International Council for the
Exploration of the Sea

C.M.1995/Assess:9

REPORT OF THE ATLANTO-SCANDIAN HERRING AND CAPELIN WORKING GROUP

ICES Headquarters, 17–21 October, 1994

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

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1 INTRODUCTION

1.1 Terms of Reference

The Atlanto-Scandian Herring and Capelin Working Group (Chairman Mr H. í. Jákupsstovu, Faroe Islands) met at ICES Headquarters from 17–21 October 1994 to (C. Res. 1993/2:6:2):

a) assess the status of and provide catch options for 1995 and 1996 for the Norwegian spring–spawning and Icelandic summer–spawning herring stocks:

b) provide any new information on the present spatial and temporal distribution of Norwegian spring-spawning herring:

c) assess the status of capelin in Sub-areas V and XIV and provide catch options for the winter 1994/1995 and summer/autumn 1995 seasons;

d) assess the status of and provide catch options for capelin in Sub-areas I and II (excluding Division IIa west of 5°W) for the winter 1994/1995 and summer/autumn 1995 seasons;

e) consider further how biological interactions can be incorporated into the assessments of capelin, herring and cod stocks.

1.2 Participants

B. Bogstad	Norway
J. Carscadden	Canada
J. Hamre	Norway
J. Jakobsson	Iceland
H. í. Jákupsstovu (Chairman)	Faroe Islands
P. Kanneworff	Denmark
A. Krysov	Russia
I. Røttingen	Norway
V. Shleinik	Russia
T. Sigurdsson	Iceland
S. Tjelmeland	Norway
R. Vaage	Norway (Part-time)

2 ICELANDIC SUMMER-SPAWNING HERRING

2.1 The Fishery

The catches of summer-spawning herring from 1973–1993 are given in Table 2.1. These include an estimated 1,245 t of discards for the 1993/1994 season. The fishery took place off the southeast coast and 63% of the catches were used for reduction while 37% were used for human consumption. As in previous years the major part of the catches were taken by purse seiners but seven trawlers were given permission to fish with pelagic trawl and their catches were about 7,700 t. Until 1990 the herring fishery took place during the last three months of each calendar year but in 1990–1993 the autumn fishery continued in January and early February the following year. Therefore all references to the years 1990–1993 refer to the season starting in October of that year.

Year	*Landings*	*TACs*	*Recommended TACs*
1984	50.30	50.0	50.0
1985	49.1	50.0	50.0
1986	65.5	65.0	65.0
1987	73.0	72.9	70.0
1988	92.8	90.0	100.0
1989	101.0	90.0	90.0
1990/1991	105.6	100.0	90.0
1991/1992	109.5	110.0	79.0
1992/1993	107.5	110.0	86.0
1993/1994	103	110	90.0

2.2 Catch in Number and Weight at Age

The catches in number at age for the Icelandic summer-spawners for the period 1973–1993 are given in Table 2.1. As usual the age is given in rings where the age in years equals the number of rings + 1. In the first years after the fishery was reopened in 1975 the 1971 year class was most abundant. During the period 1979–1982 the 1974 and 1975 year classes predominated in the catches. During the period 1983–1986 the fishery was dominated by the strong 1979 year class. In 1987 and 1988 the fishery was on the other hand based on a number of year classes ranging from 3–10 ringed herring. In the period 1989–1991 the 1983 year class predominated in the catch. The 1988 year class was also well represented in the 1991 catches and predominated during the 1992 season. In 1993 the age distribution was dominated by the strong 1989 year class although the 1988 year class was also well represented. The weights at age for each year are given in Table 2.2 and the proportion mature at age is given in Table 2.3. The most striking feature of these parameters in this stock is that despite inter-annual variation the weights at age, as well as other biological parameters, of this herring stock have remained relatively stable over a wide range of stock size and fluctuations in environmental conditions in Icelandic waters (Jakobsson, *et al.*, 1993).

2.3 Acoustic Surveys

The Icelandic summer-spawning herring stock has been monitored by acoustic surveys annually since 1973.

These surveys have been carried out in November–December or January, usually after the fishery has been closed. During a survey which took place from 13–16 January 1994 an estimate of the adult stock was obtained by two research vessels. The stock was located in four areas off the southeast coast of Iceland. No estimate of the juvenile year classes was obtained this time. The results of the January survey have been used as a basis for the present assessment for the 4-ringers and older (Table 2.4). As last year the TS value of 20 log L -72 dB was used to calculate the stock estimates. In addition the estimate from a previous survey carried out in December 1992 was used for the 1991 year class (2-ringers in 1994). In the absence of any estimate of the 1992 year class it was assumed to be average (600 million 1-ringers in 1994).

2.4 Stock Assessment

The results of the acoustic surveys together with the catch in number at age were used to calculate initial mortalities for the 1993/1994 season. Results are given in Table 2.7 as F´. In this analysis 5-ringers and older have been grouped for estimating the fishing mortality on the oldest herring, whereas the fishing mortality for the younger age groups is calculated for each year class.

As in previous years the estimation procedure from Halldórsson *et al.* (1986) was used to estimate the stock size in the final year, based on all available acoustic data for the older part of the stock (5+ ringers on 1 January each year). The procedure minimizes the sum of squares of log-transformed rather than untransformed data since there is increased variability in later years coinciding with the increase in stock size.

A series of VPAs were run using varying terminal F's on 5+-ringers. For each terminal F a sum of squares (SSE(F)) of differences between the 5+ from the VPA and acoustic estimates is computed. A plot of these values is shown in Figure 2.1. From this series of VPAs it is clear that the best (giving the minimum value of SSE) one to one relationship between the acoustic and virtual population analysis estimates is obtained with an input F of about 0.27. The confidence intervals for the fitted terminal F values (0.18, 0.42) are obtained as described by Halldórsson *et al.* (1986) and Stefánsson (1987) by using the tabled F-distribution to set bounds on the SSE and finding the terminal F values corresponding to these bounds (Figure 2.1).

The fishing mortalities for 3–4-ringers in 1993, based on the January 1994 survey have been used without modification since they cannot be estimated from a procedure using only 5+ ringers. Using the catch data given in Table 2.1 and the fitted values of fishing mortalities given in Table 2.7, a final VPA was run using a natural mortality rate of 0.1 on all age groups. Fishing mortality at age and stock in numbers at age with spawning stock biomass on 1 July are given in Tables 2.5 and 2.6, respectively, and the standard plots are shown in Figure 2.2. The resulting stock trend from VPA is plotted against the acoustic estimate in Figure 2.3 and the correspondence with acoustic estimates is shown in Figure 2.4. A summary of the VPA results is given in Table 2.14.

According to the current assessment the spawning stock biomass was about 570,000 t in July 1993 as compared to the projected spawning stock from last year's assessment of 480,000 t. This difference is largely due to a higher estimate of the 1990 year class in this assessment than last year.

2.5 Catch and Stock Projections

The input data for the projections are given in Table 2.8. As in previous years a regression of weight increase has been used to predict the weight at age of 2–8-ringers (using as input weight at age for 1–7-ringers the year before). Data for the regression included, as starting years, the period 1984–1993, except for the year 1985 which was considered to be an outlier and excluded from the regression. For 1-ringers and 9+-ringers, a simple average of mean weights at age for the period 1983–1992 was used for the prediction (1985 excluded). Weights at age for 2–8-ringers in the catch are thus obtained by using the relationship:

$$W_{y+1} - W_y = -0.2451 * W_y + 92.71 \text{ (g)}$$

Where W_y and W_{y+1} are the mean weight of the same year class in year y and y+1, respectively.

During the 1994/1995 fishing season the age distribution will be dominated by the 1988 and 1989 year classes (4- and 5-ringers). It is therefore expected that 4-ringer and older herring will be fully recruited to the fishery. The exploitation pattern used for the stock and catch predictions takes this into account. This is somewhat different from the average exploitation pattern based on the fishery during 1986–1989 as shown in Table 2.7.

As in previous assessments and in agreement with the increased level of recruitment during the 1980s and early 1990s, an assumed value of 600 million 1-ringers in 1994 has been used. The estimate of 2-ringers in 1994 is derived from the acoustic estimate of 1-ringers in 1993 (the 1991 year class).

Detailed output for the prediction assuming catches corresponding to a fishing mortality rate of F = 0.22 are given in Table 2.9 and a summary of these is given in Table 2.10. Projections of spawning stock biomass and catches ('000 t) for a range of values of F are given in the management option table (Table 2.11) and the

summary results of the yield per recruit calculations are given in Table 2.14 using the input values in Table 2.12.

2.6 Management Considerations

A TAC of 120,000 t has been set for the current 1994/1995 season. This corresponds to a fishing mortality of $F_{4\text{-}14w} = 0.22$. Fishing at $F_{0.1}$ during the 1995/1996 season would result in a catch of about 120,000 t. The Working Group points out that managing this stock at an exploitation rate at or near $F_{0.1}$ has been successful in the past. Fishing at higher fishing mortality rates than $F_{0.1}$ would give a correspondingly higher short-term yield but would reduce the stock sharply when the effect of the strong year classes presently in the stock has dwindled.

3 NORWEGIAN SPRING-SPAWNING HERRING

3.1 The Fisheries in 1993 and 1994

The initial TAC for 1993 was set at 200,000 t. This was divided into 168,000 t (Norway) and 32,000 t (Russia). In November, the Norwegian TAC was raised by 20,000 t.

The Norwegian fishery started in the beginning of January in the wintering areas in Northern Norway, and 31,529 t were taken up to the beginning of February when the herring migrated to the spawning areas. The first catch in the spawning areas of Møre were taken on 6 February. A total of 30,795 t of pre-spawning herring were taken in the Norwegian fishery on the traditional spawning grounds of Møre. There was also a fishery (9,009 t) at Karmøy (59°15'N) from mid-February to 20 April. Further there was a fishery on spent herring (13,217 t) at the start of the feeding migration into the Norwegian Sea. A Russian catch of 32,645 t was taken in the area Buagrunnen–Halten from mid–February to late March.

The catches in late spring and summer were small (2,815 t), due to lower price, quality and availability. In August/September the herring again migrated into the wintering areas, and in the autumn 107,395 t were caught, according to the nominal catch statistics. Thus, by far the greater part of the catches of Norwegian spring-spawning herring was taken in the wintering areas. Of the Norwegian catch, approximately 70% was used for human consumption and 30% for industrial purposes.

Although the initial TAC for 1994 was raised to 450,000 t the structure of the winter fisheries was the same as in 1993. By 1 June, Norway had caught approximately 220,000 t and Russia 74,400 t. In June there was an international commercial fishery for the first time in 26 years in the high sea areas of the Norwegian Sea. Approximately 30,000 t were taken in this fishery by purse seiners from Iceland, Faroes and Norway. In August the fishery started off Northern Norway on herring migrating towards the wintering areas in Ofotfjorden and Tysfjorden. The total catch of Norwegian spring-spawning herring is expected to be 485,000 t in 1994.

3.2 Catch Statistics

The total annual catches of Norwegian spring-spawning herring during the period 1972–1994 are presented in Tables 3.1 and 3.2. To account for additional mortality in the fishery (discards, private fishery), 5,000 t have been added to the reported catches in 1993. This is the same amount which was added in 1992. Table 3.3 gives the catch in number at age. The weight in catch and weight in stock (1 January) are given in Tables 3.9 and 3.10.

3.3 The Adult Stock

3.3.1 Acoustic surveys on the spawning grounds

The spawning areas were acoustically surveyed in two separate time periods in 1994.

In 1994 very little herring migrated to the spawning areas south of 62°N (i.e., Karmøy). A part of the spawning population arrived at the spawning grounds off Møre around 5 February with a main spawning around 20 February. This spawning component consisted mainly of the 1983 year class (approximately 55% in number). The larvae from this spawning component hatched in mid–March, but this hatching was probably out of phase with the spring planktonic bloom, and very few larvae were recorded in this area.

A second spawning wave took place in the Halten Bank area (64°30'N) around 10 March. In this component a larger amount of the 1988 and 1989 year classes participated. This spawning gave rise to a considerable amount of larvae. A third spawning wave seems to have occurred in the Vesterålen area (69°30'N) in the latter part of March. This spawning wave consisted of many recruit spawners. The fate of these larvae is not known.

The acoustic abundance estimates were converted to biomass using $TS = 20 \log L - 71.9$ and in the text table below the estimates (in million individuals) applying the night recordings only are presented by year class and time period:

Area:	62°N-66°N	66°N-70°N	Total
Time period:	940221-940302	940308-940408	
Year class	Estimate:	Estimate:	Estimate:
1983	1817	3	1820
1984	35	0	35
1985	140	0	140
1986	11	2	13
1987	60	3	63
1988	429	47	476
1989	848	527	1375
1990	54	622	676
1991	73	55	128
1992	11	5	16
Total	3478	1264	4742

A total of 1.39 million t of herring were recorded on the spawning grounds in 1994. However, experiments carried out on the spawning grounds (Hamre and Dommasnes, 1994) may indicate that the present TS/length relationship may not be correct for herring in a spawning situation, and that the acoustic stock estimates from the spawning area should be raised by a factor of at least 2.

3.3.2 Acoustic surveys in the wintering areas

The wintering area was acoustically surveyed in December 1993 and January 1994 (Røttingen *et al.* 1994). The following estimates were obtained, compensated for acoustic extinction and applying a target strength/length relationship of TS=20 log L -71.9):

Year class	Estimate Dec 1993 (million individuals)	Estimate Jan 1994 (million individuals)
1983	4435	3679
1984	26	131
1985	158	161
1986	13	29
1987	13	102
1988	1267	1503
1989	3287	4847
1990	2389	3431
1991	1518	642
1992	72	73
Total	13178	14598

The length and age distribution of the herring in the wintering area in December 1993 and January 1994 are given in Figure 3.1.

3.3.3 Acoustic surveys in the feeding areas

In late May 1994 the Icelandic research vessel "Bjarni Sæmundsson" reported dense concentrations of herring in the area between the cold East Iceland current and warmer Atlantic water (approximate position 67°30'N, 7°W). Soon afterwards an international purse seine fishery commenced in this area. This was the first time in 26 years that there was a herring fishery in this area.

In the period 6-14 June a joint Icelandic-Norwegian survey mapped the herring distribution and carried out a biological and environmental sampling programme in the area between 66°N-71°N and 10°W to 0°. The herring in the area were, on the basis of year class structure and scale characteristics, identified to be Norwegian spring-spawning herring. This was later confirmed by the recapture of tags from purse seine catches taken in the same area.

The abundance of herring in the survey area could not be estimated by the traditional echo integrator technique. This was due to schooling of the herring in the uppermost 10-20 meters of the water column. However, the distribution area could be found by the combined use of sonar and echo sounder and is given in Figures 3.2 and 3.3.

3.3.4 Tagging experiments

The Norwegian tagging experiment on herring, which was initiated in 1975, has been continued, and experimental fishing for recoveries was carried out in 1993 and 1994. In addition commercial catches delivered for consumption were screened at a sea food processing factory. In 1993 and 1994, 4,400 t and 7,600 t of herring were screened for tags, and 132 tagged fish were recovered, out of which 127 tags originated from releases from 1986 to 1992. Table 3.4 gives the recoveries by year of release from the year classes 1983-1988. The number of screened herring of the same year classes was 20.54 million individuals, and 72% were from the 1983 year class.

3.3.5 Mortality estimate from tagging

The total mortality Z is estimated by the method previously used by the Working Group (Anon., 1981; Hamre, 1990). In order to avoid non-random mixing of tagged fish, especially the younger ages, only releases from the year classes 1983-1988 on age-determined recoveries were used in the analysis. The plot of lnK against year of release is shown in Figure 3.4. This grouping has resulted in a very good fit of the points to a straight line (r=0.91). The slope of the line corresponds to a total mortality estimate (Z=0.269) which is close to the estimate obtained last year (Z=0.257).

3.3.6 Abundance estimate from tagging

Applying the data given in Figure 3.4 (Z=0.269), a 40% initial tagging mortality (as in last year's report) and the tags in the screened catches (20.542 million individuals), the stock in number at 1 January 1993 of the year classes 1983–1988 is estimated to be 7.68 billion individuals. The 1983 year class accounts for 72% of the estimate or 5.5 billion individuals. This is practically the same estimate as obtained last year (5.3 billion individuals).

3.3.7 Natural mortality

Last year the Working Group decided, on the basis of the results from the tagging experiment, to apply an M of 0.23 for the adult stock. Tagging experiments carried out around 1980 indicated an M of 0.13 in this stock. The outbreak of the disease *Ichthyophonus hoferi* may have contributed to the apparent increase in natural mortality.

The results from this year's experiments for recapture of tags, and apparently no decrease in the prevalence of *Ichthyophonus* in this stock, indicates that the M value of 0.23 should still be applied for the adult herring. In last year's report M=0.13 was applied for ages 3 and 4. However, in the summer of 1994, young and adolescent herring distributed off northern Norway were infested by *Ichthyophonus*. Therefore an M value of 0.23 is also applied for these year classes.

3.4 Recruitment

3.4.1 Stock estimates of immature herring

The nursery areas of Norwegian spring-spawning herring are Norwegian fjord and coastal areas and the southern part of the Barents Sea. Since 1988, when the 1983 year class spawned for the first time, the latter area has increased in importance as a nursery area for the herring. Data on immature herring are obtained from three different investigation series:

1) Acoustic estimates of 0-group herring in fjord and coastal areas of Norway (Table 3.5)

2) 0-group trawl survey in the Barents Sea in August-September (Table 3.6)

3) Acoustic estimates of immature herring in the Barents Sea (Table 3.7)

Some of the immature herring in the Barents Sea may belong to the Cheshsko-Petschorskaya stock of herring (*Clupea harengus pallasi natio suvorovi* [Robinerson]). However, the criteria for separation of these stocks are still under investigation. The Working Group recommends that research be made on this subject with the aim of establishing accepted separation criteria.

3.4.2 Natural mortality of immature herring

Barros (1994a) has shown that natural mortality of juvenile Norwegian spring spawning herring in the Barents Sea is highly variable and strongly age-dependent, but the precision of the data allows only estimation of two mortality patterns, "high" and "low". He has also shown (Barros 1994b) that this mortality is associated with the ratio between the abundance of the capelin stock and that of the juvenile cod.

Given the present state of the system (high cod abundance and low capelin abundance), it is therefore expected that both the 1993 and 1994 year classes will suffer a high mortality rate. The following values give the expected natural mortality for ages 1 and 2.

$M_1 = 1.56$

$M_2 = 0.54$

3.4.3 Assessment of immature and recruiting year classes

In the tuning procedure for the adult stock the acoustic stock size estimates are used as abundance indices only, whereas in the assessment of the immature part of the stock the acoustic estimates are used as absolute abundance estimates. However, recent investigations have indicated large variations in the TS of herring with time, area and herring fat content. In a few years' time the acoustic estimates of immature herring in the most recent years can be tuned against the VPA estimates.

1990 year class: In the wintering areas in Ofotenfjorden/Tysfjorden at 1 January 1994 2,287 million individuals were recorded. In addition 1,700 million individuals were recorded in the Barents Sea in June 1994. This estimate has been increased by a natural mortality of 0.23 for 5 months to give an estimate as at 1 January 1994 of 1,871 million individuals in the Barents Sea. This gives a total of 4158 million individuals for the 1990 year class.

1991 year class: A number of 880 million individuals were recorded in the wintering areas in Ofotenfjorden/Tysfjorden at 1 January 1994. In addition 18,000 million individuals were recorded in the Barents Sea in June 1994. This estimate has been raised by a natural mortality of 0.23 for 5 months to give an estimate as at 1 January 1994 of 19,810 million individuals in the Barents Sea. This gives a total of 20,690 million individuals for the 1991 year class, as 3 year old herring at 1 January 1994.

1992 year class: This year class has been estimated as 3 year old herring from the estimate of 59,200 million at 1 June 1994 (Table 3.7) and reducing it by a natural mortality of 0.54 for 7 months. This gives an estimate of 43,200 million individuals as 3 year old herring.

1993 year class: This year class has been estimated as 3 year old herring by using the estimate of 6600 million at 1 June 1994 (Table 3.7) and reducing it by a natural mortality of 1.56 for 7 months and a further natural mortality of 0.54 for 1 year. In addition the estimate for the fjord areas from December 1993 (Table 3.5) is reduced correspondingly and added to the estimate. This gives a total of 1637 million individuals of the 1993 year class as 3 year old herring. Concentrations of small herring have been reported within Russian territorial waters. Unfortunately, the June survey did not cover this area, so the 1993 year class may be underestimated to some extent.

3.4.4 Maturity development of the 1990 and 1991 year classes

Year class 1990: In August 1994, 20% of the 1990 year class distributed off Northern Norway were immature and will probably not spawn in 1995.

Year class 1991: In August 1994, 5% of this year class distributed off Northern Norway were maturing. However, in summer 1994 by far the larger part of this year class (95%) were distributed in the Barents Sea where all individuals were classified as immature. Thus only a very small fraction of this year class will mature as 4 year olds.

The following proportion mature at age is applied for 1995:

Age	Proportion mature
3	0
4	0.01
5	0.8
6-11+	1.0

3.4.5 Prospects for future recruitment

The Working Group points to the following factors which may influence recruitment of the Norwegian spring-spawning herring in the coming years.

1) Inflow of warm Atlantic water into the Barents Sea. Several authors (Hamre (1990), Sætersdal and Loeng (1987) have pointed out that an inflow of warm water seems to be a necessary, but not a sufficient condition for the establishment of a strong year class of herring. Ottersen *et al.* (1994) give a prognosis for the warm water inflow towards year 2000 (Figure 3.5). This prognosis indicates a reduced level of warm water inflow in the time period towards year 2000.

2) Cannibalism may be a regulatory factor in the establishment of year class abundance (Working Document by Holst and Røttingen, 1994). In the next years the strong year classes 1991 and 1992 will migrate westwards to the Norwegian Sea. On this migration route they may feed on the herring larvae and fry (0-group) drifting into the Barents Sea and consequently reduce the abundance of these year classes.

3) In the next years there will be large concentrations of young cod (Anon., 1995) and very little capelin in the Barents Sea. Thus the predation on the immature herring year classes in the Barents Sea, especially the 0- and 2-group, may increase and these year classes may be reduced correspondingly. (see Section 6.1.4).

If the factors discussed above operate in a "negative" way as indicated above, this may result in a number of weak year classes of Norwegian spring-spawning herring 3–4 years ahead. In 1993 large numbers of herring larvae were recorded. However, according to the acoustic survey of immature herring (Table 3.7) this year class seems to be poor.

3.5 VPA and Catch and Stock Prognosis

3.5.1 Tuning the VPA

The Working Group decided to use all the available information in tuning the VPA. Since the older part of the stock is dominated by the 1983 year class, this year class alone is used when finding the terminal fishing mortality on the older ages. This year class has been estimated in several acoustic surveys and by tagging, and the relevant data are given (billion individuals) in the following text table:

Surveys	Tagging estimate	Acoustics December	Acoustics January	Acoustics spawning
1988				6.81
1989				5.40
1990				4.49
1991				4.15
1992			4.69	
1993	5.50	3.77	5.70	
1994		4.44	3.68	1.82

On the basis of these estimates, it is possible to calculate the single terminal fishing mortality which in a VPA gives the minimum sum of squared deviations across all surveys. Hence, a squared error is computed for the

difference between a survey estimate and the corresponding VPA estimate. These errors can be added to obtain a single sum of squared errors (SSE).

It is clear from the above table that there is an inconsistency between the acoustic estimates in the spawning area and the more recent surveys which give considerably higher estimates. There are, however, indications that the target strength of herring at spawning time is lower than the TS generally applied (TS=20 log L - 71.9) (Hamre and Dommasnes, 1994).

In an attempt to resolve this, the Working Group decided (as in 1993) to estimate a catchability (or availability) coefficient for each survey series which had more than one data point. Thus, the fitting procedure first computes a catchability coefficient, then scales the survey to the scale of the VPA. After this, the sum of squared deviations is minimised as described above. The result of the tuning is shown in Figure 3.6 and Figure 3.7. This gives an estimate of the 1983 year class of 3.2 billion individuals at 1 January 1994.

The age distribution estimated from the wintering area varied somewhat between the December 1993 and January 1994 survey (Figure 3.1). This may partly be due to sampling problems connected to migration dynamics within the wintering area (Røttingen *et al.*, 1994). In order to estimate the age distributions at 1 January 1994 an average of the December 1993 and January 1994 age distributions (in %) were used. This age distribution seems to be in accordance with the average distribution of the adult stock on the feeding grounds in the Norwegian Sea in summer 1994.

The estimate of the year classes 1983–1991 at 1 January 1994 is given in Table 3.8.

3.5.2 VPA analysis

The input data in the VPA are given in Tables 3.3 and 3.9–3.12. The terminal Fs for the different year classes were found by tuning the catch at age data given in Table 3.3 to the stock numbers by age given in Table 3.8.

The results of the VPA are given in Tables 3.13–3.16 and in Figure 3.8A and 3.8B. This year the VPA was run back to 1950.

3.5.3 Input data for the catch and stock prognosis

For the adult herring VPA stock numbers at 1 January 1994 have been used (Table 3.17). The numbers of young herring by year class as 3-year olds are the following:

1991 year class: Table 3.8.

1992 and 1993 year class: Section 3.4.3.

The year classes 1994 and later were set equal to the 1993 year class.

The weight at age in the stock for 1994 is calculated from biological samples in December 1993 and January 1994. No trend in weight at age in the catch has been detected in recent years and therefore the weight in the catch in 1994 has been set equal to the 1990–1993 average. As the stock size is expected to increase towards the level from the 1950s and 1960s in the coming years, a slower growth may be anticipated. The weights at age in the catch data from the 1950s are not comparable to the present values due to a different structure in the fisheries (a larger portion was then taken as spent herring). The Working Group therefore chose the 1960s as a reference period for weight at age data in the stock and catch at higher stock sizes. The change in weight at age is made gradual by setting the weight at age in the stock and in the catch in 1997 equal to the 1960–1969 average, and moving from the 1994 level in equal steps in 1995 and 1996 to the 1997 level. The maturity at age in 1995 is given in Section 3.4.4. For the years 1997 and later the maturity at age observed in the years 1960–1968 was used. For 1996 the maturity at ages used is the average of the 1995 and 1997 maturity at age.

For the prognosis a flat-topped exploitation pattern was chosen, assuming full recruitment to the fishery for ages 5 and older. Further a natural mortality of M=0.23 was applied.

3.5.4 Results of the prognosis

From the expected catch in 1994 (485,000 t) the fishing mortality increased from 0.17 in 1993 to 0.20 in 1994. The effects of different levels of F on the catch in 1995 and on the stock and SSB in 1996 are presented in Table 3.18 and Figure 3.8D.

The assessment shows that the spawning stock biomass will decrease from 2.5 million t in 1994 to 2.3 million t in 1995. In 1996, the spawning stock biomass will increase to above 3 million t at all levels of fishing mortality listed in Table 3.18. The total stock biomass (3+groups) will increase from 4.8 million t in 1994 to 8.8 million t in 1995 and will be above 10 million t in 1996. This increase is due to the strong 1991 and 1992 year classes.

3.6 Management Considerations and Risk Analysis

The primary management goal for the Norwegian spring-spawning herring has been to rebuild the spawning stock to a level above 2.5 million t. Based on past records of recruitment one might expect a series of poor year classes after the rich 1992 year class. Although the

spawning stock will rise above 2.5 million t when the 1992 year class matures, it may soon decline below 2.5 million t after some period of time, the length of which will depend on the fishing pressure. The longer the spawning stock can be kept above 2.5 million t, the higher the probability of obtaining good recruitment when the recruitment conditions again become favourable.

In its minutes from November 1993, ACFM states with regard to the Norwegian spring-spawning herring that "ACFM needs a medium-term stochastic simulation to advise managers on how to achieve a variety of possible targets". The Working Group has approached this by assessing the risk of the spawning stock falling below 2.5 million t in year 2002 for various levels of fishing pressure and for both a constant TAC and a constant F management strategy.

3.6.1 Risk analysis

For the risk analysis the program @RISK was used with 300 iterations and a fixed seed for the random generator.

3.6.1.1 Input distributions

3.6.1.1.1 Natural mortality

The natural mortality for 3 year old and older fish has been modeled as a normal distribution with an expected value of 0.23 and a standard deviation of 0.05.

3.6.1.1.2 Recruitment

It is assumed that for given environmental conditions the recruitment follows a Beverton-Holt curve:

$$R=R_{max}B/(H+B)$$

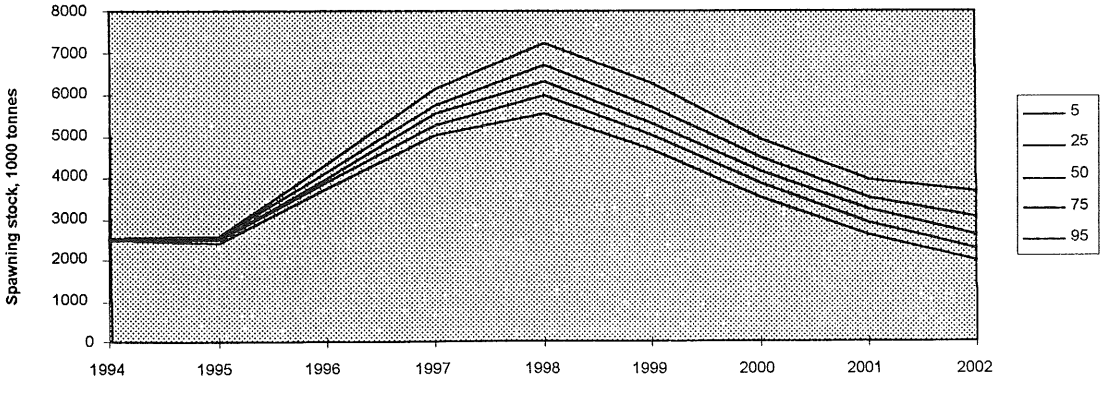
where R is the recruitment, R_{max} the maximum recruitment and B the spawning stock. H is the value of the spawning stock that yields a recruitment of half the maximum. The half value constant H will characterize the recruitment conditions; a low value corresponds to good recruitment, a high value to poor recruitment for a given spawning stock. The above equation is solved for H each year, using the number of 1 year old herring from the VPA and setting R_{max} to 1.1 times the highest observed recruitment (1950 year class). To check the sensitivity towards the factor 1.1, 1.5 was also tried. The result was not significantly different.

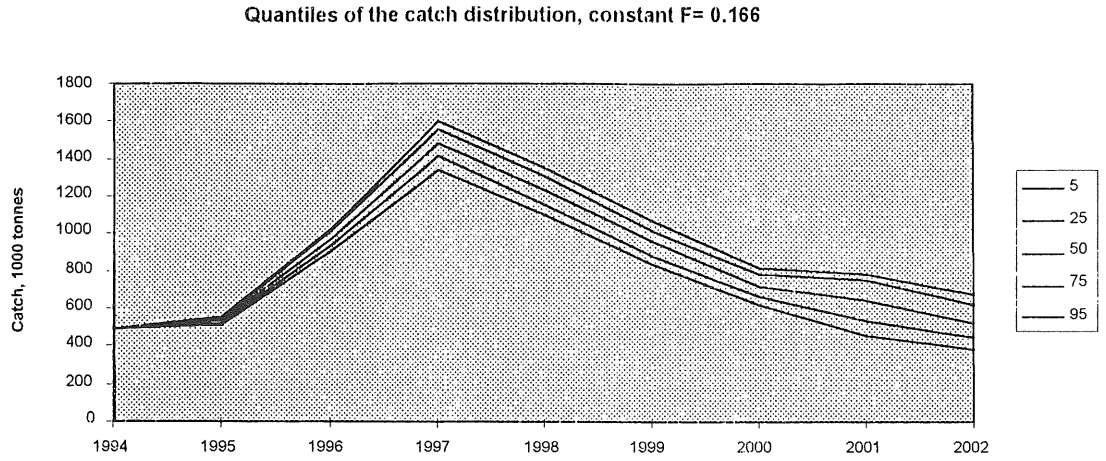
In the forecast, the number of recruits as 1 year old herring in 1994 (1993 year class) is fixed from observations. The recruitment as 1 year old herring in 1995 is modeled using a discrete probability distribution where the possible outcomes with equal probability are the values of H calculated two years after a good year class, where the year classes 1950, 1959 and 1983 have been defined as good. The recruitment as 1 year old herring in 1996 is modeled using the values of H three years after a good year class and so forth.

3.6.1.2 Results

Based on the same inputs as for the prognosis (Section 3.5.4 and Table 3.17), the stock has been projected forward to year 2002. However, the natural mortality of 3 year old and older herring and the recruitment have been modeled as probability distributions rather than as fixed values. The projections have been made many times, in each iteration drawing new values of the natural mortality and recruitment according to the modeled distributions. During this process the spawning stock and the total catch over the period 1994–2002 have been sampled. As an illustration, the Figures below show the time development of the spawning stock and the catch for a constant F-value of herring 5 years old and older of 0.166. In this case the total catch over the period amounts to 7.2 million t.

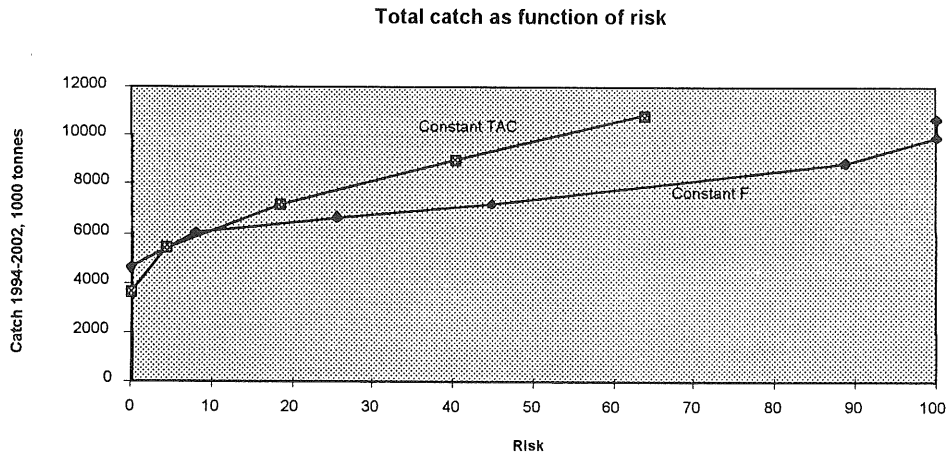
Quantiles of the spawning stock distribution, constant F = 0.166





The risk is defined as the probability of the spawning stock in year 2002 being below 2.5 million t. The Figure below shows the total catch in the period 1994–2002 as a function of the risk for constant TAC and constant F In the constant TAC runs Pope's approximation was used. The total catch is calculated as the mean of the total catch from each iteration.

Except for very low risk values, the constant TAC strategy yields a higher total catch for a given risk.



3.6.2 Management considerations

The immatures and adults of this stock form a central part of the ecosystem in the Barents and Norwegian Seas, respectively. The herring has an important role as a transformer of the production of zooplankton biomass and energy to a form which is available to organisms at a higher level of the food chain (for example the cod stocks). Thus a large stock of herring, both immature and adults, will utilize larger quantities of plankton (and over wider areas) and be able to support larger fish stocks in the higher food chain levels, than a small stock of herring will do. Seen from this ecosystem point of view the spawning stock should, in the longer term, preferably be built up to a level above 2.5 million t. In the 1950s and beginning of the 1960s the spawning stock was in the order of 5–10 million t (Table 3.16). Further, the MSY level of this stock has been estimated to be about 6 million t, and the Working Group has earlier indicated this as a preferable level in a long time perspective.

The prospects for recruitment to the spawning stock are discussed extensively in the present report. The spawning stock is expected to increase strongly in the coming years due to the recruitment of the strong 1992 year class. However, the 1993 year class seems to be weak and the prospects for the 1994–1997 year classes are also poor. Due to these extreme dynamics in the recruitment situation in the coming years, the choice of a fishing strategy for 1995 (and for the coming years) should **not** be made on the basis of the short-term prediction table (Table 3.18). Rather, the choice should be made on the basis of the long-term development of this stock and keeping in mind the important role this stock has in the Barents and Norwegian Sea ecosystems.

In the above section on risk analysis the Working Group has put forward possible developments of the spawning stock of Norwegian spring-spawning herring using two different fishing strategies, i.e., a constant TAC strategy and a constant F strategy.

3.7 Information on the Spatial and Temporal Distribution of Norwegian Spring-Spawning Herring

The recorded distribution and migrations of Norwegian spring-spawning herring in 1994 are as follows:

A) WINTER 1994

Adult stock: The entire spawning stock was, before the spawning migration commenced at the beginning of January, located in the wintering areas in Ofotfjorden and Tysfjorden in Northern Norway. The spawning migration took place along the Norwegian coast. In 1994 the spawning grounds were located on the coastal banks from 62°N to 70°N (Figures 3.9–3.11). In 1994 very little spawning took place on the historical spawning grounds south of 62°N.

Immature stock: In winter 1994 the immature stock was distributed in the south and southeastern part of the Barents Sea (Figure 3.12).

B) SPRING 1994

Adult stock: After spawning the adult stock started the feeding migration to the Norwegian Sea.

Immature stock: In April herring larvae were recorded off the Norwegian coast (Figure 3.13).

C) SUMMER 1994

Adult stock: In summer the herring were distributed over large areas in the Norwegian Sea. A joint Icelandic–Norwegian survey mapped the western boundary of the distribution area between 66°N and 71°N (Figure 3.2). In summer of 1994 the feeding migration of the Norwegian spring-spawning herring only went as far west as the eastern border of the East Icelandic current and then turned northwards to the feeding area southeast and east of Jan Mayen. In this area the herring mostly occurred in small dense schools which could be detected by sonar (Figure 3.3). Some of these schools were purse seined by vessels from Iceland, Faroes and Norway. Russian investigations give a corresponding picture of the summer distribution of Norwegian spring-spawning herring (Figure 3.11). The southern boundary of the summer distribution in 1994 was not adequately mapped.

Immature stock: In June the immatures were distributed in the southern part of the Barents Sea (Figure 3.14).

D) AUTUMN 1994

Adult stock: Adult herring were reported off Vesterålen in August, and to have entered Vestfjorden (the same fjord system as Ofotfjorden/Tysfjorden) in the beginning of September. This indicates that the wintering areas which have been utilized since 1987/1988 will be in use in the wintering season 1994/1995.

Immature stock: The distribution of the 0-group (1994 year class) was mapped during two periods in August-September (Figures 3.15–3.16). The distribution of other immature herring was mapped in September 1994 (Figure 3.17).

Figure 3.18 summarizes the distribution of Norwegian spring-spawning herring in 1994. In general, the distribution and migration pattern seem to be similar to the last years. However, there seem to have been larger concentrations of older herring in the border area between the East Iceland Current and warmer Atlantic Water in summer 1994 than in the later years.

3.8 *Ichthyophonus hoferi* Disease in the Norwegian Spring-Spawning Herring Stock

This disease was first observed in herring in the North–East Atlantic in the summer of 1991. Although its prevalence now appears to be extensive, the overall impact on the population dynamics of herring stocks has not been determined because estimates of prevalence vary according to the method of sampling, location and season.

As in 1993, samples of Norwegian spring-spawning herring examined in 1994 revealed variable but significant infestation of *I.hoferi*. Russian samples taken in January–March and July indicated a 100% infestation rate. The more detailed microscopical examination technique employed by Russian scientists has been shown by Swedish researchers to result in estimates of infection rates that are 2.3 times higher than macroscopic examinations. However, the herring were caught by trawls and, because infected herring may be unable to escape trawls, it is believed that the infection rates measured by the Russians are overestimated.

Detailed examination reveals that the symptoms change with the season which may explain the seasonal variation in infection rates documented in Norwegian studies. The Norwegian sampling from winter to summer indicated lower prevalence rates in winter increasing through the year. The rates also varied by gear type and location but were generally lower than 10%. Although attempts were made to correct the estimates for different sampling gears, the infection rates are probably underestimated because of the macroscopic technique used.

Because of the problems noted above, precise estimates of the infection rate could not be estimated from the available data. However, the prevalence of this disease does not seem to be decreasing, and the Working Group therefore decided to apply the present high natural mortality of M=0.23 in the prognosis.

Because the disease is believed to be almost 100% lethal for herring, the Working Group continues to be concerned about the infection and its effect on the stock. Research is continuing and in May 1994 specialists from Scotland, Norway and Russia met in Murmansk to address the problem. Cooperative research between Russian and Norwegian specialists is planned for 1995.

4 BARENTS SEA CAPELIN

4.1 Regulation of the Barents Sea Capelin Fishery

Since 1979, the Barents Sea capelin fishery has been regulated by a bilateral fishery management agreement between USSR (now Russia) and Norway. A TAC has been set separately for the winter fishery and for the autumn fishery. The fishery was closed from 1 May to 15 August until 1984. During the period 1984 to 1986, the fishery was closed from 1 May to 1 September. From the autumn of 1986 to the winter of 1991, no fishery took place. The fishery was re-opened in the winter season 1991, on a recovered stock. From the autumn 1993 the fishery was again closed. A minimum landing size of 11 cm has been in force for several years.

4.2 Catch Statistics

The international catch by country and season in the years 1965-1994 is given in Table 4.1. Following the recommendation from ACFM, there was no fishing for Barents Sea capelin during the winter season of 1994.

4.3 Stock Size Estimates

4.3.1 Larval and 0-group surveys

Norwegian larval surveys based on Gulf III plankton samples have been conducted in June each year since 1981. The calculated numbers by year (which should be regarded as indices only) are shown in Table 4.2. The index this year is the second lowest on record, confirming the present collapse of the stock.

During the international 0-group survey in the Barents Sea in August 1994 very small amounts of 0-group capelin were detected, as was the case also in 1993. This result was confirmed during the Russian/Norwegian acoustic survey in September.

4.3.2 Acoustic stock estimates in 1994

The 1994 acoustic survey was carried out jointly by three Russian and two Norwegian vessels in the period 8 September to 3 October. The distribution of capelin is shown in Figure 4.1. Table 4.3 gives the estimate as numbers by age and length, and the biomass at age. The results are summarized in the text table below (the estimates of the same age groups measured in 1993 are shown in brackets).

Year class		Age	Number (10^9)		Mean weight (g)		Biomass (10^3 t)	
1993	(1992)	1	19.7	(2.2)	4.4	(3.4)	86.8	(7.7)
1992	(1991)	2	3.4	(53.4)	11.2	(9.0)	38.5	(482.4)
1991	(1990)	3	4.3	(17.3)	16.5	(15.1)	71.0	(261.3)
1990	(1989)	4	0.2	(2.4)	18.4	(18.8)	3.1	(44.9)
Total stock								
1994	(1993)	1-4	27.7	(75.3)	7.2	(10.6)	199.3	(796.3)

In comparing the acoustic estimate by year class obtained this year to the estimate obtained last year, one should bear in mind that the relative error is probably large when the capelin abundance is low, both because of fewer trawl stations with large capelin catches and because the echogram scrutinizing becomes more uncertain.

The 1993 year class (1-group) consists of 20 billion individuals. The mean weight, 4.4 g, is a considerable increase from the 3.4 g measured last year. The biomass of 1 year old capelin is, consequently, 87,000 t, more than a 10-fold increase from 1993.

The estimated number of fish of the 1992 year class (2-group) is 3 billion, as opposed to 53 billion of the 1991 year class measured last year. The mean weight of this age group is 11.2 g (9.0 g in 1993), and consequently the biomass of 2 year old capelin is 38,000 t, only 8% of that of the 1991 year class at this stage.

The 1991 year class is estimated at 4.3 billion individuals with a mean weight of 16.5 g, giving a biomass of 71,000 t. This is 24% by number and 23% by weight of the size of this age group measured last year. The 1990 year class (now 4 years old) is only 8% of the number of 4 year old capelin last year. The mean weight, however, is about the same.

The 1990 year class (now 4 years old) is only 8% of the number of 4 year old capelin last year. The mean weight, however, is about the same.

The total stock is estimated at 199,000 t, only 25% of the stock size measured last year. The biomass of fish larger than 14 cm, which is more or less the part of the stock expected to make up the spawning stock in 1994, is now about 94,000 t. The decline in the maturing component has been approximately the same from 1993 to 1994 as it was from 1985 to 1986.

The text table below shows the number of fish in the various year classes, and their mortality from age 1 to 2.

Year:	83-84	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Year class:	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Age 1, Nos (10^9)	515.1	145.4	35.1	7.5	37.3	20.0	177.9	700.0	392.0	351.3	2.2
Age 2, Nos (10^9)	183.9	47.3	3.4	1.5	28.8	17.8	177.5	574.4	196.3	53.4	3.4
Total mortality	64	68	90	80	23	12	.2	18	50	85	-

As there has been practically no fishing on these age groups, the figures for total mortality constitute natural mortality only. In spite of the uncertainties, illustrated by the low value for the 1988 year class and the negative mortality for the 1992 year class, these values probably reflect quite well the trend in predation on capelin. As can be seen from the table, the mortality increased up to 1985-1987, but then a substantial decrease occurred in 1987-1990, probably caused by diminished predation pressure from cod. From 1990 the mortality increased again, in 1992 it was 50%, and last year it was 85%, i.e., back at the level measured before 1986. The negative mortality this year is due to measurement error. The increase since 1990 is consistent with an increasing stock of cod now preying on the capelin. Estimates of stock in number and weight for the period 1973–1994 are shown in Table 4.4.

4.3.3 Historical stock development

An overview of the development of the Barents Sea capelin stock in the period 1973–1994 is given in Tables 4.5-4.14. The methods and assumptions used for constructing the tables are explained in Appendix A. It should be noted that several of the assumptions and parameter values used in constructing these tables are provisional and future research may alter some of the tables considerably. For instance, M–values for immature capelin will be calculated using new estimates of the length at maturity and M–values for mature capelin will be calculated taking the predation by cod into account. However, for giving a crude overview of the development of the Barents Sea capelin stock the tables may be adequate.

Estimates of stock in number by age group and total biomass for the period are shown in Table 4.5. Catch in number by age group and total biomass is shown for the spring season and the autumn season in Tables 4.6 and 4.7. Fishing mortality coefficients by age group for the autumn season and natural mortality coefficients by age group for immature capelin are shown in Tables 4.8 and 4.9. Stock size at 1 January in numbers by age group and total biomass and the mean weight by age group at 1 January are shown in Tables 4.10 and 4.11. Proportion of mature stock by age group at 1 January and spawning stock biomass at 1 April are shown in Tables 4.12 and 4.13. Table 4.14 gives an aggregated summary.

4.4 Management Considerations

In managing the Barents Sea fishery one of the main goals has been to allow a minimum target spawning stock biomass to spawn. In the period 1979–1982, this was set at 500,000 t and later at 400,000 t based on an analysis by Hamre and Tjelmeland (1982). The present maturing component of 94,000 t, which will be reduced by predation by cod until spawning, is far below this and other conceivable levels of the target spawning stock. Therefore, there is no room for any fishery in 1995. The 1993 and 1994 year classes are very poor, and consequently any fishery for capelin in the Barents Sea cannot be expected before at least 1998.

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

5.1 The Fishery and Catch Regulations

The fishery depends for the most part upon maturing capelin, i.e., that part of each year class which spawns at age 3 as well as those fish belonging to the previous

year class which did not reach maturity until their 3rd year to spawn at age 4. The size of the immature components is difficult to assess before their recruitment to the adult stock at ages 2 and 3. This is especially true of the 3-group immatures.

The fishery on the Iceland-East Greenland-Jan Mayen capelin has, therefore, been regulated by preliminary 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. 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) in that season. A summary of the above procedure and its consequences is given in Table 5.1.

Over the years, there has generally been no fishery permitted in the period April-June and the season opened in July/August or later, depending on the state of the stock. Due to very low stock abundance there was a fishing ban lasting from December 1981 to November 1983. In addition, areas with high abundance of juvenile 1- and 2-group capelin (in the shelf region off NW, N and NE Iceland) have usually been closed to the summer and autumn fishery.

The total annual catch of capelin in the Iceland-East Greenland-Jan Mayen area since 1964 is given by weight, season and fleet in Table 5.2. The total international catch in numbers during the summer/autumn 1978-1993 and winter 1979-1994 seasons is given by age groups and years in Tables 5.3 and 5.4 respectively.

5.2 Historical Stock Abundance

The annual abundance by number and weight at age for mature and immature capelin in the Iceland-East Greenland-Jan Mayen area has been calculated with reference to 1 August (before the fishing season) and 1 January in the following year for the 1978/79-1993/94 seasons. The results are given in Tables 5.5 and 5.6 (1 August and 1 January, respectively), the latter of which also gives the remaining spawning stock by number and biomass in March/April 1979-1994.

The above calculations of stock abundance are based on the "best" acoustic estimates of the abundance of maturing capelin. These are obtained in autumn and/or winter, the "best" in each case being defined as that estimate on which the final decision on TAC was based. Taking account of the catch in number and a monthly natural mortality rate of M = 0.035 (Anon., 1991) the abundance estimates of each age group are then projected to the appropriate point in time. Since the acoustic estimates of the abundance of the juvenile part of the stock are unrealistically low and no information is available on natural mortality rates among such capelin, the abundance of juvenile capelin by number was also back-calculated using the same natural mortality rate as in the case of the adult stock.

The observed annual mean weight by age is used for obtaining the stock biomass at 1 January. However, with the exception of juvenile capelin, the average growth pattern over the last 15 years had to be used for estimating stock biomass of the other components at 1 August from mean weights observed in the autumn of the same year or in January of the following year. The remaining spawning stock biomass is calculated from the mean weight in January of the same year. It is known that some weight increase takes place in February and March. Therefore, the remaining spawning stock biomass is underestimated by a small margin.

5.3 Method of Stock Prognosis

The precautionary TAC should be set at such a level as to open the fishery before the October survey, yet keep it closed when it is likely that fishing will reduce the residual spawning stock below 400,000 t. Thus the prognosis procedure needs to predict the fishable stock in the beginning of the season in order to predict the effects of fishing. In order to account for the highly variable year class strength, the procedure needs to predict separately the two major components of the mature stock (ages 2 and 3) in the autumn. These predictions need to be done in spring.

Available data usually include acoustic survey estimates of the different age groups in August, October and January. August survey results, used for a number of years to predict 2-group recruits, have proved unreliable. This has become apparent by comparing these predictions to later assessments of the same stock components. On the other hand, it has been found that autumn (October/November) acoustic estimates of 1- and 2-group abundance are more reliable predictors of fishable stock abundance one year ahead in time. A different prediction model was, therefore, developed using the autumn survey data (Anon, 1993). A summary of the method reads as follows:

The maturing part of the 2-group in autumn (N_{2mat}) is a part of the survivors of the 1-group in the previous autumn (N_1), which is measured in October. Regressing the back-calculated maturing 2-group abundance against the 12 available 1-group acoustic estimates for the year classes from 1980 to 1991 gives $y = 0.92x + 2.7$, where $R^2 = 0.87$ and $P < 0.01$. This is the regression used for predicting the abundance of maturing 2-group capelin in autumn.

The maturing part of the 3-group in autumn corresponds to the surviving part of the year class which did not

mature and spawn in the year before. Unfortunately, the surveys of the immature 2-group (N_{2imm}) in the year before are gross underestimates and will, therefore, not be used. Similarly, the January survey of this year class only estimates the part that will spawn and thus is no indication of what will appear in autumn of the next year. It is found, however, that maturity at age 2 is closely but inversely related to year class size (N_{2tot}). Hence the total abundance of the 2-group in autumn is an indication of what will appear as 3-group in the following autumn. A regression relating the back-calculated abundance of the year classes from 1980–1990 as 2 and 3 year olds (N_{2tot} and N_{3tot}) results in $y = 0.42x - 13.7$, with $R^2 = 0.77$ and $P < 0.01$.

The data sets comprising all comparisons of numbers by age and maturity relevant to the prediction model are given in Table 5.7. The mean weight of maturing 2- and 3-group capelin in autumn 1981–1993 (year classes 1978–1991) is given in Table 5.8. The above regressions are updates using the data which have become available since 1992. They are used in Section 4 below for predicting the abundance of mature 2- and 3-group capelin in autumn 1994. A test of their performance is given in Table 5.9.

5.4 Stock Prognosis and Assessments for the 1993/1994 Season

Calculations of expected TAC for the 1993/1994 season, using the prediction method described in Section 3 and year classes 1980–1990, indicated a total catch of 1,390,000 t, with the usual prerequisite of a monthly natural mortality rate of 0.035 and a remaining spawning stock of 400,000 t, if the catch were spread evenly over the period August 1993–March 1994.

Although the model predicted roughly the same, or a slightly lower, TAC than finally recommended from acoustic assessments of fishable stock abundance in late autumn and/or winter, the series includes the notable exception of the 1989/1990 season. In this case the prediction proved to be optimistic by about one third. In view of this, as well as the short time series, ACFM recommended that a precautionary TAC should not exceed 2/3 of the total TAC predicted for the season, i.e. 900,000 t. This advice was accepted by all parties concerned. In addition extensive areas north of Iceland were closed to the fishery in order to protect the juvenile part of the stock from coming into contact with the summer fishery.

The autumn survey was carried out in the period 18 October–7 November 1993. Surveying conditions were good but the westernmost part of the channel between Iceland and Greenland as well as the Greenland plateau could not be reached because of ice. Since no capelin were recorded near the ice border it was believed that the survey covered all of the stock. However, due to the fact that the contribution by the older year class to the 1994 winter catch was almost double that recorded during the 1993 autumn survey, it now seems likely that part of this stock component may have gone undetected and was therefore underestimated by the survey.

According to the autumn 1993 survey the estimated fishable/spawning stock was 61.0 * 10^9 fish on 1 November 1993. At that time the observed mean weight in the fishable stock was 16.7 g and the stock biomass therefore about 1,020,000 t. Details of this stock estimate are given in Table 5.10.

With the usual prerequisite of a monthly natural mortality rate of 0.035, a remaining spawning stock of 400,000 t and an estimated weight increase of 2.6 g, the October abundance estimate indicated a TAC of 595,000 t in the period November 1993–March 1994 if the catch were spread evenly over the period. Counting the catch taken in July–October 1993, this corresponded to a total TAC of some 1,250,000 t for all of the 1993/94 season which subsequently was set at that level.

The January 1994 survey failed to register part of the adult stock. This was both because of difficult weather conditions and due to the fact that the first part of the spawning migration had entered the warm Atlantic waters in offshore areas off the south coast of Iceland when the research vessels arrived there. According to experience, capelin migrations cannot be assessed accurately in this area of transition before entering the more coastal spawning grounds. An attempt to assess the spawning stock after it had arrived at the south coast was not made in 1994.

5.5 The Fishery in the 1993/1994 Season

The Icelandic capelin fishery in 1993 began in the area between 68°and 68°30'N, 14°–18°W. The Icelandic boats were soon joined by Norwegian and Faroese vessels and one Greenland vessel. The fishing area gradually moved to the north and in the latter half of July the main part of the catch was taken between 68°30' and 69°N, 16°–18°W. The northward movement of the fishing area continued in August when most of the catch was taken between 69°30'N and 71°30'N, 15°–18°W. Catch rates remained high, both in July and in August, and landings were at times limited by the production capacity of the shore-based reduction plants. The Norwegian vessels fished most of their allocated TAC in July.

In September the capelin gradually began migrating back south from the northern feeding area and during the latter half of the month the catches were mainly taken between 68°30'N and 69°N, 18°–19°W. High catch rates were at times obtained in September when

Icelandic, Faroese and Greenland vessels caught about 110 thousand t in all.

In the beginning of October good catches were taken at the shelf edge NNW of the Vestfirdir peninsula. However, the fishable stock soon scattered and mixed with immatures south of 68°N off the western north coast of Iceland. The scattered condition of the fishable stock prevailed throughout the rest of the year. Due to this behaviour and area closures to protect immature capelin, only 21.5 thousand t were taken in November and December 1993.

Because of difficult weather conditions and the continued scattered distribution of the capelin, practically no catches could be taken until the last days of January 1994. At that time, however, the capelin began assembling at the southeast coast of Iceland. There began an intensive fishery which lasted throughout February and during the first half of March. After that catch rates declined sharply and only moderate to poor catches were obtained from then until the winter 1994 season officially closed in early April.

A total of 1,000,300, 142,500, 12,000 and 23,900 t were caught by Icelandic, Norwegian' Greenland and Faroese vessels, respectively, in the 1993/1994 season, or some 1,178,700 t in all (Table 5.2). About 460,000 t were left and spawned in the spring of 1994 (cf. Tables 5.1 and 5.6).

The total international catch in numbers by age groups is given for the summer-autumn 1993 and the winter 1994 seasons in Tables 5.3 and 5.4. The length distribution of the catch is given by age groups in Tables 5.11 and 5.12.

5.6 Stock Abundance and TAC in the 1994/1995 Season

The main component of the fishable stock in the 1994/1995 season will be the maturing part of the 1992 year class and that part of the 1991 year class which did not mature and spawn in the spring of 1994.

The October 1993 survey gave an estimate of 100.4 billion capelin belonging to the 1992 year class and a total of 64.9 billion capelin belonging to the 1991 year class. Of the latter some 55.1 billion were estimated to be maturing to spawn in 1994. Counting the catch and assuming a monthly natural mortality rate of 0.035 the estimate corresponds to 86.9 billion maturing capelin of the 1991 year class when back-calculated to 1 August 1993 (Table 5.7).

The October 1993 estimate of the 1992 year class and the back-calculated total estimate of the 1991 year class (98.0 billion fish, Table 5.7) were used to forecast the abundance of maturing capelin belonging to these year classes (age groups 2 and 3) on 1 August 1994, using the prediction model described in Section 3 above, after updating the appropriate regressions in the light of new information. The resulting predictions of the abundance by number of maturing capelin at ages 2 and 3 on 1 August 1994 are 89.6 and 27.0 billion fish respectively (Table 5.5).

The fishable stock biomass, obtained by multiplying the estimated stock in number by the average mean weight of maturing capelin in autumn, was then projected forward to spawning time in March 1995 with the usual prerequisites of a monthly mortality rate of M = 0.035 and a remaining spawning stock of 400.000 t. This gave a predicted TAC of 1,427,000 t if spread evenly over the time August 1994 - March 1995 (Table 5.9).

Concerning the limitations of this model and its performance (Section 3 above) it was recommended that a precautionary TAC for the 1994/1995 season should not exceed 950,000 t or about 2/3 of the total TAC predicted for the whole season; further, that decisions on the final TAC for the season should, as in earlier years, be based on the results of surveys carried out in October–November 1994 and/or January 1995.

The stock prognosis described above was submitted to the May 1994 meeting of ACFM. The resolution of that meeting concurred with the above advice of a precautionary TAC of 950,000 t for the 1994/95 season, the final decision to be made when the stock had been surveyed in autumn 1994/winter 1995. This advice was subsequently accepted by all parties concerned and a TAC of 950,000 t set for the first part of the season.

The autumn 1994 stock assessment survey is scheduled to begin on 25 October. Therefore, no further information is as yet available on the actual state of the fishable stock.

5.7 The Summer and Autumn Fishery in 1994

The season was opened on 1 July with Icelandic vessels taking fairly good catches north of Iceland, near or just north of 68°N between about 14°W and 20°W. A search of the Iceland Sea, carried out in July in the area from 68°N to about 70°N east of 18°W, did not reveal any capelin concentrations.

The Icelandic fishing fleet was soon joined by Faroese and Norwegian vessels as well as one Greenland boat operating from Iceland. In July these parties collectively fished some 215,000 t, mainly in deep waters off the western north coast of Iceland and in the northern part of the Denmark Strait. Most of this catch required much effort since the capelin tended to remain scattered or to occur in small schools.

During the first three weeks of August, the catch situation remained much the same, the capelin being mainly recorded in the area between the Vestfirdir peninsula and Greenland. In spite of a search by the fishing fleet no capelin were recorded north of Scoresby Sound. A total catch of some 93,000 t were taken during this period.

Since late August the fishery has been unsuccessful and practically no fishable concentrations have been located.

The total international catch in the period July–September 1994 amounts to 319,100 t. The division by number at age is given in Table 5.3. The length distribution of the catch is given by age groups in Table 5.13.

5.8 Stock Abundance and TAC in the 1995/1996 Season

The main components of the fishable stock in the 1995/1996 season will be the 1992 and 1993 year classes. As yet the only available information on the abundance of the 1993 year class is the 0-group and 1-group indices, obtained in August 1993 and 1994 respectively. Abundance estimates of the 1992 year class were obtained during its 1-group stage in August as well as October of 1993.

The 1993 0-group index ranks among the highest recorded in the past 17 years (Table 5.14). Further, the August 1994 1-group survey indicates a fairly strong 1993 year class. The August 1993 estimate of 1-group capelin (Table 5.15) was unsuccessful, but the October/November 1993 survey recorded large numbers of the 1992 year class (Table 5.10). Although the above information indicates good recruitment to the fishable stock of 1995/1996, experience has shown that such types of data are erroneous predictors of stock abundance one and a half to two years ahead in time.

Information necessary for predicting year class abundance in the 1995/1996 season, using the method described in Section 2, will not become available until after both the autumn 1994 and winter 1995 surveys have been completed. Therefore, even preliminary advice on a precautionary TAC for the 1995/1996 season, must be postponed, at least until late November 1994.

5.9 The 1994 0-group Index

The available series of indices of 0-group capelin abundance is given in Table 5.14. After the exceptionally rich 0-group capelin years of 1971–1974, abundance varied between 13 and 54 during 1975–1993. The 1994 0-group index is 94 and thus on a par with the 1971–1974 figures. However, there is no apparent relationship between the 0-group indices and year class abundance as measured later in life. The first reliable estimate of the abundance of this year class will not become available until the autumn of 1995.

5.10 Closed Areas During the Summer–Autumn Season

In the years 1989–1992 very few capelin seem to have migrated to feed in the central and northern parts of the Iceland Sea. Instead, most of the adult stock apparently stayed in or near the shelf area north of Iceland to feed there together with the immatures. Although on a smaller scale, this is also true for other years since as a rule only part of the fishable stock migrates to feed at high latitudes in summer. A summer fishery, and in part the autumn fishery also, is usually dependent upon mixed concentrations of mature and immature capelin when conducted over the north Icelandic shelf and in the area of the Iceland–Greenland Ridge. Such a fishery inevitably results in repeated escape of 1-group capelin, which are generally not retained by the mesh used in capelin seines.

A closure of an area contained between 66°N and 67°45'N, from 19°W in the east to a line between 67°45'N, 22°W and 66°N, 27°W in the west, would effectively force the initial fishing operations in July and August to take place in deep water areas and to concentrate on fast growing fish with maximum fat content. This area should therefore be closed to the fishery during those months.

The October–November surveys will resolve the actual size distribution of capelin within the waters of the north Icelandic shelf and allow the establishment of further area closures, if necessary, on a real time basis.

6 ECOLOGICAL CONSIDERATIONS

In item (e) of the terms of reference the Working Group is asked to consider how biological interactions can be incorporated into the assessments of capelin, herring and cod stocks.

Development of multispecies models for the areas in question (Iceland and Barents Sea) was discussed in last year's report. Also, the next meeting of the Multispecies Assessment Working Group (June 1995) will focus on multispecies models for boreal systems.

6.1 Barents Sea/Norwegian Sea

In order to get an overview of the current state of the ecosystem and what will happen in the future, the Working Group provides information on oceanographic conditions and amount of zooplankton in the ecosystem, in addition to considerations on biological interactions between the stocks of capelin, herring and cod. The

effect of marine mammals on the capelin and herring stocks is also considered.

6.1.1 Oceanography

The recruitment of herring and cod is positively influenced by high temperatures (Sætersdal and Loeng, 1987).

Ottersen *et al.* (1994) have made a first attempt at predicting the temperature some years ahead in time. Their prognosis indicates a decreasing trend, with some fluctuations, in the temperature in 1994–1999. However, this year's survey of pelagic fish showed that the temperature in the western and central part of the Barents Sea was higher than in 1993. The temperature was, however, lower than in 1989 which was the warmest year according to the monthly measurements in the Kola section.

6.1.2 Capelin

The poor recruitment of capelin in years with much young herring in the Barents Sea indicates that good herring recruitment may have an adverse effect on the recruitment of capelin, and Huse and Toresen (1994) have confirmed through stomach sampling that young herring may prey on 0-group capelin. However, 0-group cod has also been observed to eat 0-group capelin, and as good recruitment of herring and cod coincides, it is still unclear which predator is the most important.

6.1.3 Herring

The Norwegian spring-spawning herring stock is now within safe biological limits, and increasing rapidly. As the stock size increases, the growth rate is expected to decrease to a level similar to that observed in the 1950s (Toresen, 1990). Interactions between the herring stock and other stocks of plankton-feeders (e.g. blue whiting) in the Norwegian Sea must be expected and need to be considered in future assessment work. A large research effort will be required to elucidate the 'carrying capacity' of the system and the mechanisms of trophic interactions between the stocks.

The possible impact of cannibalism on herring recruitment is discussed in a Working Document by Holst and Røttingen. Stomach samples from 1991 and 1993 show that cannibalism occurred off Vesterålen/Troms during late summer, when adolescent herring emigrating from the Barents Sea constitute a filter which larvae/0-group have to pass when drifting from the spawning grounds to the Barents Sea. In 1995 and 1996 the strong 1991 and 1992 year classes will emigrate from the Barents Sea, and the filtering effect may reduce the survival of 0-group herring significantly in those years. This supports the assumptions about poor recruitment in the coming years made in the forecast of the herring stock development.

6.1.4 Cod

After the collapse of the capelin stock in the mid-1980s, the individual growth of North-East Arctic cod decreased sharply in 1986–1988 due to the lack of capelin as food (Mehl and Sunnanå, 1991).

The Barents Sea capelin stock has now collapsed again, but there are two main differences between the present situation and the situation in 1986, when the total capelin stock size and age composition was rather similar to that in 1994. There is now a large stock of young herring present in the Barents Sea, which may serve as food for the cod, while the Barents Sea was almost free of herring after the previous capelin collapse. In addition, the total stock biomass of cod is about twice that in 1986–1988.

The individual growth of cod from 1993 to 1994 is quite similar to that from 1986 to 1987, according to survey data. Also, the size at age in 1994 is very similar to that in 1987 (Anon., 1995). The Arctic Fisheries Working Group predicts a low weight at age (average of 1987–1990) and hence low individual growth in the years to come, based on anticipations of the development of the capelin stock. This prediction is supported by the present Working Group. However, models relating individual growth of cod to abundance of capelin (and possibly other prey species) and to temperature should be constructed. This could be done in a similar way as for Icelandic cod (Steinarsson and Stefánsson, 1991), taking into account the work of Nilssen *et al.* (1993) and Ozhigin *et al.* (1994).

Data on the predation by cod on various prey species, including capelin and herring, are compiled and discussed in a Working Document by Bogstad. Data from the Norwegian winter survey indicate, as expected, that the amount of capelin found in cod stomachs has decreased strongly from 1993 to 1994. The amount of herring found in cod stomachs was at the 1985 level in 1992–1993, but decreased in 1994. In all these years, the amount of herring in the stomachs was very low compared to the amount of capelin. The proportion of cod stomachs containing herring was also low during the acoustic survey on young herring in the Barents Sea in June 1994 (9 out of 312 stomachs sampled contained herring). Only very limited information on the cod stomach content in the last quarter of 1993, when much of the 1993 year class of herring may have disappeared, was available to the Working Group (174 stomachs sampled during the Russian bottom trawl survey in October/November). Some herring was found in the stomachs (about 10% of total stomach content weight).

Ponomarenko and Yaragina (1979) have plotted the frequency of occurrence of capelin, herring and euphausiids in cod stomachs in 1947–1977. The stomach samples are taken in ICES Sub-area I (mostly) and Division IIb, with very few samples in Division IIa. The seasonal coverage is good, at least in the later years. The frequency of occurrence of herring is generally much lower than that of capelin in the period prior to the collapse of the herring stock. The plot indicates that the frequency of occurrence of herring in cod stomachs is related to the abundance of young herring, and that herring only to a small extent replaced capelin in the cod diet. Cod may, however, have very high contents of herring (or capelin) in the stomach, and thus the frequency of occurrence is a less reliable measure of stomach content than the stomach content weight. It is also seen that the frequency of occurrence of euphausiids is high when the frequency of occurrence of capelin is low. This is in accordance with the diet data for North-East Arctic cod in the late 1980s (Bogstad and Mehl, 1992). This work is based on the large amount (> 1 million stomachs analyzed) of Russian qualitative cod stomach content data from 1947 onwards. A computer program for recording and analysing these data is now available. The Working Group recommends that these data be computerized, so that more detailed analyses can be performed.

Based on the information presented above one may conclude that the herring will only to a limited extent be able to replace capelin as food for cod. However, the cod may still eat enough young herring to have an impact on the young herring now present in the Barents Sea. Information on the size distribution of herring in cod stomachs indicates that the 1992 and older year classes will not be heavily preyed upon by cod. The cod stock could, however, have a significant impact on the 1993 and 1994 year classes in the coming year. In this context it is very important to relate the mortality rates calculated by Barros (1994a,b) to mortality rates calculated from stomach content data and gastric evacuation rate models.

6.1.5 Marine mammals

Cod is the most important predator on fish stocks in the Barents Sea, but predation by marine mammals (especially harp seal and minke whale) may also have a significant impact on the fish stocks in the Barents Sea. The impact of harp seal and minke whale on the cod and capelin stocks was studied by Bogstad *et al.* (1992) using the MULTSPEC model. Herring was not included in this study, however, and the prey species preferences used were not estimated from data. Data on stomach contents of minke whale (Haug *et al.*, 1994 and references therein) and harp seal (Nilssen *et al.*, 1994 and references therein) show that both herring and capelin are important in the diet of these species. Together with data on prey abundance in the area and time where the samples were taken, these data will be used to estimate prey preferences for harp seal and minke whale. Estimation of prey preferences for minke whale is now in progress at the Norwegian Computing Center in Oslo. New studies of the impact of harp seal and minke whale on the cod, capelin and herring stocks using the new information about prey species preferences will be carried out in 1995.

6.2 Icelandic Waters

As in the Barents Sea the biological interactions between cod and capelin have been modeled and used to predict the mean weight at age in Icelandic cod stock assessment. In addition a cod–shrimp model has been developed in order to assess the recruitment to the deep sea shrimp stock off north and northeast Iceland. Stefánsson *et al.* (1994) combine these models in a study of utilization of the Icelandic cod stock in a multispecies context. In that paper, the probable effects of different harvesting strategies on yield and biomass of cod, capelin and shrimp are analysed. Inaccuracies in assessments and uncertainties in predictions are taken into account. The analysis includes economic considerations.

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Table 2.1 Icelandic summer spawners. Catch in numbers(millions) and total catch in weight, '000 tonnes. Age in years is number of rings +1

Rings/year	1974	1975	1976	1977	1978	1979	1980
1	0.001	1.518	0.614	0.705	2.634	0.929	3.147
2	3.760	2.049	9.848	18.853	22.551	15.098	14.347
3	0.832	31.975	3.908	24.152	50.995	47.561	20.761
4	0.993	6.493	34.144	10.404	13.846	69.735	60.728
5	0.092	7.905	7.009	46.357	8.738	16.451	65.329
6	0.046	0.863	5.481	6.735	39.492	8.003	11.541
7	0.002	0.442	1.045	5.421	7.253	26.040	9.285
8	0.001	0.345	0.438	1.395	6.354	3.050	19.442
9	0.001	0.114	0.296	0.524	1.616	1.869	1.796
10	0.001	0.004	0.134	0.362	0.926	0.494	1.464
11	0.001	0.001	0.092	0.027	0.400	0.439	0.698
12	0.001	0.001	0.001	0.128	0.017	0.032	0.001
13	0.001	0.001	0.001	0.001	0.025	0.054	0.110
14	0.001	0.001	0.001	0.001	0.051	0.006	0.079
Catch in wt	1.274	13.280	17.168	28.924	37.333	45.072	53.269

Rings/year	1981	1982	1983	1984	1985	1986	1987
1	2.283	0.454	1.470	0.421	0.111	0.100	0.029
2	4.629	19.187	22.422	18.011	12.800	8.161	3.144
3	16.771	28.109	151.198	32.237	24.521	33.893	44.590
4	12.126	38.280	30.181	141.324	21.535	23.421	60.285
5	36.871	16.623	21.525	17.039	84.733	20.654	20.622
6	41.917	38.308	8.637	7.111	11.836	77.526	19.751
7	7.299	43.770	14.017	3.915	5.708	18.228	46.240
8	4.863	6.813	13.666	4.112	2.323	10.971	15.232
9	13.416	6.633	3.715	4.516	4.339	8.583	13.963
10	1.032	10.457	2.373	1.828	4.030	9.662	10.179
11	0.884	2.354	3.424	0.202	2.758	7.174	13.216
12	0.760	0.594	0.552	0.255	0.970	3.677	6.224
13	0.101	0.075	0.100	0.260	0.477	2.914	4.723
14	0.062	0.211	0.003	0.003	0.578	1.786	2.280
Catch in wt	39.544	56.528	58.665	50.293	49.092	65.413	75.439

Rings/year	1988	1989	1990	1991	1992	1993
1	0.869	3.963	11.061	35.872	11.820	0.870
2	4.702	22.568	14.413	92.766	78.547	35.581
3	40.855	26.578	57.293	51.052	129.508	170.207
4	98.222	77.618	34.509	87.614	43.109	87.415
5	68.533	188.155	78.187	33.439	55.215	25.161
6	22.691	43.000	152.955	54.845	41.283	28.819
7	19.899	8.095	32.417	109.428	35.663	18.317
8	31.830	5.881	8.754	9.252	44.072	24.282
9	12.207	7.273	4.453	3.796	9.101	14.327
10	10.132	4.767	4.307	2.634	2.224	3.641
11	7.293	3.440	2.529	1.826	0.573	0.879
12	7.200	1.406	1.232	0.516	0.300	0.300
13	4.752	0.842	1.024	0.262	0.200	0.200
14	1.935	0.347	0.613	0.298	0.100	0.100
Catch in wt	91.760	100.733	105.593	109.499	106.825	102.802

Table 2.2 Icelandic summer spawners. Weight at age in grammes.
Age in years is number of rings +1.

Rings/year	1974	1975	1976	1977	1978	1979	1980
1	80	110	103	84	73	75	69
2	189	179	189	157	128	145	115
3	262	241	243	217	196	182	202
4	297	291	281	261	247	231	232
5	340	319	305	285	295	285	269
6	332	339	335	313	314	316	317
7	379	365	351	326	339	334	352
8	356	364	355	347	359	350	360
9	407	407	395	364	360	367	380
10	410	389	363	362	376	368	383
11	410	430	396	358	380	371	393
12	423	416	396	355	425	350	390
13	423	416	396	400	425	350	390
14	423	416	396	420	425	450	390

Rings/year	1981	1982	1983	1984	1985	1986	1987
1	61	65	59	49	53	60	60
2	141	141	132	131	146	140	168
3	190	186	180	189	219	200	200
4	246	217	218	217	266	252	240
5	269	274	260	245	285	282	278
6	298	293	309	277	315	298	304
7	330	323	329	315	335	320	325
8	356	354	356	322	365	334	339
9	368	385	370	351	388	373	356
10	405	389	407	334	400	380	378
11	382	400	437	362	453	394	400
12	400	394	459	446	469	408	404
13	400	390	430	417	433	405	424
14	400	420	472	392	447	439	430

Rings/year	1988	1989	1990	1991	1992	1993	1994*
1	75	63	75	74	63	74	69
2	157	130	119	139	144	150	150
3	221	206	198	188	190	212	208
4	239	246	244	228	232	245	256
5	271	261	273	267	276	288	282
6	298	290	286	292	317	330	315
7	319	331	309	303	334	358	347
8	334	338	329	325	346	373	369
9	354	352	351	343	364	387	352
10	352	369	369	348	392	401	369
11	371	389	387	369	444	425	397
12	390	380	422	388	399	387	397
13	408	434	408	404	419	414	416
14	437	409	436	396	428	420	417

* Predicted

Table 2.3 Icelandic summer spawners. Proportion mature at age. Age in years is number of rings + 1. Based on samples taken in September - December by purse seine.

Rings/year	1974	1975	1976	1977	1978	1979	1980
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.14	0.27	0.13	0.02	0.04	0.07	0.05
3	0.94	0.97	0.90	0.87	0.78	0.65	0.92
4	1.00	1.00	1.00	1.00	1.00	0.98	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	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
9	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
11	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
13	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

Rings/year	1981	1982	1983	1984	1985	1986	1987
1	0.00	0.02	0.00	0.00	0.00	0.00	0.00
2	0.03	0.05	0.00	0.01	0.00	0.03	0.01
3	0.65	0.85	0.64	0.82	0.90	0.89	0.87
4	0.99	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	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
9	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
11	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
13	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

Rings/year	1988	1989	1990	1991	1992	1993	1994*
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.05	0.06	0.00	0.01	0.02	0.05	0.02
3	0.90	0.93	0.78	0.72	0.93	1.00	0.86
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	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
9	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
11	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
13	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

* Predicted (mean of 1990-1993).

Table 2.4 Acoustic estimates (in millions) of the Icelandic summer spawning herring, 1974-1993. Rings, representing the end of the fishing season for the previous year.

	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
1	-	-	-	-	-	-	-	625	3	-	-	-	201	-	392	285	5	478	410	1418	-
2	154	5	136	-	212	158	19	361	17	-	171	28	652	-	126	725	178	805	745	254	332
3	-	137	20	-	424	334	177	462	75	-	310	67	208	-	352	181	593	227	850	858	533
4	-	19	133	-	46	215	360	85	159	-	724	56	110	-	836	249	177	304	353	687	860
5	-	21	17	-	19	49	253	170	42	-	80	360	86	-	287	381	302	137	273	160	443
6	-	2	10	-	139	20	51	182	123	-	39	65	425	-	53	171	538	176	94	99	55
7	-	2	3	-	18	111	41	33	162	-	15	32	67	-	37	42	185	387	81	87	69
8	-	-	3	-	18	30	93	29	24	-	27	16	41	-	76	23	-	40	210	44	43
9	-	-	-	-	10	30	10	58	8	-	26	17	17	-	25	30	-	10	32	92	86
10	-	-	-	-	-	20	-	10	46	-	10	18	27	-	21	16	-	2	11	39	55
11	-	-	-	-	-	-	-	-	10	-	5	9	26	-	14	10	18	-	-	-	2
12	-	-	-	-	-	-	-	-	-	-	12	7	16	-	17	9	-	-	17	-	-
13	-	-	-	-	-	-	-	-	-	-	-	4	6	-	8	5	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	5	6	-	6	3	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	5	1	-	3	2	-	-	-	-	-
5+	0	25	33	0	204	260	448	482	415	0	214	538	718	0	547	692	1043	752	718	521	753

Table 2.5 Icelandic summer spawners. Fishing mortality at age (M=0.1). Age in years is number of rings + 1.

Rings/year	1974	1975	1976	1977	1978	1979	1980
1	0.000	0.008	0.001	0.002	0.014	0.004	0.013
2	0.011	0.018	0.060	0.040	0.062	0.096	0.070
3	0.012	0.104	0.040	0.183	0.131	0.162	0.165
4	0.024	0.110	0.139	0.126	0.136	0.238	0.284
5	0.009	0.237	0.149	0.253	0.133	0.212	0.326
6	0.009	0.097	0.230	0.188	0.316	0.156	0.202
7	0.001	0.104	0.147	0.331	0.282	0.316	0.244
8	0.001	0.175	0.128	0.266	0.708	0.164	0.367
9	0.003	0.140	0.200	0.199	0.492	0.409	0.123
10	0.005	0.012	0.218	0.354	0.562	0.242	0.573
11	0.129	0.005	0.368	0.056	0.729	0.503	0.558
12	0.115	0.165	0.006	1.137	0.041	0.100	0.002
13	0.087	0.145	0.220	0.007	0.615	0.158	0.510
14	0.044	0.105	0.190	0.317	0.468	0.256	0.322
W.Av 4-14	0.019	0.150	0.148	0.220	0.244	0.239	0.294
Ave 4-14	0.039	0.118	0.181	0.294	0.407	0.250	0.319
Ave 4-9	0.008	0.144	0.166	0.227	0.345	0.249	0.258

Rings/year	1981	1982	1983	1984	1985	1986	1987
1	0.003	0.002	0.007	0.001	0.000	0.000	0.000
2	0.022	0.026	0.116	0.102	0.032	0.008	0.005
3	0.098	0.159	0.258	0.218	0.176	0.101	0.049
4	0.123	0.301	0.229	0.362	0.198	0.227	0.234
5	0.249	0.222	0.246	0.175	0.341	0.264	0.284
6	0.319	0.392	0.154	0.108	0.159	0.529	0.383
7	0.171	0.568	0.216	0.087	0.106	0.347	0.614
8	0.174	0.213	0.307	0.081	0.061	0.272	0.483
9	0.412	0.337	0.154	0.141	0.104	0.299	0.576
10	0.087	0.578	0.173	0.095	0.161	0.314	0.607
11	0.725	0.260	0.334	0.018	0.182	0.421	0.813
12	2.183	1.543	0.080	0.033	0.101	0.348	0.696
13	0.204	1.967	1.159	0.045	0.072	0.434	0.889
14	0.534	0.732	0.322	0.076	0.119	0.371	0.633
W.Av 4-14	0.247	0.367	0.225	0.256	0.228	0.362	0.393
Ave 4-14	0.471	0.647	0.307	0.111	0.146	0.348	0.565
Ave 4-9	0.241	0.339	0.218	0.159	0.162	0.323	0.429

Rings/year	1988	1989	1990	1991	1992	1993	1986-1989
1	0.002	0.013	0.010	0.023	0.016	0.001	0.004
2	0.015	0.052	0.056	0.100	0.058	0.054	0.020
3	0.082	0.101	0.161	0.254	0.176	0.155	0.083
4	0.130	0.199	0.166	0.350	0.314	0.155	0.197
5	0.402	0.348	0.280	0.215	0.346	0.272	0.325
6	0.509	0.421	0.469	0.289	0.396	0.272	0.460
7	0.732	0.304	0.571	0.639	0.275	0.272	0.499
8	1.031	0.435	0.551	0.279	0.508	0.272	0.555
9	0.795	0.611	0.609	0.435	0.431	0.272	0.570
10	0.975	0.744	0.799	0.792	0.435	0.272	0.660
11	1.076	0.966	1.037	0.850	0.345	0.272	0.819
12	1.393	0.534	1.033	0.532	0.280	0.272	0.743
13	1.839	0.501	0.836	0.557	0.358	0.272	0.916
14	1.044	0.564	0.738	0.546	0.378	0.272	0.653
W.Av 4-14	0.300	0.315	0.365	0.383	0.360	0.207	0.300
Ave 4-14	0.902	0.512	0.644	0.499	0.370	0.261	0.582
Ave 4-9	0.600	0.386	0.441	0.368	0.378	0.253	0.434

Table 2.6 Icelandic summer spawners. VPA stock size in numbers(millions) and SSB in '000 tonnes. Age in years is number of rings +1.

Rings/year	1974	1975	1976	1977	1978	1979	1980
1	131.701	198.263	553.798	435.588	194.975	247.581	253.201
2	378.052	119.167	177.952	500.514	393.466	173.916	223.137
3	73.140	338.501	105.879	151.659	434.963	334.592	143.022
4	44.420	65.389	275.912	92.088	114.297	345.136	257.589
5	10.902	39.249	52.998	217.228	73.443	90.270	246.117
6	5.227	9.777	28.012	41.299	152.571	58.155	66.065
7	2.497	4.686	8.027	20.145	30.975	100.600	45.021
8	1.011	2.258	3.820	6.270	13.088	21.147	66.332
9	0.388	0.914	1.715	3.041	4.350	5.836	16.238
10	0.218	0.350	0.718	1.271	2.254	2.406	3.509
11	0.009	0.196	0.313	0.523	0.807	1.163	1.708
12	0.010	0.007	0.177	0.196	0.448	0.352	0.637
13	0.013	0.008	0.005	0.159	0.057	0.389	0.288
14	0.025	0.010	0.006	0.004	0.143	0.028	0.300
SSB	45.876	116.896	129.289	132.893	175.512	198.145	212.367

Rings/year	1981	1982	1983	1984	1985	1986	1987
1	876.280	237.704	217.419	467.367	1205.690	666.499	358.972
2	226.114	790.721	214.652	195.332	422.491	1090.848	602.978
3	188.269	200.195	697.234	172.926	159.632	370.118	979.281
4	109.698	154.420	154.453	487.427	125.873	121.160	302.697
5	175.471	87.741	103.418	111.112	307.071	93.452	87.403
6	160.747	123.787	63.615	73.151	84.361	197.510	64.964
7	48.823	105.700	75.701	49.359	59.435	65.094	105.322
8	31.926	37.247	54.218	55.193	40.942	48.356	41.617
9	41.590	24.271	27.236	36.097	46.033	34.839	33.346
10	12.987	24.919	15.672	21.116	28.373	37.531	23.382
11	1.790	10.771	12.652	11.927	17.370	21.847	24.796
12	0.885	0.784	7.512	8.202	10.600	13.098	12.970
13	0.575	0.090	0.152	6.273	7.179	8.670	8.366
14	0.157	0.425	0.011	0.043	5.429	6.042	5.084
SSB	185.746	192.721	218.872	231.858	248.750	257.427	359.749

Rings/year	1988	1989	1990	1991	1992	1993	1994
1	519.903	312.479	1147.242	1647.549	792.264	1400.464	600.000
2	324.784	469.601	278.975	1027.551	1456.662	705.633	1266.365
3	542.608	289.406	403.464	238.729	841.635	1243.393	604.667
4	843.710	452.153	236.616	310.666	167.572	638.583	963.439
5	216.682	670.129	335.445	181.332	198.038	110.742	494.804
6	59.524	131.116	427.970	229.353	132.338	126.843	76.334
7	40.061	32.375	77.895	242.373	155.504	80.620	87.432
8	51.556	17.442	21.616	39.805	115.808	106.874	55.571
9	23.232	16.639	10.211	11.273	27.240	63.058	73.667
10	16.960	9.490	8.175	5.026	6.604	16.025	43.466
11	11.527	5.789	4.082	3.328	2.060	3.869	11.046
12	9.954	3.556	1.993	1.309	1.287	1.320	2.667
13	5.852	2.237	1.887	0.642	0.696	0.880	0.910
14	3.112	0.841	1.227	0.740	0.333	0.440	0.607
SSB	422.454	394.095	357.138	299.277	375.237	571.241	

Table 2.7 Stock abundance and catches by age groups (millions) and fishing mortality rate for the Icelandic summer spawners. F′ is the F calculated from the acoustic surveys. F_{93} is the fitted fishing mortality based on the fitting procedure for 5+ and the 1994 acoustic estimates for the 1-4 ringers in 1993. $F_{p\,93}$ is the explotation pattern in 1993 (used in the prognoses) and $F_{p\,av}$ is the average explotation pattern for 1986-1989.

Rings in 1993	Year class	Acoustic estimate Jan.1994	Catch 1993/94	F′	F_{93}	$F_{p\,93}$	$F_{p\,av}$
1	1991	1283	0.87	-	0.001	0.004	0.006
2	1990	533	35.6	0.060	0.054	0.198	0.032
3	1989	860	170.2	0.170	0.155	0.570	0.134
4	1988	443	87.4	0.170	0.155	1.000	0.318
5+	1987-	310	116.1	0.300	0.272	1.000	1.000

Table 2.8 Herring, summer spawning at Iceland (Fishing area Va).

Single option prediction: Input data

Year: 1994								
Age	Stock size	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	600.000	0.1000	0.0000	0.0000	0.5000	69.000	0.0010	69.000
2	1266.365	0.1000	0.0210	0.0000	0.5000	150.000	0.0440	150.000
3	604.667	0.1000	0.8600	0.0000	0.5000	208.000	0.1250	208.000
4	963.439	0.1000	1.0000	0.0000	0.5000	256.000	0.2200	256.000
5	494.804	0.1000	1.0000	0.0000	0.5000	282.000	0.2200	282.000
6	76.334	0.1000	1.0000	0.0000	0.5000	315.000	0.2200	315.000
7	87.432	0.1000	1.0000	0.0000	0.5000	347.000	0.2200	347.000
8	55.571	0.1000	1.0000	0.0000	0.5000	369.000	0.2200	369.000
9	73.667	0.1000	1.0000	0.0000	0.5000	352.000	0.2200	352.000
10	43.466	0.1000	1.0000	0.0000	0.5000	369.000	0.2200	369.000
11	11.046	0.1000	1.0000	0.0000	0.5000	397.000	0.2200	397.000
12	2.667	0.1000	1.0000	0.0000	0.5000	397.000	0.2200	397.000
13	0.910	0.1000	1.0000	0.0000	0.5000	416.000	0.2200	416.000
14	0.607	0.1000	1.0000	0.0000	0.5000	417.000	0.2200	417.000
Unit	Millions	-	-	-	-	Grams	-	Grams

Year: 1995								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	600.000	0.1000	0.0000	0.0000	0.5000	69.000	0.0010	69.000
2	.	0.1000	0.0210	0.0000	0.5000	150.000	0.0440	150.000
3	.	0.1000	0.8600	0.0000	0.5000	208.000	0.1250	208.000
4	.	0.1000	1.0000	0.0000	0.5000	256.000	0.2200	256.000
5	.	0.1000	1.0000	0.0000	0.5000	282.000	0.2200	282.000
6	.	0.1000	1.0000	0.0000	0.5000	315.000	0.2200	315.000
7	.	0.1000	1.0000	0.0000	0.5000	347.000	0.2200	347.000
8	.	0.1000	1.0000	0.0000	0.5000	369.000	0.2200	369.000
9	.	0.1000	1.0000	0.0000	0.5000	352.000	0.2200	352.000
10	.	0.1000	1.0000	0.0000	0.5000	369.000	0.2200	369.000
11	.	0.1000	1.0000	0.0000	0.5000	397.000	0.2200	397.000
12	.	0.1000	1.0000	0.0000	0.5000	397.000	0.2200	397.000
13	.	0.1000	1.0000	0.0000	0.5000	416.000	0.2200	416.000
14	.	0.1000	1.0000	0.0000	0.5000	417.000	0.2200	417.000
Unit	Millions	-	-	-	-	Grams	-	Grams

Year: 1996								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	600.000	0.1000	0.0000	0.0000	0.5000	69.000	0.0010	69.000
2	.	0.1000	0.0210	0.0000	0.5000	150.000	0.0440	150.000
3	.	0.1000	0.8600	0.0000	0.5000	208.000	0.1250	208.000
4	.	0.1000	1.0000	0.0000	0.5000	256.000	0.2200	256.000
5	.	0.1000	1.0000	0.0000	0.5000	282.000	0.2200	282.000
6	.	0.1000	1.0000	0.0000	0.5000	315.000	0.2200	315.000
7	.	0.1000	1.0000	0.0000	0.5000	347.000	0.2200	347.000
8	.	0.1000	1.0000	0.0000	0.5000	369.000	0.2200	369.000
9	.	0.1000	1.0000	0.0000	0.5000	352.000	0.2200	352.000
10	.	0.1000	1.0000	0.0000	0.5000	369.000	0.2200	369.000
11	.	0.1000	1.0000	0.0000	0.5000	397.000	0.2200	397.000
12	.	0.1000	1.0000	0.0000	0.5000	397.000	0.2200	397.000
13	.	0.1000	1.0000	0.0000	0.5000	416.000	0.2200	416.000
14	.	0.1000	1.0000	0.0000	0.5000	417.000	0.2200	417.000
Unit	Millions	-	-	-	-	Grams	-	Grams

(cont.)

Table 2. 8 Continued

Single option prediction: Input data

(cont.)

Year: 1997								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	600.000	0.1000	0.0000	0.0000	0.5000	69.000	0.0010	69.000
2	.	0.1000	0.0210	0.0000	0.5000	150.000	0.0440	150.000
3	.	0.1000	0.8600	0.0000	0.5000	208.000	0.1250	208.000
4	.	0.1000	1.0000	0.0000	0.5000	256.000	0.2200	256.000
5	.	0.1000	1.0000	0.0000	0.5000	282.000	0.2200	282.000
6	.	0.1000	1.0000	0.0000	0.5000	315.000	0.2200	315.000
7	.	0.1000	1.0000	0.0000	0.5000	347.000	0.2200	347.000
8	.	0.1000	1.0000	0.0000	0.5000	369.000	0.2200	369.000
9	.	0.1000	1.0000	0.0000	0.5000	352.000	0.2200	352.000
10	.	0.1000	1.0000	0.0000	0.5000	369.000	0.2200	369.000
11	.	0.1000	1.0000	0.0000	0.5000	397.000	0.2200	397.000
12	.	0.1000	1.0000	0.0000	0.5000	397.000	0.2200	397.000
13	.	0.1000	1.0000	0.0000	0.5000	416.000	0.2200	416.000
14	.	0.1000	1.0000	0.0000	0.5000	417.000	0.2200	417.000
Unit	Millions	-	-	-	-	Grams	-	Grams

Year: 1998								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	600.000	0.1000	0.0000	0.0000	0.5000	69.000	0.0010	69.000
2	.	0.1000	0.0210	0.0000	0.5000	150.000	0.0440	150.000
3	.	0.1000	0.8600	0.0000	0.5000	208.000	0.1250	208.000
4	.	0.1000	1.0000	0.0000	0.5000	256.000	0.2200	256.000
5	.	0.1000	1.0000	0.0000	0.5000	282.000	0.2200	282.000
6	.	0.1000	1.0000	0.0000	0.5000	315.000	0.2200	315.000
7	.	0.1000	1.0000	0.0000	0.5000	347.000	0.2200	347.000
8	.	0.1000	1.0000	0.0000	0.5000	369.000	0.2200	369.000
9	.	0.1000	1.0000	0.0000	0.5000	352.000	0.2200	352.000
10	.	0.1000	1.0000	0.0000	0.5000	369.000	0.2200	369.000
11	.	0.1000	1.0000	0.0000	0.5000	397.000	0.2200	397.000
12	.	0.1000	1.0000	0.0000	0.5000	397.000	0.2200	397.000
13	.	0.1000	1.0000	0.0000	0.5000	416.000	0.2200	416.000
14	.	0.1000	1.0000	0.0000	0.5000	417.000	0.2200	417.000
Unit	Millions	-	-	-	-	Grams	-	Grams

Notes: Run name : PRED_01
Date and time: 18OCT94:14:17

Table 2.9

Herring, Summer Spawning at Iceland (Fishing Area Va)

Herring, Summer Spawning at Iceland (Fishing Area Va)

Single option prediction: Detailed tables

Year: 1994 F-factor: 1.0000 Reference F: 0.2200

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0010	571	39	600000	41400	0	0	0	0
2	0.0440	51894	7784	1266365	189955	26594	3989	25297	3795
3	0.1250	67684	14078	604667	125771	520014	108163	494652	102888
4	0.2200	181389	46436	963439	246640	963439	246640	916452	234612
5	0.2200	93158	26271	494804	139535	494804	139535	470672	132730
6	0.2200	14372	4527	76334	24045	76334	24045	72611	22873
7	0.2200	16461	5712	87432	30339	87432	30339	83168	28859
8	0.2200	10462	3861	55571	20506	55571	20506	52861	19506
9	0.2200	13869	4882	73667	25931	73667	25931	70074	24666
10	0.2200	8183	3020	43466	16039	43466	16039	41346	15257
11	0.2200	2080	826	11046	4385	11046	4385	10507	4171
12	0.2200	502	199	2667	1059	2667	1059	2537	1007
13	0.2200	171	71	910	379	910	379	866	360
14	0.2200	114	48	607	253	607	253	577	241
Total		460911	117753	4280975	866236	2356550	621262	2241620	590963
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Year: 1995 F-factor: 1.0000 Reference F: 0.2200

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0010	571	39	600000	41400	0	0	0	0
2	0.0440	22225	3334	542360	81354	11390	1708	10834	1625
3	0.1250	122741	25530	1096530	228078	943016	196147	897024	186581
4	0.2200	90905	23272	482836	123606	482836	123606	459288	117578
5	0.2200	131716	37144	699600	197287	699600	197287	665480	187665
6	0.2200	67647	21309	359301	113180	359301	113180	341778	107660
7	0.2200	10436	3621	55430	19234	55430	19234	52727	18296
8	0.2200	11953	4411	63489	23427	63489	23427	60392	22285
9	0.2200	7597	2674	40353	14204	40353	14204	38385	13511
10	0.2200	10071	3716	53493	19739	53493	19739	50884	18776
11	0.2200	5942	2359	31563	12530	31563	12530	30023	11919
12	0.2200	1510	600	8021	3184	8021	3184	7630	3029
13	0.2200	365	152	1937	806	1937	806	1842	766
14	0.2200	124	52	661	276	661	276	629	262
Total		483803	128212	4035574	878306	2751089	725330	2616917	689955
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

(cont.)

Table 2. 9 Continued. Herring, Summer Spawning at Iceland (Fishing Area Va)

Single option prediction: Detailed tables

(cont.)

Year: 1996 F-factor: 1.0000 Reference F: 0.2200

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0010	571	39	600000	41400	0	0	0	0
2	0.0440	22225	3334	542360	81354	11390	1708	10834	1625
3	0.1250	52567	10934	469623	97682	403876	84006	384178	79909
4	0.2200	164851	42202	875597	224153	875597	224153	832894	213221
5	0.2200	66010	18615	350611	98872	350611	98872	333512	94050
6	0.2200	95645	30128	508014	160024	508014	160024	483238	152220
7	0.2200	49122	17045	260906	90535	260906	90535	248182	86119
8	0.2200	7578	2796	40250	14852	40250	14852	38287	14128
9	0.2200	8680	3055	46102	16228	46102	16228	43854	15437
10	0.2200	5517	2036	29302	10812	29302	10812	27873	10285
11	0.2200	7313	2903	38844	15421	38844	15421	36950	14669
12	0.2200	4315	1713	22919	9099	22919	9099	21802	8655
13	0.2200	1097	456	5824	2423	5824	2423	5540	2305
14	0.2200	265	110	1406	586	1406	586	1338	558
Total		485756	135368	3791760	863442	2595043	728721	2468481	693181
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Year: 1997 F-factor: 1.0000 Reference F: 0.2200

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0010	571	39	600000	41400	0	0	0	0
2	0.0440	22225	3334	542360	81354	11390	1708	10834	1625
3	0.1250	52567	10934	469623	97682	403876	84006	384178	79909
4	0.2200	70602	18074	375001	96000	375001	96000	356712	91318
5	0.2200	119706	33757	635814	179300	635814	179300	604805	170555
6	0.2200	47933	15099	254596	80198	254596	80198	242179	76286
7	0.2200	69453	24100	368894	128006	368894	128006	350903	121763
8	0.2200	35670	13162	189457	69910	189457	69910	180217	66500
9	0.2200	5503	1937	29228	10288	29228	10288	27802	9786
10	0.2200	6303	2326	33477	12353	33477	12353	31844	11751
11	0.2200	4006	1590	21278	8447	21278	8447	20240	8035
12	0.2200	5311	2108	28207	11198	28207	11198	26831	10652
13	0.2200	3133	1303	16643	6923	16643	6923	15831	6586
14	0.2200	796	332	4229	1764	4229	1764	4023	1678
Total		443779	128097	3568806	824822	2372089	690102	2256400	656445
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

(cont.)

Table 2. 9 Continued.

Herring, Summer Spawning at Iceland (Fishing Area Va)

Single option prediction: Detailed tables

(cont.)

Year: 1998 F-factor: 1.0000 Reference F: 0.2200

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0010	571	39	600000	41400	0	0	0	0
2	0.0440	22225	3334	542360	81354	11390	1708	10834	1625
3	0.1250	52567	10934	469623	97682	403876	84006	384178	79909
4	0.2200	70602	18074	375001	96000	375001	96000	356712	91318
5	0.2200	51268	14458	272307	76791	272307	76791	259026	73045
6	0.2200	86925	27381	461696	145434	461696	145434	439178	138341
7	0.2200	34807	12078	184875	64151	184875	64151	175858	61023
8	0.2200	50433	18610	267872	98845	267872	98845	254808	94024
9	0.2200	25901	9117	137574	48426	137574	48426	130864	46064
10	0.2200	3996	1474	21224	7832	21224	7832	20189	7450
11	0.2200	4577	1817	24309	9651	24309	9651	23124	9180
12	0.2200	2909	1155	15451	6134	15451	6134	14697	5835
13	0.2200	3856	1604	20482	8521	20482	8521	19483	8105
14	0.2200	2275	949	12085	5040	12085	5040	11496	4794
Total		412913	121025	3404858	787259	2208141	652538	2100448	620714
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : PRED_01
Date and time : 18OCT94:14:17
Computation of ref. F: Weighted mean, age 4 - 14
Prediction basis : F factors

Table 2. 10 Herring, summer spawning at Iceland (Fishing area Va).

Single option prediction: Summary table

							1 January		Spawning time	
Year	F Factor	Reference F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1994	1.0000	0.2200	460911	117753	4280975	866236	2356550	621262	2241620	590963
1995	1.0000	0.2200	483803	128212	4035574	878306	2751089	725330	2616917	689955
1996	1.0000	0.2200	485756	135368	3791760	863442	2595043	728721	2468481	693181
1997	1.0000	0.2200	443779	128097	3568806	824822	2372089	690102	2256400	656445
1998	1.0000	0.2200	412913	121025	3404858	787259	2208141	652538	2100448	620714
Unit	-	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : PRED_01
Date and time : 18OCT94:14:17
Computation of ref. F: Weighted mean, age 4 - 14
Prediction basis : F factors

Table 2. 11 Herring, summer spawning at Iceland (Fishing area Va). 10:??

Prediction with management option table

Year: 1994					Year: 1995					Year: 1996	
F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	Stock biomass	Sp.stock biomass
1.0000	0.2247	866084	590819	120000	0.0000	0.0000	875903	687696	0	998432	820927
.	.	.	.	.	0.1000	0.0225	.	687696	14207	983204	806509
.	.	.	.	.	0.2000	0.0449	.	687696	28136	968274	792376
.	.	.	.	.	0.3000	0.0674	.	687696	41791	953638	778521
.	.	.	.	.	0.4000	0.0899	.	687696	55180	939289	764940
.	.	.	.	.	0.5000	0.1123	.	687696	68307	925221	751625
.	.	.	.	.	0.6000	0.1348	.	687696	81179	911428	738572
.	.	.	.	.	0.7000	0.1573	.	687696	93799	897904	725775
.	.	.	.	.	0.8000	0.1798	.	687696	106174	884645	713229
.	.	.	.	.	0.9000	0.2022	.	687696	118309	871644	700929
.	.	.	.	.	1.0000	0.2247	.	687696	130207	858897	688869
.	.	.	.	.	1.1000	0.2472	.	687696	141876	846397	677044
.	.	.	.	.	1.2000	0.2696	.	687696	153318	834140	665451
.	.	.	.	.	1.3000	0.2921	.	687696	164539	822121	654083
.	.	.	.	.	1.4000	0.3146	.	687696	175544	810334	642936
.	.	.	.	.	1.5000	0.3371	.	687696	186336	798776	632006
.	.	.	.	.	1.6000	0.3595	.	687696	196920	787441	621288
.	.	.	.	.	1.7000	0.3820	.	687696	207301	776324	610779
.	.	.	.	.	1.8000	0.4045	.	687696	217483	765422	600472
.	.	.	.	.	1.9000	0.4269	.	687696	227469	754730	590365
.	.	.	.	.	2.0000	0.4494	.	687696	237264	744243	580453
-	-	Tonnes	Tonnes	Tonnes	-	-	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes

Notes: Run name : M1_94
Date and time : 18OCT94:17:55
Computation of ref. F: Weighted mean, age 4 - 14
Basis for 1994 : F factors

Table 2. 12 Herring, summer spawning at Iceland (Fishing area Va).

Yield per recruit: Input data

Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	1.000	0.1000	0.0000	0.0000	0.5000	72.000	0.0420	72.000
2	.	0.1000	0.0200	0.0000	0.5000	140.000	0.0820	140.000
3	.	0.1000	0.9300	0.0000	0.5000	202.000	0.1640	202.000
4	.	0.1000	1.0000	0.0000	0.5000	236.000	0.2400	236.000
5	.	0.1000	1.0000	0.0000	0.5000	268.000	0.3600	268.000
6	.	0.1000	1.0000	0.0000	0.5000	301.000	0.3600	301.000
7	.	0.1000	1.0000	0.0000	0.5000	332.000	0.3600	332.000
8	.	0.1000	1.0000	0.0000	0.5000	345.000	0.3600	345.000
9	.	0.1000	1.0000	0.0000	0.5000	350.000	0.3600	350.000
10	.	0.1000	1.0000	0.0000	0.5000	359.000	0.3600	359.000
11	.	0.1000	1.0000	0.0000	0.5000	379.000	0.3600	379.000
12	.	0.1000	1.0000	0.0000	0.5000	395.000	0.3600	395.000
13	.	0.1000	1.0000	0.0000	0.5000	414.000	0.3600	414.000
14	.	0.1000	1.0000	0.0000	0.5000	420.000	0.3600	420.000
Unit	Numbers	-	-	-	-	Grams	-	Grams

Notes: Run name : Y1
Date and time: 18OCT94:16:01

Table 2. 13 Herring, summer spawning at Iceland (Fishing area Va).

Yield per recruit: Summary table

						1 January		Spawning time	
F Factor	Reference F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
0.0000	0.0000	0.000	0.000	7.917	2143.765	6.056	1945.519	5.760	1850.635
0.1500	0.0379	0.179	57.391	7.085	1835.114	5.223	1636.883	4.969	1557.051
0.3000	0.0750	0.305	95.170	6.435	1597.379	4.574	1399.162	4.351	1330.924
0.4500	0.1114	0.395	120.163	5.922	1411.913	4.061	1213.711	3.863	1154.518
0.6000	0.1469	0.460	136.776	5.510	1265.332	3.649	1067.144	3.471	1015.099
0.7500	0.1816	0.509	147.862	5.175	1147.957	3.315	949.783	3.153	903.462
0.9000	0.2157	0.546	155.278	4.900	1052.742	3.039	854.582	2.891	812.904
1.0500	0.2490	0.575	160.238	4.670	974.515	2.809	776.370	2.672	738.506
1.2000	0.2816	0.599	163.540	4.476	909.452	2.615	711.321	2.488	676.630
1.3500	0.3136	0.618	165.714	4.310	854.698	2.450	656.581	2.330	624.559
1.5000	0.3451	0.634	167.111	4.167	808.105	2.307	610.003	2.194	580.253
1.6500	0.3760	0.647	167.970	4.042	768.043	2.182	569.955	2.075	542.158
1.8000	0.4064	0.659	168.452	3.932	733.260	2.072	535.186	1.971	509.085
1.9500	0.4364	0.669	168.667	3.834	702.791	1.974	504.731	1.878	480.115
2.1000	0.4660	0.678	168.692	3.747	675.880	1.887	477.834	1.795	454.530
2.2500	0.4951	0.687	168.581	3.669	651.931	1.809	453.900	1.720	431.763
2.4000	0.5239	0.694	168.371	3.597	630.473	1.737	432.456	1.653	411.365
2.5500	0.5523	0.701	168.091	3.532	611.125	1.672	413.122	1.591	392.974
2.7000	0.5805	0.707	167.760	3.473	593.579	1.613	395.590	1.534	376.297
2.8500	0.6082	0.712	167.393	3.418	577.584	1.558	379.610	1.482	361.096
3.0000	0.6358	0.718	167.000	3.367	562.935	1.508	364.975	1.434	347.175
3.1500	0.6630	0.723	166.589	3.320	549.459	1.461	351.513	1.389	334.370
3.3000	0.6900	0.727	166.168	3.276	537.014	1.417	339.082	1.348	322.545
3.4500	0.7167	0.731	165.739	3.235	525.478	1.376	327.560	1.309	311.585
3.6000	0.7432	0.735	165.306	3.197	514.751	1.337	316.847	1.272	301.394
3.7500	0.7694	0.739	164.873	3.160	504.743	1.301	306.853	1.238	291.888
3.9000	0.7955	0.743	164.441	3.126	495.382	1.268	297.506	1.206	282.996
4.0500	0.8213	0.746	164.012	3.094	486.602	1.235	288.740	1.175	274.658
4.2000	0.8470	0.749	163.586	3.064	478.347	1.205	280.499	1.146	266.819
4.3500	0.8725	0.752	163.165	3.035	470.569	1.176	272.735	1.119	259.434
4.5000	0.8977	0.755	162.749	3.008	463.225	1.149	265.405	1.093	252.462
-	-	Numbers	Grams	Numbers	Grams	Numbers	Grams	Numbers	Grams

Notes: Run name : YIELD-94
Date and time : 18OCT94:16:20
Computation of ref. F: Weighted mean, age 4 - 14
F-0.1 factor : 0.8423
F-max factor : 2.0469
F-0.1 reference F : 0.1997
F-max reference F : 0.4504
Recruitment : Single recruit

Table 2. 14 Herring, Summer Spawning at Iceland (Fishing Area Va) (run name: HERVA RUN1)

At 18-Oct-94 11:32:16

Table 16 Summary (without SOP correction)

Traditional vpa using file input for terminal F

	RECRUITS, Age 1	TOTALBIO,	TOTSPBIO,	LANDINGS,	YIELD/SSB,	FBAR 3-12,
1947,	179506,	187248,	140720,	47800,	.3397,	.3502,
1948,	68007,	155807,	120358,	56800,	.4719,	1.5971,
1949,	77472,	109818,	90942,	5400,	.0594,	.0890,
1950,	197367,	117813,	86954,	13600,	.1564,	.1950,
1951,	116475,	128917,	87738,	15800,	.1801,	.2573,
1952,	323928,	148304,	100536,	10500,	.1044,	.4372,
1953,	197295,	174217,	108248,	17600,	.1626,	.3589,
1954,	167414,	195163,	147062,	11000,	.0748,	.1480,
1955,	191196,	216446,	169400,	20500,	.1210,	.1398,
1956,	469184,	242639,	169861,	20400,	.1201,	.1479,
1957,	791378,	318207,	179866,	22800,	.1268,	.2010,
1958,	369217,	331973,	199636,	33500,	.1678,	.2199,
1959,	555110,	382527,	278232,	35000,	.1258,	.2531,
1960,	712881,	371556,	258861,	28500,	.1101,	.0713,
1961,	531006,	393143,	286802,	74000,	.2580,	.2849,
1962,	525297,	411553,	310084,	92900,	.2996,	.4722,
1963,	467070,	350869,	267049,	130300,	.4879,	.7750,
1964,	585841,	259610,	189254,	86500,	.4571,	.8020,
1965,	507381,	265243,	156607,	122900,	.7848,	1.2134,
1966,	99674,	153782,	83727,	58400,	.6975,	.7637,
1967,	39279,	105861,	89307,	67700,	.7581,	1.3328,
1968,	178653,	47090,	27410,	16800,	.6129,	.7793,
1969,	47144,	43199,	16572,	20913,	1.2619,	.9457,
1970,	33805,	30085,	19816,	16445,	.8299,	1.1670,
1971,	70373,	23086,	13276,	11831,	.8912,	1.5835,
1972,	89677,	26806,	10694,	370,	.0346,	.1683,
1973,	418769,	74060,	28955,	255,	.0088,	.0490,
1974,	134222,	122023,	46179,	1274,	.0276,	.0292,
1975,	200239,	163808,	117438,	13280,	.1131,	.1098,
1976,	554112,	226117,	130191,	17168,	.1319,	.1573,
1977,	436442,	258946,	134036,	28924,	.2158,	.3000,
1978,	195360,	267279,	176745,	37333,	.2112,	.3229,
1979,	247634,	274698,	199447,	45072,	.2260,	.2331,
1980,	253201,	269067,	213929,	53269,	.2490,	.2827,
1981,	876281,	294166,	187323,	39544,	.2111,	.4471,
1982,	237704,	330504,	193623,	56528,	.2919,	.4598,
1983,	217420,	317830,	220198,	58665,	.2664,	.2121,
1984,	467366,	299082,	233018,	50293,	.2158,	.1311,
1985,	1205689,	391708,	249819,	49092,	.1965,	.1573,
1986,	666498,	467767,	258257,	65413,	.2533,	.3094,
1987,	358971,	526109,	360347,	75439,	.2094,	.4711,
1988,	519902,	544551,	423416,	91760,	.2167,	.7022,
1989,	312478,	496195,	394293,	100733,	.2555,	.4634,
1990,	1147242,	512901,	357659,	105593,	.2952,	.5661,
1991,	1647550,	590174,	298959,	109499,	.3663,	.4634,
1992,	792230,	661446,	375524,	106825,	.2845,	.3504,
1993,	1406950,	806018,	572027,	102802,	.1797,	.2487,
Arith. Mean ,	423147,	278413,	186817,	47809,	.3004,	.4515,
Units,	(Thousands),	(Tonnes),	(Tonnes),	(Tonnes),		

Table 3.1 Catches of Norwegian spring-spawning herring (tonnes) since 1972.

Year	A	B[1]	C	D	Total	Total catch as used by the Working Group
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	169,872[3]
1986	71,122[4]	55,507	156	-	126,785	225,256[3]
1987	62,910	49,798	181	-	112,899	127,306[3]
1988	78,592	46,582	127	-	125,301	135,301
1989	52,003	41,770	57	-	93,830	103,830
1990	48,633	29,770	8	-	78,411	86,411
1991	48,353	31,280	50	-	79,683	84,683
1992	43,688	55,737	23	-	99,448	104,448
1993	117,195	110,212	50	-	227,457	232,457
1994	215,186[5]	56,371[5]	-	-	-	-

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] Includes mortality caused by fishing operations in addition to unreported catches
[4] Includes 26,000 t of immature herring (1983 year-class) fished by USSR in the Barents Sea
[5] Preliminary Norwegian catch per 25 September 1994

Table 3.2 Total catch of Norwegian spring-spawning herring (tonnes) since 1972.

Year	Norway	USSR/Russia	Total
1972	13,161	-	13,161
1973	7,017	-	7,017
1974	7,619	-	7,619
1975	13,713	-	13,713
1976	10,436	-	10,436
1977	22,706	-	22,706
1978	19,824	-	19,824
1979	12,864	-	12,864
1980	18,577	-	18,577
1981	13,736	-	13,736
1982	16,655	-	16,655
1983	23,054	-	23,054
1984	53,532	-	53,532
1985	167,272	2,600	169,872
1986	199,256	26,000	225,256
1987	108,417	18,889	127,306
1988	115,076	20,225	135,301
1989	88,707	15,123	103,830
1990	74,604	11,807	86,411
1991	73,683	11,000	84,683
1992	91,111	13,337	104,448
1993	199,812[1]	32,645	232,457

[1]Preliminary.

Table 3.3

	Catch numbers at age Numbers*10**-3									
YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,
AGE										
3,	100,	3268,	23248,	22103,	3019,	6352,	6407,	4166,	13817,	3183,
4,	241,	132,	5436,	23595,	12164,	1866,	5814,	4591,	7892,	21191,
5,	24505,	910,	1,	336,	20315,	6865,	2278,	8596,	4507,	9521,
6,	257,	30667,	1,	1,	870,	11216,	8165,	2200,	6258,	6181,
7,	196,	5,	13086,	419,	1,	326,	15838,	4512,	1960,	6823,
8,	1,	2,	1,	10766,	620,	1,	441,	8280,	5075,	1293,
9,	1,	1,	1,	1,	5027,	1,	8,	345,	6047,	4598,
10,	1,	1,	1,	1,	1,	2534,	1,	103,	121,	7329,
11,	1,	1,	1,	1,	1,	1,	2688,	114,	37,	143,
+gp,	5,	5,	5,	5,	5,	5,	5,	968,	161,	1047,
TOTALNUM,	25308,	34992,	41781,	57228,	42023,	29167,	41645,	33875,	45875,	61309,
TONSLAND,	7619,	13713,	10436,	22706,	19824,	12864,	18577,	13736,	16655,	23054,
SOPCOF %,	121,	107,	105,	108,	104,	109,	101,	118,	102,	110,

Table 1	Catch numbers at age Numbers*10**-3									
YEAR,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,
AGE										
3,	4483,	21500,	539785,	19776,	62923,	2890,	18633,	8438,	12586,	28408,
4,	5388,	15500,	17594,	501393,	25059,	3623,	2658,	2780,	33100,	106866,
5,	61543,	16500,	14500,	18672,	550367,	5650,	11875,	1410,	4980,	87269,
6,	18202,	130000,	15500,	3502,	9452,	324290,	10854,	14698,	1193,	8625,
7,	12638,	59000,	105000,	7058,	3679,	3469,	226280,	8867,	11981,	3648,
8,	15608,	55000,	75000,	28000,	5964,	800,	1289,	218851,	5748,	29603,
9,	7215,	63000,	42000,	12000,	14583,	679,	1519,	2499,	225677,	18631,
10,	16338,	10000,	77000,	9500,	8872,	3297,	2036,	461,	2483,	410110,
11,	6478,	31000,	19469,	4500,	2818,	1375,	2415,	87,	639,	1,
+gp,	1656,	52641,	148471,	21788,	8146,	1260,	1890,	1590,	1486,	5,
TOTALNUM,	149549,	454141,	1054319,	626189,	691863,	347333,	279449,	259681,	299873,	693166,
TONSLAND,	53532,	169872,	225256,	127306,	135301,	103830,	86411,	84683,	104448,	232457,
SOPCOF %,	101,	103,	100,	103,	101,	105,	102,	101,	100,	100,

Table 3.4 Norwegian spring spawning herring. Recoveries of tags from year classes 1983-1988 by year of release.

Year of release	A	B	Sum	M	K	LnK	M_{93}
1986	4	1	5	15926	7.96	2.07	1443
1987	9	0	9	38135	10.59	2.36	4527
1988	21	1	22	43532	4.95	1.60	6770
1989	22	1	23	35875	3.90	1.36	7309
1990	21	2	23	29573	3.21	1.17	7892
1991	15	2	17	15053	2.21	0.79	5263
1992	26	2	28	23515	2.10	0.74	10770
Sum	118	9	127	201609			43973

A = Number recovered in the screened catch

B = Number recovered without data on the corresponding catch

M = Number released

K = M/(A+B)x400

M_{93} = Calculated number of survivals in 1993 using 40% initial mortality due to tagging.

Table 3.5 Norwegian spring-spawners. Acoustic abundance (TS= 20 logL - 71.9) of 0-group herring in Norwegian coastal waters in 1975-1991 (numbers in millions).

Year	Area				Total
	South of 62°N	62°N-65°N	65°N-68°N	North of 68°30'	
1975		164	346	28	538
1976		208	1,305	375	1,888
1977		35	153	19	207
1978		151	256	196	603
1979		455	1,130	144	1,729
1980		6	2	109	117
1981		132	1	1	134
1982		32	286	1,151	1,469
1983		162	2,276	4,432	6,866
1984		2	234	465	701
1985		221	177	104	502
1986		5	72	127	204
1987		327	26	57	410
1988		14	552	708	1,274
1989		575	263	2,052	2,890
1990		75	146	788	1,009
1991		80	299	2,428	2,807
1992		73	1993	621	2,891
1993	290	109	140	288	827

Table 3.6 Abundance indices for 0-group herring in the Barents Sea, 1973-1994

Year	Log index	Year	Log index
1973	0.05	1983	1.77
1974	0.01	1984	0.34
1975	0.00	1985	0.23
1976	0.00	1986	0.00
1977	0.01	1987	0.00
1978	0.02	1988	0.30
1979	0.09	1989	0.58
1980	0.00	1990	0.31
1981	0.00	1991	1.19
1982	0.00	1992	1.05
		1993	0.75
		1994	0.23

Table 3.7

Acoustic estimates of immature herring in the Barents Sea.

Year	Yearclass	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1983	Jan / feb												
	Mar / Apr												
	May / Jun												
	Juli / Aug												
	Sept / Okt												
	Nov / dec	17900											
1984	Jan / feb												
	Mar / Apr												
	May / Jun	21400											
	Juli / Aug												
	Sept / Okt												
	Nov / dec		3800										
1985	Jan / feb												
	Mar / Apr												
	May / Jun	19900											
	Juli / Aug												
	Sept / Okt			20800									
	Nov / dec			2700									
1986	Jan / feb	8100											
	Mar / Apr												
	May / Jun	3000											
	Juli / Aug												
	Sept / Okt												
	Nov / dec												
1987	Jan / feb												
	Mar / Apr												
	May / Jun												
	Juli / Aug												
	Sept / Okt												
	Nov / dec												
1988	Jan / feb												
	Mar / Apr												
	May / Jun												
	Juli / Aug												
	Sept / Okt												
	Nov / dec						4900						
1989	Jan / feb												
	Mar / Apr												
	May / Jun												
	Juli / Aug												
	Sept / Okt												
	Nov / dec												
1990	Jan / feb												
	Mar / Apr												
	May / Jun							4400					
	Juli / Aug												
	Sept / Okt						221	4748					
	Nov / dec												
1991	Jan / feb												
	Mar / Apr												
	May / Jun							5200	24300				
	Juli / Aug												
	Sept / Okt												
	Nov / dec												
1992	Jan / feb												
	Mar / Apr												
	May / Jun							5731	14027	32614			
	Juli / Aug												
	Sept / Okt										300000		
	Nov / dec												
1993	Jan / feb												
	Mar / Apr												
	May / Jun								1470	25790	102670		
	Juli / Aug												
	Sept / Okt											100000	
	Nov / dec												
1994	Jan / feb												
	Mar / Apr												
	May / Jun								1700	18000	59200	6600	
	Juli / Aug												
	Sept / Okt												
	Nov / dec												

Table 3.8 Adult stock size as at 1 January 1994.

Year class	Year class distribution %	Estimate (million individuals	Estimate (million individuals in the Barents Sea, Section 3.4.3)	Total
1983	29.1	3,200	-	3,200
1984	0.6	66	-	66
1985	1.2	132	-	132
1986	0.1	11	-	11
1987	0.4	44	-	44
1988	10.1	1,111	-	1,111
1989	29.1	3,200	-	3,200
1990	20.8	2,287	1,871	4,158
1991	8.0	880	19,810	20,690

Table 3.9

Run title : Herring, Norwegian Spring Spawners (run name: VPA7493)

At 21-Oct-94 16:11:38

Table 2 Catch weights at age (kg) YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,
AGE										
3,	.1680,	.2410,	.1890,	.3160,	.2740,	.2930,	.2660,	.1960,	.2560,	.2170,
4,	.2220,	.3180,	.2500,	.3500,	.4240,	.3590,	.3990,	.2910,	.3120,	.2650,
5,	.2490,	.3580,	.2800,	.3980,	.4540,	.4160,	.4490,	.3410,	.3780,	.3370,
6,	.2650,	.3810,	.2980,	.4390,	.4950,	.4360,	.4600,	.3680,	.4150,	.3780,
7,	.2880,	.4130,	.3230,	.4950,	.5240,	.4820,	.4850,	.3800,	.4350,	.4100,
8,	.2990,	.4290,	.3360,	.5110,	.5960,	.4820,	.4720,	.3970,	.4490,	.4260,
9,	.3370,	.4840,	.3790,	.5580,	.6130,	.5390,	.6180,	.4360,	.4480,	.4350,
10,	.3520,	.5060,	.3960,	.5830,	.6500,	.5530,	.6450,	.4500,	.5060,	.4440,
11,	.2670,	.3840,	.3000,	.5370,	.5900,	.5180,	.6080,	.4920,	.4930,	.4680,
+gp,	.3240,	.4660,	.3640,	.5370,	.5900,	.5180,	.5940,	.4810,	.4990,	.4610,
SOPCOFAC,	1.2095,	1.0675,	1.0453,	1.0766,	1.0382,	1.0865,	1.0132,	1.1828,	1.0218,	1.0976,

Table 2 Catch weights at age (kg) YEAR,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,
AGE										
3,	.2180,	.2140,	.0550,	.1240,	.1240,	.1880,	.2300,	.2080,	.1910,	.1530,
4,	.2620,	.2770,	.2490,	.1730,	.1540,	.2640,	.2390,	.2500,	.2330,	.2430,
5,	.3250,	.2950,	.2940,	.2530,	.1940,	.2600,	.2660,	.2880,	.3040,	.2820,
6,	.3460,	.3380,	.3120,	.2320,	.2410,	.2820,	.3050,	.3120,	.3370,	.3200,
7,	.3810,	.3600,	.3520,	.3120,	.2650,	.3060,	.3080,	.3160,	.3650,	.3300,
8,	.4000,	.3810,	.3740,	.3280,	.3040,	.3090,	.3760,	.3300,	.3610,	.3650,
9,	.4130,	.3970,	.3980,	.3490,	.3050,	.3910,	.4070,	.3440,	.3710,	.3730,
10,	.4050,	.4090,	.4020,	.3530,	.3170,	.4220,	.4120,	.3720,	.4030,	.3790,
11,	.4260,	.4170,	.4010,	.3700,	.3080,	.3640,	.4240,	.3540,	.3650,	.3800,
+gp,	.4150,	.4350,	.4100,	.3850,	.3340,	.4290,	.4280,	.3980,	.4020,	.3950,
SOPCOFAC,	1.0141,	1.0306,	1.0032,	1.0291,	1.0071,	1.0549,	1.0183,	1.0062,	1.0039,	1.0016,

Table 3.10

Run title : Herring, Norwegian Spring Spawners (run name: VPA7493)

At 21-Oct-94 16:11:38

Table 3 Stock weights at age (kg)

YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,
AGE										
3,	.1700,	.1810,	.1810,	.1810,	.1800,	.1780,	.1750,	.1700,	.1700,	.1550,
4,	.2590,	.2590,	.2590,	.2590,	.2940,	.2320,	.2830,	.2240,	.2040,	.2490,
5,	.3420,	.3420,	.3420,	.3430,	.3260,	.3590,	.3470,	.3360,	.3030,	.3040,
6,	.3840,	.3840,	.3840,	.3840,	.3710,	.3850,	.4020,	.3780,	.3550,	.3680,
7,	.4090,	.4090,	.4090,	.4090,	.4090,	.4200,	.4210,	.3870,	.3830,	.4040,
8,	.4440,	.4440,	.4440,	.4440,	.4610,	.4440,	.4650,	.4080,	.3950,	.4240,
9,	.4610,	.4610,	.4610,	.4610,	.4760,	.5050,	.4650,	.3970,	.4130,	.4370,
10,	.5200,	.5200,	.5200,	.5200,	.5200,	.5200,	.5200,	.5200,	.4530,	.4360,
11,	.5430,	.5430,	.5430,	.5430,	.5430,	.5510,	.5340,	.5430,	.4680,	.4930,
+gp,	.4820,	.4820,	.4820,	.4820,	.5000,	.5000,	.5000,	.5120,	.5060,	.4950,

Table 3 Stock weights at age (kg)

YEAR,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,
AGE										
3,	.1400,	.1480,	.0540,	.0900,	.0980,	.1540,	.2190,	.1470,	.1280,	.0810,
4,	.2040,	.2340,	.2060,	.1430,	.1350,	.1750,	.1980,	.2100,	.2240,	.2010,
5,	.2950,	.2650,	.2650,	.2410,	.1970,	.2090,	.2580,	.2440,	.2960,	.2650,
6,	.3380,	.3120,	.2890,	.2790,	.2770,	.2520,	.2880,	.3000,	.3270,	.3230,
7,	.3760,	.3460,	.3390,	.2990,	.3150,	.3050,	.3090,	.3240,	.3550,	.3540,
8,	.3950,	.3700,	.3680,	.3160,	.3390,	.3670,	.4280,	.3360,	.3450,	.3580,
9,	.4070,	.3950,	.3910,	.3420,	.3430,	.3770,	.3700,	.3430,	.3670,	.3810,
10,	.4130,	.3970,	.3820,	.3430,	.3590,	.3590,	.4030,	.3820,	.3410,	.3690,
11,	.4220,	.4280,	.3880,	.3620,	.3650,	.3950,	.3870,	.3660,	.3610,	.3960,
+gp,	.4370,	.4280,	.3950,	.3760,	.3760,	.3960,	.4400,	.4250,	.4630,	.3940,

Table 3.11

Run title : Herring, Norwegian Spring Spawners (run name: VPA7493)

At 21-Oct-94 16:11:38

Table 4 Natural Mortality (M) at age

YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,
AGE										
3,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
4,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
5,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
6,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
7,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
8,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
9,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
10,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
11,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
+gp,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,

Table 4 Natural Mortality (M) at age

YEAR,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,
AGE										
3,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,	.2300,
4,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,	.2300,
5,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,	.2300,
6,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,	.2300,
7,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,	.2300,
8,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,	.2300,
9,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,	.2300,
10,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,	.2300,
11,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,	.2300,
+gp,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,	.2300,

Table 3.12

Run title : Herring, Norwegian Spring Spawners (run name: VPA7493)

At 21-Oct-94 16:11:38

Table 5 Proportion mature at age

YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,
AGE										
3,	.5000,	.5000,	.5000,	.7300,	.1300,	.1000,	.2500,	.3000,	.1000,	.1000,
4,	.9000,	1.0000,	.9000,	.8900,	.9000,	.6200,	.5000,	.5000,	.4800,	.5000,
5,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	.9500,	.9700,	.9000,	.7000,	.6900,
6,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	.7100,
7,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
8,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
9,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
10,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
11,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
+gp,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,

Table 5 Proportion mature at age

YEAR,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,
AGE										
3,	.1000,	.1000,	.1000,	.1000,	.1000,	.1000,	.4000,	.1000,	.1000,	.0100,
4,	.5000,	.5000,	.2000,	.3000,	.3000,	.3000,	.8000,	.7000,	.2000,	.3000,
5,	.9000,	.9000,	.9000,	.9000,	.9000,	.9000,	.9000,	1.0000,	.8000,	.8000,
6,	.9500,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	.9000,	1.0000,	1.0000,	1.0000,
7,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	.9000,	1.0000,	1.0000,	1.0000,
8,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
9,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
10,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
11,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,
+gp,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,

Table 3.13

Run title : Herring, Norwegian Spring Spawners (run name: VPA7493)

At 21-Oct-94 16:11:38

Traditional vpa using file input for terminal F

Table 8 Fishing mortality (F) at age YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,
AGE										
3,	.0249,	.1467,	.0300,	.0436,	.0218,	.0140,	.0213,	.0104,	.0197,	.0363,
4,	.0194,	.0386,	.3549,	.0358,	.0284,	.0156,	.0148,	.0177,	.0228,	.0354,
5,	.1009,	.0881,	.0003,	.0306,	.0364,	.0187,	.0221,	.0254,	.0202,	.0322,
6,	1.6646,	.1640,	.0001,	.0004,	.0959,	.0236,	.0258,	.0249,	.0216,	.0324,
7,	2.0959,	.1014,	.0907,	.0566,	.0004,	.0439,	.0391,	.0166,	.0259,	.0274,
8,	.0452,	.0884,	.0246,	.0931,	.1032,	.0005,	.0716,	.0241,	.0217,	.0199,
9,	.0541,	.0541,	.0541,	.0288,	.0533,	.0002,	.0046,	.0685,	.0205,	.0229,
10,	.0653,	.0653,	.0653,	.0653,	.0339,	.0319,	.0002,	.0697,	.0287,	.0289,
11,	.0800,	.0800,	.0800,	.0800,	.0800,	.0400,	.0400,	.0300,	.0300,	.0400,
+gp,	.0800,	.0800,	.0800,	.0800,	.0800,	.0400,	.0400,	.0300,	.0300,	.0400,
FBAR 5-10,	.6710,	.0935,	.0392,	.0458,	.0538,	.0198,	.0273,	.0382,	.0231,	.0273,

Table 8 Fishing mortality (F) at age YEAR,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	FBAR 91-93
AGE											
3,	.0419,	.1705,	.0334,	.0565,	.1182,	.0672,	.1431,	.0039,	.0027,	.0061,	.0042,
4,	.0739,	.1842,	.1901,	.0365,	.0876,	.0083,	.0756,	.0279,	.0195,	.0292,	.0255,
5,	.1267,	.3105,	.2425,	.2915,	.0476,	.0238,	.0315,	.0511,	.0657,	.0674,	.0614,
6,	.0739,	.3916,	.4923,	.0786,	.2172,	.0333,	.0541,	.0484,	.0574,	.1600,	.0886,
7,	.0796,	.3318,	.5800,	.4007,	.1030,	.1070,	.0273,	.0558,	.0523,	.2570,	.1217,
8,	.0752,	.5257,	.8360,	.2738,	.6407,	.0272,	.0490,	.0325,	.0480,	.1820,	.0875,
9,	.1368,	.4424,	.9138,	.2739,	.2069,	.1245,	.0616,	.1236,	.0438,	.2230,	.1301,
10,	.0983,	.2627,	1.4545,	.4885,	.3082,	.0611,	.5985,	.0233,	.1795,	.1078,	.1035,
11,	.0300,	.2520,	1.0800,	.2500,	.2400,	.0660,	.0540,	.0430,	.0420,	.0001,	.0284,
+gp,	.0300,	.2520,	1.0800,	.2500,	.2400,	.0660,	.0540,	.0430,	.0420,	.0001,	
FBAR 5-10,	.0984,	.3774,	.7532,	.3012,	.2539,	.0628,	.1370,	.0558,	.0744,	.1662,	

Table 3.14

Run title : Herring, Norwegian Spring Spawners (run name: VPA7493)

At 21-Oct-94 16:11:38

Traditional vpa using file input for terminal F

Table 10 YEAR,	Stock number at age (start of year) 1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,
						Numbers*10**-4				
AGE										
3,	434,	2550,	83905,	55180,	14937,	48767,	32428,	42930,	75466,	9514,
4,	1335,	372,	1933,	71501,	46385,	12833,	42227,	27875,	37306,	64972,
5,	27190,	1150,	314,	1190,	60576,	39592,	11094,	36535,	24047,	32020,
6,	33,	21583,	925,	276,	1014,	51290,	34122,	9528,	31277,	20693,
7,	23,	6,	16085,	812,	242,	809,	43987,	29198,	8161,	26878,
8,	2,	3,	4,	12900,	674,	212,	680,	37143,	25217,	6982,
9,	2,	2,	2,	4,	10321,	534,	186,	556,	31840,	21667,
10,	2,	2,	2,	2,	3,	8592,	468,	163,	456,	27392,
11,	1,	1,	1,	1,	1,	3,	7307,	411,	133,	389,
+gp,	7,	7,	7,	7,	7,	14,	14,	3492,	581,	2846,
TOTAL,	29030,	25674,	103179,	141873,	134159,	162644,	172514,	187831,	234482,	213355,

Table 10 YEAR,	Stock number at age (start of year) 1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	1994,	GMST
						Numbers*10**-4						
AGE												
3,	11645,	14603,	1754187,	38349,	60133,	4736,	14880,	242719,	524303,	522843,	0,	265
4,	8056,	9806,	10813,	1489816,	31823,	46918,	3889,	11324,	192098,	415457,	412890,	166
5,	55068,	6570,	7162,	7851,	1261268,	25599,	40859,	3166,	8750,	149686,	320595,	144
6,	27225,	42600,	4229,	4935,	5151,	1056004,	21950,	34767,	2390,	6510,	111179,	91
7,	17592,	22203,	25285,	2270,	4005,	3640,	896917,	18258,	26317,	1793,	4408,	44
8,	22963,	14265,	13991,	12432,	1335,	3173,	2872,	766396,	13719,	19845,	1102,	19
9,	6010,	18703,	7405,	5325,	8302,	618,	2711,	2401,	589475,	10389,	13144,	7
10,	18596,	4603,	10552,	2608,	3556,	5927,	479,	2239,	1686,	448303,	6605,	3
11,	23367,	14800,	3108,	2164,	1405,	2294,	4896,	231,	1738,	1119,	319791,	1
+gp,	5973,	25133,	23702,	10476,	4061,	2102,	3832,	4225,	4041,	5597,	5336,	
TOTAL,	196496,	173287,	1860436,	1576223,	1381038,	1151012,	993285,	1085725,	1364516,	1581541,	1195050,	

Table 3.15

Run title : Herring, Norwegian Spring Spawners (run name: VPA7493)

At 21-Oct-94 16:11:38

Traditional vpa using file input for terminal F

Table 13 Spawning stock biomass at age (spawning time) Tonnes YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,
AGE										
3,	363,	2244,	74729,	71655,	3443,	8556,	13974,	21589,	12639,	1450,
4,	3066,	947,	4293,	162106,	120806,	18192,	58893,	30762,	35976,	79564,
5,	90866,	3848,	1060,	4018,	194218,	133034,	36777,	108779,	50243,	66084,
6,	107,	80478,	3505,	1045,	3677,	194456,	135051,	35463,	109362,	53197,
7,	76,	22,	64353,	3259,	977,	3339,	182081,	111353,	30772,	106891,
8,	11,	11,	19,	56014,	3034,	931,	3098,	149225,	98106,	29165,
9,	9,	9,	9,	17,	48234,	2660,	855,	2163,	129534,	93250,
10,	9,	9,	9,	9,	16,	43961,	2404,	831,	2031,	117547,
11,	7,	7,	7,	7,	7,	15,	38364,	2197,	615,	1884,
+gp,	33,	33,	33,	33,	34,	67,	67,	17594,	2892,	13852,
TOTSPBIO,	94547,	87608,	148018,	298162,	374447,	405210,	471564,	479955,	472170,	562884,

Table 13 Spawning stock biomass at age (spawning time) Tonnes YEAR,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,
AGE										
3,	1603,	2097,	93191,	3388,	5749,	715,	12684,	34855,	65567,	4136,
4,	8052,	11118,	4315,	628576,	12611,	24294,	6034,	16223,	83940,	244111,
5,	142501,	14995,	16457,	16326,	2196859,	47417,	93356,	7511,	20117,	308035,
6,	85655,	126157,	11486,	13483,	13781,	2618031,	55856,	101436,	7594,	20223,
7,	64775,	73356,	79842,	6437,	12327,	10842,	2455405,	57490,	90826,	6046,
8,	88861,	49432,	46747,	37729,	4191,	11463,	12073,	2508382,	46033,	68179,
9,	23818,	69767,	26084,	17491,	27532,	2271,	9842,	7949,	2104950,	37831,
10,	75066,	17570,	34401,	8407,	12217,	20877,	1795,	8338,	5518,	1599289,
11,	97043,	60972,	10685,	7540,	4941,	8886,	18603,	823,	6105,	4332,
+gp,	25689,	103536,	82954,	37920,	14714,	8164,	16553,	17474,	18208,	21551,
TOTSPBIO,	613063,	529000,	406162,	777298,	2304922,	2752959,	2682200,	2760481,	2448860,	2313732,

Table 3.16

Run title : Herring, Norwegian Spring Spawners (run name: V5093)

At 21-Oct-94 16:17:58

Table 16 Summary (without SOP correction)

Traditional vpa using file input for terminal F

	RECRUITS, Age 3	TOTALBIO,	TOTSPBIO,	LANDINGS,	YIELD/SSB,	FBAR 5-10,
1950,	9975288,	17242108,	13686284,	933000,	.0682,	.0718,
1951,	5416803,	14265558,	10937858,	1278400,	.1169,	.0866,
1952,	3811720,	11760410,	8900434,	1254800,	.1410,	.0969,
1953,	49068732,	15340126,	8424798,	1090600,	.1295,	.0871,
1954,	7306779,	15400232,	6029080,	1644500,	.2728,	.1208,
1955,	3425671,	13909710,	7850482,	1359800,	.1732,	.0929,
1956,	3203643,	12951094,	10191852,	1659400,	.1628,	.1094,
1957,	596557,	10866796,	9547430,	1319500,	.1382,	.0888,
1958,	494281,	8877070,	8181251,	986600,	.1206,	.0763,
1959,	181378,	7523345,	7119282,	1111100,	.1561,	.1011,
1960,	251549,	6276031,	5983441,	1101800,	.1841,	.1043,
1961,	239132,	4255945,	4093195,	830100,	.2028,	.0759,
1962,	21064656,	6387808,	4121587,	848600,	.2059,	.0849,
1963,	7244717,	6970370,	3213962,	984500,	.3063,	.0971,
1964,	2134743,	6257809,	2893054,	1281800,	.4431,	.1660,
1965,	198775,	4412105,	2922188,	1547700,	.5296,	.2877,
1966,	8271638,	3765850,	2655031,	1955000,	.7363,	.8624,
1967,	3801734,	2735170,	1218573,	1677200,	1.3764,	1.3393,
1968,	107689,	790051,	221072,	712200,	3.2216,	1.9079,
1969,	228176,	94690,	77905,	67800,	.8703,	.5612,
1970,	15894,	43544,	30537,	62300,	2.0401,	.9829,
1971,	7477,	11573,	7698,	21100,	2.7409,	1.2308,
1972,	420895,	66672,	1523,	13161,	8.6435,	1.8733,
1973,	17750,	94082,	81899,	7017,	.0857,	1.2896,
1974,	4341,	97478,	94547,	7619,	.0806,	.6710,
1975,	25495,	92482,	87608,	13713,	.1565,	.0935,
1976,	839055,	227368,	148018,	10436,	.0705,	.0392,
1977,	551802,	350870,	298162,	22706,	.0762,	.0458,
1978,	149365,	417776,	374446,	19824,	.0529,	.0538,
1979,	487668,	507973,	405211,	12864,	.0317,	.0198,
1980,	324276,	582659,	471564,	18577,	.0394,	.0273,
1981,	429297,	581898,	479955,	13736,	.0286,	.0382,
1982,	754656,	656277,	472170,	16655,	.0353,	.0231,
1983,	95143,	718335,	562884,	23054,	.0410,	.0273,
1984,	116451,	670034,	613063,	53532,	.0873,	.0984,
1985,	146029,	587551,	529000,	169872,	.3211,	.3774,
1986,	17541876,	1312888,	406162,	225256,	.5546,	.7532,
1987,	383487,	2318088,	777297,	127306,	.1638,	.3012,
1988,	601332,	2679639,	2304921,	135301,	.0587,	.2539,
1989,	47364,	2867777,	2752960,	103830,	.0377,	.0628,
1990,	148801,	3040454,	2682200,	86411,	.0322,	.1370,
1991,	2427193,	3162440,	2760480,	84683,	.0307,	.0558,
1992,	5243030,	3469986,	2448859,	104448,	.0427,	.0744,
1993,	5228427,	3473965,	2313733,	232457,	.1005,	.1662,
Arith. Mean ,	3705245,	4502593,	3167582,	573415,	.5706,	.3435,
Units,	(Thousands),	(Tonnes),	(Tonnes),	(Tonnes),		

Table 3.17

Herring, Norwegian Spring Spawners

Single option prediction: Input data

Year: 1994								
Age	Stock size	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
3	20690.000	0.2300	0.0100	0.1000	0.1000	0.075	0.0040	0.196
4	4128.900	0.2300	0.3000	0.1000	0.1000	0.151	0.0400	0.241
5	3205.950	0.2300	0.8000	0.1000	0.1000	0.254	0.1660	0.285
6	1111.790	0.2300	1.0000	0.1000	0.1000	0.318	0.1660	0.319
7	44.080	0.2300	1.0000	0.1000	0.1000	0.371	0.1660	0.330
8	11.020	0.2300	1.0000	0.1000	0.1000	0.347	0.1660	0.358
9	131.440	0.2300	1.0000	0.1000	0.1000	0.412	0.1660	0.374
10	66.050	0.2300	1.0000	0.1000	0.1000	0.382	0.1660	0.392
11	3197.910	0.2300	1.0000	0.1000	0.1000	0.407	0.1660	0.381
12+	53.360	0.2300	1.0000	0.1000	0.1000	0.410	0.1660	0.401
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Year: 1995								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
3	43203.000	0.2300	0.0000	0.1000	0.1000	0.083	0.0040	0.160
4	.	0.2300	0.0100	0.1000	0.1000	0.161	0.0400	0.216
5	.	0.2300	0.8000	0.1000	0.1000	0.245	0.1660	0.272
6	.	0.2300	1.0000	0.1000	0.1000	0.302	0.1660	0.315
7	.	0.2300	1.0000	0.1000	0.1000	0.344	0.1660	0.332
8	.	0.2300	1.0000	0.1000	0.1000	0.337	0.1660	0.353
9	.	0.2300	1.0000	0.1000	0.1000	0.384	0.1660	0.372
10	.	0.2300	1.0000	0.1000	0.1000	0.371	0.1660	0.391
11	.	0.2300	1.0000	0.1000	0.1000	0.389	0.1660	0.387
12+	.	0.2300	1.0000	0.1000	0.1000	0.393	0.1660	0.402
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Year: 1996								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
3	1637.000	0.2300	0.0100	0.1000	0.1000	0.092	0.0040	0.125
4	.	0.2300	0.0800	0.1000	0.1000	0.172	0.0400	0.190
5	.	0.2300	0.6000	0.1000	0.1000	0.236	0.1660	0.259
6	.	0.2300	0.9200	0.1000	0.1000	0.286	0.1660	0.310
7	.	0.2300	1.0000	0.1000	0.1000	0.316	0.1660	0.335
8	.	0.2300	1.0000	0.1000	0.1000	0.328	0.1660	0.349
9	.	0.2300	1.0000	0.1000	0.1000	0.355	0.1660	0.370
10	.	0.2300	1.0000	0.1000	0.1000	0.361	0.1660	0.389
11	.	0.2300	1.0000	0.1000	0.1000	0.372	0.1660	0.393
12+	.	0.2300	1.0000	0.1000	0.1000	0.376	0.1660	0.404
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Year: 1997								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
3	1637.000	0.2300	0.0200	0.1000	0.1000	0.100	0.0040	0.089
4	.	0.2300	0.1400	0.1000	0.1000	0.182	0.0400	0.165
5	.	0.2300	0.3900	0.1000	0.1000	0.227	0.1660	0.246
6	.	0.2300	0.8300	0.1000	0.1000	0.270	0.1660	0.306
7	.	0.2300	1.0000	0.1000	0.1000	0.289	0.1660	0.337
8	.	0.2300	1.0000	0.1000	0.1000	0.318	0.1660	0.344
9	.	0.2300	1.0000	0.1000	0.1000	0.327	0.1660	0.367
10	.	0.2300	1.0000	0.1000	0.1000	0.350	0.1660	0.388
11	.	0.2300	1.0000	0.1000	0.1000	0.354	0.1660	0.398
12+	.	0.2300	1.0000	0.1000	0.1000	0.359	0.1660	0.405
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

(cont.)

Table 3.17 Continued

Herring, Norwegian Spring Spawners

Single option prediction: Input data

(cont.)

Year: 1998								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
3	1637.000	0.2300	0.0200	0.1000	0.1000	0.100	0.0040	0.089
4	.	0.2300	0.1400	0.1000	0.1000	0.182	0.0400	0.165
5	.	0.2300	0.3900	0.1000	0.1000	0.227	0.1660	0.246
6	.	0.2300	0.8300	0.1000	0.1000	0.270	0.1660	0.306
7	.	0.2300	1.0000	0.1000	0.1000	0.289	0.1660	0.337
8	.	0.2300	1.0000	0.1000	0.1000	0.318	0.1660	0.344
9	.	0.2300	1.0000	0.1000	0.1000	0.327	0.1660	0.367
10	.	0.2300	1.0000	0.1000	0.1000	0.350	0.1660	0.388
11	.	0.2300	1.0000	0.1000	0.1000	0.354	0.1660	0.398
12+	.	0.2300	1.0000	0.1000	0.1000	0.359	0.1660	0.405
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Year: 1999								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
3	1637.000	0.2300	0.0200	0.1000	0.1000	0.100	0.0040	0.089
4	.	0.2300	0.1400	0.1000	0.1000	0.182	0.0400	0.165
5	.	0.2300	0.3900	0.1000	0.1000	0.227	0.1660	0.246
6	.	0.2300	0.8300	0.1000	0.1000	0.270	0.1660	0.306
7	.	0.2300	1.0000	0.1000	0.1000	0.289	0.1660	0.337
8	.	0.2300	1.0000	0.1000	0.1000	0.318	0.1660	0.344
9	.	0.2300	1.0000	0.1000	0.1000	0.327	0.1660	0.367
10	.	0.2300	1.0000	0.1000	0.1000	0.350	0.1660	0.388
11	.	0.2300	1.0000	0.1000	0.1000	0.354	0.1660	0.398
12+	.	0.2300	1.0000	0.1000	0.1000	0.359	0.1660	0.405
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Notes: Run name : P9499
Date and time: 21OCT94:14:37

Table 3.18

Herring, Norwegian Spring Spawners

Herring, Norwegian Spring Spawners

Prediction with management option table

Year: 1994					Year: 1995					Year: 1996	
F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	Stock biomass	Sp.stock biomass
1.2125	0.2013	4766063	2522561	485000	0.0000	0.0000	8753797	2352556	0	11222846	4259040
.	.	.	.	.	0.2000	0.0332	.	2344823	107679	11125088	4166430
.	.	.	.	.	0.4000	0.0664	.	2337116	212725	11029768	4076618
.	.	.	.	.	0.6000	0.0996	.	2329434	315218	10936812	3989509
.	.	.	.	.	0.8000	0.1328	.	2321778	415234	10846147	3905011
.	.	.	.	.	1.0000	0.1660	.	2314147	512848	10757704	3823037
.	.	.	.	.	1.2000	0.1992	.	2306541	608132	10671415	3743501
.	.	.	.	.	1.4000	0.2324	.	2298960	701157	10587214	3666322
.	.	.	.	.	1.6000	0.2656	.	2291405	791988	10505037	3591420
.	.	.	.	.	1.8000	0.2988	.	2283874	880694	10424824	3518719
.	.	.	.	.	2.0000	0.3320	.	2276369	967335	10346515	3448145
.	.	.	.	.	2.2000	0.3652	.	2268888	1051975	10270053	3379627
.	.	.	.	.	2.4000	0.3984	.	2261432	1134673	10195381	3313096
.	.	.	.	.	2.6000	0.4316	.	2254000	1215485	10122445	3248487
.	.	.	.	.	2.8000	0.4648	.	2246594	1294469	10051195	3185735
.	.	.	.	.	3.0000	0.4980	.	2239211	1371677	9981578	3124778
-	-	Tonnes	Tonnes	Tonnes	-	-	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes

Notes: Run name : P9496
Date and time : 21OCT94:14:16
Computation of ref. F: Simple mean, age 5 - 10
Basis for 1994 : TAC constraints

Table 4.1 Barents Sea CAPELIN. International catch ('000 t) as used by the Working Group

Year	Winter				Summer-Autumn			Total
	Norway	Russia	Others	Total	Norway	Russia	Total	
1965	217	7	0	224	0	0	0	224
1966	380	9	0	389	0	0	0	389
1967	403	6	0	409	0	0	0	409
1968	460	15	0	475	62	0	62	537
1969	436	1	0	437	243	0	243	680
1970	955	8	0	963	346	5	351	1314
1971	1300	14	0	1314	71	7	78	1392
1972	1208	24	0	1232	347	13	360	1592
1973	1078	34	0	1111	213	12	225	1336
1974	749	63	0	812	237	99	336	1149
1975	559	301	43	903	407	131	538	1440
1976	1252	228	0	1480	739	368	1107	2587
1977	1441	317	2	1760	722	504	1227	2987
1978	784	429	25	1237	360	318	678	1915
1979	539	342	5	886	570	326	896	1783
1980	539	253	9	801	459	388	847	1648
1981	784	429	28	1240	454	292	746	1986
1982	568	260	5	833	591	336	927	1760
1983	751	373	36	1161	758	439	1197	2358
1984	330	257	42	629	481	368	849	1478
1985	340	234	17	590	113	164	278	868
1986	72	51	0	123	0	0	0	123
1987	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0
1991	528	159	20	707	31	195	226	933[1]
1992	620	247	24	891	73	159	232	1123[1]
1993	402	170	14	586	0	0	0	586
1994	0	0	0	0	0	0	0	0

[1]Revised.

Table 4.2 Barents Sea CAPELIN. Larval abundance (10^{12}) in June

Year	Index
1981	9.7
1982	9.9
1983	9.9
1984	8.2
1985	8.6
1986	-
1987	0.3
1988	0.3
1989	7.3
1990	13.0
1991	3.0
1992	7.3
1993	3.3
1994	0.09

Table 4.3 Acoustic estimate of Barents Sea CAPELIN, September-October 1994

Year class	1993	1992	1991	1990	Total number (10^9)	Biomass (10^3 t.)	Mean weight (g)
Age (years)	1	2	3	4			
Length (cm)							
7.0 - 7.5	0.13				0.13	0.1	1.0
7.5 - 8.0	1.04				1.04	1.6	1.6
8.0 - 8.5	2.73				2.73	5.2	1.9
8.5 - 9.0	2.70	0.12			2.82	5.9	2.1
9.0 - 9.5	2.29	0.07			2.36	6.9	2.9
9.5 - 10.0	1.03	+			1.03	3.6	3.5
10.0 - 10.5	1.87	0.05			1.92	8.0	4.2
10.5 - 11.0	1.21	0.08			1.29	6.6	5.1
11.0 - 11.5	2.28	0.23			2.51	14.8	5.9
11.5 - 12.0	1.80	0.41	0.04		2.25	15.4	6.8
12.0 - 12.5	1.46	0.34	0.15		1.94	15.2	7.8
12.5 - 13.0	0.52	0.25	0.14		0.92	8.4	9.1
13.0 - 13.5	0.31	0.18	0.08		0.57	6.0	10.7
13.5 - 14.0	0.20	0.21	0.17	0.02	0.60	7.1	11.8
14.0 - 14.5	0.13	0.49	0.49	0.03	1.14	15.0	13.2
14.5 - 15.0	0.04	0.40	0.83	+	1.27	19.3	15.2
15.0 - 15.5	0.02	0.35	0.89	0.02	1.29	22.1	17.2
15.5 - 16.0		0.18	0.83	0.04	1.04	19.9	19.1
16.0 - 16.5		0.05	0.43	0.03	0.51	11.0	21.6
16.5 - 17.0		0.02	0.22	0.02	0.26	6.1	23.5
17.0 - 17.5			0.03	0.01	0.04	0.9	26.6
17.5 - 18.0			+		+	+	33.0
Number (10^9)	19.76	3.43	4.30	0.17	27.65		
Biomass (10^3 tonnes)	86.8	38.5	71.0	3.1		199.3	
Mean length (cm)	10.09	13.21	15.01	15.42	11.28		
Mean weight (g)	4.4	11.2	16.5	18.4			7.2

C-value used: 2,00 · 10^6 · $L^{-1,91}$

Table 4.4 Stock size in numbers by age, total stock biomass and biomass of the maturing component of the Barents Sea capelin 1973 to 1994. Both stock in numbers (10^{-9}) and stock and maturing stock biomass (10^{-3} tonnes) are at 1 October.

Year	Stock in numbers (billions)						Stock in weight ('000 t)	
	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Total	Mature
1973	770	379	42	18	+	1209	5810	1385
1974	540	564	179	4	+	1287	6624	948
1975	380	361	304	88	1	1134	8735	2965
1976	265	241	167	78	13	764	6792	2701
1977	625	181	102	42	7	957	5461	2762
1978	515	371	100	14	1	1000	5888	2013
1979	360	334	112	5	+	811	5562	1202
1980	335	197	154	33	+	719	6969	3867
1981	600	195	48	14	+	857	4287	1550
1982	496	146	57	2	0	701	3750	1365
1983	515	200	38	+	0	754	4230	1328
1984	145	184	48	3	0	380	2864	1142
1985	35	47	21	1	0	104	822	275
1986	7	3	3	+	0	14	116	63
1987	37	2	+	+	0	39	100	17
1988	20	29	+	0	0	49	427	203
1989	178	19	1	+	0	198	872	181
1990	700	177	17	+	0	894	5834	2620
1991	392	574	33	+	0	1000	7096	2117
1992	351	196	129	1	0	678	5150	2201
1993	2	53	17	2	0	75	796	330
1994	20	3	4	+	0	28	199	94

Table 4.5 Barents Sea Capelin: Estimated stock size in numbers (thousand millions) by age group and total, and biomass ('000 t) of total stock, by August 1.

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	1174.6	762.3	509.7	446.6	788.6	856.8	553.3	591.7	487.2	573.8	612.7	173.7	42.9	11.1	48.8	20.9	181.4	700.1	405.0	395.2	3.1	27.0
2	432.7	637.0	412.2	275.3	240.6	426.5	400.6	233.0	248.8	185.7	263.8	231.0	62.8	5.0	2.2	30.1	18.9	177.5	596.1	223.9	73.1	4.7
3	52.8	210.8	354.1	205.8	136.2	121.2	148.3	196.1	70.2	84.9	65.3	67.2	31.7	4.3	0.1	0.3	1.5	16.6	34.1	147.6	23.7	5.9
4	21.2	5.2	103.9	103.5	54.2	17.2	6.8	40.6	19.3	3.6	0.9	4.6	1.5	0.2	0.0	0.0	0.0	0.2	1.3	1.5	3.3	0.2
5	0.3	0.3	1.1	17.0	9.7	1.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	1681.6	1615.6	1381.0	1048.2	1229.3	1422.7	1109.0	1061.8	826.0	848.0	942.7	476.5	138.9	20.6	51.2	51.2	201.8	894.4	1036.5	768.2	103.1	37.9
Biomass	4480	5576	6639	5740	4598	4406	4375	5607	3348	2686	3019	2310	746	106	73	188	478	2931	4623	3654	704	164

Table 4.6 Barents Sea Capelin. Catch in numbers (thousand millions) by age group and total landings ('000 t) in the spring season

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
2	0,0	0,3	1,5	0,1	1,7	0,2	0,1	0,1	0,6	0,5	0,4	0,1	0,4	0,0	0,0	0,0	0,0	0,0	0,4	0,3	0,5	0,0
3	0,6	4,0	7,2	4,2	7,3	12,1	10,4	3,7	3,5	12,2	13,3	8,4	5,9	1,9	0,0	0,0	0,0	0,0	24,1	23,8	4,8	0,0
4	34,0	23,8	34,0	40,0	47,5	34,4	28,6	35,7	35,3	18,3	34,8	23,2	17,5	4,5	0,0	0,0	0,0	0,0	8,3	17,2	26,9	0,0
5	14,6	8,8	4,0	26,5	30,4	18,5	6,3	3,2	14,5	5,3	7,5	2,3	3,3	0,8	0,0	0,0	0,0	0,0	2,8	2,1	1,4	0,0
Sum	49,2	36,9	46,8	70,8	86,9	65,2	45,3	42,7	53,9	36,3	56,1	33,9	27,0	7,2	0,0	0,0	0,0	0,0	35,6	43,5	33,6	0,0
Landings	1111	812	903	1480	1760	1237	886	801	1240	833	1161	629	590	123	0	0	0	0	707	891	586	0

Table 4.7 Barents Sea Capelin. Catch in numbers (thousand millions) by age group and total landings ('000 t) in the autumn season

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0,0	1,9	1,7	2,6	1,9	1,0	0,4	1,1	2,0	1,1	3,0	2,2	1,0	0,0	0,0	0,0	0,0	0,0	2,2	0,9	0,0	0,0
2	12,4	12,0	14,6	17,3	48,5	29,3	29,5	7,8	26,0	21,4	36,1	21,3	8,3	0,0	0,0	0,0	0,0	0,0	9,3	5,8	0,0	0,0
3	5,9	12,9	20,9	29,8	34,1	17,7	31,3	24,3	15,6	24,4	26,5	15,8	10,1	0,0	0,0	0,0	0,0	0,0	3,1	7,9	0,0	0,0
4	1,3	1,3	7,8	22,2	11,8	2,9	2,3	4,3	3,7	1,5	1,3	1,7	0,9	0,0	0,0	0,0	0,0	0,0	0,9	0,8	0,0	0,0
5	0,1	0,2	0,0	4,3	2,1	0,4	0,0	0,1	0,2	0,1	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0
Sum	19,7	28,3	45,1	76,2	98,3	51,2	63,5	37,7	47,6	48,5	66,9	41,1	20,3	0,0	0,0	0,0	0,0	0,0	15,5	15,3	0,0	0,0
Landings	225	336	538	1107	1227	678	896	847	746	927	1197	849	278	0	0	0	0	0	226	232	0	0

Table 4.8 Barents Sea CAPELIN. Fishing mortality coefficients by age group and weighted average for age groups 2-5 in the autumn fishing season

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2	0.03	0.02	0.04	0.07	0.26	0.00	0.09	0.04	0.13	0.15	0.18	0.12	0.18	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.00
3	0.13	0.07	0.07	0.18	0.33	0.08	0.29	0.16	0.31	0.41	0.67	0.34	0.49	0.00	0.00	0.00	0.00	0.00	0.10	0.06	0.00	0.00
4	0.07	0.34	0.09	0.28	0.28	0.18	0.51	0.14	0.26	0.67	N/A	0.58	1.35	0.00	0.00	0.00	0.00	0.00	1.19	0.85	0.00	0.00
5	0.37	1.50	0.03	0.34	0.28	0.21	0.92	0.43	0.55	N/A	N/A	N/A	N/A	0.00	0.00	0.00	0.00	0.00	N/A	N/A	0.00	0.00
Avr (2-4)	0.05	0.04	0.06	0.15	0.28	0.04	0.15	0.10	0.18	0.24	0.31	0.18	0.30	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.00	0.00

Table 4.9 Barents Sea CAPELIN. Natural mortality coefficients (per month) for immature fish (Mimm), used for the whole year, and for mature fish (per season) (Mmat) used January to March

	1973		1974		1975		1976		1977		1978		1979		1980		1981		1982		1983	
Age	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat
1	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,07	0,22	0,07	0,22	0,07	0,22	0,07	0,22	0,09	0,26
2	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,07	0,22	0,07	0,22	0,07	0,22	0,07	0,22	0,09	0,26
3	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,07	0,22	0,07	0,22	0,07	0,22	0,07	0,22	0,09	0,26
4	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,07	0,22	0,07	0,22	0,07	0,22	0,07	0,22	0,09	0,26
5	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,07	0,22	0,07	0,22	0,07	0,22	0,07	0,22	0,09	0,26
Avr	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,05	0,15	0,07	0,22	0,07	0,22	0,07	0,22	0,07	0,22	0,09	0,26

Table 4.9 (Continued)

	1984		1985		1986		1987		1988		1989		1990		1991		1992		1993		1994	
Age	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat	Mimm	Mmat
1	0,09	0,26	0,09	0,28	0,20	0,59	0,13	0,40	0,02	0,07	0,01	0,03	0,00	0,00	0,02	0,05	0,06	0,17	0,16	0,47	0,16	0,47
2	0,09	0,26	0,09	0,28	0,20	0,59	0,13	0,40	0,02	0,07	0,01	0,03	0,00	0,00	0,02	0,05	0,06	0,17	0,16	0,47	0,16	0,47
3	0,09	0,26	0,09	0,28	0,20	0,59	0,13	0,40	0,02	0,07	0,01	0,03	0,00	0,00	0,02	0,05	0,06	0,17	0,16	0,47	0,16	0,47
4	0,09	0,26	0,09	0,28	0,20	0,59	0,13	0,40	0,02	0,07	0,01	0,03	0,00	0,00	0,02	0,05	0,06	0,17	0,16	0,47	0,16	0,47
5	0,09	0,26	0,09	0,28	0,20	0,59	0,13	0,40	0,02	0,07	0,01	0,03	0,00	0,00	0,02	0,05	0,06	0,17	0,16	0,47	0,16	0,47
Avr	0,09	0,26	0,09	0,28	0,20	0,59	0,13	0,40	0,02	0,07	0,01	0,03	0,00	0,00	0,02	0,05	0,06	0,17	0,16	0,47	0,16	0,47

Table 4.10 Barents Sea CAPELIN. Estimated stock size in numbers (thousand millions) by age group and total, and biomass ('000 t) of total stock, by January 1.

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	1678.6	1089.3	728.4	638.1	1126.9	1224.4	915.9	979.5	806.5	949.9	1110.8	317.2	82.8	43.3	124.7	24.4	194.5	700.6	453.0	593.1	9.2	81.2
2	618.3	910.2	589.0	393.5	343.8	609.4	663.1	385.7	411.9	338.2	399.5	398.2	111.2	26.0	4.2	25.0	18.7	172.5	699.8	371.8	294.9	1.4
3	120.5	324.4	483.1	306.6	198.2	144.1	304.8	255.0	156.1	152.1	111.8	143.7	133.3	32.8	1.9	1.1	26.9	18.0	177.4	541.4	162.6	33.3
4	143.1	35.8	152.1	256.0	133.4	75.9	78.5	77.6	116.7	36.1	39.2	21.9	31.2	12.1	1.6	0.1	0.2	1.4	16.6	28.5	103.7	10.8
5	18.9	15.3	2.9	73.7	60.8	31.7	10.8	2.8	24.8	10.4	1.3	0.0	1.7	0.2	0.1	0.0	0.0	0.0	0.1	0.4	0.5	1.5
Sum	2579.4	2375.0	1955.5	1668.0	1863.1	2085.6	1973.1	1700.7	1516.0	1486.7	1662.6	880.9	360.2	114.4	132.5	50.6	240.4	892.6	1346.9	1535.0	570.9	128.2
Biomass	7169	7857	7705	9152	7069	6129	7489	6807	7367	4240	4491	3787	2357	669	174	108	706	1997	7090	8134	4645	690

Table 4.11 Barents Sea CAPELIN. Mean weight (g) by age group and weighted average for the whole stock by January 1.

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	1.23	1.38	1.35	1.42	0.80	1.13	1.65	1.81	0.87	0.98	1.25	1.47	1.71	1.70	0.83	1.39	1.37	1.52	1.49	1.42	1.38	1.76
2	2.65	3.37	3.80	3.70	3.89	2.19	3.10	4.53	4.97	2.39	2.68	3.44	4.05	4.70	4.67	2.29	3.83	3.76	4.19	4.09	3.91	3.78
3	9.98	6.68	6.09	7.52	9.03	8.89	7.38	8.13	10.36	10.29	9.87	10.41	8.18	9.07	12.81	13.48	13.52	13.65	16.85	9.52	9.47	9.94
4	13.47	20.05	9.74	12.10	14.02	18.47	18.19	14.83	19.97	18.69	22.77	20.79	20.02	14.26	15.74	15.71	18.92	25.09	29.82	21.21	18.55	16.63
5	17.96	26.11	22.74	18.85	19.29	22.97	22.72	23.21	27.17	25.67	27.48	21.39	29.86	17.22	17.60	36.66	0.00	25.14	21.56	33.06	32.45	20.58
Avr	2.78	3.31	3.94	5.49	3.79	2.94	3.80	4.00	4.86	2.85	2.70	4.30	6.54	5.85	1.32	2.13	2.94	2.24	5.26	5.30	8.14	5.38

Table 4.12 Barents Sea CAPELIN. Estimated proportion of maturing stock by January 1.

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
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	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.14	0.04	0.03	0.04	0.11	0.10	0.04	0.02	0.16	0.16	0.13	0.15	0.06	0.10	0.46	0.65	0.41	0.48	0.65	0.15	0.12	0.11
4	0.65	0.89	0.23	0.29	0.50	0.73	0.77	0.49	0.88	0.86	0.98	0.85	0.73	0.53	0.85	0.82	0.72	1.00	1.00	0.89	0.74	0.71
5	0.91	1.00	0.90	0.71	0.77	0.90	1.00	0.93	0.99	1.00	1.00	0.00	1.00	0.93	1.00	0.01	1.00	0.77	1.00	0.96	0.00	0.92
Avr	0.05	0.03	0.03	0.08	0.07	0.05	0.04	0.03	0.10	0.04	0.03	0.05	0.09	0.09	0.02	0.02	0.05	0.01	0.10	0.07	0.17	0.10

Table 4.13 Barents Sea CAPELIN. Estimated spawning stock biomass ('000 t) by April 1

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	17	0	0	0
3	248	131	90	115	259	20	20	9	304	185	3	150	35	5	11	12	195	156	1600	939	132	37
4	1055	124	5	540	346	302	482	12	1158	213	22	0	67	7	19	1	3	30	177	134	532	105
5	41	134	0	0	314	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	22
Sum	1343	389	95	655	919	322	502	21	1462	398	25	150	102	13	31	13	198	187	1794	1072	663	165

Table 4.14 Barents Sea CAPELIN. Stock summary table. Recruitment (number of 1 year old fish (thousand m illions)) and stock biomass ('000 t) given at August 1., spawning stock ('000 t) at time of spawning (April 1. next year). Landings ('000 t) are the sum of the total landings in the season starting in the autumn of the year indicated and those in the following spring season.

Year	Recruitment	Total stock biomass	Landings	Spawning stock biomass
1973	1175	4480	1037	389
1974	762	5576	1239	95
1975	510	6639	2018	655
1976	447	5740	2867	919
1977	789	4598	2464	322
1978	857	4406	1565	502
1979	553	4375	1697	21
1980	592	5607	2087	1462
1981	487	3348	1579	398 >
1982	574	2686	2088	25
1983	613	3019	1826	150
1984	174	2310	1439	102
1985	43	746	401	13
1986	11	106	0	31
1987	49	73	0	13
1988	21	188	0	198
1989	181	478	0	187
1990	700	2931	707	1794
1991	405	4623	1117	1072
1992	395	3654	817	663
1993	3	704	0	165

Table 5. 1. Preliminary TACs for the summer/autumn fishery, recommended TACs for the whole season, landings and remaining spawning stock in the 1983/84-1993/94 seasons.

Season	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94
Prelim. TAC	0	300	700	1100	500	900	900	600	0	500	900
Rec. TAC	640	920	1280	1290	1115	1065	-	250	740	900	1250
Landings	573	897	1311	1333	1116	1036	808	314	677	788	1179
Spawn. stock	440	460	460	420	400	445	115	330	475	500	460

Table 5. 2. The international capelin catch 1964 - 1994 (thousand tonnes).

	Winter season			Season	Summer- and autumn season				Season	
Year	Iceland	Norway	Faroes	total	Iceland	Norway	Faroes	Others	total	Total
1964	8.6	-	-	8.6	-	-	-	-	-	8.6
1965	49.7	-	-	49.7	-	-	-	-	-	49.7
1966	124.5	-	-	124.5	-	-	-	-	-	124.5
1967	97.2	-	-	97.2	-	-	-	-	-	97.2
1968	78.1	-	-	78.1	-	-	-	-	-	78.1
1969	170.6	-	-	170.6	-	-	-	-	-	170.6
1970	190.8	-	-	190.8	-	-	-	-	-	190.8
1971	182.9	-	-	182.9	-	-	-	-	-	182.9
1972	276.5	-	-	276.5		-	-	-	-	276.5
1973	440.9	-	-	440.9	-	-	-	-	-	440.9
1974	461.9	-	-	461.9	-	-	-	-	-	461.9
1975	457.1	-	-	457.1	3.1	-	-	-	3.1	460.2
1976	338.7	-	-	338.7	114.4	-	-	-	114.4	453.1
1977	549.2	-	24.3	573.5	259.7	-	-	-	259.7	833.2
1978	468.4	-	36.2	504.6	497.5	154.1	3.4	-	655.0	1,159.6
1979	521.7	-	18.2	539.9	442.0	124.0	22.0	-	588.0	1,127.9
1980	392.1	-	-	392.1	367.4	118.7	24.2	17.3	527.6	919.7
1981	156.0	-	-	156.0	484.6	91.4	16.2	20.8	613.0	769.0
1982	13.2	-	-	13.2	-	-	-	-	-	13.2
1983	-	-	-	-	133.4	-	-	-	133.4	133.4
1984	439.6	-	-	439.6	425.2	104.6	10.2	8.5	548.5	988.1
1985	348.5	-	-	348.5	644.8	193.0	65.9	16.0	919.7	1,268.2
1986	341.8	50.0	-	391.8	552.5	149.7	65.4	5.3	772.9	1,164.7
1987	500.6	59.9	-	560.5	311.3	82.1	65.2	-	458.6	1,019.1
1988	600.6	56.6	-	657.2	311.4	11.5	48.5	-	371.4	1,028.6
1989	609.1	56.0	-	665.1	53.9	52.7	14.4	-	121.0	786,1
1990	612.0	62.5	12.3	686,8	83.7	21.9	5.6	-	111.2	798.0
1991	202.4	-	-	202.4	56.0	-	-	-	56.0	258.4
1992	573.5	47.6	-	621.1	213.4	65.3	18.9	*0.5	298.1	919.2
1993	489.1	-	*0.5	489.6	450.0	127.5	23.9	*10.2	611.6	1,101.2
1994	550.3	15.0	*1.8	567.1	**205.7	**99.0	**12.3	**2.1	**319.1	

* Greenlandic vessel

** July-September

Table 5. 3. The total international catch of capelin in the Iceland-Greenland-Jan Mayen area by age groups in numbers (billions) and the total catch by numbers and weight (thous. tonnes) the autum season (August-December) 1978 - 1994.

	Year								
Age	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	-	0.6	4.9	0.6	-	0.6	0.5	0.8	+
2	21.4	29.4	17.2	27.9	-	7.2	9.8	25.6	10.0
3	12.2	6.1	5.4	2.0	-	0.8	7.8	15.4	23.3
4	-	-	-	+	-	-	0.1	0.2	0.5
Total number	33.6	36.1	27.5	30.5	-	8.6	18.2	42.0	33.8
Total weight	655.0	588.0	527.6	613.0	-	133.4	548.5	919.7	772.9

	Year							
Age	1987	1988	1989	1990	1991	1992	1993	1994
1	+	0.3	1.7	0.8	0.3	1.7	0.2	*0.3
2	27.7	13.6	6.0	5.9	2.7	14.0	24.9	*15.7
3	6.7	5.4	1.5	1.0	0.4	2.1	5.4	*2.7
4	+	+	+	+	+	+	0.2	*+
Total number	34.4	19.3	9.2	7.7	3.4	17.8	30.7	*18.7
Total weight	458.6	371.4	121.0	111.2	56.0	298.1	611.6	*319.1

* July - September

Table 5. 4. The total international catch of capelin in the Iceland-Greenland-Jan Mayen area by age groups in numbers (billions) and the total catch by numbers and weight (thous. tonnes) the winter season (January-March) 1979 - 1994.

	Year							
Age	1979	1980	1981	1982	1983	1984	1985	1986
2	1.0	1.3	1.7	-	-	2.1	0.4	0.1
3	20.8	17.6	7.1	0.8	-	18.1	9.1	9.8
4	4.8	3.5	1.9	0.1	-	3.4	5.4	6.9
5	0.1	-	-	-	-	-	-	0.2
Total number	26.7	22.4	10.7	0.9	-	23.6	14.5	17.0
Total weight	539.9	392.1	156.0	13.2	-	439.6	348.5	391.8

	Year							
Age	1987	1988	1989	1990	1991	1992	1993	1994
2	+	+	0.1	1.4	0.5	2.7	0.2	0.6
3	6.9	23.4	22.9	24.8	7.4	29.4	20.1	22.7
4	15.5	7.2	7.8	9.6	1.5	2.8	2.5	3.9
5	-	0.3	+	0.1	+	+	+	+
Total number	22.4	30.9	30.8	35.9	9.4	34.9	22.8	27.2
Total weight	560.5	657.2	665.1	686.8	202.4	621.1	489.6	567.1

Table 5. 5. The calculated number (billions) of capelin on 1 August 1978 - 1994 by age and maturity groups. The total number (billions) and weight (thous. tonnes) of the immature and maturing (fishable) stock components are also given.

	Year								
Age/maturity	1978	1979	1980	1981	1982	1983	1984	1985	1986
1 juvenile	163.9	60.3	65.9	49.1	147.3	125.1	252.1	99.1	157.1
2 immature	15.3	16.4	4.2	3.7	15.0	42.5	40.9	100.0	29.4
2 mature	81.9	91.3	35.4	39.7	17.1	53.7	40.7	64.6	35.6
3 mature	29.1	10.1	10.8	2.8	2.3	9.8	27.9	27.0	65.8
4 mature	0.4	0.3	+	+	+	0.1	0.4	0.4	0.7
Number immat.	179.2	76.7	70.1	52.8	162.3	167.6	293.0	199.1	176.5
Number mature	111.4	101.7	46.2	42.5	19.4	63.6	69.0	92.0	102.1
Weight immat	790	337	298	228	650	882	1343	1358	812
Weight mature	2147	1482	932	743	307	985	1270	1417	2116

	Year							
Age/maturity	1987	1988	1989	1990	1991	1992	1993	1994
1 juvenile	143.5	80.8	64.2	117.8	132.9	*194.8	*177.5	-
2 immature	37.2	24.0	10.3	10.1	9.7	16.6	*41.1	-
2 mature	65.4	70.3	42.8	31.9	67.7	70.7	86.9	**89.6
3 mature	20.1	24.5	15.8	6.8	6.7	6.4	10.9	**27.0
4 mature	0.1	0.4	+	+	+	+	0.2	-
Number immat.	180.7	104.8	74.5	127.9	142.6	*211.4	*218.6	-
Number mature	85.6	95.2	58.6	38.7	74.4	77.1	98.0	**116.6
Weight immat	832	469	307	562	764	*822	*1015	-
Weight mature	1540	1528	1072	680	1146	1136	1490	**1995

* Preliminary
** Predicted

Table 5. 6. The calculated number (billions) of capelin on 1 January 1979 - 1994 by age and maturity groups. The total number (billions) and weight (thous. tonnes) of the immature and maturing (fishable) stock components and the remaining spawning stock by number and weight are also given.

	Year							
Age/maturity	1979	1980	1981	1982	1983	1984	1985	1986
2 juvenile	137.6	50.6	55.3	41.2	123.7	105.0	211.6	83.2
3 immature	12.8	13.8	3.5	3.0	12.6	35.7	34.3	83.9
3 mature	51.8	53.4	16.3	8.0	14.3	39.8	25.2	34.5
4 mature	14.8	3.6	4.9	0.5	2.0	7.6	15.6	10.5
5 mature	0.3	0.2	+	+	+	0.1	0.3	0.2
Number immat.	150.9	64.4	58.8	44.2	136.3	140.7	245.9	167.1
Number mature	65.6	57.2	21.2	8.5	16.3	47.5	41.1	45.2
Weight immat	1028	502	527	292	685	984	1467	1414
Weight mature	1358	980	471	171	315	966	913	1059
Number sp.st.	29.0	17.5	7.7	6.8	13.5	21.6	20.7	19.6
Weight sp. st	600	300	170	140	260	440	460	460

	Year							
Age/maturity	1987	1988	1989	1990	1991	1992	1993	1994
2 juvenile	131.9	120.5	67.8	53.9	98.9	111.6	*163.3	-
3 immature	25.6	31.2	20.1	8.6	8.6	8.1	13.9	-
3 mature	22.1	34.1	48.8	31.2	22.3	54.8	46.5	50.5
4 mature	37.0	11.7	16.0	12.1	4.5	5.3	3.5	4.6
5 mature	0.2	+	0.3	+	+	+	+	+
Number immat.	157.5	151.3	87.9	62.5	107.5	119.7	*187.2	-
Number mature	59.1	45.8	64.8	43.3	26.8	60.1	50.0	55.1
Weight immat	1003.0	1083	434	291	501	487	*793	-
Weight mature	1355	993	1298	904	544	1106	1017	1063
Number sp.st.	18.3	18.5	22.0	5.5	16.3	25.8	23.6	24.8
Weight sp. st.	420	400	440	115	330	475	499	460

* Preliminary

Table 5. 7. The data used in the comparisons between abundance of age groups (numbers) when predicting fishable stock abundance for calculations of preliminary TACs.

Year class	Age 1 Acoustics N_1	Age 2 Back-calc. Mature N_{2mat}	Age 2 Acoustics Immature N_{2imm}	Age 2 Back-calc. Total N_{2tot}	Age 3 Back-calc. Mature N_{3tot}
1980	23.7	17.1	1.7	32.1	9.8
1981	68.0	53.7	8.2	96.2	27.9
1982	44.1	40.7	4.6	81.6	27.0
1983	73.8	64.6	12.6	164.6	65.8
1984	33.8	35.6	1.4	65.0	20.1
1985	58.6	65.4	5.4	102.6	24.5
1986	70.2	70.3	6.7	94.3	15.8
1987	43.9	42.8	1.8	53.1	6.8
1988	29.2	31.9	1.3	42.0	6.7
1989	*39.2	67.7	5.2	77.4	6.4
1990	60.0	70.7	2.3	87.3	10.9
1991	104.6	86.9	10.8	**98.0	
1992	100.4				

* Invalid due to ice conditions.

** Calculated from total abundance recorded in autumn 1992, catches and natural mortality.

Table 5. 8. Mean weight (g) in autumn of mature capelin of the 1978-1991 year classes

Year class	Age 2	Age 3
1978		24.0
1979	19.2	24.1
1980	16.5	22.5
1981	16.1	25.7
1982	15.8	23.8
1983	15.5	24.1
1984	18.1	25.8
1985	17.9	23.4
1986	15.5	25.5
1987	18.0	25.5
1988	18.1	25.4
1989	16.3	22.6
1990	16.5	23.3
1991	16.2	
Average	16.9	24.3

Table 5. 9. Predictions of fishable stock abundance and TACs for the 1982/83 - 1993/94 seasons. The last column gives contemporary advice on TACs for comparison.

Age 2 and age 3 = Numbers in age groups at the beginning of season.
Fish.st. = calculated weight of maturing capelin in thous. tonnes (ref. 1 August).
TAC calc = predicted TAC and TAC adv = advised TAC.

Mean weight of maturing 2 and 3 group capelin in October/November 1981-1991 is 17.0 and 24.3 g respectively. Numbers are billions; weights in thous. tonnes.

Season	Year classes	Age 2	Age 3	Fish.st.	TAC calc	TAC adv
1982/83	80 - 79	26.6	4.1	549	17	0
1983/84	81 - 80	63.0	0.0	1065	465	573
1984/85	82 - 81	43.4	26.3	1373	733	897
1985/86	83 - 82	67.8	20.2	1637	963	1311
1986/87	84 - 83	34.9	55.0	1926	1215	1333
1987/88	85 - 84	55.3	13.7	1268	642	1115
1988/89	86 - 85	64.8	29.0	1800	1105	1036
1989/90	87 - 86	43.2	25.5	1350	713	550
1990/91	88 - 87	31.1	8.2	724	170	265
1991/92	89 - 88	39.4	3.7	755	197	740
1992/93	90 - 89	56.4	18.3	1398	755	*900
1993/94	91 - 90	93.1	22.6	2123	1385	1250
1994/95	92 - 91	89.6	27.0	2170	1427	

* In January 1993 80,000 t were added to the 820,000 t recommended after the October 1992 survey due to an unexpectedly large increase in mean weights.

Table 5. 10. Acoustic estimate of capelin in the Iceland-East Greenland-Jan mayen area in October-November 1993.

	Age/Year Class							
Total length (cm)	1 1992	2 1991	3 1990	4+ 1989	Number maturing (10^9)	Total number (10^9)	Biomass (10^3 t)	Mean weight (g)
7.0 - 7.4	+	-	-	-	-	+	+	1.0
7.5 - 7.9	1.1	-	-	-	-	1.1	1.6	1.5
8.0 - 8.4	5.1	-	-	-	-	5.1	9.3	1.8
8.5 - 8.9	10.5	-	-	-	-	10.5	21.0	2.0
9.0 - 9.4	15.0	-	-	-	-	15.0	34.8	2.3
9.5 - 9.9	16.4	-	-	-	-	16.4	49.3	3.0
10.0 - 10.4	16.5	-	-	-	-	16.5	55.1	3.3
10.5 - 10.9	11.7	-	-	-	-	11.7	47.3	4.1
11.0 - 11.4	9.0	-	-	-	-	9.0	42.7	4.7
11.5 - 11.9	6.6	-	+	-	-	6.6	37.5	5.7
12.0 - 12.4	4.2	0.1	-	-	-	4.3	28.7	6.6
12.5 - 12.9	2.0	2.5	-	-	-	4.5	35.1	7.9
13.0 - 13.4	1.3	7.2	-	-	-	8.5	79.6	9.4
13.5 - 13.9	0.3	9.2	0.1	-	9.6	9.6	101.6	10.7
14.0 - 14.4	0.3	9.5	+	-	9.8	9.8	119.2	12.1
14.5 - 14.9	0.1	9.4	0.2	-	9.7	9.7	136.0	14.0
15.0 - 15.4	0.2	7.8	0.3	-	8.3	8.3	131.2	16.0
15.5 - 15.9	+	6.5	0.4	-	6.9	6.9	126.8	18.3
16.0 - 16.4	0.1	5.2	0.8	-	6.1	6.1	124.2	20.6
16.5 - 16.9	-	3.5	1.0	-	4.5	4.5	104.5	23.5
17.0 - 17.4	-	2.8	0.8	-	3.8	3.8	94.9	26.0
17.5 - 17.9	-	0.9	0.8	+	1.8	1.8	51.7	29.1
18.0 - 18.4	-	0.4	0.4	-	0.8	0.8	26.3	32.9
18.5 - 18.9	-	+	0.1	-	0.1	0.1	2.7	37.1
19.0 - 19.4	-	-	+	-	+	+	1.0	37.5
19,5 - 19.9	-	-	-	-	-	-	-	-
Number (10^9)	100.4	64.9	4.9	+	61.0	170.1	-	-
Biomass (10^3 t)	366.1	981.1	114.5	0.4	1020.1	1462.2	-	-
Mean length (cm)	10.2	14.9	16.7	17.8	15.3	12.2	-	-
Mean weight (g)	3.6	15.1	23.3	26.0	16.7	8.6	-	-

Table 5. 11. The total international catch in numbers (millions) of capelin in the Iceland-east Greenland-Jan Mayen area in the autumn of 1993 by age and length, and the catch in weight ('000 t) by age groups.

Total length (cm)	Age 1	Age 2	Age 3	Age 4	Total	%
9 - 10	19	-	-	-	19	0.1
10 - 11	48	-	-	-	48	0.2
11 - 12	91	246	-	-	246	0.8
12 - 13	29	1256	-	-	1256	4.1
13 - 14	5	6852	10	-	6862	22.4
14 - 15	-	8551	450	-	9001	29.3
15 - 16	-	5655	1441	63	7159	23.3
16 - 17	-	2157	2594	55	4806	15.7
17 - 18	-	182	869	62	1113	3.6
18 - 19	-	-	46	20	66	0.2
Total	193	24899	5410	200	30702	
%	0.6	81.1	17.6	0.7		100.0
Weight ('000 t)	1.2	4631	144.2	3.1	297.6	

Table 5. 12. The total international catch in numbers (millions) of capelin in the Iceland-east Greenland-Jan Mayen area in the winter of 1994 by age and length, and the catch in weight ('000 t) by age groups.

Total length (cm)	Age 2	Age 3	Age 4	Age 5	Total	%
11 - 12	5	-	-	-	5	+
12 - 13	55	10	-	-	65	0.2
13 - 14	218	730	5	-	953	3.5
14 - 15	296	3470	45	-	3811	14.0
15 - 16	31	6332	406	-	6769	24.9
16 - 17	-	6510	1138	-	7648	28.1
17 - 18	-	4428	1396	2	5826	21.4
18 - 19	-	1153	797	-	1950	7.2
19 - 20	-	66	119	1	186	0.7
Total	600	22699	3906	3	27213	
%	2.2	83.4	14.4	+		100.0
Weight ('000 t)	7.9	454.3	104.9	+	567.1	

Table 5. 13. The preliminary total international catch in number (millions) in July-September 1994 divided on age and length groups.

Length (cm)	Age 1	Age 2	Age 3	Age 4	Total	%
12 - 13	100	543	-	-	653	3.5
13 - 14	180	3261	33	-	3474	18.8
14 - 15	10	5117	314	-	5441	29.4
15 - 16	10	4011	962	-	4983	26.
16 - 17		1899	875	20	2794	15.1
17 - 18		404	438		842	4.5
18 - 19		-	29	-	29	0.2
Total	300	15235	2951	20	18506	
%	1.6	82.3	15.9	0.1		100.0
Weight ('000 t)	1.7	248.0	68.9	0.5	319.1	

Table 5. 14. Abundance indices of 0-group capelin 1970-1994 and their division by areas.

Year class	Northwestern Irminger Sea	West	Iceland North	East	Total
1970	1	8	2	-	11
1971	+	7	12	+	19
1972	+	37	52	+	89
1973	14	39	46	17	116
1974	26	44	57	7	134
1975	3	37	46	3	89
1976	2	5	10	15	32
1978	+	2	29	+	31
1979	4	19	25	1	49
1980	3	18	19	1	41
1981	10	13	6	-	29
1982	+	8	5	+	13
1983	+	3	18	1	22
1984	+	2	17	9	28
1985	1	8	19	3	31
1986	+	16	17	4	37
1987	1	6	6	1	14
1988	3	22	26	1	52
1989	-	16	7	-	23
1990	+	7	12	2	21
1991	8	2	43	1	54
1992	3	11	20	+	35
1993	2	21	13	15	51
1994	3	9	69	10	94

Table 5. 15. Estimated numbers, mean length and weight of 1-group capelin in during the August surveys of 1982-1994.

Year class	Number in 10^{-9}	Length (cm)	Weight (g)
1981	119	10.0	3.4
1982	155	10.4	4.2
1983	286	9.7	3.6
1984	31	10.2	3.8
1985	71	9.5	3.3
1986	101	9.1	3.0
1987	147	8.8	2.6
1988	111	10.1	3.4
1989	36	10.4	4.0
1990	50	10.7	5.1
1991	87	9.7	3.4
1992	33	9.4	3.0
1993	85	9.0	2.8

Figure 2.1. Icelandic summer spawners. SSE for fit of VPA to acoustics.

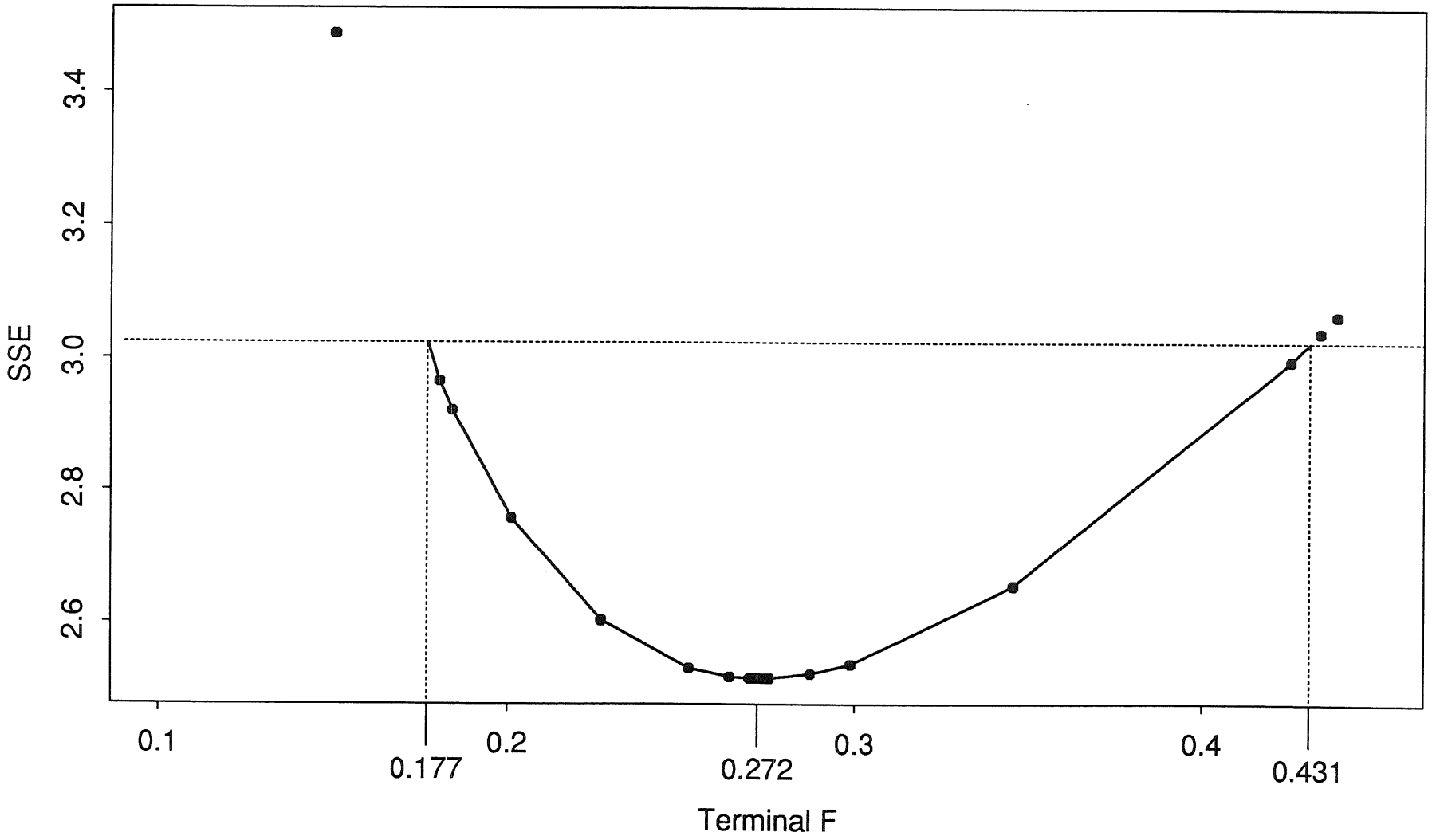


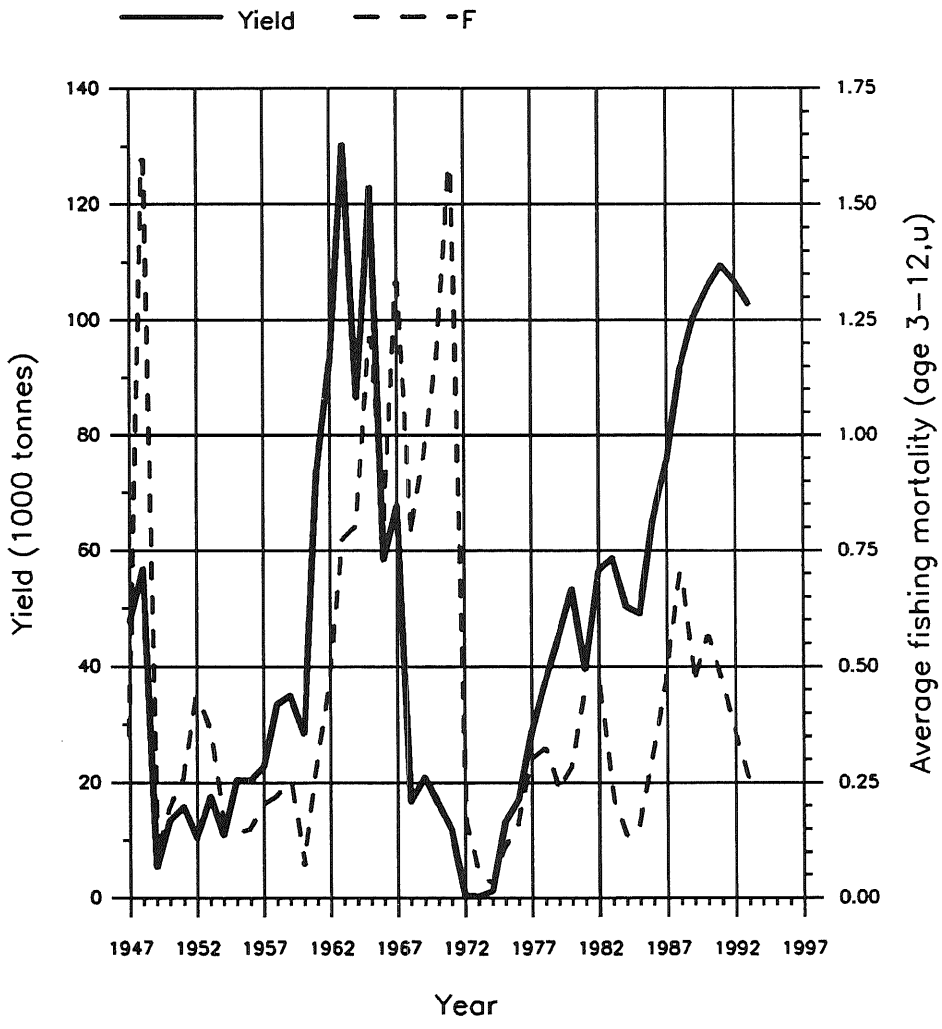
Figure 2. 2

FISH STOCK SUMMARY

STOCK: Herring, Summer Spawning at Iceland (Fishing Area Va)

18–10–1994

Trends in yield and fishing mortality (F)



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

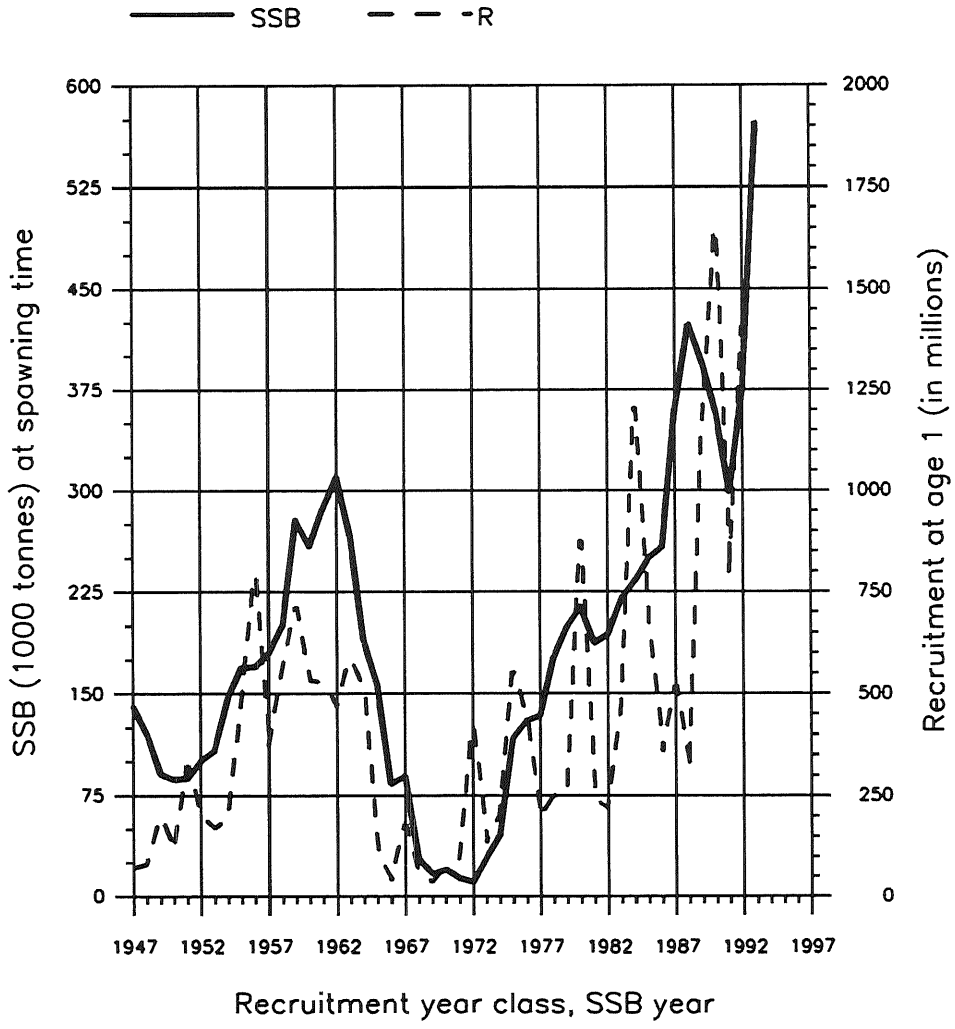


Figure 2.3. Icelandic summer spawners. Acoustic estimate vs. VPA stock numbers.

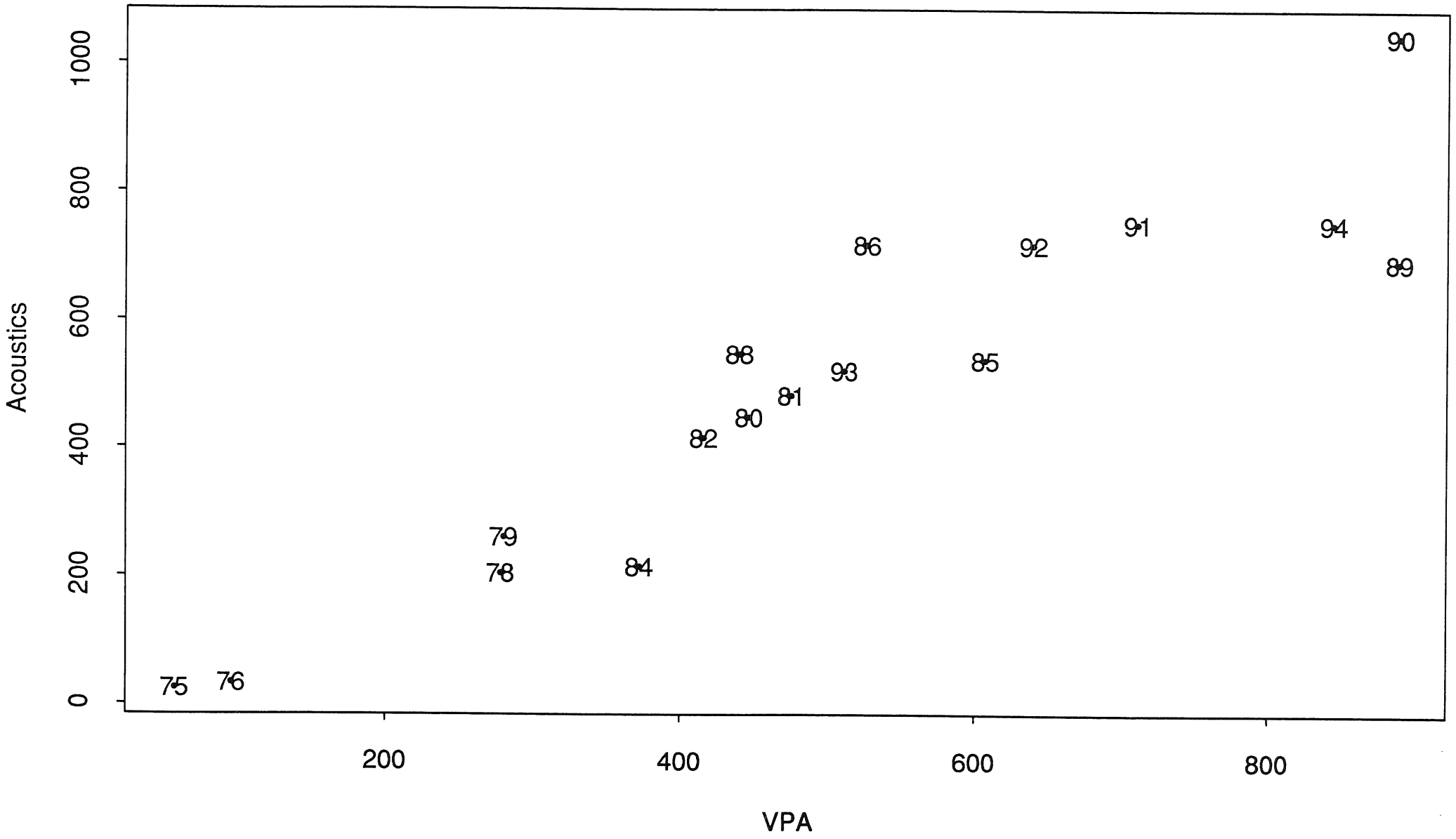
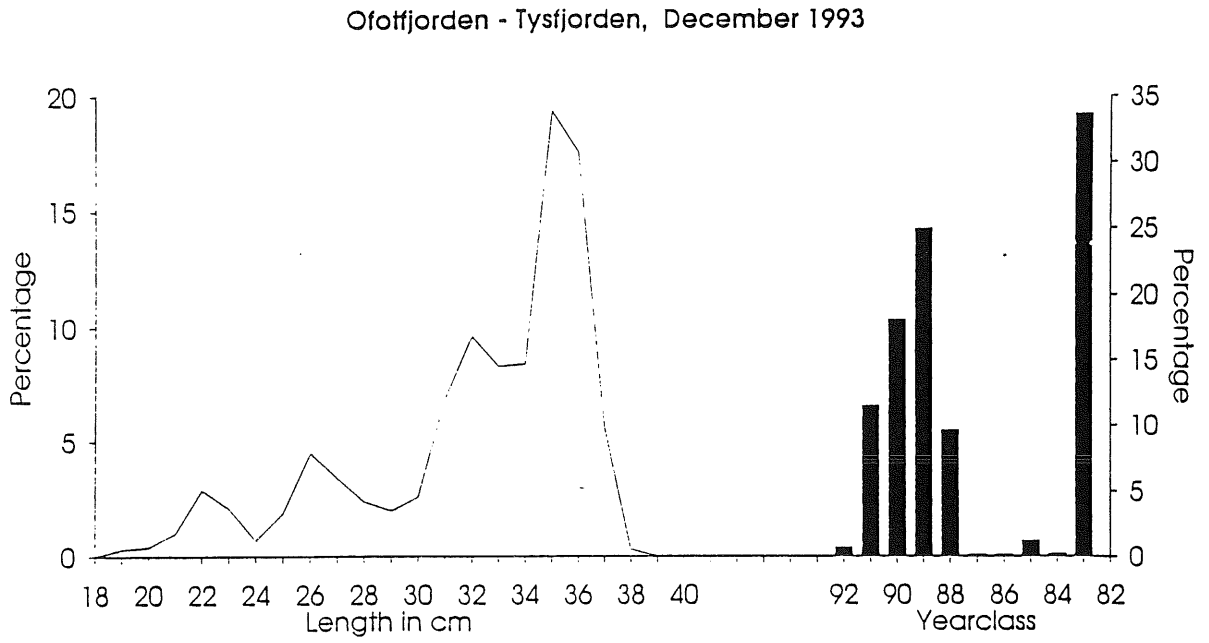


Figure 2. 4. Icelandic summer spawners. Trends in acoustics and VPA stock numbers.



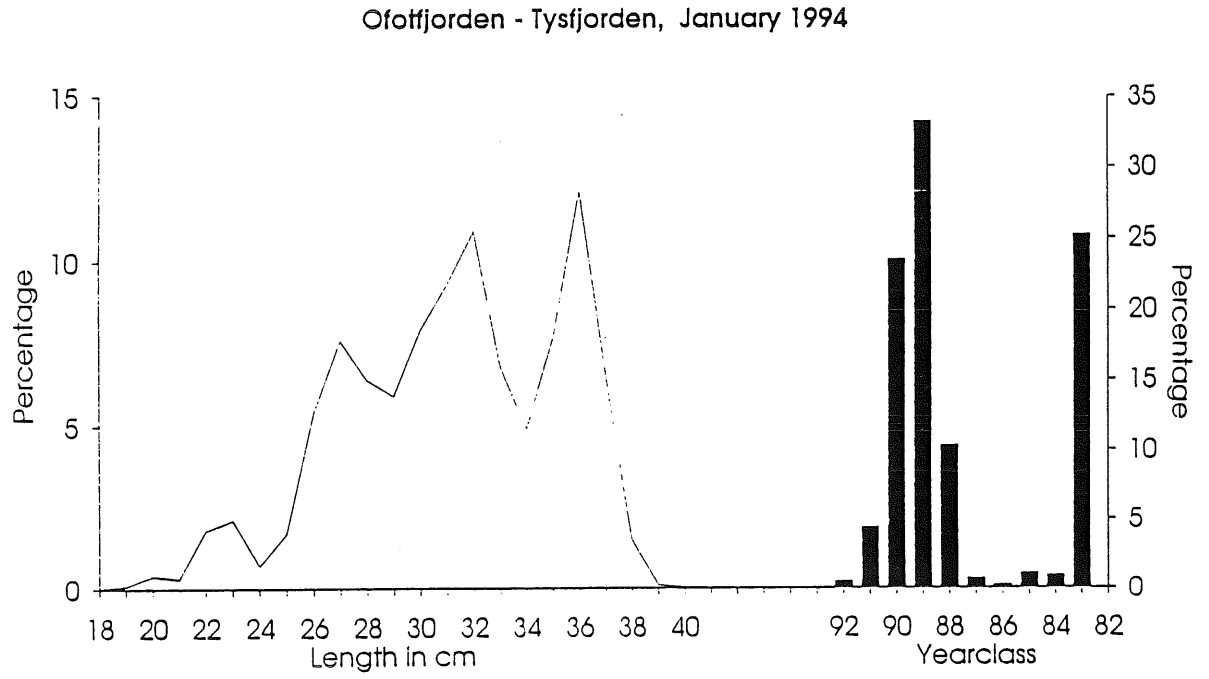


Figure 3.1 Norwegian spring spawning herring. Length and age distribution of herring in the wintering areas in December 1993 and in January 1994

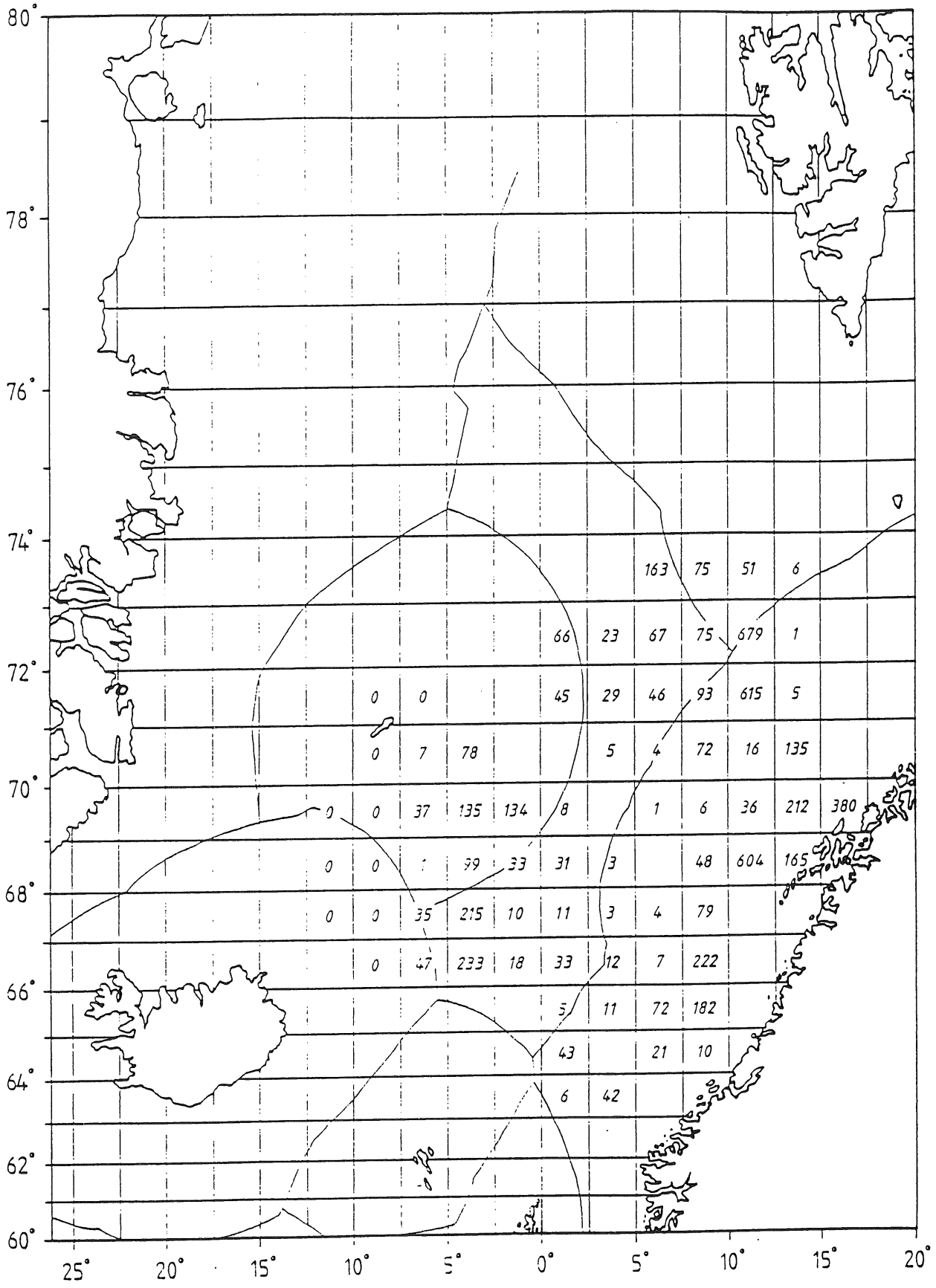


Figure 3.2 Norwegian spring spawning herring. Distribution of adult and adolescent herring in June - July 1994. Numbers denote average integrator values ($m^2/n.m.^2$.)

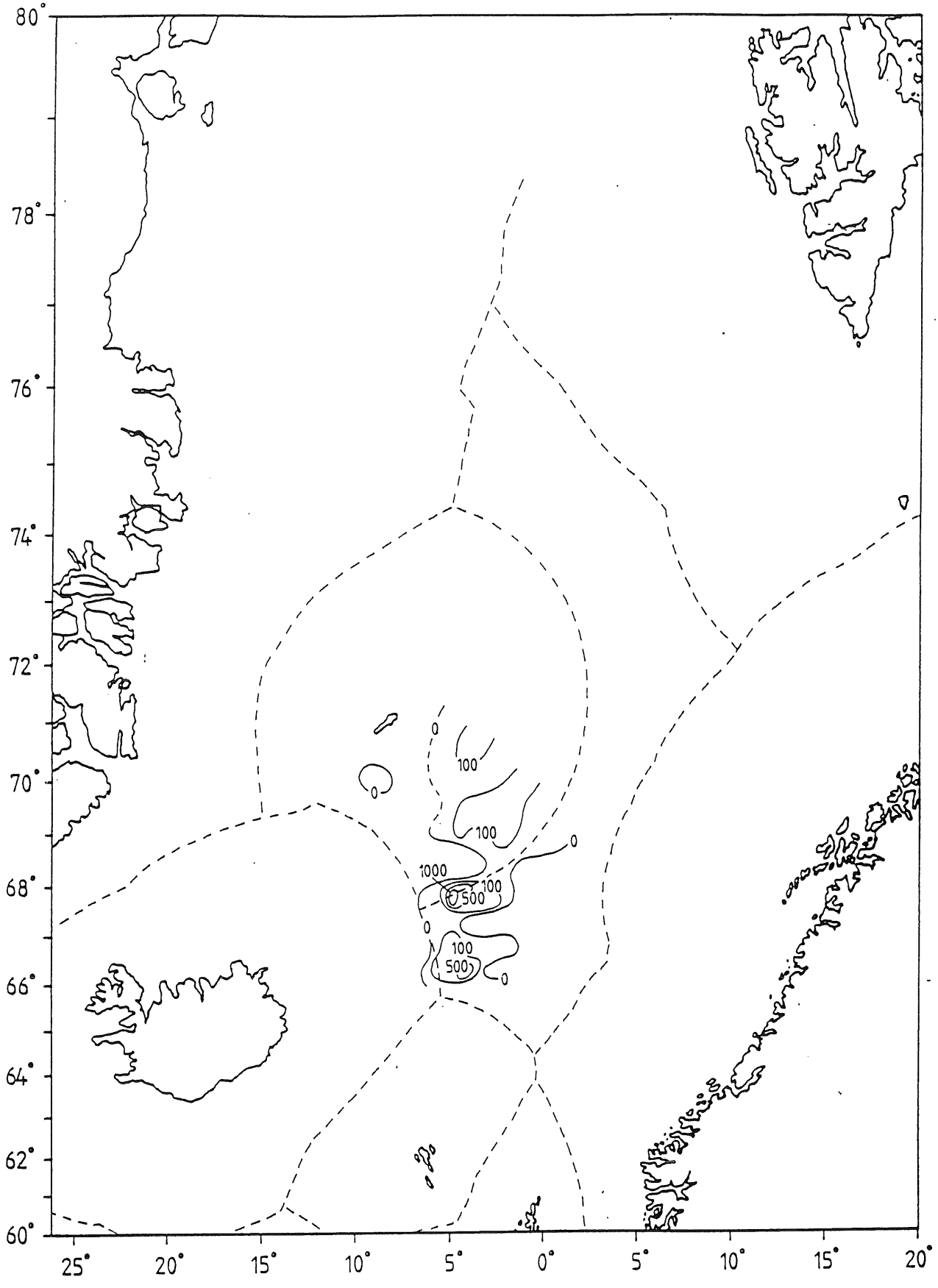
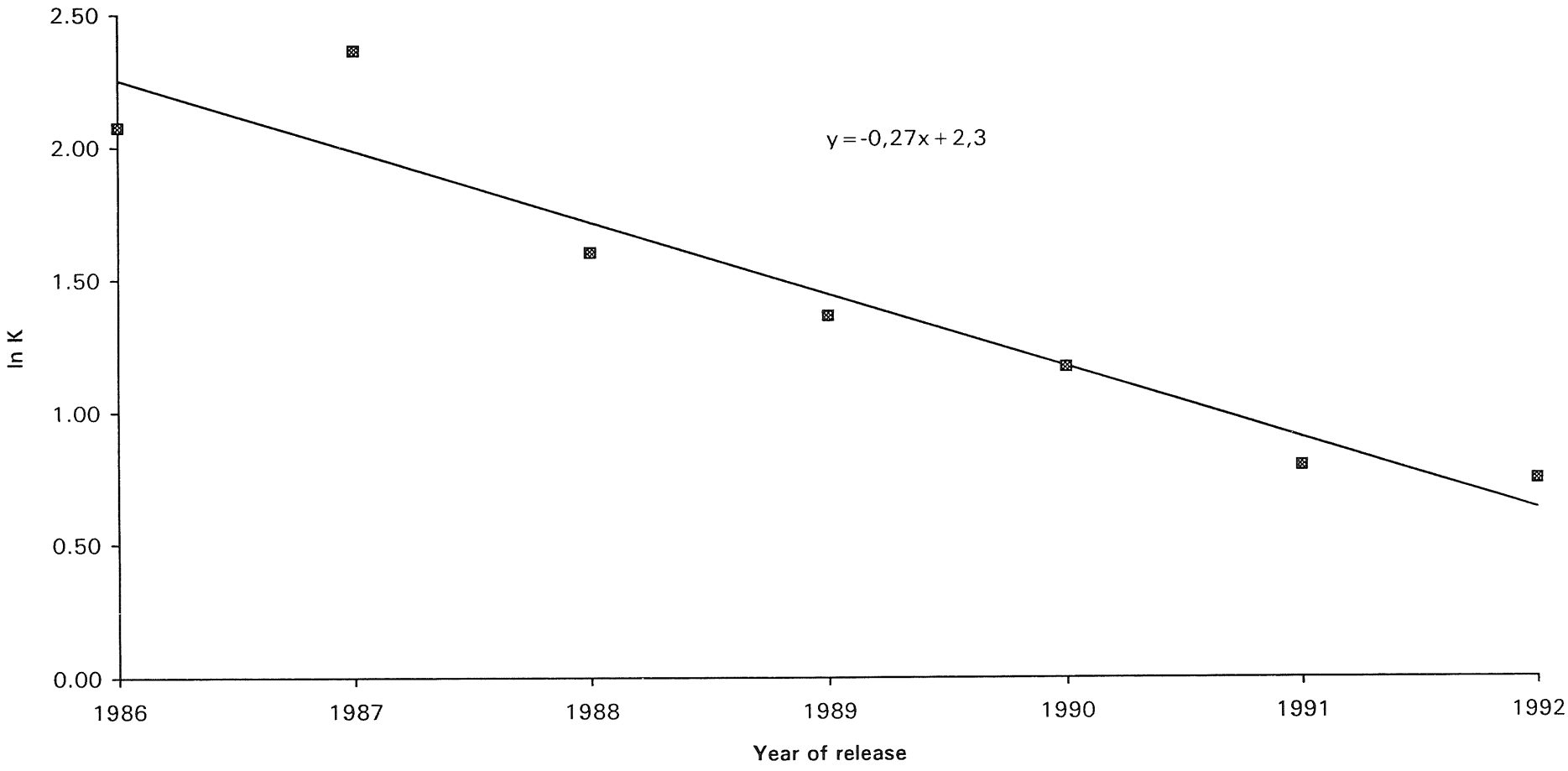


Figure 3.3 Number of herring schools per nautical miles^{*2} in the upper layers of the water column. R/V G O Sars 6.6 - 23.6 1994.

Figure 3.4 Norwegian spring spawning herring. Plot of lnK (see text) against year of release



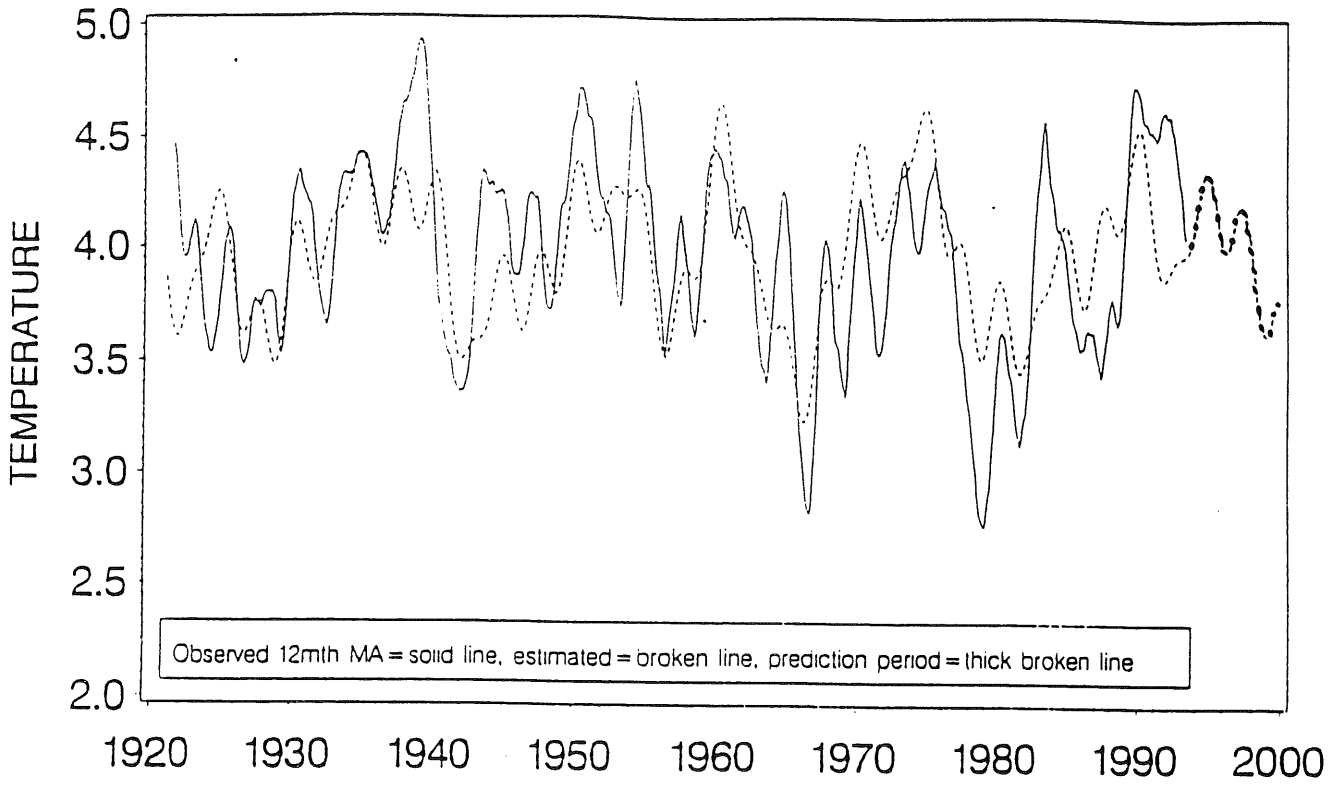


Figure 3.5 12 months moving average of monthly means of observed ocean temperature at the Kola section 1921-93, estimated values 1921-1993 and values forecasted for 1994-99

Catches and stock

	C-no	N	F	M	Z
88	0.550	12.627	0.048	0.13	0.18
89	0.324	10.572	0.033	0.13	0.16
90	0.226	8.979	0.027	0.13	0.16
91	0.219	7.673	0.033	0.23	0.26
92	0.226	5.901	0.044	0.23	0.27
93	0.410	4.487	0.108	0.23	0.34
94		3.200			

Surveys

	Tag	AcDec	AcJan	AcSpawn
88				6.81
89				5.40
90				4.49
91				4.15
92			4.69	
93	5.50	3.77	5.70	
94		4.44	3.68	1.82
q	1	1.07	1.04	0.53
SSE	1.03	1.83	3.04	0.50
	6.40			*Min.SSE*
				6.40

Fitted stock estimates

	Tag	AcDec	AcJan	AcSpawn	WG 93	WG 94
88				12.93	11.96	12.63
89				10.26	9.99	10.57
90				8.53	8.47	8.98
91				7.88	7.22	7.67
92			4.53		5.54	5.90
93	5.50	3.53	5.50		4.21	4.49
94		4.16	3.55	3.46		3.20

This spreadsheet does the assessment described in the ASH & C 1994 WG report, combining various sources of estimates. This is done by using "catchability" coefficients for fleets with 2 or more observations.

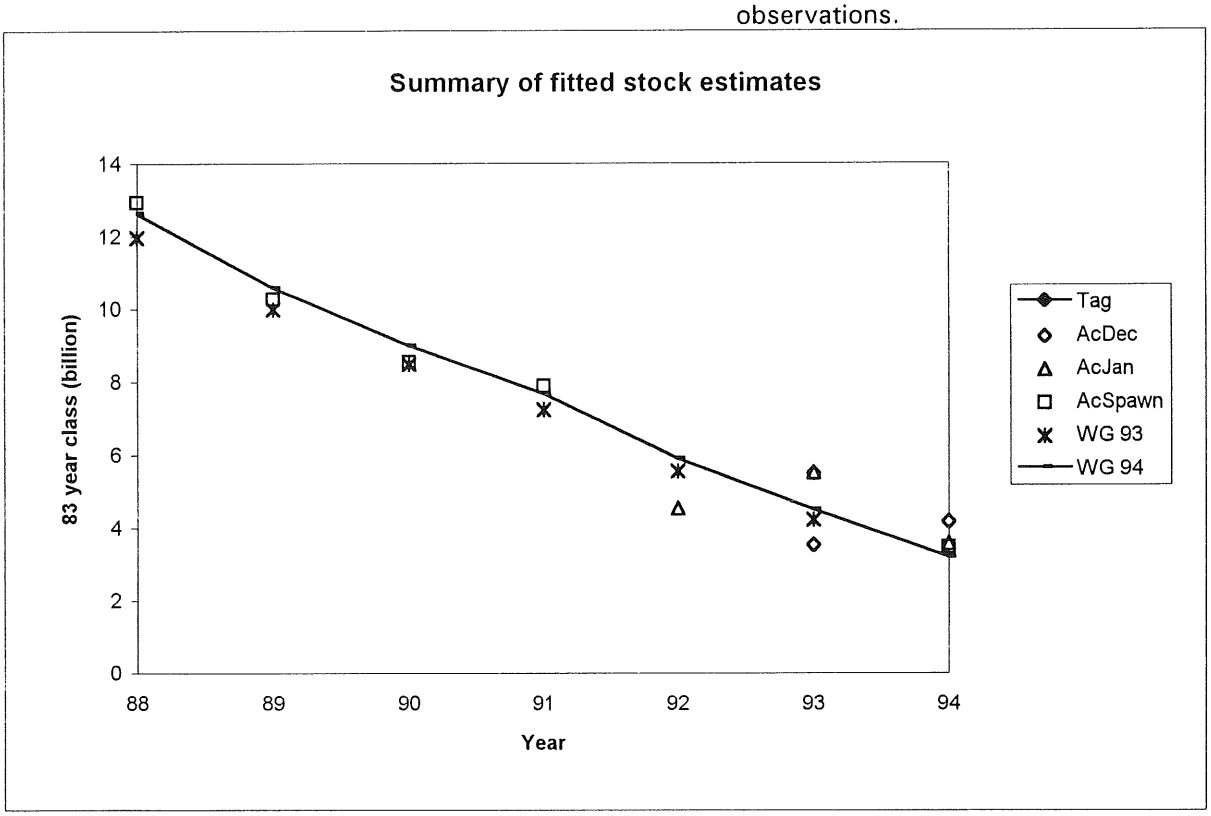
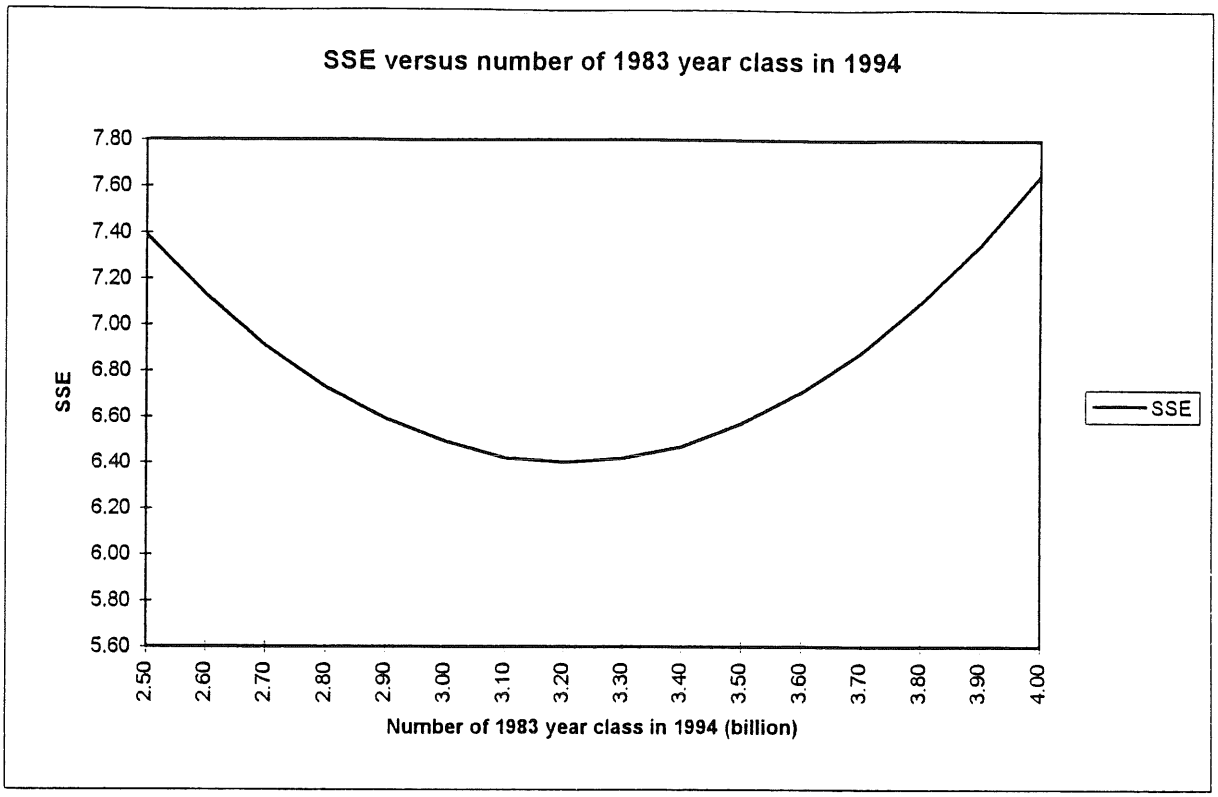


Figure 3.6



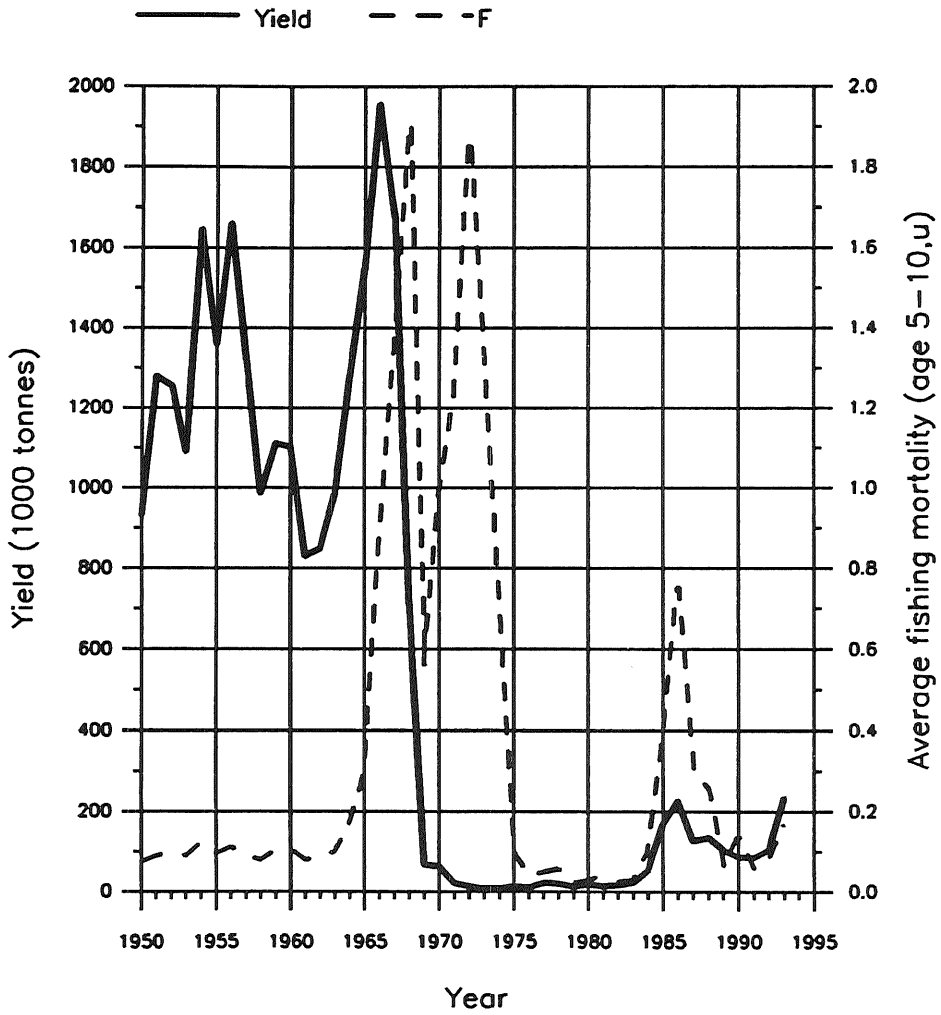
N94	SSE
2.50	7.39
2.60	7.13
2.70	6.91
2.80	6.73
2.90	6.59
3.00	6.49
3.10	6.42
3.20	6.40
3.30	6.42
3.40	6.47
3.50	6.57
3.60	6.71
3.70	6.88
3.80	7.10
3.90	7.35
4.00	7.65

Figure 3.7

Figure 3.8 A,B

FISH STOCK SUMMARY
STOCK: Herring, Norwegian Spring Spawners
21–10–1994

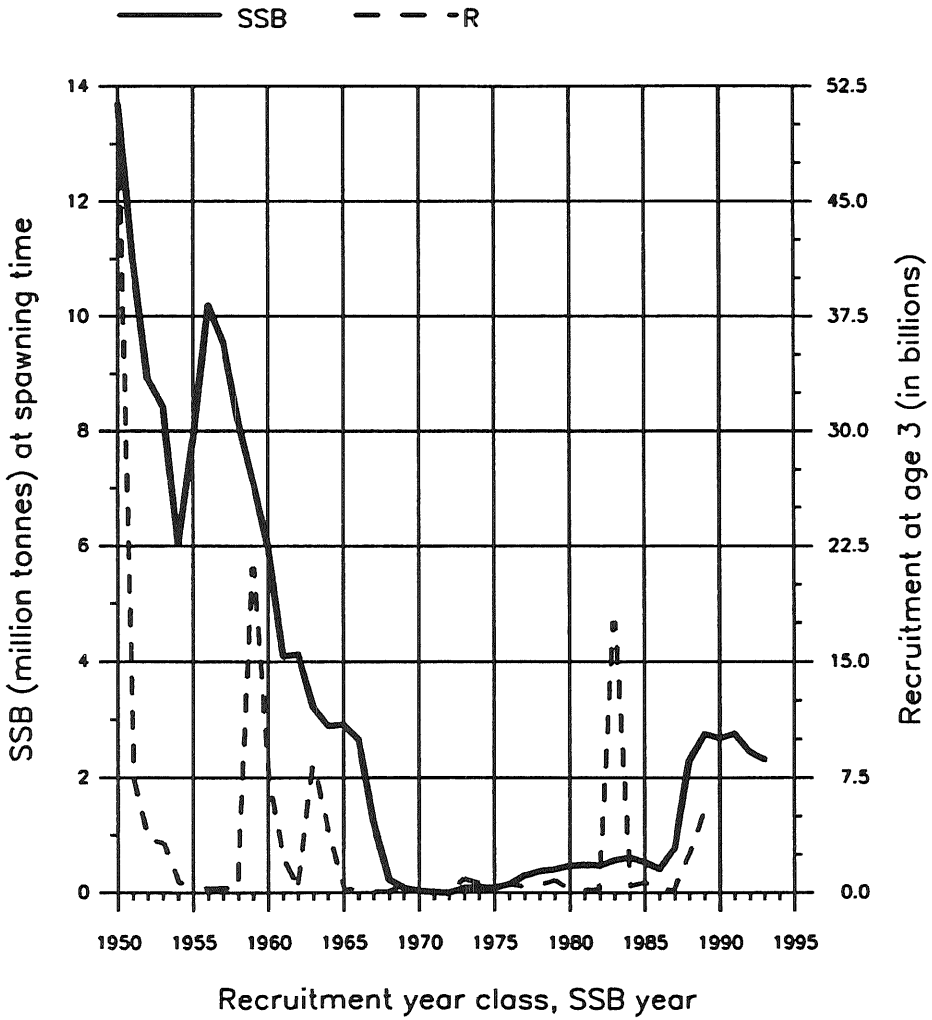
Trends in yield and fishing mortality (F)



(run: V5093)

A

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

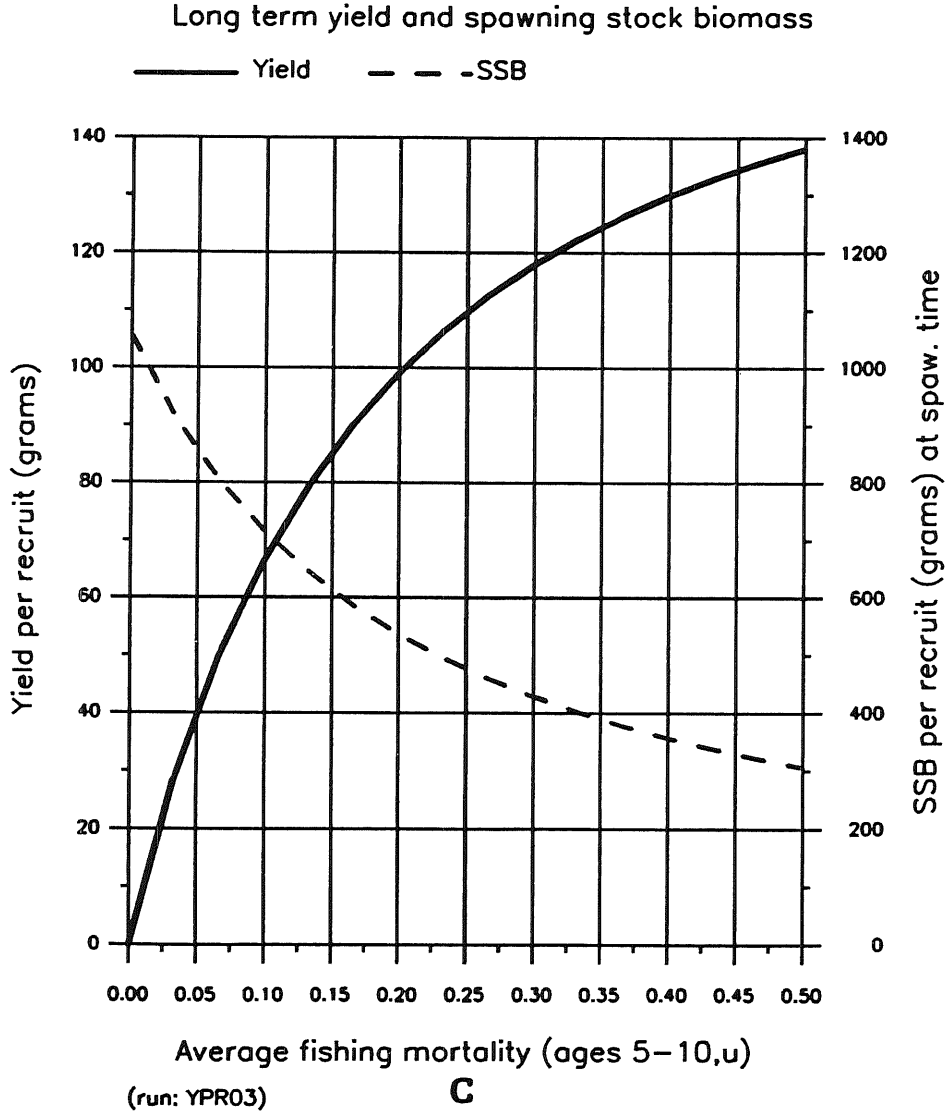


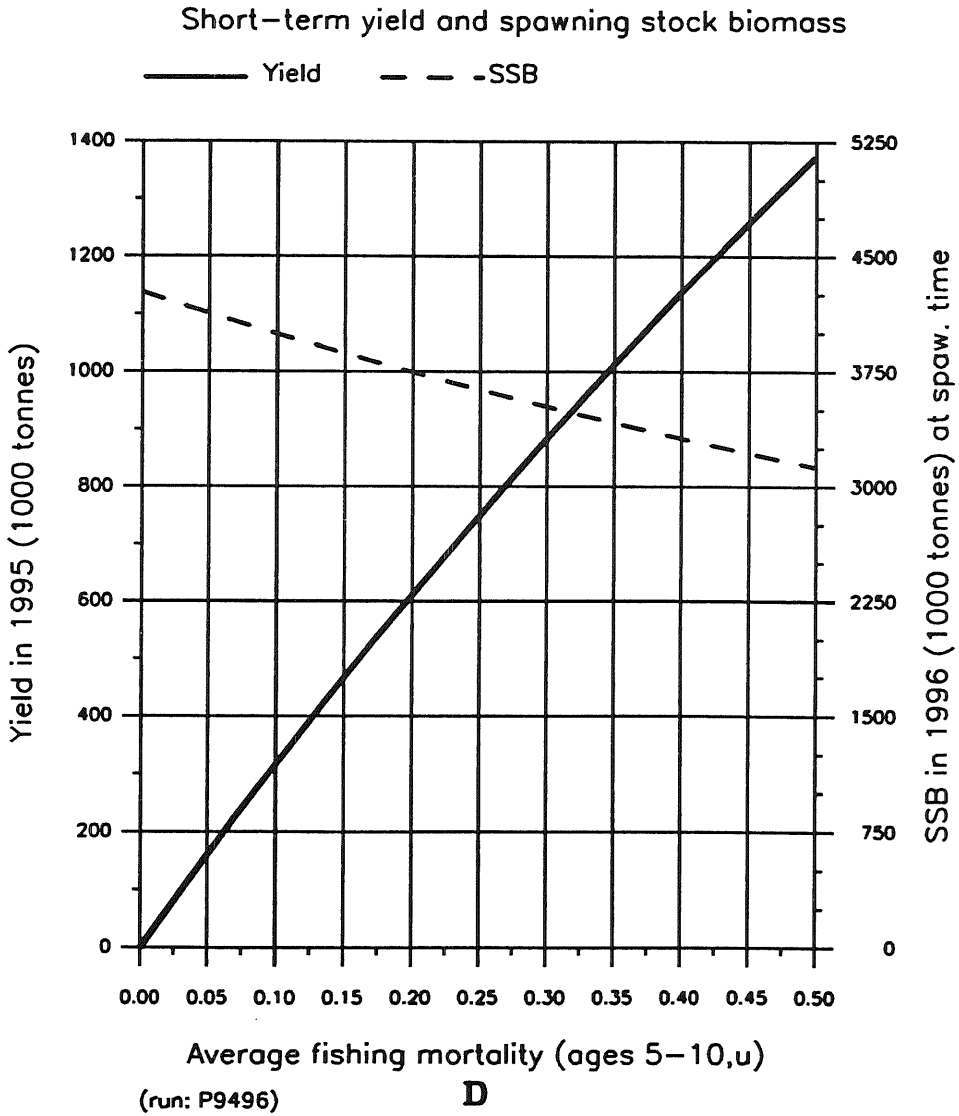
(run: V5093)

B

Figure 3.8 C,D

FISH STOCK SUMMARY
STOCK: Herring, Norwegian Spring Spawners
21–10–1994





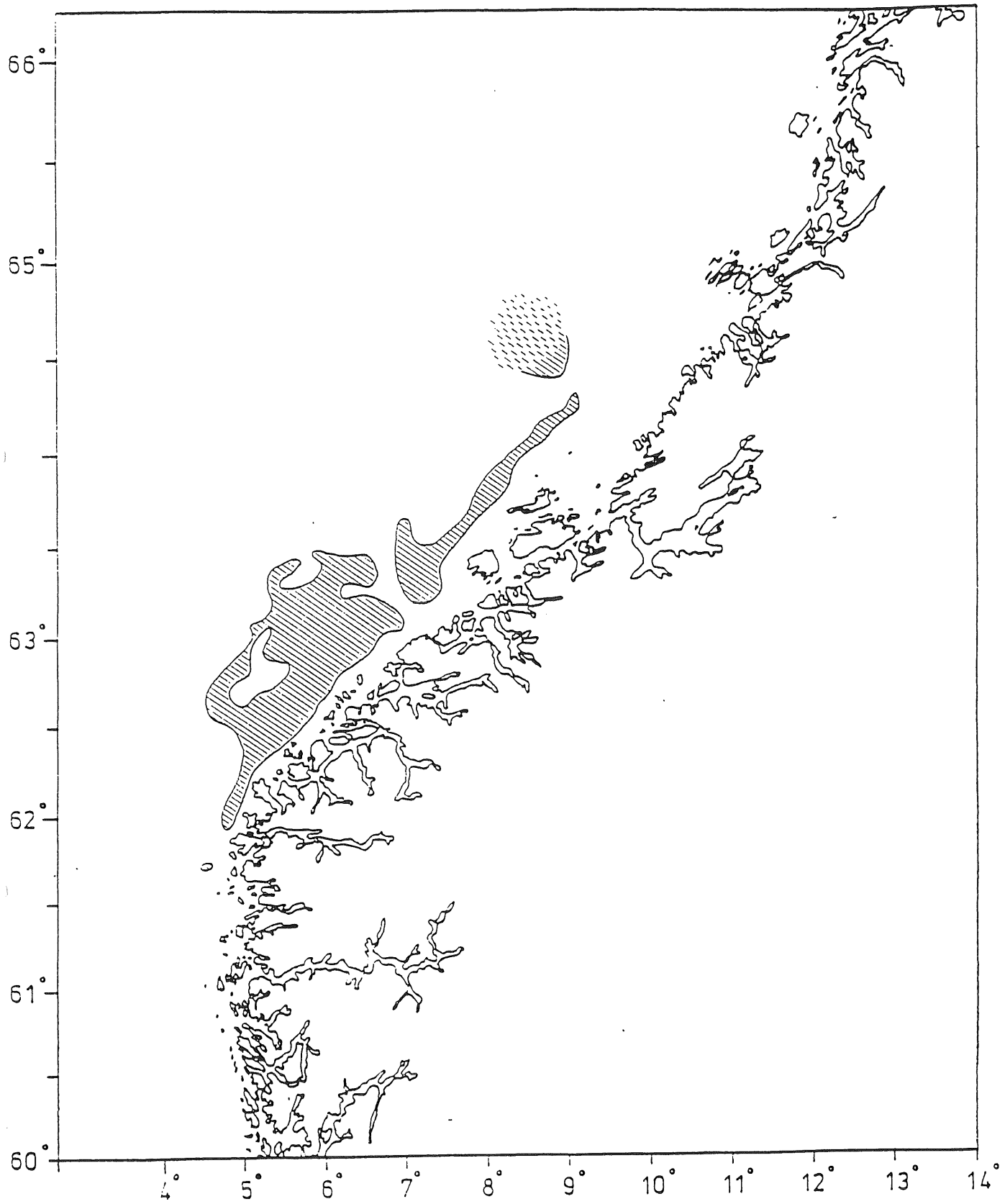


Figure 3.9 Norwegian spring spawning herring. Distribuion of herring on the spawning areas south of 65°N in the period 940221 - 940302.

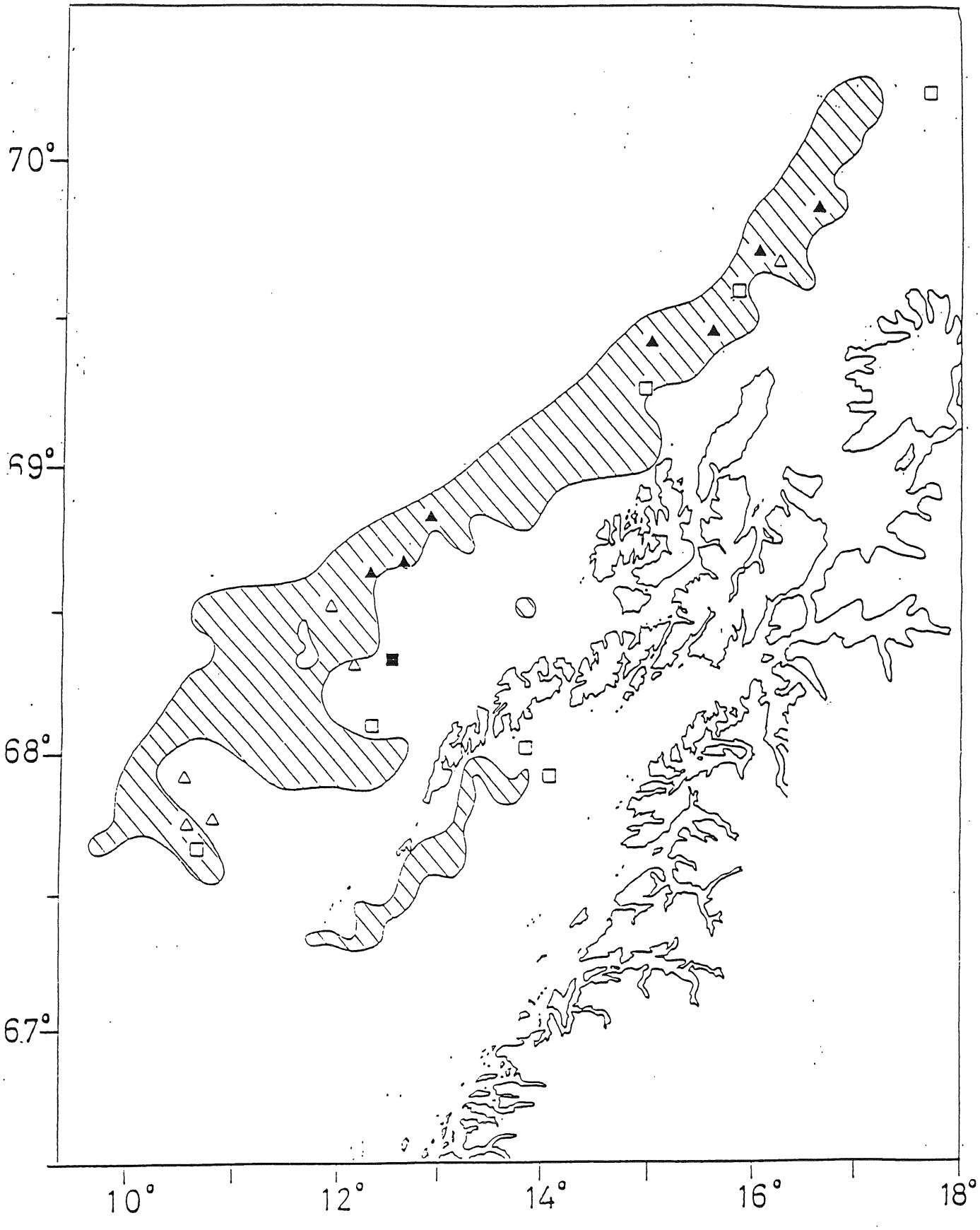
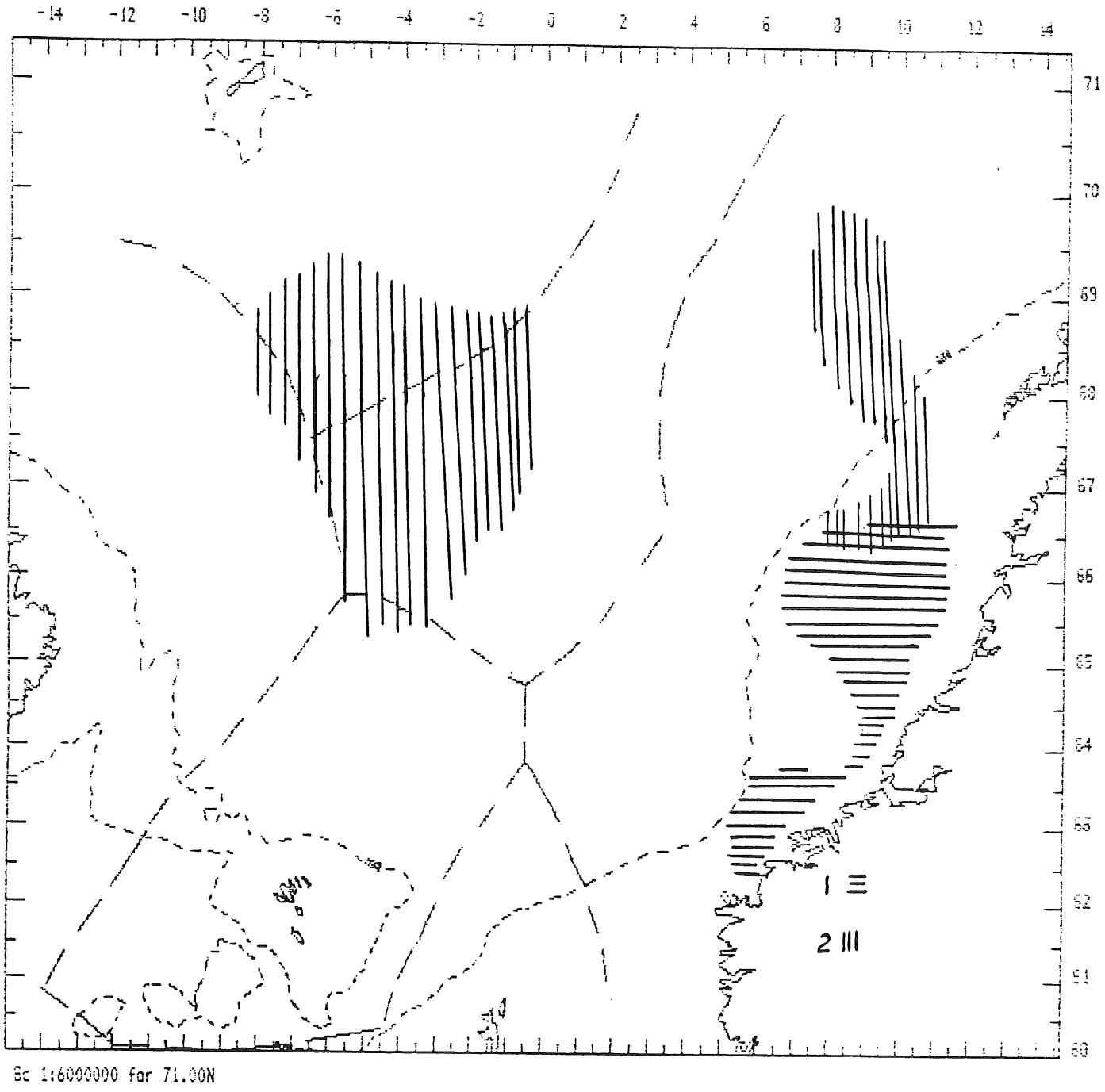


Figure 3.10 Norwegian spring spawning herring. Distribution of herring on the spawning areas north of 67°N in the period 940311- 930408.

Figure 3.11 **Distribution of herring in the Norwegian Sea in 1994. 1 February–April; 2 June–July.**



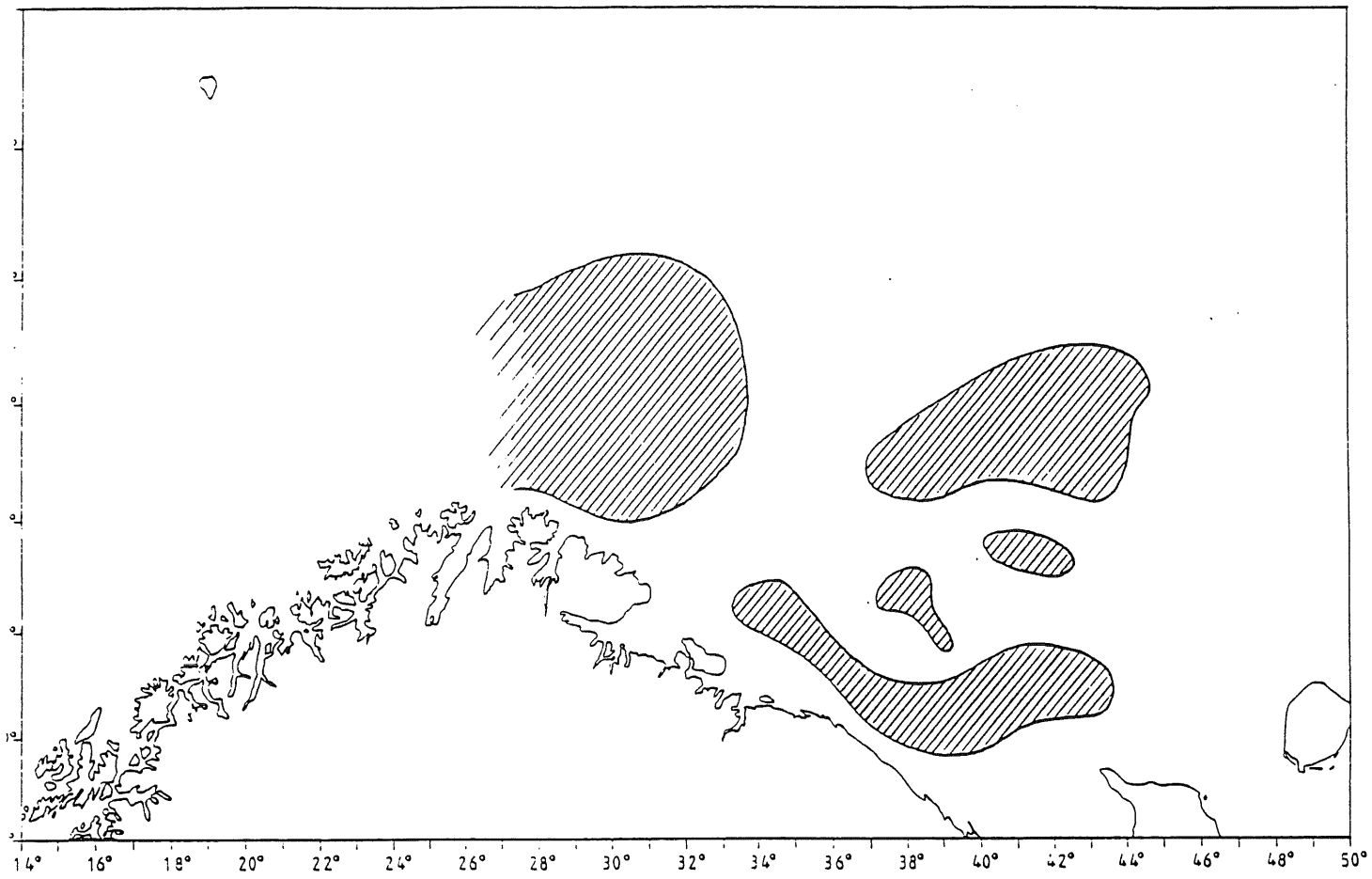


Figure 3.12 Norwegian spring spawning herring. Distribution of immature herring in Jan-Feb 1994.

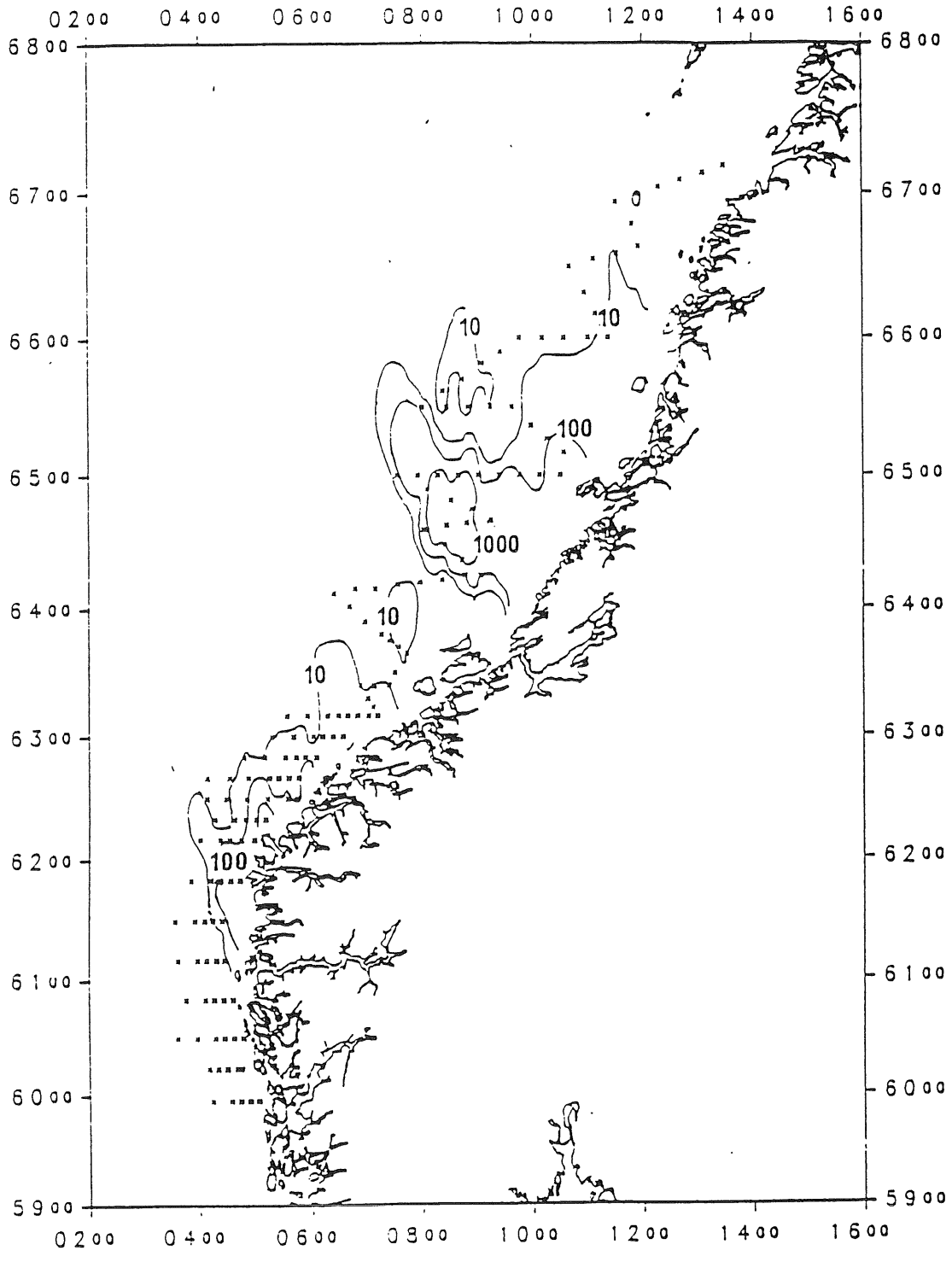


Figure 3.13 Norwegian spring spawning herring. Distribution of larvae on the coastal banks between 60°N - 67°N in the period 940406 - 940418.

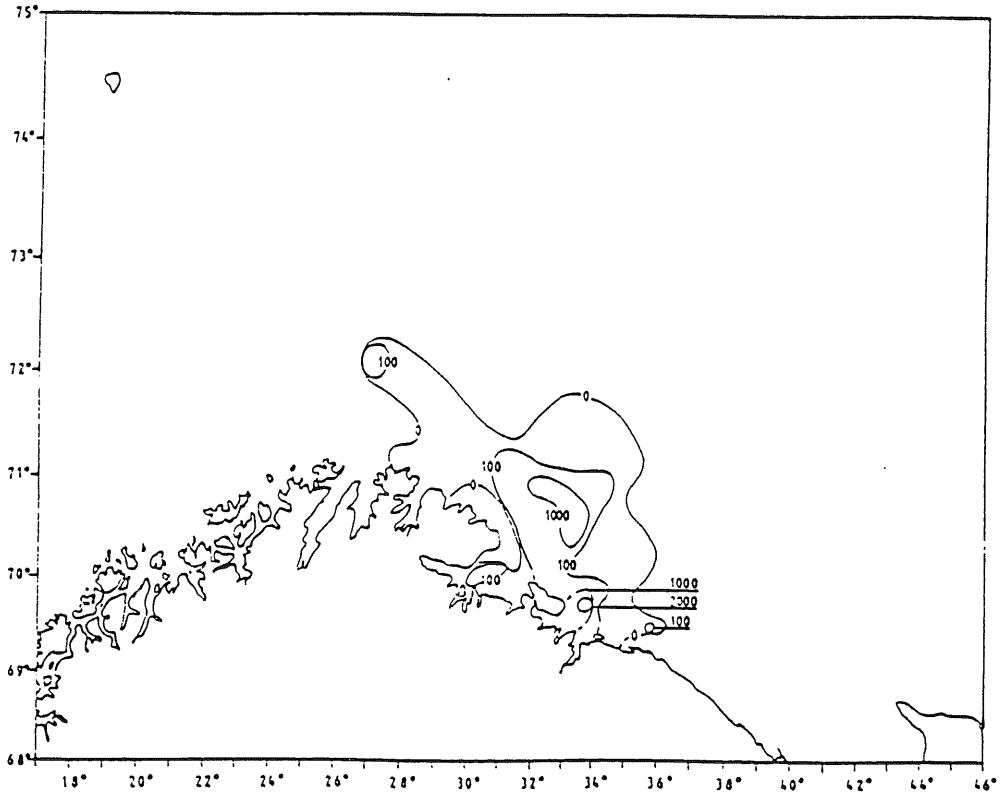


Figure 3.14 Norwegian spring spawning herring. Distribution of immatures 940606 - 940630. Isolines are given in tonnes/n.m.^{2}.

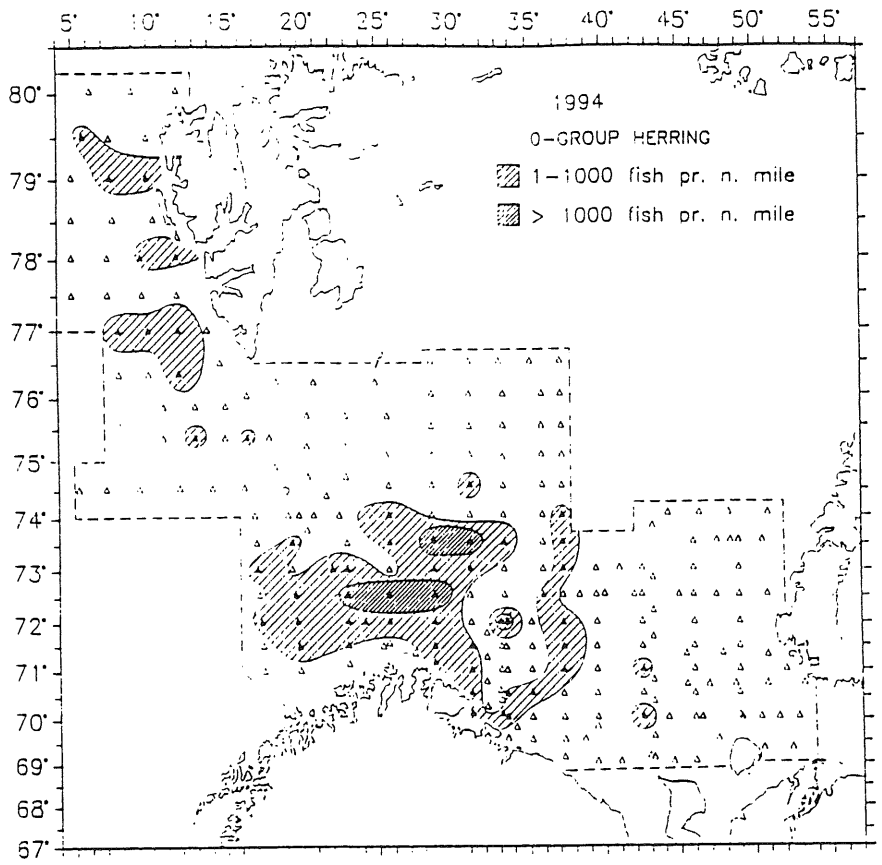


Figure 3.15 Norwegian spring spawning herrring. Distribution of 0-group herring in August 1994

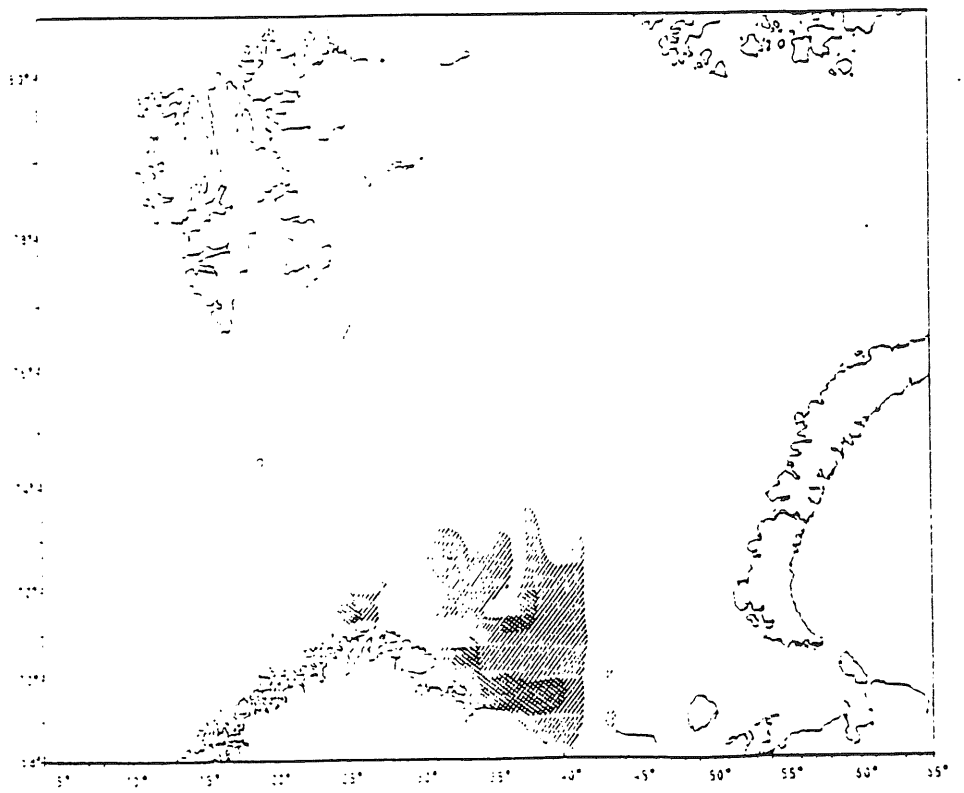


Figure 3.16 Norwegian spring spawning herring. Distribution of 0-group herring in September 1994

Figure 3.17 Norwegian spring spawning herring. Distribution of 1-group and older immature herring in September 1994.

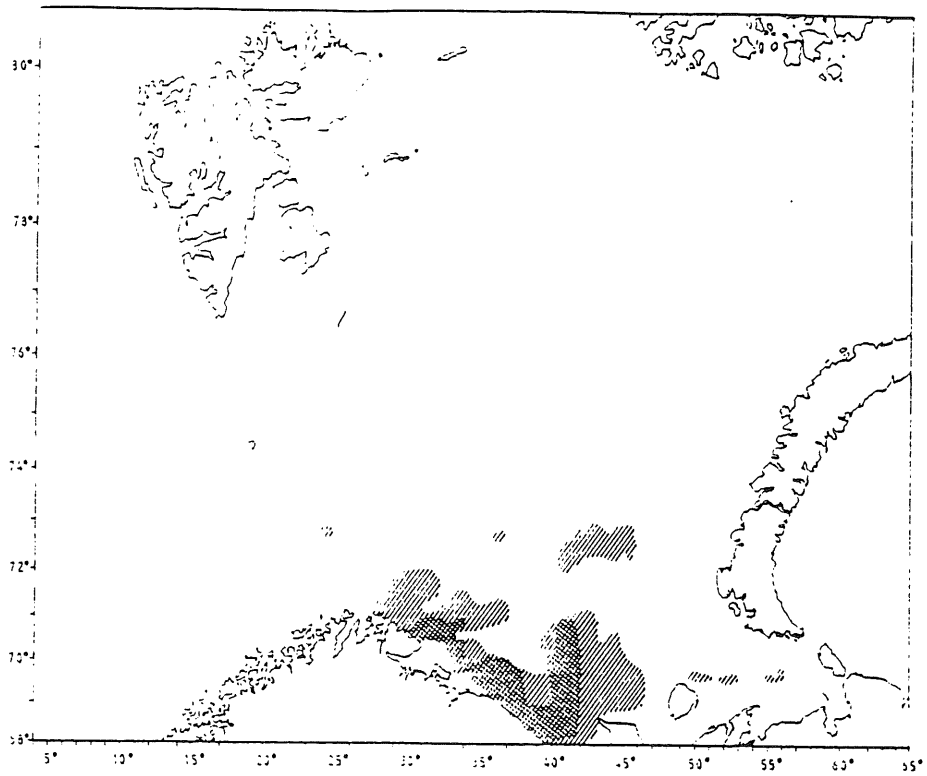


Figure 3.18 Norwegian spring spawning herring. A general picture of the distribution in 1994.

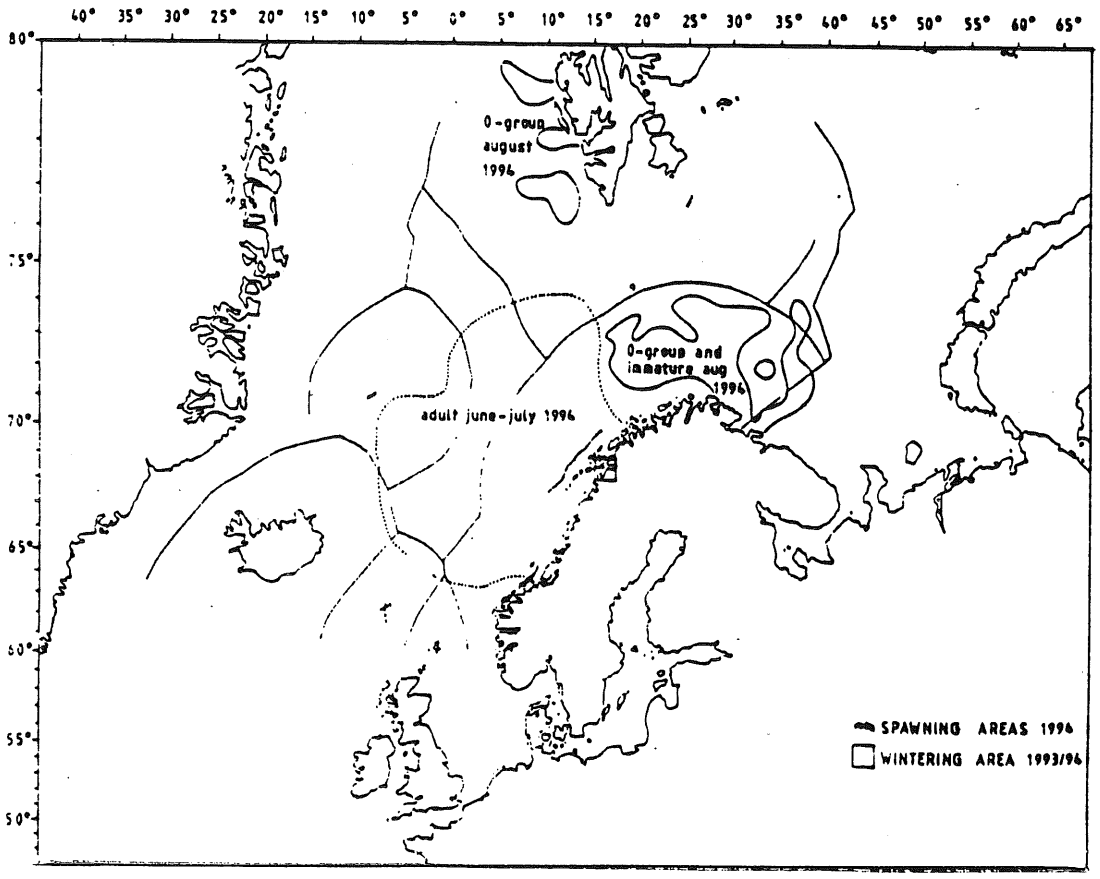
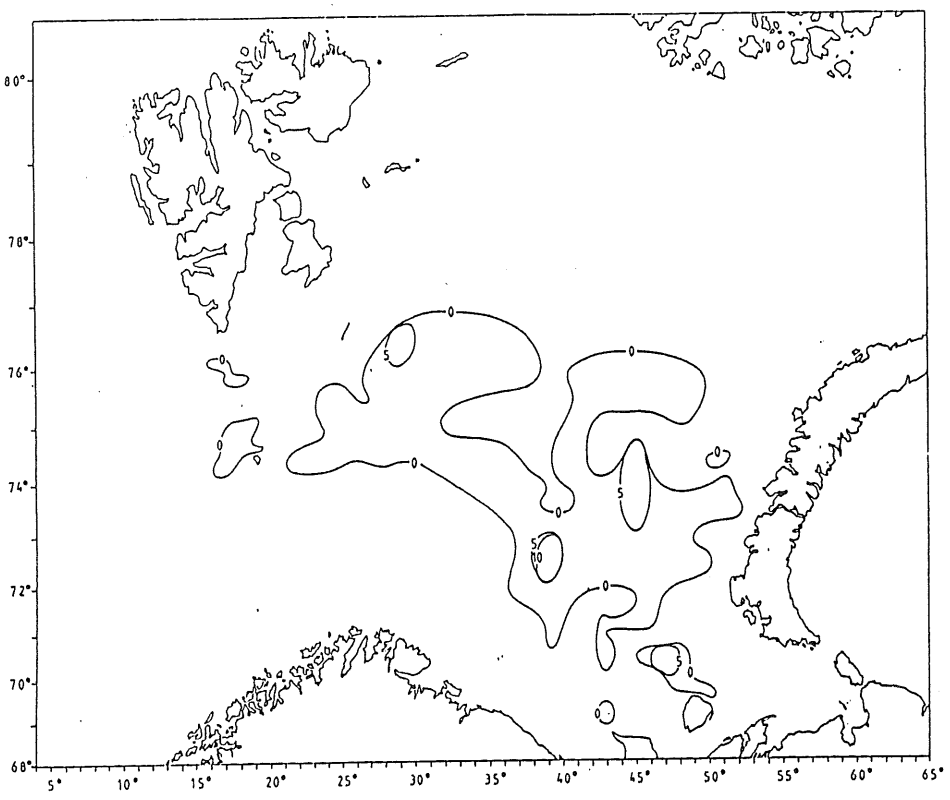


Figure 4.1 Estimated total density distribution of capelin. (tonnes/square nautical mile).



APPENDIX A

New tables for the capelin stocks

Working Paper to the Atlanto-Scandian Herring and Capelin Working Group Copenhagen, October 17-21, 1994

by

by Harald Gjøsæter, IMR, Bergen

Introduction

At the meeting of the Atlanto-Scandian Herring and Capelin Working Group in October 1993, a new set of tables presenting stock and fisheries for the Barents Sea capelin was presented in a working document by H. Gjøsæter, IMR. The tables were all extracted from a spreadsheet containing detailed information on stock development and fisheries from the beginning of the 1970's. The layout of the tables, with some minor adjustments, were adopted by the working group, to be used for both capelin stocks in the area. It was also decided that when these tables were used for the first time, they should be accompanied by a detailed description of the spreadsheet model, the data sources, etc. This working document is made to fulfil that need, and could be appended to this years Working Group report.

The spreadsheet model CapStock is built to ease the overview of the Barents Sea Capelin stock history. The capelin is a short-lived species with high spawning mortality, and cannot be managed using VPA and related tools. To grasp the main features of stock and fisheries, some tables resembling VPA tables could, though, be helpful. Also, a spreadsheet is very suitable for putting together information which up to now has been spread over various tables in survey reports, working papers to ICES working groups, working group reports etc.

Main features

In the model, implemented in "Microsoft Excel," the stock is divided on age groups one to five. In addition, each age group is split into two parts by a "maturation length" from October 1. until spawning the next spring. This maturation length splits the stock into one immature part and one maturing (autumn) and mature (spring) part, which will spawn and eventually die in late spring. The stock is presented as number of individuals, and mean weights are used to convert numbers into biomass.

Input and sources of information

1. Stock size in number

The only input is the joint Norwegian-Russian acoustic survey during autumn (October 1.). The following quantities are entered per age group: Estimated number of individuals, mean

weight, number of individuals larger than the maturation length, and their mean weight. The maturation length is fixed at 14.0 cm.

2. *Catch statistics* (Table 4.6 and 4.7)

Catch as number and biomass per. age group for the Norwegian, Russian and other countries fisheries are entered into separate columns. The autumn season is divided in two parts; August-September and October-December. This is because the autumn acoustic survey is conducted in September, and the quantity fished before the survey must be known to be able to back- and forward-calculate stock size. The catch of individuals above the maturation length in October, November and December is in addition entered separately, to be able to calculate the reduction in the maturing stock after the acoustic survey. Data for the Norwegian and Russian fishery is entered for all years. For other countries, it has been impossible to obtain detailed fisheries statistics, only total quantities landed are available. These catches have been allocated to age-groups and maturity groups using the Norwegian catches as a key. As Norway and Russia is totally dominating in the fisheries, the error that may have been introduced by this method is negligible. In most years the landings based on this new, detailed information match those listed in Table 4.1. However, some years there are minor differences, and in these cases Table 4.1 has been adjusted.

3. *Other input* (Table 4.9)

A natural mortality coefficient for immature fish applicable for the whole year is entered per. age group. After 1982, this quantity is estimated from the reduction in estimated numbers at the acoustic survey from year to year for age groups 1-2. The estimate of two years old fish in 1994 was larger than the number of 1-year-olds in 1993. Therefore, an M equalling that calculated for the period 1992-1993 was entered also for 1993-1994. The natural mortality estimates for the years prior to 1992 were obtained from the model "Capelin", previously used as a management model by the Atlanto-Scandian herring and capelin Working Group. The estimates were based on the reduction in the immature part of the age groups 2, 3, and 4 from year to year. Therefore the natural mortality was estimated together with a maturing length, because these two parameters were dependent of each other. These mortality estimates may therefore not be relevant when using a fixed maturation length, as is used in the present model. However, the maturation length for the period 1973-1982 estimated by the "Capelin" model varied between 13.9 and 14.1, and consequently, the error induced by fixing the maturation length at 14 cm should be negligible. The M-value is entered per. month. Another M-value for the mature population during the winter months is entered as per. season. This is a difficult parameter to put in. In later years, the Atlanto-Scandian Herring and Capelin Working Group has attempted to estimate the quantity of capelin removed by the predation from cod during the winter months.The method used has certain limitations, and until more reliable estimates can be obtained for a longer time period, a natural mortality of maturing capelin in winter equal to that calculated for the immature capelin during the whole year, is entered.

The mean weight at January 1. for age groups 2-5 is estimated from the mean weight measured for the same year class in the autumn of the previous year, applying a constant multiplier equal to 1.1. The mean weight of the one-year-olds is estimated from that measured for the same age group in October the same year, applying a

multiplier of 0.4. The constants 1.1 and 0.4 are estimated from some few years where reliable measurements of mean weights in January are obtained, by comparing those weights with those of the previous autumn (age 2 to 5) and the following autumn (one-year-olds). The mean weight for mature fish at time of spawning (April 1.) per. age group is taken from the sampling of the (Norwegian) catches just before spawning.

The mean weights at August 1. for all age groups are estimated as the mean weights per January 1. plus 25% of the difference between those weights and the weights measured at October 1. The condition that 25% of the growth takes place before August 1 is based on some few years of observations during July-August.

Calculated quantities

1. Stock in number per. age group at August 1. (Table 4.5)

These values are calculated differently for the one-year-olds and for older age groups. The age groups two to five are back-calculated from the survey results two months later, considering the number caught in the fisheries in August and September, and the number lost by natural mortality during the same months. The equation applied is

$$N_i = N_{io} \cdot e^{(F_i + 2 \cdot M_i)} \qquad \text{eq. (1)}$$

where

N_i is the number of fish in age group i at August 1.,
N_{io} is the number of fish in age group i at October 1.,
F_i is the fishing mortality during August-September for age group i, and
M_i is the natural mortality for immatures in age group i, per. month.

The one-group is treated separately before and after 1980. Before this year, the one-group, occupying the southeastern parts of the Barents Sea, was poorly covered during the acoustic survey in autumn, and was therefore grossly underestimated. The number of one-year-olds at August 1. is therefore back-calculated from the number of two-year-olds one year later, applying equation 1, but accounting for natural mortality during 12 months and fishing during the whole autumn period at age one. (No immature two-year-olds are caught in the spring fisheries). From 1980 onwards, the one-year-olds are back-calculated from October 1. the same year, in the same way as the older age groups, because the youngest age-group is seemingly properly covered during the acoustic survey.

2. Stock by weight at August 1. (Table 4.5)

The calculated number of fish in each age group is multiplied with the estimated mean weight for each age group.

3. Stock in number per. age group at January 1. (Table 4.10)

The recruiting year class (one-year-olds) is back-calculated from August 1. the same year, using equation 1, accounting for natural mortality during seven months. The age groups two and older are projected from August 1. the previous year, taking care of the catches during autumn, and natural mortality during five months. The following equation is used:

$$N_{ij} = N_{i-1,j-1,o} \cdot e^{-(F_{i-1,j-1} + 5 \cdot M_{i-1,j-1})} \qquad eq\ (2)$$

where

N_{ij} is number in age group *i* at January 1., year *j*,
$N_{i-1, j-1,o}$ is number in age group *i-1* at August 1., year *j-1*,
$F_{i-1,j-1}$ is fishing mortality during the whole autumn for age group *i-1*, year *j-1*, and
$M_{i-1, j-1}$ is the natural mortality coefficient for age group *i-1*, year *j-1* (per. month).

4) Stock by weight at January 1.(Table 4.10)

The number of individuals in each age group is multiplied by the estimated mean weight.

5) Mature stock in number at January 1.

The number of individuals in each age group that is maturing and will take part in the spawning three months later, is projected from October 1. the previous year, reduced by natural mortality and fishing from October to January. Equation 2 is used, but based on the number of fish above the maturation length at October 1., and applying an M for three months and an F calculated for the period October-December.

6) The spawning stock in number at April 1.(Table 4.13)

These numbers are projected from the mature part of the stock at January 1., reduced by the fishing mortality during spring and by the natural mortality for mature fish during this period. Equation 2 is used.

7) The spawning stock by weight at April 1.(Table 4.13)

The number of individuals in each age group is multiplied by the mean weight of mature fish at April 1.

8) Fishing mortality coefficients (Table 4.8)

Four F's are needed for each age group: First an F for the period August-September, another one for October-December, (their sum make up an F for the autumn fishery), an F for the catches of maturing individuals in October-December and, finally, an F for the spring fisheries. These F's are calculated by iteration, using the catch equation solved for F:

where

$$F_i = \frac{C_i(F_i + K \cdot M_i)}{N_i(1 - e^{-(F_i + K \cdot M_i)})} \qquad eq\ (3)$$

F_i is the fishing mortality coefficient for age group i,
C_i is the catch in number of age group i during the period,
N_i is the initial number of fish in age group i
M_i is the natural mortality coefficient per. month of age group i, and
K is the number of months in the period

In some instances (mostly on five years old fish) an F cannot be calculated, because the number of individuals removed by the fishery is larger than the estimated number of fish in the stock. The number of one-year-olds and five-year-olds caught is most years negligible. The mean F (weighted with the catch) for the 2-4 years old fish is presented in Table 4.9

Presentation of results

Having all these data and calculated quantities (and some more, including biomass output caused by natural mortality) accessible at the spreadsheet, many different tables and figures can be produced for presentation. The tables automatically produced during recalculation of the spreadsheet are:

1) Time series of stock in number by age group, and of stock in number and biomass of the total stock at August 1. (Table 4.5).
2) Time series of total catch in number by age group and total, and total weight, for the spring season (Table 4.6) and the autumn season (Table 4.7).
3) Time series of estimated fishing mortality coefficients for the autumn fishing season by age group and weighted mean for age groups 2–4 (Table 4.8).
4) Time series of natural mortality coefficients for immatures per. month (used for immature fish year-round and for maturing fish during the autumn period) and natural mortality coefficients for the mature population from January 1. up to spawning (April 1.) (Table 4.9).
5) Time series of stock in number by age group, and of stock in number and biomass for the total stock at January 1. (Table 4.10)
6) Time series of mean weight by age group and weighted average for the total stock at January 1. (Table 4.11).
7) Time series of proportion of maturing fish in each age group at January 1. (Table 4.12).
8) Time series of spawning stock sizes at April 1. (Table 4.13)
9) A stock summary table, consisting of recruitment (nos of 1-year-olds at August 1.), total stock biomass at August 1., spawning stock biomass at April 1. the following spring, and total landings during the autumn and the following spring. Contrasting the other tables, this one is organized with years listed vertically. (Table 4.14)

Comments on the tables

Most of the new tables include calculated quantities, the only exceptions are Tables 4.6 and 4.7, which give the landings in the two fishing season. Practically all the calculations involve estimated input values, where the estimates varies from "educated guesses" to fairly credible estimates. Consequently, the tables will in some respects differ from previous published material, and may also, if new (and better) input data are at hand, be changed in the future. The series of spawning stock sizes presented here should not, in particular, be taken as "authorised" values. These values are dependent on several uncertain factors, including natural mortality of maturing fish in autumn and mature fish in spring, and maturation length. More reliable estimates for some of the quantities listed in these tables may in the future be obtained from more sophisticated models, e.g., the "Multspec" model built at the Institute of Marine Research in Bergen. On the other hand, one should have in mind that neither these tables nor the "Capstock" model which produced them, are meant as a management tools. Their sole function is to help people within and outside the capelin assessment community grasp the main features of the resent capelin stock history.