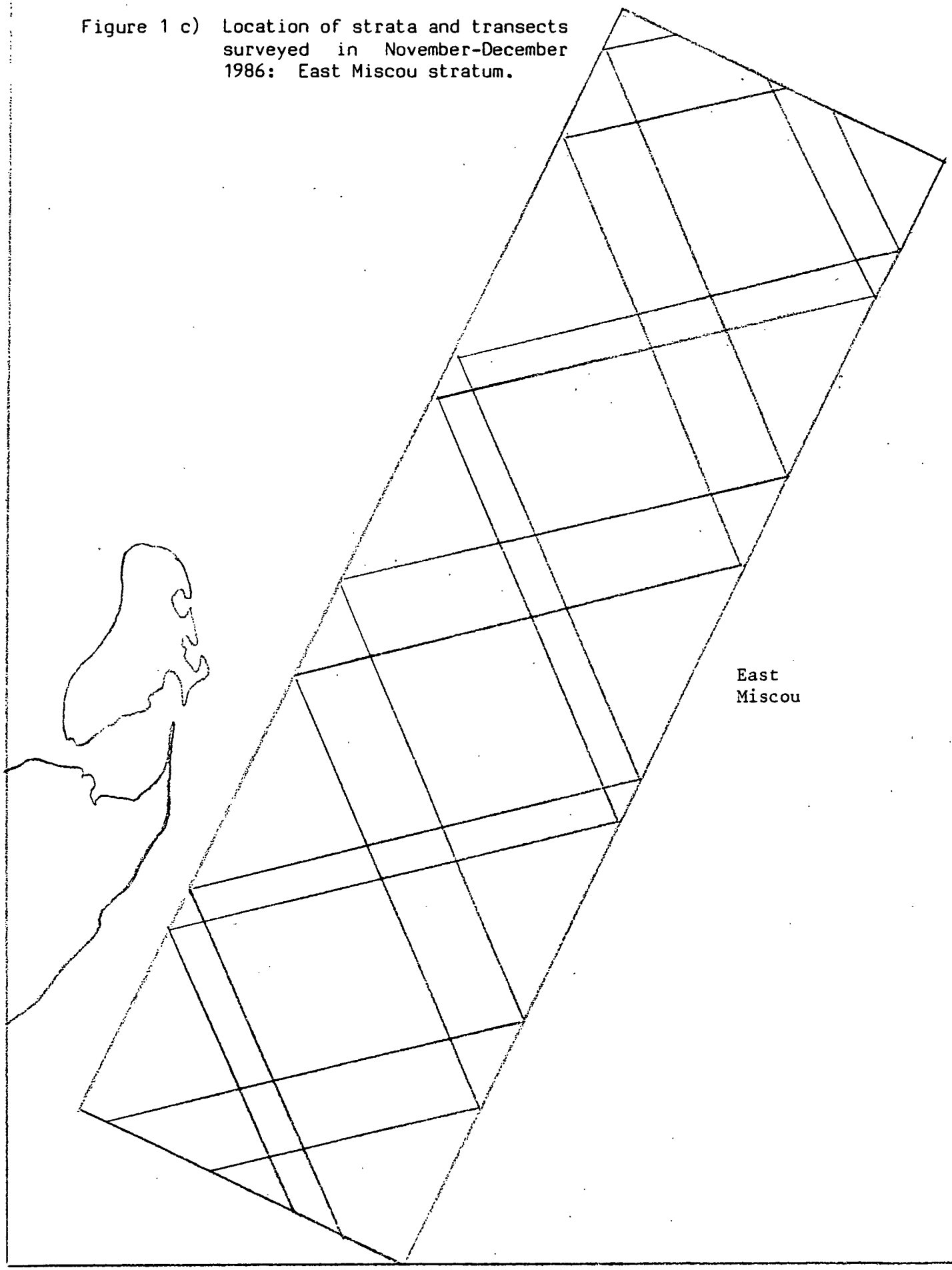


Figure 1 d) Location of strata and transects surveyed in November-December 1986: strata in P.E.I. and Cape Breton area.

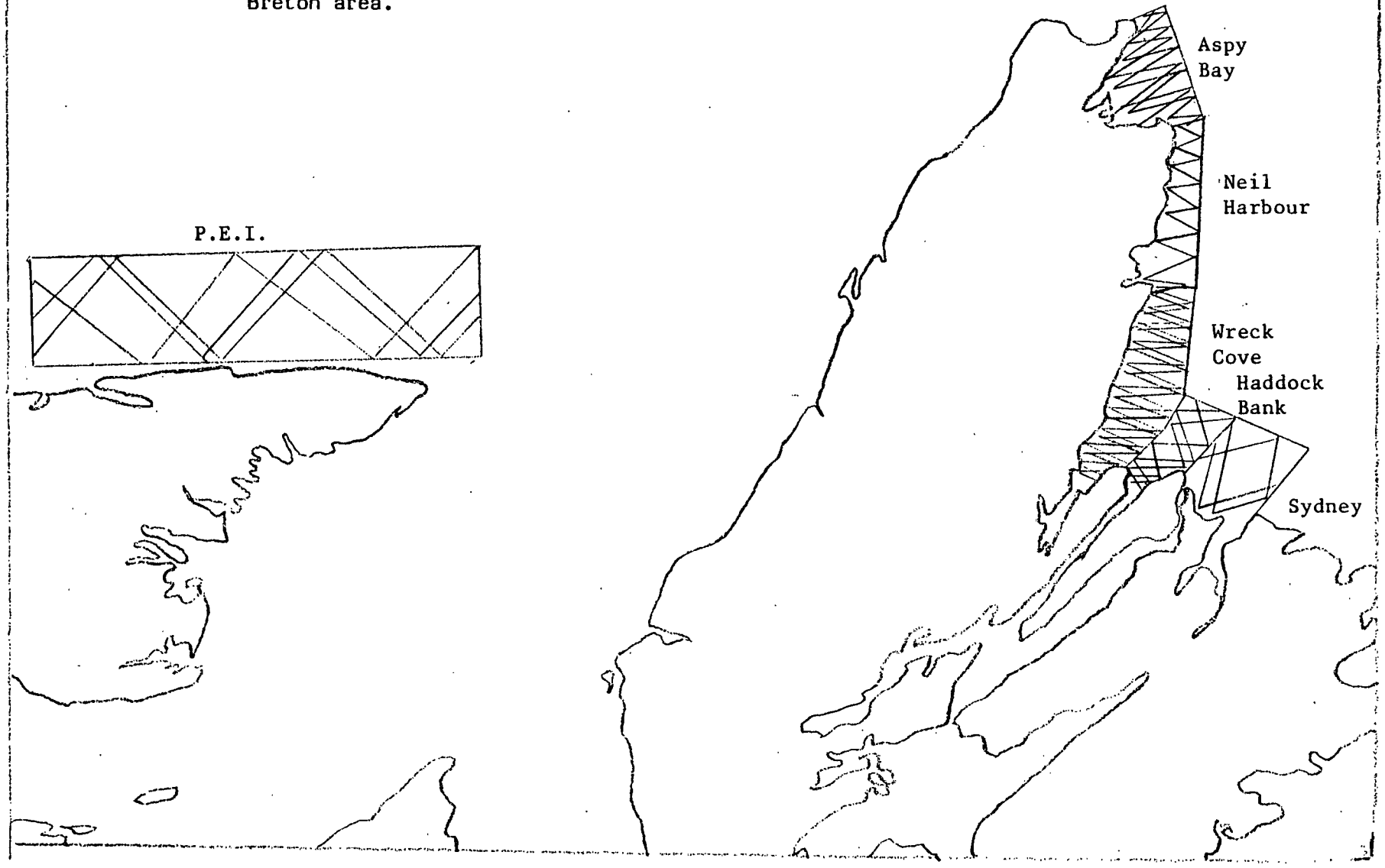
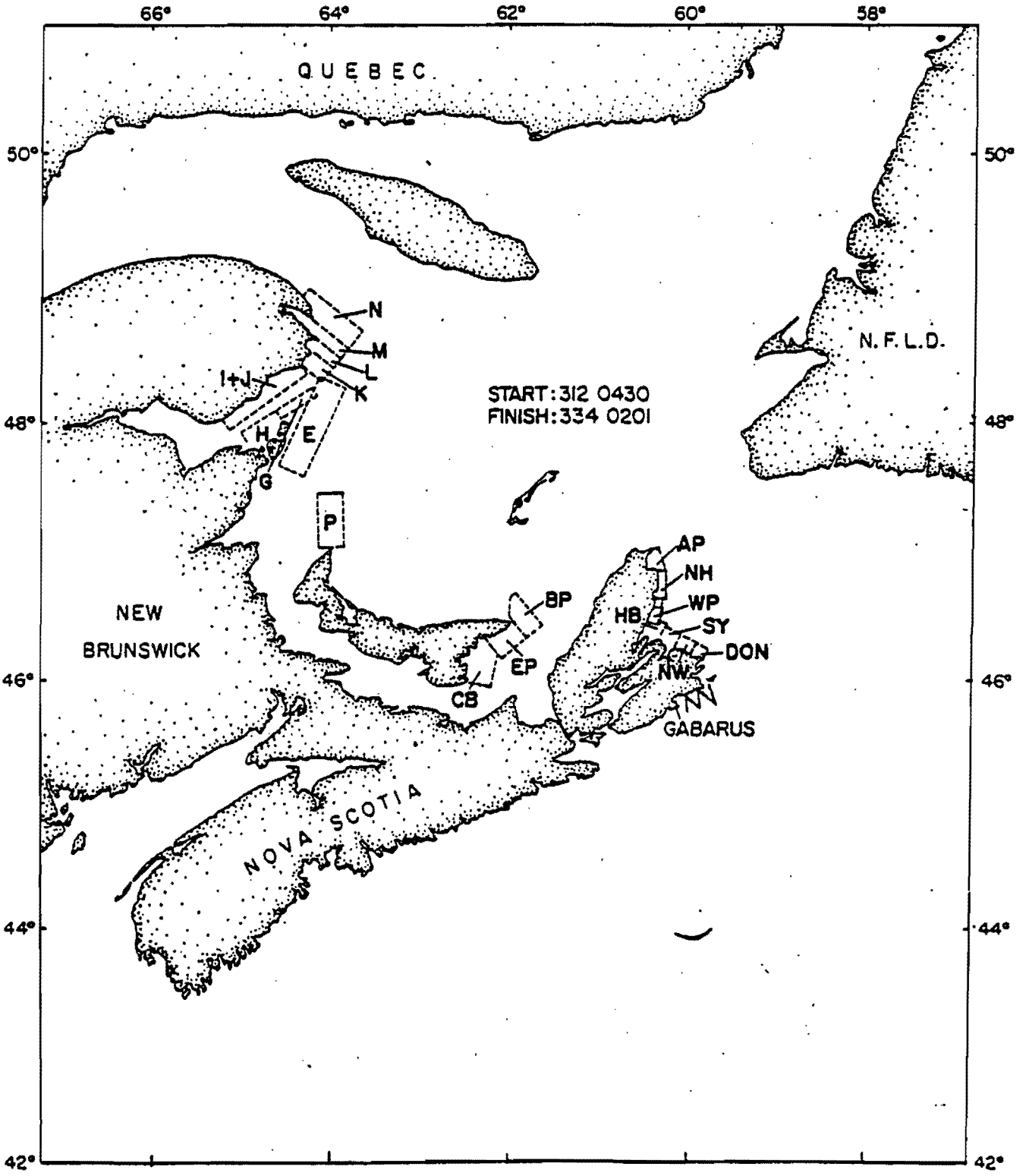


Figure 2

Areas Surveyed during November 1985



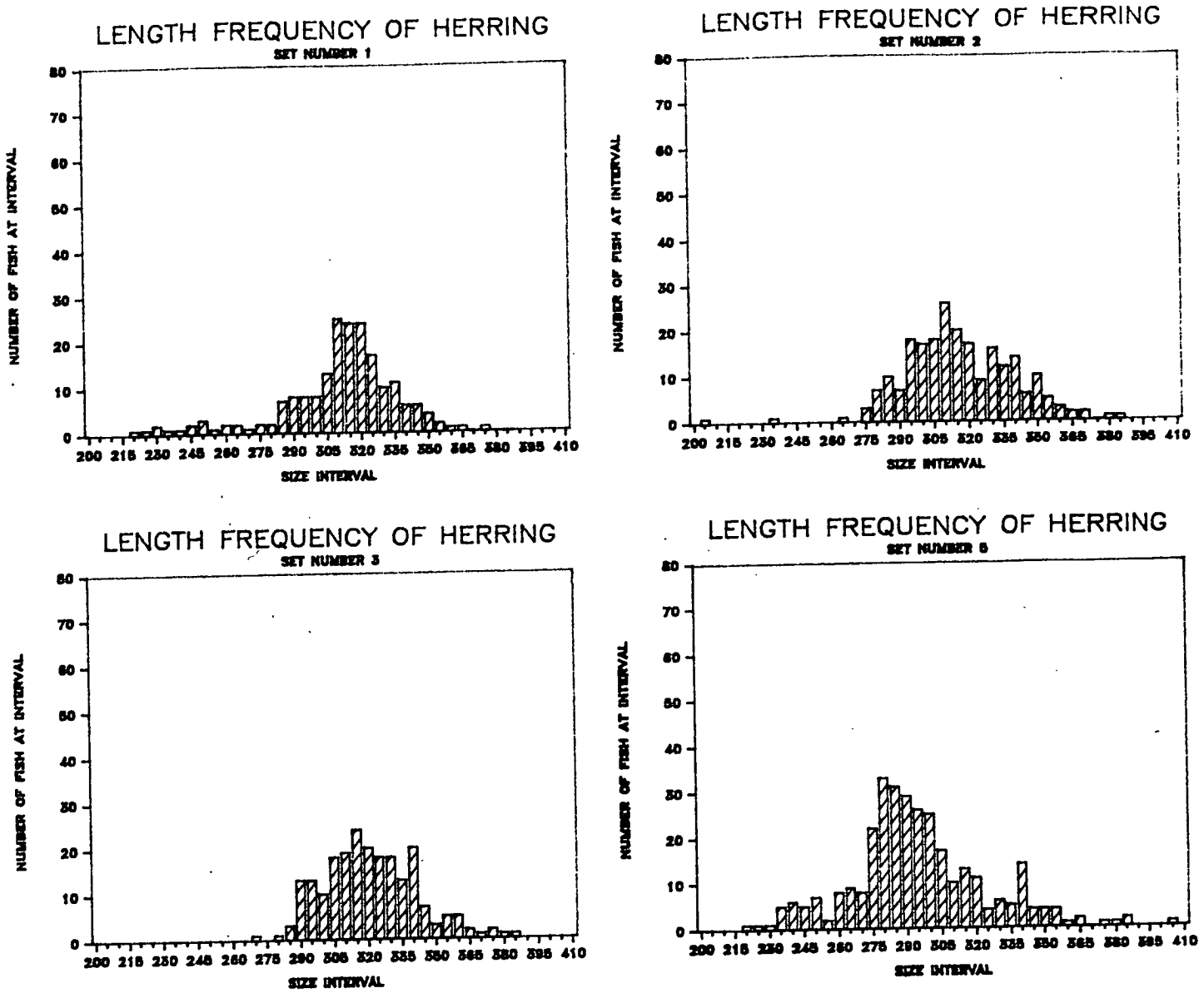


Fig. 3: Length frequency of herring captured by trawl during the acoustic survey, November 1986. Lengths are in mm.

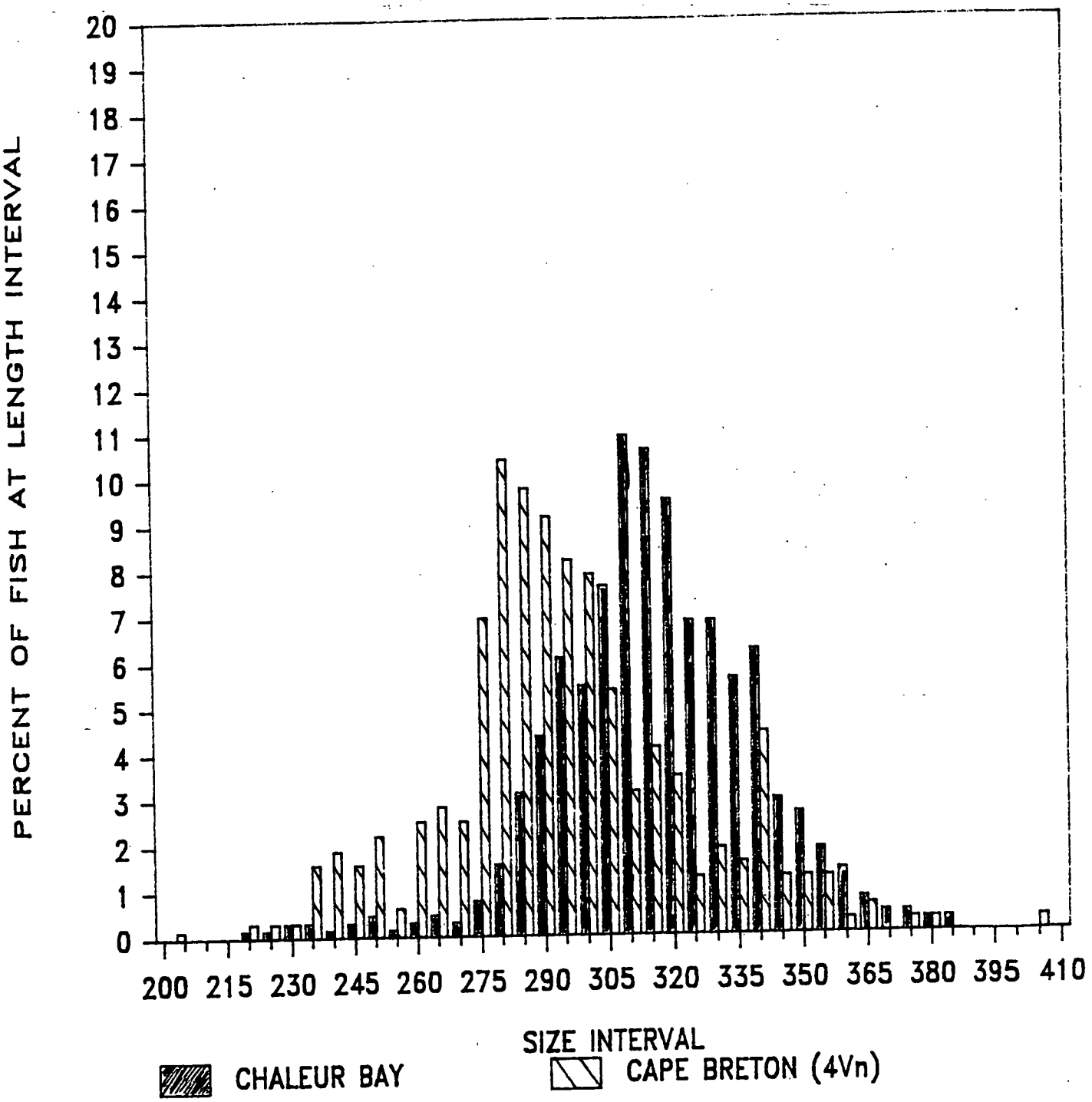


Fig. 4: Length frequency distributions of herring captured by trawl in Chaleur Bay compared to those captured off Cape Breton during the acoustic survey. November 1986. Lengths are in mm.

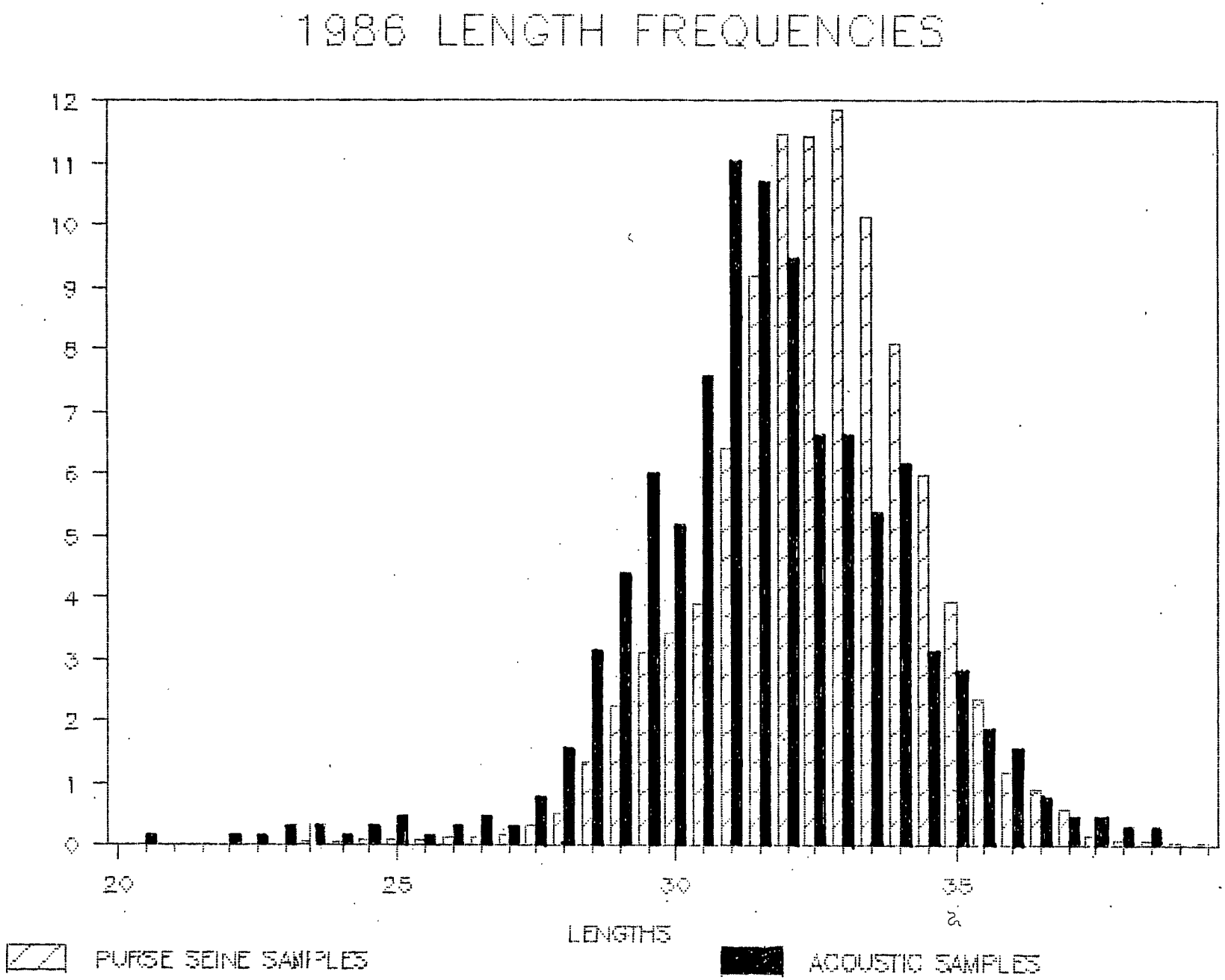


Fig. 5: Chaleur Bay 1986, length frequency distributions of herring caught by trawl during the acoustic survey (November) compared to samples collected from the purse seine fishery (October). Lengths are in centimeters.