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REPORT OF THE ATLANTO-SCANDIAN HERRING AND CAPELIN WORKING GROUP

Copenhagen, 24-28 October 1988

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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 24-28 October 1988.

The terms of reference are given in C.Res.1987/2:3:25: "The Atlanto-Scandian Herring and Capelin Working Group (Chairman: Dr V.N. Shleinik) will meet at ICES Headquarters from 24-28 October 1988 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 1989 and for the capelin for the winter 1988/1989 and summer-autumn 1989 seasons."

1.2 Participants

J. Carscadden	Canada
H. Gjøsæter	Norway
A. Kryssov	USSR
V.N. Shleinik (Chairman)	USSR
G. Stefansson	Iceland
R. Toresen	Norway

2 NORWEGIAN SPRING-SPAWNING HERRING

2.1 Working Papers Presented

The following working papers were presented:

"Working document on Norwegian spring-spawning herring" by R. Toresen,

"Soviet investigations and commercial fishery for Atlanto-Scandian herring in the Norwegian Sea in 1988" by I.V. Borkin, N.V. Mukhina, E.I. Seliverstova, and A.I. Kryssov.

2.2 Catch Statistics

The total annual catches of Norwegian spring-spawning herring from 1972-1987 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 data have been applied to convert the USSR catch of 18,892 t in the winter of 1987 to catch in numbers.

2.3 Recruitment

The nursery areas of herring recruits are the fjords, 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.

2.3.1 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.

2.3.2 The O-group index in the Barents Sea

Indices of O-group Norwegian spring-spawning herring have been estimated for the period 1965-1988 based on data from the international O-group surveys in the Barents Sea (Toresen, 1985; Anon., 1988a) (Table 2.4).

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 six 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	0	Sep 1986
1987	0	Sep 1987
1988	Not yet carried out	

The Barents Sea components of the 1984 and 1985 year classes are completely depleted, most probably due to predation by cod (Mehl, 1987). In 1986 and 1987, no O-group herring were detected in the Barents Sea. The 1988 survey has not yet been carried out.

2.4 The Adult Stock

In 1987, the adult stock was assessed in two components:

a) The part of the 1983 year class which had its nursery area in the Barents Sea, and

b) the coastal component which was the rest of the stock.

This year, the 1983 year class has recruited to the spawning stock, and the stock is, therefore, assessed as one unit.

2.4.1 Acoustic estimate of the spawning stock

In February-March 1988, an acoustic survey was carried out along the Norwegian coast to cover the spawning grounds. The conditions for measuring the biomass were favourable during the survey as the herring were not mixed with other species and were distributed in a medium-density layer at 20-100 m depth.

The distribution area of spawning herring delineated during this survey was the largest recorded since investigations started on the spawning grounds in 1982, and is probably the largest since 1967.

In the text table below, the results from the survey and the prognosis for the stock at 1 January 1988, estimated by the Working Group in 1987, are shown (millions).

Year class	1985	1984	1983	1982+	Total
Prognosis	162	202	4,845	608	5,817
Acoustic estimate	255	146	6,805	202	7,408

In the acoustic estimate, herring of the 1982 year class and older were not as abundant as expected from the prognosis made last year. On the other hand, the 1983 year class was found to be more numerous during the survey. The 1985 year class was also found to be more abundant during the survey, while the 1984 year class was found to be a little weaker than the prognosis showed.

2.4.2 The state of the stock and VPA

The Working Group discussed the possible sources of error that might explain the disparity between the acoustic estimate and the prognosis made in 1987, especially for the stock component 1982+. Three major points in this discussion were:

a) error in the acoustic estimate;

b) error in the estimate of the stock component (1982+) made in 1984 which was based on tagging and has been previously used by the Working Group (Anon., 1987); and

c) effects of discards and breaking of gear.

The Working Group found no reason to doubt the acoustic estimate of the spawning stock in spring 1988. However, the Working Group also found it hard to doubt the estimate of the spawning stock in 1984 derived from tagging. It was, therefore, decided to tune the VPA against both these estimates and explain the disparity between the acoustic estimate and the prognosis by the effects of discards and breaking of gear.

Discards and breaking of gear are well known phenomena in the Norwegian herring fisheries, especially in recent years, and they are mainly due to the practice of letting a large number of fishing vessels participate, with small quotas. The effects are not accounted for in the original catch data.

Looking at the recent history of this stock, it is clear that the older part of the stock was heavily exploited in the years before the 1983 year class recruited to the fishery (1985-1987). During these years, the catch quotas increased steadily, partly due to the promising 1983 year class. At the same time and also

for the same reason, the fishing practice was changed into a system that increased the pressure on the adults, leading to these features.

In order to reconcile the differences in the tagging and acoustic estimates for the 1982+ stock component in the VPA, additional numbers were added in the years 1985, 1986, and 1987 (detailed below). These additional numbers reflect the increased mortality believed to have occurred due to discards and breaking of gear which is not accounted for in the official catch statistics. The 1983 year class might also have been reduced by these effects, but no estimates are available.

The tuning of the VPA was done as follows. To provide a stock estimate at 1 January 1988, the acoustic estimate in spring 1988 for the 1983-1985 year classes was adjusted by Norwegian and USSR catches and natural mortality in January and February. With the original catches in the data file, the Fs in 1987 were adjusted until the VPA corresponded to the estimate.

In the acoustic estimate, the stock component older than the 1983 year class was treated as a +group. The age compositions of these year classes in 1988 were adjusted so that they corresponded with the age compositions of these year classes in 1984. The Fs were adjusted so that the total abundance of these year classes corresponded to the acoustic estimate of this +group. The final abundance estimate on 1 January 1988 in each year class was obtained by adjusting for catches and natural mortality.

This VPA did not correspond to the absolute estimate in 1984 derived from tagging. The numbers in 1984 in this VPA were too low. To tune these numbers in correspondence with the estimate, additional numbers were added in the catch file operating one year class at a time. The amounts which had to be added varied substantially between the age groups. These amounts were added to the data in the years 1985, 1986, and 1987. In 1985 and 1986, about equal numbers were added for each year class, while only smaller amounts were added for 1987 (proportional increase 0.2). The proportional increase in total numbers was 1.03 and 0.82 for 1985 and 1986, respectively. The numbers added in 1985, 1986, and 1987 corresponded to about 150,000 t. The Fs in 1987 had to be adjusted in accordance with the increase in the catch this year.

The numbers added to the catch per age group in the three years are shown in Table 2.5.

Input data in the VPA were:

Catch in number per year class	Tables 2.2 and 2.5
Weight at age in stock	Table 2.6
Proportions of maturity	Table 2.8
Natural mortality M (age 3 and older)	0.13

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

2.5 Catch and Stock Prognosis

The input data (Table 2.11) refer to the stock size on 1 January 1988. The estimate of the 1987 year class as 1-year olds was taken from the 0-group estimate in Norwegian coastal waters in November 1987. This number (262 million individuals) was reduced by an annual natural mortality of 0.9 for two months. The number of 2-year-olds (1986 year class) was also derived from the 0-group estimate in Norwegian coastal waters (408 million individuals, Table 2.3), but was reduced by the annual natural mortality of 0.9 over 14 months. For age groups 3 and older, the acoustic estimate in February-March 1988 was used, and the stock size on 1 January 1988 was estimated as described in Section 2.4.2.

The fishing pattern was changed from last year's assessment for age groups 2-4, since in that year an adjustment had been made for the 1983 year class, then 4 years old. As separable VPA does not apply to this stock (Anon., 1988b), the current fishing mortality estimates for the years 1984-1987 were simply averaged by age groups. Assuming the future fishing mortality to be constant on ages 5-12, the current average level is 0.456, which, as before, was scaled to 0.35. The mortalities for age groups 2-4 were scaled in the same proportions from the 1984-1987 average to obtain the current pattern.

2.6 Results of Prognosis

The results of the prognosis two years ahead are given in Tables 2.12 and 2.13 and Figure 2.1.

The 1983 year class was almost fully recruited in 1988, bringing the spawning stock biomass up to about 1.4 million t and increasing to about 1.5 million t in 1989. There has been almost no recruitment from the year classes after 1983, and consequently the spawning stock will make up almost 95% of the total stock by 1989. The poor recruitment will lead to a decrease in spawning stock size after 1989, whether any fishing takes place or not, because natural mortality will outweigh growth. This poor recruitment will continue at least until the 1988 year class recruits, probably until 1993. However, it is too early to assess the strength of this year class, although it appeared promising at the 0-group stage. By the time this year class recruits to the spawning stock, it will be reduced by natural mortality and fishing, and a larger contribution from the 1988 year class will be needed to increase the spawning stock to the 1988-1989 level.

A long-term prediction for the next 6 years is illustrated in Figure 2.2. It was run based on the same recruitment as assumed for the 1988 year class and with varying levels of TAC.

2.7 Yield per Recruit

For yield-per-recruit computations, the Working Group used average weights for the years 1983-1987 and recruitment at age 3, but otherwise the same values as in the catch and stock

prognosis. As the fishing pattern on the oldest fish is not well known, the reference F in this year's work was based on the average of the fishing mortalities of ages 4-9. These changes from the previous report explain the differences in the yield curves. The yield curves are shown in Figure 2.1.

2.8 Biological Reference Points

The biological reference points (F_{low}, F_{med}, and F_{high}) (Figure 2.3) were computed. It was found, as last year, that these reference points seem to be of little use for this stock, since the stock is still in a depleted state, regulated with the aim of rebuilding the stock. Due to the high variability in recruitment, it is seen that even F_{med} depends very heavily on which range of years is chosen and can, therefore, not be considered a reliable measure.

2.9 Management Considerations

The preferred level of the spawning stock, 2.5 million t, will not be reached in the near future, even without any fishing. The Working Group has no reason to assume that the problems of discarding and breaking of gear will be solved in 1988 or 1989 and, therefore, the actual catch will probably be significantly greater than the officially reported catch.

During this meeting, it has been estimated that unreported catches resulting from these practices corresponded to a total of about 150,000 t in 1985-1987. Therefore, the Working Group recommends that these calculations be taken into account and consequently that utmost caution be exercised in setting the TAC for the coming year.

3 BARENTS SEA CAPELIN

3.1 Working Papers Presented

The following working papers were presented:

"The Barents Sea Capelin" by H. Gjøsæter,

"Cruise report R/V 'Michael Sars', Barents Sea, April 1988" by H. Gjøsæter,

"Soviet investigations on capelin larvae in the Barents Sea in 1988" by N.V. Mukhina and N.G. Ushakov,

"Soviet investigations on capelin in spring 1988" by N.G. Ushakov.

"Report on the joint Norwegian/USSR acoustic survey of pelagic fish in the Barents Sea, September-October 1988".

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 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.

3.3 Catch Statistics

The international catch by country in the years 1965-1988 is given in Table 3.1.

3.4 Stock Size Estimates

3.4.1 Larval and O-group surveys

Norwegian larval surveys based on Gulf III plankton samples have been conducted in June each year since 1981. The calculated numbers ($\times 10^{12}$) by year are shown in Table 3.2. From 1981 to 1985, there was constant larval production, aside from a 20% reduction in 1984. In 1986, no larvae were caught in the Norwegian larval survey, although some spawning is known to have taken place in the Varangerfjord area. In 1987, the larval index was 0.14 (Table 3.2). The 1988 larval index was 0.13. In 1988, the capelin were larger than in 1987 and were distributed over a larger area.

A Soviet larval survey was conducted from 2 April to 15 July 1988 and occupied standard stations in the northeastern Norwegian and southwestern Barents Seas. No capelin larvae were caught. This is in contrast to previous surveys when 772 and 13 larvae were taken in 1986 and 1987, respectively.

During the international O-group survey in the Barents Sea in August (Anon., 1988a), O-group capelin were observed over a continous area from the coast of Finnmark northeastward to Novaya Semlya and the northern border of the investigated area. Unfortunately, the area surveyed was somewhat restricted compared to previous years, and the northeastern extension of the capelin O-group distribution area is, therefore, unknown (Figure 3.1). No index was calculated for capelin, but judging from the distribution area, the strength of the 1988 year class is the highest since 1984.

3.4.2 Acoustic stock estimates

Two surveys on capelin, one Soviet and one Norwegian, were conducted in spring 1988.

The Soviet survey covered the southeast and central Barents Sea from late December 1987 to March 1988. Only small prespawning concentrations of capelin were found in February-March in the areas off the Murman coast and northern Norway, comprising about

10,000 t. The 1985 year class dominated, with fish 13-15 cm.

A Norwegian survey covered the coastal waters off Troms and Finnmark in the first half of April. Practically no capelin were found; only in Varangerfjorden were some insignificant amounts of prespawning capelin detected.

These observations show that very little capelin were present in coastal areas in spring 1988, as was expected from the low stock level found in the autumn 1987.

The autumn 1988 acoustic survey was carried out during 7 September - 21 October as a joint Soviet-Norwegian cruise with three Norwegian and three Soviet research vessels participating. The distribution of capelin is shown in Figure 3.2. Table 3.3 gives the estimate as numbers by age and length groups. The following abundance estimates by year class were obtained:

Year class	Number (billions)		Mean weight (g)		Biomass ('000 t)	
1987 (1986)	20	(37)	3.5	(2.1)	69.6	(78)
1986 (1985)	29	(2)	12.3	(12.3)	353.4	(21)
1985 (1984)	0.2	(0.1)	17.1	(14.3)	4.3	(2)
1984 (1983)	-	-	-	-	-	-

The estimates of the same age groups in 1987 are shown in parentheses for comparison. The 1987 year class is about half the size by number of the 1-group measured last year. However, because the individual mean weight of the 1987 year class is higher, the biomass is almost as large as the 1986 year class as 1-group.

The 1986 year class is 15 times the abundance by number of the 2-group measured last year, with equal individual size.

According to the survey results, there are practically no fish older than 2 years in the stock. However, being so scarce, older fish are probably under-represented in the biological samples, and thus in the acoustic estimate.

The observed mean weights of the various age groups are either equal to or higher than those measured last year. The total stock biomass is estimated to be 427,000 t (Table 3.3), compared to 100,000 t in 1987.

3.5 History of Catch and Stock

Table 3.4 provides information on stock size and mortality of the Barents Sea capelin stock since 1972. 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 working paper to the 1985 Working Group meeting and the computation of the various quantities in the table was explained in the Working Group report from 1986 (Anon., 1987). This year, the table has been expanded to include

the years 1972 and 1973, as well as the latest years. Computations were not performed for 1986 in last year's Working Group report because the errors in the 1986 and 1987 acoustic estimates, which are used as input in the model, were considered to be large. Thus, while the estimates of natural mortality since 1986 may have larger errors associated with them because of the larger errors in the acoustic estimates, the Working Group considered that their inclusion in Table 3.4 would be useful to illustrate trends in natural mortality since 1972. The estimates of natural mortality and length at maturity for the latest years tentatively used in previous editions of the table are now reestimated, as outlined below.

Natural mortality is estimated using the Hamre-Tjelmeland model CAPELIN. By this method, natural mortality and length at maturity are estimated together; they cannot be separated. Two periods were found in which natural mortality and length at maturity were stable: the period 1972-1978 and 1979-1983 (Anon., 1987). For the years after 1983, an annual increase in natural mortality seems to have occurred. Since the stock collapsed during these years, the data are scarce, and it is impossible to reliably estimate natural mortality and length at maturity for these years. Consequently, it was tentatively assumed that length at maturity has not changed from the previous years, and natural mortality was estimated for this length at maturity (13.94 cm). The values for natural mortality per month were 0.08 for 1983-1984, 0.15 for 1984-1985, 0.23 for 1985-1986, and 0.25 for 1986-1987. The value of 13.94 cm for length at maturity was also used for the 1987-1988 period.

3.6 Management Considerations

The total stock biomass of about 430,000 t is approximately four times the abundance of the stock in 1986 and 1987. While the stock size shows some improvement, it is still (by number) less than 5% of the average stock size in the period 1975-1980 (Table 3.4).

A maturing length of about 14.0 cm, estimated in previous years, would produce a spawning stock of about 200,000 t in the spring 1989. However, this spawning stock would be composed of only one (1986) year class. Because younger fish mature at a larger length than older fish, the maturing length may, therefore, be somewhat larger this year, resulting in a lower spawning stock biomass. For example, a maturing length of 14.5 cm would give a spawning stock of about 160,000 t.

The recruitment is low with the 1987 year class estimated to be about 3% of the size of the average recruiting year classes in 1975-1980 (Table 3.4).

Based on these data on total stock, spawning stock, and recruitment, the Working Group recommends that no fishing should take place in 1989.

4 CAPELIN IN THE ICELAND - EAST GREENLAND - JAN MAYEN AREA

4.1 Working Papers Presented

The following working papers were presented:

"Report on an acoustic survey of 1-group capelin in the Iceland - Greenland - Jan Mayen area in August 1988" by H. Vilhjálmsson,

"Report on an acoustic survey of the capelin stock off East Greenland in September 1988" by P. Kanneworff,

"Report on an acoustic survey of the capelin stock in the Iceland - Greenland - Jan Mayen area in October 1988" by H. Vilhjálmsson,

"Cruise report "G.O. Sars", August 1988" by A. Dommasnes,

"Norwegian catch statistics of Icelandic capelin" by A. Dommasnes,

"Distribution of the capelin fishery in the Greenland economic zone in 1986-1988 based on logbook recordings", by P. Kanneworff,

"Capelin in the Iceland - Greenland - Jan Mayen area" by H. Vilhjálmsson.

4.2 Catch Regulation

As this is a very short-lived species, the fishery depends to a very large extent upon the recruiting year class.

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

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

4.3 Catch in the 1987/1988 Season

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

On the basis of an acoustic abundance estimate obtained in November-December 1987, a TAC of 1,115,000 t was set for the whole 1987/1988 season. The total catch amounted to 1,116,900 t, leaving the target spawning stock of 400,000 t.

4.4 Preliminary TAC for the 1988/1989 Fishery

In August 1987, an estimate of the abundance of 1-group capelin of the 1986 year class was obtained. All other attempts to estimate the abundance of immature capelin of either the 1986 or 1985 year classes in the autumn of 1987 and winter of 1988 failed.

The abundance of 1-group capelin has been estimated annually in August since 1982. The resulting estimates can be compared to estimates of the same year classes obtained by backcalculating their abundance as 3- and 4-group spawners to the same point in time (1 August as 1-group) taking account of the catch and the mortality rate (M). Five such pairs of estimates were available including the 1985 year class which, however, was not fully recruited to the adult stock and is underestimated due to trawl selection favouring the larger fish. The data are given in Table 4.2 and the relation between the two data sets is shown in Figure 4.1.

Using the relationship in Figure 4.1, the August 1987 survey results correspond to 83.8 billion 2-group capelin on 1 August 1988 when account has been taken of the mortality rate (M = 0.035/month). A TAC for the 1988/1989 season was then calculated making the following assumptions.

1) The fishery will depend on maturing capelin only.

2) About 70% of the capelin belonging to the 1986 year class and all the remainder of the 1985 year class will mature and spawn in 1989.

3) The 1988/1989 fishable stock and, therefore, the 1989 spawning stock will consist of the 1986 and 1985 year classes in the ratio 80/20, this being the average for the 1981-1988 period when excluding the abnormal 1986/1987 season (Table 4.3).

4) The mean weight in the fishable stock will be 17.3 and 24.3 g for the 1986 and 1985 year classes, respectively (mean weights of 2- and 3-year-olds in October in the 1981-1987 period) (Table 4.4).

5) The mean weight in the 1989 spawning stock will be 18.6 and 26.3 g for the same year classes (Figure 4.2).

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

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

Calculations based on these assumptions gave a TAC of 770,000 t spread evenly over the period. In view of the short time series and other obvious uncertainties, a precautionary TAC of 500,000 t was recommended for the August-November 1988 period. The TAC for the remainder of the season (December 1988 - March 1989) could then be set after the completion of the autumn 1988 survey of stock abundance.

4.5 October 1988 Stock Abundance Estimate

The autumn 1988 acoustic survey was carried out during 6-24 October. Two vessels participated and obtained the following abundance estimates by year class:

Year class	Number (billions)	Mean weight (g)	Biomass ('000 t)
1987	43.9	3.0	133.5
1986	59.7	14.6	870.9
1985	17.0	23.4	399.3

Further details of this stock estimate as well as the relative density distribution are given in Table 4.6 and Figure 4.3.

Judging by maturity, 1,225,000 t of capelin, comprising all the 1985 year class and about 90% of the 1986 year class, will mature and spawn in 1989. The year-class ratio in the spawning stock is about 76/24 for 2- and 3-group fish, which is not far from the forecast of 80/20 in the April 1988 stock prognosis.

Although drift ice was encountered in part of the possible distribution area of the stock in autumn, it is not thought to have affected the present stock estimate. Weather conditions during the survey were good.

About half of the maturing stock was recorded off the central and western north coast of Iceland. These were mostly 2-group fish mixed with juveniles, mainly 1-group. In this area, the abundance of the adults is, therefore, probably somewhat overestimated and that of the juveniles underrated and much more so.

On the other hand, at least half of the adult stock had not returned from its feeding migration to the East Greenland - Jan Mayen area in October 1988. In this northern area, the year-class ratio was about 65/35 for 2- and 3-group fish and there were practically no juvenile capelin there. Experience has shown that when autumn surveys of this capelin stock are carried out before the adults have returned from feeding in the northern latitudes, the resulting abundance estimates tend to be underestimates (Vilhjálmsson, 1983).

4.6 Other Acoustic Surveys

A Norwegian acoustic survey was carried out in the first half of August and, according to the age composition, covered mainly the northern component of the stock. In spite of the observed tendency towards underestimates in the summer period, the August abundance estimate is about 50% larger than the October estimate.

The area of distribution of 1-year-olds was not fully covered and, therefore, the estimates of abundance for this age group are not considered representative.

In August 1988, Iceland carried out an acoustic survey of the abundance of the 1987 year class. The total abundance estimate (in numbers) was 147 billion capelin. Surveying conditions were good and practically all the distribution area was apparently covered. Details of the August 1988 abundance estimate are given in Table 4.7 and the relative density distribution observed in Figure 4.4.

A third survey was conducted under a special grant from the Greenland Home Rule Administration in the area of East Greenland during September 1988. Although conditions were favourable, only 229,000 t of capelin were estimated in the survey area.

The Working Group noted that three independent surveys were conducted in the August-September time period and recommended that future surveys be coordinated.

4.7 TAC for the December 1988 - March 1989 Period

On the whole, the October 1988 stock abundance estimate was accepted as valid and used as a basis for calculating the TAC.

The following assumptions were made:

1) All capelin 13.5 cm and larger will mature and spawn in 1989. This length at maturity is derived from maturity observations made during the survey. These capelin will be in the catch during the rest of the fishing season.

2) Immature capelin will be an insignificant proportion of the catch in the present season.

3) Natural mortality rate will be M = 0.035/month.

4) The mean weight of the 1986 and 1985 year classes will be 17.0 and 26.9 g, respectively (Figure 4.2).

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

Based on these assumptions, it is calculated that the 1988 October survey results correspond to a TAC of 830,000 t to be spread evenly over the 5-month period late October 1988 - late March 1989.

At the time of the survey, Norwegian and Icelandic catches amounted to about 11,500 and 25,000 t, respectively, and Faroese vessels had taken 47,000 t in the economic zone of Greenland.

4.8 TAC for the Summer/Autumn 1989 Season

The fishable stock in the 1989/1990 season will consist of the 1987 year class and the part of the 1986 year class which does not mature and spawn in 1989.

The Working Group determined that the Icelandic August 1988 survey covered the distribution area of the 1987 year class and the

abundance estimates were used to calculate a preliminary TAC for the 1989/1990 season.

Using the relationship in Figure 4.2 and a natural mortality rate of M = 0.035/month, the August 1988 survey results correspond to 100 billion 2-group capelin on 1 August 1989. A TAC for the 1989/1990 season may then be calculated using the same assumptions as listed in Section 4.4.

Calculations based on these assumptions give a TAC of 1,025,000 t for the 1989/1990 season, spread evenly over the period.

It should be noted, however, that a considerable addition to the data base could become available after the completion of an acoustic survey of the stock that is planned for January-February 1989. This regards especially the abundance of the immature part of the 1986 year class and one additional year to the data series of estimates of year-class abundance as 1-group as compared to adults, as well as mean weights, year-class ratios, and maturity rates.

Advice on the TAC for the 1989 summer and autumn season should, therefore, be delayed until spring 1989.

5 REFERENCES

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Mehl, S. 1987. The North-east Arctic cod stocks consumption of commerically 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 international 0-group survey in the Barents Sea. ICES Doc. C.M.1985/H:54.

Vilhjálmsson, 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 including unreported catches
1972	-	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	-	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	71,122	55,507	156	-	126,785	136,785
1987	62,910	49,798	181	-	112,899	122,889
1988[3]	70,962	-	-	-	-	-

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 up to 1 September 1988.

Table 2.2 Catch in numbers ('000) 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	1987
0	6,900	8,300	22,600	127,000	33,857	28,571	13,805	13,846
1	800	1,100	1,100	4,679	1,700	13,149	1,381	6,327
2	400	11,900	200	1,675	2,489	207,224[1]	3,091	35,770
3	6,407	4,166	13,817	3,183	4,483	15,615	539,785[2]	19,776
4	5,814	4,591	7,892	21,191	5,388	11,268	14,662	501,393
5	2,278	8,596	4,507	9,521	61,543	11,605	9,964	18,672
6	8,165	2,200	6,258	6,181	18,202	77,203	13,386	3,502
7	15,838	4,512	1,960	6,823	12,638	27,803	69,267	7,058
8	441	8,280	5,075	1,293	15,608	18,306	36,460	25,922
9	8	345	6,047	4,598	7,215	22,631	16,260	9,587
10	-	103	121	7,329	16,338	7,268	30,311	7,553
11	2,688	114	37	143	6,478	16,552	19,469	4,214
12	-	964	37	40	-	12,467	45,092	7,834
13	-	-	37	143	-	-	26,970	5,531
14	-	-	-	862	-	-	-	2,330
15	-	-	-	-	1,652	-	-	453
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 1975-1987 (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
1987	179	26	57	262

Table 2.4 Abundance indices for 0-group herring in the Barents Sea, 1973-1988 (Toresen, 1985; Anon., 1988a).

Year	Log index	Year	Log index
1973	0.05	1981	0.00
1974	0.01	1982	0.00
1975	0.00	1983	1.77
1976	0.00	1984	0.34
1977	0.01	1985	0.23
1978	0.02	1986	0.00
1979	0.09	1987	0.00
1980	0.00	1988	0.30

Table 2.5 HERRING.
Numbers (thousands) added to the catch in tuning of the VPA towards the 1984 and 1988 estimates.

Age	Year		
	1985	1986	1987
3	5,885	-	-
4	4,232	2,932	-
5	4,895	4,536	-
6	52,797	2,114	-
7	31,197	35,733	-
8	36,694	38,540	2,078
9	40,369	25,740	2,413
10	-	46,689	1,947
11	14,448	-	286
12	37,533	20,908	-
13	-	53,030	969
14	-	-	4,670
Sum	228,050	230,222	12,363
%	103.3	81.7	19.6

Table 2.6 Average weight (gm) in stock (1 January), Norwegian spring spawners, 1976-1988.

Age	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
3	181	181	180	178	175	170	170	155	140	148	146	90	96
4	259	259	294	232	283	224	204	249	204	234	206	143	143
5	342	342	326	359	347	336	303	304	295	265	265	241	200
6	384	384	371	385	402	378	355	368	338	312	289	279	250
7	409	409	409	420	421	387	383	404	376	346	339	299	300
8	444	444	461	444	465	408	395	424	395	370	368	316	333
9	461	461	476	505	465	397	413	437	407	395	391	342	343
10	520	520	520	520	520	520	453	436	413	397	382	343	352
11	543	543	543	551	534	543	468	493	422	425	388	362	400
12	412	412	500	500	500	512	512	480	459	434	383	370	358
13	412	412	500	500	500	512	500	470	449	443	403	378	360
14	412	412	500	500	500	512	500	500	427	452	403	381	385
15	412	412	500	500	500	512	500	500	437	463	450	388	400
16	412	412	500	500	500	512	500	500	437	480	470	390	400

Table 2.7 Average weight (gm) in catch, Norwegian spring spawners, 1975-1987.

Age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
3	259	259	294	232	283	224	204	249	204	233	226	160	121
4	342	342	326	359	347	336	303	304	250	281	292	244	169
5	384	384	371	385	402	378	355	368	317	348	311	288	248
6	409	409	409	420	421	387	383	404	356	371	357	306	287
7	444	444	461	444	465	408	395	424	386	408	380	345	306
8	461	461	476	505	465	397	413	437	401	428	402	367	321
9	520	520	520	520	520	520	453	436	410	442	419	390	342
10	543	543	543	551	534	543	468	493	418	434	432	394	346
11	412	412	500	500	500	512	512	480	441	456	440	393	362
12	412	412	500	500	500	512	500	470	455	469	458	392	371
13	412	412	500	500	500	512	500	500	438	460	460	409	379
14	412	412	500	500	500	512	500	500	432	460	465	434	380
15	412	412	500	500	500	512	500	500	432	445	470	450	390
16	412	412	500	500	500	512	500	500	432	445	470	454	400

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

Age	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
0	0.00	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	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	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	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	0.30
5	1.00	1.00	1.00	0.95	0.97	0.97	0.70	0.69	0.90	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	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	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	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	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	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	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	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	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	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	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	1.00

Table 2.9 VIRTUAL POPULATION ANALYSIS

NORWEGIAN SPRING SPAWNING HERRING

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

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
3	.023	.012	.017	.011	.023	.035	.076	.269	.058	.117
4	.028	.016	.034	.014	.025	.042	.071	.368	.339	.065
5	.036	.018	.023	.021	.016	.035	.156	.295	.641	.664
6	.217	.023	.025	.026	.018	.025	.080	.511	.456	.285
7	.002	.109	.038	.016	.027	.023	.061	.368	.944	.357
8	.716	.003	.195	.023	.021	.021	.063	.373	1.019	.651
9	.038	.002	.026	.213	.020	.022	.145	.351	.499	.393
10	.018	.022	.002	.491	.100	.028	.095	.197	.872	.183
11	.016	.021	.027	.337	.301	.152	.029	.243	1.071	.098
12	.019	.019	.025	.011	.161	.565	.001	.300	1.083	2.050
13	.029	.022	.022	.029	.001	1.418	.022	.001	1.001	.250
14	.034	.034	.026	.026	.034	.013	.026	.026	.002	.190
15	.080	.040	.040	.030	.030	.040	.030	.030	.030	2.000
16+	.080	.040	.040	.030	.030	.040	.030	.030	.030	2.000
(4-16)W	.034	.021	.032	.019	.019	.031	.089	.348	.776	.079
(4-10)W	.034	.021	.033	.020	.020	.031	.100	.398	.769	.075

Table 2.10 VIRTUAL POPULATION ANALYSIS

NORWEGIAN SPRING SPAWNING HERRING

STOCK SIZE IN NUMBERS UNIT: thousands

BIOMASS TOTALS UNIT: tonnes

ALL VALUES ARE GIVEN FOR 1 JANUARY

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
3	142566	585208	410313	398339	634975	98979	65617	9699610258648		191532	0
4	475622	122360	507921	354295	345879	544634	83934	53424	65097	8502928	149688
5	620645	406255	105697	431201	306806	296327	458406	68660	32454	40746	6997204
6	4752	525969	350303	90679	370588	265186	251291	344487	44889	15013	18419
7	429	3360	451351	299956	77566	319552	227072	203628	181428	24974	9914
8	1284	376	2646	381505	259166	66275	274210	187564	123776	61971	15345
9	145490	551	329	1911	327246	222821	56985	226177	113403	39212	28379
10	59	123048	483	281	1356	281692	191354	43293	139834	60460	23242
11	66	51	105676	423	151	1077	240492	152743	31224	51352	44211
12	57	57	44	90277	265	98	812	205111	105171	9393	40882
13	38	49	49	38	78369	198	49	712	133438	31252	1062
14	32	32	42	42	32	68781	42	42	625	43051	21372
15	14	27	27	36	36	27	59589	36	36	548	31261
16+	14	27	27	36	36	27	36	95156	89059	1	65
TOTAL NO	1391067	1767372	1934909	2049020	2402472	2165676	1909890	167802911319082		9072432	
SPS NO	1219472	1173875	1370043	1549915	1559095	1635513	1750462	1557155	2030975	2943929	
TOT.BIOM	439752	546864	641224	645410	710314	751107	670346	594274	1885854	1358856	
SPS BIOM	403443	435034	514399	543838	548584	613266	635747	573284	526279	491217	

Table 2.11

List of input variables for the ICES prediction program.

NORWEGIAN SPRING-SPAWNING HERRING
The reference F is the mean F for the age group range from 4 to 9

The number of recruits per year is as follows:

Year	Recruitment
1988	262000.0
1989	7000000.0
1990	7000000.0

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	262000.0	.05	.90	.00	.073	.010
2	143000.0	.02	.90	.00	.089	.055
3	267000.0	.10	.13	.10	.121	.096
4	149688.0	.16	.13	.30	.169	.143
5	6997204.0	.35	.13	.90	.248	.200
6	18419.0	.35	.13	1.00	.287	.250
7	9914.0	.35	.13	1.00	.306	.300
8	15345.0	.35	.13	1.00	.321	.333
9	28379.0	.35	.13	1.00	.342	.343
10	23242.0	.35	.13	1.00	.346	.352
11	44211.0	.35	.13	1.00	.362	.400
12	40882.0	.35	.13	1.00	.371	.358
13	1062.0	.15	.13	1.00	.379	.360
14	21372.0	.10	.13	1.00	.380	.385
15	31261.0	.03	.13	1.00	.390	.400
16+	65.0	.03	.13	1.00	.400	.400

Table 2.12

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

NORWEGIAN SPRING-SPAWNING HERRING

Year 1988					Year 1989					Year 1990	
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
.2	.07	1541	1353	120	.0	.00	1639	1533	0	1875	1636
					.1	.03			58	1819	1581
					.2	.06			114	1766	1528
					.3	.10			168	1714	1477
					.4	.13			220	1663	1428
					.5	.16			271	1615	1380
					.6	.19			320	1568	1334
					.7	.22			367	1523	1289
					.8	.25			413	1479	1246
					.9	.29			457	1436	1205
					1.0	.32			500	1395	1165

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 9

Table 2.13
Results

16.09.19 28 OCTOBER 1988
NORWEGIAN SPRING-SPAWNING HERRING

****
* Year 1988. F-factor .208 and reference F .0661 *
----
* Run depending on a TAC value *
****

age	absolute F	catch in numbers	catch in weight	stock size	stock biomass	at 1 January: sp.stock size	at 1 January: sp.stock biomass
1	.0104	1539	112	226000	2260	0	0
2	.0042	390	34	143000	7865	0	0
3	.0208	5145	622	267000	25632	26700	2563
4	.0332	4587	775	149688	21405	44906	6421
5	.0727	460190	114127	6997204	1399440	6297483	1259496
6	.0727	1211	347	18419	4604	18419	4604
7	.0727	652	199	9914	2974	9914	2974
8	.0727	1009	323	15345	5109	15345	5109
9	.0727	1866	638	28379	9733	28379	9733
10	.0727	1528	528	23242	8181	23242	8181
11	.0727	2907	1052	44211	17684	44211	17684
12	.0727	2688	997	40882	14635	40882	14635
13	.0311	30	11	1062	382	1062	382
14	.0208	411	156	21372	8228	21372	8228
15	.0062	182	70	31261	12504	31261	12504
16+	.0062	0	0	65	26	65	26
Total		484342	120000	8017044	1540668	6603241	1352546

****
* Year 1989. F-factor .200 and reference F .0637 *
****

age	absolute F	catch in numbers	catch in weight	stock size	stock biomass	at 1 January: sp.stock size	at 1 January: sp.stock biomass
1	.0100	45959	3355	7000000	70000	0	0
2	.0040	239	21	90935	5001	0	0
3	.0200	1075	130	57898	5558	5789	555
4	.0320	6783	1146	229634	32837	68890	9851
5	.0700	8066	2000	127146	25429	114431	22886
6	.0700	362496	104036	5713625	1428406	5713625	1428406
7	.0700	954	291	15040	4512	15040	4512
8	.0700	513	164	8095	2695	8095	2695
9	.0700	794	271	12530	4297	12530	4297
10	.0700	1470	508	23173	8156	23173	8156
11	.0700	1204	435	18978	7591	18978	7591
12	.0700	2290	849	36100	12924	36100	12924
13	.0300	925	350	33382	12017	33382	12017
14	.0200	16	6	903	348	903	348
15	.0060	103	40	18381	7352	18381	7352
16+	.0060	153	61	27336	10934	27336	10934
Total		433047	113671	13413162	1630962		

Table 2.12 cont'd.

```
************************************************************
* Year 1990. F-factor    .200 and reference F    .0637 *
************************************************************
```

age	absolute F	catch in numbers	catch in weight	stock size	stock biomass	sp.stock size (at 1 January)	sp.stock biomass (at 1 January)
1	.0100	45959	3355	7000000	70000	0	0
2	.0040	7418	660	2817669	154971	0	0
3	.0200	683	82	36824	3535	3682	353
4	.0320	1472	248	49833	7126	14950	2137
5	.0700	12390	3072	195290	39058	175761	35152
6	.0700	6604	1895	104098	26024	104098	26024
7	.0700	296787	90816	4677920	1403376	4677920	1403376
8	.0700	781	250	12313	4100	12313	4100
9	.0700	420	143	6627	2273	6627	2273
10	.0700	650	225	10258	3611	10258	3611
11	.0700	1203	435	18972	7589	18972	7589
12	.0700	985	365	15538	5562	15538	5562
13	.0300	819	310	29556	10640	29556	10640
14	.0200	528	200	28446	10951	28446	10951
15	.0060	4	1	778	311	778	311
16+	.0060	223	89	39904	15961	39904	15961
Total		376934	102155	15044030	1765094	5138811	1528046

Table 3.1 International catch of Barents Sea capelin ('000 t) in the years 1965-1988.

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	1,493	846	36	2,375
1984	811	628	42	1,481
1985	453	398	17	868
1986	72	51	-	123
1987	-	-	-	-
1988	-	-	-	-

Table 3.2 Larval index (number x 10^{12}) for Barents Sea Capelin.

Year	Index
1981	9.71
1982	9.88
1983	9.94
1984	8.15
1985	9.25
1986	-
1987	0.14
1988	0.13

Table 3.3 Acoustic estimate, autumn 1988, for Barents Sea capelin.

Total length (cm)	Age 1	Age 2	Age 3	Total number (10^7)	Biomass ('000 t)	Biomass (cum.) ('000 t)
4.5- 4.9	2	-	-	2	-	-
5.0- 5.4	2	-	-	2	-	-
5.5- 5.9	1	-	-	1	-	-
6.0- 6.4	1	-	-	1	-	-
6.5- 6.9	4	-	-	4	-	-
7.0- 7.4	20	-	-	20	0.2	-
7.5- 7.9	63	-	-	63	0.7	-
8.0- 8.4	138	-	-	138	2.9	-
8.5- 8.9	298	-	-	298	7.5	-
9.0- 9.4	393	-	-	393	11.4	-
9.5- 9.9	380	9	-	389	13.4	-
10.0-10.4	240	9	-	250	9.9	-
10.5-10.9	237	35	-	272	12.5	-
11.0-11.4	131	38	-	169	9.0	-
11.5-11.9	69	133	-	202	13.1	-
12.0-12.4	13	199	-	211	15.7	-
12.5-12.9	5	426	-	431	37.1	-
13.0-13.4	5	379	2	387	37.6	-
13.5-13.9	-	458	5	463	53.1	-
14.0-14.4	-	347	-	347	46.0	203.3
14.5-14.9	-	300	2	301	46.2	157.3
15.0-15.4	-	250	4	254	45.1	111.1
15.5-15.9	-	148	9	157	30.7	66.0
16.0-16.4	-	82	3	85	18.8	35.3
16.5-16.9	-	32	-	32	7.9	16.5
17.0-17.4	-	26	-	27	7.0	8.6
17.5-17.9	-	4	-	4	1.1	1.6
18.0-18.4	-	2	-	2	0.5	0.5
Number	2000	2876	25	4900		
Biomass	69.6	353.4	4.3	427.2		
Mean length	9.7	13.8	15.0	12.1		

Table 3.4 The development of the Barents Sea capelin stock since 1972.

LM = length for 50% maturation
Mmon. = inst. nat. mort. per month
(does not include spawning mort.)
Zmon.spr. = inst. tot. mort. per month in spring
Zmon.aut. = inst. tot. mort. per month in autumn
Fmon.aut. = inst. fishing mort. per month in autumn

1972				Mmon = 0.051	LM = 14.01			
Age	Stock Jan$_7$1 (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_7$1 (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1				79227	-	0.000	0.000	0.051
2				16797	1114.9	0.078	0.016	0.067
3				20139	1345.5	0.079	0.016	0.067
4				2721	183.5	0.079	0.016	0.067
5				228	14.2	0.073	0.015	0.066
Σ				130571	2658.1			

1973				Mmon = 0.051	LM = 14.01			
Age	Stock Jan$_7$1 (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_7$1 (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	117359	102.2	0.001	0.000	0.051
2	61300	-	-	42962	1015.9	0.027	0.005	0.056
3	12023	61.2	144	5215	534.9	0.123	0.025	0.076
4	14403	5901.7	516	2092	104.7	0.058	0.012	0.063
5	1945	1673.3	21	23	0.7	0.035	0.007	0.058
Σ		7636.2	681	167658	1758.3			

1974				Mmon = 0.051	LM = 14.01			
Age	Stock Jan$_7$1 (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_7$1 (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	76083	-	0.000	0.000	0.051
2	90714	9.3	-	63562	1139.5	0.021	0.004	0.055
3	32357	439.4	120	20877	1059.0	0.059	0.012	0.063
4	3567	2746.6	56	436	42.2	0.112	0.023	0.074
5	2092	991.6	104	8	-	0.000	0.000	0.051
Σ		4186.9	280	160966	2240.7			

contd.

Table 3.4 (contd.)

1975 Mmon = 0.051 LM = 14.01

Age	Stock Jan$_7$ 1 (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_7$ 1 (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	50895	-	0.000	0.000	0.051
2	58867	250.3	-	41076	1364.9	0.038	0.008	0.059
3	48181	1009.6	138	35050	1795.5	0.060	0.012	0.063
4	15225	3499.3	64	10108	613.8	0.071	0.014	0.065
5	300	390.5	-	107	-	0.000	0.000	0.051
Σ		5149.7	203	137236	3774.2			

1976 Mmon = 0.051 LM = 14.01

Age	Stock Jan$_7$ 1 (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_7$ 1 (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	44445	-	0.000	0.000	0.051
2	39379	83.8	-	27492	1726.2	0.074	0.015	0.066
3	30586	672.5	117	20325	2752.4	0.166	0.033	0.084
4	25548	4400.1	578	10074	1960.0	0.248	0.049	0.100
5	7284	2802.5	520	1661	394.0	0.311	0.062	0.113
Σ		7958.9	1215	103997	6832.6			

1977 Mmon = 0.051 LM = 14.01

Age	Stock Jan$_7$ 1 (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_7$ 1 (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	78519	-	0.000	0.000	0.051
2	34388	683.0	-	23609	4517.9	0.243	0.048	0.099
3	19764	1424.9	291	12733	2617.9	0.269	0.052	0.103
4	13320	5022.1	454	5064	862.5	0.213	0.042	0.093
5	6085	3028.7	381	902	146.2	0.202	0.040	0.091
Σ		10158.7	1126	120827	8144.5			

Contd.

Table 3.4 (contd.)

1978				Mmon = 0.051 LM = 14.01				
Age	Stock Jan$_1$ (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_1$ (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	95113	99.5	0.001	0.000	0.051
2	60752	53.6	-	42547	2875.2	0.079	0.016	0.067
3	14327	1227.5	68	12050	1726.5	0.177	0.035	0.086
4	7568	3507.3	401	1699	265.3	0.194	0.039	0.090
5	3165	1780.8	206	96	19.8	0.264	0.053	0.104
Σ		6569.2	675	151505	4986.3			

1979				Mmon = 0.072 LM = 13.94				
Age	Stock Jan$_1$ (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_1$ (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	55220	30.5	0.001	0.000	0.072
2	73511	8.1	-	40024	2767.2	0.086	0.017	0.089
3	30409	1047.2	29	14829	3047.5	0.278	0.055	0.127
4	7815	2883.5	252	681	224.1	0.488	0.097	0.169
5	1083	634.9	-	4	2.2	1.012	0.201	0.273
Σ		4573.7	281	110758	6071.5			

1980				Mmon = 0.072 LM = 13.94				
Age	Stock Jan$_1$ (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_1$ (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	59131	90.4	0.002	0.000	0.072
2	38419	10.0	-	23195	683.9	0.036	0.007	0.079
3	25575	468.1	70	19420	2109.0	0.138	0.027	0.099
4	7817	3834.8	49	3996	334.1	0.105	0.021	0.093
5	291	344.7	-	38	7.5	0.266	0.053	0.125
Σ		4657.6	119	105780	3224.9			

Contd.

Table 3.4 (contd.)

1981				Mmon = 0.072	LM = 13.94			
Age	Stock Jan$_7$ 1 (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_7$ 1 (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	44327	203.0	0.005	0.001	0.073
2	41095	59.0	-	24831	2596.7	0.132	0.026	0.098
3	15581	339.9	337	7002	1564.9	0.306	0.061	0.133
4	11778	3452.0	1226	1920	372.3	0.261	0.052	0.124
5	2506	1417.1	204	43	15.8	0.563	0.112	0.184
Σ		5268.0	1767	78123	4752.7			

1982				Mmon = 0.072	LM = 13.94			
Age	Stock Jan$_7$ 1 (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_7$ 1 (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	1.0	-	61204	107.0	0.002	0.000	0.072
2	30692	47.1	-	18526	2139.0	0.147	0.029	0.101
3	15142	1127.7	214	8464	2443.0	0.415	0.083	0.155
4	3588	1655.7	259	357	149.0	0.669	0.133	0.205
5	1030	513.9	109	-	6.0	-	-	-
Σ		3345.4	582	88551	4844.0			

1983				Mmon = 0.072	LM = 13.94			
Age	Stock Jan$_7$ 1 (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_7$ 1 (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	4.0	-	53790	298.1	0.007	0.001	0.073
2	42520	40.0	-	25705	3634.9	0.163	0.037	0.109
3	11132	1298.8	68	6383	2671.9	0.672	0.134	0.206
4	3890	3371.2	55	78	120.7	-	-	-
5	127	718.9	-	-	0.2	-	-	-
Σ		5432.9	123	85956	6725.8			

Contd.

Table 3.4 (contd.)

1984				Mmon = 0.080 LM = 13.94				
Age	Stock Jan$_1$ (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_1$ (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	37122	219.9	0.008	0.002	0.142
2	37201	6.6	-	22428	2109.6	0.140	0.028	0.168
3	14897	839.7	219	6528	1571.6	0.397	0.079	0.219
4	2270	2264.6	-	442	165.0	0.693	0.138	0.278
5	-	225.2	-	-	9.0	-	-	-
Σ		3336.1	219	66520	4075.1			

1985				Mmon = 0.150 LM = 13.94				
Age	Stock Jan$_1$ (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_1$ (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	2415	78.6	0.046	0.009	0.149
2	24649	35.1	-	6821	672.6	0.146	0.029	0.169
3	13292	571.0	60	3414	790.8	0.379	0.075	0.215
4	3103	1698.5	23	157	59.3	0.704	0.140	0.280
5	164	326.4	-	-	-	-	-	-
Σ		2631.0	83	12807	1601.3			

1986				Mmon = 0.230 LM = 13.94				
Age	Stock Jan$_1$ (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug$_1$ (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	1200	-	-	-	0.140
2	1083	1.4	-	449	-	-	-	0.140
3	2762	149.0	10	382	-	-	-	0.140
4	1088	445.0	26	20	-	-	-	0.140
5	36	74.0	2	-	-	-	-	0.140
Σ		669.4	36	2051	-			

Contd.

Table 3.4 (contd.)

1987				Mmon = 0.250 LM = 13.94				
Age	Stock Jan 1 (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug 1 (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	-	-	-	-	-
2	377	-	-	224	-	-	-	0.140
3	141	-	5	14	-	-	-	0.140
4	120	-	10	2	-	-	-	0.140
5	6	-	1	-	-	-	-	0.140
Σ		-	16	240	-			

1988				Mmon = 0.250 LM = 13.94				
Age	Stock Jan 1 (10^7)	Catch spr. (10^7)	Sp. stock (10^3 t)	Stock Aug 1 (10^7)	Catch aut. (10^7)	F aut.	F mon. aut.	Z mon. aut.
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	64	-	1	-	-	-	-	-
4	4	-	-	-	-	-	-	-
5	1	-	-	-	-	-	-	-
Σ		-	2	-	-			

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

	Winter season		Summer/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]	-	1,019.5
1988	600.6	57.3	25.0[1]	11.5[1]	47.0[1]		741.4[1]

[1] Until 24 October.

Table 4.2 Abundance by number of Capelin year classes as indicated by two different methods of estimation.

Year classs	Estimates in August as 1-group	Calculated from estimates of 3- and 4-group spawners
1981	119	145
1982	155	134
1983	286	220
1984	31	102
1985	71	107[1]
1986	101	-
1987	147	-

[1] The 1985 year class is not fully recruited to the surveys of the adult stock and consequently somewhat underestimated.

Table 4.3 The percentage of 4-group Capelin in the spawning stock in the years 1981-1987. (The high contribution in 1987 is due to the very rich 1983 year class and was omitted when calculating the mean.)

Year	Percentage
1981	22
1982	7
1983	12
1984	16
1985	34
1986	25
1987	63
1988	21
Mean	20

Table 4.4 Mean weight (g) of mature 2- and 3-group Capelin in October in the years 1981-1987.

Year	2-group	3-group
1981	19.1	24.7
1982	17.2	24.1
1983	16.8	22.5
1984	17.1	25.7
1985	15.5	23.8
1986	17.8	24.1
1987	17.3	25.4
Mean	17.3	24.3
Weight increase until spawning	1.3	2.0

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

Table 4.6 Biomass computations for capelin, October 1988.

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+	g	Total	Wt	Ave. vol.
7.5- 7.9	1,714	-	-	-	-	-	-	1,714	1	1.0
8.0- 8.4	6,128	-	-	-	-	-	-	6,128	12	2.0
8.5- 8.9	7,471	-	-	-	-	-	-	7,471	14	2.0
9.0- 9.4	6,922	-	-	-	-	-	-	6,922	16	2.3
9.5- 9.9	6,253	-	-	-	-	-	-	6,253	18	3.0
10.0-10.4	4,440	-	-	-	-	-	-	4,440	15	3.4
10.5-10.9	4,139	-	-	-	-	-	-	4,139	16	4.0
11.0-11.4	3,013	-	-	-	-	-	-	3,013	15	5.0
11.5-11.9	3,176	-	-	-	-	-	-	3,176	17	5.4
12.0-12.4	449	832	-	-	-	-	-	1,281	8	6.2
12.5-12.9	-	1,923	-	-	-	-	-	1,923	14	7.3
13.0-13.4	98	3,932	-	-	-	-	-	4,030	35	8.7
13.5-13.9	93	5,590	-	-	-	96	5,779	5,779	59	10.2
14.0-14.4	-	8,903	225	-	-	-	9,128	9,128	106	11.6
14.5-14.9	-	8,349	218	-	-	-	8,567	8,567	118	13.8
15.0-15.4	-	10,620	759	106	-	-	11,485	11,485	178	15.5
15.5-15.9	-	10,000	1,468	96	-	-	11,564	11,564	206	17.8
16.0-16.4	-	7,045	2,301	-	-	-	9,346	9,346	184	19.7
16.5-16.9	-	2,250	4,452	85	-	-	6,787	6,787	153	22.5
17.0-17.4	-	221	3,745	-	-	-	3,966	3,966	98	24.7
17.5-17.9	-	82	2,728	83	-	-	2,893	2,893	80	27.7
18.0-18.4	-	-	1,076	-	-	-	1,076	1,076	34	32.0
18.5-18.9	-	-	54	33	-	-	87	87	2	32.0
19.0-19.4	-	-	17	-	-	-	17	17	-	38.0
Number:	43,896	59,747	17,043	403	-	96	70,695	121,185		
Ave.length:	9.65	14.91	16.84	16.49	-	13.75	15.56	13.28		
Weight:	133.5	870.9	399.3	8.4	-	1.1	1224.9	1413.2		
Av.volume:	3.0	14.6	23.4	20.9	-	11.0	17.3	11.7		
Condition:	3.2	4.3	4.8	4.7	-	4.2	4.5	4.0		

Table 4.7 Biomass computations for capelin, August 1988.

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

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

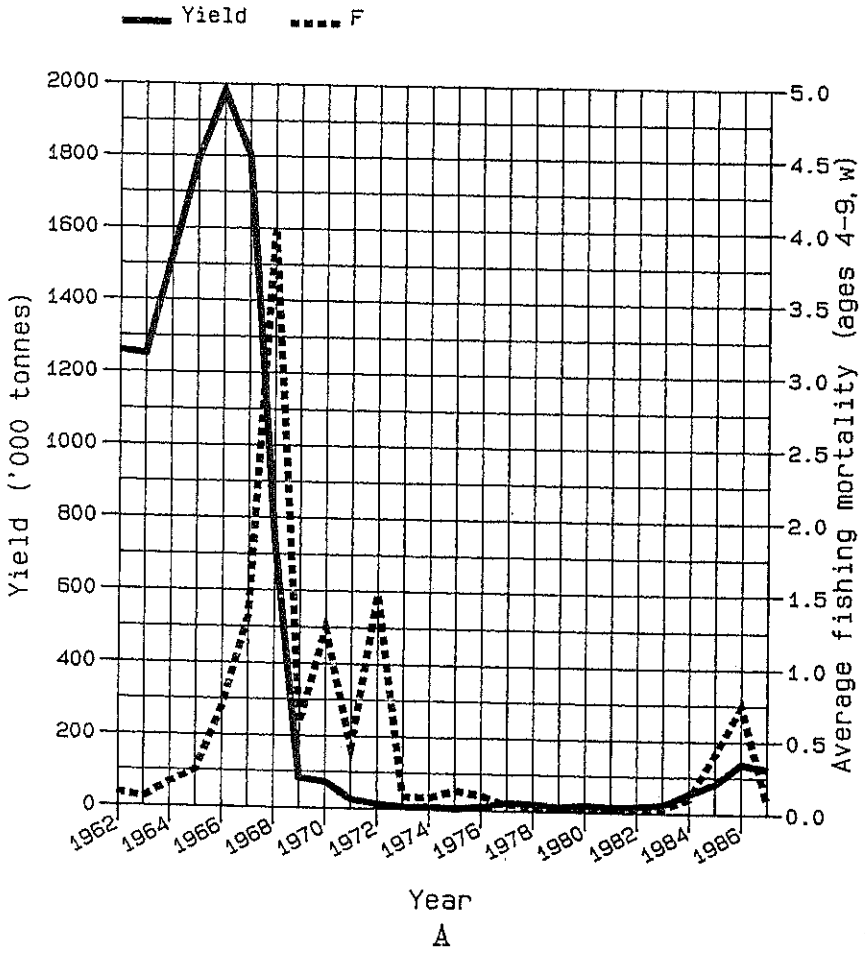
Region: all

Length	1	2	3	4	5	6+	g	Total	Wt	Ave. vol.
6.5- 6.9	230	-	-	-	-	-	-	230	-	1.0
7.0- 7.4	15,489	-	-	-	-	-	-	15,489	15	1.0
7.5- 7.9	22,649	-	-	-	-	-	-	22,649	32	1.4
8.0- 8.4	32,383	-	-	-	-	-	-	32,383	65	2.0
8.5- 8.9	21,223	-	-	-	-	-	-	21,223	45	2.2
9.0- 9.4	16,436	-	-	-	-	-	-	16,436	48	2.9
9.5- 9.9	14,262	-	-	-	-	-	-	14,262	53	3.8
10.0-10.4	11,824	201	-	-	-	-	-	12,025	50	4.2
10.5-10.9	7,692	90	-	-	-	-	-	7,782	38	5.0
11.0-11.4	3,509	434	-	-	-	-	-	3,943	23	6.0
11.5-11.9	953	448	-	-	-	-	-	1,401	9	7.0
12.0-12.4	122	1,060	-	-	-	-	-	1,182	9	8.4
12.5-12.9	39	1,405	18	-	-	-	-	1,462	14	9.6
13.0-13.4	31	2,455	190	-	-	-	2,676	2,676	29	11.2
13.5-13.9	42	2,919	588	-	-	-	3,549	3,549	45	12.8
14.0-14.4	-	2,019	429	44	-	-	2,492	2,492	35	14.3
14.5-14.9	-	1,080	430	41	-	-	1,551	1,551	25	16.4
15.0-15.4	39	740	470	83	-	-	1,332	1,332	23	17.6
15.5-15.9	-	286	277	74	-	-	637	637	13	20.9
16.0-16.4	-	185	267	29	-	-	481	481	11	23.0
16.5-16.9	-	48	231	19	-	-	298	298	7	24.9
17.0-17.4	-	17	17	-	-	-	34	34	-	23.8
17.5-17.9	-	-	4	-	-	-	4	4	-	33.0
Number:	146,923	13,387	2,921	290	-	-	13,054	163,521		
Ave.length:	8.79	13.55	14.85	15.35	-	-	14.28	9.30		
Weight:	378.1	165.0	51.2	5.9	-	-	192.6	600.2		
Ave.volume:	2.6	12.3	17.5	20.5	-	-	14.8	3.7		
Condition:	3.5	4.8	5.3	5.6	-	-	5.0	3.6		

Figure 2.1

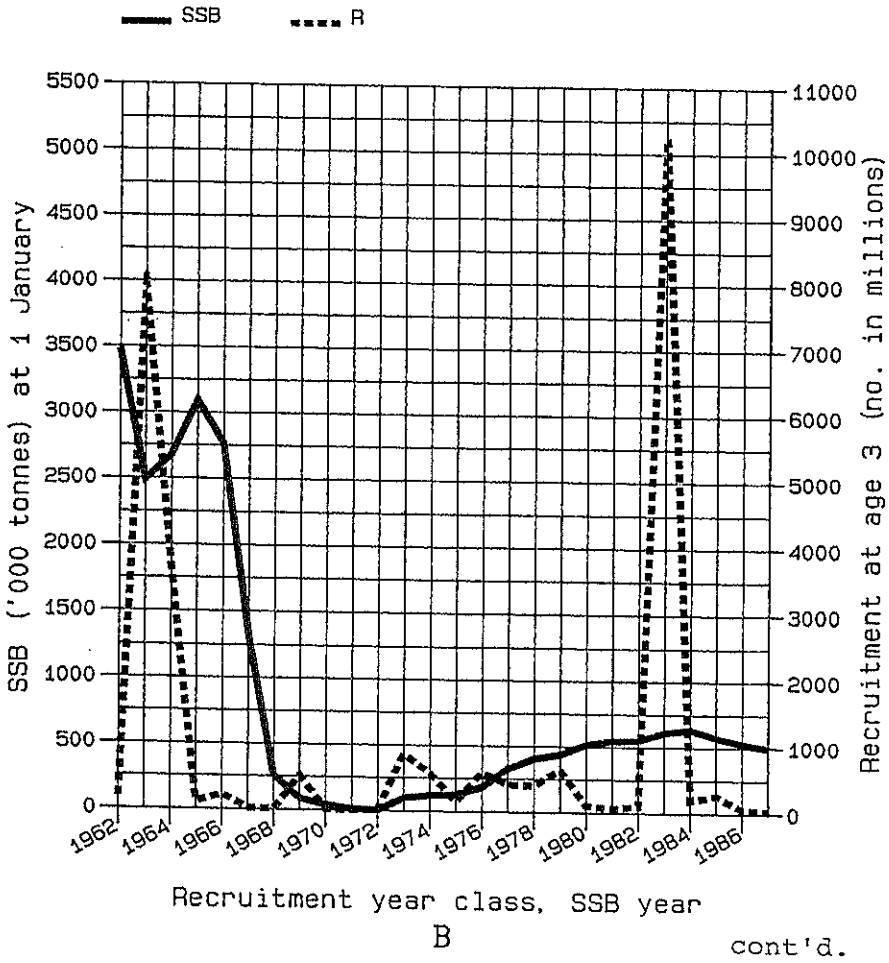
FISH STOCK SUMMARY
STOCK: Norwegian Spring-Spawning Herring
31-10-1988

Trends in yield and fishing mortality (F)



A

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



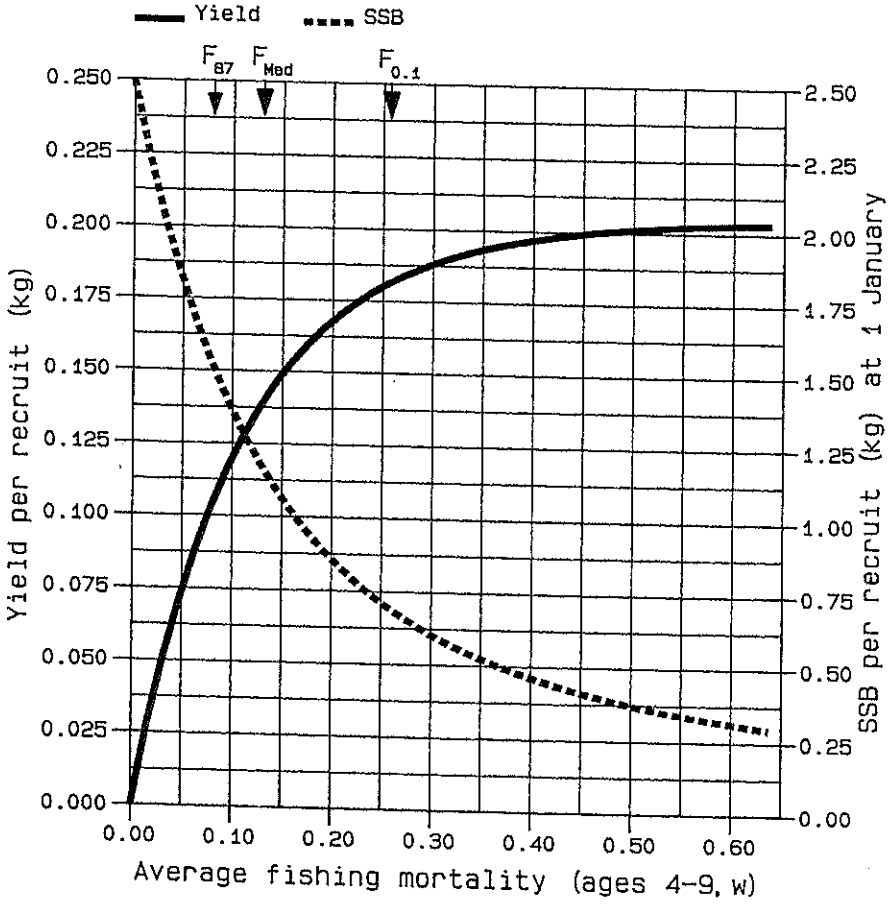
B

cont'd.

Figure 2.1 cont'd.

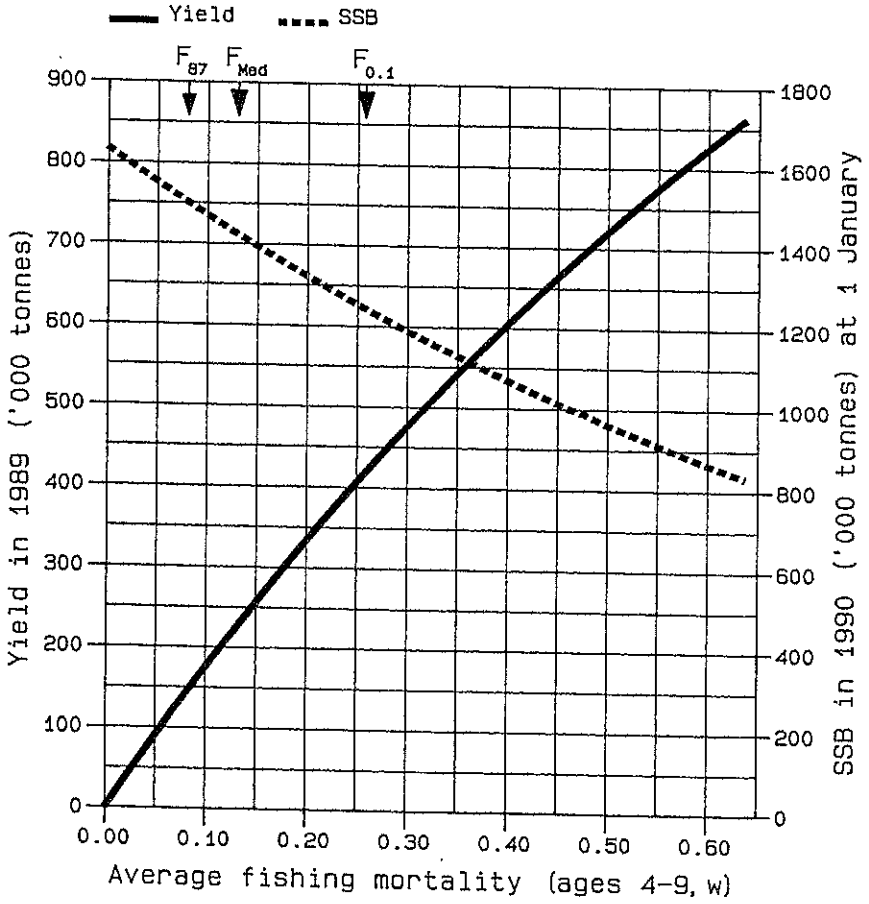
FISH STOCK SUMMARY
STOCK: Norwegian Spring-Spawning Herring
31-10-1988

Long-term yield and spawning stock biomass



C

Short-term yield and spawning stock biomass



D

Figure 2.2 Norwegian spring-spawning herring. Catch in 1988: 120,000 t.

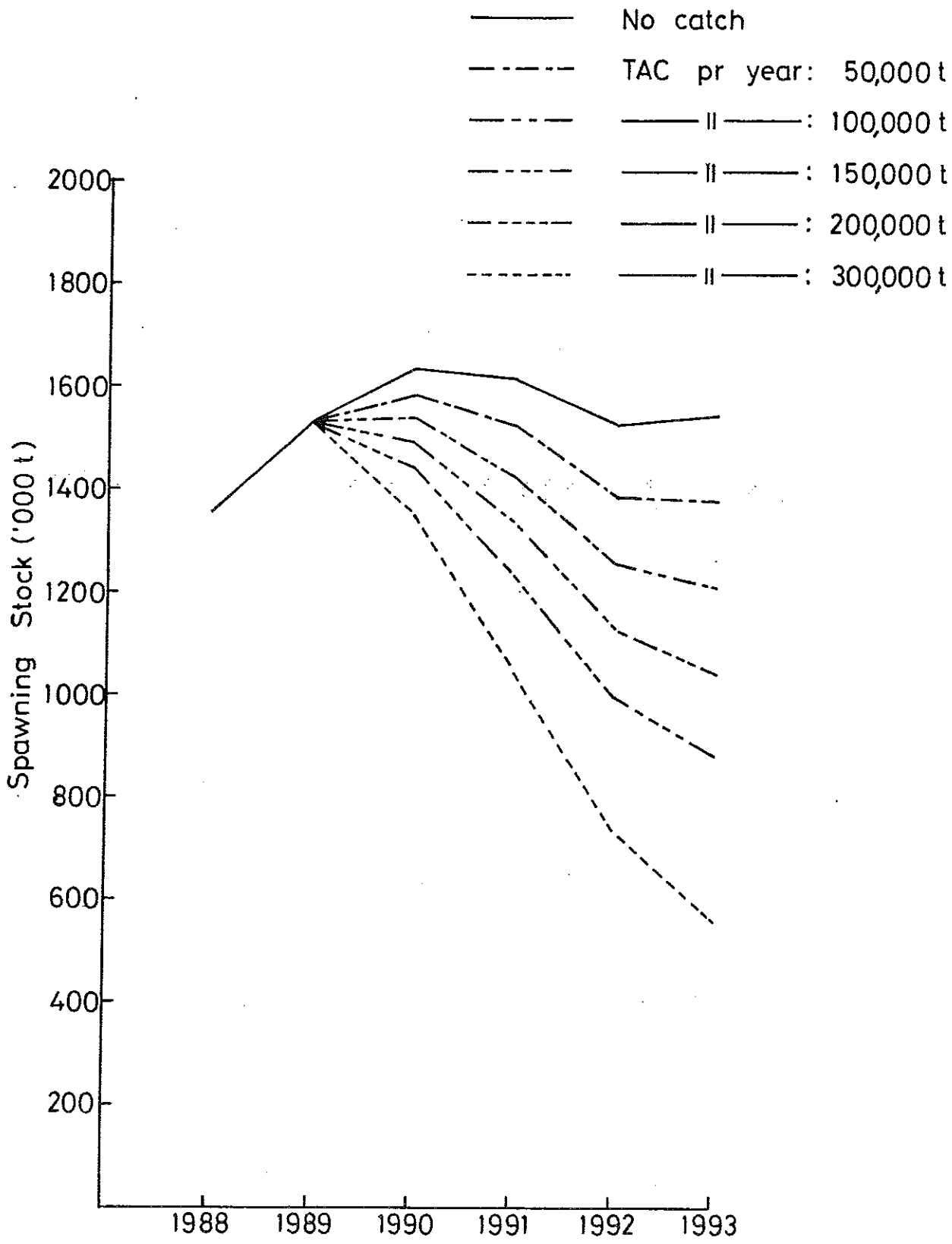


Figure 2.3 Norwegian spring-spawning herring. Stock-recruitment relationship.

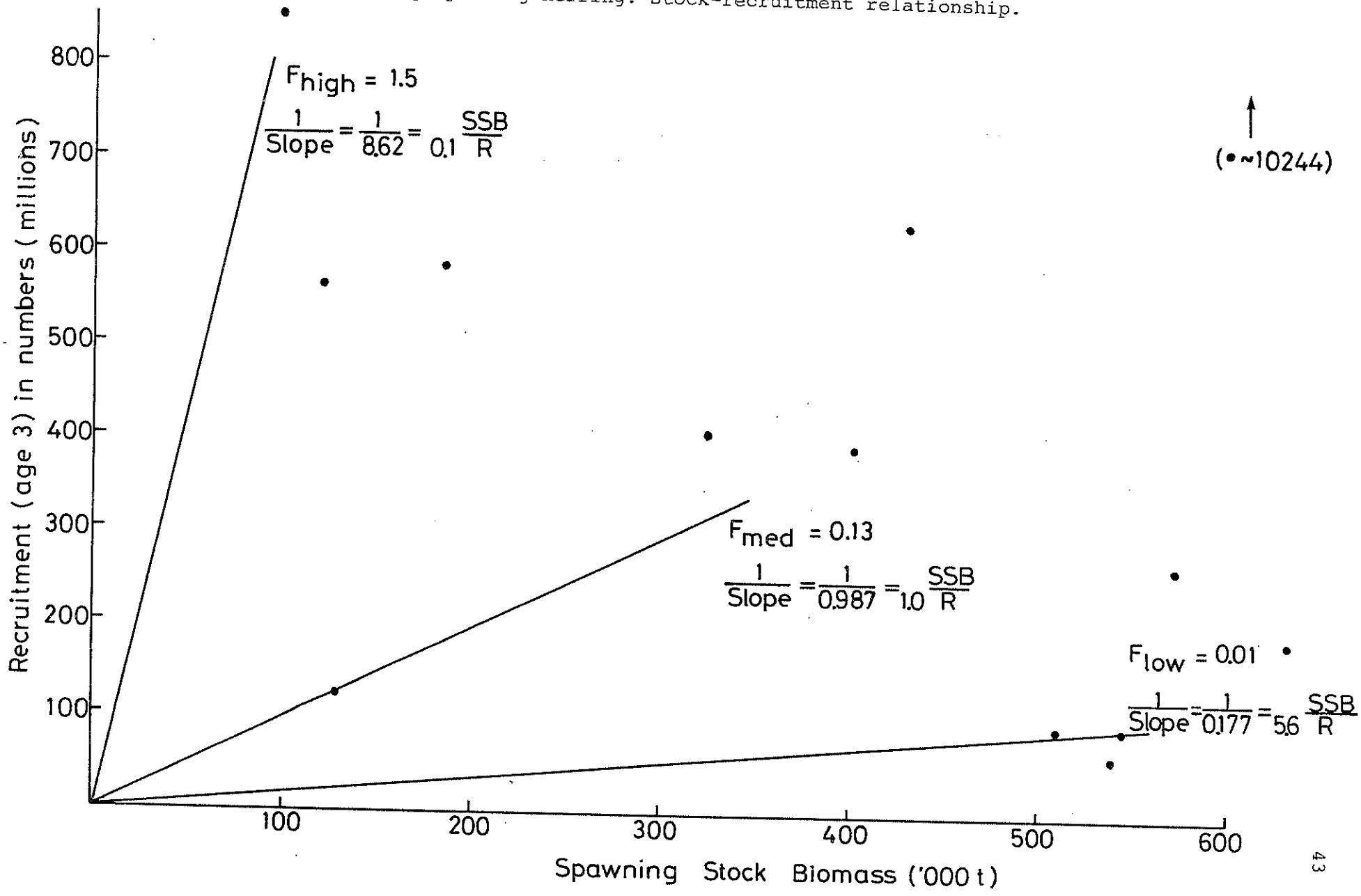


Figure 3.1 Distribution of 0-group capelin, Barents Sea 1988.

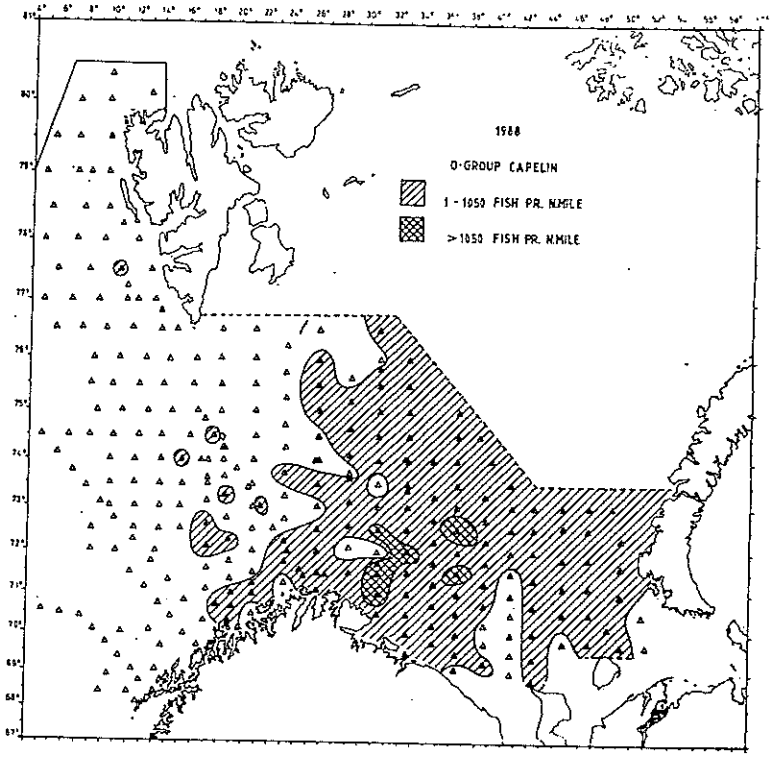
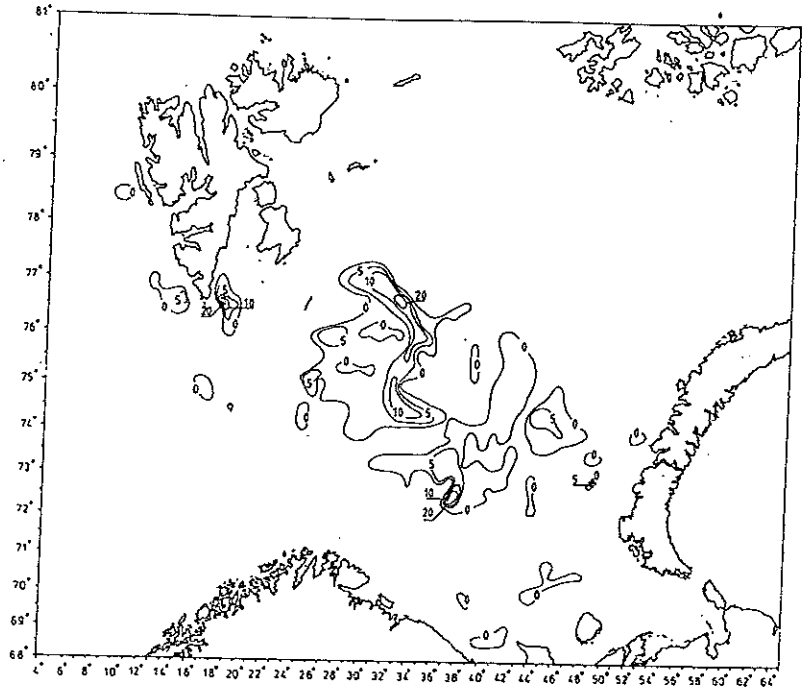


Figure 3.2 Total density distribution of Barents Sea capelin in autumn 1988 (tonnes/square nautical mile).



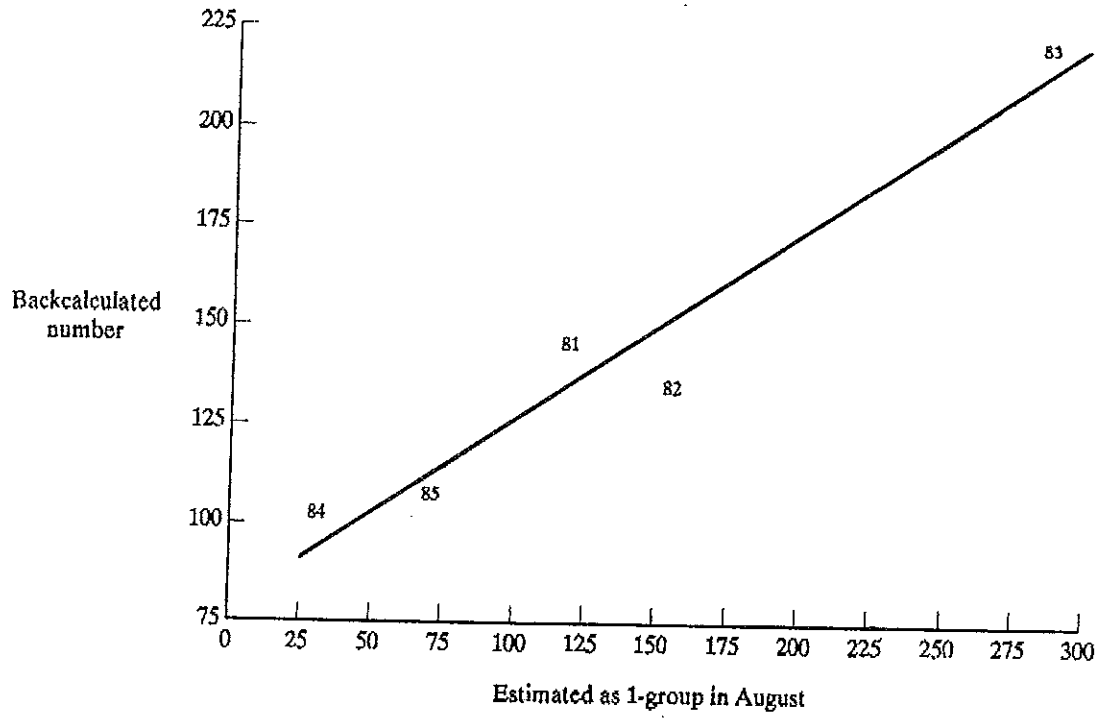
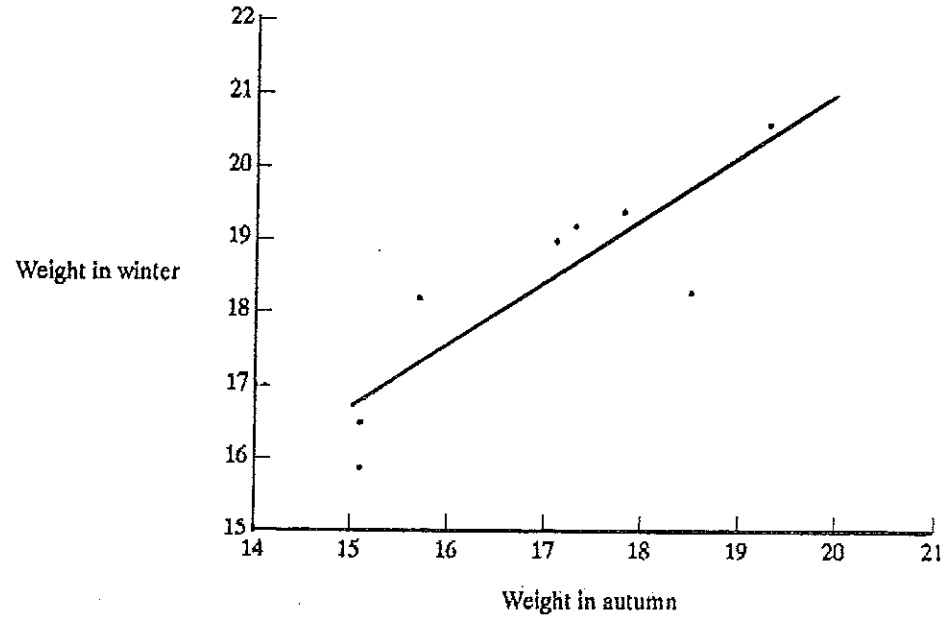
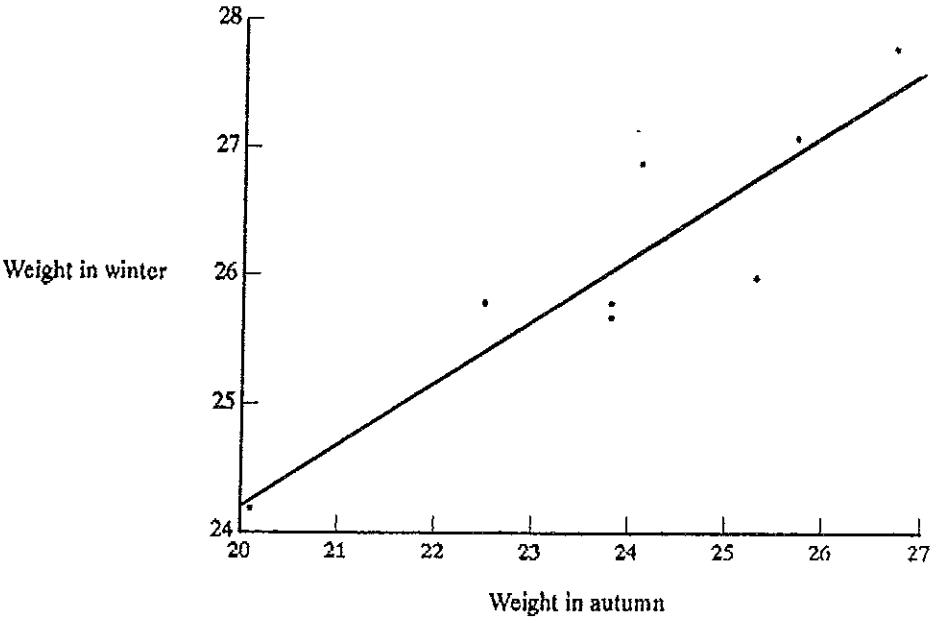


Figure 4.1 The relation between two different estimates of the abundance of the 1981-1985 year classes of capelin. $R^2 = 0.94$, a = 79.55, b = 0.47. Numbers are in 10^9.



2-group, R^2 = 0.74, a = 3.93, b = 0.85



3-group, R^2 = 0.81, a = 14.55, b = 0.48

Figure 4.2 Average weight (g) of maturing 2 and 3 group capelin in autum plotted against average weight among the same year classes in January/February in the following year for the 1979/1980 - 1987/1988 period. Comparable data are not available for the winter of 1986.

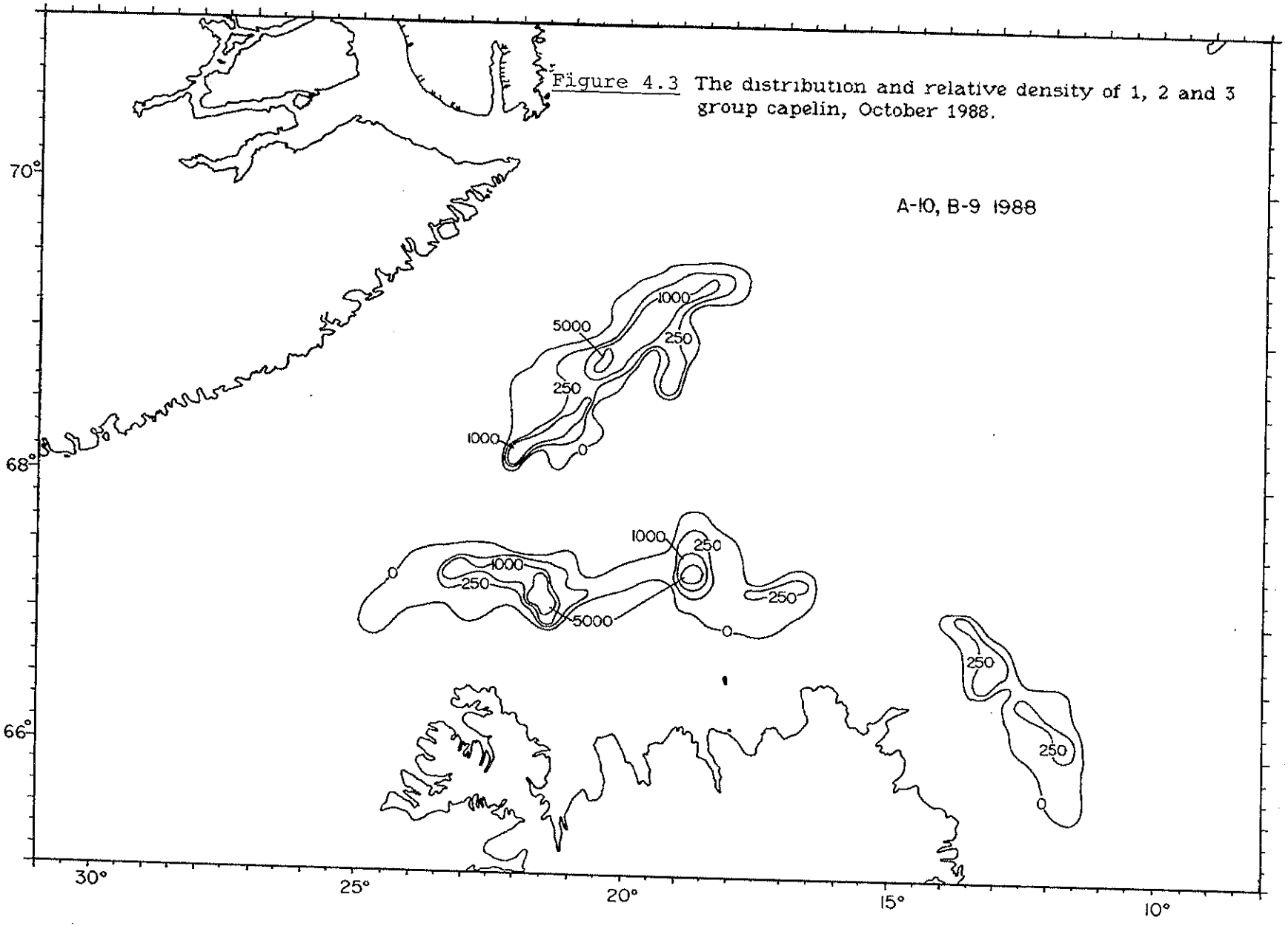


Figure 4.3 The distribution and relative density of 1, 2 and 3 group capelin, October 1988.

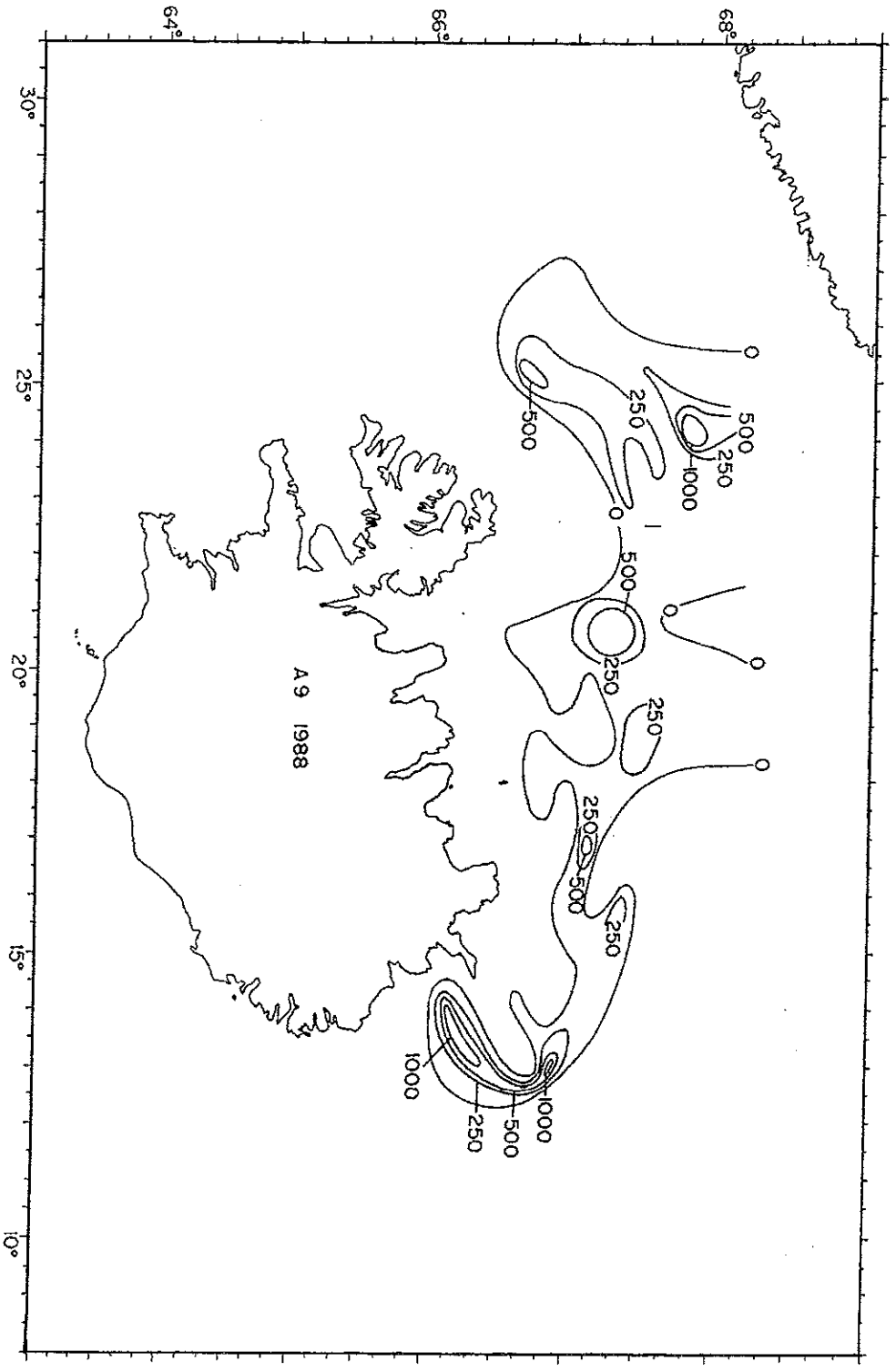


Figure 4.4 The distribution and relative density of capelin, August 1988.