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REPORT OF THE ATLANTO-SCANDIAN HERRING AND CAPELIN WORKING GROUP

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

TABLE OF CONTENTS

1 INTRODUCTION AND PARTICIPATION

1.1 Terms of Reference

The Working Group on Atlanto-Scandian Herring and Capelin met at ICES headquarters from 29 October to 1 November 1985 to 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.

1.2 Participants

J Carscadden	Canada
Y Chuksin	USSR
J Hamre (Chairman)	Norway
O Haldórsson	Iceland
J Jakobsson	Iceland
H í Jakupsstovu	Faroes
I Røttingen	Norway
E Friis Sørensen	Denmark
S Tjelmeland	Norway
N Ushakov	USSR
S Voronskaya	USSR

2 NORWEGIAN SPRING-SPAWNING HERRING

2.1 Working Paper Presented

The following working paper was presented: "Norwegian spring-spawning herring" by J Hamre and I Røttingen.

2.2 Catch Statistics

A catch quota of 38,000 tonnes was set for 1984. In addition, 7,750 tonnes remained of a catch quota which was originally set for the period August 1983 - March 1984. The fishery is regulated with a quota per vessel.

The catch of Norwegian spring-spawning herring since 1972 in terms of weight and number is presented in Tables 2.1 and 2.2. As in 1984, 5,000 tonnes were added in Table 2.2 for herring of age 3 and older to compensate for unreported catches. These tables also include the by-catches of 0- and 1-group herring in the sprat fishery north of 62^{0} N.

2.3 Recruitment

2.3.1 Larval surveys in 1985

The larval survey carried out in March-April in previous years was not conducted in 1985. However, a survey on O-group saithe recorded herring larvae in the period 11 - 31 May 1985. Figure 2.1 gives the distribution of the herring larvae. The length of the herring larvae at that time was approximately 30 mm. Figure 2.2 gives the geographical distribution of herring post-larvae in June-July 1985.

2.3.2 The O-group index from the international O-group survey in the Barents Sea

Indices of O-group Norwegian spring-spawning herring have been estimated for the period 1965-85 based on data from the international O-group surveys in the Barents Sea (Toresen, 1985). The estimated indices of abundance for the last 13 years are given in Table 2.3.

The recruitment of herring has been very low in the period since the O-group surveys started in 1965. However, in spite of the fact that the spawning stock biomass is still at a low level, a very strong year class was recorded in 1983. The strength of this year class has been verified several times by acoustic abundance estimation (Røttingen, 1985). The estimated O-group indices of the 1984 and 1985 year classes are on a considerably lower level than that for the 1983 year class. However, compared to the level of recruitment in the 1970s and early 1980s, these year classes may also be considered as strong at the O-group level.

2.3.3 Acoustic O-group estimates in the Barents Sea

The acoustic estimates of O-group herring in the Barents Sea for the last three years are shown in the text table below:

Year class	Estimated number x 10^{-9}	Time of survey
1983	35.7	Nov 1983
1984	6.2	Nov 1984
1985	41.5	Sept 1985

Due to bad weather conditions, the total areas of distribution were not covered in 1983 and 1984, and the estimates for these years are, therefore, too low. During the capelin survey in 1985 four vessels participated and covered the distribution area of herring to the east of 22^{0}E (Figure 2.3). The conditions for abundance estimation of O-group herring were favourable and the estimate is considered far more reliable than the corresponding estimates for the two previous years.

The correlation between the index of the international 0-group survey and the acoustic 0-group estimates in the Barents Sea in 1983-85 is rather poor. There is, however, no doubt about the strength of the 1983 year class. The 1984 year class came out with a fairly high index in the 0-group survey, but later it has failed to appear, both at the 0-group stage in late autumn and at the 1-group stage this year. The lack of appearance during the acoustic survey in 1984 can be explained by the lack of coverage due to bad weather conditions. However, the reasons for the almost complete absence of this year class during the acoustic survey this autumn cannot be explained in the same way. The severe decline in the stock of capelin in the last year indicates a dramatic increase in predation pressure caused by the increase in the stocks of cod and haddock in the area. These species are also feeding heavily on small herring, and the disappearance of the 1984 year class is assumed to be caused by predation. According to this year's acoustic estimate, the 1985 year class is also abundant as 0-group herring, but the predation pressure from cod and haddock may reduce the abundance strongly in the year to come.

2.3.4 Acoustic 0-group estimates in Norwegian coastal areas

An acoustic survey of 0-group herring distributed in the coastal areas of Norway has been conducted in November-December each year since 1975. The results are presented in Table 2.4.

2.3.5 Acoustic estimates of the 1983 year class

The text table below reviews the acoustic abundance estimates of the 1983 year class:

Abundance of the 1983 year class ($N \times 10^{-9}$)				
Survey		Norwegian coast	Barents Sea	
			West of 32^0E	East of 32^0E
Nov-Dec	1983	13.7	-	35.7
June	1984	-	4.6	38.1
May	1985	-	10.1	29.7
Sept	1985	-	6.7	16.6

The 0-group estimate in the Barents Sea is considered to be an underestimate due to bad weather conditions. The surveys in June 1984 and May 1985 were carried out under favourable conditions for acoustic stock estimates, while the September estimate in 1985 may be too low due to avoidance of the herring schools in the upper 50 metres.

2.4 Adult stock

2.4.1 Tagging

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 the 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. The differences in distribution and age pattern have made it necessary to assess the stock in two separate units.

A tagging project using internal steel tags was initiated in 1975, and herring since then have been tagged and released annually at various localities along the west coast. The herring are tagged in April-May.

The tagged herring are recovered by screening herring catches using a specially constructed internal tag detector. The effect of the detector is tested by mixing test-tagged herring with the catch before screening.

The recoveries used for stock assessment are all obtained from winter catches of mainly spawners and pre-spawners. The commercial winter herring fishery was prohibited until 1983, but experimental fishing was allowed during the winters 1977-83. These experimental fisheries have yielded about 400 recoveries. A commercial winter fishery was opened in 1984, and screening of catches in 1984 and 1985 has produced 596 recoveries. Details of the 1984 and 1985 samples by components are shown in Tables 2.5 and 2.6. The recoveries from the southern area (south of 63^0N) are obtained by screening commercial catches, the northern area (north of 63^0N) is sampled mostly by experimental fishing as in previous years.

The tagged herring are released in batches of 2,000 - 10,000 individuals. The allocation of the batches to components is done on the basis of the recoveries, i.e., the position and age structure of the catches from which the bulk of the recoveries is retained. The boundary between the spawning grounds of the two components is at about 63^0N.

In 1985, the releases allocated to the southern component resulted in 218 recoveries from catches taken in the south (r_{ss}) and 21 recoveries from catches taken in the north (r_{sn}). The corresponding figures for 1984 are 179 and 16, respectively. For the northern component the figures are 56 and 11 (r_{nn} and r_{ns}) for 1985 and 100 and 11 for 1984. It is assumed that the recoveries r_{sn} and r_{ns} reflect mixing of stock components when tagged and not when recovered.

The recoveries in 1985 are retained from catches by age and components as shown in Table 2.7. The table refers to number effectively screened, i.e., the catch corrected by the estimated detector efficiency, the total number screened (C_N in 000's) and the catch in weight (C_W in tonnes).

2.4.2 Mortality estimates

With respect to the basic theory concerning the estimation of mortality, reference should be made to the working paper available at the ICES Secretariat.

Using the recovery data from 1984 and 1985 combined, the plot of ln(m/r) against t is shown in Figure 2.4A and B for the southern and northern component, respectively. For the northern component, recoveries from the last year releases are excluded. The last year releases are obviously under-represented and even recoveries from the second last year of release are relatively low. This is demonstrated by plotting the point which corresponds to the 1983 estimate, but measured by the 1985 recoveries only. The corresponding Σr, which is found in Table 2.6, is derived from the relationship:

$$\begin{bmatrix} t=75 \\ \Sigma r_t \\ \underline{t=82} \\ \Sigma r_{83} \end{bmatrix}_{1985} = \begin{bmatrix} t=75 \\ \Sigma r_t \\ \underline{t=82} \\ \Sigma r \end{bmatrix}_{1984+1985}$$

This gives:

$$(\Sigma r)_{84+85} = \frac{148 \times 11}{50} = 32$$

It is seen from Figure 2.4B that this point is located above the regression line, which indicates that $\Sigma r_{83} = 11$ in the 1985 sample is below average. The low recovery rate of recent marked herring in the north may be explained by the fact that the tagged herring are released outside the area of recovery. In the south, however, the tagged herring are normally recovered very close to the area of release. The recoveries from the last year release are very close to the average, as indicated by the 1984 estimate plotted in Figure 2.4A. The corresponding Σr for 1984+85 given in brackets in Table 2.5 is calculated in the same way as above.

$$(\Sigma r)_{84+85} = \frac{371 \times 63}{176} = 132$$

In the calculation of the regression lines, the 1982 releases of the southern component are omitted due to failure of recoveries. The regression is calculated by weighting the points by $\sqrt{\Sigma r}$. The total mortality rate Z is estimated to be 0.17 for both components. The estimate for the northern component refers to the period 1975-82 and for the southern component to the period 1975-83. The overall fishing mortality in the same period is calculated to be 0.04 (Table 2.11) and M is estimated to be 0.13. The present mortality estimates of the tagged herring are regarded as the most reliable obtained so far.

2.4.3 Stock abundance estimates

The calculated number of surviving tagged herring in the winter of 1984 by components is shown in the right hand columns of Tables 2.5 and 2.6. In this calculation, a value for Z of 0.17 has been assumed for the whole period. The releases are allocated to components according to the position of the catches from which the bulk of the recoveries are retained, and the recoveries r_{sn} and r_{ns} are considered to represent mixed releases. The former represents tagged and released herring in the southern area, which are expected to belong to the northern stock component, and the latter represents herring tagged in the north but belonging to the southern stock component. The corresponding numbers of surviving tagged herring, m_{sn} and m_{ns}, were calculated by the formulas:

$$m_{sn} = \frac{X \times m'_n - m'_s}{X \times Y - 1} \quad \text{and} \quad m_{ns} = \frac{Y \times m'_s - m'_n}{X \times Y - 1}$$

where

$$\frac{r_{ss}}{r_{ns}} = X \quad \text{and} \quad \frac{r_{nn}}{r_{ns}} = Y$$

These two equations may be applied to estimate $m_s = m'_s - m_{sn}$ and $m_n = m'_n - m_{ns}$, respectively, where m_s and m_n are the actual number of surviving tagged herring in the respective areas by components. For further description of the method, reference is made to the working paper.

The calculations were based on the sum of recoveries in 1984 and 1985 and from the releases in 1975-83. The following data were obtained from Tables 2.5 and 2.6:

Southern component:

$$r_{ss} = 145 + 170 = 315$$
$$r_{sn} = 18 + 16 = 34$$

Northern component:

$$r_{nn} = 54 + 100 = 154$$
$$r_{ns} = 7 + 11 = 18$$

Disregarding tagging mortality, the surviving tagged herring in the spring of 1984 from the releases in 1975-83 number 53,427 (excluding 1982) and 71,842 for the southern and northern components, respectively. These data inserted in the formulas for m_{sn} and m_{ns} give:

$$X = \frac{r_{ss}}{r_{ns}} = \frac{315}{18} = 17.5 \qquad Y = \frac{r_{nn}}{r_{sn}} = \frac{154}{34} = 4.54$$

$$m_{sn} = \frac{17.5 \times 71,842 - 53,427}{78.3} = 15,374$$

$$m_{ns} = \frac{4.54 \times 53,427 - 71,842}{78.3} = 2,180$$

The corresponding m_s and m_n in 1984 are:

$$m_s = m'_s - m_{sn} = 53,427 - 15,374 = 38,053$$

$$m_n = m'_n - m_{ns} = 71,842 - 2,180 = 69,662$$

Assuming 30% tagging mortality as in previous years, the following stock abundance estimates refering to spring 1984 are obtaining by using the 1985 samples:

$$N_s = \frac{0.7 \times 38,053 \times 5,340 \times 10^3}{145} = 980 \times 10^6$$

$$N_n = \frac{0.7 \times 69,662 \times 1,763 \times 10^3}{54} = 1,592 \times 10^6$$

The abundance estimate of the southern component agrees with the estimate made last year (840×10^6 individuals), the difference being equal to the contribution from the younger age groups (1980+) in the 1985 catches, i.e., the recruitment.

For the northern component, the 1985 estimate is substantially larger than that obtained in 1984 (895×10^6 individuals). Recruitment from the 1979 and younger year classes, which have increased in relative strength from 7% to 17%, may account for about 200×10^6 individuals, but still the estimate is about 60% higher than last year. The difference is found in the calculated m_n values and in the estimated tag density index, C_n/r_n.

Last year, Z was estimated to be 0.21, whereas Z this year is estimated to be 0.17. Accepting the new Z-value, a substantial increase in the calculated m_n is to be expected. With respect to the tag density indices of the two samples, one has to compare the index referring to fully recruited age groups, i.e., the year classes 1978+. In 1985 this index is according to the catch and recovery data given in Table 2.7:

$$\left[\frac{C_n}{r_{nn}}\right]_{85} = \frac{1,454}{54} = 26.9$$

For 1984, the corresponding index is:

$$\left[\frac{C_n}{r_{nn}}\right] = \frac{2,480}{100} = 24.8$$

The 1985 index is about 8% larger than the index in 1984 or 5% above the average for both years combined. The estimated abundance N is proportional to the C/r and the average abundance estimate for the two samples combined is N_n = 1,592 x 0.95 ≈ 1,500.

Distributed by year classes according to the age composition of the screened catches, the abundance estimates in 1984 (in million individuals) are:

Component	Year class						Total
	1980+	1979	1978	1977	1976	1975+	
N_n^s	176	373	127	118	127	59	980
N_n	30	225	210	195	165	675	1,500
Total	206	598	337	313	392	734	2,480

These abundance estimates by age group were accepted as input parameters in the VPA and in the stock predictions.

2.4.4 Virtual population analysis

A VPA was run using the following input data:

Catch in number per year class ..... Table 2.2
Weight at age ..... Table 2.8
Weight in catch ..... Table 2.9
Natural mortality M 0.13

Maturation ..... age 3 = 0.1
age 4 = 0.5
age 5 = 0.9
age 6+= 1.0

Initial stock ..... Abundance estimates from tagging experiments

The results of the VPA are shown in Tables 2.10 and 2.11 and Figure 2.5. The back-calculated stock and corresponding fishing mortality in 1973-80 are in close agreement with the VPA estimates based on the stock abundance estimate obtained from tagging in 1982 (Anon., 1984). The stock increased from a level of about 80,000 tonnes in 1973 to about 500,000 tonnes in 1980. In

1980-84, the relative growth of the stock was slower, although the fishing mortality has remained at the same low level, i.e., below 5%. This is caused by very poor recruitment from the 1980 and 1981 year classes. In Figure 2.5, the data for years prior to 1973 are taken from Dragesund and Ulltang (1978).

2.4.5 Conversion factors

The O-group estimates obtained in coastal waters in November-December (Table 2.4) were regarded as representative of 1-group estimates on 1 January. Abundance estimates of 3-group fish on 1 January were taken from the VPA estimate (Table 2.10). To relate the estimates of 1-group and 3-group fish, annual conversion factors (C-Fact) were calculated for the 1975-1980 year classes, and an average conversion factor was calculated. The results are given in the text table below:

Year class	1-group (1 January)	3-group) (1 January)	C-Fact
1975	1,075	83	0.28
1976	3,775	754	0.45
1977	412	532	-
1978	1,208	519	0.66
1979	3,457	798	0.48
1980	234	114	0.69
		Mean C-Fact	0.51

The estimate of the 1977 year class as 1-group is obviously an underestimate and is omitted from the calculation of the mean C-Fact. The conversion factor has changed from last year. This is due to an additional year class (1980) and to changed estimates of 3-group due to changed natural mortality from 0.1 to 0.13 in the VPA run (Section 3.1).

2.4.6 Yield per recruit and spawning stock per recruit

Yield per recruit was calculated based on the growth pattern of the 1960s and a minimum landing size of 25 cm. The results are given in Figure 2.5 as yield per recruit at age 3. According to this, $F_{0.1} = 0.18$.

2.4.7 Catch and stock prognosis

Due to a reduced growth rate for that portion of the 1983 year class which is distributed in the Barents Sea, the prognosis of catch and stock size for the period 1986-87 was run in two separate sections.

A) Input data for the component in Norwegian coastal waters

The input data are given in the text table below:

Age	Stock size x 10^{-6} 1985	Fishing pattern 1985-86	Maturity ogive 1985-87	Weight in the catch (kg) 1985-86	Weight in the stock (kg) 1985-87
1	1,401	0.10	0.00	0.085	0.010
2	6,400	0.10	0.00	0.155	0.085
3	764	0.50	0.10	0.233	0.155
4	74	1.00	0.80	0.281	0.233
5	80	1.00	1.00	0.348	0.281
6	455	1.00	1.00	0.371	0.348
7	275	1.00	1.00	0.408	0.371
8	251	1.00	1.00	0.428	0.408
9+	920	1.00	1.00	0.442	0.428

Natural mortality is 0.67 for ages 1-2 and 0.13 for ages 3 and older.

Conversion factor ($C\text{-}Fact_{1-2}$) = 0.51.

Recruitment at age 1 (x 10^{-6}) in 1985-87 = 1,401.

The input data refer to the stock at 1 January 1985. The age 2 estimate is the estimate of the 1983 year class in coastal waters on 1 January 1984 (set equal to the estimate in November-December 1983, Table 2.4) reduced one year by the conversion factor. The 1-group estimate is set equal to the estimate of the 1984 year class in coastal waters in November-December 1984 (Table 2.4). The recruitment in 1985-87 is set equal to the recruitment from the 1984 year class in coastal waters. The remaining parameters are the same as used last year. The catch prognosis was run by assuming a catch of 60,000 tonnes in 1985, and the results are given in the text table below (in '000 tonnes):

1985				1986				1987	
Spawn. stock	Spawn. stock biom.	F	C	Spawn. stock	Spawn. stock biom.	F	C	Spawn. stock	Spawn. stock biom.
1,474	805	0.07	60	1,413	851	0.00	0	1,579	1,319
						0.05	65	1,519	1,263
						0.07	78	1,507	1,252
						0.10	115	1,473	1,220
						0.15	178	1,413	1,164
						0.20	225	1,370	1,124

C = Catch

B) Input data for the Barents Sea component of the 1983 year class

Due to uncertainties concerning the fate of the 1984 and 1985 year classes in the Barents Sea, only the 1983 year class in the Barents Sea is considered in this prognosis. The input data are given in the text table below:

Age	Stock size x 10^{-6} 1985	Fishing pattern 1986	Maturity ogive 1986-87	Weight in the catch (kg) 1986	Weight in the stock (kg) 1985-87
0	-	-	-	-	-
1	-	-	-	-	-
2	35,000	0.00	0.00	0.056	0.028
3	-	0.17	0.00	0.081	0.056
4	-	0.96	0.10	0.146	0.081
5	-	1.00	0.62	0.202	0.146
6	-	1.00	0.95	0.216	0.202
7	-	1.00	1.00	0.241	0.216
8	-	1.00	1.00	0.285	0.241
9+	-	1.00	1.00	0.299	0.285

Natural mortality is 0.67 for age 2 and 0.13 for ages 3 and older.
Conversion factor (C-Fact) = 0.51.

The input data refer to the stock at 1 January 1985. In May 1985 the number of 2-year-old herring in the Barents Sea was estimated at 39,800 million. However, some of these herring may have emigrated from the fjords (and are, therefore, included in the estimate of the coastal component of this year class). It was agreed that an estimate of 35,000 million 2-year-old herring on 1 January 1985 could be representative of the Barents Sea component.

The 1983 year class in the Barents Sea seems to have a growth rate similar to earlier strong year classes which were distributed in the Barents Sea, i.e. 1959 year class. Data on the growth rate of the 1959 year class in the Barents Sea are given in Jørgensen (1979) and shown in the tables of the weight at age of the stock and catch. Maturation is calculated by assuming a maturing length of 30 cm and a growth pattern similar to the 1960s. Fishing pattern was calculated assuming a minimum landing size of 25 cm. The conversion factor and natural mortality were assumed to be the same as for the coastal component. The result of this catch and stock prognosis is given in the text table below (in '000 tonnes):

1985				1986				1987	
Spawn. stock	Spawn. stock biom.	F	C	Spawn. stock	Spawn. stock biom.	F	C	Spawn. stock	Spawn. stock biom.
980	0	0	0	1,003	0	0.00	0	1,274	127
						0.05	14	1,261	126
						0.07	16	1,259	126
						0.10	24	1,251	125
						0.15	38	1,239	114
						0.20	48	1,229	123

C = Catch

The combined prognoses for the two components are given in the text table below:

1985				1986				1987	
Spawn. stock	Spawn. stock biom.	F	C	Spawn. stock	Spawn. stock biom.	F	C	Spawn. stock	Spawn. stock biom.
2,454	805	0.07	60	2,416	851	0.00	0	2,853	1,446
						0.05	79	2,780	1,389
						0.07	94	2,766	1,378
						0.10	139	2,724	1,345
						0.15	216	2,652	1,288
						0.20	273	2,599	1,247

C = Catch

The result of this prognosis is more optimistic than the prognosis made last year, particularly with regard to the juvenile stock in 1985. This is due to the new input value of the 1983 year class in 1985 obtained from the acoustic survey of the Barents Sea in May 1985. This prognosis indicates, however, no growth in the stock biomass from 1985 to 1986, which is a consequence of the use of 50% mortality rate (the conversion factor) as 2-year olds. Taking into account the predation pressure from cod and haddock, this is considered to be realistic. It should also be noted that the prognosis of the Barents Sea component excluded contribution from younger age groups. From 1986 to 1987, the prognosis predicts a considerable increase in biomass, particularly of the spawners. This is mainly due to maturing of the coastal component of the 1983 year class. The Working Group points out that the present exploitation rate of an F of 0.07 and even an F of 0.1 will have very little effect on this development. Referring to the yield per recruit ogive, it is noted that an F of 0.07 implies a loss of about 30% in potential yield compared to the yield at $F_{0.1}$ (F = 0.18), whereas an F of 0.1 would provide about 90% of the long-term optimum yield.

2.4.8 Minimum landing size

The 1983 Working Group considered the effect of minimum landing size on the basis of relevant data given in Dragesund et al. (1980). In this paper, it was considered that if a minimum landing size protecting 0- and 1-group fish had been set in the 1960s, this regulation alone could have prevented the depletion of the stock. Given the growth pattern in the 1960s, this measure corresponds to a minimum landing size of 20 cm.

The Working Group calculated yield per recruit and corresponding spawning stock per recruit curves for 20 cm, 25 cm, 27 cm and 30 cm minimum landing sizes (Figure 2.6 and Table 2.12).

The main part of the 1983 year class is distributed in the Barents Sea, and it seems to have a growth rate similar to the components of the 1959 and 1960 year classes which were located in the same areas as juveniles. Length distributions of the 1959 and 1960 year classes at ages 2-6 were used to calculate fishing patterns for different minimum landing sizes. The results are given in the text table below:

Age	20 cm	25 cm	27 cm	30 cm
0	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00
2	0.48	0.00	0.00	0.00
3	0.85	0.17	0.02	0.00
4	1.00	0.96	0.60	0.10
5	1.00	1.00	1.00	0.62
6	1.00	1.00	1.00	0.95
7	1.00	1.00	1.00	1.00

The calculations of yield per recruit show that if M is as low as 0.13, there may be a little gain in the potential yield by increasing the maximum landing size from 20 cm to 25 cm at an exploitation level above F = 0.15. However, there is nothing to gain in the yield by increasing the minimum landing size above 25 cm, if the stock is fished at an F of 0.15.

Therefore, the Working Group recommends that a minimum landing size of 25 cm should be set for all herring fisheries exploiting the Norwegian spring spawners.

However, the following members (Messrs. Jakobsson, Jakupsstovu and Halldórsson) strongly expressed their preference for a 27 cm minimum landing size, because this would give the strong 1983 year class additional protection and also this would increase the yield per recruit at levels of fishing mortality higher than F = 0.15. In addition, the 27 cm minimum landing size would result in a higher spawning stock per recruit (Figure 2.6).

The members of the USSR delegation expressed their opinion that management of the Atlanto-Scandian herring stock by TAC is the safest measure for its conservation.

2.5 NEAFC Request

The Working Group considered the request from NEAFC "to prepare an outline in time and space of the different life stages of Atlanto-Scandian spring-spawning herring based on the situation before the collapse of the stock in the late sixties". Using ICES Coop. Res. Rep. 86 (Anon., 1979) as a basis, the following summary was made.

2.5.1 General biology

Spawning times and areas
From the beginning of this century and up to about 1955, the main spawning took place off the coast of western Norway, between Egersund and Stad. From 1955 onwards, the main spawning gradually shifted northwards off Møre and Trøndelag. However, spawning also took place off Helgeland and, especially in recent years, as far north as off Lofoten. Since 1955, the spawning time changed from January or February to March. In addition, there has been, at least since 1950, a considerable spawning of Norwegian spring-spawners off the Faroe Islands. The changes in spawning grounds during the period 1950-68 are shown in Figures 2.7, 2.8 and 2.9.

Larval, post-larval and juvenile fish distribution
The larvae from the Norwegian spawning grounds are transported northward with the coastal currents. The larval stage lasts for about 2 months, and during that time, some larvae drift into fjords and bays on the Norwegian coast, but others remain in the outer coastal areas until metamorphosis.

The 0-group in the coastal areas migrate into the fjords in autumn, but in years of high 0-group abundance, their distribution is very widespread and ranges from the fjords of western and northern Norway to the open ocean of the Norwegian Sea and the Barents Sea.

2.5.2 Distribution and migration of young and adult stock components

As 1- and 2-group, herring feed in Norwegian coastal areas and in the SW Barents Sea. During periods of exceptionally high abundance, these age groups have had a much wider distribution. Young herring from the southern coastal areas usually accumulate as 1- and 2-year-old fish in the Helgeland-Troms area. Young herring in Finnmark usually spend one more year in the coastal areas before they begin their migration to the Norwegian Sea to join the adult stock.

The traditional adult herring migration was from the spawning grounds on the Norwegian coast to the summer feeding grounds in the Iceland-Jan Mayen area. In the late 1960s, the main feeding grounds moved further north and east to the Jan Mayen-Bear Island area. During autumn, the adult herring concentrate in the area east of Iceland, where they remain until January when the migrations begin to the spawning areas at the Norwegian coast. The changes in migration pattern of the adult herring during the period 1958-68 are shown in Figures 2.7, 2,8 and 2.9.

ICES Coop. Res. Rep. 86 also contains a summary of the fishery and management of the Atlanto-Scandian herring, and if NEAFC requires more information on either the biology or fishery of this herring stock, a special Working Group should be formed to address these questions.

In addition, more detailed information on the biology, the fishery and its management is available in other documents.

The NEAFC request to ICES "to develop appropriate studies to determine the distribution features of the stock during and following its period of recovery" is discussed under Future Research (Section 2.5.3).

2.5.3 Future Research

International Monitoring Programmme for Atlanto-Scandian Herring
As a basis for discussion, the USSR presented a proposal for an international cooperative research programme to monitor the Atlanto-Scandian herring (Working Paper available from Secretariat). These research proposals stressed the importance of an ecosystem approach. The Working Group discussed the timing and types of surveys that would be most appropriate to monitor the Atlanto-Scandian herring. A reliable annual acoustic estimate of the adult stock is necessary and the most appropriate time may be during the overwintering period. To obtain an estimate of recruiting year classes, a survey in the Norwegian fjords and certain areas of the Barents and Norwegian Seas during late autumn would be most appropriate, especially for O-group herring. Finally, the Working Group recommended that future research be aimed at providing quantitative estimates of the distribution of all year classes, especially during the migration periods. The most appropriate time to provide these estimates would be during the spawning migrations (approximately December-February) and during the period between spawning and feeding (approximately April-June).

The Working Group noted that the annual International Blue Whiting Survey conducted during August in the Norwegian Sea and adjacent areas would provide an opportunity to obtain additional information on the Atlanto-Scandian herring when they start to migrate into the Norwegian Sea.

Multispecies Research
The Working Group noted that there is a lack of information on multispecies interactions. While this Working Group is especially interested in the interactions of capelin and herring with other species and with each other, it recommends that ACFM encourage further research into multispecies interactions.

3 BARENTS SEA CAPELIN

3.1 Working Papers presented

The following working papers were presented: "Soviet investigations on capelin larvae in the Barents Sea in 1985" by N V Mukhina, E I Seliverstova and N G Ushakov, "Assessment of Barents Sea capelin 1985" by J Hamre and S Tjelmeland, "Comments to the state of the Barents Sea capelin stock" by J Hamre and "On the applicability of the capelin management model" by S Tjelmeland.

3.2 Regulation of the Barents Sea Capelin Fishery

Since 1979, the Barents Sea fishery has been regulated by a bilateral fishery management agreement between the USSR and Norway. A TAC has been set separately for the winter fishery and for the autumn fishery. The fishery has been closed from 1 May to 15 August until 1984. Since 1984, the fishery has been closed from 1 May to 1 September. A minimum landing size of 11.0 cm has been enforced, and a minimum mesh size of 16 mm introduced.

3.3 Catch Statistics

The international catch by country in the years 1965-83 is given in Table 3.1. The capelin catch (USSR and Norway combined) in numbers by age and month for the period 1 September 1984 - 30 April 1985 is given in Table 3.2. The age composition of the winter catch is about the same as in 1984. The autumn catch by the end of September is reported to be about 100,000 tonnes and 50,000 tonnes for Norway and USSR, respectively.

3.4 Stock Size Estimates

3.4.1 Larval and 0-group surveys

Larval surveys based on Gulf III plankton samples have been conducted in June each year since 1981. The calculated numbers by year are shown in Table 3.3. There has been a constant larval production since 1981, aside from a 20% reduction in 1984.

No index was calculated from the international 0-group survey in the Barents Sea (Anon., 1985). The 0-group distribution area observed in this cruise is narrower than the distribution observed in 1984 (Figure 3.1).

3.4.2 Acoustic stock estimates

The 1985 acoustic survey was carried out in the period 6 September - 6 October as a joint Soviet-Norwegian cruise. The distribution of capelin in 1985 is shown in Figure 3.2. Four research vessels, two Norwegian and two Soviet, participated in this survey. The following abundance estimates by year class were obtained:

Year class	Number (10^{-9})	Mean weight (g)	Biomass (10^{-6} tonnes)
1984 (1983)	35 (145)	4.3 (3.7)	0.15 (0.54)
1983 (1982)	47 (184)	8.2 (7.4)	0.39 (1.37)
1982 (1981)	21 (47)	13.0 (18.2)	0.27 (0.87)
1981 (1980)	1 (3)	15.6 (27.1)	0.01 (0.09)

The estimates of the same age groups in 1984 are shown in parenthesis for comparison. The 1984 year class is 4 times lower by number than the 1-group measured last year. A similar difference in abundance between the 1982 (515) and 1983 (145) year classes as 1-year olds was reported last year.

The 1983 year class is more than 3 times lower by number than the 2-group measured last year and the low abundance of this year class, first measured in 1984, is confirmed this year. The 1985 estimate of 2-year-old capelin is the lowest ever obtained. The mean weight is, however, a little higher.

The strength of the 1982 year class is also the lowest estimate for 3-year-old capelin ever obtained. Also, the mean weight is considerably lower than the mean weight of 3-year-old capelin measured in 1984.

The 1981 year class is of negligible strength, as was the case for the 4-year-old capelin in 1983 and in 1984.

The total stock biomass is estimated to be 0.82 million tonnes (Table 3.4), compared to 2.9 million tonnes in 1984.

Table 3.5 provides some information on the Barents Sea capelin stock since 1973. The model dependent quantities are calculated from the same assumptions as used by the Working Group in 1984 (adjusting of 1982 estimate). The model used is documented in a separate working paper. The 1983 catch quotas were set on the basis of an overestimate of the number of 2-year-old capelin in 1982, as judged by the Working Group in 1983 and 1984. This is reflected in particularly high F-values in 1983. With this exception, there is no trend in the F-data that could explain the present state of the capelin stock.

The text table below shows the predicted stock based on the 1984 survey and the measured stock in 1985.

Year class	Predicted		Measured	
	N	W	N	W
1982	66	16.0	21	13.0
1981	5	21.6	1	15.6

N = number (x 10^{-9})
W = mean weight (g)

The number of 3-year-old capelin is more than 3 times lower than predicted. Also, as the number of 2-year-old capelin is only about 25% of the strength of the weakest year classes observed earlier at this age, it is concluded that the mortality on both young and adult capelin has increased dramatically compared to previous years.

The fishery on the 1982 year class in October-December caught 9.44 billion individuals and in September 1985 about 4.7 billion individuals. Thus, correcting for natural mortality, the strength of the 1982 year class would be somewhat above 30 billion individuals if no fishing had taken place. Correcting the 1983 year class for a catch in September of about 11 billion individuals, the estimate would be about 60 billion individuals if no fishing had taken place.

The decrease in the capelin stock, therefore, exceeds by far what can be explained by the fishery.

3.4.3 Management considerations

The decline of the capelin stock is probably connected to the substantial change in the rest of the ecosystem observed in recent years. An increased inflow of Atlantic water since 1980 (Gjøsæter and Loeng, 1984) was noted as a factor in the physical environment that may have affected fish stocks in the Barents Sea. The change in the hydrological environment may have provided improved conditions for the recruitment to the stocks of cod, haddock and herring. The increase of the cod, haddock and herring stocks may thus have caused a higher predation on the capelin. Also, the abrupt increase of the herring stock that started in 1983 may have negatively influenced the juvenile capelin through competition for food, predation or both (Moksness and Øiestad, 1985).

The recent changes in the ecosystem invalidate both the estimates of natural mortality on immature capelin as well as the spawning stock-recruitment relation obtained from data prior to 1983.

However, when the 1986 spawning stock biomass is calculated using the same length at maturity and natural mortality on the mature population that was applied by the Working Group in 1984, a value of about 200,000 tonnes is obtained, provided no catch is taken after October 1.

Based on the present low estimate of capelin abundance and taking into account the lack of information on multispecies interactions in the Barents Sea, the Working Group cannot recommend any fishing of Barents Sea capelin in 1986.

4 THE ICELANDIC CAPELIN

One working paper was presented: "Report of the acoustic survey of the Icelandic capelin stock 8-29 October 1985".

4.1 The Fishery

The total annual and seasonal catch of capelin in the Iceland-East Greenland-Jan Mayen area since 1964 is shown in Table 4.1

Prior to the 1985 summer-autumn season, Iceland and Norway had agreed to a TAC of 700,000 tonnes for the 1 August - 31 November period. This was based on results from an acoustic survey of immature capelin carried out in January 1985. The TAC for the remaining part of the 1985/86 season was to be set after the customary autumn acoustic survey would be carried out in October 1985. When that survey was completed on 30 October, Norwegian and Icelandic capelin catches amounted to 190,000 and 350,000 tonnes, respectively. In addition, Faroese and Danish vessels had caught 72,000 and 16,000 tonnes, respectively.

4.2 The October 1985 Stock Abundance Estimate

The autumn 1985 acoustic survey was carried out during the period 8 - 29 October. Two vessels participated and obtained the following abundance estimates by year class:

Year class	Number ($\times 10^{-9}$)	Mean weight (g)	Biomass ($t \times 10^{-3}$)
1984	33.8	3.8	129.0
1983	53.3	14.1	754.8
1982	14.4	23.8	341.9
1981	0.4	29.5	12.0
Total	101.9	-	1,237.7

Further details of this stock estimate are given in Table 4.2.

Judging by the maturity stage, approximately 1,030,000 tonnes, comprising all of the 1981 and 1982 year classes and the larger part of the 1983 year class, will mature and spawn in March-April 1986.

During this year's survey, there was no drift ice and coverage of the area was comparatively good. Due to unfavourable weather conditions in the western part of the survey area, it is, however, likely that this survey produced an underestimate of the older age groups (2-3).

For the same reason, but particularly due to an unusual distribution pattern, the low abundance of the 1984 year class may also be an underestimate. It should, however, be noted that October surveys through the years have yielded considerably variable results concerning the abundance of 1-group capelin.

4.3 TAC for the November 1985 - March 1986 Period

The October 1985 stock abundance estimate was used as a basis for calculating the TAC.

The following assumptions were made:

1) All capelin 13.5 cm and larger will mature to spawn in 1986. This length at maturity is derived from maturity observations made during the survey. These capelin will be in the catch during the whole fishing season.

2) In the period November-January, immature capelin of the 1983 year class will be 6% of the catch.

3) Natural mortality rate will be 0.035/month.

4) The mean weight of the 1983 and 1982 year classes will increase by 1.9 and 2.3 grammes, respectively.

5) There will be 400,000 tonnes left to spawn in 1986.

Based on these assumptions, the Working Group calculated that the October 1985 survey results correspond to a TAC of 680,000 tonnes to be evenly distributed over the 4-month period November 1985 - February 1986. At the time of the October survey, about 190,000 tonnes of the TAC for the August - November period remained to be taken. Consequently, the Working Group recommends that the TAC for the December 1985 - February 1986 period be set at about 500,000 tonnes.

4.4 TAC for the Summer-Autumn 1986 Season

The main stock component in the fishery will be the present 1-group capelin (1984 year class).

In August 1985, Iceland and Norway carried out a joint acoustic survey of the capelin in the Iceland - East Greenland - Jan Mayen area. In this survey, the observed abundance of the 1984 year class amounted to about 1/10 of its predecessor (1983) as recorded during an Icelandic survey in August 1984. The distribution and behaviour of the 1984 year class was, however, very unlike that observed for the 1983 year class in the year before and less suitable for successful acoustic abundance estimation. A somewhat similar situation apparently prevailed during the October 1985 survey.

Due to the large uncertainties concerning the abundance of the 1984 year class, the Working Group recommends that decisions on the TAC for the 1986 summer-autumn season be deferred until further surveys have taken place. The results from additional

surveys should be made available to the May 1986 ACFM meeting, when a preliminary TAC for the 1986 summer-autumn season can be recommended.

5 REFERENCES

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Table 2.1 Catches north of 62^0N of Norwegian spring-spawning herring (tonnes) since 1972

Year	Catches of adult herring in winter	Mixed herring fishery in autumn*	By-catches of 0- and 1-group herring in the sprat fishery	Total
1972	0	9,895	3,266**	13,161
1973	139	6,602	276	7,017
1974	906	6,093	620	7,619
1975	53	3,372	288	3,713
1976	0	247	189	436
1977	374	11,834	498	12,706
1978	484	9,151	189	9,824
1979	691	1,866	307	2,864
1980	878	7,634	65	8,577
1981	844	7,814	78	8,736
1982	983	10,447	225	11,655
1983	3,857	13,290	907	18,054
1984	18,730	29,463	339	48,532
1985	33,230			

*Includes also by-catches of adult herring in other fisheries

**In 1972, there was also a directed herring 0-group fishery

Table 2.2 Catch in numbers (x 10^{-3}) of Norwegian spring-spawners. Unreported catches are included for age 3 and older herring

Age	1972	1973	1974	1975	1976	1977	1978
0	347,100	29,300	65,900	30,600	20,100	43,000	20,100
1	41,000	3,500	7,800	3,600	2,400	6,200	2,400
2	20,400	1,700	3,900	1,800	1,200	3,100	1,200
3	35,376	2,389	100	3,268	23,248	22,103	3,019
4	3,476	25,220	241	132	5,436	23,595	12,164
5	3,583	651	24,505	910	-	336	20,315
6	2,481	1,506	257	30,667	-	-	870
7	694	278	196	5	13,086	419	-
8	1,486	178	-	2	-	10,766	620
9	198	-	-	-	-	-	5,027
10	-	-	-	-	-	-	-
11	494	-	-	-	-	-	-
12	593	-	-	-	-	-	-
13	593	-	-	-	-	-	-
14	-	178	-	-	-	-	-
15	-	-	-	-	-	-	-

Age	1979	1980	1981	1982	1983	1984
0	32,600	6,900	8,300	22,600	127,000	33,857
1	3,800	800	1,100	1,100	4,679	1,700
2	1,900	400	11,900	200	1,675	2,489
3	6,352	6,407	4,166	13,817	3,183	4,483
4	1,866	5,814	4,591	7,892	21,191	5,388
5	6,865	2,278	8,596	4,507	9,521	61,543
6	11,216	8,165	2,200	6,258	6,181	18,202
7	326	15,838	4,512	1,960	6,823	12,638
8	-	441	8,280	5,075	1,293	15,608
9	-	8	345	6,047	4,598	7,215
10	2,534	-	103	121	7,329	16,338
11	-	2,688	114	37	143	6,478
12	-	-	964	37	40	-
13	-	-	-	37	143	-
14	-	-	-	-	862	-
15	-	-	-	-	-	1,652

Table 2.3 Abundance indices for O-group herring in the Barents Sea, 1973-85 (Toresen 1985, Anon. 1985)

Year	Log index
1973	0.05
1974	0.01
1975	0.00
1976	0.00
1977	0.01
1978	0.02
1979	0.09
1980	0.00
1981	0.00
1982	0.00
1983	1.77
1984	0.34
1985	0.23

Table 2.4 Norwegian spring-spawners. Acoustic abundance of O-group herring in Norwegian coastal waters in 1975-84 ($N \times 10^{-6}$)

	Area			
Year	62^0N-65^0N	65^0N-68^0N	North of $68^0$30'	Total
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	263	2	1	265
1982	64	571	2,301	2,936
1983	323	4,543	8,864	13,730
1984	4	467	930	1,401

Table 2.5. Details of tagging samples, southern component of Norwegian spring-spawning herring

Year of release	m'_s	1985			1984			1984 + 1985			$(m'_s)84$
		r_{sn}	r_{ss}	Σr_s	r_{sn}	r_{ss}	Σr_s	Σr_s	K_s	ln K_s	
1975	5,000	1	3	4	-	5	5	9	5.6	1.71	1,082
1976	7,998	1	6	7	-	4	4	11	7.3	1.98	2,051
1977	16,044	1	14	15	2	15	17	32	5.0	1.61	4,881
1978	11,988	5	8	13	3	11	14	27	4.4	1.49	4,323
1979	5,995	2	12	14	1	9	10	24	2.5	0.92	2,563
1980	19,994	3	11	14	4	20	24	38	5.3	1.66	10,128
1981	24,967	4	51	55	6	56	62	117	2.1	0.76	14,992
1982	12,380	-	13	13	-	9	9	22	5.6	1.73	8,812
1983	15,891	1	40	41	-	50	50	91	1.7	0.56	13,407
1984	15,338	3	60	63			(69)	(132)	(1.2)	(0.15)	15,338
Sum 1975-84		21	218	239							77,577
Sum 1975-83		18	158	176	16	179	195	371			62,239
Sum 1975-83 excluding 1982		18	145	163	16	170	186	349			53427

Table 2.6 Details of tagging samples, northern component of Norwegian spring-spawning herring

Year of release	m'_n	1985			1984			1984 + 1985			$(m'_n)84$
		r_{nn}	r_{ns}	Σr_n	r_{nn}	r_{ns}	Σr_n	Σr_n	K_n	ln K_n	
1975	20,991	3	2	5	7	1	8	13	16.1	2.78	4,546
1976	15,946	5	-	5	2	3	5	10	15.9	2.77	4,093
1977	23,989	5	-	5	11	-	11	16	15.0	2.71	7,298
1978	19,998	8	2	10	15	2	17	27	7.4	2.00	7,211
1979	20,792	7	-	7	9	1	10	17	12.1	2.50	8,886
1980	15,988	4	-	4	17	1	18	22	7.3	1.98	8,100
1981	9,977	10	-	10	11	-	11	21	4.7	1.56	5,992
1982	14,884	4	-	4	15	3	18	22	6.8	1.91	10,594
1983	17,925	8	3	11	13	-	13	(32)	(5.6)	(1.72)	15,122
1984	13,975	2	4	6							13,975
Sum 1975-84		56	11	67							85,817
Sum 1975-83		54	7	61	100	11	111	172			71,842

Table 2.7 Effectively screened catches (C) in 1985 (in '000s, C_N in '000, C_W in tonnes) of Norwegian spring-spawning herring

		Year class						C	C_N	C_W
		1980+	1979	1978	1977	1976	1975+			
Southern	n	960	2,006	695	635	729	315	5,340	5,793	1,668
component	%	18	38	13	12	13	6			
Northern	n	42	267	244	223	189	798	1,763	1,822	659
component	%	2	15	14	13	11	45			

Table 2.8 Average weight in stock (1 January), in grammes, Norwegian spring-spawners, 1975-85

Age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3	181	181	181	180	178	175	170	170	155	140	155
4	259	259	259	294	232	283	224	204	249	204	233
5	342	342	342	326	359	347	336	303	304	295	281
6	384	384	384	371	385	402	378	355	368	338	348
7	409	409	409	409	420	421	387	383	404	376	371
8	444	444	444	461	444	465	408	395	424	395	408
9	461	461	461	476	505	465	397	413	437	407	428
10	520	520	520	520	520	520	520	453	436	413	442
11	543	543	543	543	551	534	543	468	493	422	434
12	412	412	412	500	500	500	512	512	480	459	456
13	412	412	412	500	500	500	512	500	470	449	469
14	412	412	412	500	500	500	512	500	500	427	460
15	412	412	412	500	500	500	512	500	500	437	460
16	412	412	412	500	500	500	512	500	500	437	445

Table 2.10 Results from VPA. Norwegian spring-spawning herring. Stock numbers in millions, stock weight in '000 tonnes

Age	1973	1974	1975	1976	1977	1978	1979	1980
3	21	0	33	701	420	83	754	532
4	371	16	0	26	594	348	70	656
5	1	302	14	0	18	499	294	60
6	2	0	243	11	0	15	419	252
7	0	0	0	184	10	0	13	358
8	3	0	0	0	150	8	0	11
9+	3	0	0	0	0	69	68	74
Total	401	319	290	923	1,191	1,023	1,618	1,942
Spawn. stock	308	286	259	287	693	829	896	1,326
Spawn. biom.	81	97	98	105	207	272	323	468

Age	1981	1982	1983	1984	1985
3	519	798	114	89	
4	461	452	688	97	74
5	561	401	389	584	80
6	50	485	348	333	455
7	213	42	420	300	275
8	299	183	35	362	251
9+	54	237	357	736	920
Total	2,159	2,598	2,351	2,501	
Spawn. stock	1,644	1,749	2,072	2,343	
Spawn. biom.	507	555	714	840	

Table 2.9 Average weight in catch, in grammes, Norwegian spring-spawners, 1974-84

Age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
3	259	259	259	294	232	283	224	204	249	204	233
4	341	342	342	326	359	347	336	303	304	250	281
5	384	384	384	371	385	402	378	355	368	317	348
6	409	409	409	409	420	421	387	383	404	356	371
7	444	444	444	461	444	465	408	395	424	386	408
8	461	461	461	476	505	465	397	413	437	401	428
9	520	520	520	520	520	520	520	453	436	410	442
10	543	543	543	543	551	534	543	468	493	418	434
11	412	412	412	500	500	500	512	512	480	441	456
12	412	412	412	500	500	500	512	500	470	455	469
13	412	412	412	500	500	500	512	500	500	438	460
14	412	412	412	500	500	500	512	500	500	432	460
15	412	412	412	500	500	500	512	500	500	432	445

Table 2.11 Fishing mortality obtained from VPA run, Norwegian spring-spawning herring

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
3	0.132	0.470	0.112	0.036	0.058	0.039	0.009	0.013	0.009	0.019	0.030	0.055
4	0.075	0.013	1.135	0.248	0.043	0.038	0.029	0.026	0.011	0.019	0.033	0.061
5	1.062	0.090	0.072	0.025	0.018	0.044	0.025	0.042	0.016	0.012	0.026	0.119
6	1.906	2.433	0.145	0.000	0.029	0.064	0.029	0.035	0.048	0.014	0.019	0.060
7	3.030	2.031	0.514	0.079	0.044	0.034	0.025	0.048	0.023	0.051	0.017	0.046
8	0.080	0.080	0.080	0.080	0.080	0.080	0.040	0.040	0.030	0.030	0.040	0.047
9+	0.080	0.080	0.080	0.080	0.080	0.080	0.040	0.040	0.030	0.030	0.040	0.047
$F_{(3-9)w}$	0.092	0.091	0.138	0.050	0.053	0.045	0.019	0.029	0.017	0.019	0.028	0.066

Table 2.12 Yield per recruit (g) for different Fs and minimum landing sizes, Norwegian spring-spawning herring

	Minimum landing size (cm)			
F	20	25	27	30
0.05	60.3	59.6	58.4	54.9
0.10	88.2	88.9	88.0	83.8
0.15	102.2	105.0	104.8	100.9
0.20	109.4	114.2	115.0	111.9
0.25	112.9	119.7	121.5	119.3
0.30	114.3	123.0	125.7	124.4
0.40	114.0	126.0	130.4	130.8
0.50	111.9	126.5	132.4	134.3

Table 3.1 International catch of Barents Sea capelin ('000 tonnes) in the years 1965-84

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
1983	1,421	812	-	2,233
1984	810*	624	-	1,434

*Preliminary figure

Table 3.2 Capelin catches in the Barents Sea in August-December 1984 and in January-April 1985 in numbers (x 10^{-6})

Age	1984					1985			
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1	0.01	0.88	0.74	0.09	0.46	-	-	-	-
2	-	11.37	4.59	1.38	3.47	0.07	0.02	0.13	0.03
3	0.01	9.21	3.07	1.15	2.07	1.90	1.10	1.34	0.71
4	0.01	0.65	0.60	0.29	0.18	6.42	3.46	3.85	2.03
5	-	0.10	0.40	0.30	0.10	1.07	0.56	0.84	0.66

Table 3.3. Larval index for Barents Sea capelin

Year	Index
1981	9.71
1982	9.88
1983	9.94
1984	8.15
1985	9.25

Table 3.4 Acoustic estimate, autumn 1985, for Barents Sea capelin

Total length (cm)	Age 1	2	3	4+	Total number ($\times 10^{-7}$)	Biomass, tonnes ($t \times 10^{-3}$)	Biomass (Cum.)
7.0- 7.5	4	-	-	-	4	0.0	
7.5- 8.0	3	-	-	-	3	0.0	
8.0- 8.5	33	-	-	-	33	0.6	
8.5- 9.0	123	-	-	-	123	2.9	
9.0- 9.5	382	1	-	-	383	10.3	
9.5-10.0	647	52	-	-	699	24.6	
10.0-10.5	848	166	6	-	1,020	41.7	
10.5-11.0	875	362	5	-	1,242	59.2	
11.0-11.5	395	624	25	-	1,044	57.8	
11.5-12.0	104	654	57	-	815	53.3	
12.0-12.5	153	890	115	-	1,058	80.3	
12.5-13.0	26	651	183	-	860	74.6	
13.0-13.5	18	508	237	1	764	76.3	
13.5-14.0	1	287	283	3	574	65.3	
14.0-14.5	-	244	372	16	632	81.2	274.7
14.5-15.0	-	129	253	15	397	57.7	193.5
15.0-15.5	-	79	246	22	347	56.0	135.8
15.5-16.0	-	23	129	20	172	30.6	79.8
16.0-16.5	-	32	77	6	115	22.7	49.2
16.5-17.0	-	10	45	8	63	14.2	26.5
17.0-17.5	-	13	23	1	37	8.8	12.3
17.5-18.0	-	-	8	1	8	2.2	3.5
18.0-18.5	-	-	4	-	4	1.3	1.3
Number	3,512	4,725	2,068	92	10,397	-	-
Biomass (tonnes)	150.0	389.4	268.1	14.4	-	821.8	-
Mean length	10.32	12.39	14.15	15.29	12.07	-	-

Table 3.5 The development of the Barents Sea capelin stock since 1973.

Year	Spawning stock ('000 t)	Recruitment (Year + 2) (billion)	F-value autumn	F-value spring	Stock 1 Oct ('000 t)
1973	783	650	0.035	0.87	3,500
1974	288	435	0.028	1.31	4,793
1975	268	380	0.054	1.25	7,323
1976	1,328	708	0.142	0.69	5,758
1977	1,243	607	0.268	0.84	4,215
1978	685	356	0.102	0.95	4,451
1979	320	377	0.133	1.13	4,080
1980	228	281	0.078	1.34	5,462
1981	2,023	390	0.162	0.40	2,967
1982	720	341	0.216	0.65	2,539*
1983	215	102	0.254	1.63	2,621
1984	302	62**	0.165	0.80	2,328
1985	400	-	0.198	0.68	672

*The 1982 estimate is adjusted.

**Based on the measurement of 1-year-old capelin in 1985.

Table 4.1 The total annual and seasonal catch of capelin in the Iceland - East Greenland - Jan Mayen area (in '000 tonnes) during 1964-85

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	-	0.0	0.0	0.0	0.0	13.0
1983	0.0	-	0.0	0.0	0.0	0.0	133.3
1984	439.6	-	425.2	104.3	6.2	8.0	983.3
1985	348.5		*	188.7	72.0	16.0	

*Autumn season in progress

Table 4.2 Acoustic estimate, October 1985, for the Iceland - East Greenland - Jan Mayen capelin

Total length (cm)	Age 1	2	3	4+	Total number ($\times 10^{-6}$)	Biomass ($t \times 10^{-3}$)	Mean weight (g)
8.5- 8.9	616	-	-	-	616	1	2.0
9.0- 9.4	1,252	-	-	-	1,252	2	2.2
9.5- 9.9	5,173	-	-	-	5,173	15	3.0
10.0-10.4	10,622	-	-	-	10,622	32	3.0
10.5-10.9	7,235	-	-	-	7,235	29	4.0
11.0-11.4	4,189	-	-	-	4,189	19	4.7
11.5-11.9	2,943	837	-	-	3,780	20	5.5
12.0-12.4	1,023	1,723	-	-	2,746	18	6.6
12.5-12.9	645	2,370	-	-	3,015	23	7.8
13.0-13.4	17	4,687	17	-	4,721	41	8.9
13.5-13.9	84	7,569	-	-	7,653	78	10.2
14.0-14.4	17	6,794	134	-	6,945	79	11.5
14.5-14.9	-	7,329	79	-	7,408	98	13.4
15.0-15.4	-	5,798	631	-	6,429	96	15.1
15.5-15.9	-	5,681	1,348	52	7,081	120	17.0
16.0-16.4	-	4,048	2,198	-	6,246	120	19.2
16.5-16.9	-	3,022	2,558	-	5,580	124	22.4
17.0-17.4	-	2,101	2,953	-	5,054	127	25.3
17.5-17.9	-	1,199	2,146	219	3,564	101	28.3
18.0-18.4	-	135	1,436	50	1,621	50	30.9
18.5-18.9	-	53	473	28	554	18	33.4
19.0-19.4	-	-	318	55	373	13	37.5
19.5-19.9	-	-	79	-	79	2	35.5
Number	33,816	53,346	14,370	404	101,936	-	-
Mean length	10.59	14.76	17.02	17.84	13.71	-	-
Biomass	129.0	754.8	341.9	12.0	-	1,237.6	-
Mean weight	3.8	14.1	23.8	29.5	-	-	12.1

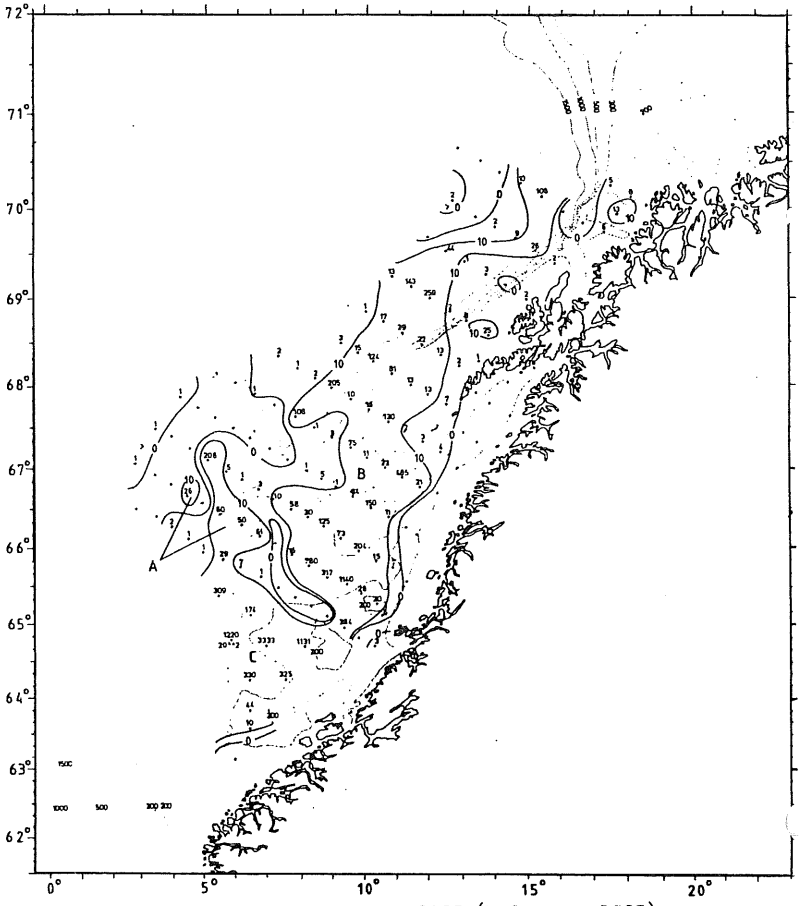


Figure 2.1 Herring larvae, May 1985 (Nedreaas, 1985).

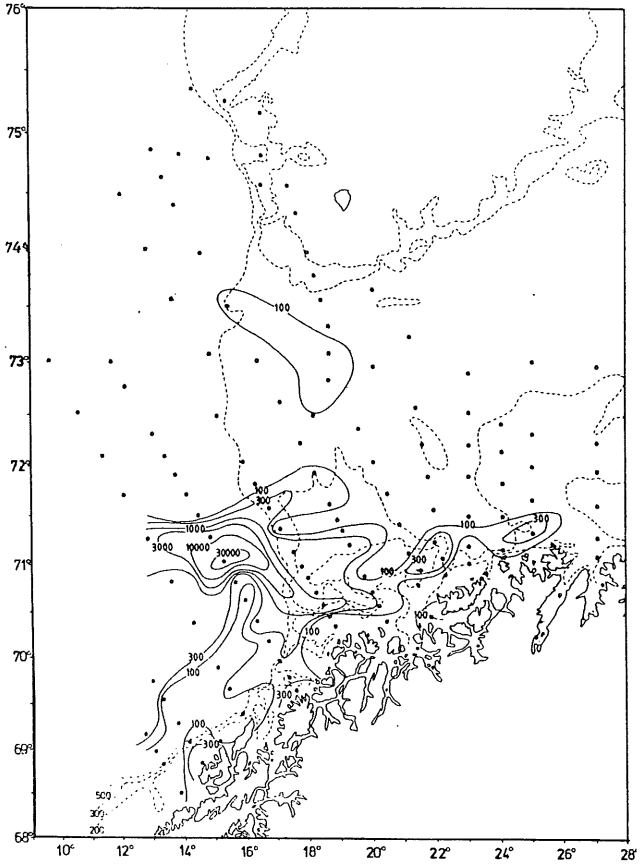


Figure 2.2 Herring post-larvae, June-July 1985 (Bjørke et al., 1985).

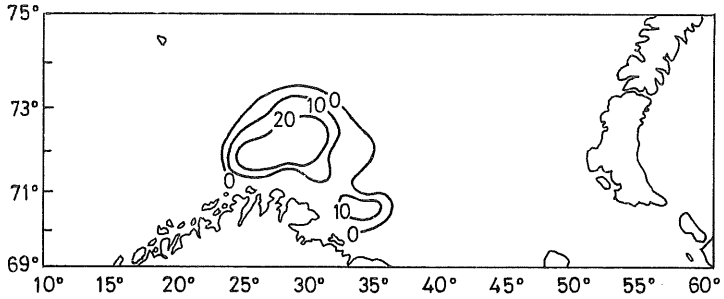
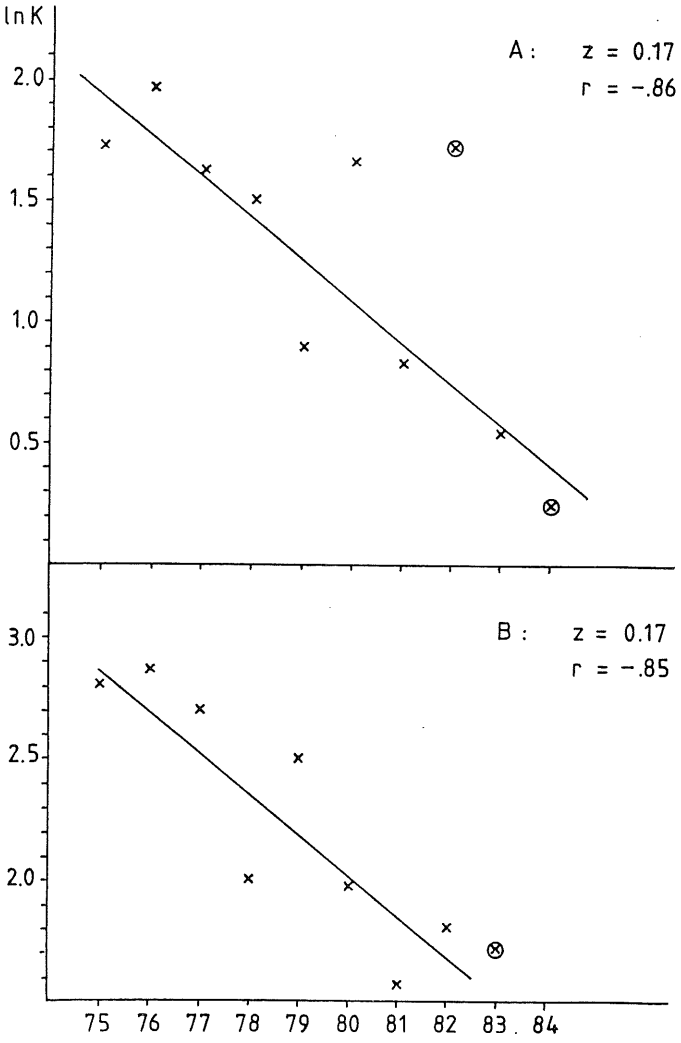


Figure 2.3 Distribution of 1985 year class in September 1985 (tonnes/ n miles^2).



A = Southern component
B = Northern component
⊗ = Excluded in mortality-estimate

Figure 2.4 Plot of lnK against time at liberty where $K = \frac{m}{r} \times 10^{-2}$.

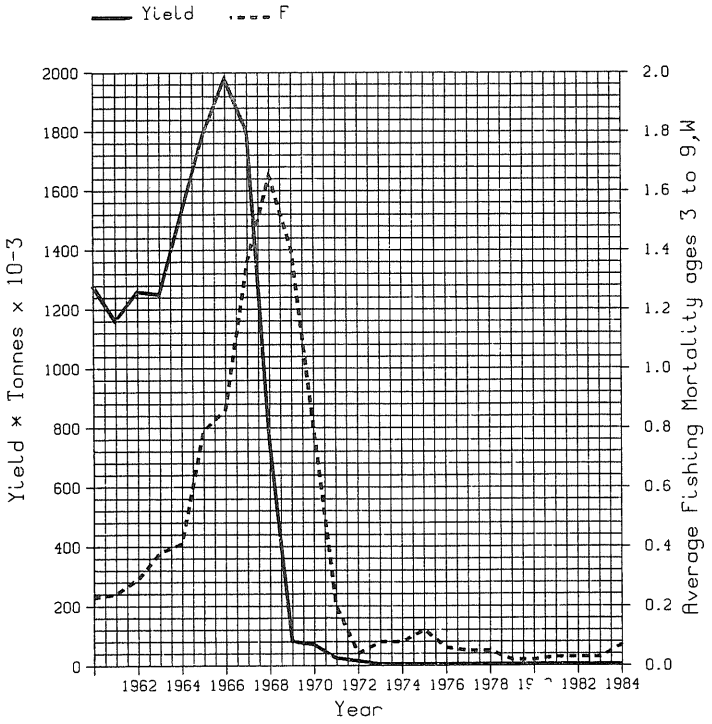
FISH STOCK SUMMARY

STOCK: NORWEGIAN SPRING SPAWNING HERRING

05-11-1985

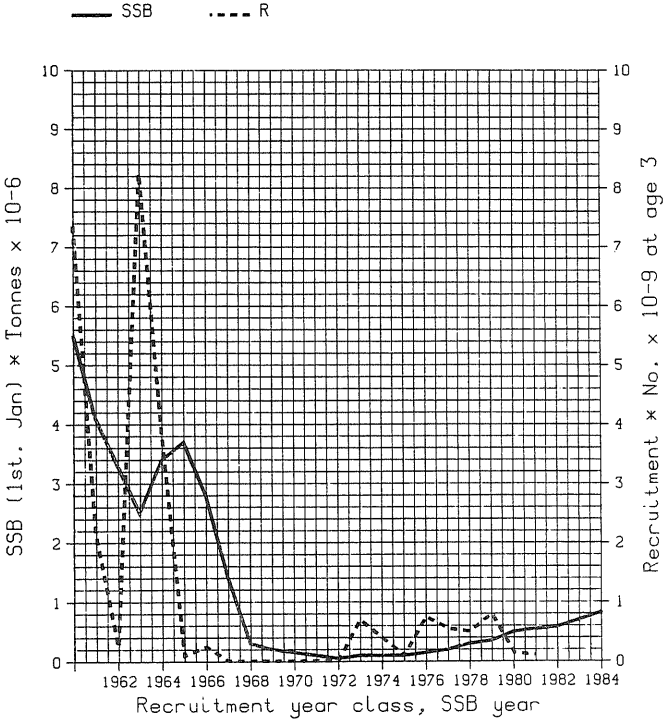
Figure 2.5 A - B

Trends in yield and fishing mortality (F)



A

Trends in spawning stock biomass (SSB) and recruitment (R)



B

ctd.

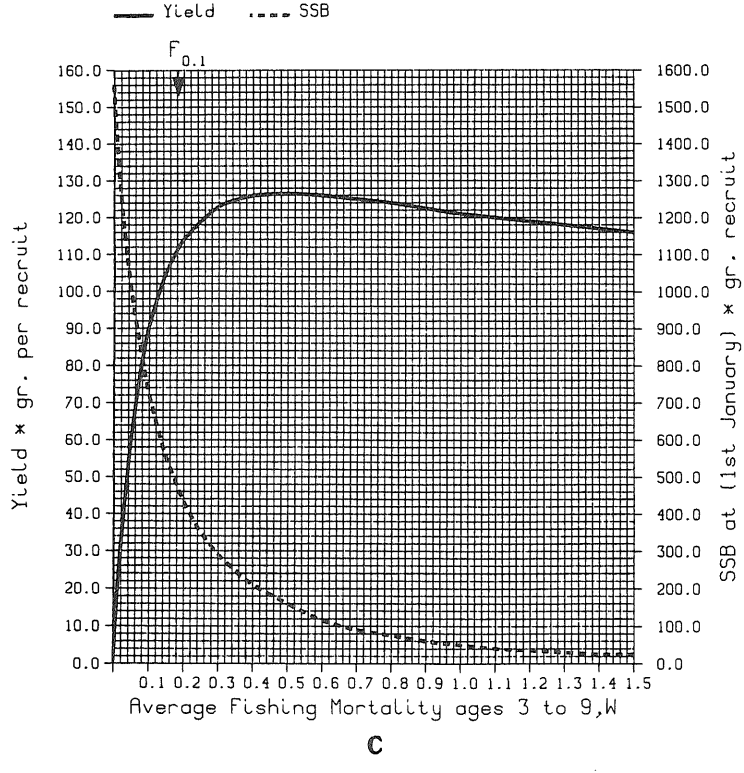
FISH STOCK SUMMARY

STOCK: NORWEGIAN SPRING SPAWNING HERRING

05-11-1985

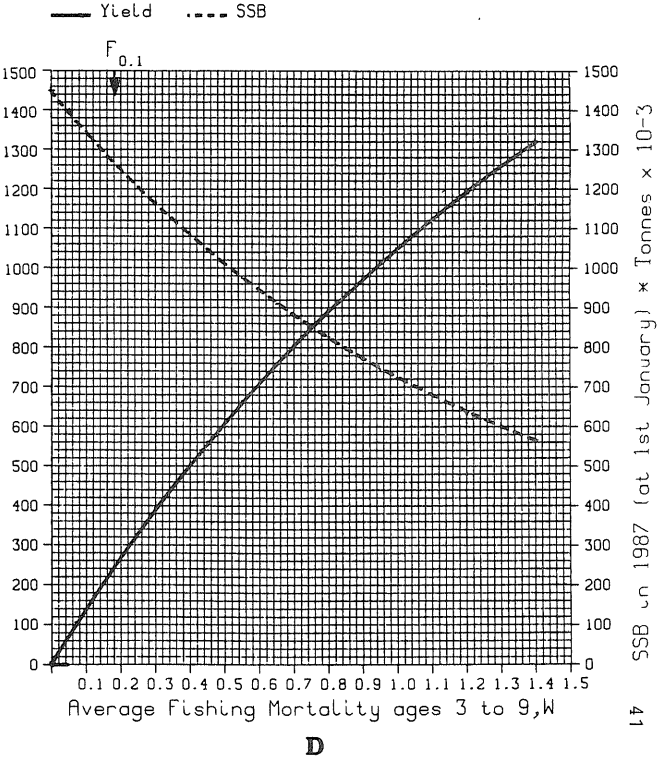
Figure 2.5 (ctd) C - D

Long term yield and spawning stock biomass



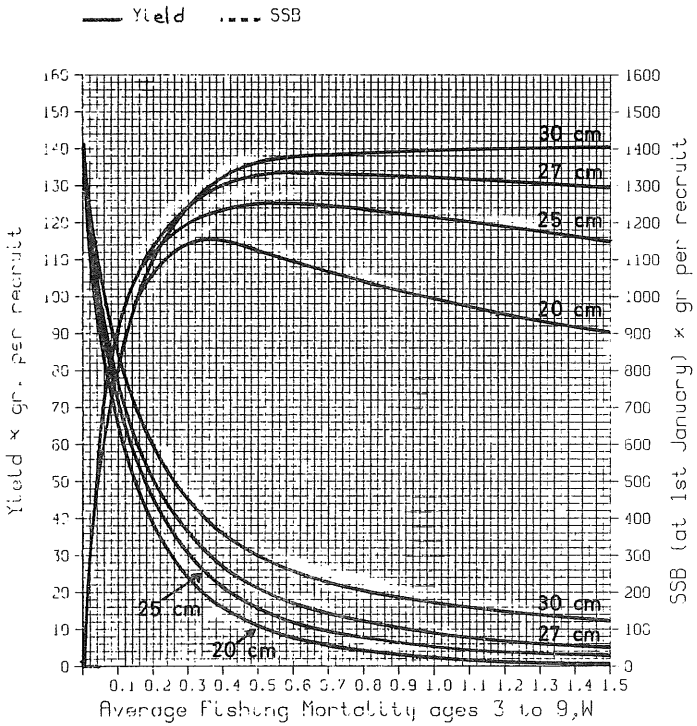
C

Short-term yield and spawning stock biomass



D

Figure 2.6 Yield per recruit and corresponding spawning stock biomass per recruit for 20 cm, 25 cm, 27 cm, and 30 cm minimum landing size.



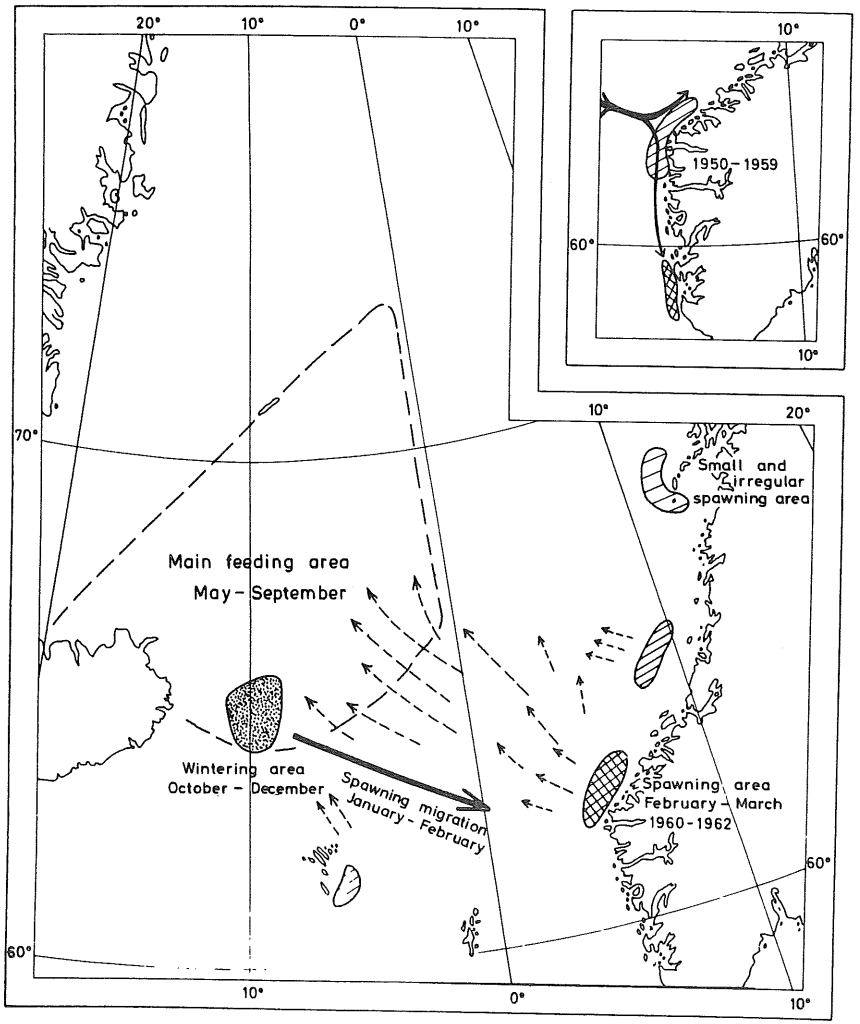


Figure 2.7 Migration routes of Norwegian spring-spawning herring, 1950-62.

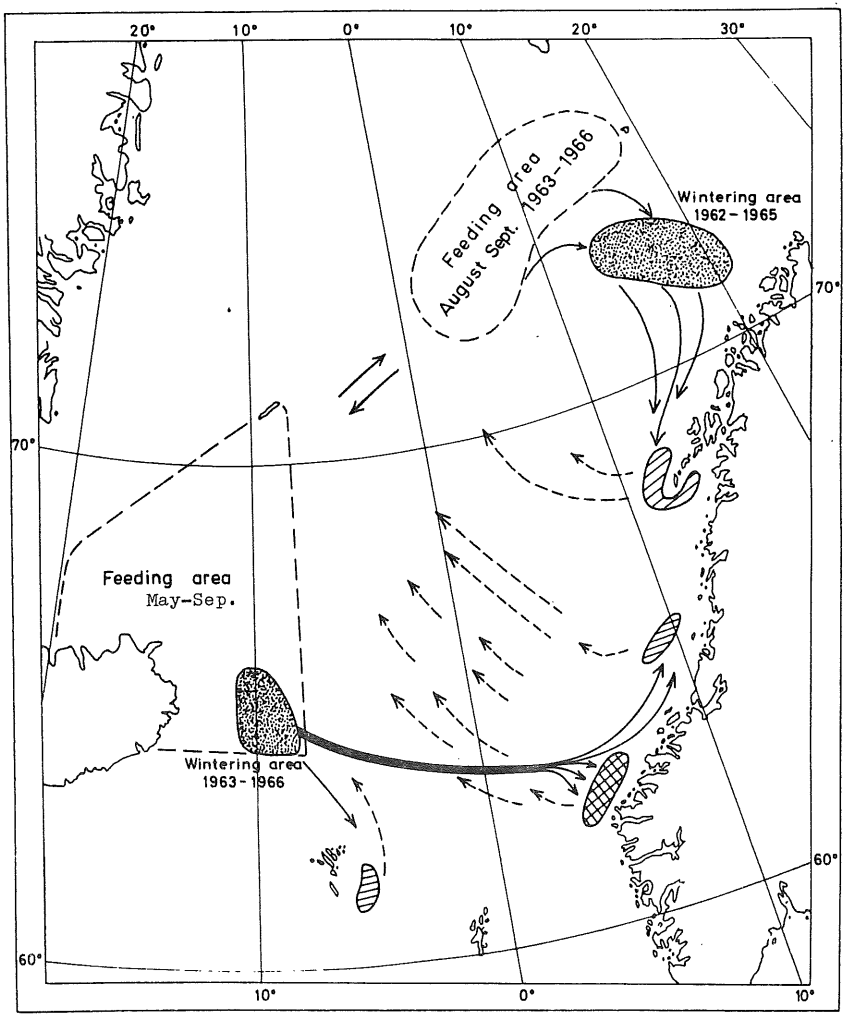


Figure 2.8 Migration routes of Norwegian spring-spawning herring, 1963-66. It should be noted that the feeding and wintering areas in the Bear Island area during 1962-65 were occupied by only a portion of the 1959 year class.

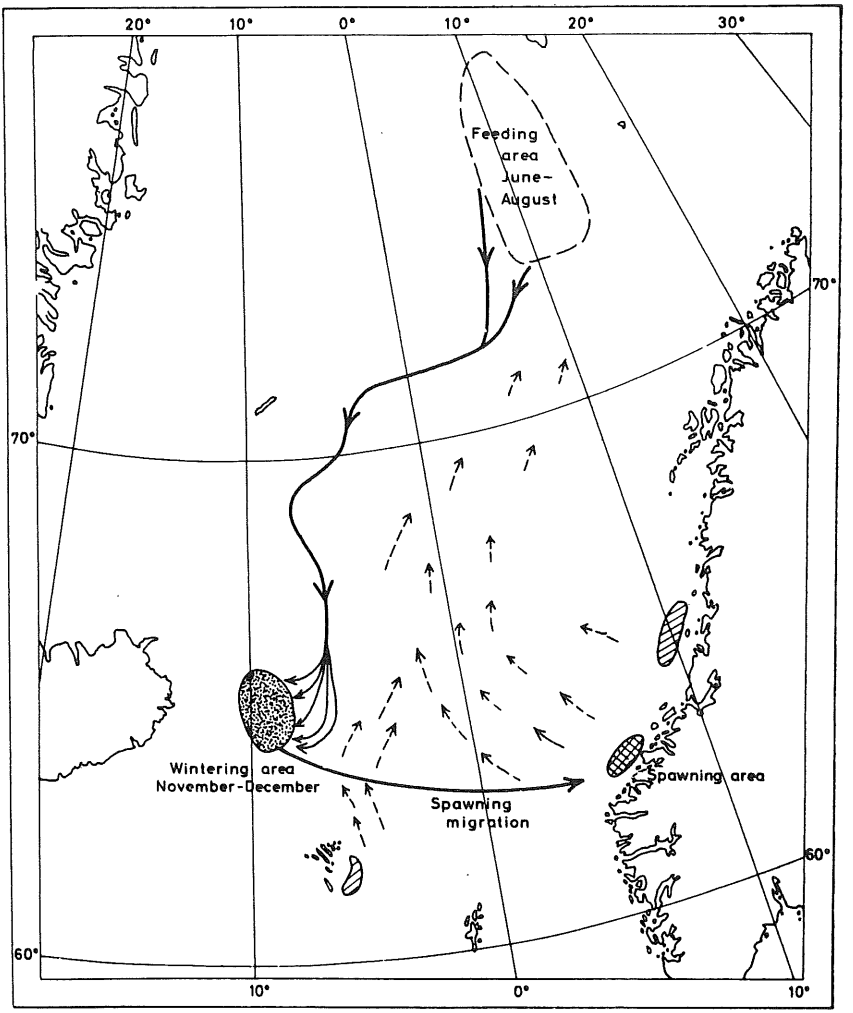


Figure 2.9 Migration routes of Norwegian spring-spawning herring, 1967-68.

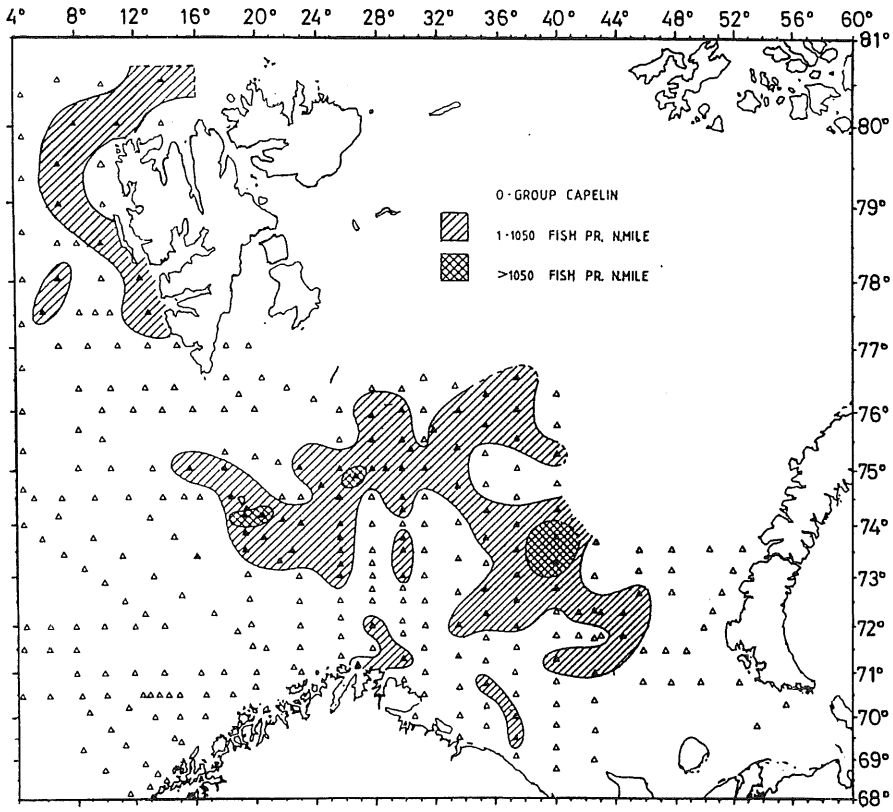


Figure 3.1 0-group distribution of capelin, 1985.

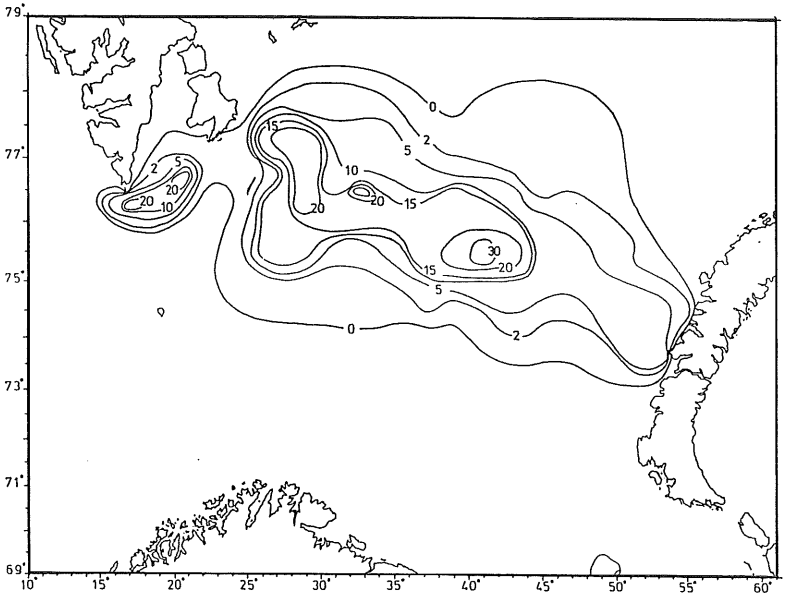


Figure 3.2 Estimated total density distribution of capelin (tonnes/n.mile^2).