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Capelin Acoustic Surveys in NAFO Divisions 2J+3K, 3LNO, and 3L, 1981-82

by

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ABSTRACT

The acoustic surveys of capelin stocks in Div. 2J+3K, 3LNO and 3L were conducted from the research vessel *Gadus Atlantica* during the period June 3-29, 1981; October 1-20, 1981; and April 2-21, 1982 respectively. Overall biomass estimates of capelin from each of three surveys are made. Age and length distributions of capelin sampled during each of the three surveys are provided.

INTRODUCTION

These surveys are a continuation of an annual acoustic survey program for capelin started by Canada in 1977. The USSR also conducts a similar acoustic survey program over the same area. The biomass estimates from both countries are used as a basis to provide advice on quota levels for capelin stock complexes in Div. 2J3K, 3L, and 3NO.

MATERIALS AND METHODS

Acoustic data was collected using a custom built hydroacoustic acoustic data acqusition system (HYDAS) developed at the Northwest Atlantic Fisheries Centre, St. John's, Newfoundland. The system utilizes a 50 khz SIMRAD EK50 sounder with a 2 kilowatt transmitter. The returned echo signal is sampled at a 15 khz rate and signals are digitized and stored on a 9 track computer tape for subsequent analysis.

The transducer for the system is typically towed 10 to 15 meters below the surface in a remote 'towed body' structure. Sampling of the returned echo signal begins at a time corresponding to a depth 5 m below transducer surface. Subsequent analysis of the digitized output on magnetic tape is carried out on an HP-1000 computer system. RMS voltage levels are squared, averaged over 1 m depth intervals and accumulated over 10 min time intervals.

The density per cubic meter λ at depth R is then calculated from.

$$\lambda = V_R^2 \times \frac{1}{r_x^2\ p_o^2\ \bar{b}2\ (\frac{\bar{\sigma}}{4\pi})\ c\tau\ TG_o^2}$$

where V_R^2 is the average rms voltage squared at depth R, r_x is the receiving sensitivity of the transducer, P_o is the rms transmitted pressure level, $\bar{b}^2$ is the average beam pattern factor, $(\frac{\sigma}{4\pi})$ is the target strength, C is the speed of sound in sea water, T is the pulse length of the sound pulse, and G_o^2 is the fixed gain of the echo sounder system.

The densities per cubic meter for each 1 m depth layer are then summed to provide an estimate of density per square meter of surface area.

The area to be surveyed was subdivided into discrete blocks and the survey within each block was of a systematic uniform nature with transects of equal length in a zig-zig pattern. Sampling with an Engel 80 mid water trawl was carried out when fish concentrations were encountered. Catches were sampled for length, age, weight, and sex. Target strengths for each block were calculated from available sampling data using the relationship

$$T.S._{dB} = 11.56 \log_{10} W - 65.95$$

where W is the weight in grams of the target species (Buerkle, pers. comm.). Mean weights and age distributions were also calculated from the available sampling data for each block. Mean biomass per square meter was then calculated using the average density estimates and the mean weight data for each block. Total biomass for the block was then calculated using the method of aerial expansion. Variance estimates due to sampling were calculated using a cluster sampling model (Nakashima 1981).

DISCUSSION

The transect patterns and areas covered for each of the three surveys are shown in Fig. 1-5. Blocks D, E, and F from the Gadus #52 survey are replicates over approximately the same area. Estimates from the 3 blocks were averaged and grouped with blocks A, B and C to provide a total estimate for the survey. Results for each of the 3 cruises are summarized in Table 1. Table 3 gives age composition by both numbers and weight for each of the 3 surveys. The lower biomass indicated from Gadus 64 may be attributable to the fact that ice cover prevented complete survey coverage of fish concentrations found in the northern and north eastern extremities of the survey area. Substantial concentrations of capelin were also found in the near shore area and could not be completely surveyed. The difference may also be attributable to the fact that the Gadus 64 survey occurred 2 months earlier in the year when capelin may have been less available to the acoustic survey. Figures 6-8 show length compositions and Fig. 9-11 show age distribution for each of the survey blocks for all three cruises. The totals are weighted mean distributions for each cruise. In the 1981 3LNO survey, 1978 year-class capelin were predominant in Div. 3NO. Division 3L showed a more equal distribution between the 1978, 1979, and 1980 year-class. In the 1981 2J3K survey, 1979 year-class capelin predominated to the north while the 1980 year-class was predominant in the south. In the 1982 3L survey, the 1979 year-class has predominant in all survey blocks. The 1980 year-class was abundant only in the northern 2 blocks.

The results of the variance estimates due to survey and sampling design (Tables 1 and 2) are probably a reflection of the low coverage of the survey area and the aggregated nature of capelin schools. For all 3 surveys, the indication of variance heterogenity (δ) per block approached the upper limit of 1.0 (Table 1). Therefore the variation associated with the biomass estimates in Table 1 can be attributed entirely to inter-transect differences (Nakashima 1981). There is a large range in mean transect densities ($\bar{x}_i$) within each survey block (Table 2). Since the sampling intervals (n_i) per transect do not vary considerably (Table 2), the wide range in mean transect densities is probably due to the variable distribution of capelin schools. The prescribed solution which would lead to lower variance is to increase the number of transects within each block until an acceptable level of error is attained. However, the amount of time and added expense to run more survey lines could be substantial. The coefficients of variation per block except one are quite reasonable in view of the low sampling intensity and in comparison to error levels reported in other studies (Nakashima 1981). The coefficient of variation of 78.84% for Gadus 64 survey which was much higher than the value for the other surveys (Table 2) was a function of one inshore transect line having encountered very high concentrations of capelin. To reduce variation in the biomass estimates at this time is not feasible due to the large area which had to be surveyed. However, the analysis does enable the investigator to make discussions on allocation of sampling effort for future studies on a meaningful basis.

The estimates of capelin biomass given in Table 1 are substantially higher than those provided for the stocks in 1980 (Miller and Carscadden 1981; Bakanev 1981). This is due to good recruitment from the 1979 year-class which was abundant during the 1980 3LNO survey as 1-yr-old (Miller and Carscadden 1981).

REFERENCES

Bakanev, V. S. 1981. Results of Soviet investigations on capelin in the Northwest Atlantic in 1980. NAFO SCR Doc. 81/II/10.

Miller, D. S., and J. E. Carscadden. 1981. Acoustic survey results for capelin (*Mallotus villosus*) in Divisions 2J3K and 3LNO, 1980. NAFO SCR Doc. 81/II/5.

Nakashima, B. S. 1981. Sampling variations and survey design for capelin (*Mallotus villosus*) densities from an acoustic survey in Divisions 3LNO, 1980. NAFO SCR Doc. 81/II/14.

Table 1. Summary of acoustic survey results for Gadus Atlantica Cruise 52, 56, and 64.

Trip	Block	Area ($m^2 \times 10^{10}$)	Mean wt. (gms)	Biomass/m^2 (gms)	σ^2	δ	Lower Limit of δ	Total Biomass ('000's tons)	95% Confidence Interval	NAFO Division
Gadus 52 (3LNO)	A	2.33	11.1	18.47	29.57	0.98	-0.02	430.4	±248.4	3L
	B	4.64	12.1	24.77	29.07	0.99	-0.01	1149.3	±490.3	3L
	C	2.31	22.0	4.30	1.30	0.97	-0.02	99.3	± 51.5	3NO
	{D	1.03	24.2	3.74	3.28	0.96	-0.03	38.5	± 36.6	3N
	* {E	1.17	21.4	9.15	3.56	0.92	-0.04	107.3	± 43.4	3N
	{F	1.17	22.0	9.21	23.93	0.97	-0.02	108.1	±112.5	3N
Total		10.40		16.96	7.46			1763.6	±556.8	
Gadus 56 (2J3K)	A	2.15	17.9	48.49	100.82	0.98	-0.02	1042.5	±423.1	2J
	B	1.22	11.4	12.53	8.09	0.97	-0 02	152.9	± 68.0	2J
	C	0.83	7.4	31.57	51.29	0.96	-0.03	262.0	±116.5	2J
	D	1.89	9.1	6.88	1.85	0.97	-0.02	130.0	± 50.4	3K
	E	1.87	5.3	6.94	7.23	0.98	-0.02	129.8	± 98.6	3K
	F	1.58	3.5	4.87	1.45	0.98	-0.02	76.9	± 37.3	3K
Total		9.54		18.81	6.03			1794.1	±459.2	
Gadus 64 (3L)	A	0.95	13.6	3.03	0.51	0.94	-0.05	28.7	± 13.3	3L
	B	1.90	13.6	18.25	31.32	0.97	-0.03	346.8	±208.4	3L
	C	2.09	24.3	1.75	0.21	0.95	-0.04	36.6	± 18.6	3L
	D	2.64	25.5	4.30	10.44	0.96	-0.02	113.5	±167.2	3L
Total		7.58		6.93	3.26			525.6	±268.2	

* replicates of same area - average for total estimates.

Table 2. Number of transects (t), total transect length, the range of mean densities per transect ($\bar{x}_i$), the range of intervals per transect (n_i), and the coefficient of variation for each survey block referred to in the analysis.

Trip	Block	t	Total transect length (km)	Range of $\bar{x}_i$'s	Range of n_i's	$V_{\bar{x}}$
Gadus 52	A	6	211.1	5.0 - 44.0	41 - 69	29.44
	B	9	275.4	4.9 - 52.6	92 - 92	21.76
	C	8	155.8	1.0 - 11.7	47 - 51	26.45
	D	6	95.4	0.5 - 13.1	26 - 31	48.44
	E	8	78.7	1.9 - 18.5	23 - 27	20.64
	F	5	111.1	1.8 - 31.8	43 - 48	53.1
Gadus 56	A	6	187.6	18.5 - 90.8	55 - 65	20.71
	B	3	162.8	7.7 - 19.6	50 - 53	22.70
	C	4	113.2	8.1 - 45.5	33 - 36	22.70
	D	6	170.6	1.9 - 13.6	51 - 54	19.80
	E	5	162.8	1.9 - 18.4	50 - 54	38.74
	F	5	213.9	2.5 - 9.7	59 - 68	24.78
Gadus 64	A	6	68.5	.95 - 5.5	22 - 24	23.57
	B	17	94.5	1.1 - 94.49	27 - 38	30.66
	C	15	75.9	.02 - 6.09	24 - 41	25.88
	D	16	129.6	.06 - 55.0	42 - 61	78.94

Table 3. Capelin Age Composition of Acoustic Biomass Estimates.

Cruise	Division	Year-class	1980	1979	1978	1977	1976	1975
52	3L	N	43	33	45	10	3	<1
		W	135	342	760	248	90	5
	3NO	N	<1	<1	7	1	<1	<1
		W	<1	2	141	35	7	<1
56	2J	N	35	60	9	2	1	<1
		W	208	950	213	55	29	2
	3K	N	49	11	1	<1	<1	0
		W	206	113	14	2	<1	0
	2J3K	N	84	71	10	2	1	<1
		W	414	1063	227	57	29	2
Cruise	**Division**	**Year-class**	**1981**	**1980**	**1979**	**1978**	**1977**	**1976**
64	3L	N	<1	11	18	3	1	<1
		W	<1	55	370	70	25	6

N = No's in billions.
W = Wt's in metric tons × 10^3

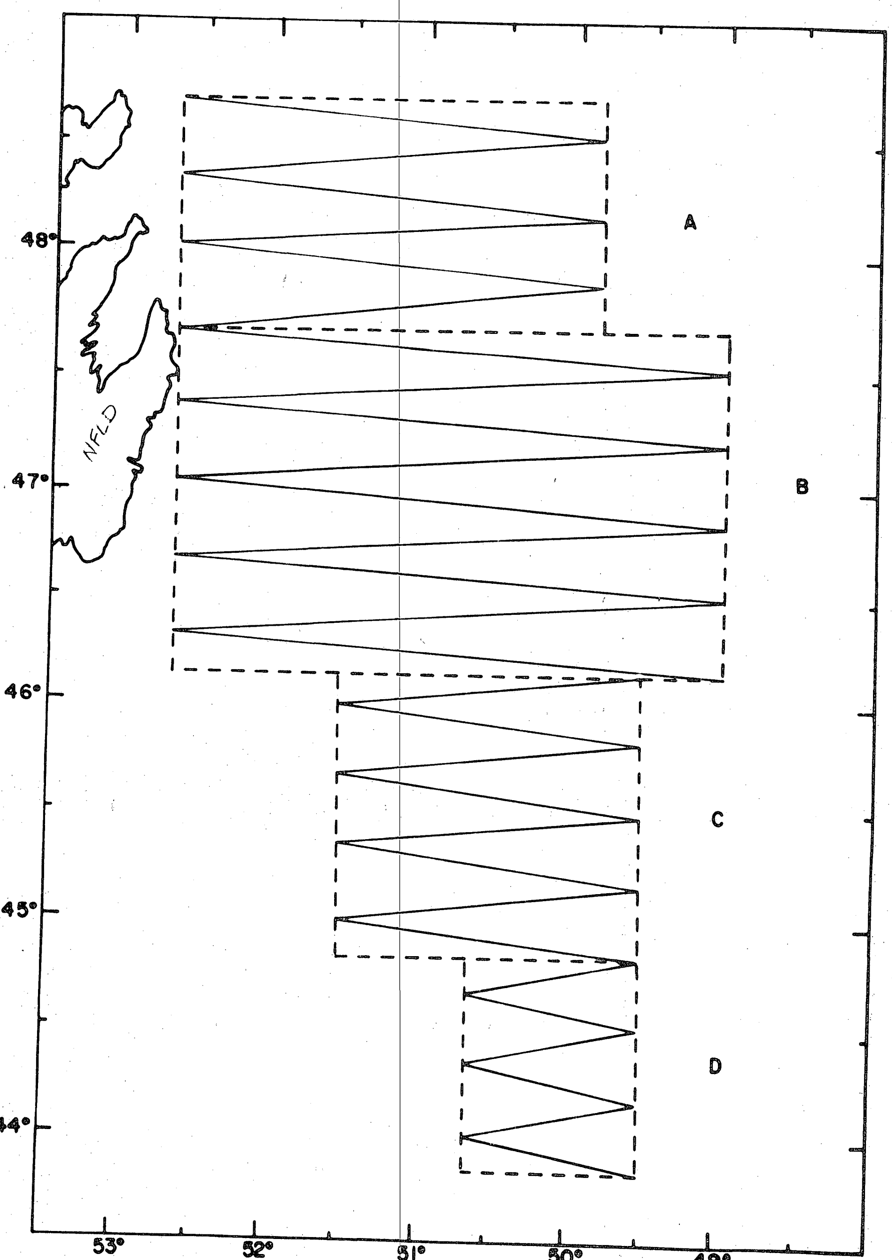

Fig. 1. Gadus Atlantica #52 Survey Track - Blocks A-D.

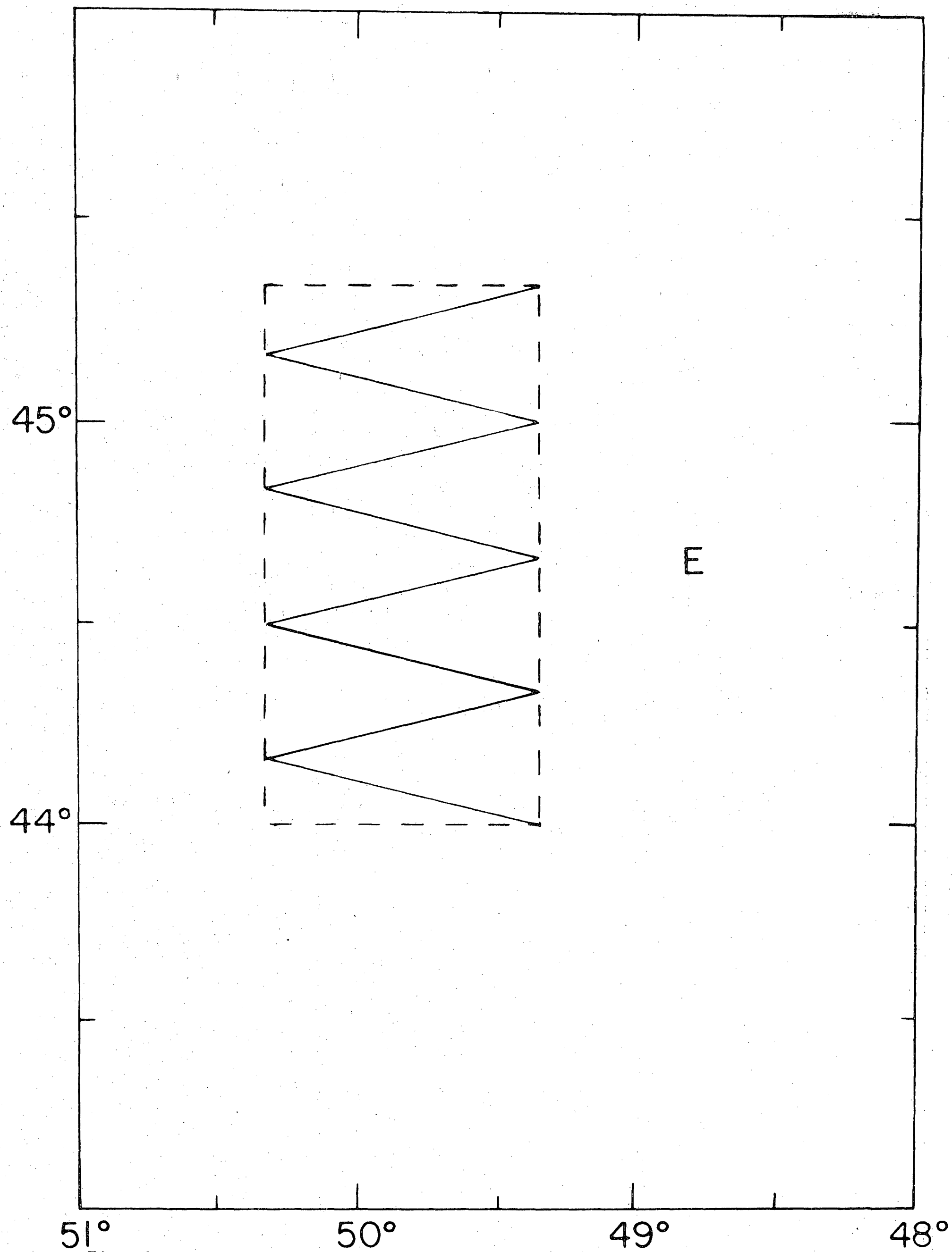

Fig. 2. Gadus Atlantica #52 Survey Track - Block E.

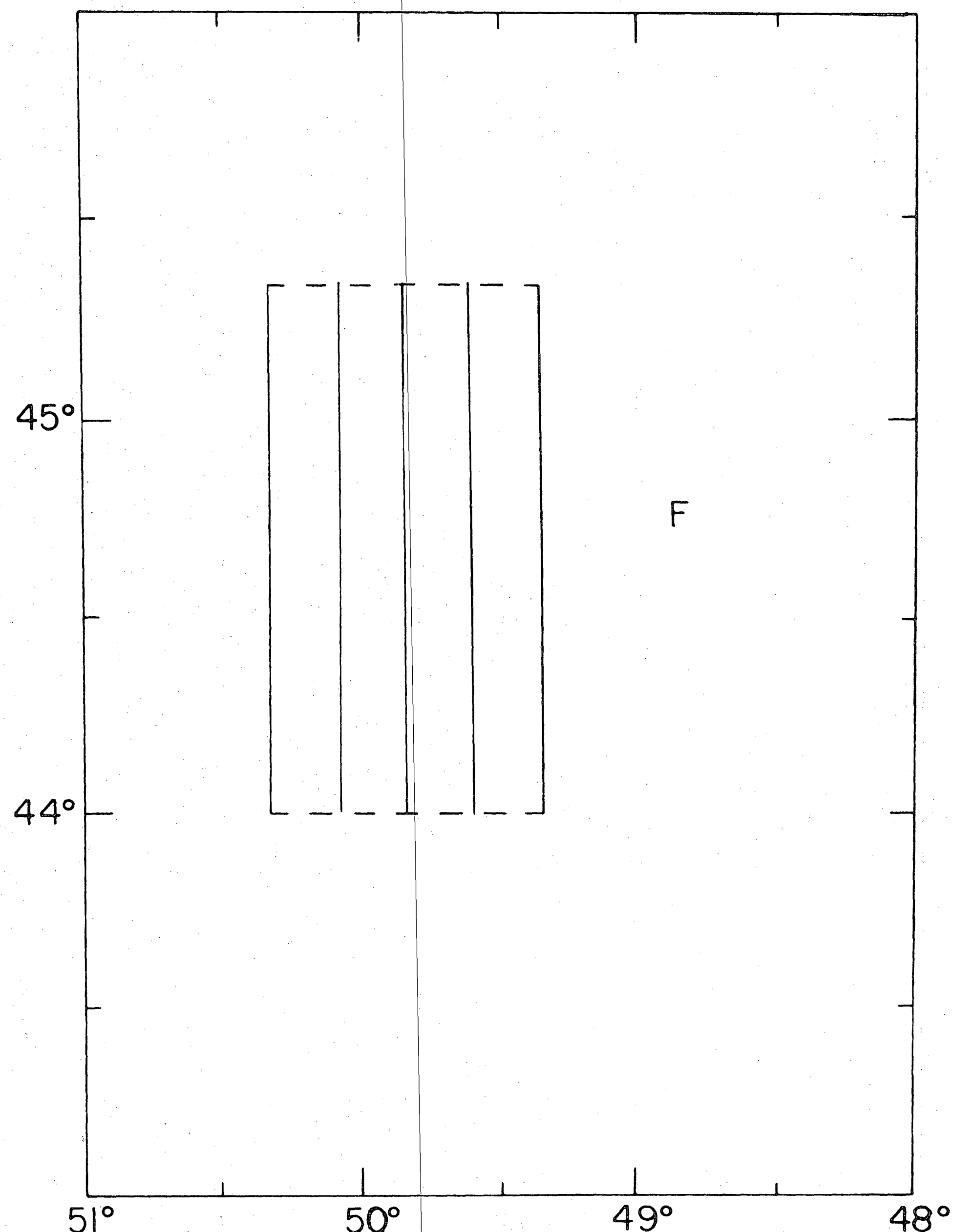

Fig. 3. Gadus Atlantica #52 Survey Track - Block F.

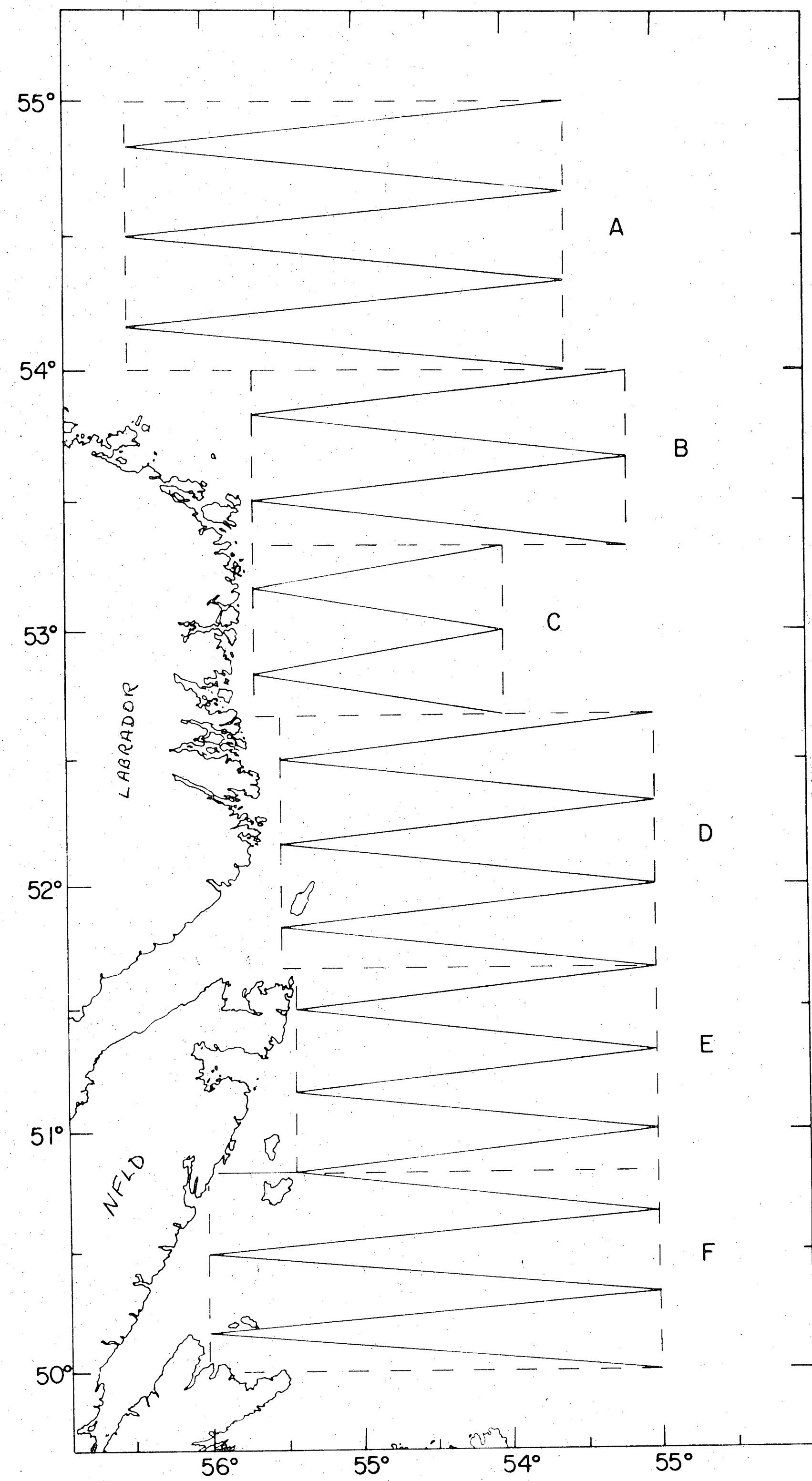

Fig. 4. Gadus Atlantica #56 Survey Tracks.

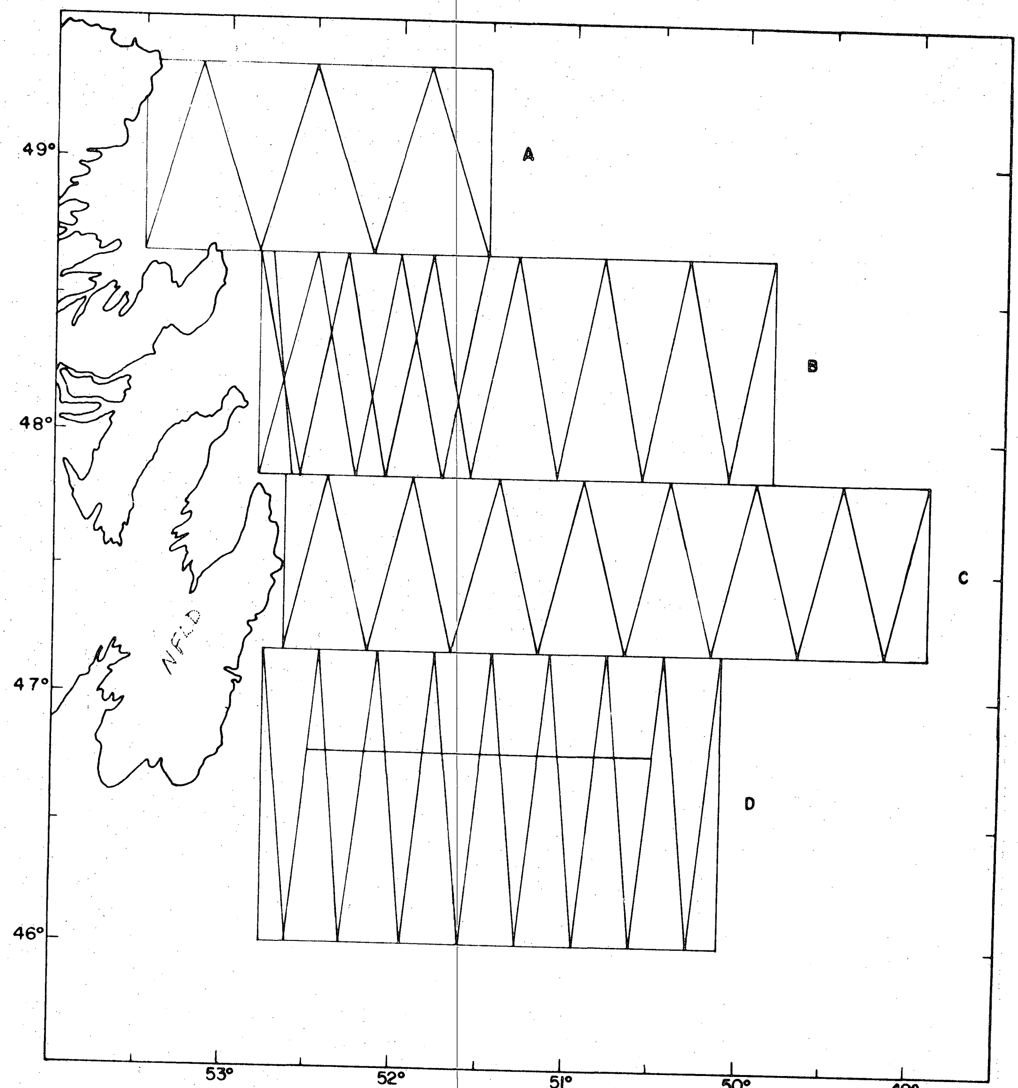

Fig. 5. Gadus Atlantica #64 Survey Tracks.

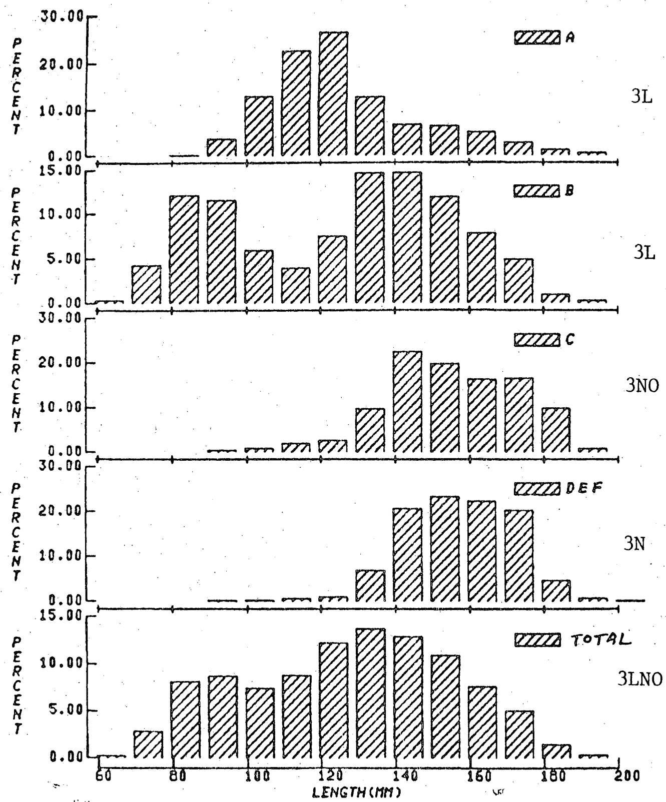

Fig. 6. Capelin length distributions, Gadus Atlantica, Cruise #52.

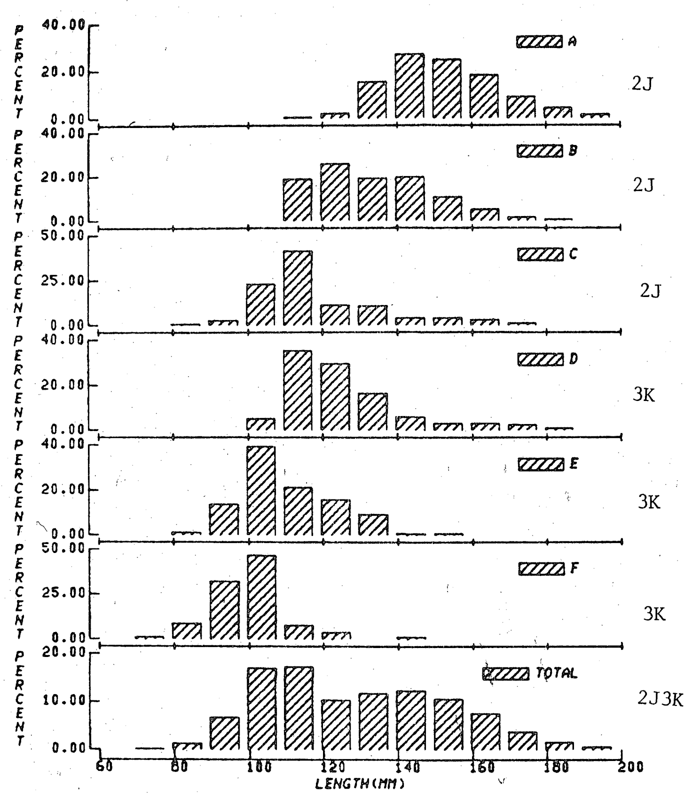

Fig. 7. Capelin length distributions, Gadus Atlantica, Cruise #56.

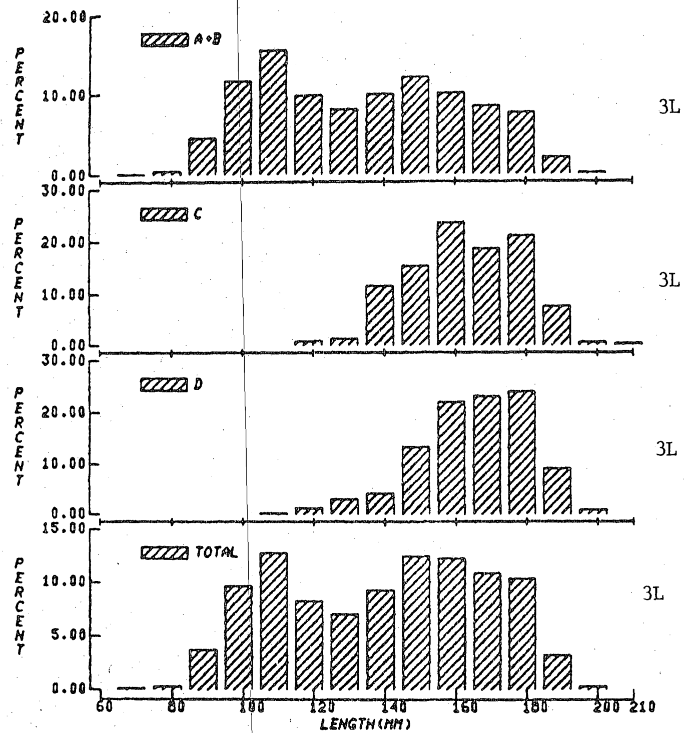

Fig. 8. Capelin length distributions, Gadus Atlantica, Cruise #64.

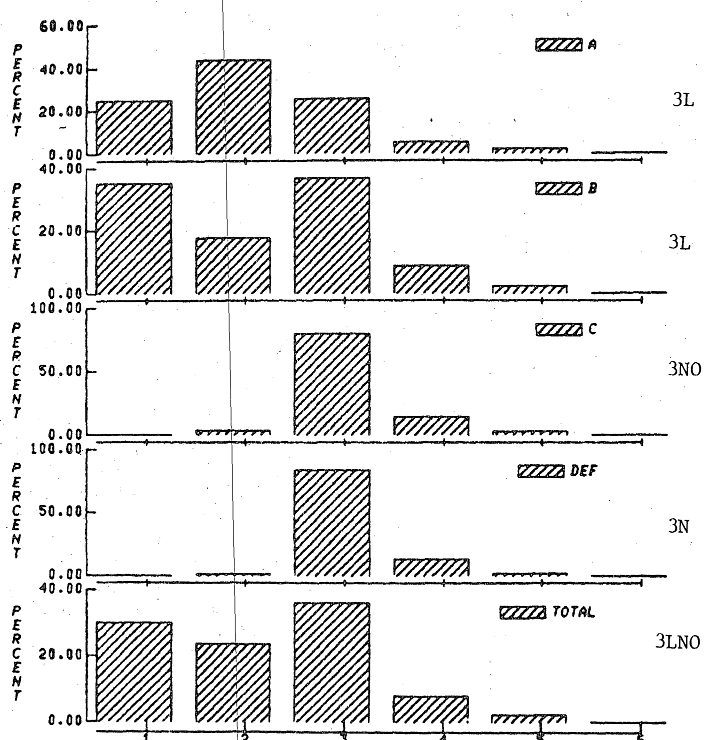

Fig. 9. Capelin age distributions, Gadus Atlantica, Cruise #52.

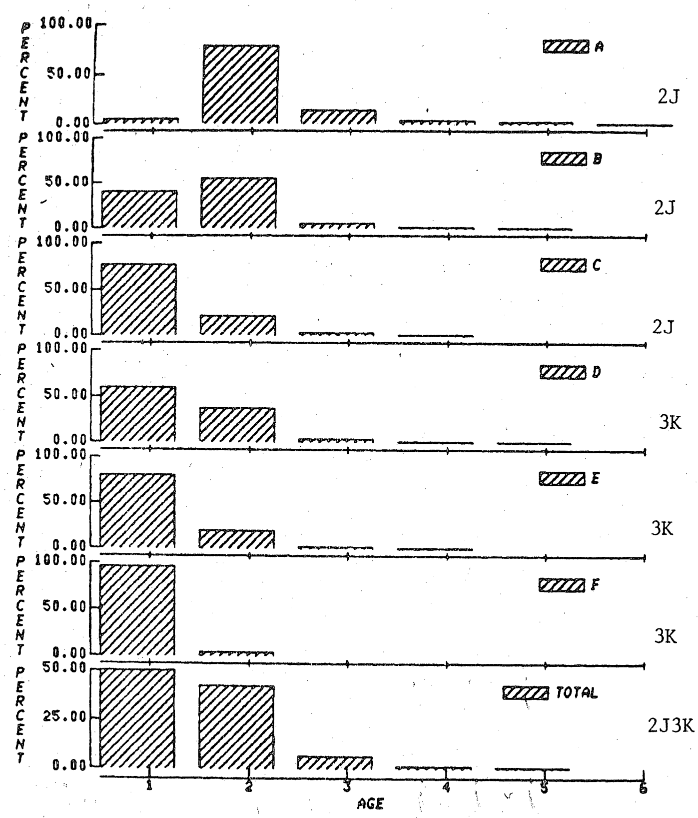

Fig. 10. Capelin age distributions, Gadus Atlantica, Cruise #56.

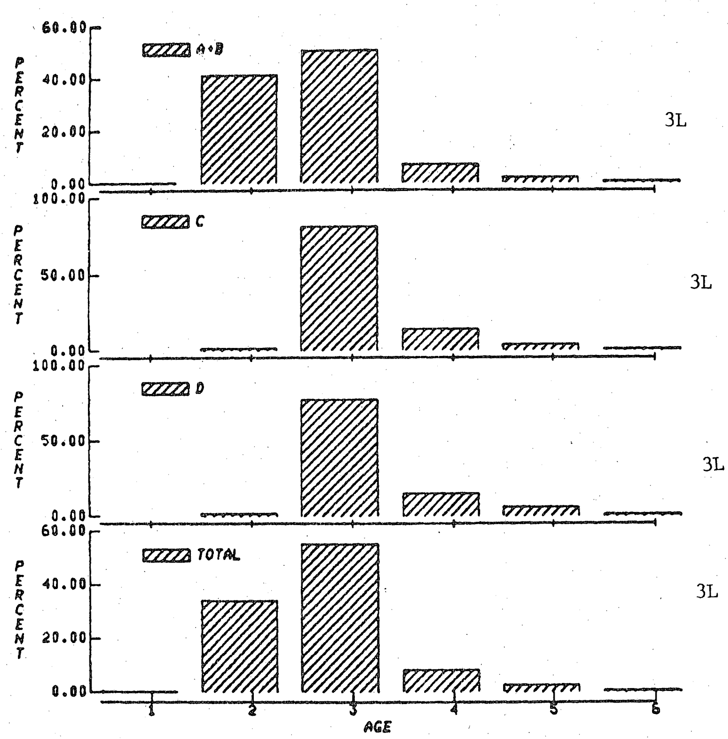

Fig. 11. Capelin age distributions, Gadus Atlantica, Cruise #64.