Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Research Document 87/63

Comité scientifique consultatif des
pêches canadiennes dans d'Atlantique

CSCPCA Document de recherche 87/63

Results of an Acoustic Survey of Herring in the Southern Gulf of St. Lawrence and Sydney Bight, November 1984

by

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Abstract

Results are presented from the first quantitative acoustic survey of herring in (1) the Gaspe - Baie de Chaleur area, (2) about Cape Breton Island, and (3) along the southwestern coast of Newfoundland, in November 1984. In the Baie de Chaleur area, most herring were found close to the shore, especially between Grande Riviere and Cap d'Espoir. Concentrations of schools were also found about Cap de Gaspe, and north and northwest of Miscou Island. No herring were located in the area surveyed about Newfoundland. Scattered small schools were located along the west coast of Cape Breton Island, between MacKenzie Pt and Lowland Cove. In Sydney Bight a large concentration of herring schools was located between Neil Harbor and Ingonish Bay, and a lesser amount along the southern coast of the Bight in the Sydney-New Waterford area.

If the backscattering cross section/weight relations of Halldorson and Reynisson (1983) and Edwards and Armstrong (1983) and are used, the survey results are as follows:

Area	Total Area Scatter	Halldorson and Reynisson (1983)	Edwards and Armstrong (1983)
	(sr^{-1})	(t)	(t)
Baie de Chaleur	28 700	132 000	95 000
West Coast, Cape Breton Island	10 900	49 300	35 300
Sydney Bight	22 600	102 000	73 100

Résumé

On présente les résultats de la première prospection acoustique quantitative du hareng effectuée en novembre 1984 1) dans la région de Gaspé - Baie des Chaleurs, 2) aux environs de l'Île-du-Cap-Breton, et 3) le long de la côte sud-ouest de Terre-Neuve. Dans la région de la Baie des Chaleurs, on a constaté que la plus forte concentration de harengs se trouvait près de la côte, surtout entre Grande Rivière et Cap d'Espoir. On a également constaté des concentrations de bancs près du cap de Gaspé ainsi qu'au nord et au nord-ouest de l'Île Miscou. Aucun hareng n'a été repéré dans le secteur prospecté près de Terre-Neuve. Des petits bancs éparpillés ont été repérés le long de la côte ouest de l'Île du Cap-Breton, entre la pointe MacKenzie et l'anse Lowland. Dans Sydney Bight, une forte concentration de bancs de harengs a été repérée, entre Neils Harbour et la baie Ingonish, et un volume moins important le long de la côte sud de Sydney Bight, dans la région de Sydney - New Waterford.

Si on utilise les rapports section efficace/pondération de rétrodiffusion de Halldorson et Reynisson (1983) et d'Edwards et Armstrong (1983), les résultats de la prospection s'établissent comme suit

Région	Diffusion totale	Halldorson et Reynisson (1983)	Edwards et Armstrong (1983)
	(sr^{-1})	(t)	(t)
Baie de Chaleur	28 700	132 000	95 000
Côte ouest de l'Île du Cap-Breton	10 900	49 300	35 300
Sydney Bight	22 600	102 000	73 100

1. Introduction

In 1984 cruise time became available in November on the R.T. Alfred Needler. This opportunity was used to survey the herring stocks in the southern Gulf of St. Lawrence, southwest Newfoundland and Cape Breton Island areas. Although it was expected that November would be a good time to survey stocks in Aspy Bay, little was certain about the availability and distribution of herring about the southwestern area of Newfoundland, the Gaspe-Baie de Chaleur area and the other parts of Sydney Bight at that time. Thus the survey was designed primarily to search for herring schools to determine if the herring stocks in these areas might be good candidates for an ongoing acoustic assessment program. The design of the survey was primarily exploratory, i.e., in most areas a continuous zig-zag design was used. However, in the Sydney Bight, sufficient time was available to allow replication of sampling effort in some areas.

2. Survey Area and Survey Times

Figure 1 shows the areas that were surveyed in the Gulf of St. Lawrence, Cabot Strait and Sydney Bight areas. Figures 2-11 show the locations of most of

the survey transects. The dates during which the areas were surveyed are as follows:

	November
Baie de Chaleur - Gaspe	7 - 14
Cape Breton Island	14 - 21
Southwestern Newfoundland	22 - 25
Sydney Bight	25 - 27

Times of surveying are listed in Table 1.

Not all of the survey data has been used to estimate herring abundance. Many transects were not "randomized" with respect to herring schools but were done to obtain acoustic measurements of herring schools and to confirm the locations of herring school concentrations .

3. Sampling Methods

3.1 Acoustic System

Acoustic data were collected using the ECOLOG system. Echo data were collected on the transducer's narrow and wide beam arrays. Only data from the narrow beam are used in this analysis. Relevant details of the ECOLOG system are described by Shotton and Randall (1982). The system was run with a pulse rate of 125/s, pulse width of 0.4 ms, and echo sample frequency of 10 kHz. The equivalent beam angle of the narrow beam is 0.00640 sr. Transmitted power was approximately 5 kW. Ship speed along transects was 8 knots. The source level and the receiver sensitivity of the system had been calibrated at the acoustic barge in Bedford Basin (Dowd, pers. comm.) and by relative measurements with a standard target (a copper sphere).

3.2 Calculation of the Area Backscattering Coefficient and Herring Biomass

The volume backscattering coefficients were calculated using the conventional acoustic integration model (Forbes and Nakken 1972). The problems of determining an appropriate value for the backscattering cross section per tonne of herring are well known and are discussed by several workers (e.g., Shotton 1985, Buerkle 1985). Two models for the backscattering cross section per kg are used here to indicate a range in possible estimates:

(1) Halldorson and Reynisson (1983)

$$TS_{kg} = -10.9 \log L - 20.9 \text{ dB (All TS are ref a sphere 2m radius)}$$

or $$\sigma_{b/kg} = 10^{-2.09} L^{-1.09} m^2 sr^{-1} \quad (1)$$

(2) Edwards and Armstrong (1983)

$$TS_{kg} = -17.09 \log L - 10.6 \text{ dB}$$

or $$\sigma_{b/kg} = 10^{-1.06} L^{-1.709} m^2 sr^{-1} \quad (2)$$

Two separate estimates of $\sigma_{b/kg}$ have been calculated, one based on the herring length frequency data for those fish caught in the Gaspe-Baie de Chaleur area, and the other based on the herring length measurements from the fish caught in the Sydney Bight area. These data are summarized in Table 2. The herring length frequencies are shown in Figure 13. The mean value was obtained using

$$\bar{\sigma}_{b/kg} = \frac{1}{n} \sum_{i=1}^{n} 10^{a} L_i^{b}$$

where n = total number of herring observed in each area, i.e., all length measurements from all trawl catches in the respective areas were pooled,

L_i = length of the i^{th} herring.
a,b = regression coefficients from fitting (1) and (2).

With (1), the relation of Halldorson and Reynisson (1983) gives:

Gaspe-Baie de Chaleur	$\bar{\sigma}_{b/t} = 0.2181\ m^2 sr^{-1} t^{-1}$
Sydney Bight	$\bar{\sigma}_{b/t} = 0.2215\ m^2 sr^{-1} t^{-1}$.

With (2), the relation of Edwards and Armstrong (1983) gives:

Gaspe-Baie de Chaleur	$\sigma_{b/t} = 0.3024\ m^2 sr^{-1} t^{-1}$
Sydney Bight	$\sigma_{b/t} = 0.3093\ m^2 sr^{-1} t^{-1}$

Herring length data are given in Table 2. The grand mean length for the Gaspe-Baie de Chaleur area was 28.0 cm; for the Sydney Bight area, 27.7 cm.

4. Regional Estimates of Herring Abundance

4.1 Gaspe-Baie de Chaleur

Two estimates of herring abundance have been made for the Baie de Chaleur, one estimate is based on a large scale zig-zag design (Figure 2) and the other on a small scale zig-zag design (Figure 4). The estimates are surprisingly close (See Table 3), the second "inshore" estimate being 77% of that determined from the complete coverage of the Bay. The estimate of the area scatter for the Baie de Chaleur-Gaspe area has been obtained from:

(1) The mean of the two estimates from the Baie de Chaleur (Figures 2 and 4) plus,

(2) The Miscou Island area (Figure 5, shaded area), plus (3) Cap de Gaspe (Figure 3, shaded area).

The results of the estimates are as follows:

	Halldorson and Reynisson (1983) (t)	Edwards and Armstrong (1983) (t)
Baie de Chaleur (mean)	40 300	29 200
Miscou Is.	49 400	35 600
Cap de Gaspe	41 800	30 200
	131 500	95 000

4.2 Sydney Bight

The Sydney Bight area estimate has been taken as

(1) The Cape Egmont-Ingonish estimate (Figure 11) (based on only the first transect estimate, i.e., northwest of Pt Aconi), plus

(2) the mean of the estimates of the two transects along the southern coast of the Bight i.e., southeast of Pt Aconi.

The results of these estimates are as follows:

	Halldorson and Reynisson (1983) (t)	Edwards and Armstrong (1983) (t)
West Cape Breton Is.	49 300	35 300
Sydney Bight	102 000	73 100

Judgement has been used in selecting the biomass estimate for Sydney Bight. No herring were encountered in the Aspy Bay stratum or along the western coast of the Bight, south of Cape Smokey. The design of the transects in the Cape Egmont-Cape Smokey area was considered good. Four consecutive transects were sampled whose positions were randomized within the stratum area (see Figure 11). However, it appears that the herring were leaving the survey area as it was surveyed as there was a progressive decline in the estimate of the total area scatter for the stratum with each successive transect (see Cape Egmont-Ingonish estimate, Table 3), or at least the herring were becoming "invisible" to the acoustic system. The results for the four consecutive transects can be summarized as follows:

Transect	Start	Stop	t (mins)	No. of Schools	$s_{v/a}$ (sr^{-1})
1	0723	0929	126	96	10 830
2	1003	1214	127	88	4 736
3	1443	1618	94	27	4 106
4	1624	1824	118	0	0

As the schools appear to have been leaving the stratum while the survey was in progress, the result given by the first transect only should give the least biased population estimate. Estimation of precision from the four sample values, in this case, is meaningless.

Judgment has also been used in obtaining an estimate for the southern Sydney Bight area. Herring schools were encountered on 2 transects which did not cover exactly the same area. Thus two estimates were derived based on two survey strata with one transect each. These two transects gave radically different results, the result from transect 1 was 4% of the first transect's result! Here I have elected to use the simple average as I believe these results do reflect the sampling variability in this area.

4. Discussion

As this was the first acoustic survey in this region during a November, considerable uncertainty existed as to where herring schools might be located and the nature of their distribution. It was for this reason that emphasis was placed on a survey of an exploratory nature, rather than one in which transects were rigorously randomized and replicated.

In the Gaspe-Baie de Chaleur area, herring were located off Cap de Gaspe, along the shore of the Baie de Chaleur, particularly about Newport, and to the west, north and sorthwest of Miscou Island. This pattern of herring distribution occurred again in 1985 with the exception that no herring were located about Cap de Gaspe. Herring were located on both the west coast, and the east coast of the northern part of Cape Breton Island. No schools were located in Aspy Bay in 1984 despite a fishery having been reported there in earlier years. Herring were found in the New Waterford-Glace Bay area, in approximately the same position in which they were found in 1985.

With the exception of one area (Neil Harbor-Cape Smokey), the herring schools did not appear to be particularly mobile, so we have reasonable confidence that replicated transects, at least over a short period (48 hr), sampled the same population. This is not the case for the herring schools that were encountered between Cape Egmont (Neil Harbor) and Cape Smokey (Ingonish). When this area was surveyed on 25 November between 2354 and 0710 on 26 November only 2 schools were encountered (see parallel transects, Figure 10). When the area was resurveyed, immediately afterward, from 0723 to 0929, 96 schools were encountered; by the time of a fourth transect in the early evening (1624-1824) no schools could be located. Experience from the 1985 survey indicates that on the night of November 25, the herring may have been very close inshore, relative to the parallel transects that were run. However, if this was the case the following

night, some schools should have been located at the shore end of the zig-zag transects. The possibility of high mobility of schools into and out of a survey area raises the possibility of bias in population estimates if the population being surveyed changes during the period that transects are run. At present no further speculation is warranted about the importance of such a possible phenomenon.

The 1984 survey has been followed by a similar survey in 1985. The results of the 1985 survey were presented in Shotten (1986) and were reviewed at the May, 1986, CAFSAC assessment meetings.

5. Literature Cited

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Edwards, J. I. and F. Armstrong. 1983. Measurement of the target strength of live herring and mackerel. 69-77. In Nakken, O. and S. C. Venema (eds). Symposium on Fisheries Acoustics. Bergen, Norway, 21-24 June 1982. FAO Fish. Rep., (300):331p.

Forbes, S.T. and O. Nakken. 1972. Manual of methods for Fisheries Resource Survey and Appraisal. Part 2. Use of Acoustic Instruments for Fish Detection and Abundance Estimation. FAO Manuals in Fisheries Science. (5) FIRM/MF 138pp.

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Shotton, R. 1985. An analysis of the structure of herring Schools. Ph. D. Thesis. Dalhousie University, Nova Scotia. 427 pp.

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Table 1
Sampling Time.
The actual sampling time will be less than the difference between the start and finish times because of time for fishing, moving from one transect to the next, etc.

Area	Start	Finish	Sampling Time (mins)
	Day hr	Day hr	
Baie de Chaleur, Figure 1	312 : 1702	314 : 1053	1973
Cap de Gaspe, Figure 2	314 : 2240	315 : 0344	339
Baie de Chaleur, Figure 3	316 : 0142	316 : 2149	906
North East Miscou Is., Figure 4	316 : 2219	317 : 1911	1214
West Coast, Cape Breton Is., Figure 5	322 : 0156	322 : 1116	556
Sydney Bight, Figure 6	323 : 1020	325 : 0651	2306
Cape Egmont-Cape Smokey, Figure 11	331 : 0723	331 : 1824	465
Southern Sydney Bight, Figure 12	332 : 0037	332 : 1052	568

Table 2
Length Data of Herring Measured

Set	Location	Lat.	Long.	No. Measured		s.d.
		Baie de Chaleur				
2	Baie de Chaleur: Pte aux Loups Marins	48 03 49	64 58 57	124	30.3	1.9
5	Cap de Gaspe	48 46 73	64 08 72	9	25.7	1.4
9	West Miscou Is.	48 00 31	64 37 39	245	24.8	2.2
10	East Miscou Is.	47 59 89	64 20 85	102	28.4	3.3
11	N.E. Miscou Banks	48 10 19	64 02 80	64	27.1	2.1
12	Grande-Riviere	48 22 39	64 30 16	49	27.8	2.9
13	Baie de Chaleur: Pabos	48 20 98	64 33 51	199	29.6	2.4
15	Newport	48 16 04	64 42 87	188	28.9	1.9
16	Baie de Chaleur: Shigawake	48 04 52	65 03 24	26	31.3	1.7
		Sydney Bight				
18	New Waterford	46 16 91	60 04 00	20	29.3	3.2
23	Cape Egmont	46 50 07	60 17 61	6	27.0	2.8
24	Cape Egmont	46 50 38	60 17 63	202	26.7	3.5

Table 3

Estimates of Regional Summed Area Scattering Coefficients

Area	$s_{v/a}$	s_v (within school)	No. of Schools
Baie de Chaleur			
Figure 2	9 980	1.667×10^{-5}	31
Figure 4	7 670	4.017×10^{-5}	27
Miscou Is.			
Figure 5	10 800	4.098×10^{-5}	37
Cap de Gaspe			
Figure 3	9 130	2.554×10^{-5}	14
West Cape Breton Is.			
Figure 6	10 900	7.132×10^{-5}	70
Sydney Bight			
Figure 7	5 750	7.712×10^{-6}	54
Cape Egmont-Ingonish			
Figure 11			
*Transect 1	10 800	2.479×10^{-4}	96
1 + 2	7 780	1.782×10^{-4}	184
1 + 2 + 3	6 670	1.146×10^{-4}	211
1 + 2 + 3 + 4	5 000	1.146×10^{-4}	211
Southern Sydney Bight			
Figure 12			
Transect 1	22 600	1.1693×10^{-4}	22
Transect 2	887	5.208×10^{-5}	54
Mean	11 800	1.107×10^{-4}	76

* Value averaged over successive transects.

Figure 1

Area Surveyed during November 1984

Cruise N38

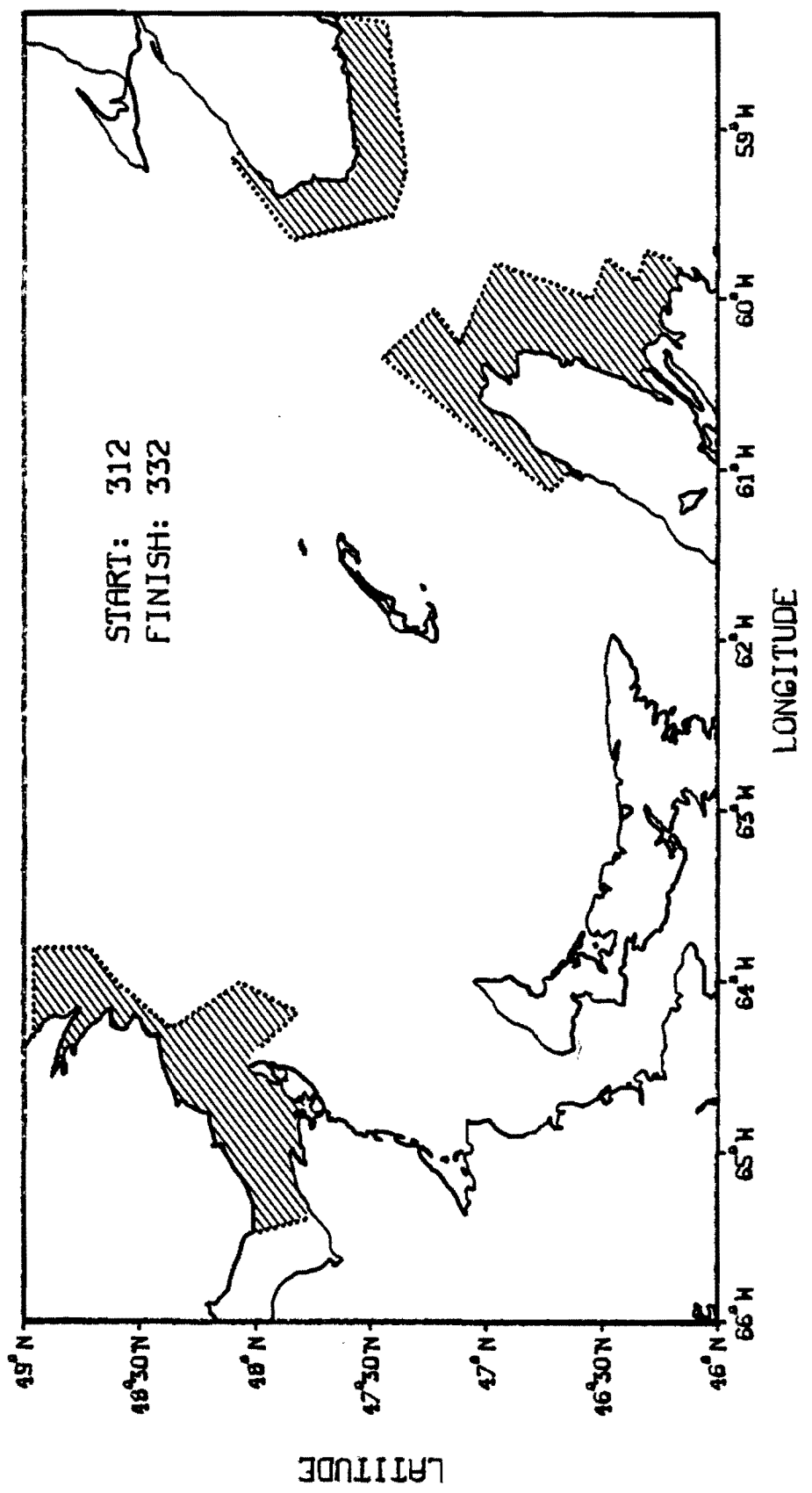


FIGURE 2

BAIE DE CHALEUR - MISCOU IS : 7-9 NOV.

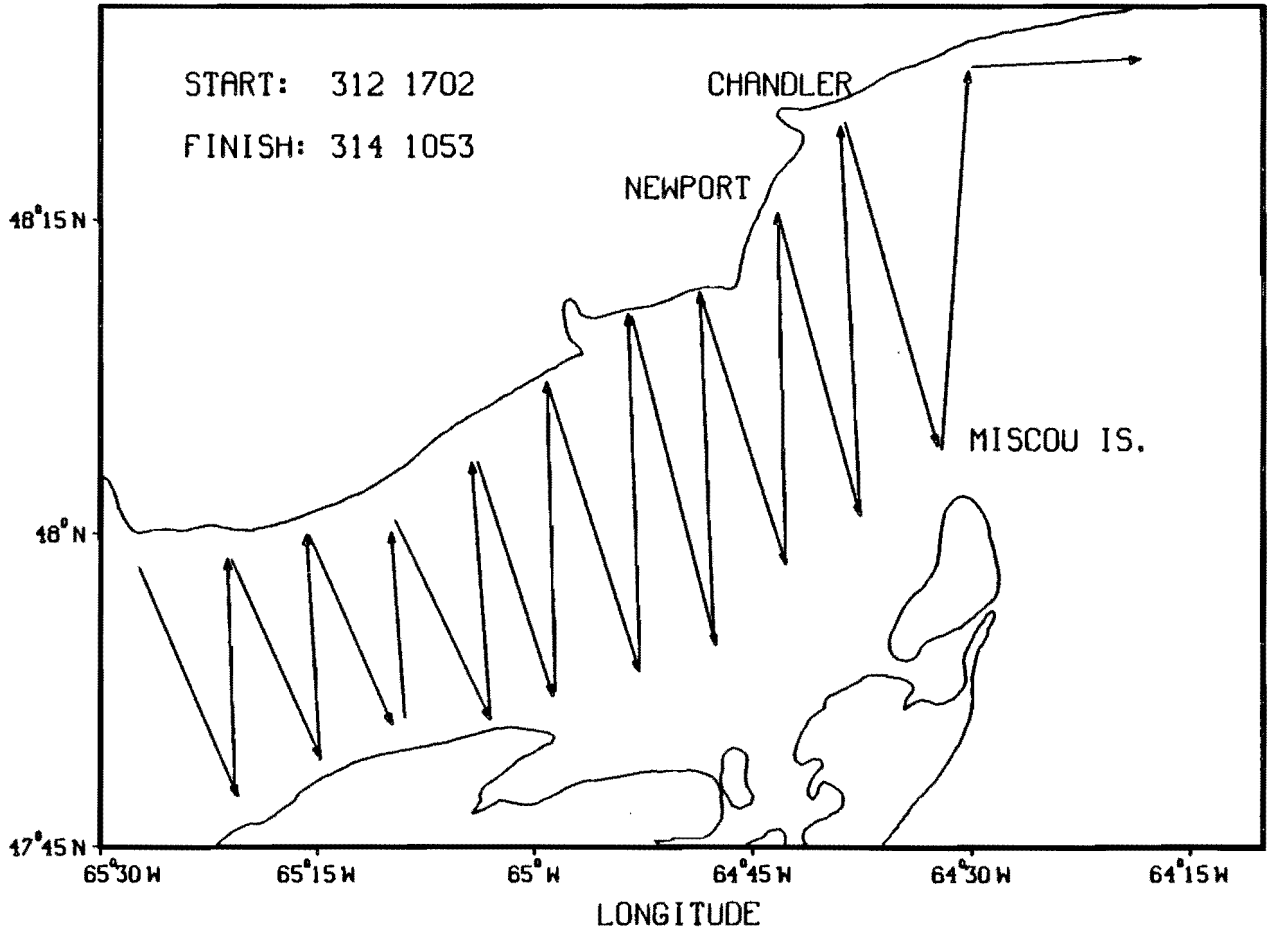


FIGURE 3

GASPE - ILE DE BONAVENTURE : 9-11 NOV.

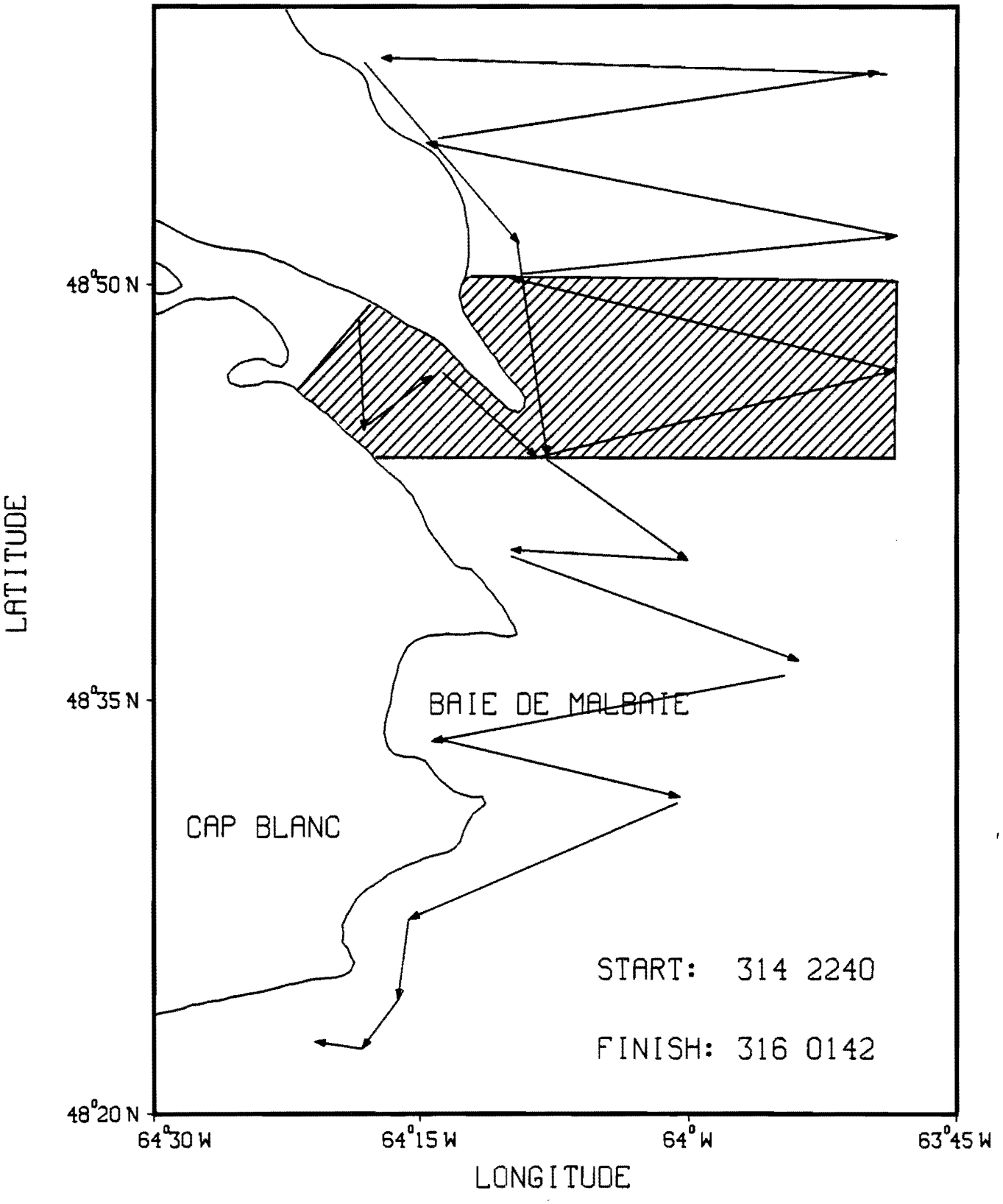


FIGURE 4

BAIE DE CHALEUR - MISCOU IS : 11 NOV.

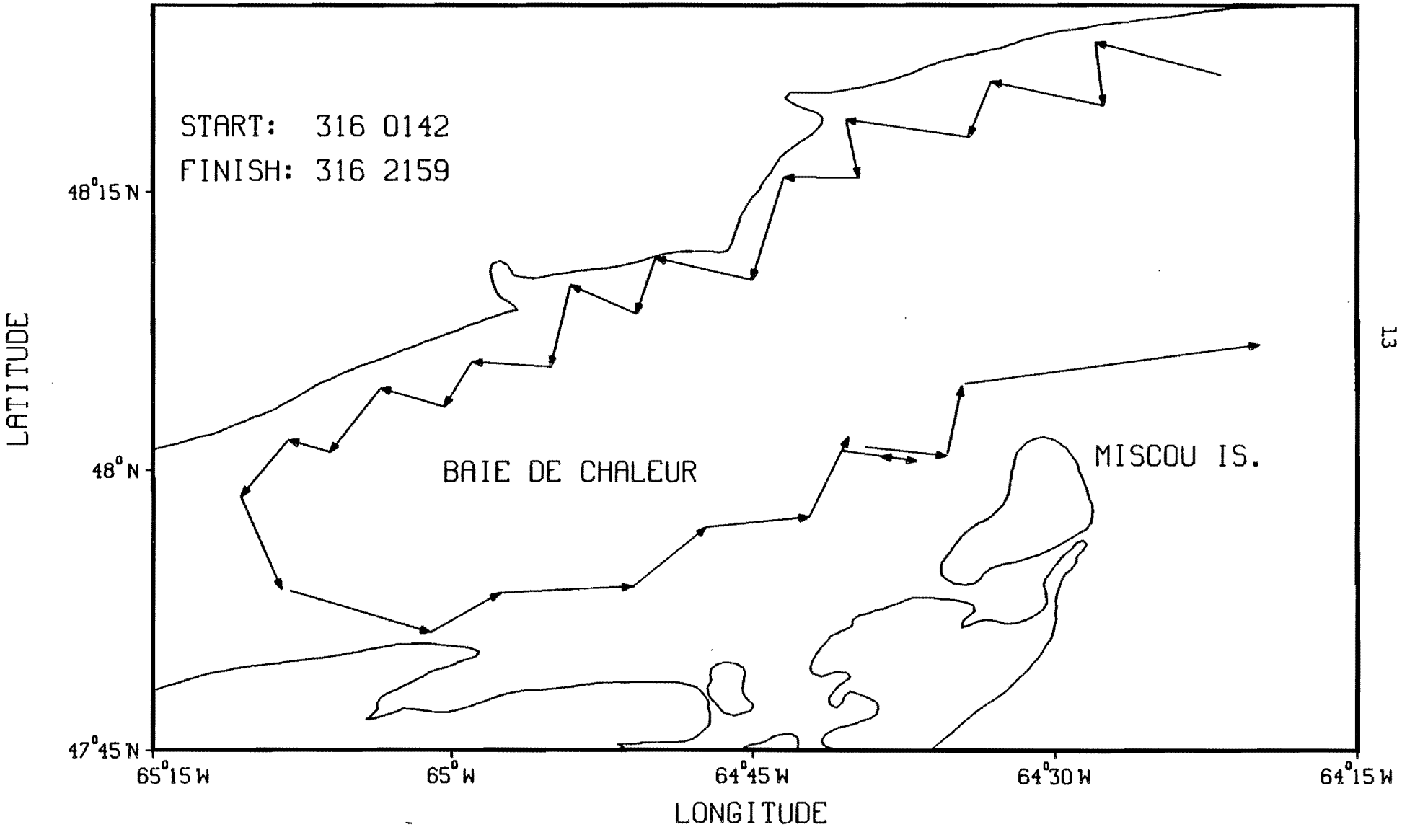


FIGURE 5

BAIE DE CHALEUR - MISCOU IS : 11-14 NOV.

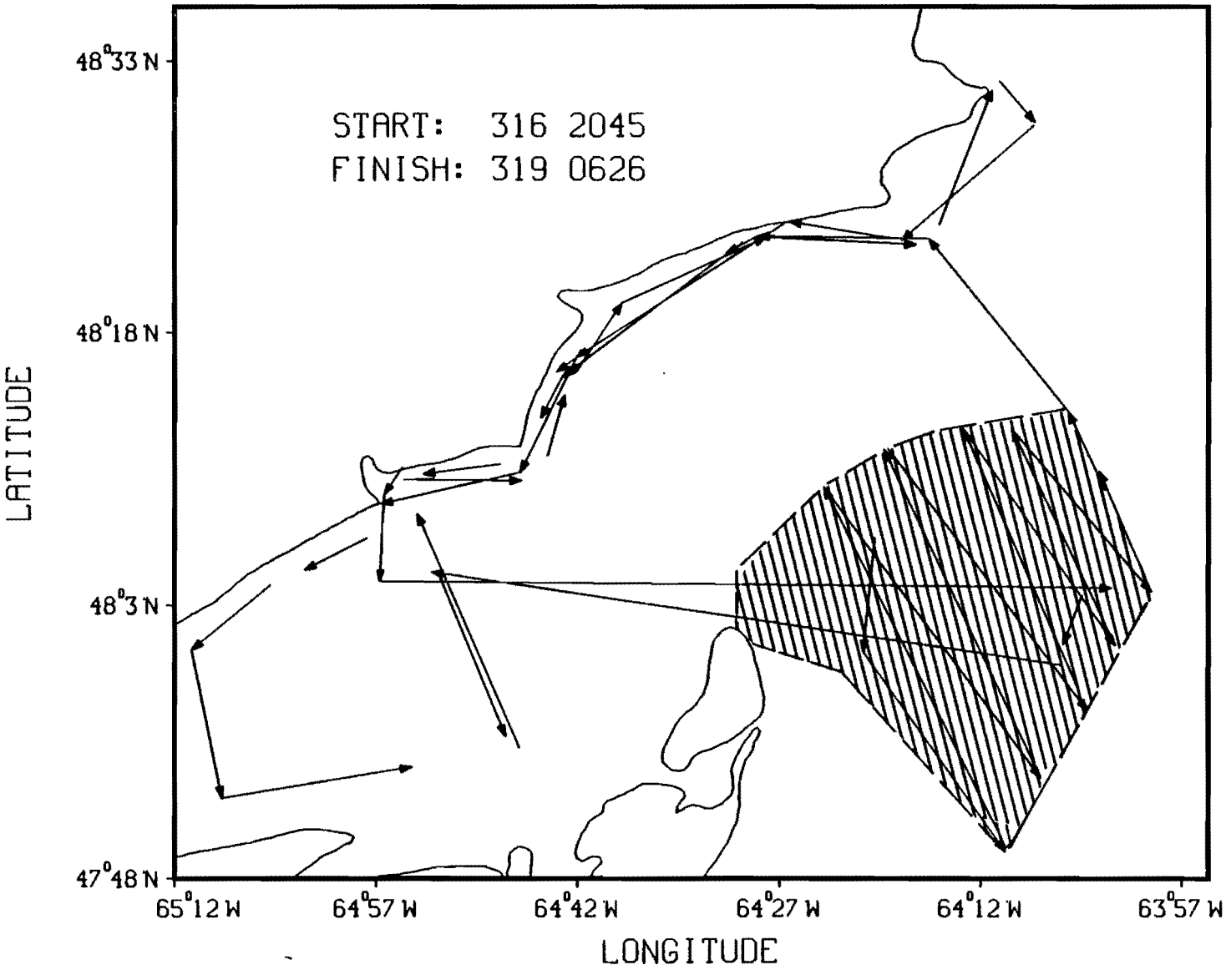


Figure 6

West Coast, Cape Breton Is.

CRUISE N38 : 17-18 NOV. 1984

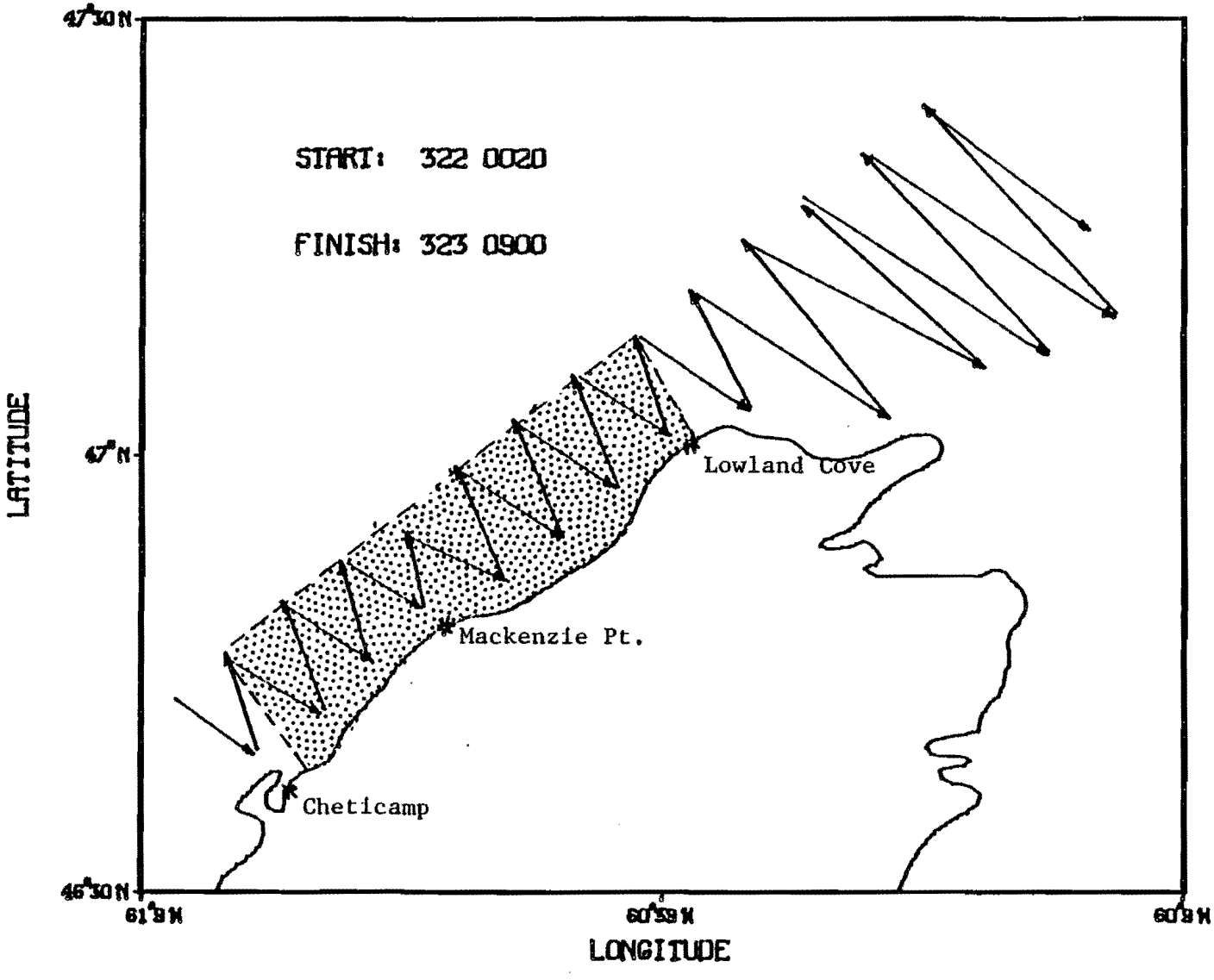


FIGURE 7

SYDNEY BIGHT : 18-21 NOV.

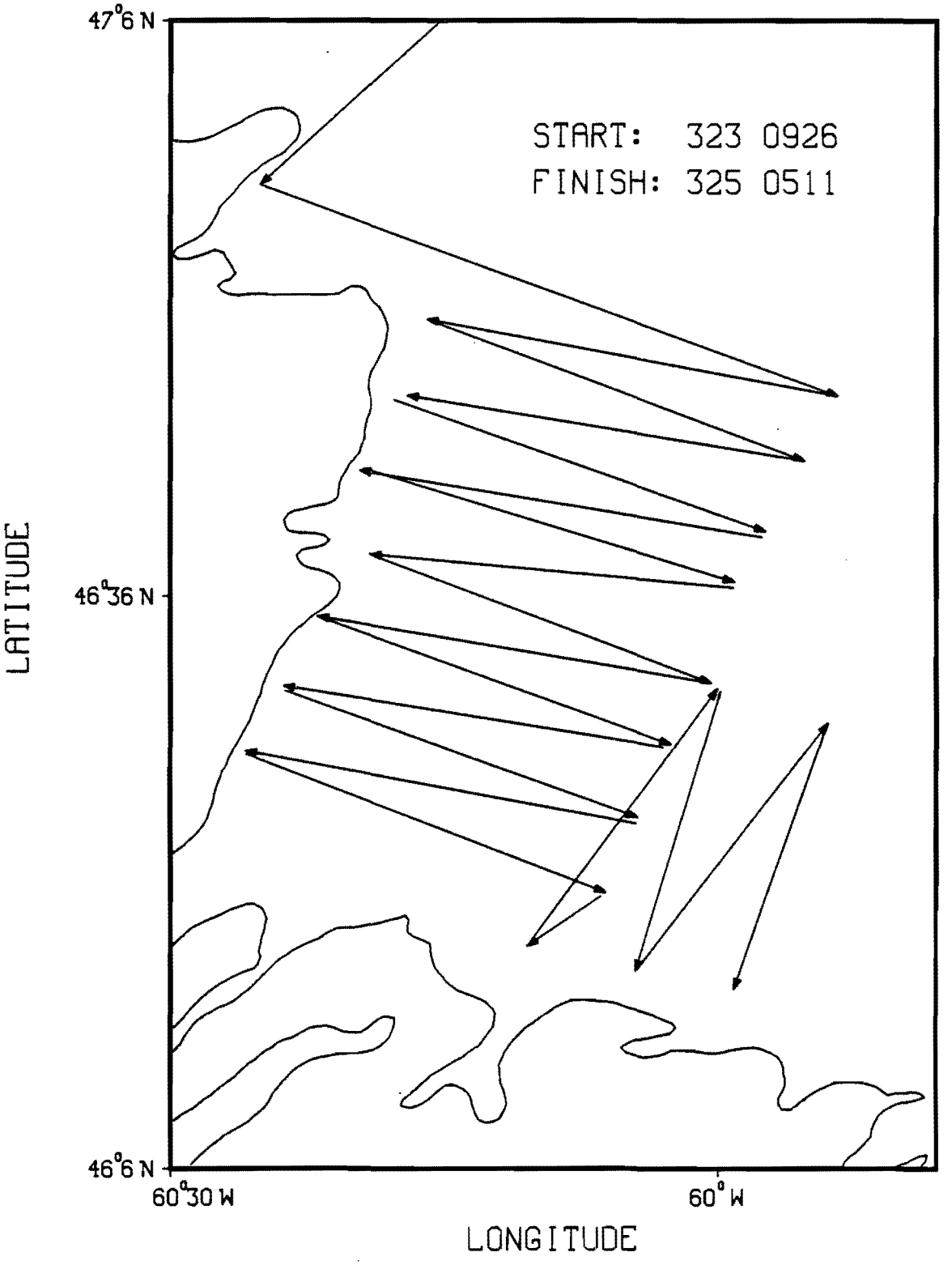


FIGURE 8

ASPY BAY - FLINT IS : 20-21 NOV.

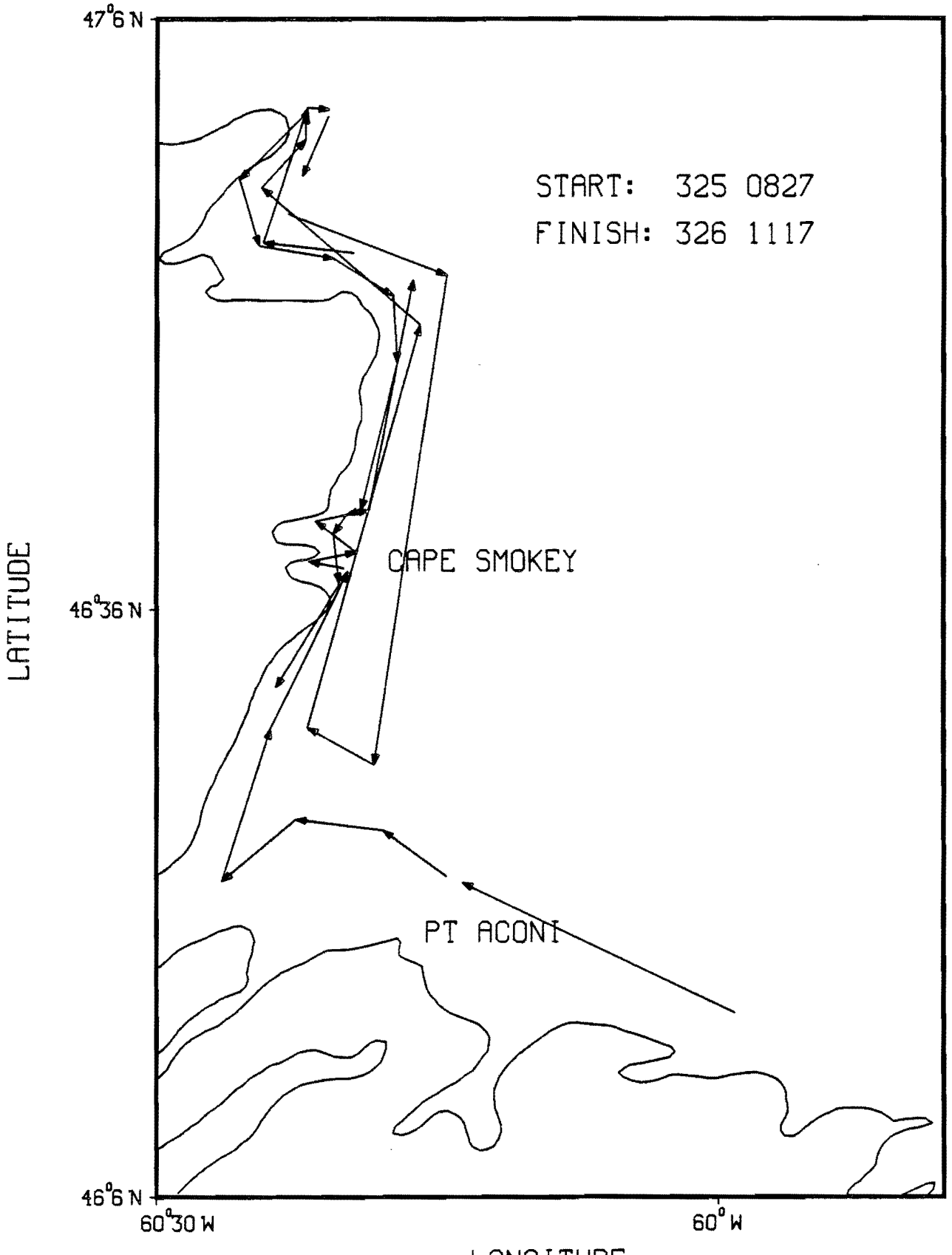


FIGURE 9

S.W. NEWFOUNDLAND 22-24 NOV.

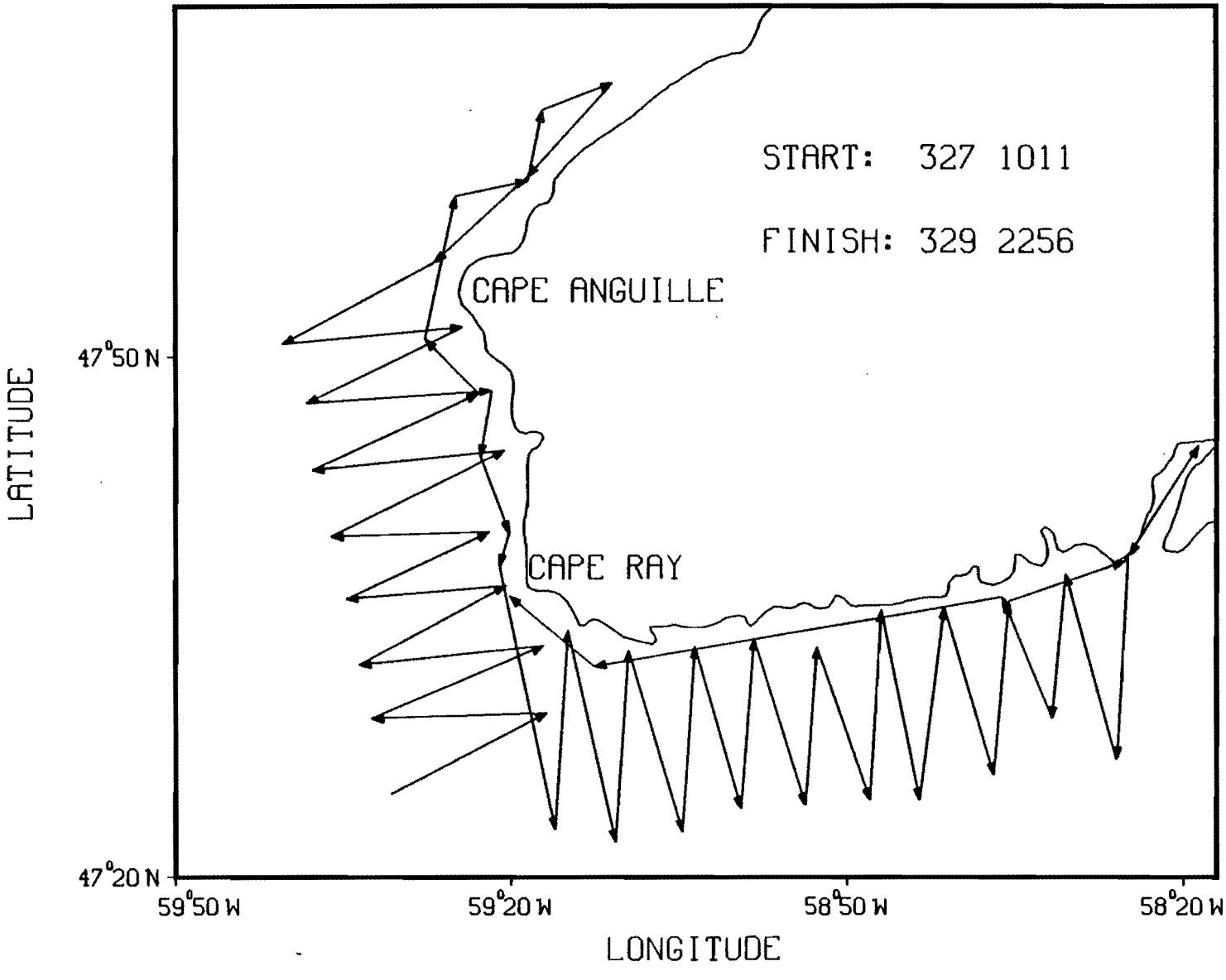


FIGURE 10

ASPY BAY - INGONISH : 25 - 26 NOV.

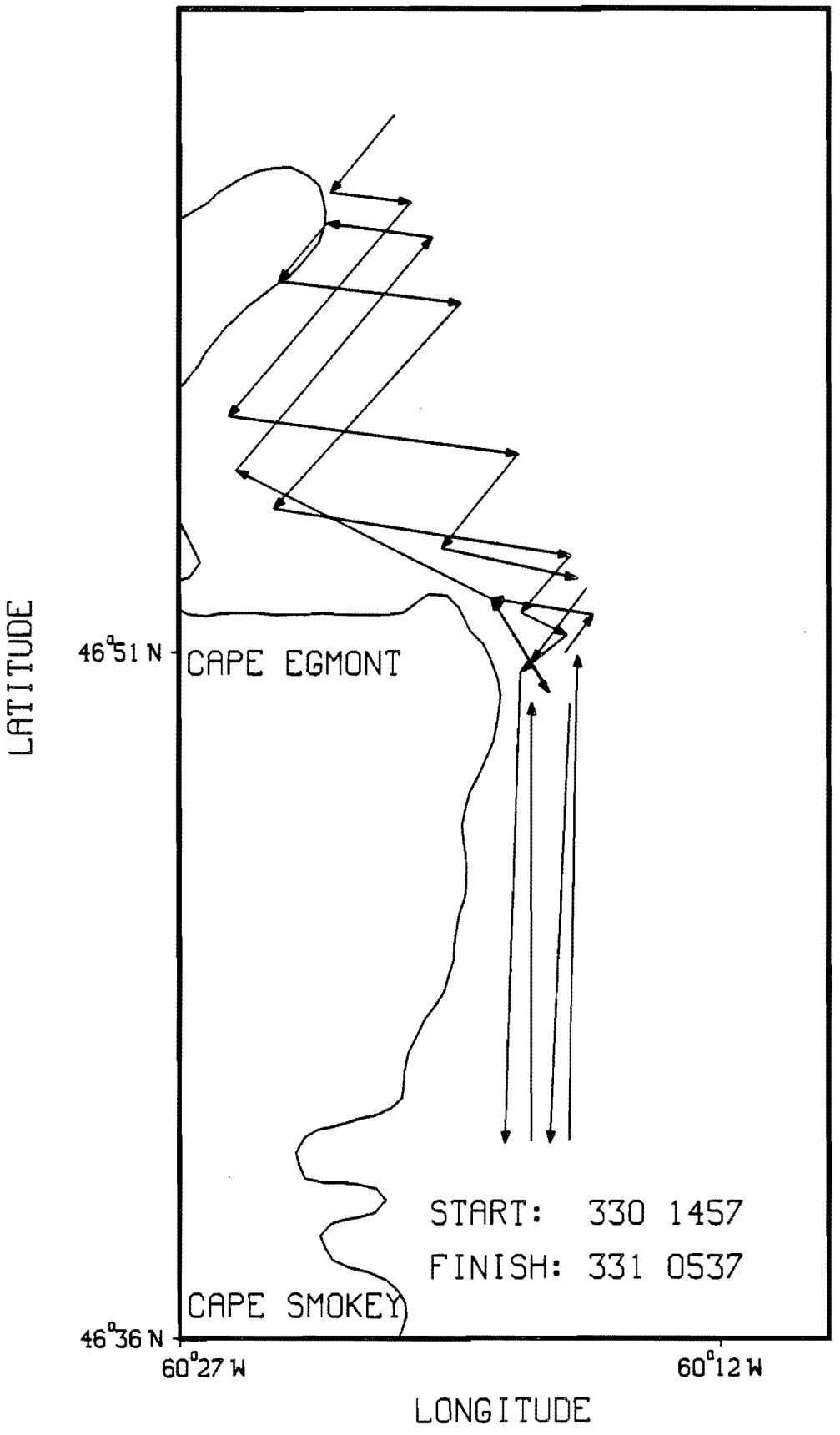


FIGURE 11

CAPE EGMONT - CAPE SMOKEY : 26 NOV.

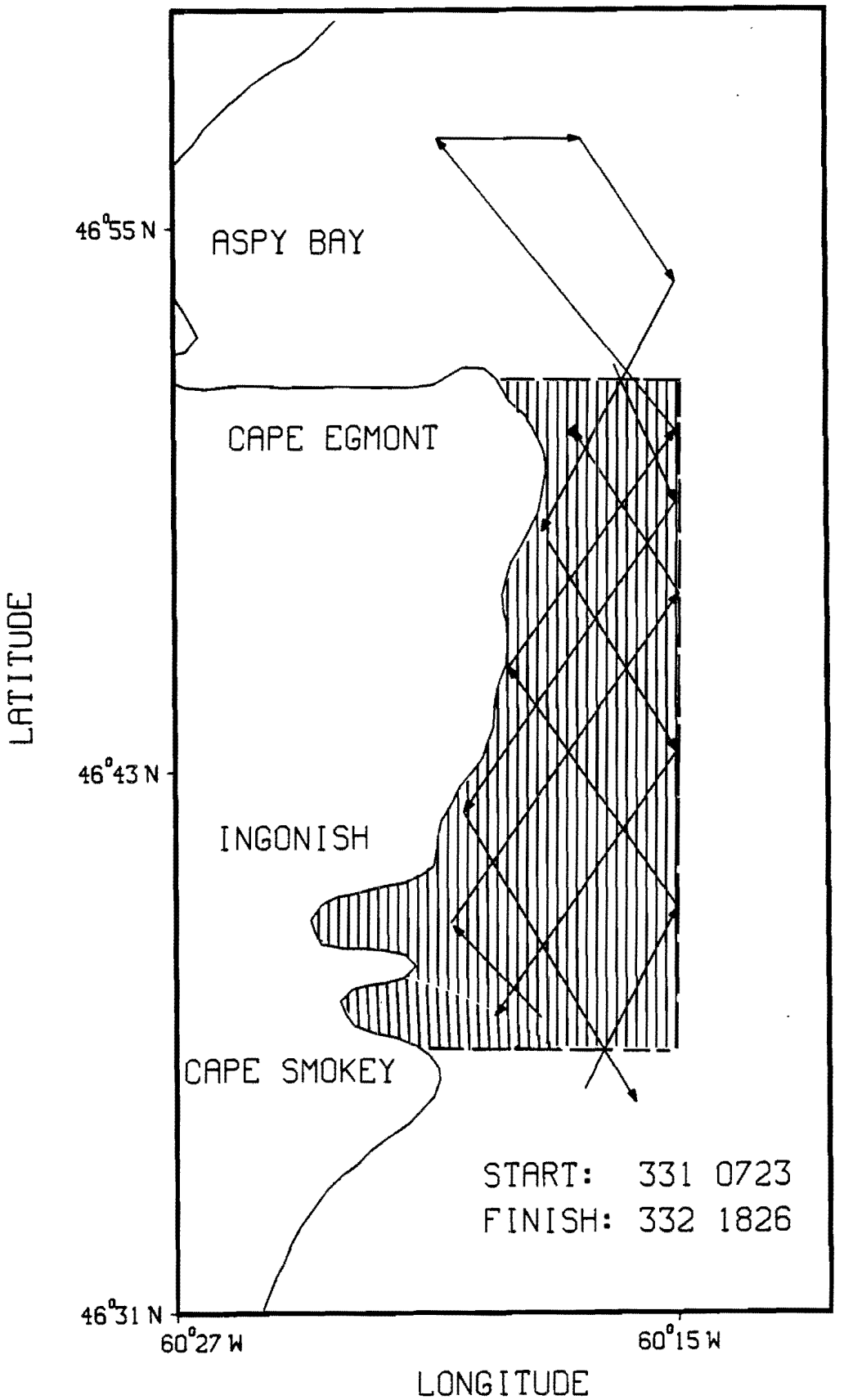


FIGURE 12

SOUTHERN SYDNEY BIGHT

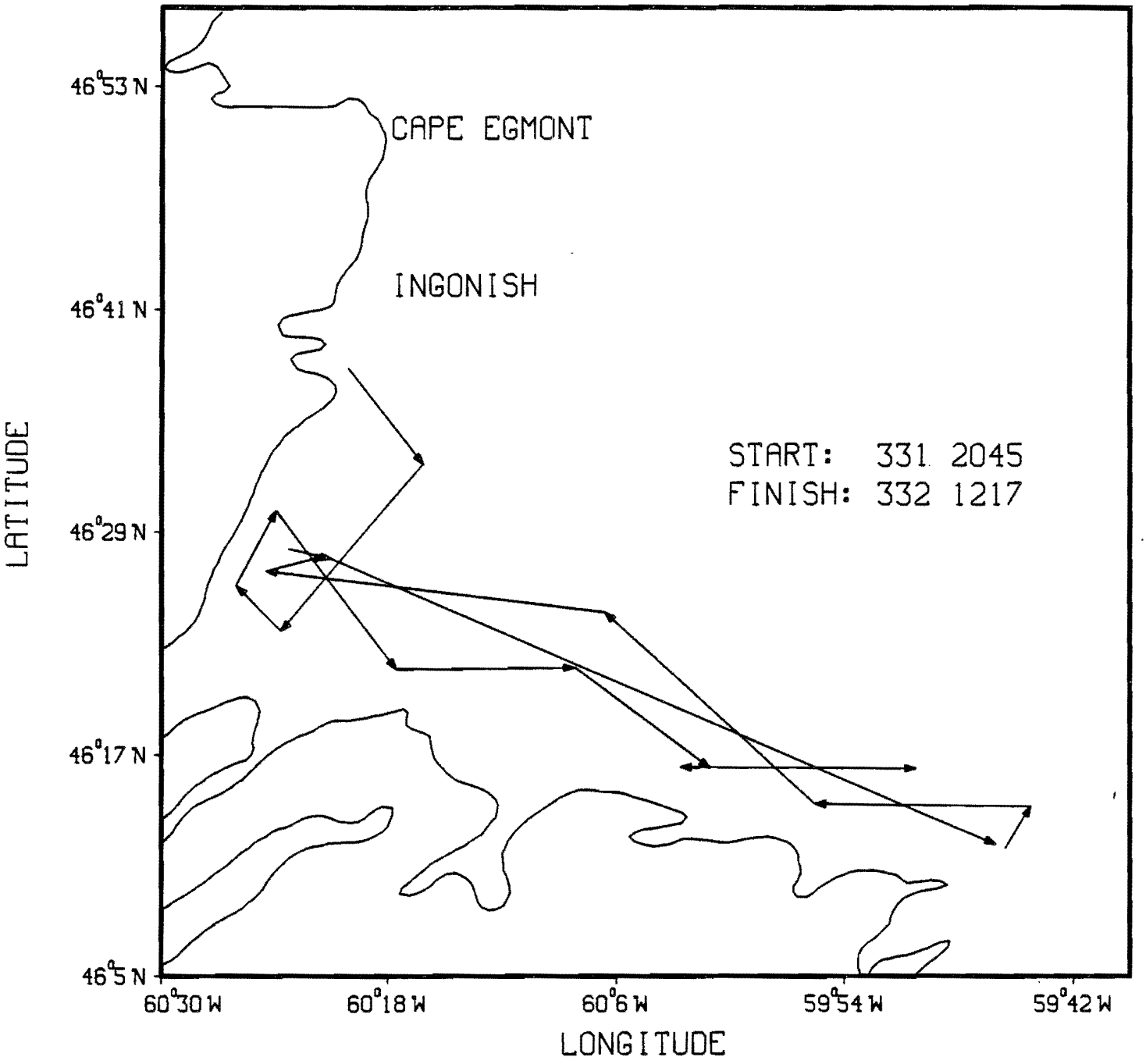
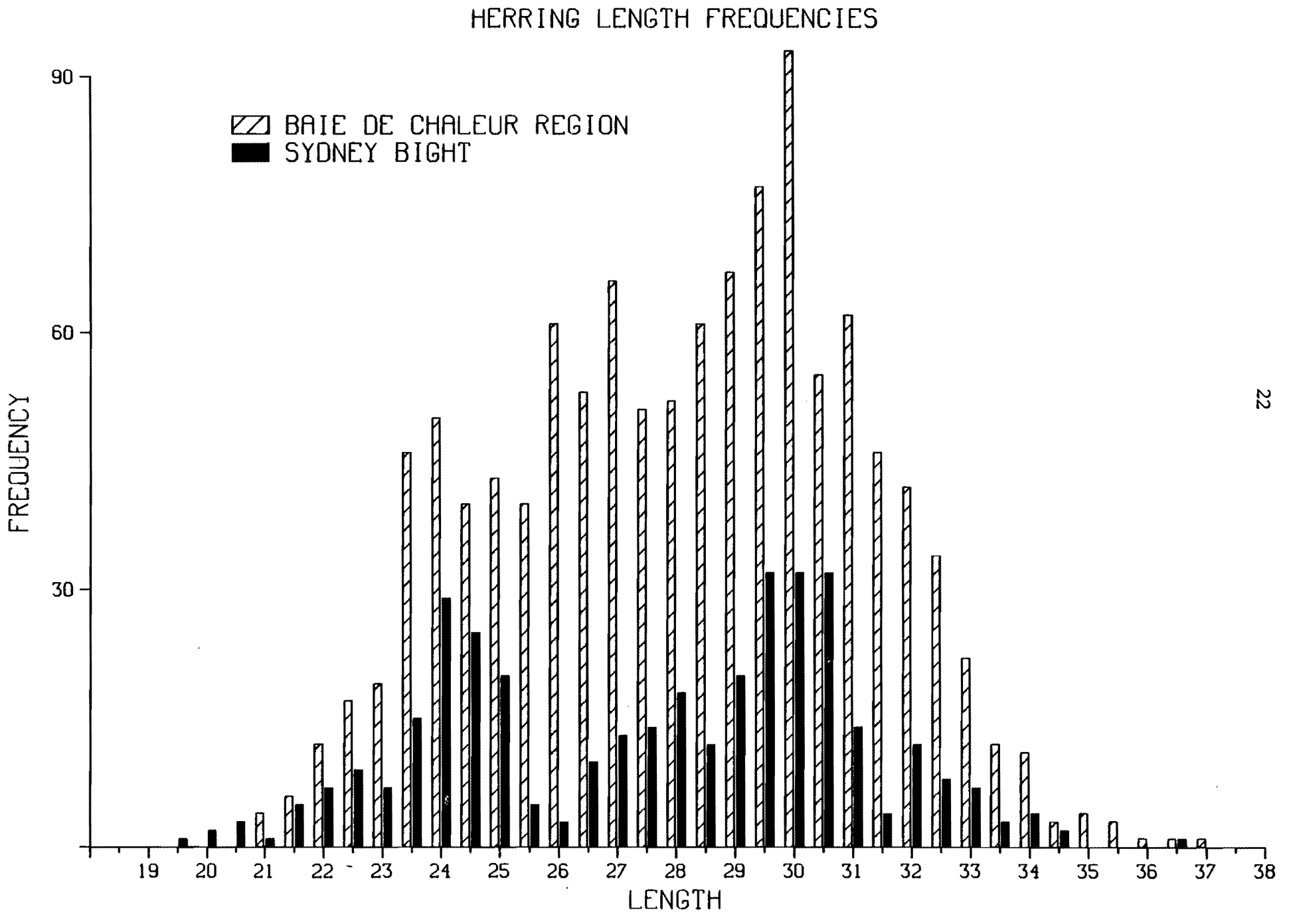


FIGURE 13


HERRING LENGTH FREQUENCIES
BAIE DE CHALEUR REGION
SYDNEY BIGHT
FREQUENCY
90
60
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LENGTH
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