Fol.4/Assess

This Report not to be quoted without prior reference to the Council*

International Council for the
Exploration of the Sea

C.M.1984/Assess:4

ATLANTO-SCANDIAN HERRING AND CAPELIN WORKING GROUP REPORT

ICES headquarters, 25 - 28 October 1983

This document is a report of a Working Group of the International Council for the Exploration of the Sea and does not necessarily represent the views of the Council. Therefore, it should not be quoted without consultation with the General Secretary.

*General Secretary
ICES
Palægade 2-4
DK-1261 Copenhagen K
Denmark

TABLE OF CONTENTS

- - - - - - -

ATLANTO-SCANDIAN HERRING AND CAPELIN IN SUB-AREAS V AND XIV

1. INTRODUCTION AND PARTICIPANTS

1.1 Terms of Reference

The Working Group on Atlanto-Scandian Herring and Capelin met at ICES headquarters from 25-28 October 1983 to:

1. assess the state of the Atlanto-Scandian spring-spawning herring and capelin in Sub-areas I, II, V and XIV and advise on any necessary management measures for these stocks,

2. consider the need for the introduction of a minimum size of herring to be fished in ICES statistical areas I + II, and to recommend an appropriate length of fish. The Working Group should also discuss other possible regulatory measures which would restrict the fishing mortality on the 1983 year class as juveniles,

3. establish the Atlanto-Scandian herring data base at ICES headquarters,

4. review which data are available in the Working Group files for evaluating density dependence in the parameters of the models used in fish stock assessment,

5. specify deficiencies in data required for assessment.

1.2 Participants

Prof. J Hamre (Chairman)	Norway
Mr J Jakobsson	Iceland
Mr H í Jakupsstovu	Faroes
Mr P Kanneworff	Denmark
Dr S Messieh	Canada
Mr B Nakashima	Canada
Mr I Røttingen	Norway
Dr H S Seliverstov	USSR
Mr S Tjelmeland	Norway
Dr N Ushakov	Poland
Mr H Vilhjálmsson	Iceland
Ms S Voronovskaya	USSR

2. NORWEGIAN SPRING SPAWNING HERRING

2.1 Catch Statistics

The total catch quota for the herring fishery in Norwegian coastal waters was set to 130 thousand hectolitres (approx. 12 000 tonnes). The fishery was opened 30 August 1982 and closed 15 February 1983. A minimum landing size of 25 cm, with allowance of 15% undersized fish, was also enforced.

The catch of Norwegian spring spawners north of 62°N since 1972 in terms of weight and number is presented in Tables 2.1 and 2.2. As in 1981, 5 000 tonnes were added in Table 2.2 for herring of age 3 years and older to compensate for unreported catches. The tables also include the by-catches of 0- and 1-group herring in the sprat fishery.

2.2 Stock Abundance Estimates

2.2.1 Tagging

The international tagging project as described in previous Working Group reports has been continued in 1983. Experimental fishing for recovering tagged herring was carried out in the overwintering area of Lofoten in January and on the spawning grounds off Møre in February-March. A catch of 589 tonnes of herring was taken and 59 tags were recovered. Details of stock composition and catch are given in Table 2.3. The stock in Lofoten consists mainly of old herring, whereas the stock of Møre is dominated by the first-time spawners (1979 year class).

In previous years, the adult stock occurred in two separate components: a northern component overwintering in the fjords of the Lofoten area and spawning along the coast from northern Møre to Lofoten, and a southern component overwintering in the fjords of Møre and Romsdal and spawning along the southern coast of Møre. In the mid-1970s the northern component was by far the largest and was dominated by the 1973 year class. The southern component, however, has increased in abundance faster, and is now dominated by younger age groups. This distribution pattern made it necessary to assess the stock in two separate units by allocating releases and recoveries on components according to corresponding areas.

In the following text table the percentage age compositions of the component overwintering in the Lofoten area in 1980-83 are presented:

	Year class								
Year	1979	1978	1977	1976	1975	1974	1973	1972	1971+
1980				8	3	27	47	3	12
1981			1	12	3	22	48	1	13
1982		16	3	14	2	19	40	1	5
1983	1	9	12	19	7	22	22	2	6

The table shows that the relative strength of year classes 1974/73, which has been in proportion 1:2 in previous years, has changed in 1983. The relative decrease in the 1973 year class was compensated by a corresponding increase in the year classes 1977 and 1976. Mixing of herring from the southern component with the northern component explains this change. This is confirmed by tag recoveries in Lofoten from herring tagged and released in southern Møre in 1975-80. No herring from these releases have been recovered as far north before. The recoveries found in the Møre catches do not show a similar mixing on the spawning grounds. The most important spawning grounds for the northern component were, however, not properly sampled this year due to technical difficulties.

The values shown in Table 2.3 cannot be considered representative for the total stock. The age composition and tag recoveries show that the oldest herring of the southern component have wintered in the Lofoten area together with herring from the northern stock. However, the first-time spawners (mainly the 1979 year class), which have recruited to the stock on the spawning grounds, were not present in the mixed wintering population in Lofoten.

An abundance estimate based on the tagging data may be obtained by separating releases and recoveries by age groups, assuming random mixing of the releases within each group. According to this procedure, the samples are divided into two groups; one containing the releases and recoveries of the 1976 year class and younger, and the other those of the 1975 year class and older fish. The number of tagged herring released each year and recovered in 1983 are listed below:

Year of release	m	r	m_{83}	m'	r'	m'_{83}	Total m^t	Total r^t	Total m^t_{83}
1975	25 991	3	4 128				25 991	3	4 128
1976	23 944	4	4 786				23 944	4	4 786
1977	40 033	8	10 073				40 033	8	10 073
1978	24 404	6	7 726	7 592	1	2 404	31 996	7	10 130
1979	23 519	5	9 373	12 462	3	4 966	35 981	8	14 339
1980	19 812	4	9 937	16 170	3	8 110	35 982	7	18 047
1981	6 659	5	4 204	18 387	5	11 607	25 046	10	15 811
1982	5 771	5	4 585	21 493	7	17 077	27 274	12	21 662
Sum	170 133	40	54 813	76 104	19	44 164	246 237	59	98 976

m and r denote the releases and recoveries of the year classes 1975 and older; m' and r' are those of the year classes 1976 and younger. The m_{83} denotes the estimated number of surviving tagged herring in 1983 using a total mortality rate Z = 0.23 (Anon., 1981a and 1982a).

Estimated stock strength in number is then obtained by the formula:

$$N_{83} = \frac{54813 \times 0.7 \times 427 \times 10^3}{40} = 410 \times 10^6$$

referring to the year classes 1975 and older. For the year classes 1976 and younger we have

$$N_{83} = \frac{44164 \times 0.7 \times 1336 \times 10^3}{19} = 2170 \times 10^6$$

assuming a mortality due to the tagging of 30% (Anon., 1981a and 1982a). Catches used in the above equations are shown in Table 2.3.

Taking the sample from Lofoten as representative of the older age groups and that from Møre of the younger ones (Table 2.3) we obtain the estimate shown below:

For 1975 year class and older:

	Year class						Total
	1975	1974	1973	1972	1970	1969	
Number screened ($n \cdot 10^{-3}$)	36	105	108	8	3	26	286
% composition	12	36	38	3	1	10	100
$N_{83} \cdot 10^{-6}$	49	148	156	12	4	41	410

Compared to previous years, these values are underestimating the older year classes, particularly that of 1973 (Table 2.7).

For 1976 year class and younger:

	Year class					Total
	1980	1979	1978	1977	1976	
Number screened ($n \cdot 10^{-3}$)	64	703	128	115	128	1 138
% composition	6	62	11	10	11	100
$N_{83} \cdot 10^{-6}$	122	1 350	240	218	240	2 170

The 1983 tagging estimates of the year classes 1976-78 indicate a 20% overestimate in abundance compared to previous years, projected one year ahead (Table 2.7). The estimate reduced by 20% was therefore used as basis for the assessment of the 1979 year class. This resulted in an abundance estimate for the 1979 year class of approximately $1100 \cdot 10^6$ fish.

2.2.2 Acoustic investigations on spawning grounds located between 62°N and 63°N

Herring on the spawning grounds between 62°N and 63°N have been estimated by acoustic techniques in 1982 and 1983. The methods used are described by Hagström and Røttingen (ICES, C.M.1982/B:33).

The results are shown in Table 2.4. Shown below are the acoustic estimates compared with estimates of the adult stock.

Year	Total stock in spawning areas	Acoustic estimate 62°N-63°N	% of total estimate
1982	1 306	506	39
1983	2 250	908	40

2.2.3 Virtual population analysis

VPA has been run, using the following input data:

Catch in number per year class		Table 2.2
Weight at age		Table 2.5
Natural mortality M		0.10
Maturation	3 years old	0.1
	4 years old	0.8
	5 years old	0.9
	6 years old	1.0
Initial stock		Abundance estimates from tagging in 1982.

The results of the VPA run are shown in Tables 2.6 and 2.7. The sum of age groups 4 years and older is comparable to the stock estimates obtained by tagging. The 1982 stock estimate obtained by tagging is selected as initial stock in the VPA run and the corresponding estimates obtained by tagging in 1981 and 1980 are included for comparison. An M-value of 0.10 in the VPA run gave a better fit to the estimates obtained by tagging than a value of 0.18 used last year (Anon., 1982a). It is therefore suggested that an M-value of 0.1 is used in the assessment of the adult stock.

Table 2.6 shows the back-calculated fishing mortality by age for the years 1972-83. As seen, in this table, the exploitation of Norwegian spring spawners has been kept on the same low level in 1982 as in previous years.

2.2.4 0-group surveys in 1982

The results from the Joint International 0-group Survey in the Barents Sea in 1982 show that 0-group herring were found at more stations than in previous years. However, the overall density was still very low (Anon., 1982b). An acoustic survey of 0-group herring distributed in the coastal areas of Norway was conducted in November-December 1982 (Table 2.8). It is observed that the estimate for 1982 is higher than the previous two years.

2.2.5 Larval survey in 1983

Figure 2.1 shows larval distribution charts in April 1983. The figure shows a continuous larval distribution from Stad (62°N) to Bodø (67°30'N). The number of larvae sampled in 1983 is the largest since these investigations started in 1976.

2.3 The State of the Stock

2.3.1 Adult stock

The validity of the present assessment of the adult stock depends mostly on the reliability of the 1979 year class abundance estimate. Judging from the consistency of the abundance estimates of year classes by year for the period 1980-82, the assessment of the year classes 1978 and older herring in 1982 appears to be reliable. The 1983 estimate, shown in the prognosis column in Table 2.7, is based on the 1982 estimate, projected one year ahead by adding catch and adjusting for natural mortality (M = 0.1). The last column of the table shows the estimates in 1983 obtained by tagging. The abundance of the year classes 1976-78 in 1983 based on the 1982 data is about 20% below that obtained by tagging. This indicates that the 1983 tagging data overestimate the 1979 year class by about 20%. The 1982 abundance estimates of the year classes 1978 and older, adjusted as previously discussed and supplemented with the adjusted 1983 abundance estimate of the 1979 year class obtained by tagging (1100×10^6 individuals) is thus considered the best available estimate of the present state of the adult herring stock (prognosis column in Table 2.7). This estimate shows that the stock has increased by 165 000 tonnes from 1982 to 1983, due mainly to recruitment from the 1979 year class.

2.3.2 Juvenile stock

The juvenile stock consists of the year classes 1980 to 1983, and a small component of the 1979 year class which may mature and spawn for the first time next year. According to the 0-group estimates (Table 2.8) both the year classes 1980 and 1981 are very weak, but the 1982 year class is more abundant. The latter may be of similar strength as the 1979 year class.

The report from the Joint International 0-group Survey in the Barents Sea in August-September 1983 concluded that the amount of 0-group herring in the Barents Sea was the highest since the investigations started in 1965 (Anon., 1983a).

The abundance of 0-group herring in the Barents Sea in 1983 was compared to the abundance of the 0-group in the Barents Sea in 1979 (Table 2.8 gives the abundance in the coastal area only). Abundance indices were calculated for these years and are shown in the table below:

	Year	
	1979	1983
Abundance index	8	431

Figure 2.2 gives the geographical distribution of 0-group herring in the Barents Sea in 1966, 1973, 1979 and 1983.

The Working Group concluded that the 1983 year class was very strong as 0-grup compared to any year class since the collapse of the stock in the late 1960s, and that it could well turn out to be of the same order of magnitude as the year classes which were produced in the period 1961-66. These year classes had an average strength of 17×10^9 individuals in terms of VPA estimates of 0-group fish (Dragesund and Ulltang, 1978).

2.4 Catch and Stock Prognosis

A prognosis of catch and stock size for the period 1984-86 has been run using the following input data:

Stock number x 10^{-6} in 1983	0 year old 10 000 1 year old 1 500 2 years old 150 3 years old 150 4+ 1983 estimate (Table 2.7)
Recruitment x 10^{-6}	1984 500 1985 500
Weight at age	1982 data (Table 2.5)
Maturation	as in the VPA run
Natural mortality	$M_{0-2} = 0.2$ $M_{3+} = 0.1$
Fishing pattern	$F_0 = 0.1$ $F_1 = 0.1$ $F_2 = 0.1$ $F_3 = 0.5$ $F_{4+} = 1.0$

The juvenile stock is judged according to the 0-group surveys. The 1982 year class is set to the same strength as the 1979, and 1980 and 1981 about 1/10 of that year class strength. The catch prognosis was run by assuming a catch of 20 000 tonnes in 1983 (F = 0.03) and the results are given in the text table below.

1983				Management option	1984			1985		
Stock biom.	Spawn. stock biom.	F	Catch		Stock biom.	Spawn. stock biom.	Catch	Stock biom.	Spawn. stock biom.	Catch
925	635	0.03	20	F=0	1 145	740	0	1 545	810	0
				F=0.03		740	23	1 521	780	26
				F=0.05		740	38	1 504	770	42
				F=0.10		740	74	1 464	730	79
				F=0.15		740	109	1 425	700	110

The table shows that the spawning stock will not increase to any appreciable degree from 1984 to 1985 under any management option. This is due to the poor year classes of 1980 and 1981.

However, in 1986-87 the 1983 year class will start to recruit to the spawning stock. As described earlier in this report, it is reasonable to believe that the 1983 year class is very much stronger than the relatively good 1979 year class. In view of the greatly improved prospects for recruitment to the spawning stock, a fishing mortality on the adult component of the stock in the order of F = 0.05 will have very little effect on the long-term development of the stock.

2.5 Minimum Landing Size

The effects of a minimum landing size have two main aspects:

(a) it affects the yield per recruit over a range of fishing mortality values and

(b) it affects the size of the spawning stock at various equilibrium levels of stock and yield.

Yield per recruit curves taken from Dragesund et al. (1980) for various values of age at first capture (t_c) are shown in Figure 2.3. The Figure shows that for the present low level of fishing mortality ($F < 0.05$), an introduction of a minimum landing size of herring may not affect the yield per recruit. On the other hand, this low exploitation rate reduces the yield per recruit by more than 50% compared to that obtainable at F_{max} for reasonable values of t_c (2-4).

Dragesund et al. (1980) discussed in detail the expected effects of introducing various regulation measures on the small and fat herring fisheries in the 1960s. The authors concluded that the fishery on 0- and 1-group herring constitutes the most irrational fishing strategy when the fishing mortality approaches F_{max}. By simulating the effect of various fishing strategies it was shown that if a minimum landing size protecting 0- and 1-group fish had been set in the 1960s, this regulatory measure alone could have prevented the depletion of the stock. With the same observed recruitment, an introduction of a $t_c = 2$ in the 1960s would have conserved a spawning stock in 1970 at a level of 2.4 - 4.7 million tonnes if the stock had been fished by F-values between $F_{0.1}$ and F_{max}.

Figure 2.4 shows length frequency curves of 1- and 2-year old herring sampled in the autumn and winter for two year classes with different growth rates (1974 and 1979). It is seen that a minimum legal length of 20 cm may protect the majority of the 1 year old fish even in the case of the most fast growing year classes, whereas a minimum legal size of 25 cm may protect a year class also in winter and spring as 2 years old, but not in the autumn. At present, Norway has a national regulation with a minimum legal size of 25 cm (Section 2.1).

In view of the expected future development of this stock, there was a strong feeling among several members of the Working Group that 27 cm would be an appropriate minimum legal size measure.

3. BARENTS SEA CAPELIN

3.1 Regulation of the Barents Sea Capelin Fishery

Since 1979, the Barents Sea capelin fishery has been regulated by a bilateral fishery management agreement between USSR and Norway. A TAC has been set for the winter fishery and for the autumn fishery separately. The fishery has been closed from 1 May to 15 August. A minimum landing size of 11.0 cm has been enforced, and a minimum mesh size of 16 mm introduced.

ACFM recommended in its 1982 report that:

1. the TAC for the period 1 January to 1 May 1983 should be set to 1 million tonnes;
2. the TAC for the autumn fishery (15 August to 31 December) should be in the order of 1.2 million tonnes, this being approximately half the expected catch in the 1983/84 season.

Following a recommendation from the USSR/Norwegian Fishery Commission the two countries agreed that the total catch of Barents Sea capelin in 1983 should not exceed 2.3 million tonnes, of which 1.1 million tonnes was allocated to the winter fishery. The total winter catch in 1983 amounted to 1.1 million tonnes.

3.2 Catch Statistics

The international catch by countries in the years 1965-82 is given in Table 3.1. The capelin catch (USSR and Norway combined) in numbers by age and month for the period 15 August 1982 - 30 April 1983 is given in Table 3.2. Average age of the capelin in the winter catch was higher in 1983 than in 1982. The autumn catch by the end of September 1983 is reported as 530 000 and 200 000 tonnes for Norway and USSR, respectively.

3.3 Stock Size Estimates

3.3.1 Larvae and 0-group surveys

Larval surveys based on Gulf III plankton sampler have been conducted in June each year since 1981 (Figure 3.1). The calculated total numbers by year are shown in Table 3.3. The larval production has been remarkably constant in the three years, indicating that the spawning stock has been kept on a rather constant level. The same conclusion can be drawn from the reports of the international 0-group surveys of the Barents Sea (Anon., 1981b-1983b).

The 1983 acoustic survey was carried out for the period 7 September to 1 October. Four research vessels participated in this survey. The following abundance estimate by year class was obtained:

Year class	Number x 10^{-9}	Mean weight (g)	Biomass (tonnes x 10^{-6})
1982 (1981)	515 (496)	3.1 (2.4)	1.61 (1.19)
1981 (1980)	200 (311)	9.5 (9.0)	1.89 (2.80)
1980 (1979)	38 (63)	18.9 (20.9)	0.72 (1.32)
1979 (1978)	+ (2)	19.4 (24.9)	0.01 (0.05)

The 1982 estimates of the corresponding age groups are shown in parentheses.

The 1982 year class is abundant and of similar strength as the 1981 year class measured as 1-year-old fish. The average weight of 1-year-old fish is higher in 1983 than in 1982.

The 1981 year class is considerably lower than the 1980 year class measured in 1982. This was weak compared to what would be expected from the 1981 year class measured as 1-year-old fish. The average weight of the 1981 year class was higher than that of the 1980 year class measured in 1982. Due to the low number of fish in 1983, the biomass is nearly 30% lower than that of the 1980 year class measured in 1982.

The 1980 year class is about 40% lower than the 1979 year class measured in 1982. The average weight is lower, resulting in a decrease in biomass of 3-year-old fish of nearly 50% from 1982 to 1983.

The 1979 year class has more or less disappeared. The total stock biomass is estimated as 4.2 million tonnes, compared to 5.4 million tonnes in 1982. Details of the estimate are shown in Table 3.4.

The stock size measured this year is considerably lower than would be expected from the 1982 estimate, which was the basis for the autumn 1983 TAC and the preliminary winter 1984 TAC. The text table below shows a comparison between the stock size obtained this year and the expected stock size.

	Predicted 1983		Measured 1983	
	Number	Mean weight	Number	Mean weight
1981 year class	32.0	8.2	20.0	9.5
1980 year class	13.3	18.0	3.8	18.9

The growth is better than predicted, but there is a large discrepancy in the number of fish, especially with regard to the 1980 year class. This year class was assumed to comprise the bulk of the spawning population in winter 1984. This discrepancy may have resulted from one or more of the following causes:

an overestimate of the 1982 stock;

an underestimate of the 1983 stock;

errors in the prognosis model;

a real increase in the M-value.

Both estimates of 1982 and 1983 have been recalculated by different persons, but yielded significant deviations from the original values.

Errors in the prognosis model other than errors in the M-value used (i.e., error in the maturing length) can be ruled out, for two reasons:

- Lowering the maturing length from 14.0 to 13.0 cm in 1982 decreases the 3-year-old prognosis from 13 x 10^{10} to 10 x 10^{10}, much less than could be explained from the observed number. Maturing lengths below 13.0 cm are unrealistic unless other factors are involved, such as an abrupt increase of late spawners.

- The prognosed age distribution of mature capelin shows many more 3-year-old fish than expected (see Figure 3.2). Lowering the maturing length makes the prognosed age distribution even more unrealistic.

There are, however, observations indicating that the 1982 estimate was an overestimate. The 1980 year class measured as 2-year-olds in 1982 was unaccountably strong in view of the low 0-group index measured in 1980. Also, the spawning biomass in 1980 is among the lowest observed, indicating that the measured strength of the 2-year-old fish in 1982 was too high.

Figure 3.2 shows the prognosed age distribution of the spawning stock and the associated age distribution of the March catches for the years 1978-83. In 1983 the prognosed spawning stock, based on the 1982 acoustic estimate, consists of too many 3-year-old fish compared to the March catches. This indicates an overestimate of the 2-year-olds in 1982. Substituting the 1982 estimate by the corresponding prognosed values of 3- and 4-year-old fish, and using the value from the recruitment function for the 2-year-old fish, gives the age composition shown in Figure 3.3. The age distribution of the spawning stock in 1983, obtained by ruling out the 1982 stock estimates, fits better to the observed one. Also, the number of 3-year-old fish in autumn 1983 predicted from the recruitment function gives 7 x 10^{10} which is closer to the observed value.

The possibility of an underestimate in 1983 cannot be completely ruled out. However, based upon the above discussion the 1983 estimate should be taken as the basis for the 1984 TAC regulations.

3.4 TAC for the Winter Fishery in 1984

The stock in numbers by age predicted for 1 January 1984 is calculated from the acoustic estimate shown in Table 3.4, reduced by the remaining catch quota after 1 October and a natural mortality of 0.05 $month^{-1}$. By using a maturing length of 14.0 cm and a natural mortality of 0.05 $month^{-1}$ as in previous years, the catch/spawning stock biomass relation was obtained as shown in Table 3.5.

A spawning biomass of 500 000 tonnes has been used as a guideline for the management of Barent Sea capelin. However, recent studies (Hamre and Tjelmeland, 1982) show that the yield curve has its peak value at a spawn-

ing stock level of about 400 000 tonnes. This year's surveys indicated that both the 1982 and 1981 year classes are good. A general safe-guarding limit of 500 000 tonnes for the spawning stock biomass should be used more strictly in situations of weak juvenile year classes. Therefore, the Working Group feels that a catch bringing the spawning stock biomass in 1984 somewhat below 500 000 tonnes could be allowed. The estimated spawning stock biomass in 1975 and 1979 was about 200 000 tonnes, yielding recruits of 18-20 x 10^{10} measured as 2-year-old fish. The Working Group points out that the spawning stock has been on occasions below 500 000 tonnes and still produced reasonably good recruiting year classes.

3.5 TAC for the Autumn Fishery in 1984

The autumn catch in 1984 is expected to consist mainly of the 1981 and 1982 year classes. It is expected that the 1980 year class would be depleted as 4-year-old fish due to the present low number of fish and the fast maturation resulting from the present high growth rate. The change in age structure towards younger fish in recent years has resulted in fewer age groups in the catchable stock. This makes the TAC calculation for a period 1½ year ahead in time more uncertain. The TAC will depend, to a larger extent, on the recruiting year class strength.

Spawning stock indices for the winter 1985 are shown in Table 3.6. The assumptions underlying these calculations are: maturing length of 14.0 cm, natural mortality of 0.05 $month^{-1}$, growth as in 1982 and a strength of 2-year-olds in 1984 of 270 x 10^9. The latter figure is considered a realistic value in view of the good abundance index for the 1-year-old fish in 1983. Equal catches for the autumn 1984 and winter 1985 seasons have been assumed. This has been the practice in previous years.

The consequence of failing of one or more of the assumptions underlying the 1½ year forecast calculation can be made less severe by allocating a smaller fraction of the catch on the autumn fishery. A wrong prognosis may then have a smaller effect on the autumn stock. Therefore, an autum catch of 600 000 tonnes is recommended. This would imply a winter catch in 1985 somewhat above 800 000 tonnes.

4. THE ICELANDIC CAPELIN

4.1 The Fishery

The fishery up to and including the 1982 winter season has been described by previous Working Groups. The total international catch from 1971 onwards is shown in Table 4.1. This includes catches from Sub-areas V, XIV and catches during the summer off Jan Mayen in Division IIa.

Due to the poor state of the 1983 spawning stock, a complete fishing ban was recommended by ACFM at its meeting in July 1982 until further management advice could be given after the completion of the Joint Icelandic-Norwegian Acoustic Stock Assessment Survey in October 1982. On the basis of the results from this survey ACFM recommended a complete fishing ban on the 1983 spawning stock at its meeting in November 1982. In view of uncertainties regarding the abundance of the 1984 spawning stock, ACFM further recommended that a complete fishing ban be in force until further management advice could be given.

This advice was accepted by all parties concerned and to date there has been no fishing conducted upon this stock of capelin as of the 1982 winter season when the catch was 13 000 tonnes.

4.2 Estimates of the 1984 Spawning Stock Abundance

The 0-group index of the 1981 year class, which was expected to be the most important contributor to the 1984 spawning stock by far, was comparatively low. Additional evidence on the abundance of the 1981 year class obtained during acoustic surveys in August and October 1982 did, however, indicate a spawning stock in March-April 1984 of more than 400 000 tonnes, providing no fishing took place. In its report from 27-29 October 1982 the Herring and Capelin Working Group pointed out that these estimates were, however, highly uncertain and could not for various reasons be compared to other estimates of the abundance of older year classes (Anon., 1983a).

In October 1983 Iceland and Norway carried out an acoustic survey of the distribution and abundance of the Icelandic capelin stock as has been the practice since 1978. The resulting stock abundance estimate and, for comparison, the corresponding values from the 1980-82 surveys are shown in the following text table:

	1983		1982		1981*		1980	
Age	N x 10^{-9}	T x 10^{-3}	N x 10^{-9}	T x 10^{-3}	N x 10^{-9}	T x 10^{-3}	N x 10^{-9}	T x 10^{-3}
1	44.1	225	68.0	260	24.0	90	23.6	171
2	75.8	1 142	16.6	262	23.8	420	19.6	378
3	5.6	127	1.6	39	0.6	15	4.8	128
Total	125.5	1 494	86.2	561	48.4	525	48.0	677

*This estimate was obtained in November 1981 and back-calculated to correspond to the other surveys. The 1981 October survey was inconclusive because of extensive drift ice.

Judging by the length and maturity stage approximately 970 000 tonnes comprising all the 1980 year class and the majority of the 1981 year class will spawn in March-April 1984.

This year there was no interference by drift ice and the coverage of the distribution area of the capelin as well as general working conditions appeared to be satisfactory.

4.3 O-Group Abundance

Comparative measurements of O-group capelin have been obtained annually since 1972. Indices from these measurements are shown in Table 4.2.

The 1982 O-group index is the lowest on record after the 1983 index. As pointed out on previous occasions the downward trend observed since 1976 coincides with the increase in fishing effort and catches in the 1976-81 period. During the last five years, when estimates of spawning stock abundance have been available, a similar trend is observed in parent stock abundance as in the resulting O-group indices (Table 4.2).

4.4 Abundance of Juvenile 1-2-Group Capelin

In the past it has proved difficult to assess the relative or absolute abundance of the juvenile 1-2-group capelin. This is mainly because of their frequent distribution in or near areas which are periodically covered by drift ice and consequently impassable.

From the autumn acoustic abundance surveys conducted annually since 1978 it is evident that because of ice conditions and several other factors they were inadequate with regard to juvenile 1-group capelin in the period 1978-81.

However, in view of the apparently comparable coverage of this stock component during the 1982 and 1983 surveys, the abundance estimates obtained for the 1981 and 1982 year classes as 1-group fish during those surveys were considered comparable.

The difference, therefore, reflects a considerably reduced abundance of the 1982 year class as compared to that of 1981 as shown in the text table on page 13.

The above conclusion is further supported by the O-group indices of the 1981 and 1982 year classes which were 29 and 13 respectively (Table 4.2).

4.5 TAC for the Autumn Fishery 1983 - Winter Fishery 1984

Since most of the capelin spawn only once and die thereafter, the main management objective is to prevent the stock from being reduced to the level of reduced recruitment not to mention recruitment failure. Since 1979, management advice has aimed at preserving a spawning stock of 400 000 tonnes. However, this objective has not been reached except in 1979.

In view of previous years' experience the autumn and winter catch is presumed to consist exclusively of maturing capelin.

The October estimate of stock abundance was used as a basis for calculating the abundance of capelin maturing to spawn in 1984. As judged from the length and maturity stage the abundance of maturing capelin in mid-October is about 970 000 tonnes.

Taking the October estimate of maturing capelin, assuming a monthly natural mortality of 0.04 until 31 December and 0.08 during January-March, and allowing 400 000 tonnes to spawn in 1984, the Working Group recommends a TAC of 375 000 tonnes to be divided about equally between the autumn 1983 and winter 1984 seasons.

4.6 TAC for the Autumn 1984 Fishery

The main contributor to the 1985 spawning stock and consequently the fishery during this period will be the 1982 year class. On the basis of the October 1983 survey it is, however, surmised that a proportion of the 1981 year class will not mature to spawn in 1984 but will contribute to the 1985 spawning stock.

Using the data from the October 1983 survey and reducing them with a monthly natural mortality of 0.04, the Working Group has calculated that the abundance of maturing capelin will be about 650 000 tonnes on 1 August 1984. Allowing 400 000 tonnes to spawn in 1985, this would allow a TAC of about 100 000 tonnes in the period August 1984 - March 1985.

In view of the very low abundance of the Icelandic capelin stock in recent years as well as the extremely low 0-group index in 1982, the Working Group recommends that a preliminary TAC of 50 000 tonnes be set for the autumn fishery in 1984. This TAC should be reassessed and adjusted if necessary when a new stock abundance estimate becomes available.

5. DENSITY-DEPENDENT PARAMETERS

It was agreed that the most important density-dependent parameters which directly affect stock assessment are the growth rate and natural mortality. Growth rate is linked with age at first maturity and fecundity and their variation with stock size.

The Working Group stressed the importance of these two parameters for stock assessment. However, it was felt that the data bases available in ICES' member countries is not suitable at present for studying the variations in natural mortality rates. As far as growth parameters are concerned, several members stated that some data are available but require further analyses before these data can be used in stock assessment.

In Canada several scientists are currently working on various aspects related to density dependence in pelagic fish stocks in the northwest Atlantic. Some of the questions being addressed relate to responses in growth, fecundity, and age at maturity with respect to changes in stock size of herring and capelin. The data are in various stages of compilation and analyses and no results are readily available.

- - - - - - -

REFERENCES

Anon., 1981a. Report of the Atlanto-Scandian Herring and Capelin Working Group, Part I. Copenhagen, 12-14 May 1981. ICES, C.M.1981/H:11.

Anon., 1981b. Preliminary report of the International 0-group Fish Survey in the Barents Sea and Adjacent Waters in August-September 1981. ICES, C.M.1981/G:78.

Anon., 1982a. Atlanto-Scandian Herring and Capelin Working Group Report. Part I. Copenhagen, 4-6 May 1982. ICES, C.M.1982/Assess:12.

Anon., 1982b. Preliminary report of the International 0-group Fish Survey in the Barents Sea and Adjacent Waters in August - September 1982. ICES, C.M.1982/G:44.

Anon., 1983a. Preliminary report of the International 0-group Fish Survey in the Barents Sea and Adjacent Waters in August - September 1983. ICES, C.M.1983/G:35.

Anon., 1983b. Report of the Atlanto-Scandian Herring and Capelin Working Group. Copenhagen, 27-29 October 1982. ICES, C.M.1983/Assess:4.

Dragesund, O., Hamre, J. and Ulltang, Ø. 1980. Biology and population dynamics of the Norwegian spring spawning herring. Rapp. P.-v. Réun. Cons. int. Explor. Mer., 177:43-71.

Dragesund, O. and Ulltang, Ø. 1978. Stock size fluctuations and rate of exploitation of the Norwegian spring spawning herring, 1950-1974. Fisk Dir. Skr., Ser. Havunders., 16:315-337.

Hagström, O. and Røttingen, I. 1982. Measurements of the density coefficient and average target strength of herring using purse seine. ICES, C.M.1982/B:33.

Hamre, J. and Tjelmeland, S. 1982. Sustainable yield estimates of the Barents Sea capelin. ICES, C.M.1982/H:45.

Table 2.1. Catches north of 62°N of Norwegian Spring Spawning Herring (tonnes) since 1972.

Year	Catches of adult herring in winter[1]	Mixed herring fishery in autumn[2]	By-catches of 0- and 1-group herring in the sprat fishery
1972	0	9 895	3 266[3]
1973	139	6 602	276
1974	906	6 093	620
1975	53	3 372	288
1976	0	247	189
1977	374	11 834	498
1978	484	9 151	189
1979	691	1 866	307
1980	878	7 634	65
1981	844	7 814	78
1982	983	10 447	225
1983	3 370[4]		

1) Mostly experimental fishing
2) Includes also by-catches of adult herring in other fisheries
3) In 1972 there was also a directed herring 0-group fishery
4) Preliminary 1 January - 30 June 1983

Table 2.2. Catch in number, millions, Norwegian Spring Spawners. Unreported catches are included for 3-year and older herring.

Age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	347 100	29 300	65 900	30 600	20 100	43 000	20 100	32 600	6 900	8 300	22 600
1	41 000	3 500	7 800	3 600	2 400	6 200	2 400	3 800	800	1 100	1 100
2	20 400	1 700	3 900	1 800	1 200	3 100	1 200	1 900	400	11 900	200
3	35 376	2 389	100	3 268	23 248	22 103	3 019	6 352	6 407	4 166	13 817
4	3 476	25 220	241	132	5 436	23 595	12 164	1 866	15 814	4 591	7 892
5	3 583	651	24 505	910	000	336	20 315	6 865	2 278	8 596	4 507
6	2 481	1 506	257	30 667	000	000	870	11 216	8 165	2 200	6 258
7	694	278	196	005	13 086	419	000	326	15 838	4 512	1 960
8	1 486	178	000	002	000	10 766	620	000	441	8 280	5 075
9	198	000	000	000	000	000	5 027	000	008	345	6 047
10	000	000	000	000	000	000	000	2 534	000	103	121
11	494	000	000	000	000	000	000	000	2 688	114	037
12	593	000	000	000	000	000	000	000	000	964	037
13	593	000	000	000	000	000					037
14	000	178	000	000	000	000					

Table 2.3. Age composition (%) and catch in number (N x 10^{-3}) screened for tags in winter 1983.

Area		1980	1979	1978	1977	1976	1975	1974	1973	1972	1970	1969	Total	1975+
Lofoten	Stock comp.		1	9	12	19	7	22	22	2	1	5	100	59
	Catch		5	44	57	92	36	105	108	8	3	26	484	286
Møre	Stock comp.	5	55	10	9	10	3	6	2				100	11
	Catch	64	703	128	115	128	38	77	26				1 279	141
	Total catch	64	708	172	172	220	74	182	134	8	3	26	1 763	427

Table 2.4. Acoustic estimates of herring on spawning grounds between 62°N and 63°N.

Year	Year class (N x 10^{-6})									Total	Tonnes (x 10^{-3})
	1980	1979	1978	1977	1976	1975	1974	1973	1972+		
1982		127	80	133	155	41	57	34	6	633	169
1983	35	440	141	71	121	45	71	19		943	237

Table 2.5. Average weight at age, in grammes, Norwegian Spring Spawners, 1973-82.

	Year class									
Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
3	170	181	181	181	180	178	175	170	170	155
4	259	259	259	259	294	232	283	224	204	249
5	342	342	342	342	326	359	347	336	303	304
6	384	384	384	384	371	385	402	378	355	368
7	409	409	409	409	409	420	421	387	383	404
8	444	444	444	444	461	444	465	408	395	424
9	461	461	461	461	476	505	465	397	413	437
10	520	520	520	520	520	520	520	520	453	436
11	543	543	543	543	543	551	534	543	468	493
12	412	412	412	412	500	500	500	512	512	480
13										470

Table 2.6. Calculated fishing mortality, Norwegian Spring Spawners, 1973-82, M = 0.10.

	Year class									
Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
3	0.100	0.017	0.121	0.033	0.057	0.033	0.017	0.038	0.017	0.012
4	0.041	0.023	0.019	0.266	0.039	0.036	0.023	0.047	0.031	0.037
5		0.131	0.130	0.000	0.019	0.038	0.023	0.032	0.029	0.035
6			0.215	0.000	0.000	0.065	0.024	0.032	0.035	0.024
7				0.120	0.078	0.000	0.025	0.039	0.020	0.036
8					0.123	0.145	0.000	0.038	0.023	0.025
9						0.070	0.000	0.003	0.033	0.019
10							0.041	0.000	0.036	0.015
11								0.051	0.036	0.015
12									0.022	0.015
Average F(3-12)	0.120	0.128	0.193	0.051	0.052	0.040	0.022	0.039	0.024	0.019

Table 2.7. Stock estimates of Norwegian Spring Spawners 3 years and older in million individuals M = 0.10. The two figures in bracket are backcalculated from the subsequent year. Spawning biomass is in 1 000 tonnes. For further explanation see text.

Age	VPA 1973	VPA 1974	VPA 1975	VPA 1976	VPA 1977	VPA 1978	VPA 1979	VPA 1980	Tagging 1980	VPA 1981	Tagging 1981	Tagging 1982	Prog. 1983	Tagging 1983
3	13	6	30	748	421	98	410	180	(181)	257	(247)	(1 217)	100	122
4	260	9	6	24	655	360	86	365	223	157	138	223	1 100	1 350
5		210	8	5	17	570	314	76	80	315	295	138	196	240
6			167	6	4	15	496	278	276	67	58	276	122	218
7				121	6	4	13	439	395	243	235	59	243	240
8					97	5	4	11	21	381	400	214	52	42
9						78	4	3	0	10	7	340	188	148
10							66	3	0	3	7	9	299	156
11								57	82	3	0	3	8	12
12										48	86	3	3	0
13												41	3	4
14													36	41
Total	273	225	211	904	1 200	1 130	1 393	1 412	1 258	1 484	1 479	2 523	2 350	2 573
Spawn. stock	198	198	182	227	689	913	975	1 170	-	1 192	-	1 375	2 020	-
Spawn. biom.	64	67	68	79	196	300	359	445	-	435	-	470	635	-

Table 2.8. Norwegian Spring Spawners. Acoustic abundance estimates of 0-group herring in 1975-82 ($N \times 10^{-6}$)

Year	Area			Total
	62°N-65°N	65°N-68°N	North of 68°30'	
1975	328	692	55	1 075
1976	415	2 610	750	3 775
1977	70	305	37	412
1978	302	511	392	1 205
1979	909	2 260	288	3 457
1980	12	4	218	234
1981	262	2	1	265
1982	64	571	2 301	2 936

Table 3.1. International catch of Barents Sea capelin (1 000 tonnes) in the year 1965-82.

Year	Norway	USSR	Other	Total
1965	217	7		224
1966	380	9		389
1967	403	6		409
1968	522	15		537
1969	679	1		680
1970	1 301	13		1 314
1971	1 371	21		1 392
1972	1 556	37		1 593
1973	1 291	45		1 336
1974	987	162		1 149
1975	943	431	43	1 417
1976	1 949	596		2 545
1977	2 116	822	2	2 940
1978	1 122	747	25	1 894
1979	1 109	669	5	1 783
1980	999	641	9	1 649
1981	1 238	721	28	1 987
1982	1 158	596	5	1 759

Table 3.2. Capelin catches in the Barents Sea in August-December 1982 and in January-April 1983 in numbers

	Numbers x 10^{-9}								
	1 9 8 2					1 9 8 3			
Age	August	September	October	November	December	January	February	March	April
1		0.61	0.41	0.04	0.01				0.04
2	5.88	9.79	4.17	1.13	0.42	0.02	0.01		0.37
3	8.71	9.31	3.68	1.33	1.40	5.23	3.24	3.21	1.17
4	0.50	0.51	0.18	0.15	0.15	12.64	9.47	9.69	0.83
5	0.01	0.02	0.01		0.01	0.90	3.18	2.14	0.16
6+					0.01		0.15	0.13	
SUM	15.10	20.24	8.45	2.65	2.00	18.79	16.05	15.17	2.57

Table 3.3 Total number (N x 10^{12}) of capelin larvae for the years 1981-83.

Year	Area				Total
	16°-25°E	25°-28°E	28°-31°E	31°→east	
1981	5.4	2.4	1.5	0.4	9.7
1982	1.6	3.2	3.3	1.8	9.9
1983	4.4	1.8	2.3	1.4	9.9

Table 3.4. Acoustic estimate autumn 1983.

Total length (cm)	AGE GROUP					Total number x 10^{-7}	Biomass tonnes x 10^{-3}	Biomass (Cumulative)
	1	2	3	4	5			
6.5- 6.9	527					527	5.3	
7.0- 7.4	718					718	7.2	
7.5- 7.9	1 016					1 016	10.9	
8.0- 8.4	2 756					2 756	55.7	
8.5- 8.9	9 643					9 643	208.3	
9.0- 9.4	11 953	146				12 099	340.1	
9.5- 9.9	10 966	291				11 257	353.2	
10.0-10.4	6 710	440				7 150	278.1	
10.5-10.9	3 815	1 571				5 386	249.8	
11.0-11.4	2 161	2 339				4 500	249.1	
11.5-11.9	849	2 467				3 316	212.6	
12.0-12.4	216	3 013	27			3 256	248.3	
12.5-12.9	144	2 393	64			2 601	231.1	
13.0-13.4	14	2 212	232			2 458	253.0	
13.5-13.9		1 425	252			1 677	199.2	
14.0-14.4	5	1 152	532			1 689	231.2	1 327.8
14.5-14.9	9	812	466			1 287	199.4	1 096.6
15.0-15.4		734	521	7		1 262	225.6	897.2
15.5-15.9		388	438	6		832	168.8	671.6
16.0-16.4	9	278	545	14		846	192.0	502.8
16.5-16.9		165	277	9		451	117.1	310.8
17.0-17.4		107	264			371	106.1	193.7
17.5-17.9		33	133			166	54.1	87.6
18.0-18.4		11	36			47	16.1	33.5
18.5-18.9		18	22			40	16.1	17.4
19.0-19.4		1	2			3	1.3	1.3
Number x 10^{-7}	51 511	19 996	3 811	36		75 354		
Number > 14.0 cm	23	3 699	3 236	36		6 994		
Biomass (tonnes x 10^{-3})	1 609.1	1 893.3	720.4	7.0			4 229.8	
Mean length (cm)	9.5	12.7	15.4	16.1		10.7		

Table 3.5. Catch/spawning stock biomass for the winter fishery 1984 (1 000 tonnes)

Catch	750	630	520	410	300	195
Spawning stock biomass	100	200	300	400	500	600

Table 3.6. Catch/spawning stock biomass for the autumn fishery 1984 / winter fishery 1985 (1 000 tonnes)

Catch autumn 1984	Catch winter 1985	Spawning stock 1985
890	890	300
800	800	400
725	725	500
650	650	600

Table 4.1. The total annual and seasonal catch of capelin in the Iceland, E-Greenland, Jan Mayen area

Year	Winter season		Summer and autumn season				Total
	Iceland	Faroes	Iceland	Norway	Faroes	EEC	
1964	8.6						8.6
1965	49.7						49.7
1966	124.5						124.5
1967	97.2						97.2
1968	78.1						78.1
1969	170.6						170.6
1970	190.8						190.8
1971	182.9						182.9
1972	276.5						276.5
1973	440.9						440.9
1974	461.9						461.9
1975	457.6		3.1				460.7
1976	338.7		114.4				453.1
1977	549.2	25.0	259.7				833.9
1978	468.4	38.4	497.5	154.1			1 158.4
1979	521.7	17.5	441.9	126.0	2.5		1 109.6
1980	392.0		367.2	118.6	24.4	14.3	916.5
1981	156.0		484.6	91.4	16.2	20.8	769.0
1982	13.0						13.0
1983	0.0						

Table 4.2. 0-group indices 1972-83 and abundance of parent stock 1979-83

Year	0-group index	Parent stock 1 000 tonnes
1972	89	
1973	116	
1974	134	
1975	89	
1976	60	
1977	43	
1978	31	
1979	49	600
1980	41	300
1981	29	160
1982	13	140
1983	22	260

Figure 2.1. Distribution of herring larvae pr. m^2 surface in 1983.

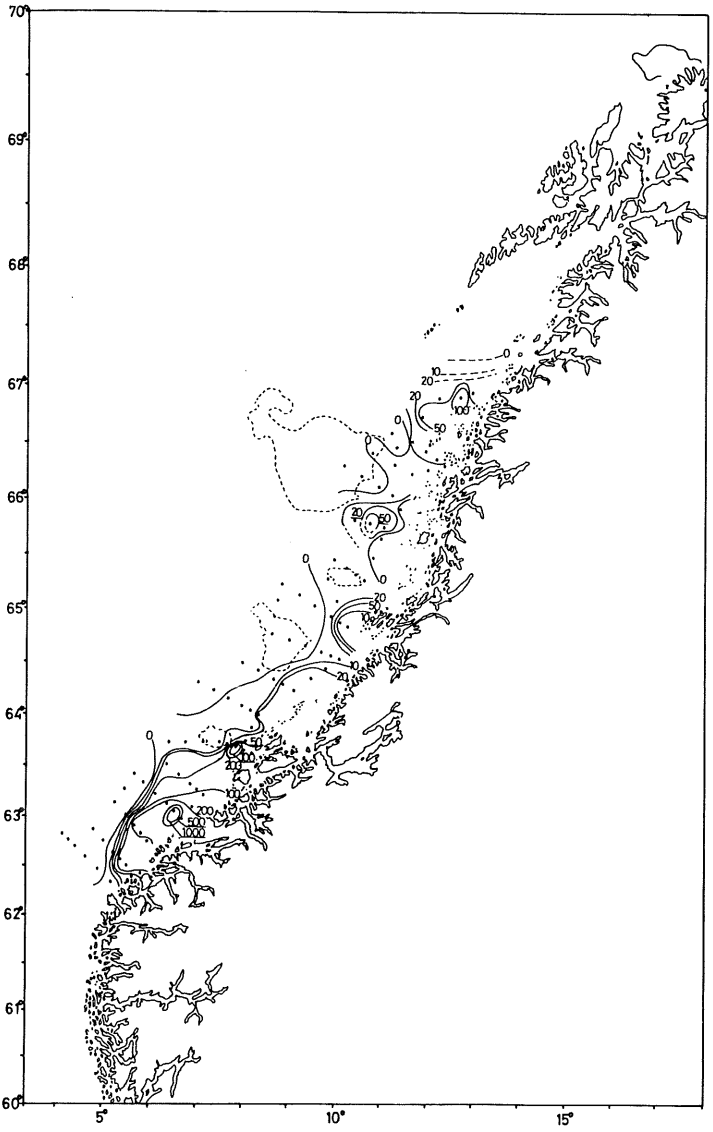
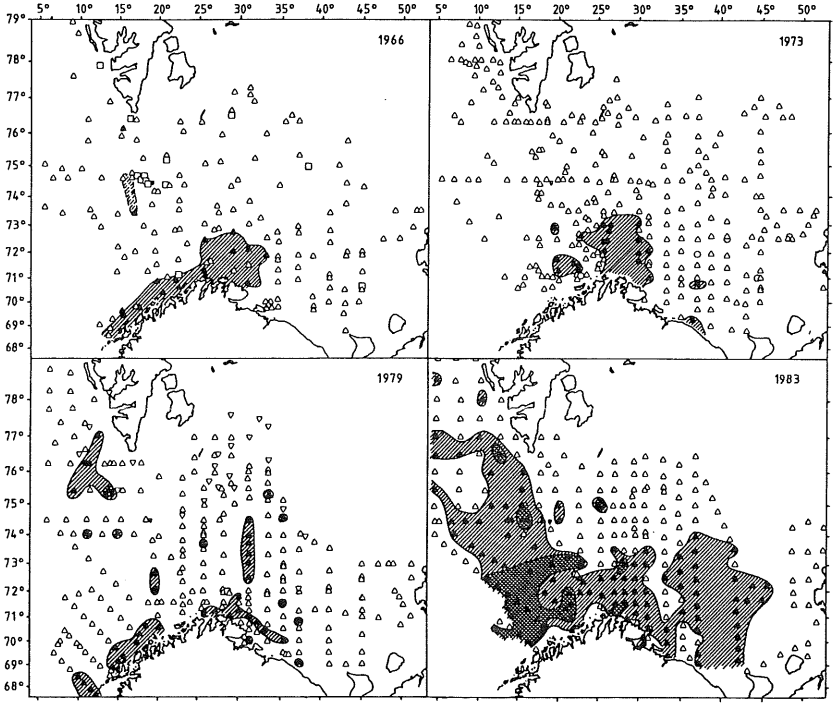


Figure 2.2. Distribution of 0-group herring in the Barents Sea. Single hatching: 1 - 1 000 herring per nautical mile caught in pelagic trawl; double hatching: more than 1 000 herring. (1) Pelagic trawl in 0-group layer, (2) pelagic trawl below 0-group layer, (3) bottom trawl, (4) purse seine.



Δ 1
▽ 2
□ 3
o 4

Figure 2.3. Yield per recruit for various values of age at first capture (t_c).

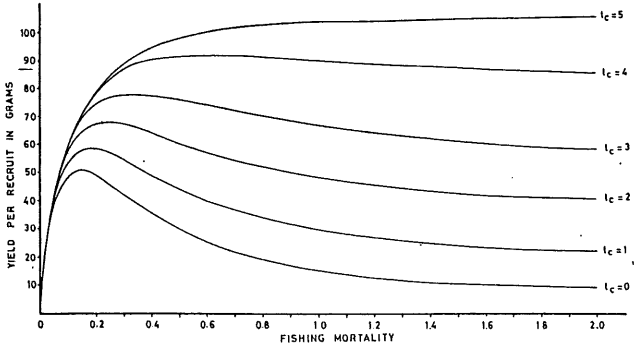


Figure 2.4. Length frequency diagrams of Norwegian spring spawning herring.

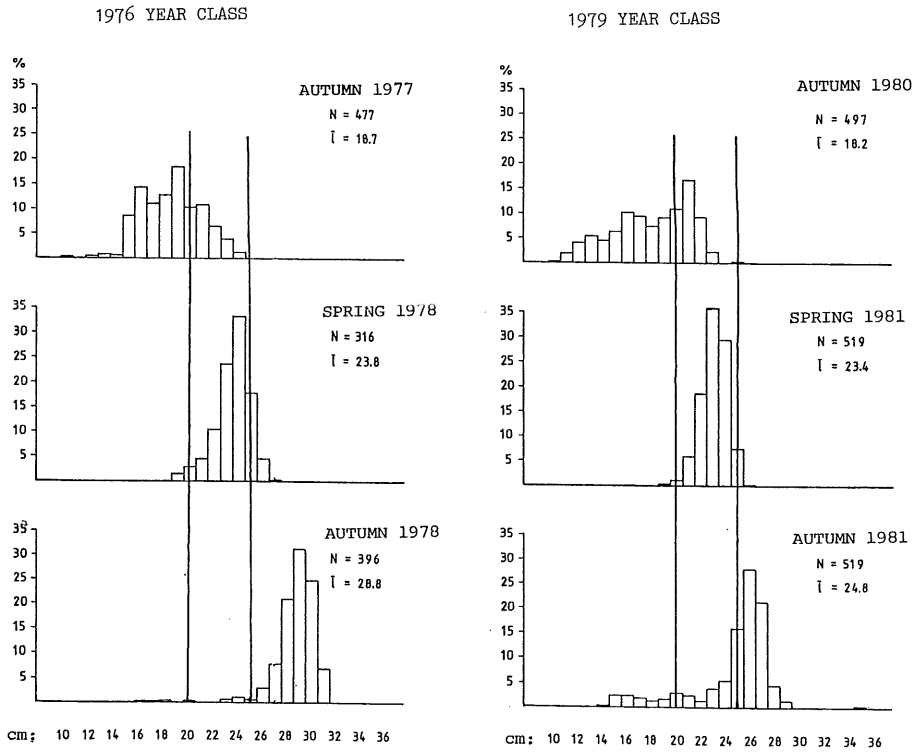


Figure 3.1. Number of capelin larvae per square metre surface.

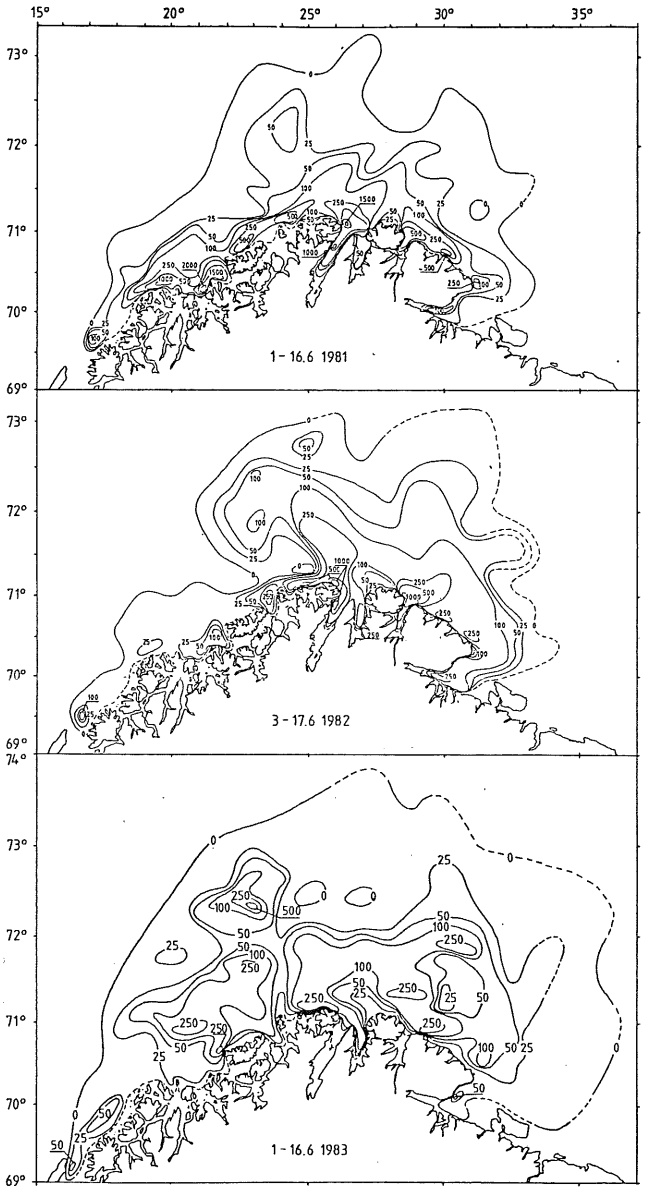


Figure 3.2. Spawning stock age distributions 1978-83.

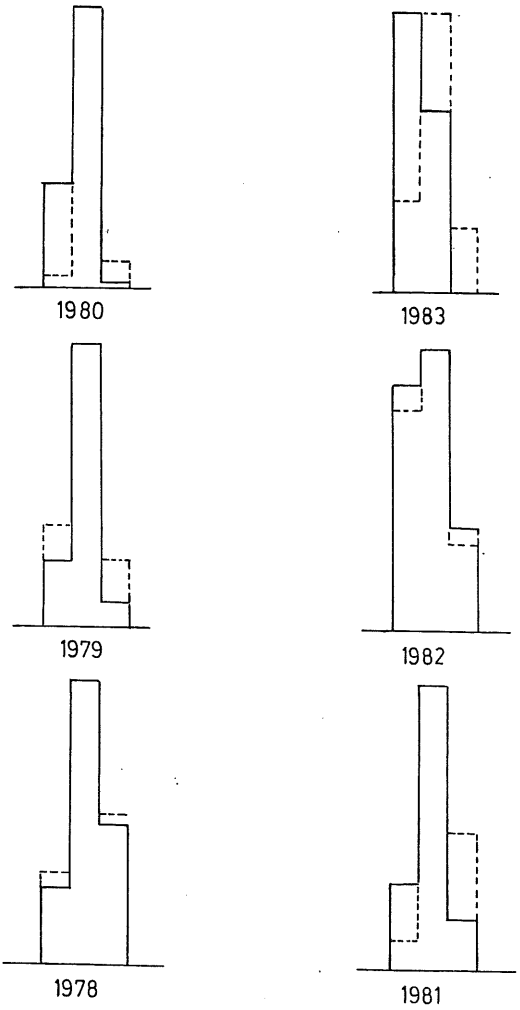
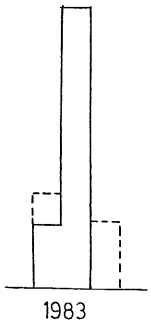


Figure 3.3. Spawning stock age distributions 1983



-------- March catches

———— Prognosed by substituting the 1982 estimate by the prognosed values.