International Council for
the Exploration of the Sea

C.M. 1981/H:45
Pelagic Fish Committee

STOCK SIZE AND MORTALITY ESTIMATES FOR BARENTS SEA CAPELIN BASED ON ACOUSTIC METHODS.

by

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ABSTRACT

Acoustic estimates are presented for the Barents Sea capelin for the years 1975-80 in numbers by yearclass. The estimates are combined with catch statistics to obtain natural mortality and fishing mortality. The suitability of the acoustic estimates as relative measures of stock size is discussed in view of the obtained coefficients for natural mortality.

INTRODUCTION

The Institute of Marine Research in Bergen started investigations on the Barents Sea capelin in 1960, and since the early 1970-ies, attempts have been made to assess the size of the stock based on acoustic data. The institute's advice on the management of this stock has to a large extent been based on these estimates.

This paper will be presented by T. Monstad,
Institute of Marine Research, Bergen.

Acoustic surveys during the autumn have been carried out regularly since 1970 (BLINDHEIM et al. 1971; DRAGESUND og NAKKEN, 1972; DOMMASNES et al. 1973 and 1974; BUZETA et al. 1975; DOMMASNES et al. 1975; DOMMASNES og RØTTINGEN, 1976; MONSTAD og RØTTINGEN, 1977; DOMMASNES et al. 1979). In the period 1973-79 acoustic investigations were also carried out during summer (May-June-July) (HAUG and MONSTAD, 1973; DALEN og DOMMASNES, 1974; BUZETA et al. 1976; DOMMASNES et al. 1978; DOMMASNES 1978) and since 1976 also during the winter (January). Acoustic estimates from the summer cruises tended to be rather unreliable (NAKKEN and DOMMASNES, 1977), and the acoustic survey during summer has now been abandoned. The investigations in January do not give a quantitative estimate, but provide useful information for describing the migration of different components of the stock.

The routines for collecting and organizing data as well as the general method for calculating stock size in numbers and biomass have been outlined by NAKKEN and DOMMASNES (1975, 1977).

During the first cruises these calculations were made by hand, but since 1974 the calculations have been done with the computer system on board the "G.O. Sars". The programs have gradually been improved, as more experience has been gained.

RESULTS

The acoustic estimates in numbers by yearclass from the autumn cruises 1975-1980 are presented in Table 1.

Total catches in numbers by yearclass are available for this period, and natural mortality can be calculated by the formulas below:

$$e^{-Z} = \frac{N_{t+1}}{N_t}$$

$$F = \frac{C \cdot Z}{N_t (1-e^{-Z})}$$

$$M = Z-F$$

where:

N_t is the number of a given yearclass at time t, in this case 1 October.

C is catch in numbers of the yearclass during the period 1 October - 31 September.

F and M are the instantaneous mortality coefficients from fishing and natural causes, respectively.

The input data used and the resulting values of natural mortality and fishing mortality are given in Table 2. In Table 3 the natural mortalities have been organized by age and yearclass.

DISCUSSION

The ways in which the acoustic estimates can be used in fishery management and the emphasis that can be placed on them depends on their reliability. The acoustic estimates do not necessarily give the real stock size, but may still be used as relative measures of stock size, as an index to compare stock size and fishing mortality.

If the acoustic estimates are to be used as measures of stock size, they should be consistent. In Fig. 1 the calculated numbers of each yearclass have been plotted against time. It is seen that the yearclass numbers measured as one year old capelin are too low compared to the numbers of older fish. There are two main reasons for this:

1) The area of distribution for 1 year old capelin is not properly covered during these cruises. This refers to both geographical distribution and the vertical distribution of the fish in the water column.

2) The 1 year old capelin are so small that they are caught efficiently only by the central part of the trawl. They are therefore underrepresented in the catches and in the acoustic estimates, which use the composition of the catches to distribute the measured echo intensity between yearclasses.

For two years and older fish the decline in numbers seems reasonable, although variable.

More detailed information about the consistency of the acoustic estimates from year to year is obtained from Tables 2 and 3.

The causes of natural mortality may be classified as natural mortality due to the spawning, and natural mortality due to "other causes". It is assumed that a large proportion of the capelin, probably the majority, die after spawning. A small proportion of the Barents Sea capelin mature at 3 years age, most mature at 4 years age, and almost all of the remaining at 5 years age.

Although the proportions of capelin that mature at various ages is different in different years, the natural mortality from 2 to 3 years of age is mostly due to "other causes" and should be expected to be less variable from year to year. From 3 to 4 years age "spawning mortality" is assumed to be substantial and the total natural mortality from 3 to 4 years is therefore expected to be much higher than from 2 to 3 years. From 4 to 5 years spawning mortality may be even more important and the total mortality can be expected to be highest in the older age group.

Table 3 gives natural and fishing mortalities by age and yearclass. From 2 to 3 years three of the yearclasses have a natural mortality from 0.63 to 0.67, but the 1975 and 1976 yearclasses have natural mortalities of 0.35 and 1.03, respectively.

From 3 to 4 years the natural mortalities for the 1975- and 1976 yearclasses are also conspicious, with values of 1.80 and 0.37, respectively. The other three yearclasses have values from 0.68 to 1.00.

From 4 to 5 years the 1975 yearclass is conspicious again with a natural mortality of 0.01 (no value has beeen obtained yet for the 1976 yearclass), while the other yearclasses have values from 1.16 to 2.66.

The very high natural mortalities from 4 to 5 years indicate an underestimate of the older age groups. This can be explained by the tendency of larger fish to stay near the bottom while the smaller capelin is found in midwater and can be more frequently sampled with pelagic trawl. Larger capelin are also stronger swimmers, and can more easily escape the trawl. This means that a too small part of the integrated echo intensities is assigned to the oldest fish.

A rough correction for the underrepresentation of older fish can be made by transferring fish from the younger yearclasses to the older ones. In Table 4 is given the natural mortalities obtained when 10 percent of the calculated numbers are transferred successively from 2 to 3 years, from 3 to 4 years, and from 4 to 5 years age. This "smoothes out" the natural mortalities and makes the results more consistent for all yearclasses except the 1975. This was a weak yearclass with two neighbouring strong yearclasses, and it is thus very sensitive to errors in age distribution.

As a consequence of the discrepancies in the natural mortalities that have been pointed out, considerable caution should be exercised when acoustic estimates are used in assessment work. If possible, the acoustic estimates should be compared with previous estimates of the yearclasses in question, and natural mortalities and fishing mortalities calculated. However, this is often difficult for the younger yearclasses, as no previous estimates exist.

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Table 1. Acoustic estimates of the Barents Sea capelin stock by yearclasses in the autumn (approximately 1 October) during the years 1975 - 1980. Numbers x 10^{-8}.

Year	Yearclass									
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1975	9.7	879	3041	3607	1999					
1976		127	784	1673	2407	2272				
1977			74.3	416	1017	1812	3771			
1978				7.1	143	996	3709	1100		
1979					.2	47.8	1125	3340	147	
1980						3.0	326	1541	1991	3289

Table 2. Input data (N and C) used to calculate instantaneous natural mortality (M) and instantaneous fishing mortality (F) for capelin in the Barents Sea 1975-1980.

N=population size for 2 years old and older capelin in numbers x 10^{-8} at the start of the period indicated. Obtained from acoustic estimates.

C=catch in numbers x 10^{-8} during the period indicated. Obtained from Norwegian and Russian fisheries statistics and samples from commercial and research vessel catches.

Time period		Yearclass						
		1971	1972	1973	1974	1975	1976	1977
1/10/1975-	N	879	3041	3607				
1/10/1976	C	303	586	243				
	M	1.16	1.00	.67				
	F	.78	.35	.10				
1/10/1976-	N	127	784	1673	2407			
1/10/1977	C		349	646	367			
	M		1.20	.68	.63			
	F		1.16	.72	.23			
1/10/1977-	N		74.3	416	1017	1812		
1/10/1978	C			194	482	332		
	M			2.14	.88	.35		
	F			1.93	1.08	.24		
1/10/1978-	N			7.1	143	996	3709	
1/10/1979	C				85	385	363	
	M				2.66	1.80	1.03	
	F				3.91	1.23	.17	
1/10/1979-	N				0.2	47.8	1125	3340
1/10/1980	C					44.8	563	306
	M					.012	.37	.64
	F					2.76	.87	.13
1/10/1980	N					3.0	326	1541

Table 3. Instantaneous natural mortality for Barents Sea capelin by yearclass and age, as obtained by combining acoustic estimates and catch statistics.

Age	Yearclass						
	1971	1972	1973	1974	1975	1976	1977
2 - 3 years			.67	.63	.35	1.03	.64
3 - 4 years		1.00	.68	.88	1.80	.37	
4 - 5 years	1.16	1.20	2.14	2.66	.01		

Table 4. Instantaneous natural mortality for Barents Sea capelin by yearclass and age. Based on the same data as Table 3, but after 10 percent of the calculated numbers in each yearclass have been transferred successively from 2 to 3 years age, from 3 to 4 years age, and from 4 to 5 years age within the same cruise.

Age	Yearclass						
	1971	1972	1973	1974	1975	1976	1977
2 - 3 years			.53	.46	.05	.77	.51
3 - 4 years		.91	.61	.61	1.24	.37	
4 - 5 years	1.03	1.03	1.48	1.62	.75		

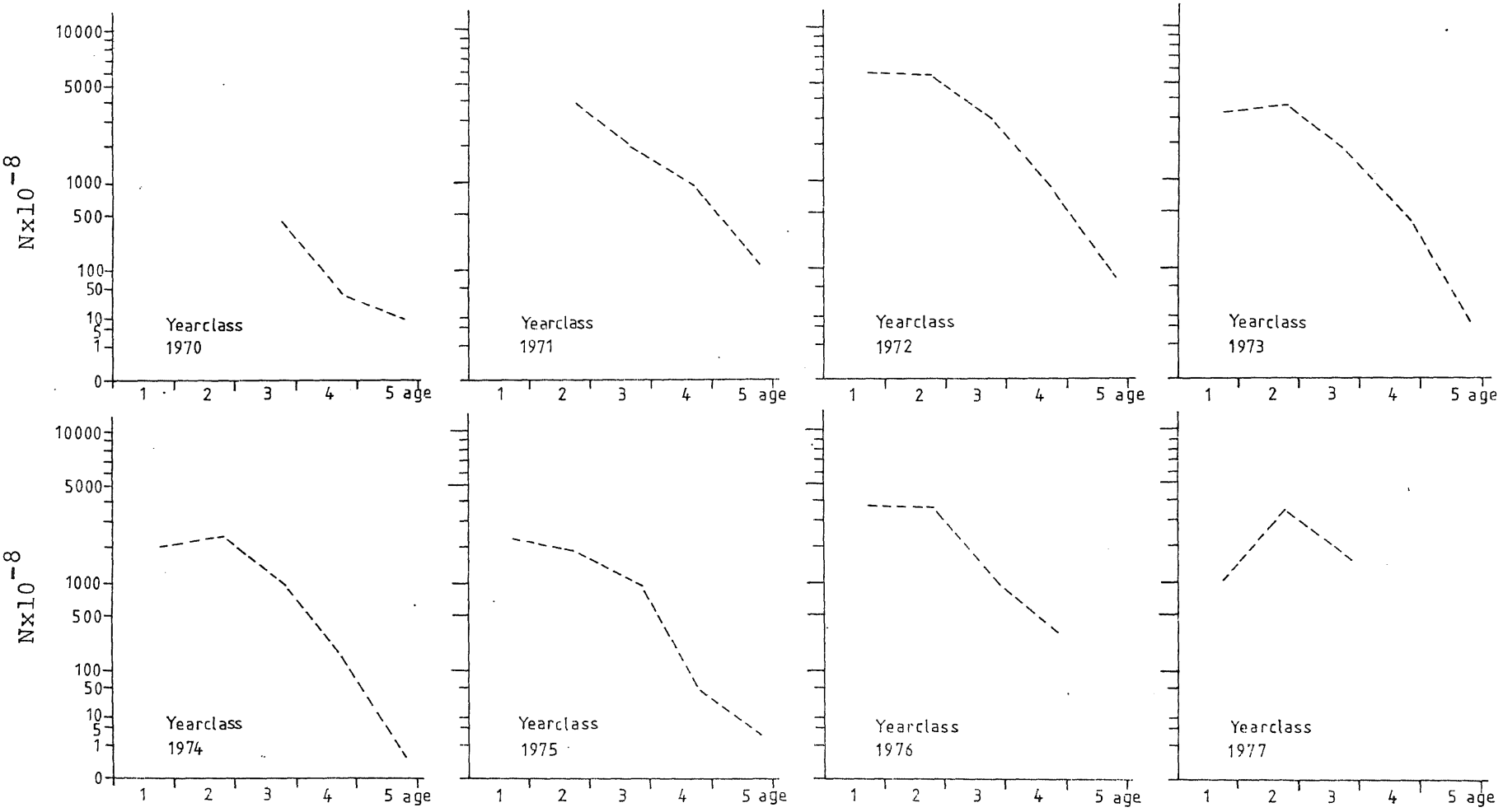

Fig. 1. Population numbers according to the acoustic estimates. Based on Table 2. (Vertical scale compressed as $\sqrt[4]{N}$).