International Council for the Exploration of the Sea

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REPORT OF THE ATLANTO-SCANDIAN HERRING AND CAPELIN WORKING GROUP

Copenhagen, 26-30 October 1987

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1 INTRODUCTION AND PARTICIPATION

1.1 Terms of Reference

The Atlanto-Scandian Herring and Capelin Working Group met at ICES Headquarters from 26-30 October 1987.

The terms of reference are given in C.Res.1986/2:5:25:

"The Atlanto-Scandian Herring and Capelin Working Group (Chairman: Dr V.N. Shleinik) will meet at ICES Headquarters from 26-30 October 1987 to assess the status of the Norwegian spring-spawning herring and capelin stocks in Sub-areas I, II, V, and XIV and provide catch options within safe biological limits for the herring for 1988 and for the capelin for the winter 1987/1988 and summer-autumn 1988 seasons."

In addition, NEAFC, in November 1986, asked ICES to "provide information on the distribution and state of Atlanto-Scandian spring-spawning herring."

As the Chairman V. Shleinik could not participate, the meeting was chaired by H.í Jakupsstovu.

1.2 Participants

J. Carscadden	Canada
A. Dommasnes	Norway
J. Efimov	USSR
J. Hamre	Norway
H. í Jákupsstovu (Acting Chairman)	Faroe Islands
P. Kanneworff	Denmark
J.-D. Lambert	Canada
P. Reynisson	Iceland
A. Rjazhskikh	USSR
I. Røttingen	Norway
H. Vilhjàlmsson	Iceland

1.3 Working Documents

The documents listed in Appendix I were presented to the Working Group as working documents.

2 NORWEGIAN SPRING-SPAWNING HERRING

2.1 Catch Statistics

The total annual catches of Norwegian spring-spawning herring from 1972 to 1986 in terms of weight and numbers are presented in Tables 2.1 and 2.2. The estimated unreported catches have been converted to catch in numbers using Norwegian data on catch at age in the adult fisheries. Norwegian research vessel data have been applied to convert the USSR catch of 26,000 t in the winter of 1986 to catch in numbers.

2.2 Recruitment

The nursery areas of herring recruits are the fjords and the area off the Norwegian west coast, and in some years the southern part of the Barents Sea. The recruitment has, therefore, been assessed in two components, one coastal and one from the Barents Sea.

2.2.1 Acoustic O-group estimates in Norwegian coastal areas

An acoustic survey of O-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 2.3.

2.2.2 The O-group index in the Barents Sea

Indices of O-group Norwegian spring-spawning herring have been estimated for the period 1965-1987 based on data from the international O-group surveys in the Barents Sea (Toresen, 1985) (Table 2.4).

2.2.3 Acoustic O-group estimates in the Barents Sea

The acoustic estimates (Anon., 1986) of O-group herring in the Barents Sea for the last five years are shown in the text table below:

Year class	Estimated number (billions)	Time of survey
1983	35.7	Nov 1983
1984	6.2	Nov 1984
1985	41.5	Sep 1985
1986	-	Sep 1986
1987	-	Sep 1987

The estimates for the years 1983-1984 are looked upon as underestimates. The conditions for abundance estimation of O-group herring in 1985 were more favourable, and the estimate was considered far more reliable than the corresponding estimate for the two previous years. In 1987, as in 1986, no O-group herring were detected in the Barents Sea.

According to Mehl (1987), the Barents Sea components of the 1984 and 1985 year classes are completely depleted due to predation by cod (Table 2.5).

2.3 The Adult Stock

The adult stock was assessed in two components: a) the part of the 1983 year class which has had its nursery area in the Barents Sea and b) the coastal component which is the rest of the stock.

2.3.1 Acoustic estimate of the oceanic component of the 1983 year class

The most favourable conditions for absolute biomass estimation of this component by echo integration occurred in August 1987. To convert the echo integrator readings to herring abundance the following target strength-length relationship [TS = 20.0 log L - 71.9 (Foote, 1987)] was applied to give an abundance estimate in number of 4.1 billion.

This TS value is comparable to the TS value applied in the North Sea herring surveys. When comparing the VPA to acoustic estimates of the Icelandic herring, this TS value gives an almost optimal 1:1 relationship (Halldorsson et al., 1986).

2.3.2 The coastal component

2.3.2.1 Tagging

In the past, the Working Group tuned the VPA on the coastal component using estimates of mortalities obtained from tag return data in the same year. This was not possible in 1987. The strong 1983 year class dominated the landings during the winter in 1987, and since few herring of that year class have been tagged, the tag return was expected to be low. The effort of screening winter catches in 1987 was thus reduced, and very few tags were recovered. New data for updating the 1986 stock and mortality estimates are, therefore, not available.

2.3.2.2 State of the stock and VPA

Since new tagging information was not available, the Working Group, as in 1986, tuned the VPA against the spawning stock in 1984 derived from tagging, referring to the 1979 and older year classes.

The Working Group discussed the usefulness of the separable VPA to calculate the input Fs, and made some trial runs. The underlying assumption for the separable VPA, however, of a stable exploitation pattern was not found to be valid for any time period in the last 10 years, and the method was, therefore, not used.

The 1980, 1981, and 1982 year classes were assessed by assuming an F value in 1986 equal to the calculated average F of the 1978 and 1979 year classes. The coastal component of the 1983 year class was assessed according to the acoustic estimate of the coastal component in 1983 and reduced by the regression function shown in Figure 2.1.

Other input data in the VPA were:

Catch in number per year class (not including the oceanic component)	Table 2.2
Weight at age in stock	Table 2.6
Weight at age in catch	Table 2.7
Natural mortality M (age 3 and older)	0.13
Proportions of maturity	Table 2.8

The results of the VPA are given in Tables 2.9 and 2.10.

2.3.3 Combined assessment of the oceanic and coastal components

The total stock estimate of Norwegian spring-spawning herring for ages 4+ at 1 January 1987 was obtained by adding the assessments for the coastal and oceanic components (Table 2.11). The historic development of the stock and yield is shown in Figure 2.2.

2.4 Catch and Stock Prognosis

The input data (Table 2.12) refer to the stock size on 1 January 1987. The estimate of the 1986 year class as 1-year-olds is taken from the 0-group acoustic estimate (Table 2.3). The estimates of the 1985 and 1984 year classes are derived from the acoustic estimates of 0-group herring (Table 2.3) and reduced by the regression factor shown in Figure 2.1. The estimate of the 1983 year class is a sum of the estimates of the coastal component (from VPA) and the oceanic component (Section 2.3.1). The estimates of the 1982 and older year classes are from the VPA.

The fishing pattern is assumed to be similar to last year's, with the exception of the 1983 year class. Here the fishing pattern was calculated on the basis of the total stock on 1 January 1987 and the estimated catch of this year class in 1987. The natural mortality and maturity ogive are the same as in 1986. The weight in the catch and weight in the stock for the 1983 year class were adjusted according to the low growth rate of this year class.

2.5 Results of Prognosis

The results of the prognosis two years ahead are given in Table 2.13 and Figure 2.2.

The significant increase in the spawning stock from 1987 to 1988 is due to the strong incoming 1983 year class. However, recruitment to the spawning stock from the 1984-1986 year classes will be very low (Table 2.3). A long-term prediction based on this recruitment and varying levels of TAC is illustrated in Figure 2.3 assuming a similarly low recruitment from the 1987 and 1988 year classes.

Based on the low recruitment in 1988 and 1989, and with regard to the preferred level of the spawning stock of 2.5 million t (ACFM meeting in November 1986), the Working Group recommends utmost caution in setting the TAC for the coming year.

2.6 Yield per Recruit

The input values in the catch and stock prognosis (Table 2.12) refer to the actual fishing pattern and mean weights for the 1983 year class (4-year-olds). The input values in the yield-per-recruit run (Table 2.14) refer to a more general fishing pattern and mean weights in the catch and the stock for the 4-year-old herring. The results of the yield-per-recruit run are shown in Figure 2.2.

The yield per recruit is higher than given in last year's report. Last year, this run was made with a recruitment age of 1 year and applying a constant natural mortality of 0.13 on all age groups.

2.7 Biological Reference Points

The Working Group discussed the usefulness of the new biological reference points suggested by ACFM.

Since the depletion of the stock in the late 1960s, it has never been in a stable state. Furthermore, the stock has since then been regulated with the aim to rebuild the stock.

The new biological reference points (Figure 2.4) may, therefore, not be relevant for the management of this stock.

2.8 NEAFC Request

The Atlanto-Scandian Herring and Capelin Working Group in 1985 addressed a similar but broader question posed by NEAFC.

Since then, only the oceanic component of the 1983 year class has been found to be distributed outside Norwegian coastal waters. In the period autumn 1983 to May-June 1986, this component was found to be distributed over wide areas in the southern Barents Sea in the EEZ of both Norway and USSR. In the early summer of 1986, this herring component migrated out of the Barents Sea, and it has since been found to be distributed on the coastal banks of western Norway (between 63^0N and 69^0N). (Ongoing investigations have revealed significant north-south migrations, however, within the Norwegian EEZ). There are no indications yet whether it will resume any of the migration patterns observed prior to 1970.

3 BARENTS SEA CAPELIN

3.1 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 used to be set separately for the winter fishery and the autumn fishery. The fishery was closed from 1 May to 15 August until 1984. During the period 1984-1986, the fishery was closed from 1 May to 1 September. Since May 1986, there has been no fishing.

3.2 Catch Statistics

The international catch by country in the years 1965-1987 is given in Table 3.1. The capelin catch (USSR and Norway combined) in numbers by age and month for the period 1 September 1985 - 30 April 1986 is given in Table 3.2.

3.3 Stock Size Estimates

3.3.1 Larval and O-group surveys

Norwegian larval surveys based on Gulf III plankton samples have been conducted in June-July each year since 1981. In 1986, no larvae were caught. In 1987, 659 capelin larvae were found in sections along 31^0 and 32^0E, south of 71^0N, and in the Varanger Fjord (there was no coverage farther east). The mean length was 8.7 mm.

Soviet larval surveys were carried out with ring trawl and IKS-80 egg nets during the period 24 March - 15 July 1986 and during the periods 28 March-4 April and 5-11 July 1987. In both years, larval capelin were found only at 3 stations of the Kola section: in July 1986, 772 larvae with a mean length of 11.9 mm, and in July 1987, 13 larvae with a mean length of 12.8 mm.

During the international O-group survey in the Barents Sea in August 1987, O-group capelin were observed in only a few trawl hauls spread over the central and eastern parts of the surveyed area and in a small continuous area in the southeastern part of the Sea (Figure 3.1). No index was calculated for capelin. However, the narrow distribution area and the low density indicate the 1987 year class to be as poor as the 1986 year class.

3.3.2 Acoustic stock estimates

The 1987 acoustic survey was carried out in the period 6 September - 12 October as a joint Soviet-Norwegian survey. The distribution of capelin in 1987 is shown in Figure 3.2. Seven research vessels (three Norwegian and four Soviet) participated in this survey. The following abundance estimates by year class were obtained:

Year class	Number (billions)	Mean weight (g)	Biomass ('000 t)
1986 (1985)	32 (8)	2.1 (4.2)	66 (32)
1985 (1984)	2 (3)	12.2 (11.7)	18 (40)
1984 (1983)	0.1(3)	14.0 (14.3)	1 (42)

The estimates of the same age groups in 1986 are shown in parentheses for comparison. The 1986 year class is four times larger by number than the 1-group measured last year, but has a much lower mean weight. The length distribution (Table 3.3) shows two peaks, one at 6.5 cm and the other at 8.5 cm. The former indicates a contribution of 1-group capelin originating from summer spawners, whereas the latter peak value of 8.5 cm indicates recruits from spring spawners. This latter modal length is very low compared to the normal size of 1-year-old capelin, but may be explained by the late spawning observed during the spring of 1986. The 1985 year class is less than 70% in number of the 2-group measured last year and is the lowest 2-group abundance ever recorded. The strength of the 1984 year class is likewise the lowest 3-group estimate recorded and is about 3% by number of the 3-group estimate obtained last year. The 4-year-old fish have almost disappeared from the stock.

The total stock biomass is estimated to be 86,000 t (Table 3.3), compared to 116,000 t in 1986 and 820,000 t in 1985.

It is a general observation that the acoustic method underestimates stock size, and it is likely that the relative error will be larger when the stock density is low. Moreover, the occurrence of the capelin together with a dominating stock of polar cod has added a new source of error to the abundance estimate of the capelin stock. Nevertheless, it must be concluded that the stock is seriously depleted, and may suffer from recruitment failure in the years to come.

3.4 History of Catch and Stock

Table 3.4 gives information on stock size and mortality of the Barents Sea capelin stock during the period 1974-1985. The data and methods used to calculate the numbers in the table are explained in the Working Group report from last year (Anon., 1987).

The Working Group wants to point out that the model used does not take into account the increased natural mortality since 1984 due to predation by cod. Furthermore, when the stock is very small and spread thinly over a large area, like it was during the acoustic cruises in September-October 1986 and 1987, the errors in the acoustic estimates are likely to be high. The Working Group, therefore, decided not to extend Table 3.4 by including the year 1986.

3.5 Management Considerations

The present estimate of the maturing stock (capelin above 14 cm) is the lowest ever recorded and is less than 1% of a normal stock measurement obtained in the 1970s and in the early 1980s.

Moreover, the recruitment of the upcoming 1986 year class is far below average, and the further development of the stock will, to a large extent, depend on the growth of the year class.

Based on these low stock estimates and recruitment figures, the Working Group recommends that no fishing should take place in 1988.

4 ICELANDIC CAPELIN

4.1 Catch Regulation

The capelin is a short-lived species where the fishery depends on the recruiting year class.

The fishery on the Iceland-Greenland-Jan Mayen stock of capelin has been regulated by precautionary catch quotas set prior to each fishing season (July-March) based on the results of surveys of the abundance of immature 1- and 2-group capelin carried out in autumn and/or winter in the preceding year.

Final catch quotas for each season have then been set in accordance with the results of acoustic abundance surveys of the maturing (fishable) stock carried out in autumn (October) and/or winter (January-February) in that season.

4.2 The Catch in the 1986/1987 Season

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

On the basis of the October 1986 survey, a TAC for the whole 1986/1987 season was set at 1,170,000 t. In January 1987, the mature stock was surveyed again and estimated to be about 1,015,000 t. As about 400,000 t of the TAC allocated for the season remained to be taken, this result indicated that another 120,000 t could be added to the TAC for the 1986/1987 season and still preserve the target spawning stock of 400,000 t.

4.3 The Preliminary TAC for the 1987/1988 Fishery

In January/February 1987, Iceland carried out a survey of immature capelin of the 1985 and 1984 year classes which would constitute the fishable stock in the 1987/1988 season. The survey yielded an abundance estimate by number of 40.9 billion and 11.5 billion for the above year classes, respectively. Immature capelin were mainly recorded north of Iceland west of 18^{0}W. In that area, drift ice covered the outer part of the distribution, particularly in the case of the 1985 year class and, as a result,

it was concluded that the abundance of capelin of this year class was underestimated.

Since there was no way to judge how much these capelin were underestimated during the January/February 1987 survey, other methods of estimating their abundance were considered by a group of scientists from Greenland, Iceland, and Norway (see Working Document: Anon., Capelin in the Iceland-East Greenland-Jan Mayen area, Appendix I). Numbers from the August and October 1986 acoustic surveys were used in four different ways to project the numbers for the 1985 year class to August 1987, while accepting the January/February estimate as a starting point for projection of the 1984 year class.

All of the methods used regression analysis of the relationship between the numbers obtained for 1-year-old fish and the numbers obtained from acoustic surveys of the same year classes when they were 2-, 3-, or 4-year-olds.

The resulting TAC values based on the different projections of the 1985 year class were 304,000, 501,000, 504,000, and 1,072,000 t. For all the TAC calculations, an assumption was made for the maintenance of a target spawning stock of 400,000 t.

Because the above procedure of examining different relationships by regression analysis was being used for the first time for forecasting the abundance of the fishable stock of capelin in the Iceland-East Greenland-Jan Mayen area, and in view of the highly variable results, a precautionary TAC of 500,000 t was set for the July/November 1987 season. It was assumed that a TAC for the period December 1987/March 1988 could then be set after further information on the state of the stock became available during acoustic surveys in the autumn of 1987.

All of the methods have the disadvantage of using data from a short time series. The Working Group considered the relationship described by Method 2 to be most acceptable because of the comparative reliability of the data collected during these surveys. They are conducted when juveniles and older fish are separate and the acoustic estimates are, therefore, not affected by trawl selectivity. This method used numbers as 1-year-olds in August from acoustic surveys and numbers as 1-year-olds in August back-calculated from acoustic surveys in January when the fish are 3 and 4 years old.

4.4 The October 1987 Stock Abundance Estimate

The autumn 1987 acoustic survey was carried out during 2-20 October. Two vessels participated and obtained the following abundance estimates by year class:

Year class	Number (billions)	Mean weight (g)	Biomass ('000 t)
1986	21.4	2.8	59.7
1985	17.7	17.3	306.5
1984	4.1	25.4	103.0
1983	0.1	30.7	2.4

Further details of this stock estimate are given in Table 4.2, and the estimated relative density distribution in Figure 4.1.

Judging by maturity, about 405,000 t, comprising practically all the capelin recorded of the 1984 and 1985 year classes, will mature and spawn in March 1988. As last year, the maturity ratio in the younger year classes is very high. The ratio (81/19) of year classes in the spawning stock (1985 year class/older year classes) is close to the forecast in the April 1987 stock prognosis (84/16).

In October 1987, the adult stock had a very westerly distribution and, at the time of the survey, much of it had apparently not returned from its feeding migration to the Jan Mayen-Greenland area.

The ice cover over most of the Greenland shelf south of the Scoresby Sund prevented the survey from reaching the western limit of the distribution area of adult capelin as well as that part of the juvenile stock which, in late August - early September, had been recorded in deep waters off the western north coast of Iceland.

Experience from the 1981 autumn and 1982 winter surveys has shown that, when autumn surveys of this capelin stock have been carried out before most of the adults have returned from feeding in the northern latitudes, the resulting abundance estimates have been underestimates (Vilhjálmsson, 1983).

The results of the October 1987 acoustic survey are, therefore, considered to be underestimates of both the juvenile and adult components of the stock, the magnitude of which cannot be judged.

4.5 TAC for the December 1987/March 1988 Period

In the past, estimates of abundance of this capelin stock from the autumn survey have been used as a basis for setting the TAC for the following winter season. However, the estimates from the 1987 autumn survey are underestimates and the spawning stock estimated from the results of this survey would be about equal to the target spawning stock biomass of 400,000 t. Since a new Icelandic acoustic survey is planned for November 1987, when the capelin are expected to have returned to their usual wintering areas off north or northwest Iceland, the Working Group recommends that a final decision on the December 1987/March 1988 TAC be deferred until after completion of this survey.

4.6 TAC for the Summer/Autumn 1988 Season

The fishable stock in the 1988/1989 season will consist of the 1986 year class and that part of the 1985 year class that did not mature and spawn in 1988.

Attempts to estimate the abundance of 1-group capelin in summer began with a pilot survey in August 1982. In August 1983, the survey grid was adjusted in light of the findings in the previous year, and these surveys have since been continued annually in August. When the abundance estimates of the 1981-1984 year classes as 1-year-olds in August are plotted against back-calculations of the size of the same year classes from winter estimates of 3- and 4-group spawners (see Section 4.3), taking account of the catch and natural mortality rate, the four sets of data seem to be closely related (Figure 4.2).

In August-September 1987, an acoustic survey of 1-group capelin was carried out in the area south of 68^0 30'N. The total abundance estimate (in numbers) was 101 billion, but it should also be noted that the survey did not cover the total distribution of the year class. Details of the above estimate are given in Table 4.3, and the estimated relative density distribution of the 1986 year class as 1-group in August-September in Figure 4.3.

Using the relationship in Figure 4.2, the August-September survey results correspond to 79.2 billion 2-group fish on 1 August 1988, when account has been taken of the natural mortality rate. A TAC for the 1988/1989 season may then be calculated making the following assumptions:

1) The 1988/1989 fishable stock and, therefore, the 1989 spawning stock will consist of the 1986 and 1985 year classes in the ratio 85/15. This is a lower ratio of 4-year-old fish than the average for the 1981-1985 period (Table 4.4).

2) The mean weight in the fishable stock will be 17.2 and 24.1 g for the 1986 and 1985 year classes, respectively (mean weights in 1981-1986 of 2- and 3-year-olds, respectively).

3) The mean weight in the 1989 spawning stock will be 18.3 and 26.1 g for the same year classes (Figure 4.4).

4) The natural mortality rate will be M = 0.035/month (Table 4.5).

5) There will be 400,000 t left to spawn in 1989.

The calculations based on these assumptions give a TAC for the 1988/1989 season of 625,000 t, spread evenly over the period.

However, as additional information on immature capelin of both year classes may be obtained from the acoustic surveys of the stock in November 1987 and in January-February 1988, and in view of the short August data series, advice on TAC for the 1988 summer and autumn season should be deferred until spring 1988.

5 RECOMMENDATION

In the discussion on the Norwegian spring-spawning herring during the two last Working Group meetings, doubt has been raised on the validity of some of the weights at age in the ICES data files.

In order to rectify this, the Working Group recommends that a special study group be set up to investigate this matter.

6 REFERENCES

Anon. 1986. Report of the Working Group on Atlanto-Scandian Herring and Capelin, 29 October to 1 November 1985. ICES, Doc. C.M. 1986/Assess:7.

Anon. 1987. Report of the Working Group on Atlanto-Scandian Herring and Capelin. ICES, Doc. C.M.1987/Assess:8.

Foote, K.G. 1987. Fish target strengths for use in echo integrator surveys. J. Acoust. Soc. Am. 82(3): 981-987.

Halldorsson, O., Reynisson, P., and Stefansson, G. 1986. A method for estimating terminal Fs from a series of acoustic surveys - comparison of VPA and acoustic estimates of the Icelandic herring. ICES, Doc. C.M. 1986/H:62.

Mehl, S. 1987. The north-east Arctic cod stocks consumption of commercially exploited prey species in 1984-1986. ICES, Doc. 1987 Symp. Pap.No.9.

Toresen, R. 1985. Recruitment indices of Norwegian spring-spawning herring based on results of the international O-group survey in the Barents Sea. ICES, Doc. C.M. 1985/H:54.

Vilhjàlmsson, H. 1983. Biology, abundance estimates and management of the Icelandic stock of capelin. Rit Fiskideildar (3): 153-181.

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

Year	A	B[1]	C	D	Total	Total included unreported catches
1972	0	9,895	3,266[2]	-	13,161	13,161
1973	139	6,602	276	-	7,017	7,017
1974	906	6,093	620	-	7,619	7,619
1975	53	3,372	288	-	3,713	13,713
1976	0	247	189	-	436	10,436
1977	374	11,834	498	-	12,706	22,706
1978	484	9,151	189	-	9,824	19,824
1979	691	1,866	307	-	2,864	12,864
1980	878	7,634	65	-	8,577	18,577
1981	844	7,814	78	-	8,736	13,736
1982	983	10,447	225	-	11,655	16,655
1983	3,857	13,290	907	-	18,054	23,054
1984	18,730	29,463	339	-	48,532	53,532
1985	29,363	37,187	197	4,300	71,047	81,047
1986[3]	71,122	55,507	156	-	126,785	136,785
1987[4]	71,919	-	-	-	-	-

A = catches of adult herring in winter.
B = mixed herring fishery, in autumn.
C = by-catches of 0- and 1-group herring in the sprat fishery.
D = USSR-Norway by-catch in the capelin fishery (2-group).
[1] Includes also by-catches of adult herring in other fisheries.
[2] In 1972, there was also a directed herring 0-group fishery.
[3] Preliminary.
[4] Preliminary up to 1 September 1987.

Table 2.2 Catch in numbers (thousands) of Norwegian spring spawners. Unreported catches are included for age 3 and older herring.

Age	1972	1973	1974	1975	1976	1977	1978	1979
0	347,100	29,300	65,900	30,600	20,100	43,000	20,100	32,600
1	41,000	3,500	7,800	3,600	2,400	6,200	2,400	3,800
2	20,400	1,700	3,900	1,800	1,200	3,100	1,200	1,900
3	35,376	2,389	100	3,268	23,248	22,103	3,019	6,352
4	3,476	25,220	241	132	5,436	23,595	12,164	1,866
5	3,583	651	24,505	910	-	336	20,315	6,865
6	2,481	1,506	257	30,667	-	-	870	11,216
7	694	278	196	5	13,086	419	-	326
8	1,486	178	-	2	-	10,766	620	-
9	198	-	-	-	-	-	5,027	-
10	-	-	-	-	-	-	-	2,534
11	494	-	-	-	-	-	-	-
12	593	-	-	-	-	-	-	-
13	593	-	-	-	-	-	-	-
14	-	178	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-

Age	1980	1981	1982	1983	1984	1985	1986
0	6,900	8,300	22,600	127,000	33,857	28,571	13,805
1	800	1,100	1,100	4,679	1,700	13,149	1,381
2	400	11,900	200	1,675	2,489	207,224[1]	3,091
3	6,407	4,166	13,817	3,183	4,483	15,615	539,785[2]
4	5,814	4,591	7,892	21,191	5,388	11,268	14,662
5	2,278	8,596	4,507	9,521	61,543	11,605	9,964
6	8,165	2,200	6,258	6,181	18,202	77,203	13,386
7	15,838	4,512	1,960	6,823	12,638	27,803	69,267
8	441	8,280	5,075	1,293	15,608	18,306	36,460
9	8	345	6,047	4,598	7,215	22,631	16,260
10	-	103	121	7,329	16,338	7,268	30,311
11	2,688	114	37	143	6,478	16,552	19,469
12	-	964	37	40	-	12,467	45,092
13	-	-	37	143	-	-	26,970
14	-	-	-	862	-	-	-
15	-	-	-	-	1,652	-	-
16	-	-	-	-	-	2,029	2,029

[1] 197,244 are from the oceanic component.
[2] 481,481 are from the oceanic component.

Table 2.3 Norwegian spring-spawners. Acoustic abundance of 0-group herring in Norwegian coastal waters in 1975-1986 (number in millions).

Year	Area			Total
	62^0N-65^0N	65^0N-68^0N	North of $68^0$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	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
1985	441	354	208	1,003
1986	10	144	254	408

Table 2.4 Abundance indices for 0-group herring in the Barents Sea, 1973-1987 (Toresen, 1985; Anon., 1987).

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
1986	0.00
1987	0.00

Table 2.5 Consummation of juvenile herring by North-East Arctic cod in the period 1984-1986 (modified from Mehl, 1987).

Year class of by herring	Age group of herring		Number (billions) consumed by cod (north of 67° N)
1983	1		7.0
	2		5.4
	3		1.8
		Total	14.2
1984	0		12.0
	1		9.5
	2		0.6
		Total	22.1
1985	0		35.2
	1		10.3
		Total	45.5
1986	0	Total	0

Table 2.6 Average weight (gm) in stock (1 January), Norwegian spring-spawners, 1975-1987.

Age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
3	181	181	181	180	178	175	170	170	155	140	148	146	93
4	259	259	259	294	232	283	224	204	249	204	234	206	144
5	342	342	342	326	359	347	336	303	304	295	265	265	261
6	384	384	384	371	385	402	378	355	368	338	312	289	289
7	409	409	409	409	420	421	387	383	404	376	346	339	310
8	444	444	444	461	444	465	408	395	424	395	370	368	346
9	461	461	461	476	505	465	397	413	437	407	395	391	360
10	520	520	520	520	520	520	520	453	436	413	397	382	369
11	543	543	543	543	551	534	543	468	493	422	425	388	354
12	412	412	412	500	500	500	512	512	480	459	434	383	374
13	412	412	412	500	500	500	512	500	470	449	443	403	385
14	412	412	412	500	500	500	512	500	500	427	452	403	389
15	412	412	412	500	500	500	512	500	500	437	463	450	470
16	412	412	412	500	500	500	512	500	500	437	480	470	460

Table 2.7 Average weight (gm)in catch, Norwegian spring-spawners, 1974-1986.

Age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
3	259	259	259	294	232	283	224	204	249	204	233	226	160
4	341	342	342	326	359	347	336	303	304	250	281	292	244
5	384	384	384	371	385	402	378	355	368	317	348	311	288
6	409	409	409	409	420	421	387	383	404	356	371	357	306
7	444	444	444	461	444	465	408	395	424	386	408	380	345
8	461	461	461	476	505	465	397	413	437	401	428	402	367
9	520	520	520	520	520	520	520	453	436	410	442	419	390
10	543	543	543	543	551	534	543	468	493	418	434	432	394
11	412	412	412	500	500	500	512	512	480	441	456	440	393
12	412	412	412	500	500	500	512	500	470	455	469	458	392
13	412	412	412	500	500	500	512	500	500	438	460	460	409
14	412	412	412	500	500	500	512	500	500	432	460	465	434
15	412	412	412	500	500	500	512	500	500	432	445	470	450
16	-	-	-	-	-	-	-	-	-	-	-	470	454

Table 2.8 Norwegian spring-spawning herring. Proportions of maturity.

Age	1976	1977	1987	1979	1980	1981	1982	1983	1984	1985	1986
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.50	0.73	0.13	0.10	0.25	0.30	0.10	0.10	0.10	0.10	0.10
4	0.90	0.89	0.90	0.62	0.50	0.50	0.48	0.50	0.50	0.50	0.20
5	1.00	1.00	1.00	0.95	0.97	0.97	0.70	0.69	0.90	0.90	0.90
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.71	0.95	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 2.9 VIRTUAL POPULATION ANALYSIS

ATLANTO SCANDIAN HERRING, COASTAL AREA

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = .13

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
3	.04	.05	.01	.02	.01	.02	.04	.08	.24	.05
4	.03	.03	.02	.05	.01	.05	.04	.07	.26	.35
5	.10	.03	.02	.05	.02	.02	.04	.16	.20	.35
6	.00	.36	.02	.02	.05	.02	.02	.08	.27	.35
7	.27	.00	.20	.04	.02	.05	.02	.06	.16	.39
8	.07	.72	.00	.42	.02	.02	.02	.06	.11	.30
9	.02	.04	.00	.05	.65	.02	.02	.17	.11	.12
10	.01	.02	.02	.00	.49	.44	.03	.09	.24	.20
11	.02	.02	.02	.05	.34	.50	1.31	.03	.12	1.60
12	.02	.02	.02	.02	.01	.16	.56	.02	.06	.50
13	.05	.05	.02	.02	.03	.00	1.42	.02	.05	.18
14	.07	.03	.03	.03	.05	.05	.01	.03	.03	.05
15	.03	.08	.04	.04	.05	.05	.04	.05	.03	.05
16+	.06	.08	.04	.04	.03	.05	.04	.03	.05	.05
(4-16)w	.04	.03	.02	.03	.02	.02	.03	.09	.16	.30
(4-10)w	.04	.03	.02	.03	.02	.02	.03	.10	.19	.28

Table 2.10 VIRTUAL POPULATION ANALYSIS

ATLANTO SCANDIAN HERRING, COASTAL AREA

STOCK SIZE IN NUMBERS UNIT: thousands

BIOMASS TOTALS UNIT: tonnes

ALL VALUES ARE GIVEN FOR 1 JANUARY

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
3	574594	126605	580439	422453	392046	630527	97072	64912	76677	2173083	0
4	750698	433861	108545	509003	364956	340353	540728	82259	52805	52747	1722133
5	3862	657098	415439	95390	432150	316158	291475	454977	57190	35846	52659
6	490	5077	540417	556655	79873	371421	275406	247030	341476	48156	22181
7	1907	429	1391	464037	305554	63077	320284	234200	100837	227770	29793
8	177101	1284	376	1556	392644	264063	57943	274353	193902	149559	135414
9	63	145490	551	529	779	357027	227122	49669	226741	155142	97271
10	76	59	123048	483	281	363	291251	195130	56879	177934	114257
11	66	66	51	105676	423	151	206	243033	156052	25587	127921
12	44	57	57	44	90277	265	98	49	211733	121555	4536
13	38	38	49	49	38	78363	198	49	42	174255	64750
14	17	32	32	42	42	32	68781	42	42	55	127807
15	14	14	27	27	56	56	27	59589	36	36	51
16+	14	14	27	27	56	56	27	36	73198	74254	65229
TOTAL NO	1509043	1378122	1774799	1955571	2059115	2476890	2167648	1911210	1656650	3343917	
SPS NO	1271351	1234589	1185155	1579428	1558990	1557581	1640275	1755519	1534519	1405556	
TOT.BIOM	579351	444043	551374	646079	649216	713454	755346	671836	581843	753053	
SPS BIOM	550083	409992	440452	518235	547167	552137	615838	637670	555670	477064	

Table 2.11 Estimate of total stock (thousands) of Norwegian spring-spawning herring (ages 4+).

Age	Coastal component	Oceanic component	Total stock
4	1,792,133	4,100,000	5,892,133
5	32,639	-	32,639
6	22,181	-	22,181
7	29,798	-	29,798
8	135,414	-	135,414
9	97,271	-	97,271
10	119,267	-	119,267
11	127,921	-	127,921
12	4,536	-	4,536
13	64,739	-	64,739
14	127,807	-	127,807
15	31	-	31
16+	63,289	-	63,289

Table 2.12
List of input variables for the ICES prediction program.

ATLANTO-SCANDIAN HERRING TOTAL STOCK
The reference F is the mean F for the age group range from 4 to 16

The number of recruits per year is as follows:

Year	Recruitment
1937	408000.0
1938	1418000.0
1939	1418000.0

Data are printed in the following units:

Number of fish:	thousands
Weight by age group in the catch:	kilogram
Weight by age group in the stock:	kilogram
Stock biomass:	tonnes
Catch weight:	tonnes

age	stock size	fishing pattern	natural mortality	maturity ogive	weight in the catch	weight in the stock
1	408000.0	.05	.90	.00	.075	.010
2	411230.0	.05	.90	.00	.075	.075
3	235508.0	.03	.15	.10	.226	.095
4	5892136.0	.10	.15	.20	.290	.144
5	32659.0	.55	.15	.90	.283	.251
6	22181.0	.55	.15	1.00	.305	.289
7	29796.0	.55	.15	1.00	.345	.317
8	155414.0	.55	.15	1.00	.367	.345
9	97271.0	.55	.15	1.00	.377	.360
10	119267.0	.55	.15	1.00	.374	.369
11	127921.0	.55	.15	1.00	.375	.354
12	4530.0	.55	.15	1.00	.392	.374
13	64759.0	.15	.15	1.00	.409	.335
14	127607.0	.10	.15	1.00	.434	.389
15	51.0	.03	.15	1.00	.450	.470
15+	63289.0	.03	.15	1.00	.454	.460

Table 2.13

Effects of different levels of fishing mortality on catch, stock biomass and spawning stock biomass.

ATLANTO-SCANDIAN HERRING TOTAL STOCK

Year 1987					Year 1988					Year 1989	
fac-tor	ref. F	stock biomass	sp.stock biomass	catch	fac-tor	ref. F	stock biomass	sp.stock biomass	catch	stock biomass	sp.stock biomass
.7	.08	1206	472	120	.0	.00	1571	1382	0	1573	1423
					.0	.02			26	1549	1466
					.1	.03			51	1525	1442
					.2	.05			76	1502	1419
					.2	.07			101	1479	1396
					.3	.08			125	1457	1374
					.3	.10			149	1434	1352
					.4	.13			195	1391	1309
					.5	.16			240	1350	1268
					.6	.20			283	1309	1228
					.7	.23			325	1270	1190
					.8	.26			366	1233	1152
					.9	.30			405	1196	1116
					1.0	.33			443	1161	1081

The data unit of the biomass and the catch is 1000 tonnes.
The spawning stock biomass is given for 1 January.
The reference F is the mean F for the age group range from 4 to 16 (weighted).

Table 2.14
List of input variables for the ICES prediction program.

ATLANTO-SCANDIAN HERRING TOTAL STOCK
The reference F is the mean F for the age group range from 4 to 16

Data are printed in the following units:

Total yield and weight by age group in the catch: kilogram
Total biomass and weight by age group in the stock: kilogram

Age	fishing pattern	natural mortality	maturity ogive	weight in the catch	weight in the stock
3	.03	.15	.10	.226	.095
4	.10	.15	.20	.290	.144
5	.35	.15	.90	.288	.261
6	.35	.15	1.00	.306	.287
7	.35	.15	1.00	.345	.310
8	.35	.15	1.00	.367	.345
9	.35	.15	1.00	.390	.361
10	.35	.15	1.00	.394	.369
11	.35	.15	1.00	.395	.354
12	.35	.15	1.00	.392	.374
13	.15	.15	1.00	.409	.385
14	.10	.15	1.00	.434	.389
15	.03	.15	1.00	.450	.470
16+	.03	.15	1.00	.454	.460

Table 3.1 International catch of Barents Sea capelin ('000 t) in the years 1965-1987.

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	811	624	42	1,477
1985	453	398	17	868
1986	72[1]	51	-	123[1]
1987	-	-	-	-

[1] Preliminary figure.

Table 3.2 Capelin catches in the Barents Sea in August-December 1985 and in January-April 1986 in numbers (billions). There have been no catches after April 1986.

Age	1985					1986			
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1	-	0.46	0.01	0.16	0.14	-	-	-	-
2	-	5.21	0.58	0.50	0.43	0.01	0.002	0.01	0.002
3	-	6.06	0.69	0.62	0.54	0.44	0.05	0.44	1.00
4	-	0.32	0.07	0.11	0.09	0.67	0.10	0.78	2.95
5	-	-	-	0.003	0.02	0.05	0.02	0.11	0.56
6	-	-	-	-	-	0.003	-	0.01	0.02
7	-	-	-	-	-	-	-	0.001	0.001

Table 3.3 Acoustic estimate of capelin autumn 1987.

Total length (cm)	Age				Total number ($x 10^7$)	Biomass tonnes ('000 t)	Biomass (Cum.)
	1	2	3	4+			
5.0- 5.4	6	-	-	-	6	0.1	-
5.5- 5.9	49	-	-	-	49	0.5	-
6.0- 6.4	216	-	-	-	216	2.2	-
6.5- 6.9	345	-	-	-	345	3.5	-
7.0- 7.4	270	-	-	-	270	2.7	-
7.5- 7.9	262	-	-	-	262	3.0	-
8.0- 8.4	404	-	-	-	404	6.6	-
8.5- 8.9	581	-	-	-	581	11.8	-
9.0- 9.4	450	-	-	-	450	10.8	-
9.5- 9.9	273	-	-	-	273	8.2	-
10.0-10.4	122	3	-	-	125	4.4	-
10.5-10.9	106	-	-	-	106	4.6	-
11.0-11.4	46	-	-	-	46	2.3	-
11.5-11.9	41	-	-	-	41	2.3	-
12.0-12.4	24	2	-	-	26	1.7	-
12.5-12.9	13	9	-	-	22	1.7	-
13.0-13.4	7	14	-	-	21	1.9	-
13.5-13.9	1	25	1	-	27	2.8	-
14.0-14.4	-	38	1	-	39	4.7	14.4
14.5-14.9	-	35	2	-	37	5.2	9.7
15.0-15.4	-	15	2	-	17	2.6	4.5
15.5-15.9	-	8	1	-	9	1.6	1.9
16.0-16.4	-	-	-	-	-	-	0.3
16.5-16.9	-	-	-	-	-	-	0.3
17.0-17.4	-	-	-	-	-	-	0.3
17.5-17.9	-	-	-	1	1	0.3	0.3
Number	3,216	149	7	1	-	-	-
Biomass ('000 t)	66.1	18.1	1.0	0.3	85.6	-	-
Mean length (cm)	8.5	14.2	14.8	17.8	-	-	-

Table 3.4 The development of the Barents Sea capelin stock during the period 1974-1985.

1974				M = 0.051	LM = 14.01	
Age	Stock 1 Jan (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock 1 Aug (10^7)	Catch aut. (10^7)	F aut.
1	-	-	-	76,083	-	-
2	-	9.3	-	63,562	1,139.5	0.02
3	-	439.4	120	20,877	1,059.0	0.05
4	-	2,746.6	56	436	42.2	0.11
5	-	991.6	104	8	-	-
Σ		4,186.9	280	160,966	2,240.7	

1975				M = 0.051	LM = 14.01	
Age	Stock 1 Jan (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock 1 Aug (10^7)	Catch aut. (10^7)	F aut.
1	-	-	-	50,895	-	-
2	58,867	250.3	-	41,076	1,364.9	0.03
3	48,181	1,009.6	138	35,050	1,795.5	0.05
4	15,225	3,499.3	64	10,108	613.8	0.06
5	300	390.5	-	107	-	-
Σ		5,149.7	203	137,236	3,774.2	

1976				M = 0.051	LM = 14.01	
Age	Stock 1 Jan (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock 1 Aug (10^7)	Catch aut. (10^7)	F aut.
1	-	-	-	44,445	-	-
2	39,378	83.8	-	27,492	1,726.2	0.07
3	30,586	672.5	117	20,325	2,752.4	0.15
4	25,547	4,400.1	578	10,074	1,960.0	0.22
5	7,284	2,802.5	520	1,661	394.0	0.28
Σ		7,958.9	1,215	103,997	6,832.6	

(cont'd)

Table 3.4 (cont'd)

1977				M = 0.051	LM = 14.01	
Age	Stock 1 Jan (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock 1 Aug (10^7)	Catch aut. (10^7)	F aut.
1	-	-	-	78,519	-	-
2	34,388	683.0	-	23,609	4,517.9	0.22
3	19,764	1,424.9	291	12,733	2,617.9	0.24
4	13,320	5,022.1	454	5,064	862.5	0.19
5	6,084	3,028.7	381	902	146.2	0.18
Σ		10,158.7	1,126	12,0827	8,144.5	

1978				M = 0.051	LM = 14.01	
Age	Stock 1 Jan (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock 1 Aug (10^7)	Catch aut. (10^7)	F aut.
1	-	-	-	95,113	99.5	-
2	60,752	53.6	-	42,547	2,875.2	0.07
3	14,327	1,227.5	68	12,050	1,726.5	0.16
4	7,568	3,507.3	401	1,699	265.3	0.17
5	3,165	1,780.8	206	96	19.8	0.23
Σ		6,569.2	675	151,505	4,986.3	

1979				M = 0.072	LM = 13.94	
Age	Stock 1 Jan (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock 1 Aug (10^7)	Catch aut. (10^7)	F aut.
1	-	-	-	55,220	30.5	-
2	73,510	8.1	-	40,024	2,767.2	0.07
3	30,408	1,047.2	29	14,829	3,047.5	0.24
4	7,814	2,883.5	252	681	224.1	0.41
5	1,082	634.9	-	4	2.2	0.84
Σ		4,573.7	281	110,758	6,071.5	

(cont'd)

Table 3.4 (cont'd)

1980				M = 0.072	LM = 13.94	
Age	Stock 1 Jan (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock 1 Aug (10^7)	Catch aut. (10^7)	F aut.
1	-	-	-	59,131	90.4	-
2	38,418	10.0	-	23,195	683.9	0.03
3	25,575	468.1	70	19,420	2,109.0	0.12
4	7,817	3,834.8	49	3,996	334.1	0.09
5	290	344.7	-	38	7.5	0.23
Σ		4,657.6	119	105,780	3,224.9	

1981				M = 0.072	LM = 13.94	
Age	Stock 1 Jan (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock 1 Aug (10^7)	Catch aut. (10^7)	F aut.
1	-	-	-	44,327	203.0	-
2	41,094	59.0	-	24,831	2,596.7	0.11
3	15,581	339.9	337	7,002	1,564.9	0.26
4	11,777	3,452.0	1,226	1,920	372.3	0.22
5	2,505	1,417.1	204	43	15.8	0.48
Σ		5,268.0	1,767	78,123	4,752.7	

1982				M = 0.072	LM = 13.94	
Age	Stock 1 Jan (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock 1 Aug (10^7)	Catch aut. (10^7)	F aut.
1	-	1.0	-	61,204	107.0	-
2	30,691	47.1	-	18,526	2,139.0	0.06
3	15,142	1,127.7	214	8,464	2,443.0	0.32
4	3,588	1,655.7	259	357	149.0	0.55
5	1,030	513.9	109	-	6.0	-
Σ		3,345.4	582	88,551	4,844.0	

(cont'd)

Table 3.4 (cont'd)

1983				M = 0.072 LM = 13.94		
Age	Stock 1 Jan (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock 1 Aug (10^7)	Catch aut. (10^7)	F aut.
1	-	4.0	-	53,790	298.1	0.01
2	42,519	40.0	-	25,705	3,634.9	0.16
3	11,131	1,298.8	68	6,383	2,671.9	0.56
4	3,890	3,371.2	55	78	120.7	-
5	127	718.9	-	-	0.2	-
Σ		5,432.9	122	85,956	6,725.8	

1984				M = 0.140 LM = 13.06		
Age	Stock 1 Jan (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock 1 Aug (10^7)	Catch aut. (10^7)	F aut.
1	-	-	-	37,122	219.9	-
2	37,200	6.6	-	22,428	2,109.6	0.10
3	14,897	839.7	251	6,528	1,571.6	0.28
4	2,270	2,264.6	-	442	165.0	0.48
5	-	225.2	-	-	9.0	-
Σ		3,336.1	251	66,520	4,075.1	

1985				M = 0.140 LM = 13.06		
Age	Stock 1 Jan (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock 1 Aug (10^7)	Catch aut. (10^7)	F aut.
1	-	-	-	-	78.6	-
2	25,660	35.1	-	6,821	672.6	0.17
3	13,870	571.0	240	3,414	790.8	0.52
4	3,253	1,698.5	104	157	59.3	0.15
5	173	326.4	-	-	-	-
Σ		2,631.0	344	10,392	1,601.3	

Table 4.1 The total annual and seasonal catch of CAPELIN in the Iceland - Greenland Jan Mayen area since 1964 (in '000 t).

	Winter season		Summer and Autumn season				
Year	Iceland	Far/Nor	Iceland	Norway	Faroes	EEC	Total
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	-	-	133.3	-	-	-	133.3
1984	439.6	-	425.2	104.6	10.2	8.5	988.1
1985	348.5	-	644.8	188.7	81.4		1,263.4
1986	342.0	49.9	552.3	149.7	64.4	5.3	1,163.6
1987	500.6	59.9	16.0[1]	82.0[1]	66.3[1]	-	724.8[1]

[1] Until October 15.

Table 4.2 Biomass computations for Capelin - October 1987.

Average length: cm
Average volume: ml
No. in region: millions
Weight in region: '000 t
Condition: 1000 x vol/length^3

$C = 2.820 \times 10^6 \times l^{-1.910}$

Region: all

Length	1	2	3	4	5	6+	9	Total	Wt	Av. vol.
7.0- 7.4	23	-	-	-	-	-	-	23	-	1.0
7.5- 7.9	888	-	-	-	-	-	-	888	-	1.0
8.0- 8.4	1,388	-	-	-	-	-	-	1,388	2	2.0
8.5- 8.9	4,783	-	-	-	-	-	-	4.783	9	2.0
9.0- 9.4	3,938	-	-	-	-	-	-	3,938	9	2.4
9.5- 9.9	5,103	6	-	-	-	-	-	5,109	15	3.0
10.0-10.4	3,563	7	-	-	-	-	-	3,570	14	3.9
10.5-10.9	1,036	6	-	-	-	-	-	1,042	4	4.1
11.0-11.4	414	23	-	-	-	-	-	437	2	5.2
11.5-11.9	109	-	-	-	-	-	-	109	-	5.0
12.0-12.4	52	19	-	-	-	-	-	71	-	6.6
12.5-12.9	4	173	-	-	-	-	-	177	1	8.6
13.0-13.4	-	462	-	-	-	-	-	462	4	9.6
13.5-13.9	32	1,152	-	-	-	-	1,184	1,184	13	11.3
14.0-14.4	-	1,810	58	-	-	-	1,868	1,868	24	12.9
14.5-14.9	21	2,615	43	-	-	-	2,679	2,679	39	14.7
15.0-15.4	-	3,595	225	-	-	-	3,820	3,820	62	16.4
15.5-15.9	-	3,024	439	-	-	-	3,463	3,463	63	18.3
16.0-16.4	-	2,438	463	-	-	-	2,901	2,901	59	20.6
16.5-16.9	-	1,285	582	-	-	-	1,867	1,867	44	23.7
17.0-17.4	-	819	743	26	-	-	1,588	1,588	41	26.2
17.5-17.9	-	203	880	21	-	-	1,104	1,104	31	28.9
18.0-18.4	-	94	380	18	-	-	492	492	15	32.1
18.5-18.9	-	-	138	12	-	-	150	150	5	36.4
19.0-19.4	-	10	84	-	-	-	94	94	3	39.9
19.5-19.9	-	-	15	-	-	-	15	15	-	42.0
Number	21354	17741	4050	77	-	-	21225	43222		
Av.length	9.44	15.36	17.02	17.85	-	-	15.76	12.59		
Weight	59.7	306.5	103.0	2.4	-	-	405.9	471.6		
Av.volume	2.8	17.3	25.4	30.7	-	-	19.1	10.9		
Condition	3.2	4.7	5.1	5.4	-	-	4.7	4.0		

Table 4.3 Biomass computations for Capelin - August-September 1987.

Average length: cm
Average volume: ml
No. in region: millions
Weight in region: '000 t
Condition: 1000 x vol/length^3

$C = 2.820 \times 10^6 \times l^{-1.910}$

Region: all

Length	1	2	3	4	5	6+	9	Total	Wt	Av. vol.
6.0- 6.4	410	-	-	-	-	-	-	410	-	1.0
6.5- 6.9	1,928	-	-	-	-	-	-	1,928	1	1.0
7.0- 7.4	5,229	-	-	-	-	-	-	5,229	5	1.0
7.5- 7.9	7,559	-	-	-	-	-	-	7,559	14	1.9
8.0- 8.4	12,076	-	-	-	-	-	-	12,076	24	2.0
8.5- 8.9	17,851	-	-	-	-	-	-	17,851	50	2.8
9.0- 9.4	19,595	-	-	-	-	-	-	19,595	58	3.0
9.5- 9.9	16,906	-	-	-	-	-	-	16,906	54	3.2
10.0-10.4	10,340	-	-	-	-	-	-	10,340	41	4.0
10.5-10.9	3,783	-	-	-	-	-	-	3,783	18	4.8
11.0-11.4	3,738	-	-	-	-	-	-	3,738	22	6.0
11.5-11.9	1,714	-	-	-	-	-	-	1,714	10	6.1
12.0-12.4	392	599	-	-	-	-	-	991	6	6.9
12.5-12.9	18	55	-	-	-	-	-	73	-	8.2
13.0-13.4	-	146	-	-	-	-	146	146	1	9.4
13.5-13.9	-	363	-	-	-	-	363	363	3	10.9
14.0-14.4	-	137	9	-	-	-	146	146	1	13.3
14.5-14.9	-	457	58	-	-	-	515	515	8	15.8
15.0-15.4	-	234	56	-	-	-	290	290	5	17.3
15.5-15.9	-	100	46	-	-	-	146	146	2	19.0
16.0-16.4	-	73	145	-	-	-	218	218	4	20.6
16.5-16.9	-	44	174	-	-	-	218	218	4	22.6
17.0-17.4	-	-	73	-	-	-	73	73	2	28.0
17.5-17.9	-	-	146	-	-	-	146	146	4	30.0
Number	101539	2,208	707	-	-	-	2,261	104,454		
Av.length	9.14	13.92	16.53	-	-	-	15.20	9.29		
Weight	306.1	27.4	16.2	-	-	-	39.0	349.7		
Av.volume	3.0	12.4	22.9	-	-	-	17.3	3.3		
Condition	3.8	4.4	5.0	-	-	-	4.7	3.8		

Table 4.4 The percentage of 4-group capelin in the spawning stock in the years 1981-1987. (The very high percentage in 1987 is due to the large and late maturing 1983 year class and is the highest on record ever for this stock).

Year	Percentage of 4-group
1981	22
1982	7
1983	12
1984	16
1985	34
1986	25
1987	63
Average 1981-1986	19

Table 4.5 Natural mortality rates of the Icelandic capelin as calculated from successive acoustic estimates of spawning stock abundance and catch.

Estimate	Period	Mortality rate per month
1	1 November 1978 - 31 January 1979	0.045
2	1 November 1979 - 31 January 1980	0.026
3	1 November 1980 - 31 January 1981	0.030
4	15 November 1981 - 31 January 1982	0.048
5	1 December 1981 - 31 January 1982	0.035
6	1 November 1982 - 31 January 1983	0.028
7	1 November 1983 - 31 January 1984	0.034
8	15 November 1984 - 31 January 1985	0.035
	Mean	0.035
	Std.dev.	0.008

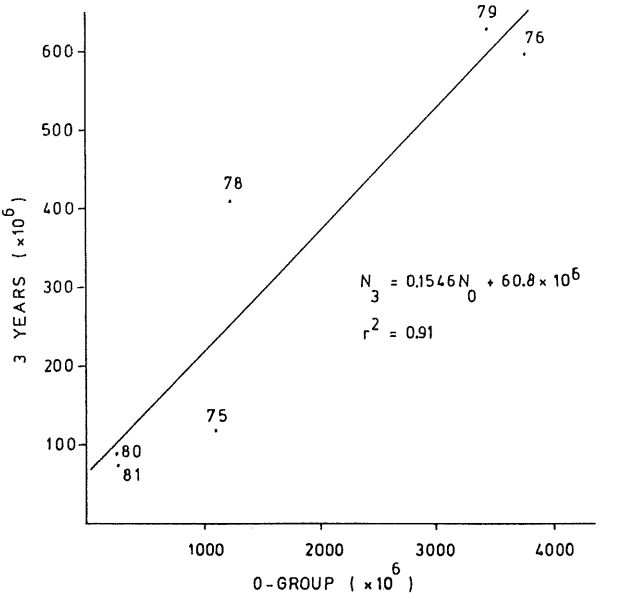
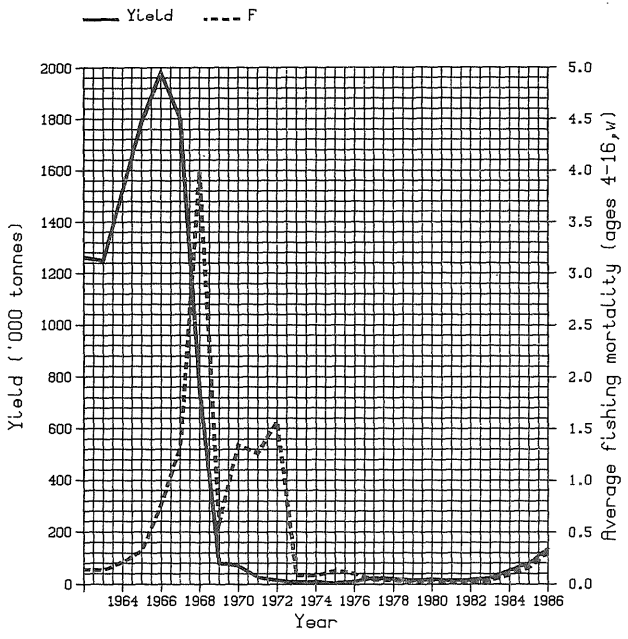


Figure 2.1 Relationship between age 3 numbers from VPA and 0-group estimates from acoustic survey (Anon., 1987).

Figure 2.2

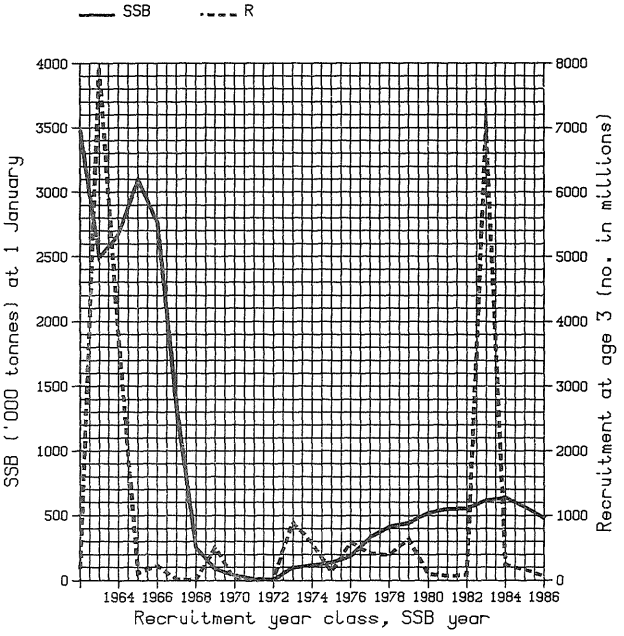
FISH STOCK SUMMARY
STOCK: Norwegian Spring–Spawning Herring
02–11–1987

Trends in yield and fishing mortality (F)



A

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



B

ctd.

FISH STOCK SUMMARY

Figure 2.2 (cont'd.)

STOCK: Norwegian Spring–Spawning Herring

02–11–1987

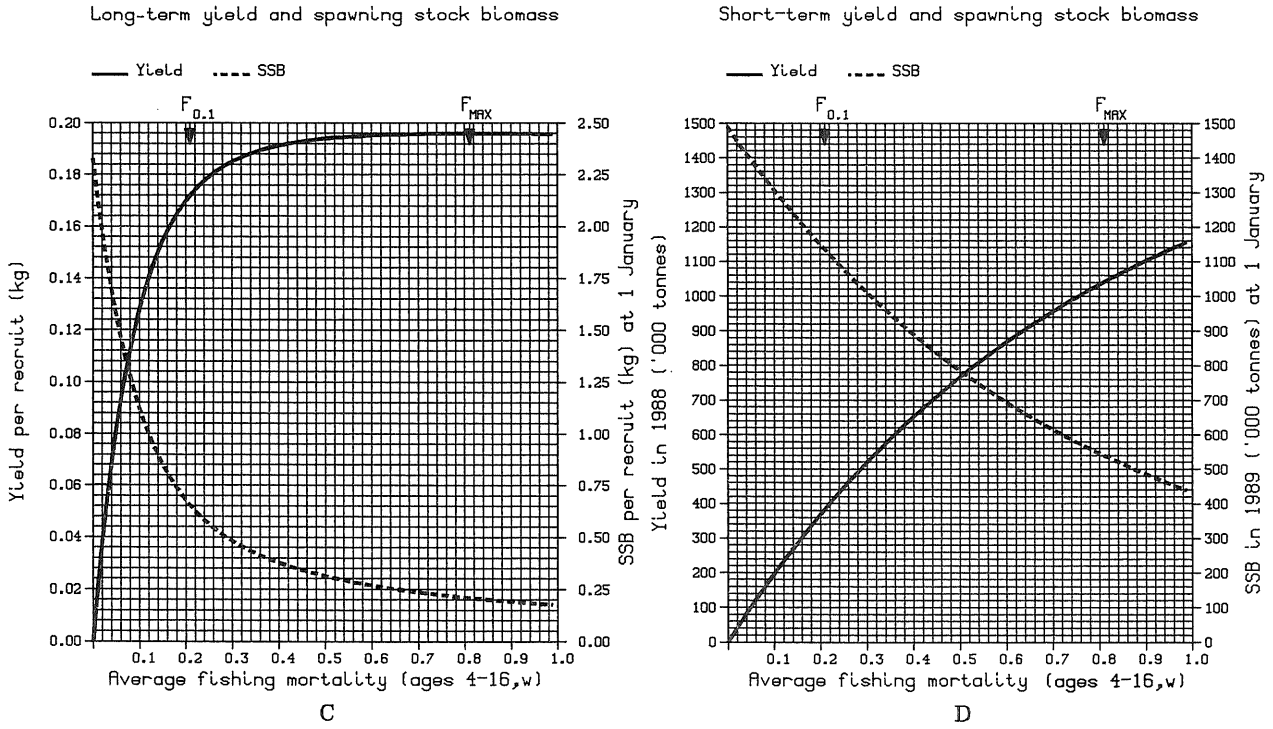
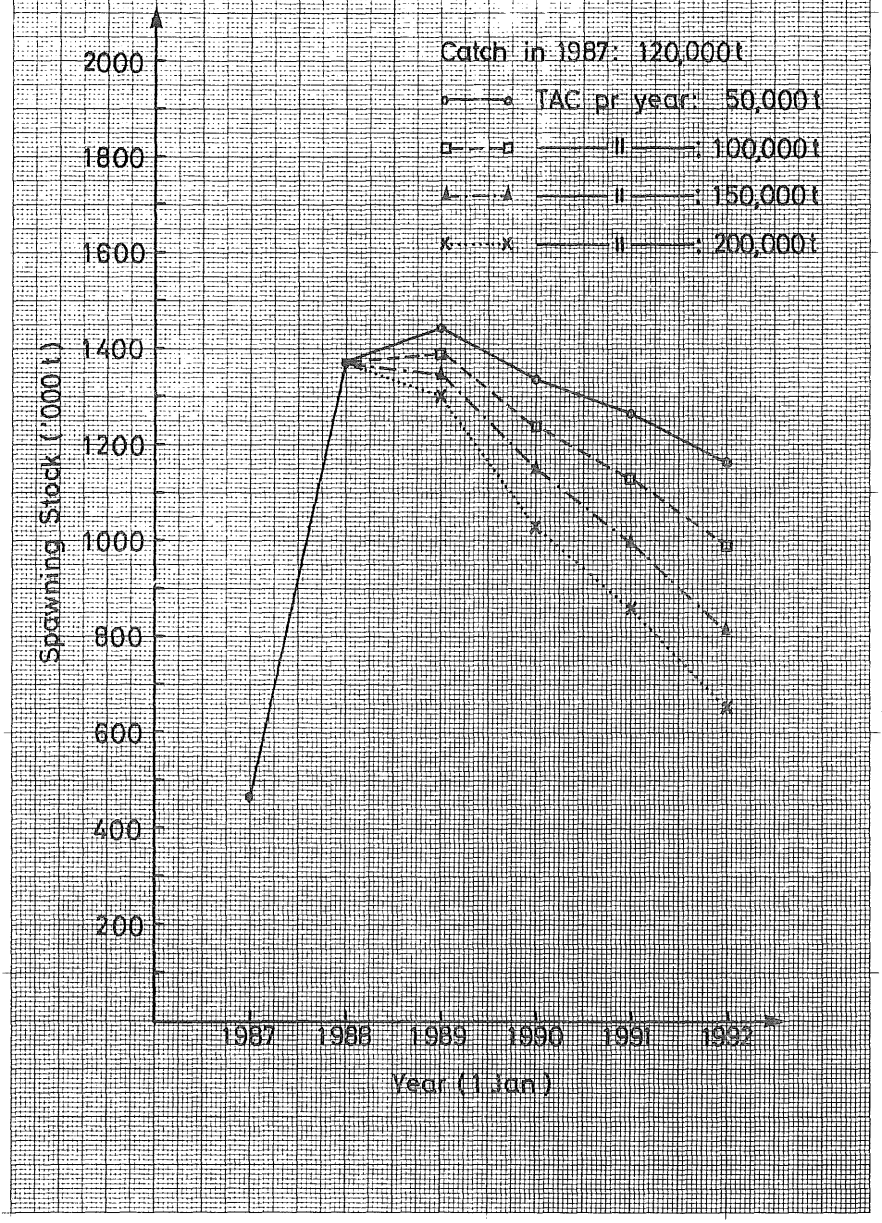


Figure 2.3 NORWEGIAN SPRING-SPAWNING HERRING



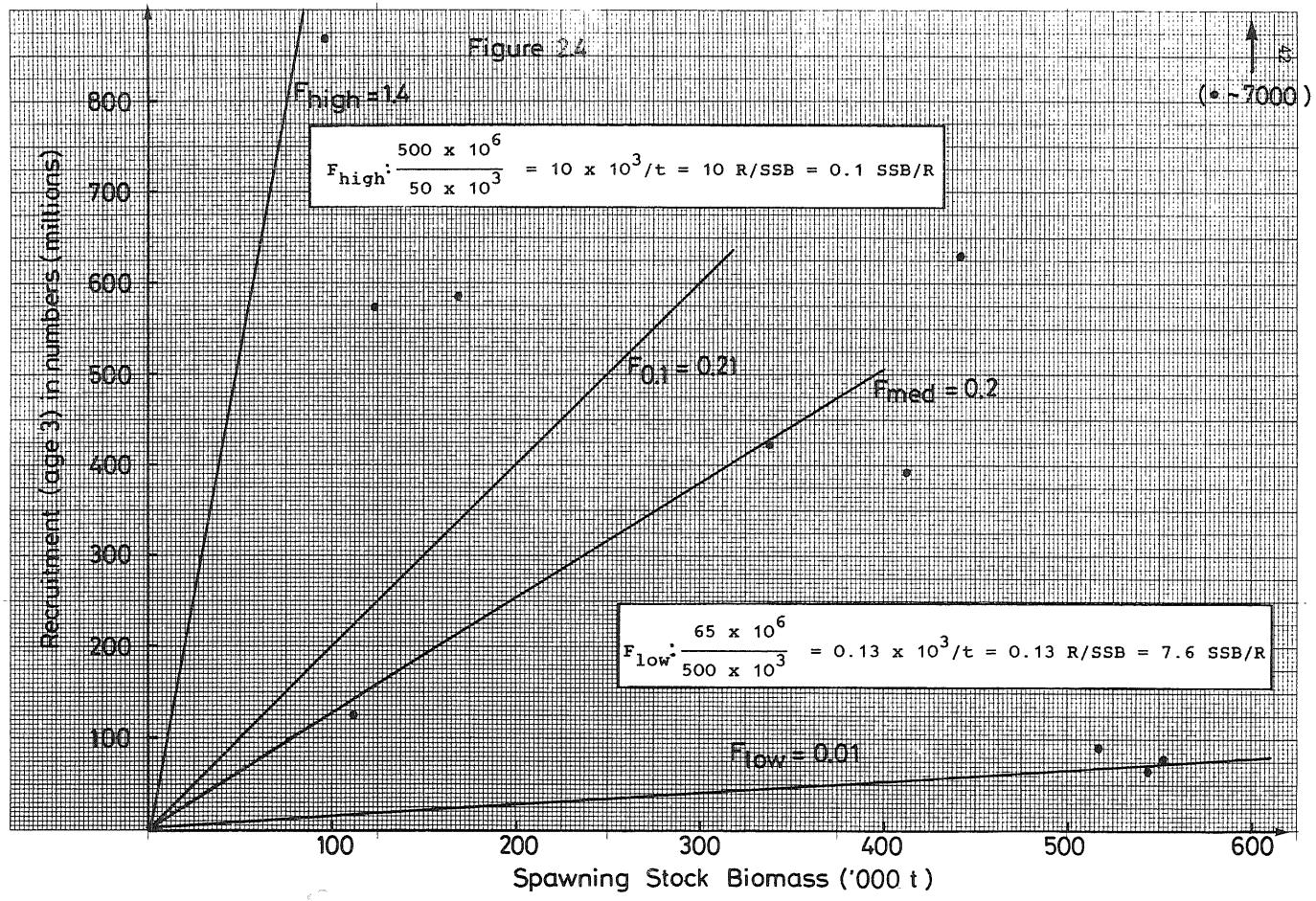


Figure 24
F_{high} = 1.4
F_{high}: $\frac{500 \times 10^6}{50 \times 10^3}$ = 10 x 10^3/t = 10 R/SSB = 0.1 SSB/R
$F_{0.1}$ = 0.21
F_{med} = 0.2
F_{low}: $\frac{65 \times 10^6}{500 \times 10^3}$ = 0.13 x 10^3/t = 0.13 R/SSB = 7.6 SSB/R
F_{low} = 0.01
(• ~7000)
Recruitment (age 3) in numbers (millions)
800
700
600
500
400
300
200
100
100
200
300
400
500
600
Spawning Stock Biomass ('000 t)

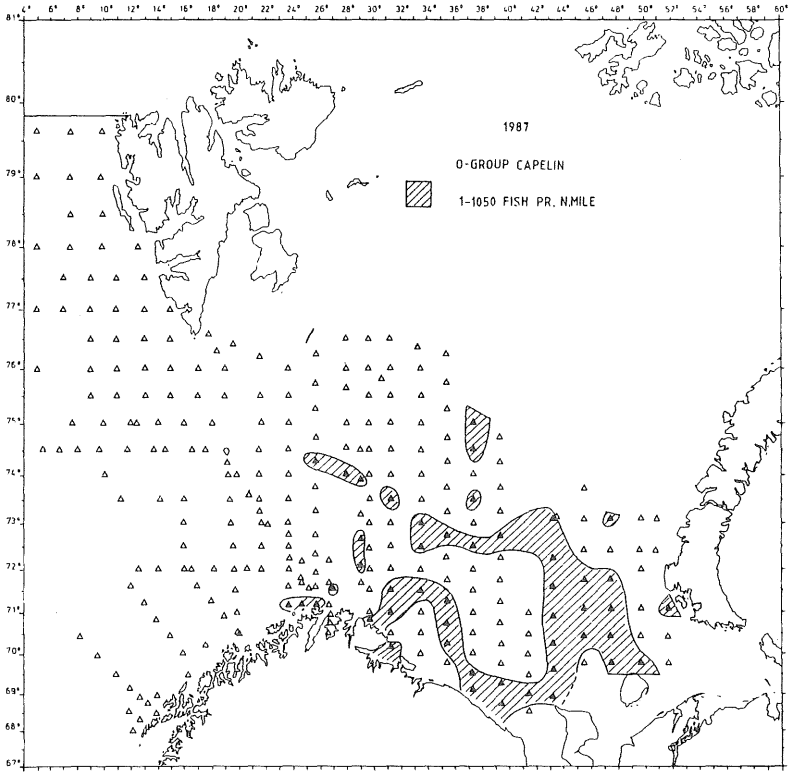
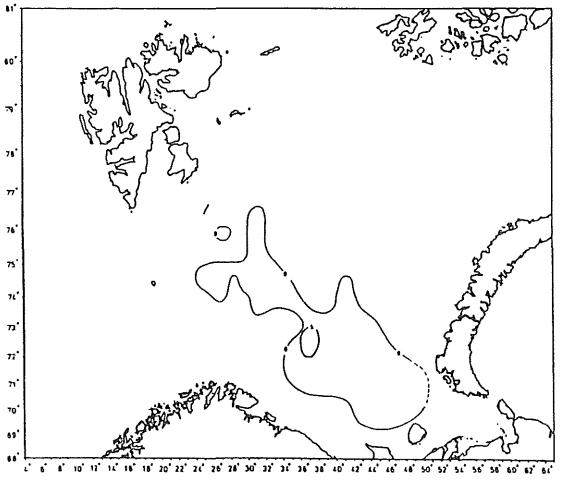


Figure 3.1 Distribution of 0-group capelin.

Figure 3.2 Estimated total density distribution of capelin (tonnes/square nautical mile).



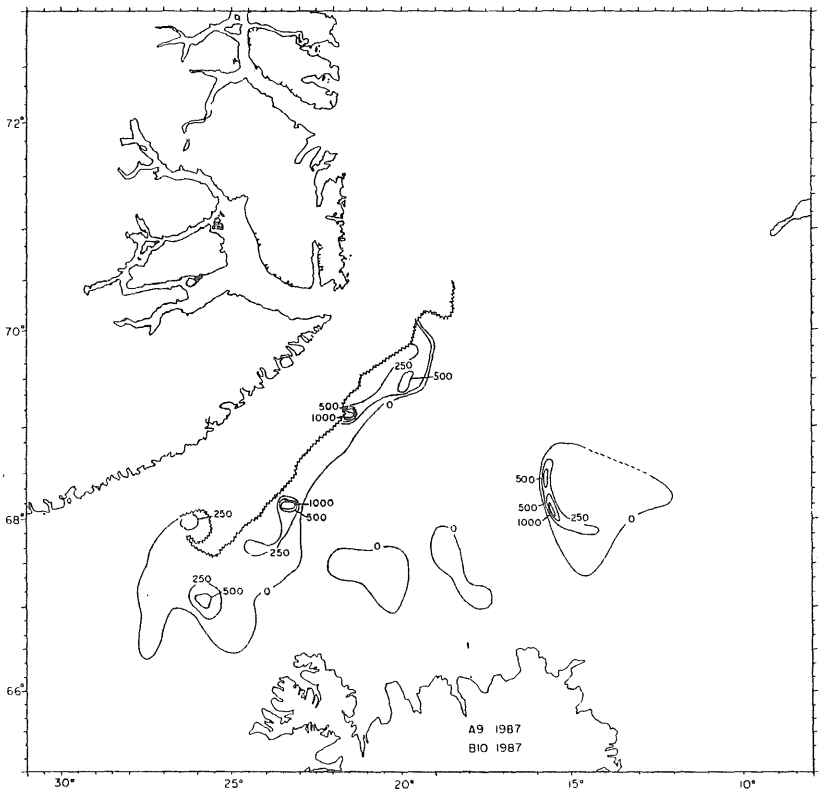


Figure 4.1 Distribution and relative density of 1-, 2-, and 3-group capelin, October 1987.

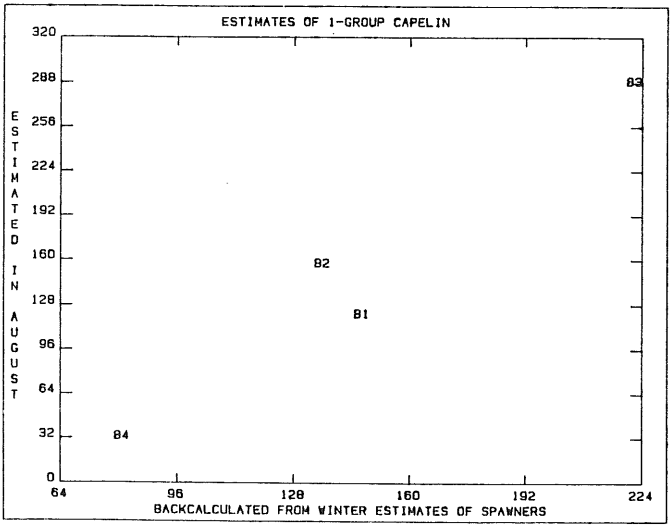


Figure 4.2 The relation between acoustic estimates of the abundance of the 1981-1984 capelin year classes as 1-group in August and calculated from January/February estimates of the abundance of 3- and 4-group spawners. The regression coefficients are: $R^2 = 0.95$; a = 65.43; b = 0.54.

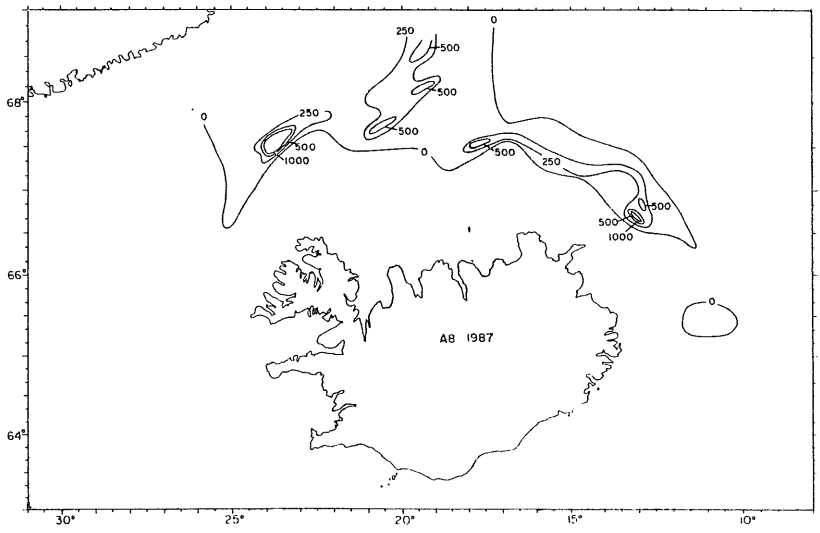


Figure 4.3 Distribution and relative density of 1-group capelin, August-September 1987.

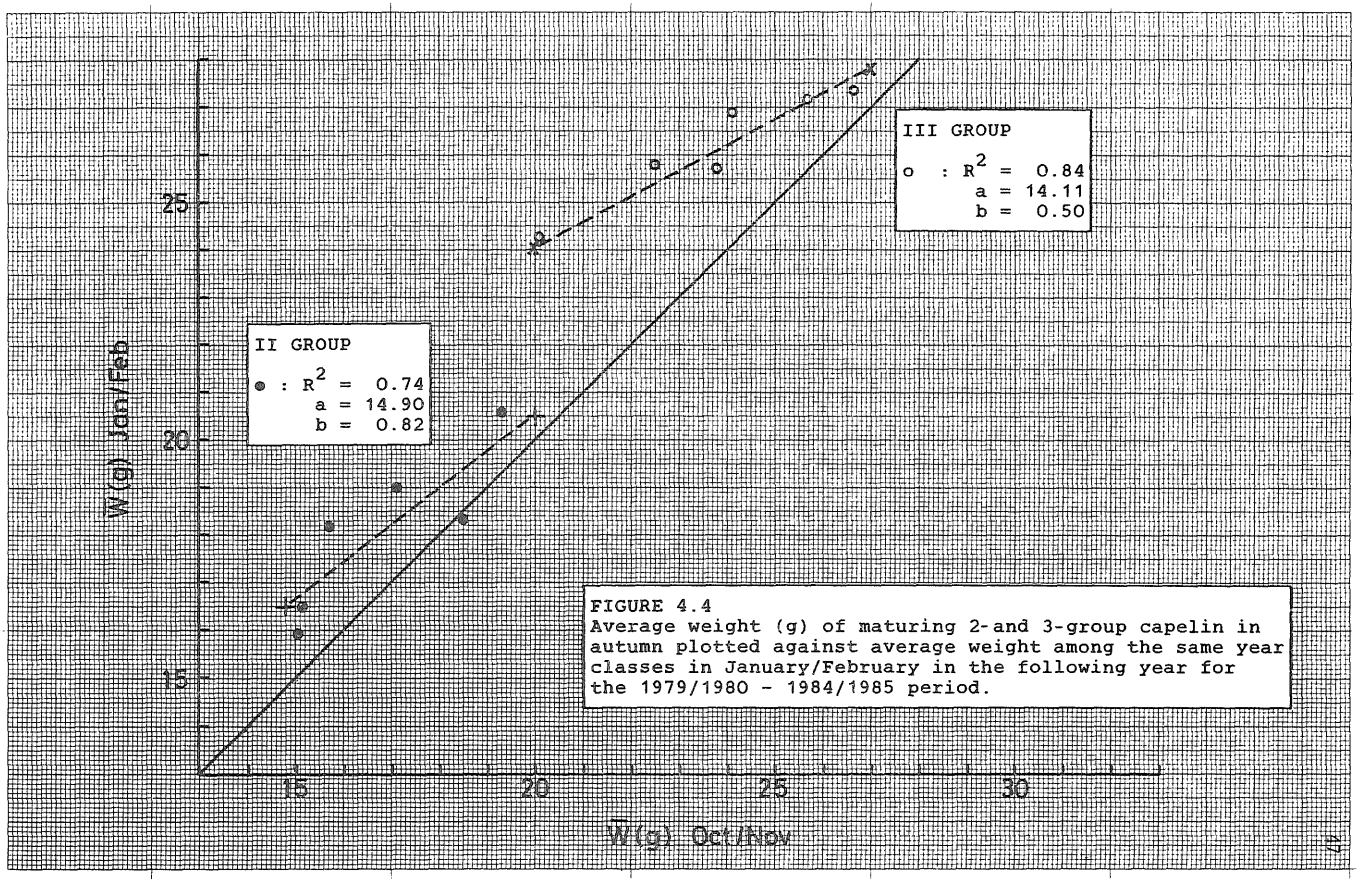


FIGURE 4.4
Average weight (g) of maturing 2-and 3-group capelin in autumn plotted against average weight among the same year classes in January/February in the following year for the 1979/1980 - 1984/1985 period.

APPENDIX I

WORKING PAPERS PRESENTED TO THE ATLANTO-SCANDIAN HERRING AND CAPELIN WORKING GROUP

Anon. Preliminary report of the International O-group Fish Survey in the Barents Sea and Adjacent Waters in August-September 1987.

Anon. Preliminary report on the Joint Norwegian/USSR Acoustic Survey of Capelin, Herring and Polar Cod in the Barents Sea in Sep-Oct 1987.

Anon. Capelin in the Iceland-East Greenland-Jan Mayen area.

Appendix I. Report of the Working Group on the Capelin in the Iceland-Greenland-Jan Mayen area.

Appendix II. Report on the Acoustic Survey of the Capelin Stock in the Iceland-Greenland-Jan Mayen area in October 1987.

Appendix III. Report on the Survey of 1-group Capelin in the Iceland-Greenland-Jan Mayen area in August-September 1987.

Appendix IV. Vilhjálmsson, H. 1987. Acoustic abundance estimates of the capelin in the Iceland-Greenland-Jan Mayen area in 1978-1987. International Symposium on Fisheries Acoustics.

Dommasnes, A. Capelin in the Barents Sea during the winter of 1987. Observations from Norwegian research vessels and scouting vessels.

Dommasnes, A. and Blindheim, J. Cruise report. "G.O.Sars" 28 July-16 August 1987, Norwegian Sea and Greenland Sea.

Dommasnes, A. The Icelandic capelin. Norwegian landings of Icelandic capelin in 1987 in weight and number by age groups and months. Preliminary numbers.

Hamre, J. and Røttingen, I. Norwegian data on Norwegian spring spawning herring.

Kanneworff, P. Capelin catches in the Greenland zone of the Greenland-Jan Mayen-Iceland area in 1986 and 1987 based on logbook recordings.

Krysov, A.I., Mukhina, N.V. and Seliverstova, E.I. Soviet investigations and fishery of Atlanto-Scandian herring in the Norwegian Sea in 1987.

Mukhina, N.V. and Seliverstova, E.I. Soviet investigations of capelin larvae in the Barents Sea in 1987.

Røttingen, I. Data on the 1983 year class of Norwegian spring spawning herring from the period August 1986-August 1987. ICES Doc. C.M. 1987/H:36.

Ushakov, N.G. Peculiarities of capelin approaches in the coastal spawning grounds in spring 1987.