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Capelin Acoustic Biomass Survey for NAFO Division 2J3K, October 1983

by

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Abstract

An acoustic survey of capelin in NAFO Division 2J3K was carried out from the research vessel 'Gadus Atlantica' during the period October 2-23, 1983. Biomass for the 2J3K capelin stock was estimated to be 223,600 t. Age and length distributions of capelin sampled in the survey area are also presented.

Résumé

Du 2 au 23 octobre 1983, on a procédé à un relevé acoustique du capelan dans les divisions 2J3K de l'OPANO à partir du navire de recherche "Gadus Atlantica". On a évalué la biomasse du stock de capelan des divisions 2J3K à 223 600 tonnes. Le rapport indique également les distributions par âge et par taille du capelan échantillonné dans la zone d'études.

Introduction

The northern NAFO Division 2J3K capelin stock was exploited only in very limited inshore fisheries prior to 1972. In 1972, the U.S.S.R. initiated an intensive offshore midwater trawl fishery for capelin. Catches in 1972 were 45,600 t and rose to 216,300 t by 1976. Stock abundance decreased rapidly after 1976 and catches declined to only 11,500 t in 1979. Catches in the most recent years have been 10,000 t annually.

Quota regulation of this fishery by NAFO has been in place since 1974. Because of the short lifespan and high variability in recruitment of this species, it has been necessary to assess the stock status on an annual basis to provide advice for quota levels. Standard analytical models such as VPA and cohort analysis are not suitable for capelin stock assessment because of extremely high spawning mortality rates (1.5 to 2.0) which occur during the short reproductive phase of the life history.

A sequential capelin abundance model similar to virtual population analysis but accounting for the high spawning mortality has been developed for the 2J3K capelin stock (Miller and Carscadden 1979 (b)). The model has provided an historical perspective of capelin population dynamics but has been limited in its usefulness because of the extremely low fishing mortality rates in recent years.

Capelin are particularly well suited for hydroacoustic stock assessment for several reasons. Capelin school sizes and distribution can be highly variable depending on seasonality of the survey and age composition of the population. Acoustic surveys permit large spatial coverage in a relatively short time period allowing complete coverage of the expected range of the stock. Acoustic surveys also allow estimation of the pre-recruit portion of the stock which cannot be estimated from commercial fishing models. Acoustic surveys are independent of capelin school size, shape, and depth distribution and allow for complete coverage except for the near bottom and surface zones. Biomass estimates from these surveys are free of the potential bias inherent in using sequential abundance models that are tuned by commercial catch per unit effort indices.

An annual acoustic survey of the 2J3K stock has been carried out since 1977 (Miller et al. 1978, Miller and Carscadden 1979 (a), Carscadden and Miller 1980, Miller and Carscadden 1981, Miller et al. 1982). This paper presents the results of the 1983 acoustic survey (Gadus Atlantica Cruise #85) in Div. 2J3K conducted October 2-23.

Materials and Methods

Acoustic data were collected using a Simrad EK 400 echo sounder operating at 49 kHz with a pulse length of 0.3 milliseconds. A time-varied-gain of 20 log R +2 αR was used. Returned echo signals were demodulated and fed to a custom designed microprocessor controlled data acquisition system. This system sampled the signal at a 15 kHz sampling rate corresponding to one sample every 5 cm of water depth. Any samples exceeding a predefined threshold voltage were digitized and written to 9 track computer tape for subsequent echo integration analysis on another computer system.

Examination of the EK 400 TVG amplifier has shown that it varies significantly from an ideal 20 log R +2 α R function over the depth range of 0 to 500 m (Miller and Stevens 1984). Also, the attenuation coefficient α= 0.0122 dB/m used by Simrad is not appropriate for the salinity and temperature of waters off Labrador. Consequently, all data collected were corrected to an ideal TVG with an attenuation coefficient α = 0.0175 dB/m.

The transducer used was an Ametek-Straza SP187LT with a half power beam angle of six degrees. The transducer was housed in a remote towed body that was kept at a depth of 10-20 m below the surface at a distance of 100-150 m behind the ship to minimize any effects of vessel noise. Vessel speed was maintained at 10 knots except during bad weather when it was reduced accordingly.

The geographic area to be covered for each survey was subdivided into discrete blocks based on the expected distribution of capelin determined from earlier surveys (Fig. 1). Within each block, a systematic zigzag survey design was used.

Midwater trawl fishing sets were conducted throughout the survey to provide length and age distributions of capelin and to determine the extent of mixing with other species. Capelin target strengths were calculated for each survey block using sampling data from that block and a weight/target strength regression; T.S. (dB) = 11.56 log W (gms) - 65.95. This regression was calculated using data from *in situ* target strength measurements using live capelin specimens (U. Buerkle, pers. comm.).

Subsequent analysis of the digitized acoustic data was carried out by squaring the sample voltage (rms) levels and averaging over 1 m depth intervals. Data were accumulated over 10-minute intervals corresponding to a survey track distance of 3.1 km and averaged. The density per cubic meter (λ) for depth R is then calculated from:

$$\lambda = \overline{V}_R^2 K \text{ where } K = 10^{-(Rx + Io + \bar{b} + TS + GO + 10 \log (Ct\pi))/10} \qquad (1)$$

where $\overline{V}_R^2$ the average rms voltage squared at depth R, Rx is the receiving sensitivity of the transducer (dB), Io is the rms transmitted intensity level (dB), $\bar{b}$ is the average beam pattern factor (dB), TS is the target strength (dB), c is the speed of sound in seawater, t is the pulse length of the transmitted pressure level, and Go is the fixed gain of the echo sounder (dB). The density per square meter of surface area is then calculated by summing the individual densities per cubic meter over the depth range. If sampling within the survey block indicated the presence of other species in the acoustic sample, the density estimate was adjusted proportionally to the percentage by weight of capelin in the midwater trawl samples. An average density estimate was then calculated from these individual estimates for the entire survey block. Total biomass for the block is calculated by applying the mean block density to the total surface area of the block.

Coefficients of variation due to sampling variations only were calculated using a cluster sampling model (Nakashima 1981).

Results

Figure 1 shows the sampling blocks and cruise track followed for the survey. Location of midwater trawl and bottom trawling sets made during the survey are also indicated. Length and age compositions of capelin from sets in each survey block are shown in Figure 2. Total age and length distributions are means of the four survey blocks weighted by the total number for each block. As in surveys from previous years, small juvenile capelin were predominant in the southern survey blocks.

Tables 1 and 2 show the results of the acoustic survey for each survey block. Table 3 shows age composition both by weight and numbers of the acoustic biomass estimate for 2J3K. Table 4 shows age composition by number and weight for acoustic surveys during the period 1980-1983.

Estimates of stock biomass from acoustic surveys are directly dependent on the measure of reflectivity (target strength) of the species being surveyed. The target strength has been shown to vary greatly with swimming angle (Nakken and Olsen 1973, Haslett 1973) and can vary downwards by 400% from maximum values with changes in tilt angle as small as 5°. The major component of sound reflectivity in fish is contributed by the swim bladder and changes in the volume of this organ caused by vertical migration within the water column can also have a significant effect on the target strength value. Although mean target strength estimates are adjusted down from maximum values to compensate for tilt angle, it should still be recognized that there can be a large degree of variability in the mean target strength value, and consequently also in the acoustic biomass estimate provided from equation 1.

The Canadian inshore capelin fishery in Division 2J3K exploits mature fish of age group 3 and 4. In 1985, this fishery will exploit capelin of the 1981 and 1982 yearclasses. The 1981 yearclass is known to be much smaller than the strong 1979 yearclass (Table 4). Relative abundance at age 1 from samples taken during the acoustic surveys is not a good indicator of yearclass strength as the strong 1979 yearclass did not appear in the 1980 acoustic survey. Consequently, the strength of the 1982 yearclass cannot be predicted with confidence from samples taken during the 1983 survey.

The offshore fishery by the U.S.S.R. has historically exploited capelin of age groups 2, 3, and 4. There is no abundance estimate for the 1983 yearclass which would be in the 1985 fall offshore fishery as two-year-olds and as previously mentioned, there is no reliable estimate for the 1982 yearclass. The results from the acoustic surveys indicate that the 1981 yearclass is weak in comparison to the 1979 yearclass.

Thus, the results of this survey give no clear prognosis for 1985, either for an inshore Canadian fishery or an offshore U.S.S.R. fishery.

References

Carscadden, J. E. and D. S. Miller. 1980. Analytical and acoustic assessments of the capelin stock and Subarea 2 and Division 3K, 1979. NAFO Res. Doc. 80/13, Ser. No. N045.

Haslett, R. W. G. 1973. Automatic plotting of polar diagrams of target strength of fish in roll, pitch, and yaw. Hydroacoustics in Fisheries Research Rapports et Procès-Verbaux des Réunions, Vol. 170, p. 74-81.

Miller, D. S. and J. E. Carscadden. 1979(a). An acoustic estimate of capelin biomass in ICNAF Divisions 2J and 3K, October 1978 and Corrigendum. ICNAF Res. Doc. 79/34, Ser. No. 5360.

1979(b). Biological characteristics and biomass estimates of capelin in ICNAF Division 2J + 3K using a sequential capelin abundance model. ICNAF Res. Doc. 79/32, Ser. No. 5358.

1981. Acoustic survey results for capelin (Mallotus villosus) in Divisions 2J3K and 3LNO, 1980. NAFO Res. Doc. 81/5, Ser. No. N269.

Miller, D. S., J. E. Carscadden, and B. Bennett. 1978. An acoustic estimate of capelin (Mallotus villosus) biomass. ICNAF Divisions 2J and 3K, October and November 1977. ICNAF Res. Doc. 78/43, Ser. No. 5205.

Miller, D. S., B. S. Nakashima, and J. E. Carscadden. 1982. Capelin acoustic surveys in NAFO Divisions 2J + 3KL and 3LNO and 3L, 1981-82. NAFO Res. Doc. 82/54, Ser. No. N547.

Miller, D. S. and C. R. Stevens. 1984. Calibration of the Time-varied Gain Function in a Hydroacoustic Data Collection System. ICES C.M. 1984/B:24.

Nakashima, B. S. 1981. Sampling variation and survey design for capelin (Mallotus villosus) densities from an acoustic survey in Divisions 3LNO, 1980. NAFO Res. Doc. 81/14, Ser. No. N278.

Nakken, O. and K. Olsen. 1973. Target strength measurements of fish. Hydroacoustics in Fisheries Research Rapports et Procès-Verbaux des Réunions Vol. 170, p. 52-69.

Table 1. Summary of acoustic survey results from Gadus Atlantica Cruise 85, NAFO Divisions 2J3K.

Block	Area km^2	$\bar{W}$ (gm)	Target strength (dB)	Biomass/m^2 (gms)	Coefficient of variation	Total biomass
A	22675	8.9	54.4	1.43	0.17	32425
B	13263	6.8	55.8	4.58	0.24	60744
C	13572	15.1	51.8	6.34	0.17	86046
D	16877	19.0	50.7	2.63	0.18	44386
TOTAL	66387			3.37		223601

Table 2. Number of transects (t), total transect length, the range of mean densities ($\bar{x}i$) and the range of intervals (ni) per transect for each survey block.

Block	t	Length (km)	Range of $\bar{x}i$'s	Range of ni's
A	12	114.8	0-67.74	35-41
B	6	121.3	0-108.85	39-41
C	14	123.5	0-155.06	34-42
D	20	141.9	0-72.25	44-51

Table 3. Numbers and biomass at age, Gadus Atlantica Cruise 85, NAFO Division 2J3K.

	Age					
	1	2	3	4	5	6
Numbers (billions)	12.4	5.5	2.4	0.3	0.1	0
Biomass (000't)	78.6	82.7	53.8	8.1	0.4	0

Table 4. Comparison of yearclass contribution by number and weight for 2J3K acoustic surveys, 1980-83.

Survey year						
	Yearclass	1979	1978	1977	1976	1975
1980	N (%) *	9	50	36	4	1
	Yearclass	1980	1979	1978	1977	1976
	N (billions)	84	71	10	2	1
1981	N (%)	50	42	6	1	<1
	W (000't)	414	1063	227	57	29
	Yearclass	1981	1980	1979	1978	1977
1982	N (%) *	21	63	14	2	<1
	Yearclass	1982	1981	1980	1979	1978
	N (billions)	12	6	2	<1	<1
1983	N (%)	60	27	11	2	<1
	W (000't)	79	83	54	8	<1

* acoustic biomass estimates not available for these years

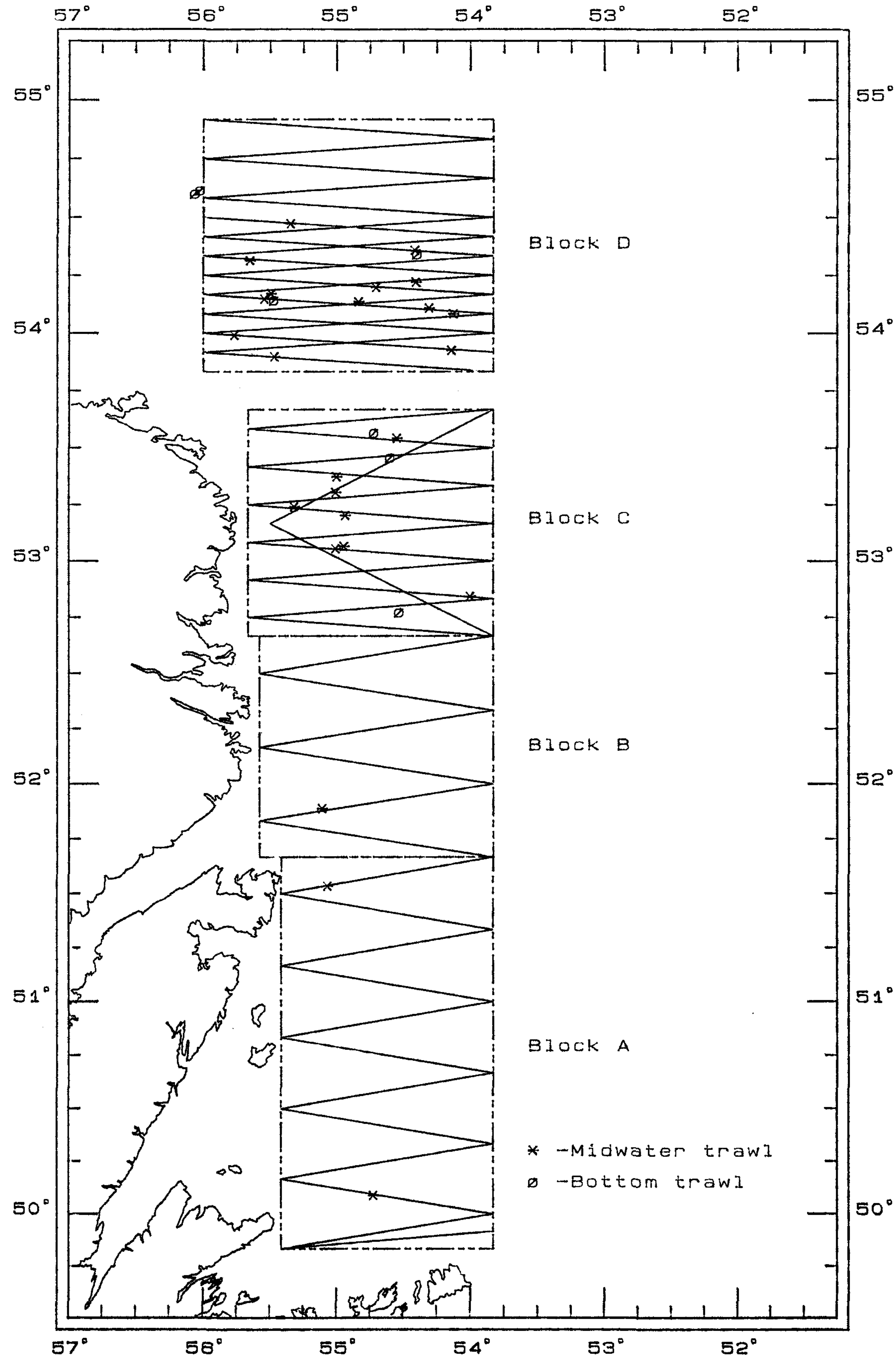

Figure 1. Survey track for Gadus Atlantica cruise #85

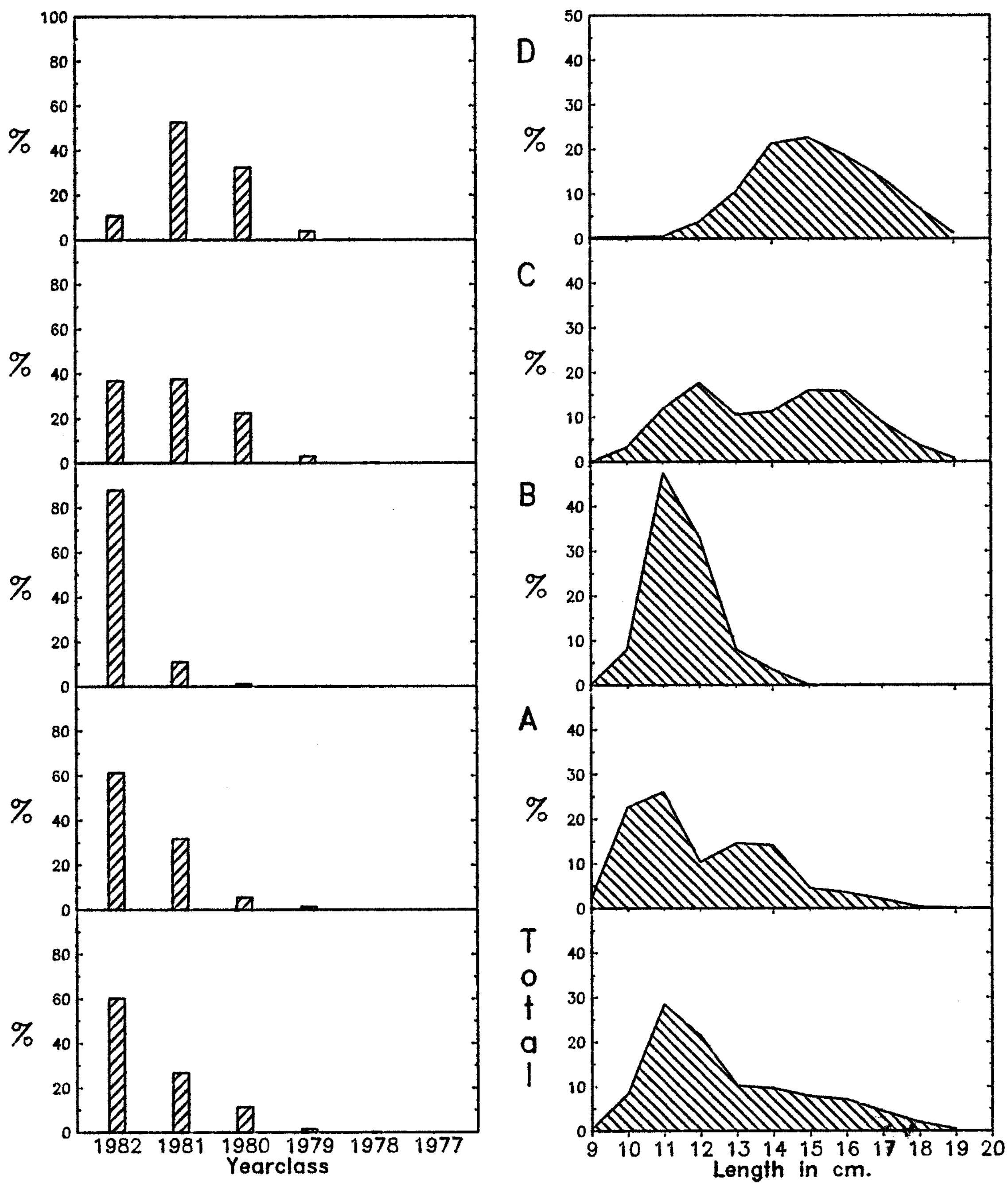

Figure 2. Age and length composition of samples from Gadus Atlantica cruise #85