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Results of the 1990 Winter Acoustic Surveys of NAFO Div. 4WX Herring Stocks

by

U. Buerkle
Marine Fish Division
Department of Fisheries and Oceans
Biological Station
St. Andrews, New Brunswick E0G 2X0

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ABSTRACT

Results of the 1990 winter acoustic herring survey are presented. An offshore survey between Country Island the the mouth of Chedabucto Bay found no herring. The index area in Chedabucto Bay was surveyed 23 times. Only 11 surveys are reported on here because the other 12 were done with a replacement transducer after the original one was lost. A calibration of the replacement transducer could not be done in time for this report. Results from the 11 surveys indicate a biomass of about 194,000 tonnes in 1990 compared to 450,000 tonnes in 1989.

RÉSUMÉ

Le présent document contient les résultats des études acoustiques sur le hareng réalisées en hiver 1990. Notons qu'on n'a pas trouvé de hareng lors d'une étude effectuée au large entre l'île Chedabucto et l'embouchure de la baie Chedabucto. La zone de référence a fait l'objet de 23 relevés acoustiques. Les résultats de onze d'entre eux seulement sont pris en compte ici, les douze autres ayant été réalisés au moyen d'un transducteur de remplacement qui n'a pu être étalonné avant la parution du présent rapport. D'après les résultats des onze relevés considérés, la biomasse en 1990 était d'environ 194 000 tonnes, comparativement à 450 000 tonnes en 1989.

INTRODUCTION

The 1990 acoustic winter herring survey was done with the *Alfred Needler* from Jan. 4-26. The aim was to survey the 7 x 44 km area along the southern shore of Chedabucto Bay that was selected as the index area in 1989. The area was to be surveyed repeatedly by integral day and night surveys. New regulations introduced by Ships Branch in 1990 required that the captain be in the wheelhouse all the time the boat is operating in pilotage waters. Unlike in previous years, the captain could not be spelled off by the mate during the Chedabucto Bay surveys. Because the captain also needs rest, work had to be stopped for 6 h after every 12 h of operation. Efficient use of time under this constraint, together with the requirement for integral day surveys and night surveys, required a different survey design than used in 1989.

Another aim of the 1990 work was to survey the offshore area SE of Canso. This area is not in pilotage waters and could be surveyed on usual 24-h basis. The offshore survey was attempted on Jan. 10 after completing 11 surveys in Chedabucto Bay. During this attempt, we lost the towed body and the SP302 transducer. It dropped off the end of the cable where the cable parted inside the cable termination. There is no indication on the sounder record of the body hitting anything. We can only guess that the cause of the break was cable fatigue. The lost body is at 45°08.55'N and 61°05.61'W in 77 m of water. Bottom trawling at that location is difficult and did not recover the body.

A further 12 surveys in Chedabucto Bay and the offshore survey were completed with a replacement towed body and transducer SP268. Calibration parameters for the SP268 transducer were unknown at the time, and calibration was planned for after the survey. Wiring diagrams were also not available and the transducer was operated on what was thought to be wide beam. Examination of the wiring diagrams and calibration data after the survey showed that the diagrams did not correspond to transducer performance. More work needs to be done to determine exactly how that transducer operates.

The results presented here describe the work with the calibrated SP302 transducer only.

SURVEY DESIGN

To meet the requirement for 6 h of rest after every 12 h of operation in Chedabucto Bay meant that the 12 h of operation would be alternately during the day, during night and day, during night, during day and night, and so on. To maintain integral day and night surveys, therefore, required 6-h surveys. From 0600 to 1800 h we could do two daytime surveys, from 1800 to 0600 h we could do two nighttime surveys, from 1200 to 2400 we could do one day and one night survey and from 2400 to 1200 we could do one night and one day survey.

Each survey consisted of eight transects 5.6 km apart placed randomly in the survey area. The rationale for equidistant transects was to avoid large spacing between transects as explained in last year's report (Buerkle 1989).

When a 12-h work period was half day and half night or half night and half day the surveys were run separately. That is eight transects were run during the day (or night) proceeding across the area in one direction, then eight transects were run at night (or day) proceding back across the area in the other direction. When the 12-h work period was all day or all night, the two surveys were run together. That is, all 16 transects were run proceding from one side of the area to the other. This allowed more time for trawling.

EQUIPMENT, EDITING AND PROCESSING

Until the towed body was lost, the acoustic equipment for this survey was the same as that for the 1989 survey (Buerkle 1989). After that, the cable, towed body and transducer were different but results from that equipment are not reported here.

Data editing and processing were also the same as for the 1989 survey except that the integration program was changed to weight integration by distance. This makes the results independent of boat speed and allows the boat to slow down as a safety measure when approaching the inshore end of transects.

TRAWL SAMPLING

Trawl sampling was done by nine tows with an IGYPT midwater trawl and by 11 tows with a Western IIA bottom trawl. Fewer midwater tows were made this year than last year because the survey requirements allowed less time. Midwater tows were spaced more or less evenly throughout the survey period and were done in the midwater concentration of herring in the eastern half of the survey area. Bottom tows were done in areas not occupied by midwater herring, mostly in the western half of the survey area. Tow No. 3 early in the survey was aimed at sampling the fish seen near bottom on the echo sounder in the western part of the area. During the tow, no fish could be seen on the sounder but the tow caught 3 1/2 baskets of herring. To determine the extent of undetected fish, 10 other bottom tows were made during one 24-h period. Only two of these tows caught no herring. Tow No. 17 was made outside the survey area on the western end, tow No. 12 was the most easterly of the bottom tows and was made north of the area of midwater fish concentration.

One can conclude that there are herring close to bottom all over the western half of the survey area that are missed by the acoustics when they are not seen on the sounder. From the size of the catches, generally a fraction of a basket per 20-min tow, and from the low acoustic abundance in the western half of the area, one can conclude that there are not many fish involved.

The herring length-frequency distributions in the trawl samples show big differences between midwater, bottom, day and night samples (Fig. 1). There are three main length modes, one around 15 cm, one around 22 cm and one around 27 cm. The midwater samples show the 27-cm herring during day and night but the 22-cm herring are not well represented during the day. The bottom night samples are mostly 15-cm herring and the bottom day samples show 15-cm herring but a much higher proportion of 22-cm herring. The large herring occur only in midwater, small herring occur mostly near the bottom, but some come up at night, and the mid-size herring occur near bottom during day and in midwater during the night.

TARGET STRENGTH

The length-weight relationship calculated from all fish samples from Chedabucto Bay (Power, pers. commun.) was:

$$W_{kg} = 6.223 \, . \, L^{3.0156} \times 10^{-6} \, .$$

The target strength-length relationship of herring from Foote (1987) is:

$$TS = 20 \log L - 71.9 \, .$$

With the length-weight relationship for the Chedabucto Bay herring, the target strength per kg becomes:

$$TS_{kg} = -10.156 \log L - 19.84$$

The length dependence of the target strength results in a different target strength for each length-frequency distribution of fish. In Chedabucto Bay, there are four length-frequency distributions, midwater night, midwater day, bottom night and bottom day (Fig. 1). The distributions and resulting target strengths are presented in Table 3.

ACOUSTIC SURVEYS

The offshore survey (Fig. 2) covered an area of about 1400 km^2. It was surveyed twice; each time half the area was surveyed by one set of random parallel transects during the day and the other half was surveyed by another set of random parallel transects during the night so each half was surveyed once during day and once during night. No herring were found.

Transect locations in the Chedabucto Bay surveys are shown in Fig. 3. The thin lines show the transects, the thick lines show the location of herring along the transects as identified in echo sounder charts. The herring in the eastern half of the area are the major midwater herring concentrations. The herring in the western helf of the area occupy a larger area, but show on the echo sounder only as light traces near the bottom. Herring biomass per transect is shown by longitude in Fig. 4; it shows that a very small portion of the biomass is located in the western half of the area. In fact, almost all the biomass is found in one 10-km section of the survey area between Canso and Grimes Rock.

The survey results are shown by transect in Table 1 and by survey in Table 2. Each survey is treated like a stratum in the CAFSAC scheme of things (O'Boyle and Atkinson 1989). The stratum name indicates whether the survey was done by day (D) or night (N), the date (e.g. 05) and whether it was a single survey in one direction (11), the first of a combined survey (21) or the second of a combined survey (22). The standard errors reported in Table 2 are calculated as for random transects and do not apply here.

Herring biomass for the 11 Chedabucto Bay surveys is shown in Fig. 5. The estimates ranged from about 25,000-551,000 tonnes, with the three highest estimates coming from daytime surveys.

There are two reasons for excluding daytime estimates from the overall abundance estimate. First, the target strengths used to calculate biomass here are calculated from the target strength-length relationship derived by Foote (1987) from nighttime measurements on *in situ* herring. It is well known that fish orient at different tilt angles during the day than at night. Traynor and Williamson (1983) found nighttime target strengths of walleye pollock to be about half those of daytime target strengths and suggest that the difference is due to different tilt angle distributions. Buerkle (1983) photographed tilt angle distributions of herring in daytime and at night. These distributions suggest that daytime target strengths could be as much as four times those at night. Applying nighttime target strengths to daytime fish orientations likely overestimates biomass and maybe by as much as two to four times.

Second, sampling by parallel transects assumes that the average fish density in a fish school along a transect applies to a rectangular area that is as wide as the fish patch and extends sideways half way to each adjacent transect. These areas are shown for the two highest daytime estimates in Fig. 6. During survey DO9.21 and DO9.22, it became obvious that they would result in high estimates. To determine the actual east-west extent of the herring school, a perpendicular transect was run through the fish. This is shown as the east-west line (Fig. 6); the thickening of the line indicates the extent of the fish. The east-west extent of the fish was 3.9 km, not the 5.6 km assumed in the survey results, and these fish are thus overestimated by at least 1.4 times. It may be argued that this is part of normal sampling error that some schools will be overestimated and others, those that are longer than 5.6 km, will be underestimated, but that the mean will be unbiased. If, however, the herring are aggregated in one school as they were in these surveys, and if they are more aggregated in daytime than at night, it would lead to daytime estimates that are higher than the nighttime estimates.

The herring in this survey were very aggregated. In eight of the 11 surveys, the major concentration in the eastern half of the area was encountered in only one transect (Fig. 7). That indicates that the herring concentration is less than the 5.6

km transect spacing long, and that all these estimates are overestimates. In two of the surveys, N05-11 and N10-11, a major concentration was not encountered at all. It could be that there were no herring in the area during those nights, but it is more likely that the surveys simply missed them. Such results should be expected when the fish concentration is smaller than the transect spacing. In fact, the occurrence of the low estimates should compensate for the overestimate in other surveys.

The overall survey results for the Chedabucto Bay nighttime surveys are shown in Table 4. The mean biomass of 193,490 tonnes is 43% of the 450,000 tonnes estimated from the 1989 surveys. The standard error of the difference is 92,115 tonnes and the difference is significant at the 2% level.

The 1990 survey results are shown in relation to other years in Fig. 8. The downward trend indicated in 1989 has continued in 1990.

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TABLE 1. 1 Backscatter and biomass for transects.

Stratum	Transect Number	Transect Length (m)	Transect Area (km²)	Target Strength (dB/kg)	Sa - Area Scattering (sr⁻¹)	Total Scattering (m²/sr)	Biomass Density (kg/m²)	Total Biomass (t/transect)	Set Number
N05_11	2	6458	35.90	-32.0	0.000116	4164	0.1838	6600.133	
N05_11	3	6972	38.76	-32.0	0.000018	698	0.0285	1105.673	
N05_11	4	6610	36.74	-32.0	0.000284	10436	0.4501	16539.275	
N05_11	5	6760	37.58	-34.0	0.000000	0	0.0000	0.000	
N05_11	6	6630	36.86	-34.0	0.000000	0	0.0000	0.000	
N05_11	7	6525	36.27	-34.0	0.000007	254	0.0176	637.786	
N05_11	8	7246	40.28	-34.0	0.000000	0	0.0000	0.000	
N05_11	9	7173	39.87	-34.0	0.000000	0	0.0000	0.000	
D05_11	10	7085	39.39	-34.4	0.000000	0	0.0000	0.000	
D05_11	11	7045	39.16	-34.4	0.000000	0	0.0000	0.000	
D05_11	12	6380	35.47	-34.4	0.001471	52171	4.0515	143691.152	
D05_11	13	7233	40.21	-34.4	0.000000	0	0.0000	0.000	
D05_11	14	6127	34.06	-34.4	0.000000	0	0.0000	0.000	
D05_11	15	6483	36.04	-34.4	0.000000	0	0.0000	0.000	
D05_11	16	6460	35.91	-34.4	0.000000	0	0.0000	0.000	
D05_11	17	5813	32.31	-34.4	0.000000	0	0.0000	0.000	
N06_21	18	5993	33.32	-32.0	0.000045	1499	0.0713	2376.038	
N06_21	20	6554	36.43	-34.0	0.000000	0	0.0000	0.000	
N06_21	22	6476	36.00	-32.0	0.000301	10836	0.4771	17173.943	
N06_21	24	6768	37.62	-34.0	0.000000	0	0.0000	0.000	
N06_21	26	6198	34.45	-34.0	0.000000	0	0.0000	0.000	
N06_21	28	6676	37.11	-34.0	0.003546	131599	8.9071	330561.091	1
N06_21	30	7342	40.81	-34.0	0.000000	0	0.0000	0.000	
N06_21	32	6810	37.86	-34.0	0.000000	0	0.0000	0.000	
N06_22	19	6430	35.74	-32.0	0.000031	1108	0.0491	1756.181	
N06_22	21	5402	30.03	-32.0	0.000136	4084	0.2155	6472.770	
N06_22	23	6275	34.88	-32.0	0.000392	13674	0.6213	21671.874	
N06_22	25	6261	34.80	-34.0	0.000000	0	0.0000	0.000	
N06_22	27	6537	36.34	-34.0	0.001576	57271	3.9587	143857.124	
N06_22	29	6100	33.91	-34.0	0.000000	0	0.0000	0.000	
N06_22	31	6207	34.50	-34.0	0.000000	0	0.0000	0.000	
N06_22	33	7390	41.08	-34.0	0.000000	0	0.0000	0.000	
N07_21	35	6400	35.58	-34.0	0.000000	0	0.0000	0.000	
N07_21	37	7339	40.80	-34.0	0.000000	0	0.0000	0.000	
N07_21	39	6608	36.73	-34.0	0.000295	10836	0.7410	27220.038	
N07_21	41	6757	37.56	-34.0	0.001680	63104	4.2200	158511.171	2
N07_21	43	6147	34.17	-34.0	0.000000	0	0.0000	0.000	
N07_21	45	6297	35.01	-34.0	0.000000	0	0.0000	0.000	
N07_21	47	6529	36.29	-32.0	0.000100	3629	0.1585	5752.324	
N07_21	49	6571	36.53	-32.0	0.000557	20346	0.8828	32246.556	
N07_22	36	7238	40.24	-34.0	0.000000	0	0.0000	0.000	
N07_22	38	6612	36.76	-34.0	0.000000	0	0.0000	0.000	
N07_22	40	6382	35.48	-34.0	0.003963	140597	9.9546	353164.910	

TABLE 1. 2 Backscatter and biomass for transects.

Stratum	Transect Number	Transect Length (m)	Transect Area (km²)	Target Strength (dB/kg)	Sa - Area Scattering (sr^{-1})	Total Scattering (m^2/sr)	Biomass Density (kg/m^2)	Total Biomass (t/transect)	Set Number
N07_22	42	6469	35.96	-34.0	0.000000	0	0.0000	0.000	
N07_22	44	5918	32.90	-34.0	0.000000	0	0.0000	0.000	
N07_22	46	6370	35.41	-34.0	0.000000	0	0.0000	0.000	
N07_22	48	6158	34.23	-34.0	0.000000	0	0.0000	0.000	
N07_22	50	5482	30.47	-32.0	0.000030	914	0.0475	1448.962	
D08_11	51	6359	35.35	-34.4	0.000000	0	0.0000	0.000	
D08_11	52	8246	45.84	-34.4	0.000000	0	0.0000	0.000	
D08_11	53	6285	34.94	-34.4	0.000000	0	0.0000	0.000	
D08_11	54	6601	36.69	-34.4	0.000000	0	0.0000	0.000	
D08_11	55	5311	29.52	-34.4	0.000000	0	0.0000	0.000	
D08_11	56	6112	33.98	-34.4	0.004537	154152	12.4959	424569.506	
D08_11	57	6433	35.76	-34.4	0.000000	0	0.0000	0.000	
D08_11	58	6986	38.84	-34.4	0.000000	0	0.0000	0.000	
N08_11	59	7918	44.02	-34.0	0.000000	0	0.0000	0.000	
N08_11	60	7210	40.08	-34.0	0.000000	0	0.0000	0.000	
N08_11	61	6591	36.64	-34.0	0.001633	59832	4.1019	150291.414	
N08_11	62	6612	36.76	-34.0	0.000000	0	0.0000	0.000	
N08_11	63	6392	35.53	-34.0	0.000000	0	0.0000	0.000	
N08_11	64	6120	34.02	-34.0	0.000000	0	0.0000	0.000	
N08_11	65	8204	45.61	-34.0	0.000000	0	0.0000	0.000	
N08_11	66	8374	46.55	-32.0	0.000517	24067	0.8194	38143.468	
D09_21	67	6849	38.07	-34.0	0.000045	1713	0.1130	4303.644	
D09_21	69	6401	35.58	-34.4	0.000000	0	0.0000	0.000	
D09_21	71	5946	33.05	-34.4	0.000000	0	0.0000	0.000	
D09_21	73	6533	36.32	-34.4	0.000000	0	0.0000	0.000	
D09_21	75	6511	36.19	-34.4	0.000000	0	0.0000	0.000	
D09_21	77	6505	36.16	-34.4	0.003844	139004	10.5873	382848.856	
D09_21	81	6720	37.36	-34.4	0.000000	0	0.0000	0.000	
D09_21	83	6892	38.31	-34.4	0.000000	0	0.0000	0.000	
D09_22	68	6917	38.45	-34.0	0.000114	4383	0.2864	11010.811	
D09_22	70	6419	35.68	-34.4	0.000000	0	0.0000	0.000	
D09_22	72	6057	33.67	-34.4	0.000000	0	0.0000	0.000	
D09_22	74	6425	35.72	-34.4	0.000000	0	0.0000	0.000	
D09_22	76	6554	36.43	-34.4	0.000000	0	0.0000	0.000	
D09_22	80	6330	35.19	-34.4	0.005571	196035	15.3438	539925.131	4
D09_22	82	6653	36.98	-34.4	0.000000	0	0.0000	0.000	
D09_22	84	7386	41.06	-34.4	0.000000	0	0.0000	0.000	
N10_11	85	5572	30.97	-34.0	0.000000	0	0.0000	0.000	
N10_11	86	6583	36.59	-34.0	0.000260	9515	0.6531	23899.779	
N10_11	87	6288	34.95	-34.0	0.000000	0	0.0000	0.000	
N10_11	88	6299	35.02	-34.0	0.000000	0	0.0000	0.000	
N10_11	89	6293	34.98	-34.0	0.000000	0	0.0000	0.000	
N10_11	90	6567	36.51	-34.0	0.000000	0	0.0000	0.000	

TABLE 1. 3 Backscatter and biomass for transects.

Stratum	Transect Number	Transect Length (m)	Transect Area (km^2)	Target Strength (dB/kg)	Sa - Area Scattering (sr^{-1})	Total Scattering (m^2/sr)	Biomass Density (kg/m^2)	Total Biomass (t/transect)	Set Number
N10_11	91	6473	35.98	-32.0	0.000263	9464	0.4168	14998.852	
N10_11	92	7364	40.94	-34.0	0.000000	0	0.0000	0.000	

TABLE 2. Backscatter and biomass for strata.

Stratum	Target Strength (dB/kg)	Stratum Area (km²)	Area Scattering (sr^{-1})	Total Scattering (m^2/sr) Total	S.E.	Biomass Density (kg/m^2)	Total Biomass (t/stratum) Total	S.E.
N05_11	-32.0	302.27	0.000051	15552	10505	0.0823	24883	16608
D05_11	-34.4	292.55	0.000178	52171	52171	0.4912	143691	143691
N06_21	-33.9	293.61	0.000490	143934	130267	1.1924	350111	328197
N06_22	-33.6	281.30	0.000271	76137	56165	0.6177	173758	141161
N07_21	-33.6	292.67	0.000335	97917	61675	0.7644	223730	153745
N07_22	-34.0	281.45	0.000503	141512	140470	1.2600	354614	352961
D08_11	-34.4	290.92	0.000530	154152	154152	1.4594	424570	424570
N08_11	-33.5	319.20	0.000263	83899	61218	0.5903	188435	149681
D09_21	-34.4	291.05	0.000483	140717	138770	1.3302	387153	382258
D09_22	-34.4	293.19	0.000684	200418	195457	1.8791	550936	538462
N10_11	-33.1	285.95	0.000066	18978	12424	0.1360	38899	26339

Table 3. Summary of Chedabucto Bay night survey results.

Survey data	Biomass (tonnes)
Jan. 5	24,883
Jan. 6	350,111
Jan. 6	173,758
Jan. 7	223,730
Jan. 7	354,614
Jan. 8	188,435
Jan. 10	38,899
Mean biomass	193,490
Standard error	49,796
A.05	2.477
95% CI	±121,852
Confidence limits	71,638 to 315,342

Table 4. Length frequencies and target strengths for Chedabucto Bay herring.

Length cm	$m^2\ sr^{-1}$	Frequency Midwater night	Frequency Midwater day	Frequency Bottom night	Frequency Bottom day
10	.001001	-	-	-	-
11	.000909	-	-	5	-
12	.000832	-	-	41	4
13	.000767	4	-	113	26
14	.000711	1	-	129	70
15	.000663	7	-	82	81
16	.000621	35	-	29	57
17	.000584	28	-	9	19
18	.000551	10	-	23	19
19	.000522	5	-	37	10
20	.000495	59	-	22	55
21	.000471	140	15	4	154
22	.000449	161	23	1	167
23	.000430	122	25	1	106
24	.000411	111	26	1	102
25	.000395	93	29	2	20
26	.000379	206	76	3	21
27	.000365	202	99	-	12
28	.000352	120	55	3	12
29	.000339	92	38	-	12
30	.000328	100	40	1	4
31	.000317	57	27	4	5
32	.000307	43	18	-	4
33	.000298	9	4	-	4
34	.000289	8	2	-	1
35	.000280	5	-	-	-
36	.000273	4	1	-	-
37	.000265	1	-	-	-
38	.000257	2	-	-	-
39	.000251	1	-	-	-
40	.000245	-	-	-	-
Total frequency		1626	478	511	1225
Product .frequency		.6548	.1767	.3240	.4856
Mean		.000403	.000363	.000634	.000396
TS		.34.0	-34.4	-32.0	-34.0

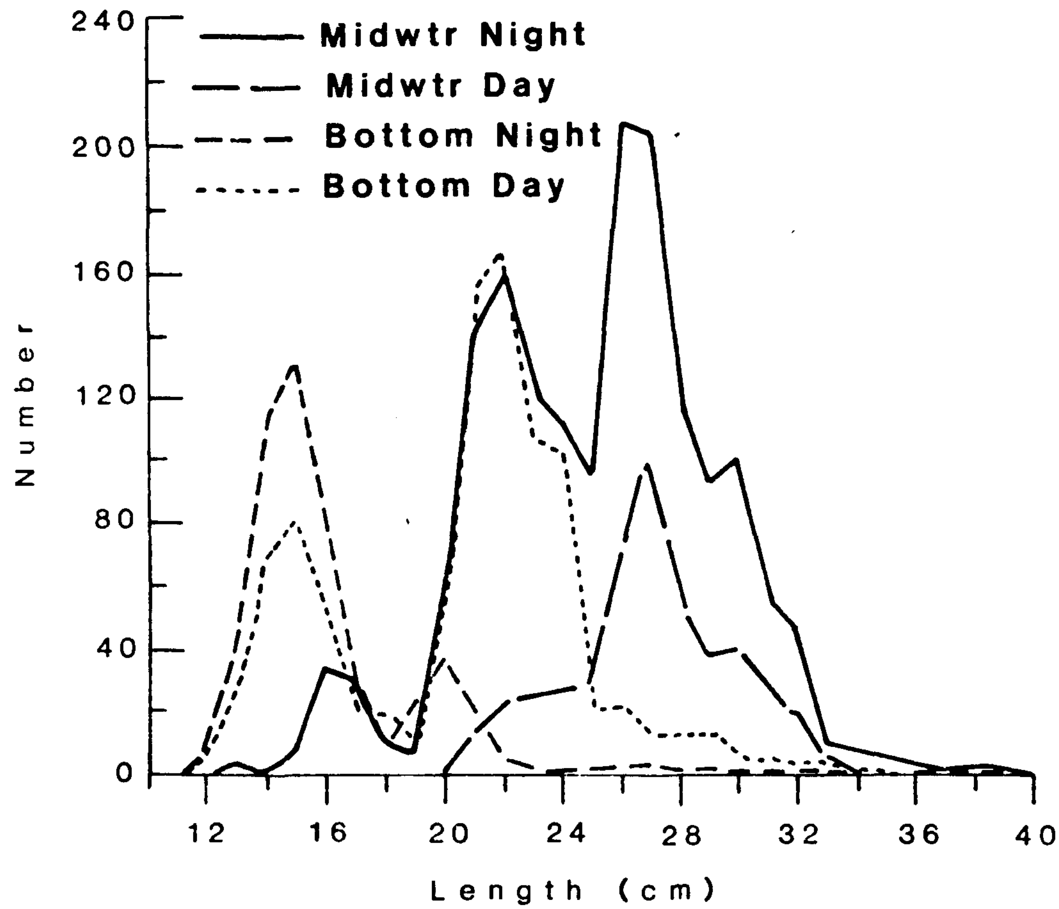

Fig. 1. Herring length frequencies from Chedabucto Bay samples in 1-cm length classes.

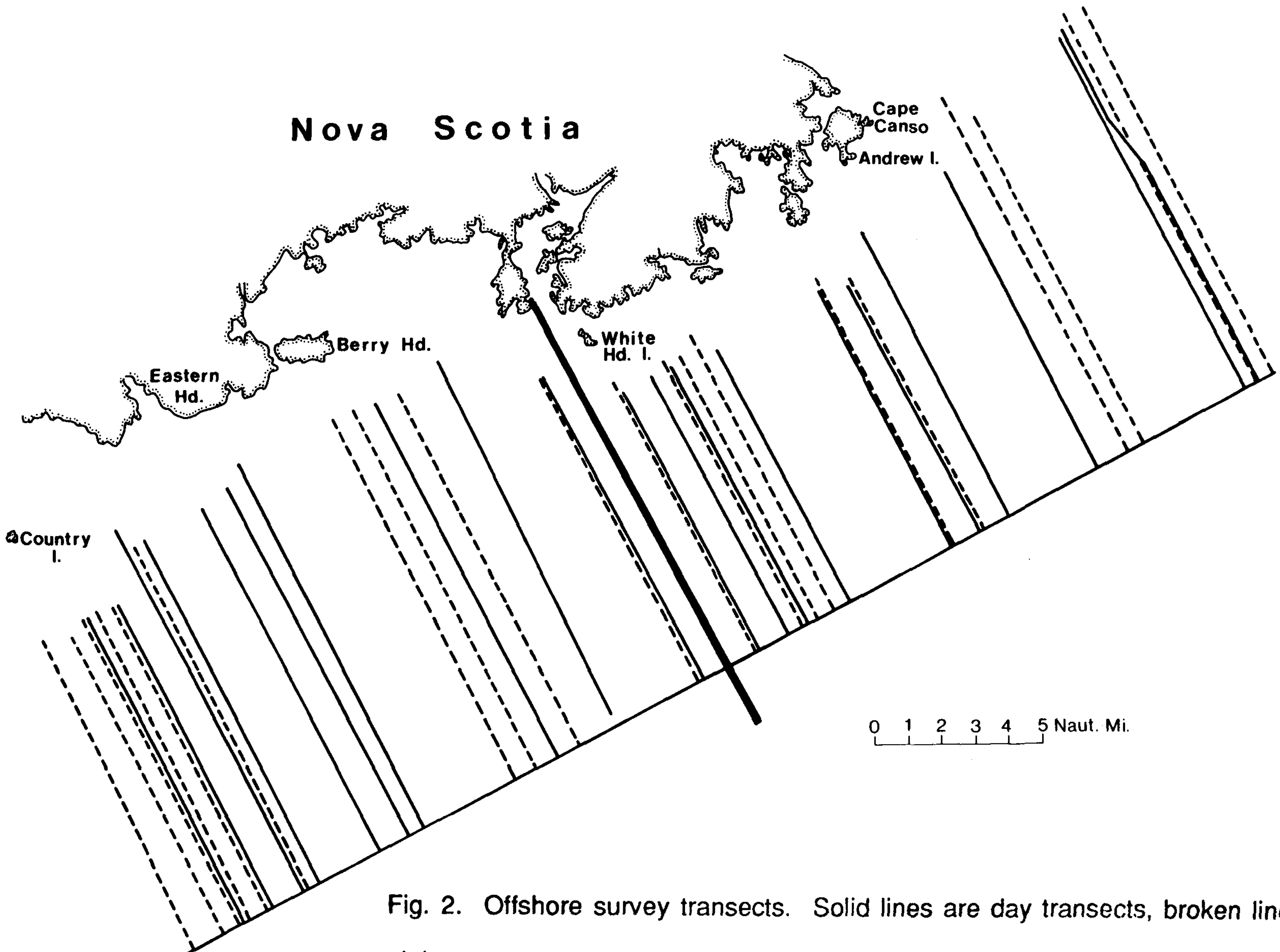

Fig. 2. Offshore survey transects. Solid lines are day transects, broken lines are night transects.

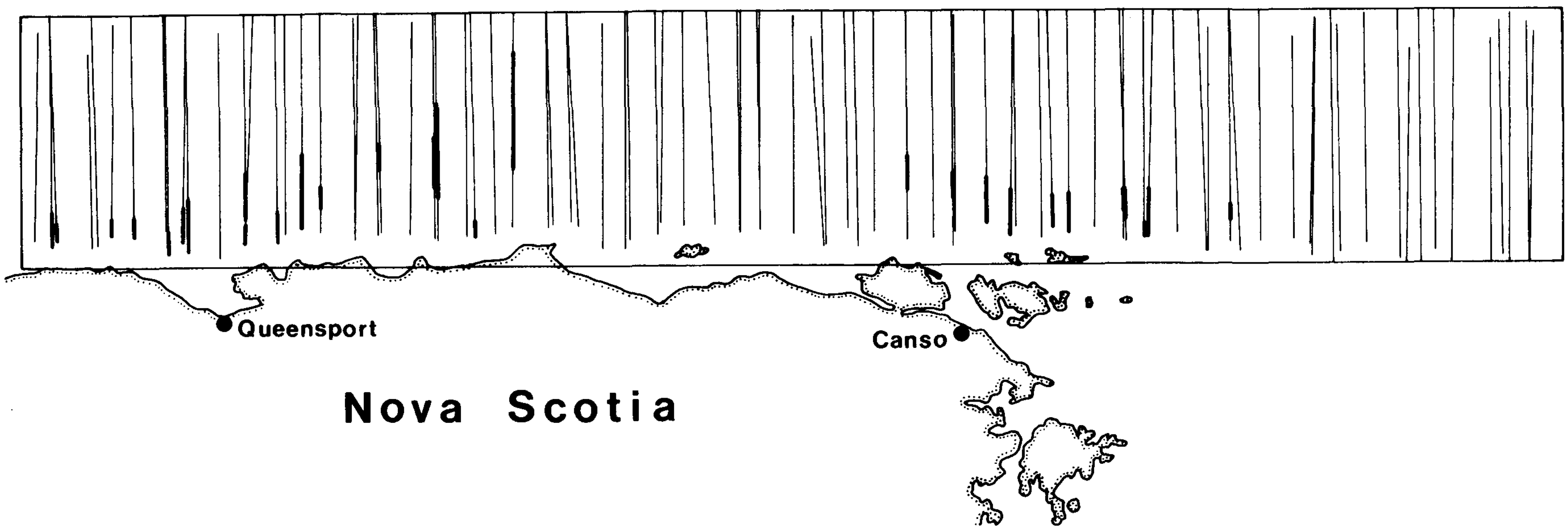

Fig. 3. Chedabucto Bay survey area and transects. Thick lines show distribution of herring along transects.

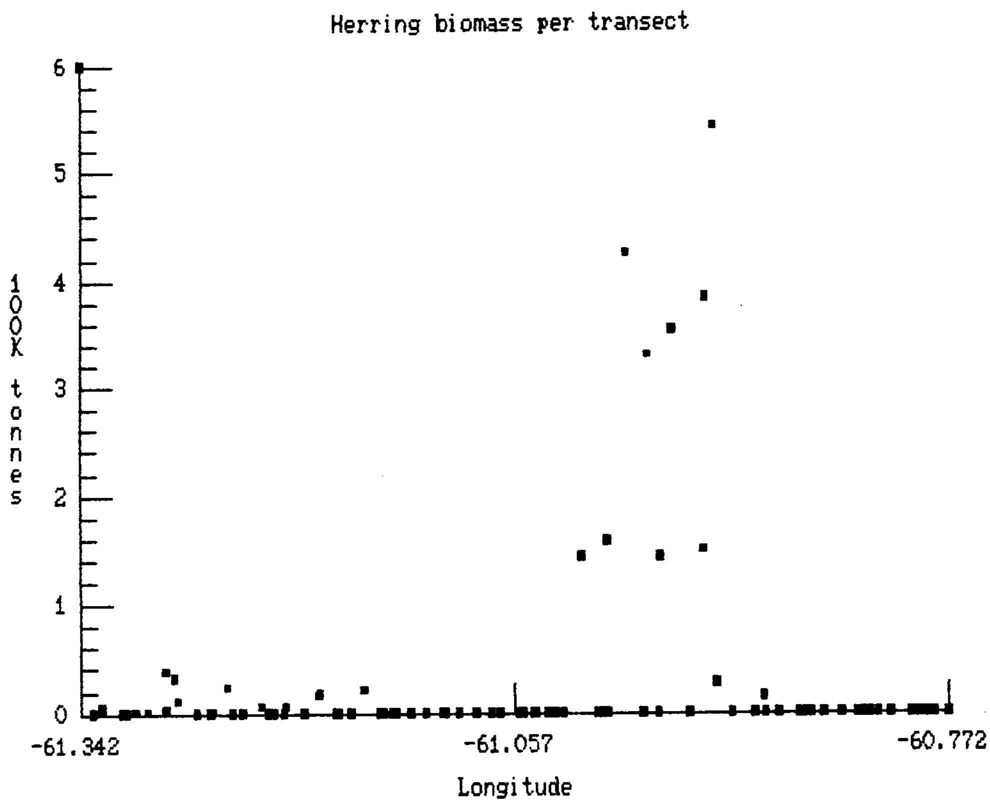

Fig. 4. Herring biomass per transect in Chedabucto Bay by longitude.

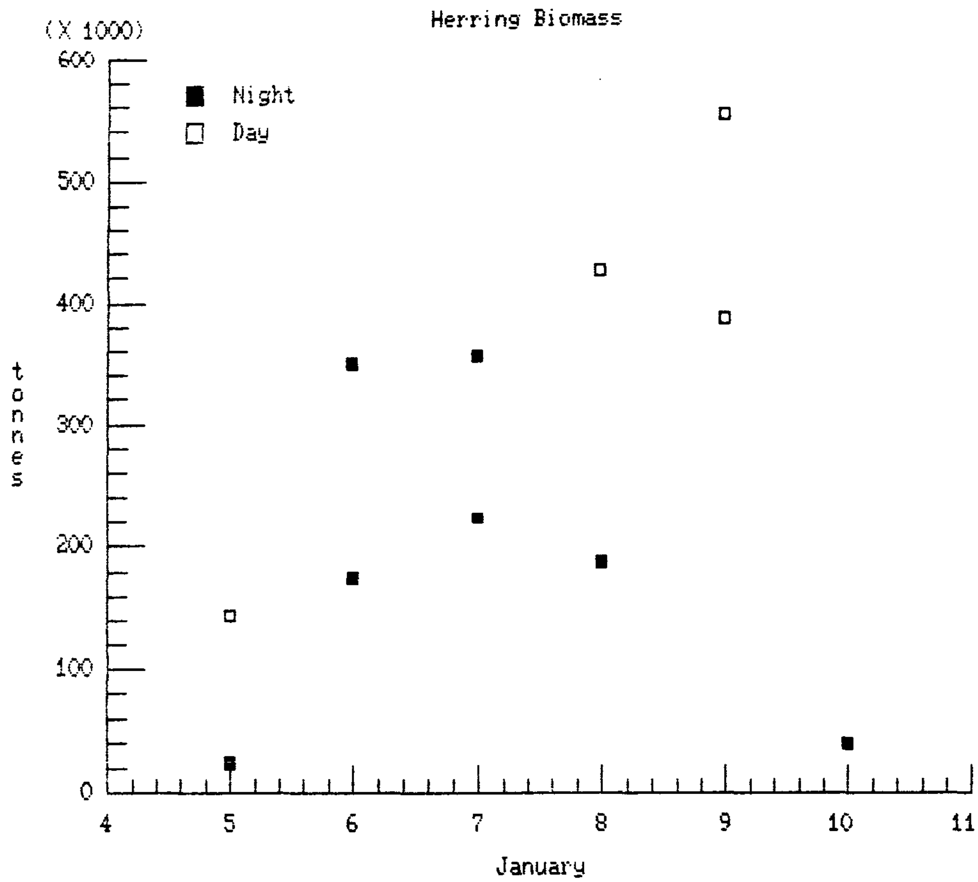

Fig. 5. Herring biomass in 11 Chedabucto Bay surveys.

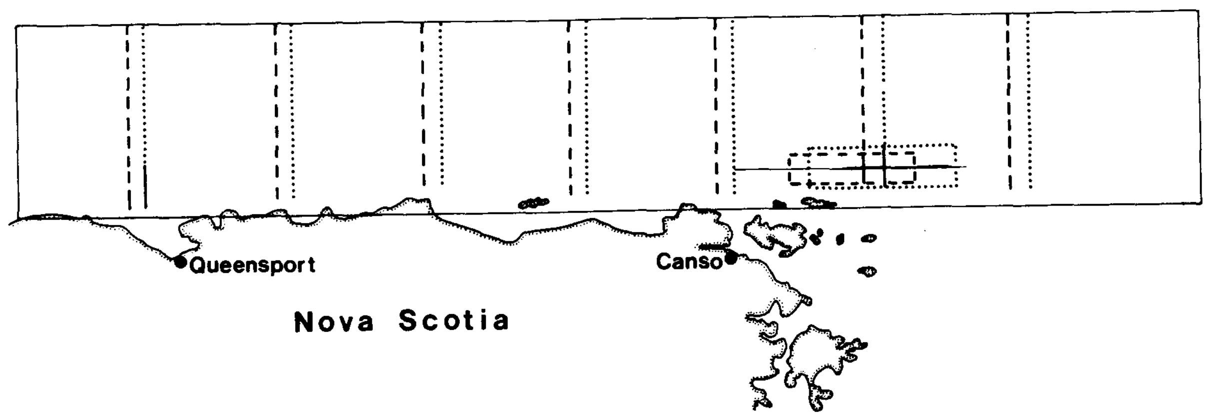

Fig. 6. Survey D09-21 and D09-22 transects and fish distribution.

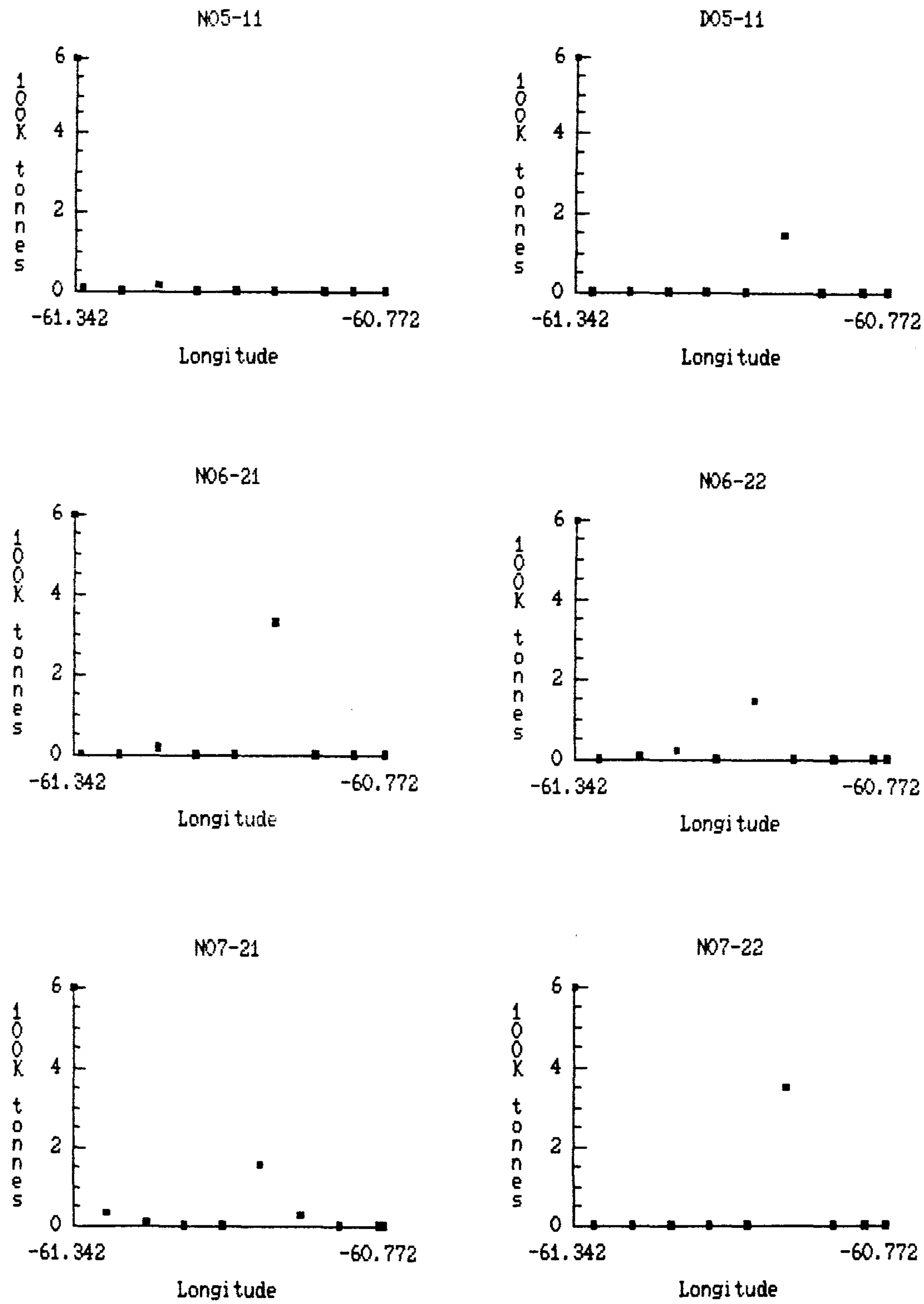

Fig. 7a. Herring biomass per transect for individual surveys.

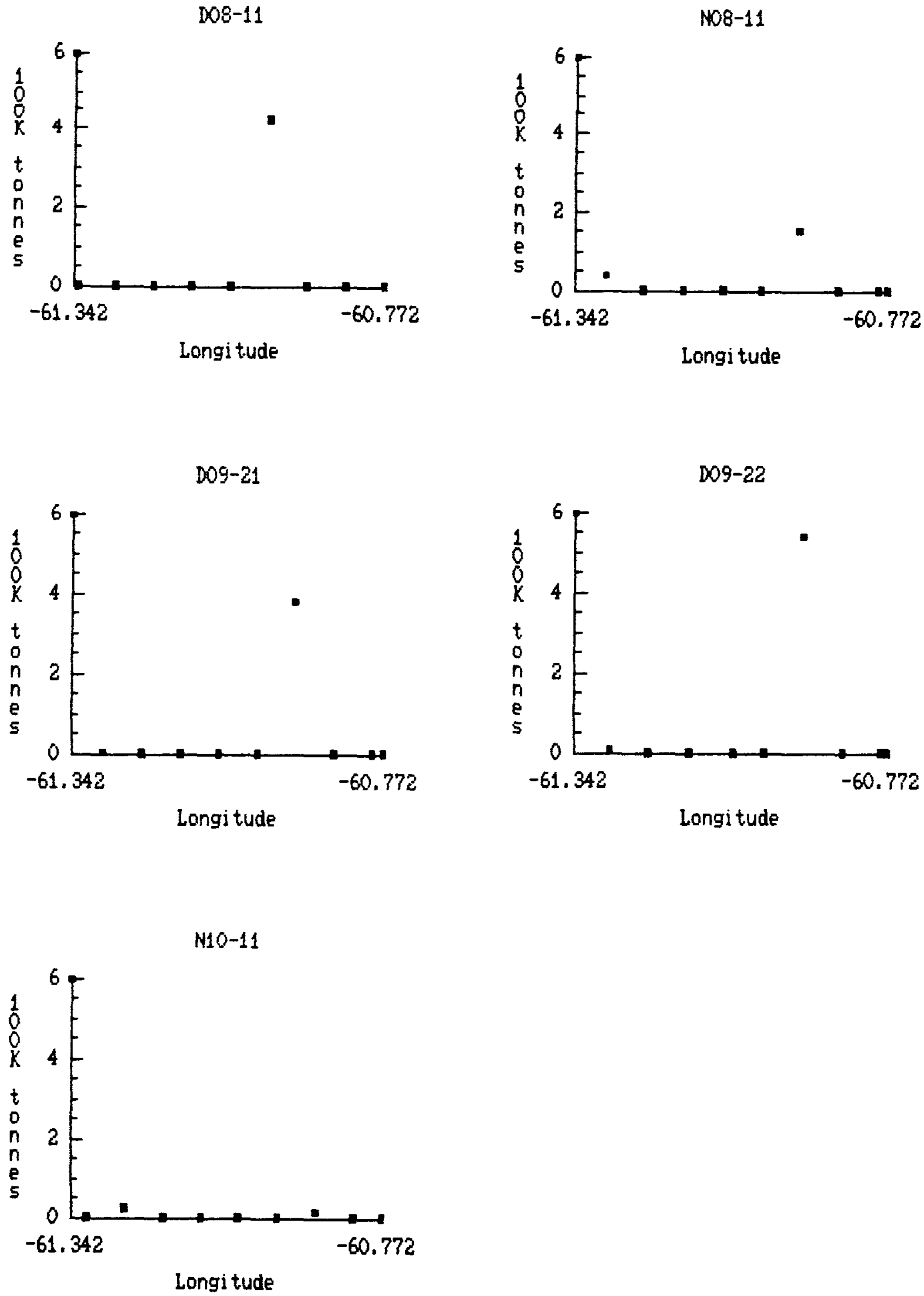

Fig. 7b. Herring biomass per transect for individual surveys.

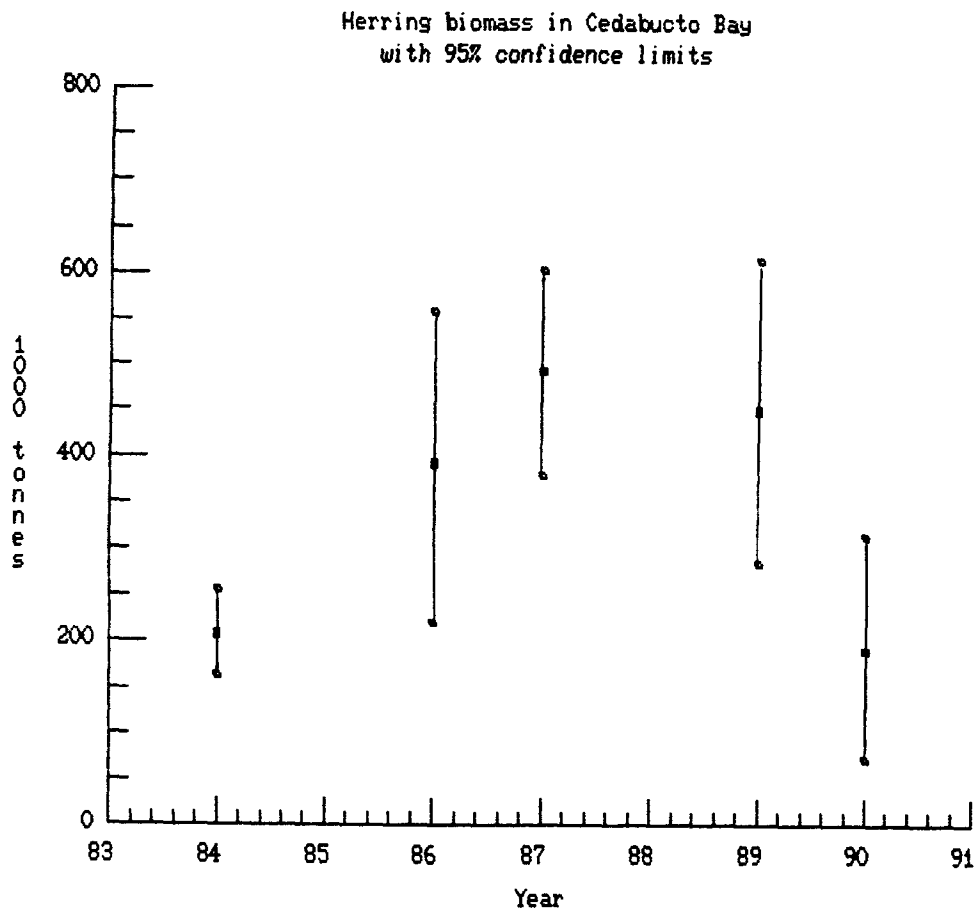

Fig. 8. Herring biomass in Chedabucto Bay 1984-90.