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Exploration of the Sea

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REPORT OF THE ATLANTO-SCANDIAN HERRING AND CAPELIN WORKING GROUP

Copenhagen, 18-22 October 1993

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CONTENTS

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 18-22 October 1993 to (C.Res. 1992/2:8:18):

a) assess the status of and provide catch options for 1994 and 1995 for the Norwegian spring-spawning herring stock, and review the status of the Icelandic summer-spawning herring stock;

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 1993/1994 and summer/autumn 1994 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 1993/1994 and summer/autumn 1994 seasons;

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

1.2 Participants

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H. Gjøsæter	Norway
J. Hamre	Norway
J. Jakobsson	Iceland
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2 ICELANDIC SUMMER-SPAWNING HERRING

2.1 The Fishery

The catches of summer-spawning herring from 1973-1992 are given in Table 2.1. These include an estimated 1,850 t of discards for the 1992/1993 season. The fishery took place off the southeast coast and 74% of the catches were used for reduction while 26% were used for human consumption. Until 1990 the herring fishery took place during the last 3 months of each calendar year but in 1990, 1991 and 1992 the autumn fishery continued in January and early February the following year. Therefore all references to the years 1990-1992 refer to the season starting in October of that year.

The landings, including discard estimates, recommended TACs and agreed TACs are given in the table below in thousand t.

Year	Landings	Catches including discard estimates since 1989	Recommended TACs[1]	Agreed TAC
1984	50.3	50.3	50.0	50.0
1985	49.1	49.1	50.0	50.0
1986	65.5	65.5	65.0	65.0
1987	73.0	73.0	70.0	72.9
1988	92.8	92.8	100.0	90.0
1989	97.3	101.0	90.0	90.0
1990/1991	102.3	105.6	90.0	100.0
1991/1992	100.3	109.5	79.0	110.0
1992/1993	105.6	107.5	86.0	110.0

[1]Recommended by ACFM.

2.2 Catch in Number and Weight at Age

The catches in number at age for the Icelandic summer spawners for the period 1973-1992 are given in Table 2.1. As usual 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.

The weights at age for each year are given in Table 2.2. Jakobsson *et al.* (1993) have examined the stock-related changes in various biological parameters of the Icelandic summer-spawning herring including the weight at age in the period 1960-1992. The most striking feature of this examination is that despite some 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. It is only when the stock was reduced to an extremely low level of abundance that these parameters changed. It should be noted that the stability has continued despite the fact that during the period in question the environmental conditions in Icelandic waters have been extremely variable (Malmberg and Kristmannsson, 1992). The proportion mature at age is given in Table 2.3.

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 21 November to 14 December 1992 an estimate of all age components of the stock was obtained. The stock was located in three areas off the southeast coast of Iceland with the exception of the 1991 year class which was mainly located in Eyjafjörður in the north of Iceland. Surveys outside these areas did not detect herring. The results of the December survey have therefore been used as the basis for the present assessments (Table 2.4).

2.3.1 Target strength

In previous years the acoustic abundance estimates were calculated using the equation TS = 21.7 log L - 75.5 dB. When comparing the acoustic estimates to the VPA estimates of the Icelandic summer-spawning herring it is clear that the acoustic estimates are on several occasions well above the estimates obtained from the VPA. This is shown in Figure 2.1a. Jakobsson *et al.* (1993) examined the relationship between the VPA and acoustic estimates taking into account the possibility of varying the natural mortality coefficient M. They found that the best fit between the VPA and acoustic estimates is obtained when using a TS value which is about 1 dB higher for adult herring than has been used so far. Reynisson (1993) has shown that a 20 log L relationship is significantly better than the 21.7 log L relationship used in earlier acoustic estimates of the Icelandic summer spawning herring. For the adult component of the stock (30-35 cm) the relationship TS = 20 log L - 72 dB corresponds to about a 1 dB increase in the TS value and this relationship has, therefore, been used to recalculate the acoustic estimates presented in Table 2.4. This is 27% higher than the TS value which has been used previously for this stock (Halldórsson *et al.*, 1986). This new relationship gives a better fit between the acoustic survey estimates and the VPA as shown in Figure 2.1.b, and is almost identical to that used for the acoustic estimates of the Norwegian spring-spawning herring.

2.3.2 Natural mortality

Jakobsson *et al.* (1993) also calculated SSE-values between acoustic and VPA abundance estimates for different values of M. As shown in Table 2.8 the currently used M of 0.1 gives the best fit for 5 ringers and older herring for M values in the range 0.1-0.2.

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 1992/1993 season. Results are given in Table 2.7 as F^1. 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 2.2. From this series of VPAs it is clear that the best (giving the minimum value of SSE) one to one relation between the acoustic estimates and virtual population analysis is obtained with an input F of about 0.36. The confidence intervals for the fitted terminal F values (0.24, 0.56) 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 2.2).

The fishing mortalities for 1-4-ringers in 1992, based on the 1992 surveys 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 2.4. The resulting stock trend from VPA is plotted along with the acoustic estimates in Figure 2.1b and the correspondence with acoustic estimates is shown in Figure 2.3 using the new TS values of TS = 20 log L - 72 dB.

According to the current assessment the spawning stock biomass was about 400,000 t in July 1992 as compared to the projected spawning stock from last year's assessment of 548,000 t. This difference is largely due to the change in the target strength levels in the acoustic estimate. In Table 2.16 and Figure 2.4 a summary of a VPA run back to 1947 is given.

2.5 Catch and Stock Projections (Tables 2.9-2.15)

The input data for the projections are given in Table 2.9. As in previous years a regression of weight increase has been used to predict the weight at age for 2-8 ringers (using as input weights at age for 1-7 ringers the year before). Data for the regression included, as starting years, the period 1983-1992, 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 relation:

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

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

The exploitation pattern used for the stock and catch predictions is the same as that estimated for 1992. This is somewhat different from the average exploitation pattern based on the fishery during 1985-1988 as shown in Table 2.7. In these reference years the fishing took place in the east coast fjords where the older part of the herring stock overwintered. Therefore the younger part of the stock was very lightly fished on the overwintering grounds off the southeast coast. In the most recent years the entire stock and the fishery have been concentrated off the southeast coast and therefore the former fishing pattern is not considered valid for the present fishery.

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 of 1-ringers in 1994 has been used. This indicates a steady-state yield of 87,000 t at $F_{0.1}$ = (0.20). (Table 2.15). The catch in 1993 is assumed to be equal to the TAC of 100,000 t.

Detailed output for the prediction assuming catches corresponding to a fishing mortality rate (F4-14w) of $F_{0.1}$ = 0.20 are given in Table 2.11 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 2.13) and the summary results of the yield per recruit calculations are given in Table 2.15 using the input values in Table 2.14.

2.6 Management Considerations

A TAC of 100,000 t has been set for the current 1993/94 season. This corresponds to a fishing mortality of $F_{4\text{-}14w}$ = 0.25. Fishing at $F_{0.1}$ during the following three seasons would result in an average catch of about 92,000 t.

Setting a TAC for the 1994 and 1995 season at 90,000 t would result in a fishing mortality which is very near $F_{0.1}$. This is some 25,000 t less than predicted in the 1992 report but corresponds to about the same as was calculated in 1991 (Anon., 1991). The reason for this discrepancy is mainly the change in TS values described above. 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 1988 and 1989 year classes presently in the stock has dwindled. Therefore, the Working Group stresses that managing this stock at an exploitation rate at or near $F_{0.1}$ has been successful in the past.

3 NORWEGIAN SPRING-SPAWNING HERRING

3.1 The Fisheries in 1992

The initial TAC for 1992 was set at 78,000 t (Norway 65,000 t and Russia 13,000 t). However, the Norwegian TAC was raised from 65,000 t to 85,000 t in August 1992.

In 1992 the Norwegian fishery started at the beginning of January in the wintering areas in the fjords of northern Norway. Approximately 10,000 t were caught in this area up to the first week of February. The herring migrates out of this area to the spawning areas of Møre which becomes the main fishing area from mid-February. The Norwegian catch in the spawning area at Møre amounted to about 15,000 t. In addition, 2,600 t were caught in the spawning area at Karmøy. The Russian

catch in the spawning area was 13,337 t. The catches in late spring and summer were small due to lower quality, price and availability. In August/September, the herring again migrated into the wintering areas, and in autumn approximately 58,000 t were caught in this area. Compared with previous years, a larger proportion of the total catch was taken on the wintering grounds, while the proportion taken on the spawning ground decreased. Of the total Norwegian catch, 73% was used for human consumption and 27% for reduction. The TAC for 1993 is set at 200,000 t.

3.2 Catch Statistics

The total annual catches of Norwegian spring-spawning herring during the period 1972-1993 are presented in Tables 3.1 and 3.2. To account for additional mortality in the fishery, 5,000 t have been added to the reported catches in 1992. This is the same amount which was added in 1991.

Table 3.3 gives the catch in number. The catches in 1992 show an increasing number of herring of the 1988 and 1989 year classes. The weight in the catch and weight in the stock (1 January) are given in Tables 3.6 and 3.7. About 7,000 herring were analysed for age, length, weight and sexual maturity.

3.3 The Adult Stock

3.3.1 Acoustic survey on the spawning grounds

As in 1992, it was not possible to carry out a complete stock estimate on the spawning grounds in February-March 1993. Due to bad weather only a limited area at Møre could be surveyed. The biomass of spawning herring in this area was estimated to be approximately 1.1 million t. However, samples taken from this area (both from the research vessel and from the fishery) showed that the age distribution was not similar to the age distribution of the mature stock in the wintering areas. At Møre, the 1983 year class constituted a larger part of the samples than in the wintering areas. Thus, the survey in February-March 1993 covered neither the whole spawning area nor the younger part of the spawning population (i.e., 1988 and 1989 year classes) and cannot be used for stock assessment purposes.

3.3.2 Acoustic survey on the wintering areas

Two acoustic surveys were carried out in the wintering areas in Ofotfjord/Tysfjord. The first survey was carried out in December 1992 and the second in January 1993. The survey in December 1992 in Ofotfjord was designed as a series of 7 acoustic surveys, and the results are reported in Foote (1993). These include compensation for the effect of extinction when estimating mean abundance, and variance by means of geostatistical methods.

The overall results from the wintering areas, covering the entire spawning stock, are as follows when a TS = 20 log L - 71.9 is applied:

Year class	December 1992 (million individuals)	January 1993 (million individuals)
1982+	69	128
1983	3742	5691
1984	139	182
1985	208	269
1986	16	27
1987	173	256
1988	1317	2048
1989	1247	1905
1990	36	61

This corresponds to a biomass of 2.2 million t in December 1992 and 3.4 million t in January 1993. The reason for the difference between the two estimates is not known. In December the herring are permanently in the wintering area and are orientated in a very irregular manner (which is confirmed by underwater photography). In January, however, the herring have started their spawning migration and are probably orientated in a more uniform manner.

Different behaviour patterns will result in different tilt angle distributions and thus different *in situ* target strength. The target strength/length relationship which is in use, TS = Log L - 71.9 (Foote, 1987) is based on *in situ* measurements on herring from many geographical locations and under varying conditions. It is not known if the *in situ* measurements which are the basis of the above TS/L relationship are representative for the

December or January situation. Thus, it cannot at present be concluded which of the estimates is the most reliable. Information on tilt angle distributions is needed to solve this problem.

3.3.3 Tagging experiments

The Norwegian tagging experiments on herring which were initiated in 1975 have been continued, and experimental fishing for recoveries was carried out in the wintering area in January 1993. 4,400 t of herring were caught and screened for tags and 57 tags were recovered from releases in 1987 to 1992 (Figure 3.1). In addition, 71 tags were retained on magnets in Bodø fish meal plant in 1993. These tags are used in the mortality estimate. The recoveries by year of release are shown in the following text table.

Year of release	m	r	r'	Σr	lnK	m_{93}
1987	38500	3	7	10	2.04	4955
1988	44000	11	11	22	1.39	7319
1989	37600	8	15	23	1.18	8084
1990	29596	13	18	31	0.65	8224
1991	18292	10	7	17	0.77	6570
1992	25800	12	13	25	0.72	11977
Sum	193788	57	71	128		47128

m = number released
r = number recovered in the experimental catch
r' = number recovered in Bodø fish meal plant
K = m/Σr x 500
m_{93}= calculated number of survivals in 1993 using 40% initial mortality due to tagging

3.3.4 Mortality estimate from tagging

The total mortality Z over the period 1987-1992 was estimated by the method previously used by the Working Group (Anon., 1981; Hamre, 1990). The plots of lnK against year of release are shown in Figure 3.2.

The annual mortality Z is estimated at 0.257 with a correlation coefficient of 0.9.

3.3.5 Abundance estimate from tagging

Applying Z = 0.257 as the annual mortality rate of the tagged population, the estimate of the tagged population in the winter of 1993 is shown in the last column of the text table in Section 3.3.3. In this calculation 40% initial tagging mortality was used compared to 30% in previous reports. The increase in the initial mortality rate is due to the new tagging method introduced in 1982 (Anon., 1987). Recoveries from comparable releases by the two methods show a slight increase in the initial mortality of the new method in the order of 10% (Hamre, Working Document). The catch in number effectively screened for tags was 11.938 million individuals, which gave a stock abundance estimate of 9.9 billion individuals. The 1983 year class accounted for 54% of the estimate or 5.3 billion individuals.

3.3.6 Natural mortality

Previously the Working Group has applied M = 0.13 in the adult stock. This value was derived from tagging experiments in the early 1980s. Taking into account the possible effect of *Ichthyophonus hoferi*, and the recent mortality estimate obtained from tagging (Section 3.3.5), the Working Group decided, for the time being, to apply an M of 0.23 for the adult stock.

Samples of herring from the wintering areas show that herring of age 5 and older have a higher prevalence of the *Ichthyophonus* disease than the younger age groups. In the VPA, for the years 1991-1992, an M of 0.13 is applied to ages 3 and 4, while 0.23 is used for the older age groups.

3.3.7 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	5.30	3.77	5.70	

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 earlier 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). *In situ* target strength measurements carried out on the spawning areas by comparing integrator values and purse seine catches gave TS = 20 log L - 73.5 (Hagström and Røttingen, 1982).

In an attempt to resolve this, the Working Group decided 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 3.3.

This gives an estimate of the 1983 year class, of 4.206 billion individuals at 1 January 1993. Using this, and the age distribution from the January 1993 survey, the estimate of the herring in the wintering area is as follows:

3.3.8 VPA analysis

The input data in the VPA are given in Tables 3.1, 3.3 and 3.6-3.9. 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 the text table in Section 3.3.7.

The results of the VPA are given in Tables 3.10-3.13 and in Figure 3.5A and 3.5B.

Year Class	Estimate (million individuals)
1982+	95
1983	4,206
1984	135
1985	199
1986	20
1987	189
1988	1,513
1989	1,409

Work has been initiated to compile and eventually revise the input data for a VPA back to the 1950s (Dommasnes *et al.* Working Document). This work will continue with special emphasis on the catch at age and weight at age data from the 1950s and 1960s. In the present report the VPA is, therefore, only run back to 1974.

3.4 Recruitment

3.4.1 Stock estimates of immature herring

The nursery areas of Norwegian spring-spawning herring are the Norwegian fjord and coastal areas and the southern part of the Barents Sea. Since 1988, when the major part of the 1983 year class spawned for the first time, the latter area has increased in importance as a nursery area for the herring. Concentrations of 0-group herring were located east of Jan Mayen in August 1993. Juvenile herring have not been located in that area in the past 40 years. Data on immature herring are available from three investigation series:

1. Acoustic estimates of 0-group herring in fjord and coastal areas of Norway (Table 3.4).
2. 0-group trawl survey in the Barents Sea in August-September (Table 3.5).
3. Acoustic estimates of immature herring in the Barents Sea (Table 3.5A).

The 0-group herring found in the Jan Mayen area in 1993 are not included in the tables above.

3.4.2 Natural mortality of immature herring

The Working Group has previously calculated the natural mortality of the immature herring by comparing the acoustic estimates of young herring, and estimates of the same year class obtained from VPA as 3 year old. On the basis of this, the Working Group in 1992 calculated an annual M = 0.9 for herring of ages 0-2 years.

This year the stock and VPA estimates (Table 3.11) have been revised upwards. This would result in lower values of natural mortality for immature herring in the Barents Sea if similar calculations as last year are carried out. However, in view of the situation in the Barents Sea with an increasing stock of cod and a rapidly declining stock of capelin (see Section on multispecies considerations), the Working Group decided to apply as in previous years annual M of 0.9.

3.4.3 Assessment of immature herring

The following text table gives an assessment (million individuals) of the 1989-1992 year classes as 3-year-old herring.

Year class	Basis of estimate (million individuals)	Time of Survey (Table 3.5A)	M	Time span (months)	Estimated as 3-year olds
1989	5,731	June 1992	0.13	-5	6,050[1]
1990	14,027	June 1992	0.9	7	8,298
1991	25,790	June 1993	0.9	7	15,256
1992	102,670	June 1993	0.9	19	24,693

[1]Back-calculated.

3.4.4 Maturity development of the 1989 year class

In January 1993, 1409 million out of a total of 5400 million individuals from the 1989 year class were mature in the wintering areas. This would indicate a maturing proportion of 0.3 for 4-year-old herring.

The distribution in August 1993 (Figure 3.4) most probably covers the entire distribution area of the 1989 year class. Investigations on maturity from this and other surveys indicate that 20% of the 1989 year class were immature. These herring will probably not spawn in 1994. Thus, the maturing proportion for 5-year-olds in 1994 is set at 0.8. Complete maturation of this year class is expected as 6-year-olds.

The same development of maturity may be expected for the year classes 1990-1992. Thus, the following proportions of maturity are used in the prognosis:

0-2 years	0
3 years	0.01
4 years	0.3
5 years	0.8
6 years and older	1.0

3.5 Catch and Stock Prognosis

The numbers of young herring by year class as 3-year-olds are given in the text table in Section 3.4.3. For the adult herring VPA values at 1 January 1993 have been used.

No trends in weight in the catch and weight in the stock have been detected in recent years and an average for the years 1986-1992 has been used in the prognosis. Thus, the average will include weight data from the 1983 year class. Further, the maturation ogive for the 1989 year class has been used in the prognosis. The input data to the prognosis are given in Table 3.14. A natural mortality of 0.23 has been applied.

3.5.1 Results of the prognosis

Table 3.15 and Figure 3.5D give the effects of different levels of fishing mortality on the catch in 1994, and on the stock and spawning stock biomass.

The assessment shows that the spawning stock biomass at 1 January 1994 will increase above 2.5 million t with the anticipated high recruitment (Section 3.4.3). The increase will continue in 1995 at all levels of fishing mortalities listed in Table 3.15.

3.6 Management Considerations

In its 1992 report (Anon., 1993a), the Working Group pointed out that the exploitation rate for this stock should not be increased above the present low level until the recruitment to the spawning stock from the 1989 and 1990 year classes has been confirmed, and until the spawning stock biomass had reached the minimum target size of 2.5 million t. When these requirements are met, the fishing mortality could be increased gradually to $F_{0.1}$ (which corresponds to F = 0.26), at which the spawning stock reaches the MSY-level of about 6 million tonnes (Anon., 1993).

According to the assessment and prediction carried out this year (Table 3.15), the spawning stock biomass will

exceed 2.5 million t in 1994, with the 1989 and 1990 year classes contributing 29% and 13%, respectively. Using the same input parameters as in the prognosis (Table 3.14) $F_{0.1}$ equals 0.40. This rather high value is mainly caused by the increased natural mortality coefficient applied for the adult herring this year and on resumption of lower natural mortality, $F_{0.1}$ will be at the lowest level of 0.26 given above. The Working Group is, therefore, of the opinion that F = 0.40 is not suitable as a target level of fishing mortality.

On the basis of the present assessment, the spawning stock size may reach 6 million t by 1997-1998.

The Working Group reiterates its advice on stock recovery policy given last year. However, taking into account the possibility of an increase in the natural mortality on immature fish (because the cod may eat more herring after the collapse of the Barents Sea capelin stock), as well as on mature fish (because of the *Ichthyophonus* infection), a cautious approach is advised if there is to be any increase in the exploitation rate.

The Working Group notes that several methods exist for managing the stock in such a fashion that $F_{0.1}$ is approximately reached in the longer term. One such method is given by Pelletier and Laurec (1990) and is based on applying the formula $F(y+1) = aF(y) + (1-a)F_{0.1}$, where a is a number between 0 and 1. Values of a above 0.5 could be used to obtain an orderly development of the fishery in the direction of $F_{0.1}$. Such values of a will result in higher stability since most weight is given to the current (low) fishing mortality.

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

Three Norwegian research vessels undertook a survey of a major part of the Norwegian Sea (areas south of 66°N were not completely covered) at the end of July - beginning of August 1993. The recorded distribution of Norwegian spring-spawning herring is shown in Figure 3.4. Information on wintering and spawning areas in 1993 and on the distribution of immature herring in the Barents Sea in August 1993 is also included in the figure. For comparison, the distribution recorded in 1991 (the last time there was a comprehensive herring survey in the Norwegian Sea) is also included. Russian and Faroe Island investigations in June-August 1993 confirmed that the herring were distributed south to 60°N and 5°W in the Norwegian Sea. In the south-eastern area of the Faroese Exclusive Economic Zone a few herring of the spring spawning type were observed in May-July. There seems to have been both a more northerly and a more southerly distribution of adult herring in the Norwegian Sea in 1993 than in 1991.

3.8 *Ichthyophonus hoferi* Disease in Herring

This disease was first observed in herring in the North-East Atlantic in the summer 1991 and since then, infected herring have been observed in nearly every sample examined. *I. hoferi* infection has been reported in all year classes of herring but the overall impact on the population dynamics of the stocks has not been determined because estimates of prevalence vary according to the method of sampling, location and season.

Samples of herring taken in 1993 again revealed variable but significant infestation of *I. hoferi*. In the wintering areas in January, 1,500 herring caught by purse seine had an infection rate of 6.7% (compared to 1-2% in January 1992), with 75% of the infected fish belonging to the 1983 year class. Later catches, when most herring had left the area, gave prevalences of 60-70%. Catches from Møre in the later part of the spawning season also indicated higher prevalences.

Herring sampled by trawl generally exhibited higher infection rates. Herring, mainly of the 1989 year class, sampled during January on the Malangen Bank, exhibited a 64% infection rate. The infestation of herring appeared to have occurred earlier in 1993 than in 1992 as evidenced by the prevalence (18%) of encapsulated spores in infected fish. During February, 82% of the fish from three samples on the spawning grounds were infected. In one sample from March 1993, the infection rate was 75% with 94% of the infected fish exhibiting encapsulated spores.

Herring sampled by purse seine in Faroese waters in July were not infected.

A diagnostic standard for epidemiological studies was agreed upon at a special meeting at Lysekil in November 1991 using lesions in the heart as the main criterion. In a recent study, Karaseva *et al.* (1993) reported that pathological changes as observed in histological sections were apparent in higher proportions for spleen, kidney, liver and muscle than for heart tissue.

Because the disease is believed to be almost 100% lethal for herring, the Working Group is concerned about the increase in infection rates and the resulting increase in natural mortality. Although infection rates were variable and although there is a lack of precise data on the time course of the disease, the increase in natural mortality in recent years estimated from the tagging data is consistent with the outbreak of this disease in this herring stock.

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 agreement between the 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. 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 1965-1993 is given in Table 4.1. Statistics for the autumn season 1992 and the winter season 1993 are given in Tables 4.2 and 4.3, respectively. The TAC for the autumn fishery 1992 was 265,000 t, and the total landings were 232,000 t. In winter 1993, 586,000 t were landed, while the TAC was set for 600,000 t + the amount of the autumn TAC which was not taken, i.e., a total of 633,000 t. Following the recommendation from ACFM, there was no fishing for Barents Sea capelin during the autumn season of 1993.

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 4.4. The index in 1993 equals that of 1991 and shows that the larval production in 1993 was sufficient for a rather strong year class to emerge.

During the international 0-group survey in the Barents Sea in August 1993, very small qwuantities of 0-group capelin were detected. This result was confirmed during the Russian/Norwegian acoustic survey in September. The capelin larvae must have disappeared between late June (larval survey) and mid-August (0-group survey). In conclusion, the recruitment may fail two years in a row, which alone will have a serious negative effect on the stock.

4.3.2 Acoustic stock estimates

The 1993 acoustic survey was carried out jointly by three Russian and two Norwegian vessels in the period 9 September to 3 October. The distribution of capelin is shown in Figure 4.1. Table 4.5 gives the estimates of numbers at 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 1992 are shown in brackets).

Year class		Age	Number (10^9)		Mean weight (g)		Biomass (10^3 t)	
1992	(1991)	1	2.2	(351.3)	3.4	(3.6)	7.7	(1249.1)
1991	(1990)	2	53.4	(196.3)	9.0	(8.6)	482.4	(1690.6)
1990	(1989)	3	17.3	(128.8)	15.1	(16.9)	261.3	(2171.7)
1989	(1988)	4	2.4	(1.3)	18.8	(29.5)	44.9	(39.0)
Total stock								
1993	(1992)	1-4	75.3	(677.7)	10.6	(7.6)	796.3	(5,150.4)

According to this estimate, the 1992 year class (1-group) consists of 2.2 billion individuals. The mean weight is 3.4 g in 1993, compared to 3.6 g in 1992. The biomass of the 1-year-olds is, consequently, about 8,000 t, the lowest abundance of 1-group recorded since these surveys started in 1972.

The estimated number of the 1991 year class (2-group) is 53 billion, as compared to 196 billion for the 1990 year class estimated last year. The mean weight of this age group is 9.0 g (8.6 g in 1991), and consequently the biomass of 2-year-old fish is 482,000 t, 29% of that of the 1990 year class at this stage.

The 1990 year class is estimated at 17.3 billion individuals with a mean weight of 15.1 g, giving a biomass of 261,000 t. This is 14% by number and about 12% by weight, the size of this age group was estimated last year.

The 1989 year class (now 4 years old) was originally very strong. It has, however, contributed to the spawning stock over two years, and has in addition experienced considerable natural mortality. It has, therefore, been much reduced during the last years. The estimated number of fish at this stage is still 2.4 billion individuals and, with a mean weight of 18.8 g, this age group makes up more than 5% of the total stock, the largest fraction of 4-year-old capelin since 1981.

The total stock is estimated at 796,000 t, only 15% of the stock size estimated 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 330,000 t. This stock is of the same size as that measured in 1985, when the collapse of the stock was fully apparent.

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

Year:	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93
Year class:	1983	1984	1985	1986	1987	1988	1989	1990	1991
Age 1, Nos (10^9)	145.4	35.1	7.5	37.3	20.0	177.9	700.0	392.0	351.3
Age 2, Nos (10^9)	47.3	3.4	1.5	28.8	17.8	177.5	574.4	196.3	53.4
Total mortality(%)	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, 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 a diminished predation pressure from cod. From 1990 the mortality increased again, last year it was 50%, and in the present year it is 85%, i.e. back at the level measured before 1986. This increase is consistent with an increasing stock of cod now predating on the capelin.

Estimates of stock in number and weight for the period 1973-1993 are shown in Table 4.6.

4.4 Management Considerations

In managing the Barents Sea capelin fishery one of the main goals has been to allow a minimum target spawning stock biomass to spawn. In the period 1970-1982, this was set at 500,000 t and later at 400,000 t on the basis of an analysis by Hamre and Tjelmeland (1982). This analysis was based on a situation in the Barents Sea with virtually no young herring in the area and also with low recruitment of cod. Following the very good year classes of cod and herring in 1982-1985, the capelin recruitment failed completely in 1984 and 1985.

A new period with rich cod and herring year classes, starting in 1990, is now followed by at least two years of poor capelin recruitment in 1992 and 1993. The prospects for the recruitment in 1994 are difficult to assess, but the amount of young herring and cod in the Barents Sea will remain high again next year.

The calculations which resulted in target spawning stocks of 500,000 and 400,000 t, respectively, were based on the assumption that the natural mortality of capelin was proportional to the size of the capelin stock. This may not be relevant in periods when the stocks sizes of herring and cod and the recruitment to these stocks differ substantially from those in the period for which the analyses were undertaken. Further analyses are, therefore, needed to determine a relevant target spawning stock size and, hence, a criterion for regulation for various cod - herring - capelin regimes in the Barents Sea. Such work has been initiated (Tjelmeland and Bogstad, 1993) and should continue.

In previous years, a calculated amount of capelin eaten by cod during winter (based on a method introduced by Bogstad and Gjøsæter in working documents to the last three meetings of the Working Group) was used to estimate the natural mortality of mature capelin. The method used is based on the assumption that the amount of capelin is not a limiting factor on the predation by cod. Obviously, this assumption will not be valid during the coming winter. However, in the present situation, with a maturing stock of only 330,000 t at 1 October 1993, the spawning stock in 1994 will be much lower than the target spawning stock, irrespective of the natural mortality during winter. There is, therefore, no need to make any consumption calculations of consumption at this stage.

In previous years (Anon., 1986), when no direct estimates of natural mortality during winter were available, the natural mortality estimated for the immature capelin was used to estimate the reduction in the maturing stock from 1 October to 1 April. If this method is applied this year, based on age 1-2 estimates, the resulting spawning stock at 1 April 1994 will be about 130,000 t.

Even if the prospects for capelin spawning and recruitment in 1994 are weak, this should not be taken as an argument that the spawning stock of capelin may be reduced by fishing without affecting the future condition of the stock. The timing and/or routes of the spawning migration may change in a way that makes the spawning stock more or less inaccessible to the cod stock, and/or the spawning places and time of larval release may favour the survival of capelin larvae in 1994. Consequently, there is no case for allowing the spawning stock to be reduced by a fishery as it was in the winter of 1986. In that year, a late, easterly spawning migration and easterly drifting routes for the capelin larvae

favoured larval survival. The 1986 year class was, consequently, quite strong in relation to the limited spawning stock size. Thus, environmental conditions during 1994 may be favourable for larval survival, as they were in 1986, and the largest possible biomass should be allowed to spawn to take advantage of the possibility of a high survival rate of capelin larvae.

Besides, the feeding conditions for plankton feeders in the northern Barents Sea will probably be good next year as the amount of overwintering plankton has been found to be high this autumn. The stock size of capelin will be low next year, and consequently, the prospects for individual growth should be good (see Section 6).

4.5 TAC Recommendations

The spawning stock in spring 1994 will be much lower than the spawning stock size aimed at in previous years. The spawning in 1994 may, moreover, be critical for the rebuilding of the capelin stock. The Working Group therefore strongly recommends that no fishing should take place on this stock in 1994.

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

5.1 Introduction

The capelin in the Iceland-East-Greenland-Jan-Mayen area is assessed annually using acoustic surveys. As a general rule, one of the surveys is in October/November and the other is in January/February. The fishing season starts in summer if capelin are abundant, in which case a precautionary TAC is used. Due to the timing involved, it follows that results from these surveys cannot be used by this Working Group to give advice for the season which had already started when the group met. It also follows that such problems will persist, regardless of the timing of the Working Group meeting.

The Working Group agreed that the best solution to this problem is for the group regularly to verify the methodology used in the TAC-setting process and to verify the data, assumptions and computations underlying the TAC decisions taken in the previous year.

5.2 The Fishery and Catch Regulations

The fishery depends for the most part on maturing capelin, i.e. that part of each year class which spawns at age 3 as well as those fish, which do not spawn until age 4. The size of the immature components is difficult to assess before their recruitment to the adult stock at ages 2 and 3.

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) on the basis of 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 fishery has been permitted in the period April-June and the season has opened in July/August or later, depending on the state of the stock. Due to very low stock abundance there was a fishing ban from December 1981 - 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 international 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 autumn 1978-1992 and winter 1979-1993 seasons is given by age groups and years in Tables 5.3 and 5.4, respectively.

5.3 Historic 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 1978/1979 - 1992/1993 seasons. The results are given in Table 5.5 (1 August) and Table 5.6 (1 January), the latter of which also gives the remaining spawning stock by number and biomass in March/April 1979 - 1993.

The above calculations of stock abundance are based on acoustic estimates of the abundance of maturing capelin obtained in autumn and/or winter, and 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 back-calculated to the appropriate point in time. Since the acoustic estimates of the abundance of the juvenile part of the stock are unrealistically low and since no information is available on natural mortality rates of this component of the capelin stock, its abundance 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 at age is used for obtaining the stock biomass on 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 on 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. The remaining spawning stock biomass is thus underestimated by a small amount.

5.4 Method of Stock Prognosis

The precautionary TAC is set at such a level as to open the fishery before the October survey, yet to 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 at 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, have been found to be unreliable. This has become apparent by comparing these to the more reliable abundance estimates obtained by retrospectively back-calculating year class abundance. It has been found that a autumn (October/November) acoustic estimate of 1- and 2-group abundance gives a more reliable prediction of fishable stock abundance one year head. A new prediction model was, therefore, developed using these data (Anon. 1993a). A summary of the method reads as follows:

The maturing part of the 2-group in autumn (N2mat) is a part of the survivors of the 1-group in the previous autumn (N1), which is measured in October. Regressing the back-calculated maturing 2-group abundance against the 1-group acoustic estimates for the 9 year classes from 1980 to 1988 gives an R^2 value of 0.88 (P=0.001). This is the regression that was used for predicting the abundance of maturing 2-group capelin in autumn 1992. The inclusion of the 1990 year class (the 1990 autumn survey of the 1989 year class was invalid due to ice conditions) which has now been back-calculated, gives the relationship $y = 0.94x + 1.98$, where $R^2 = 0.84$ ($P \leq 0.001$).

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 (N2imm) 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 which will spawn and thus provides no indication of what will appear in the autumn of the next year. It is found, however, that maturity at age 2 is closely but inversely related to year class size (N2tot); hence the total abundance of the 2-group in autumn is an indication of what will appear as the 3-group in the following fall. A regression relating the back-calculated abundance of the year classes from 1980-1989 as 2 and 3 year olds (N2tot and N3tot) results in the relationship $y = 0.43x - 13.4$, where $R^2 = 0.80$ ($P \leq 0.001$).

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 1981-1992 (year classes 1978-1990) is given in Table 5.8. The new regressions give a slightly different prediction of abundance from those used for the 1992 prediction. They are used in Section 5.6 below for predicting the abundance of mature 2-group in autumn 1993. A test of their performance is given in Table 5.9.

5.5 Stock Prognosis and Assessments for the 1992/1993 Season

Calculations of the expected TAC for the 1992/1993 season, using the prediction method described in Section 5.4 and year classes 1980-1988, indicated a total catch of 810,000 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 was to be spread evenly over the period August 1992-March 1993.

Although the model predicted roughly the same or 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 over-estimated the calculated TAC by 33%. In view of this, and because of the short time series, the Working Group and ACFM recommended that a precautionary TAC should not exceed 2/3 of the total TAC predicted for the season, i.e. 500,000 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 13-29 October 1992. Surveying conditions were good and the survey covered all the usual distribution area with the exception of the westernmost part of the Greenland Sea. According to this survey the estimated fishable/spawning stock on 1 November 1992 was 59.7 * 10^9 fish. Observed mean weight in the fishable stock in October 1992 was 16.9 g and the stock biomass was, therefore, about 1,010,000 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 assuming an average weight increase of 2.0 g, the October abundance estimate indicated a TAC of 595,000 t in the period November 1992 - March 1993 if the catch was to be spread evenly over the period. Counting the catch taken in July-October 1992 this corresponded to a total TAC of some 820,000 t for the entire 1992/93 season which subsequently was set at that level.

The January 1993 survey covered only a part of the adult stock, due to poor survey, but established without doubt that the mean weight in the fishable/spawning stock was higher than forecast in October 1992 by at least 1.5 g. Taking account of the catches in the intervening period the new mean weight of 20.4 g corresponded to a total TAC of 900,000 t for the 1992/1993 season. The final TAC was set accordingly.

5.6 The Fishery in the 1992/1993 Season

The summer 1992 fishery began around mid-July with good catches of large capelin taken between 68°-69°N around 16°W. Catch rates remained reasonably high in and near this area until the second week of August when this part of the stock began migrating back south towards Iceland. Around 20 August the migration was located about 50 n.m. north of Melrakkasléttа on the eastern north coast of Iceland, whereupon it turned west to mix with other mature capelin and large concentrations of immature located off the western north coast.

Due to area closures to protect immature capelin and the scattered condition of adult capelin, catch rates remained low in most of the September-December 1992 period. The same was true for January 1993 when practically no catches were taken in the deep water area east and northeast of Iceland. However, in spite of extremely difficult weather conditions in the winter 1993 season, catch rates were very high from the last week in January when the first spawning migration arrived at the south-east coast until the main spawning activity subsided in the second week of March. Although the fishery was pursued until the second week of April, catch rates were generally low during this last part of the season.

A total of 786,700 t were caught (Table 5.2) and consequently 500,000 t were left to spawn in the spring of 1993 (Tables 5.1 and 5.6).

The total international catch in numbers by age groups and length is given for the summer/autumn 1992 and winter 1993 seasons in Tables 5.11 and 5.12.

5.7 Stock Abundance and TAC in the 1993/1994 Season

The main component of the fishable stock in the 1993/1994 season will be the maturing part of the 1991 year class and that part of the 1990 year class that did not mature and spawn in spring 1993.

The October 1992 survey gave an estimate of 104.6 billion capelin belonging to the 1991 year class and some 54.5 billion capelin belonging to the 1990 year class. Counting the catch and assuming a monthly natural mortality rate of 0.035, the latter corresponds to 70.7 billion maturing capelin of the 1990 year class when back-calculated to 1 August 1992 (Table 5.7).

The October 1992 estimate of the 1991 year class and the back-calculated total estimate of the 1990 year class (73.1 billion, Table 5.7) were used to forecast the abundance of maturing capelin at age belonging to these year classes on 1 August 1993, using the prediction model described above, after updating the appropriate regressions in the light of new information. The resulting predictions of the number of maturing capelin at ages 2 and 3 on 1 August 1993 are 99.9 and 17.7 billion fish, respectively (Table 5.5).

The fishable stock biomass, gives a calculated TAC of 1,390,000 t for the period August 1993 - March 1994 (Table 5.9).

Concerning the limitations of this model and its performance (Section 5.4 above) it was recommended that a precautionary TAC for the 1993/1994 season should not exceed 900,000 t or about 2/3 of the total TAC predicted for the whole season. Further, it was recommended 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 1993 and/or January 1994.

This advice was given by ACFM at its May 1993 meeting. The precautionary TAC for the summer/autumn 1993 season was subsequently set at 900,000 t. The autumn 1993 survey of the capelin in the Iceland-East-Greenland-Jan Mayen area was due to begin on 18 October. Hence no data were available at the Working Group meeting for reconsidering the TAC presently in force.

5.8 The Summer Fishery in 1993

The 1993 summer fishery was opened on 1 July with good catches being taken by Icelandic vessels around 68°15'-68°30'N between 15°and 16°W.

The capelin slowly migrated northwards from the above position and in August most of the catch was taken in the central Iceland Sea from 69°30' - 71°30'N, between 14° and 18°W. The same was true for early September but in the second half of the month the capelin seemed to begin their southward migration towards Iceland and dispersed.

The reported catches in the period July-September 1993 are given in Table 5.2. A very preliminary division of this catch by age groups and numbers is given in Table 5.13.

5.9 Stock abundance and TAC in the 1994/95 Season

The main components of the fishable stock in this season will be the 1991 and 1992 year classes. As yet the only available information on the abundance of the 1992 year class is the 0-group index obtained in August 1992 and an estimate of 1-group capelin abundance from August 1993.

The 1992 0-group index ranks among the higher indices recorded in the past 15 years or so (Table 5.14). Although the 0-group index indicates a good 1992 year class, larval indices are unreliable for predicting later stock abundance.

The August 1993 estimate of the 1992 year class as 1-group was comparatively low (Table 5.15). However, this survey did not reach the area north of 68°N where large schools of 1-group capelin were reported by Icelandic fishing vessels north west of 68°N and 22°W in the latter part of the month. Therefore, the 1-group capelin may have been severely underestimated in the August 1993 survey.

Information necessary for predicting year-class abundance in the 1994/1995 season, using the method described in Section 5.4, will not become available until after both the autumn 1993 and winter 1994 surveys have been completed. Advice on a precautionary TAC for the 1994/1995 season must, therefore, be postponed at least until November 1993.

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 together with the immature. In these years the summer fishery and the autumn fishery have been dependent on mixed concentrations of mature and immature capelin. Such a fishery inevitably results in the repeated escape of 1-group capelin, which are generally not retained by the mesh used in capelin seines. While there are no measurements of mortalities caused by escape, it is likely that fishing for prolonged periods on such mixed concentrations can cause mass mortality of 1-group capelin that goes unnoticed (Anon., 1993a). In the 1992 October/-November report ACFM recommended that the most important areas of juvenile capelin be closed to the commercial fishery.

In the beginning of the 1993/1994 season an area off the western north coast of Iceland, 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 was closed. A closure of this area forces 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. It would be appropriate to continue this regulation in 1994. The August and October 1994 surveys will resolve the actual size distribution of capelin within the closed area and elsewhere in the waters of the north Icelandic shelf and allow for a reshaping of the closed area, and the establishment of other closed areas if necessary, on a real-time basis.

6 MULTISPECIES CONSIDERATIONS

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

In the last three years, the Working Group has provided an estimate of how much mature capelin will be consumed by the cod stock in January-March of the coming year. The method for doing this was described in last year's report. The method gives upper bounds on how large the consumption of capelin may be, and is designed for situations where the capelin abundance is high so that the cod can be assumed to feed very intensively on capelin for a given period. With the low abundance estimate of maturing capelin this year, this method is not valid, and other approaches have to be made.

The Working Group agreed that new and enhanced multispecies models need to be developed in order to quantify biological interactions better.

Some comments on the development of such models are given in this chapter, together with an outline of possible ways of approaching these tasks given the current knowledge.

6.1 Development of Multispecies Models

The nature of the biological interactions to be studied together with the biology of the species involved dictates to some extent how these models need to be structured. In particular, models developed for one region may not be useful in other regions.

6.1.1 Basic issues

Issues which are relevant to management and need to be considered in a multispecies context include the following:

Growth of cod. As seen, e.g., in Steinarsson and Stefánsson (1991) and Mehl and Sunnanå (1991) , growth of cod is highly variable and is related to abundance of capelin. It follows that increasing the predictive power of models for growth can potentially have high gains in terms of providing better forecasts.

Natural mortality of juvenile cod. As seen, e.g., in Bogstad *et al.* (1993), cod cannibalism may cause significant fluctuations in the natural mortality rate of juvenile cod. It follows that potentially better use may be made of survey indices if this is taken into account.

Natural mortality of capelin. As seen e.g. in the first results from using MULTSPEC to calculate predation mortalities on capelin by cod (Bogstad and Tjelmeland, 1992; Tjelmeland and Bogstad, 1993), and in the well established results within the Working Group, the effect of cod consumption on capelin abundance can be considerable. It follows that predation of cod on capelin is an important factor to be considered in terms of capelin biomass forecasts and mortality estimation.

Growth of capelin. The individual growth rate of capelin has varied considerably, and a very high growth rate in 1989-1990 led to a faster recovery of the Barents Sea capelin stock than expected.

Maturation of capelin. This process has already been studied in close connection with the studies on natural mortality of capelin. Maturation is closely linked to individual growth. It should also be noted that management of species with a very high post-spawning mortality rate, like capelin, poses special problems.

Natural mortality of herring. Cod and marine mammals are known to prey on herring. Variations in the size of the prey or predator stocks will affect the level of natural mortality inflicted on herring.

6.1.2 Model requirements

As noted in Anon. (1993a), the spatial overlap between the predator and prey species has to be taken into account when estimating consumption. This indicates a need to use a spatially disaggregated model. Similarly, since predation processes tend to be length-based and since time increments need to be used, the model needs to be disaggregated by age and length.

In a spatially disaggregated model the migratory patterns (including drift) of predators and prey need to be considered. These will typically differ according to the maturity stage.

It follows from these requirements that models to explain the basic processes in the ecosystems where cod-capelin-herring interactions are of primary importance, need to be disaggregated by area, age, length and maturity for the fish species considered.

6.1.3 Model structure

Models that are to explain in detail the processes involved need to account for feeding, growth, maturation and fishing. This sets certain criteria for the models that are to explain the processes involved in any detail.

6.1.4 Existing models

Two models have been developed along these lines: MULTSPEC (Bogstad *et al.*, 1992) and Bormicon (Working Document).

MULTSPEC now contains the species capelin, cod, harp seal and minke whale. Stock and catch data for these species have been prepared for use in the model. Work is also underway to include herring. Parameterization of the model will be the main task in the future.

Bormicon is still in the development stage. The construction of the model is almost finished, while there is still a lot of work to do on preparation of data for the model.

6.1.5 Modelling of interactions between plankton and plankton feeders

A model is being developed to describe the distribution and migration of capelin using fitness-maximizing habitat selection rules (Giske *et al.*, 1992). This model will be coupled to a 3-D circulation model and models for plankton production. Such coupled models are being developed and may provide a tool to simulate transport, survival and production of zooplankton and could then provide a link and input of environmental parameters to MULTSPEC.

6.2 Barents Sea

In order to get an overview of the current state of the ecosystem and some indications of what will happen in the near future, the Working Group found it appropriate to include some information on oceanographic conditions and amount of zooplankton in the ecosystem in this section, in addition to considerations on biological interactions between the stocks of capelin, herring and cod.

6.2.1 Oceanography

The temperature in the Barents Sea has been markedly above the long-term mean during the last few years, but this year's survey on pelagic fish (Working Document) indicates that the temperature is now decreasing. This may indicate that the period with very good recruitment of herring and cod may end in 1993, as the recruitment

of these stocks is positively influenced by high temperatures (Sætersdal and Loeng, 1987).

6.2.2 Zooplankton

The amount of zooplankton in the Barents Sea has been monitored by Russian investigations in spring and summer since the 1960s and by Norwegian investigations in summer and autumn since 1979. The Norwegian investigations have aimed at describing the feeding conditions of capelin in order to explain and predict capelin growth. Since 1986 the zooplankton biomass has been estimated during the acoustic surveys of the capelin stock in the autumn.

During the 1980s variations in zooplankton abundance contributed to the fluctuations of the capelin stock (Skjoldal *et al.*, 1992). Low zooplankton biomass caused a low individual growth rate which contributed to the rapid decline of the capelin stock between 1984 and 1986. High zooplankton biomass, particularly of larger forms such as euphausids and amphipods, contributed to the high growth rate and rapid recovery of the capelin stock in the late 1980s.

Monitoring of zooplankton in the Barents Sea during four cruises from mid-August to early October 1993 revealed generally high biomass. The mean biomass for MULTSPEC sub-areas was similar or higher than in previous years and much higher than the minimum biomass recorded in 1983-1984 in the central Barents Sea (Skjoldal *et al.*, 1992). Time-series of mean biomass in three size fractions for the different sub-areas from 1986 to 1993 are shown in Figure 6.1.

The species composition of zooplankton has not yet been worked up but some qualitative information can be given from examination of samples. High abundance of *Calanus* spp. contributed to the high zooplankton biomass. Amphipods (*Parathemisto* spp.) and euphausids appeared not to be particularly abundant. This could reflect their longer life-span and slower population response to a reduction in predation pressure. The high biomass of zooplankton recorded this autumn will provide a high stock of overwintering zooplankton which can spawn next spring. The low stock size of capelin is likely to result in lower grazing on zooplankton in the central and northern Barents Sea. The prospects are, therefore, good for a high production of zooplankton in the Barents Sea in 1994. This will contribute to a good individual growth rate of capelin, particularly as density-dependent factors are reduced at the low capelin stock size.

Juvenile herring which is distributed in the southern Barents Sea, is predicted also to have reasonably good feeding conditions in 1994. The plankton situation in these areas is directly influenced by transport of plankton with the inflowing currents. The high biomass of juvenile herring may, however, have a grazing impact on the zooplanton levels, restricting the herring growth rate.

6.2.3 Capelin

Some work has already been done to establish a relationship between capelin abundance and cod consumption which is valid for all stock levels of capelin (Bogstad and Tjelmeland, 1992; Tjelmeland and Bogstad, 1993) and this work will be given high priority in the future. However, there are still some problems in combining acoustic estimates of capelin, VPA estimates of cod and consumption estimates.

The Working Group appreciates that the problems of age-reading of cod, which directly affected the consumption estimate made in previous years, seem to have been solved. However, the large changes in the assessment of the biomass of immature cod from one year to another creates significant problems in such consumption estimates. When comparing the estimate of the immature cod stock at 1 January 1993 made by the Arctic Fisheries Working Group (Anon., 1994) this year and last year (Anon., 1993b), the discrepancy is unacceptably large (67 % or 570,000 t increase).

Young herring may eat 0-group capelin, and 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. However, 0-group cod has also been observed to eat 0-group capelin and, as good recruitment of herring and cod often coincides, it is still unclear which predator is the most important. Further studies on the feeding of 0-group cod and herring are now being carried out.

6.2.4 Herring

The Norwegian spring-spawning herring stock is now recovering. The stock should be allowed to increase to a level where the plankton production in the Norwegian Sea is optimally utilized. As the stock size increases, the growth rate is expected to decrease to a level similar to that observed at high stock levels in the 1950s (Toresen, 1990). Interactions between the herring stock and other stocks of plankton-feeders in the Norwegian Sea must be expected and needs to be considered in future assessment work. This will require a large research effort to elucidate the "carrying capacity" of the system and the mechanisms of trophic interaction between the stocks. The research program "*Mare Cognitum*" aims at providing such information.

The relationship between the stocks of herring and cod is an important issue in an assessment context. The mortality of juvenile herring may increase because of the increase in cod stock size and the lack of capelin as food

for cod. While a large spawning stock of herring can be important for the long-term recruitment level, it may also be important for sustaining a high stock level of cod in the Barents Sea. Since both stocks are increasing, special attention needs to be paid to the role of herring spawning stock size for the condition of the cod stock.

6.2.5 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).

A new collapse of the Barents Sea capelin stock is now imminent, but there are two main differences between the present situation and the situation in 1985, when the total stock size and age composition was rather similar to that in 1993. 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. Also, the total stock biomass of cod is about twice that in 1986-1988.

Stock sizes of other prey species should also be taken into account when calculating food requirements for the cod stock in the years to come. The consumption by cod of various prey species has been calculated by Bogstad and Mehl (1992) for the period 1984-1989, and is given in Table 6.1 together with similar estimates for 1992.

In the latter estimates, the 1993 VPA for cod has been used, and the mature cod stock is assumed to be outside the Barents Sea for three months during the first half of the year. The consumption of capelin in 1992 is estimated to be approximately 3.1 million t and the consumption of herring is estimated to be approximately 440,000 t. The total consumption by cod is estimated at 5.1 million t, which is approximately three times the biomass of the cod stock when taking into account the assumption that the mature cod stock is outside the Barents Sea for three months during the first half of the year.

The stock size of shrimp and young redfish is now relatively low, while the Polar cod stock was estimated at 1 million t during the September-October pelagic fish survey, which is the highest estimate in the time series (starting in 1986).

Given the present state of the Barents Sea ecosystem, it is very important that the large amount of Russian data on feeding of cod in the 1950s and 1960s, when herring was probably a major source of food for cod, is computerized. This is now in progress within a joint project between PINRO and the Institute of Marine Research, Norway.

The cod-capelin-herring system is still insufficiently understood. As far as management of cod is considered, it can be argued that the highest option for individual growth of cod (meaning about *status quo*), given by the Arctic Fisheries Working Group, is not very likely, due to the decline of the capelin stock. The development of the individual growth of cod has to be monitored closely in the years to come.

6.3 Icelandic Waters

As in the Barents Sea, the biological interaction of primary interest in Icelandic waters is between cod and capelin. In terms of importance to the cod, the next step is to expand this basic model to cod-capelin-shrimp (Magnusson and Palsson, 1991) and this is currently under consideration.

6.4 Further Work on Studies of Feeding and Food Requirements of Cod

The Working Group recommends that studies on the food requirements of cod are given high priority. There are still some problems with use of the stomach evacuation rate model in consumption calculations (e.g. meal size, see Appendix C in last year's report), and the coverage in time and space of stomach samples may also lead to errors in the consumption estimates. A Working Document on the food requirement of cod in the coming years and how this may affect the stocks which are prey for cod should be prepared for next year's meetings of the Arctic Fisheries Working Group and the present Working Group. Also, one should attempt to establish a relationship between capelin abundance and cod growth for the Barents Sea, as has been done in Icelandic waters. Such a relationship is currently used by the North-Western Working Group (Anon., 1993c).

6.5 Cooperation Between Working Groups

The two cod stocks in question here (North-East Arctic cod and Icelandic cod) are handled by the Arctic Fisheries Working Group and the Northwestern Working Group, respectively. This year, one participant from each of these Groups took part in the present Working Group meeting, and it is recommended that this practice be continued.

At its upcoming meeting, the Multispecies Assessment Working Group will devote itself almost exclusively to work connected with use of the 1991 "Year of the Stomach" data in the MSVPA model for the North Sea. At its next meeting in early 1995, that Working Group will probably devote a substantial amount of its time to boreal multispecies problems. As the present Working Group devotes a significant part of its time to multispecies studies, how these two groups could make more use of each others work should be considered.

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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	1973	1974	1975	1976	1977	1978	1979
1	0.001	0.001	1.518	0.614	0.705	2.634	0.929
2	0.159	3.760	2.049	9.848	18.853	22.551	15.098
3	0.678	0.832	31.975	3.908	24.152	50.995	47.561
4	0.104	0.993	6.493	34.144	10.404	13.846	69.735
5	0.017	0.092	7.905	7.009	46.357	8.738	16.451
6	0.013	0.046	0.863	5.481	6.735	39.492	8.003
7	0.006	0.002	0.442	1.045	5.421	7.253	26.040
8	0.006	0.001	0.345	0.438	1.395	6.354	3.050
9	0.003	0.001	0.114	0.296	0.524	1.616	1.869
10	0.003	0.001	0.004	0.134	0.362	0.926	0.494
11	0.001	0.001	0.001	0.092	0.027	0.400	0.439
12	0.001	0.001	0.001	0.001	0.128	0.017	0.032
13	0.001	0.001	0.001	0.001	0.001	0.025	0.054
14	0.001	0.001	0.001	0.001	0.001	0.051	0.006
Catch in wt	0.255	1.274	13.280	17.168	28.924	37.333	45.072

Rings	1980	1981	1982	1983	1984	1985	1986
1	3.147	2.283	0.454	1.470	0.421	0.111	0.100
2	14.347	4.629	19.187	22.422	18.011	12.800	8.161
3	20.761	16.771	28.109	151.198	32.237	24.521	33.893
4	60.728	12.126	38.280	30.181	141.324	21.535	23.421
5	65.329	36.871	16.623	21.525	17.039	84.733	20.654
6	11.541	41.917	38.308	8.637	7.111	11.836	77.526
7	9.285	7.299	43.770	14.017	3.915	5.708	18.228
8	19.442	4.863	6.813	13.666	4.112	2.323	10.971
9	1.796	13.416	6.633	3.715	4.516	4.339	8.583
10	1.464	1.032	10.457	2.373	1.828	4.030	9.662
11	0.698	0.884	2.354	3.424	0.202	2.758	7.174
12	0.001	0.760	0.594	0.552	0.255	0.970	3.677
13	0.110	0.101	0.075	0.100	0.260	0.477	2.914
14	0.079	0.062	0.211	0.003	0.003	0.578	1.786
Catch in wt	53.269	39.544	56.528	58.665	50.293	49.092	65.413

Rings	1987	1988	1989	1990	1991	1992
1	0.029	0.869	3.963	11.061	35.872	11.820
2	3.144	4.702	22.568	14.413	92.766	78.547
3	44.590	40.855	26.578	57.293	51.052	129.508
4	60.285	98.222	77.618	34.509	87.614	43.109
5	20.622	68.533	188.155	78.187	33.439	55.215
6	19.751	22.691	43.000	152.955	54.845	41.283
7	46.240	19.899	8.095	32.417	109.428	35.663
8	15.232	31.830	5.881	8.754	9.252	44.072
9	13.963	12.207	7.273	4.453	3.796	9.101
10	10.179	10.132	4.767	4.307	2.634	2.224
11	13.216	7.293	3.440	2.529	1.826	0.573
12	6.224	7.200	1.406	1.232	0.516	0.300
13	4.723	4.752	0.842	1.024	0.262	0.200
14	2.280	1.935	0.347	0.613	0.298	0.100
Catch in wt	75.439	91.760	100.733	105.593	109.499	106.825

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

Rings	1973	1974	1975	1976	1977	1978	1979
1	90	80	110	103	84	73	75
2	199	189	179	189	157	128	145
3	257	262	241	243	217	196	182
4	278	297	291	281	261	247	231
5	337	340	319	305	285	295	285
6	381	332	339	335	313	314	316
7	380	379	365	351	326	339	334
8	397	356	364	355	347	359	350
9	385	407	407	395	364	360	367
10	450	410	389	363	362	376	368
11	450	410	430	396	358	380	371
12	450	423	416	396	355	425	350
13	450	423	416	396	400	425	350
14	450	423	416	396	420	425	450

Rings	1980	1981	1982	1983	1984	1985	1986
1	69	61	65	59	49	53	60
2	115	141	141	132	131	146	140
3	202	190	186	180	189	219	200
4	232	246	217	218	217	266	252
5	269	269	274	260	245	285	282
6	317	298	293	309	277	315	298
7	352	330	323	329	315	335	320
8	360	356	354	356	322	365	334
9	380	368	385	370	351	388	373
10	383	405	389	407	334	400	380
11	393	382	400	437	362	453	394
12	390	400	394	459	446	469	408
13	390	400	390	430	417	433	405
14	390	400	420	472	392	447	439

Rings	1987	1988	1989	1990	1991	1992	1993
1	60	75	63	75	74	63	72
2	168	157	130	119	139	144	140
3	200	221	206	198	188	190	202
4	240	239	246	244	228	232	236
5	278	271	261	273	267	276	268
6	304	298	290	286	292	317	301
7	325	319	331	309	303	334	332
8	339	334	338	329	325	346	345
9	356	354	352	351	343	364	350
10	378	352	369	369	348	392	359
11	400	371	389	387	369	444	379
12	404	390	380	422	388	399	395
13	424	408	434	408	404	419	414
14	430	437	409	436	396	428	420

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	1973	1974	1975	1976	1977	1978	1979
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.64	0.14	0.27	0.13	0.02	0.04	0.07
3	0.99	0.94	0.97	0.90	0.87	0.78	0.65
4	1.00	1.00	1.00	1.00	1.00	1.00	0.98
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	1980	1981	1982	1983	1984	1985	1986
1	0.00	0.00	0.02	0.00	0.00	0.00	0.00
2	0.05	0.03	0.05	0.00	0.01	0.00	0.03
3	0.92	0.65	0.85	0.64	0.82	0.90	0.89
4	1.00	0.99	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	1987	1988	1989	1990	1991	1992	1993
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.01	0.05	0.06	0.00	0.01	0.02	0.02
3	0.87	0.90	0.93	0.78	0.72	0.93	0.93
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

Table 2.4 Acoustic estimates (in millions) of the Icelandic summer-spawning herring, 1974-1993.

Years, representing the end of the fishing season for the previous year.																				
Rings	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
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
3	.	137	20	.	424	334	177	462	75	.	310	67	208	.	352	181	593	227	850	858
4	.	19	133	.	46	215	360	85	159	.	724	56	110	.	836	249	177	304	353	687
5	.	21	17	.	19	49	253	170	42	.	80	360	86	.	287	381	302	137	273	160
6	.	2	10	.	139	20	51	182	123	.	39	65	425	.	53	171	538	176	94	99
7	.	2	3	.	18	111	41	33	162	.	15	32	67	.	37	42	185	387	81	87
8	.	.	3	.	18	30	93	29	24	.	27	16	41	.	76	23	.	40	210	44
9	.	.	.	.	10	30	10	58	8	.	26	17	17	.	25	30	.	10	32	92
10	.	.	.	.	.	20	.	10	46	.	10	18	27	.	21	16	.	2	11	39
11	.	.	.	.	.	.	.	.	10	.	5	9	26	.	14	10	18	.	.	.
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	.	204	260	448	482	415	.	214	538	718	.	547	692	1043	752	718	521

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

Rings	1973	1974	1975	1976	1977	1978	1979
1	0.000	0.000	0.008	0.001	0.002	0.014	0.004
2	0.002	0.011	0.018	0.060	0.040	0.062	0.096
3	0.014	0.012	0.104	0.040	0.183	0.131	0.162
4	0.009	0.024	0.110	0.139	0.126	0.136	0.238
5	0.003	0.009	0.237	0.149	0.253	0.133	0.212
6	0.005	0.009	0.097	0.230	0.188	0.316	0.156
7	0.006	0.001	0.104	0.147	0.331	0.282	0.316
8	0.015	0.001	0.175	0.128	0.266	0.708	0.164
9	0.013	0.003	0.140	0.200	0.199	0.492	0.409
10	0.283	0.005	0.012	0.218	0.354	0.562	0.242
11	0.094	0.129	0.005	0.368	0.056	0.729	0.503
12	0.072	0.115	0.165	0.006	1.137	0.041	0.100
13	0.038	0.087	0.145	0.220	0.007	0.615	0.158
14	0.066	0.044	0.105	0.190	0.317	0.468	0.256
W.Av4-14	0.007	0.019	0.150	0.148	0.220	0.244	0.239
Ave4-14	0.055	0.039	0.118	0.181	0.294	0.407	0.250
Ave 4-9	0.009	0.008	0.144	0.166	0.227	0.345	0.249

Rings	1980	1981	1982	1983	1984	1985	1986
1	0.013	0.003	0.002	0.007	0.001	0.000	0.000
2	0.070	0.022	0.026	0.116	0.100	0.032	0.007
3	0.165	0.098	0.159	0.258	0.218	0.173	0.099
4	0.284	0.123	0.301	0.229	0.363	0.198	0.222
5	0.326	0.249	0.222	0.246	0.175	0.342	0.264
6	0.202	0.319	0.392	0.154	0.108	0.159	0.530
7	0.244	0.171	0.568	0.216	0.087	0.106	0.347
8	0.367	0.174	0.213	0.307	0.081	0.061	0.271
9	0.123	0.412	0.337	0.154	0.141	0.104	0.299
10	0.573	0.087	0.578	0.173	0.095	0.161	0.314
11	0.558	0.725	0.260	0.334	0.018	0.182	0.421
12	0.002	2.183	1.543	0.080	0.033	0.101	0.348
13	0.510	0.204	1.967	1.159	0.045	0.072	0.434
14	0.322	0.534	0.732	0.322	0.076	0.119	0.371
W.Av4-14	0.294	0.246	0.367	0.225	0.257	0.228	0.361
Ave4-14	0.319	0.471	0.647	0.307	0.111	0.146	0.348
Ave 4-9	0.258	0.241	0.339	0.218	0.159	0.162	0.322

Rings	1987	1988	1989	1990	1991	1992	1985-1988
1	0.000	0.002	0.011	0.010	0.032	0.042	0.001
2	0.006	0.015	0.053	0.047	0.093	0.082	0.015
3	0.046	0.091	0.096	0.165	0.206	0.164	0.102
4	0.228	0.122	0.222	0.157	0.361	0.240	0.193
5	0.277	0.388	0.320	0.324	0.200	0.360	0.318
6	0.384	0.491	0.399	0.413	0.351	0.360	0.391
7	0.618	0.735	0.288	0.524	0.518	0.360	0.451
8	0.483	1.044	0.439	0.509	0.246	0.360	0.465
9	0.576	0.796	0.628	0.616	0.383	0.360	0.443
10	0.607	0.973	0.744	0.847	0.812	0.360	0.514
11	0.812	1.076	0.961	1.039	0.977	0.360	0.623
12	0.696	1.387	0.533	1.018	0.534	0.360	0.633
13	0.888	1.836	0.496	0.834	0.540	0.360	0.808
14	0.633	1.042	0.561	0.725	0.545	0.360	0.541
W.Av4-14	0.388	0.286	0.310	0.354	0.372	0.331	0.289
Ave4-14	0.564	0.899	0.508	0.637	0.497	0.349	0.489
Ave 4-9	0.428	0.596	0.383	0.424	0.343	0.340	0.377

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	1973	1974	1975	1976	1977	1978	1979
1	417.806	131.696	198.273	553.813	435.645	194.980	247.634
2	81.002	378.046	119.162	177.962	500.527	393.517	173.921
3	49.804	73.142	338.495	105.875	151.667	434.975	334.638
4	12.158	44.420	65.391	275.907	92.085	114.304	345.147
5	5.795	10.902	39.249	53.000	217.223	73.440	90.277
6	2.774	5.227	9.777	28.013	41.300	152.567	58.152
7	1.123	2.497	4.686	8.027	20.145	30.976	100.596
8	0.435	1.011	2.258	3.820	6.270	13.088	21.148
9	0.244	0.388	0.914	1.715	3.041	4.350	5.836
10	0.013	0.218	0.350	0.718	1.271	2.254	2.406
11	0.012	0.009	0.196	0.313	0.523	0.807	1.163
12	0.015	0.010	0.007	0.177	0.196	0.448	0.352
13	0.028	0.013	0.008	0.005	0.159	0.057	0.389
14	0.017	0.025	0.010	0.006	0.004	0.143	0.028
SSB	28.641	45.876	116.895	129.288	132.893	175.514	198.153

Rings	1980	1981	1982	1983	1984	1985	1986
1	253.190	875.510	237.498	220.149	476.977	1280.372	608.172
2	223.185	226.104	790.024	214.465	197.801	431.187	1158.423
3	143.026	188.312	200.187	696.603	172.757	161.867	377.986
4	257.631	109.702	154.459	154.445	486.857	125.721	123.182
5	246.127	175.508	87.745	103.453	111.105	306.555	93.314
6	66.071	160.756	123.821	63.618	73.183	84.355	197.044
7	45.018	48.829	105.707	75.731	49.362	59.464	65.088
8	66.329	31.924	37.252	54.225	55.221	40.945	48.382
9	16.240	41.587	24.268	27.240	36.104	46.059	34.841
10	3.509	12.988	24.916	15.670	21.120	28.379	37.553
11	1.708	1.790	10.772	12.650	11.925	17.373	21.852
12	0.637	0.885	0.784	7.513	8.199	10.599	13.102
13	0.288	0.575	0.090	0.152	6.274	7.177	8.668
14	0.300	0.157	0.425	0.011	0.043	5.430	6.041
SSB	212.380	185.765	192.736	218.824	231.737	249.010	259.363

Rings	1987	1988	1989	1990	1991	1992	1993
1	376.611	509.835	372.118	1217.633	1194.153	303.492	1418.000
2	550.202	340.744	460.491	332.938	1091.243	1046.415	263.376
3	1040.425	494.854	303.848	395.221	287.556	899.261	872.201
4	309.816	899.034	408.945	249.682	303.209	211.732	690.713
5	89.231	223.121	720.181	296.364	193.152	191.298	150.676
6	64.839	61.177	136.934	473.218	194.018	143.029	120.750
7	104.902	39.949	33.867	83.153	283.249	123.558	90.282
8	41.612	51.177	17.341	22.966	44.550	152.692	77.992
9	33.370	23.227	16.298	10.119	12.492	31.531	96.381
10	23.385	16.981	9.486	7.868	4.943	7.705	19.903
11	24.817	11.529	5.808	4.078	3.052	1.985	4.864
12	12.975	9.972	3.558	2.010	1.306	1.039	1.253
13	8.369	5.856	2.253	1.889	0.657	0.693	0.656
14	5.083	3.115	0.845	1.242	0.742	0.346	0.437
SSB	371.759	428.069	400.930	362.944	310.743	398.719	

Table 2.7 Stock abundance and catches by age groups (millions) and fishing mortality rate for the Icelandic summer spawners. F^1 is the F calculated from the acoustic surveys. F_{92} is the fitted fishing mortality based on the fitting procedure for 5+ and the 1993 acoustic estimates for the 1-4 ringers in 1992. $F_{p\ 92}$ is the exploitation pattern in 1992 (used in the prognoses) and $F_{p\ av}$ is the average exploitation pattern for 1985-1988.

Rings in 1992	Year class	Acoustic estimate Dec. 1992	Catch 1992/93	F^1	F_{92}	$F_{p\ 92}$	$F_{p\ av}$
0	1991	1418					
1	1990	264	11.8	0.04	0.042	.117	.001
2	1989	876	78.5	0.08	0.082	.228	.029
3	1988	696	129.5	0.16	0.164	.456	.197
4	1987	160	43.1	0.23	0.240	.667	.372
5+	1986-	356	188.5	0.40	0.360	1.000	1.000

Table 2.8. SSE-values between acoustic and VPA abundance for different values of M and scaling factors on the acoustic abundance.
(The stock abundance based on the TS value obtained by Halldórsson and Reynisson is set to 100).

b20(dB) (at 33 cm)	Scaling factor	M		
		0.1	0.15	0.2
-73.0	100	404	316	383
-72.4	85	207	251	465
-72.2	80	181	266	528
-72.0	75	174	300	609
-71.8	70	187	353	709
-71.6	60	274	518	966

Table 2.9 Herring, Summer spawning at Iceland (Fishing Area Va).

Single option prediction: Input data

Year: 1993								
Rings	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	1418.000	0.1000	0.0000	0.0000	0.5000	72.000	0.0420	72.000
2	263.000	0.1000	0.0200	0.0000	0.5000	140.000	0.0820	140.000
3	872.000	0.1000	0.9300	0.0000	0.5000	202.000	0.1640	202.000
4	691.000	0.1000	1.0000	0.0000	0.5000	236.000	0.2400	236.000
5	151.000	0.1000	1.0000	0.0000	0.5000	268.000	0.3600	268.000
6	121.000	0.1000	1.0000	0.0000	0.5000	301.000	0.3600	301.000
7	90.000	0.1000	1.0000	0.0000	0.5000	332.000	0.3600	332.000
8	78.000	0.1000	1.0000	0.0000	0.5000	345.000	0.3600	345.000
9	96.000	0.1000	1.0000	0.0000	0.5000	350.000	0.3600	350.000
10	20.000	0.1000	1.0000	0.0000	0.5000	359.000	0.3600	359.000
11	4.900	0.1000	1.0000	0.0000	0.5000	379.000	0.3600	379.000
12	1.300	0.1000	1.0000	0.0000	0.5000	395.000	0.3600	395.000
13	0.700	0.1000	1.0000	0.0000	0.5000	414.000	0.3600	414.000
14	0.400	0.1000	1.0000	0.0000	0.5000	420.000	0.3600	420.000
Unit	Millions	-	-	-	-	Grams	-	Grams

Year: 1994								
Rings	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	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	Millions	-	-	-	-	Grams	-	Grams

Year: 1995								
Rings	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	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	Millions	-	-	-	-	Grams	-	Grams

(cont.)

Table 2.9 Continued

Single option prediction: Input data

(cont.)

Year: 1996								
Rings	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	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	Millions	-	-	-	-	Grams	-	Grams

Year: 1997								
Rings	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	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	Millions	-	-	-	-	Grams	-	Grams

Notes: Run name : PREDSNGLE
Date and time: 20OCT93:13:29

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
1993	0.8414	0.2473	431523	99967	3807300	655423	2070520	504914	1969540	480289
1994	0.6031	0.1855	344405	82796	3635081	686769	1805794	470505	1717724	447558
1995	0.6031	0.2075	377897	94895	3561770	728413	2368372	597509	2252866	568368
1996	0.6031	0.1834	378560	98463	3463537	734319	2312891	612051	2200090	582200
1997	0.6031	0.2020	390622	104302	3373219	729089	2222573	606820	2114177	577225
Unit	-	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : PREDSNGLE
Date and time : 20OCT93:13:29
Computation of ref. F: Weighted mean, age 4 - 14
Prediction basis : F factors

Table 2.11 Herring, Summer Spawning at Iceland (Fishing Area Va)

Single option prediction: Detailed tables

Year: 1993 F-factor: 0.8414 Reference F: 0.2473						1 January		Spawning time	
rings	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	0.0353	46867	3374	1418000	102096	0	0	0	0
2	0.0690	16695	2337	263000	36820	5260	736	5003	700
3	0.1380	107080	21630	872000	176144	810960	163814	771409	155825
4	0.2019	120441	28424	691000	163076	691000	163076	657300	155123
5	0.3029	37647	10089	151000	40468	151000	40468	143636	38494
6	0.3029	30167	9080	121000	36421	121000	36421	115099	34645
7	0.3029	22438	7450	90000	29880	90000	29880	85611	28423
8	0.3029	19447	6709	78000	26910	78000	26910	74196	25598
9	0.3029	23934	8377	96000	33600	96000	33600	91318	31961
10	0.3029	4986	1790	20000	7180	20000	7180	19025	6830
11	0.3029	1222	463	4900	1857	4900	1857	4661	1767
12	0.3029	324	128	1300	514	1300	514	1237	488
13	0.3029	175	72	700	290	700	290	666	276
14	0.3029	100	42	400	168	400	168	380	160
Total		431523	99967	3807300	655423	2070520	504914	1969540	480289
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Year: 1994 F-factor: 0.6031 Reference F: 0.1855						1 January		Spawning time	
rings	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	0.0253	14284	1028	600000	43200	0	0	0	0
2	0.0495	56892	7965	1238509	173391	24770	3468	23562	3299
3	0.0989	19921	4024	222107	44866	206560	41725	196485	39690
4	0.1447	88246	20826	687320	162207	687320	162207	653799	154297
5	0.2171	95060	25476	510915	136925	510915	136925	485998	130247
6	0.2171	18778	5652	100925	30378	100925	30378	96003	28897
7	0.2171	15047	4996	80874	26850	80874	26850	76929	25541
8	0.2171	11192	3861	60154	20753	60154	20753	57220	19741
9	0.2171	9700	3395	52133	18247	52133	18247	49591	17357
10	0.2171	11938	4286	64164	23035	64164	23035	61035	21911
11	0.2171	2487	943	13368	5066	13368	5066	12716	4819
12	0.2171	609	241	3275	1294	3275	1294	3115	1231
13	0.2171	162	67	869	360	869	360	827	342
14	0.2171	87	37	468	197	468	197	445	187
Total		344405	82796	3635081	686769	1805794	470505	1717724	447558
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

(cont.)

Table 2.11 Continued

Single option prediction: Detailed tables

(cont.)

Year: 1995 F-factor: 0.6031 Reference F: 0.2075

						1 January		Spawning time	
rings	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	0.0253	14284	1028	600000	43200	0	0	0	0
2	0.0495	24315	3404	529323	74105	10586	1482	10070	1410
3	0.0989	95664	19324	1066577	215449	991917	200367	943540	190595
4	0.1447	23373	5516	182044	42962	182044	42962	173166	40867
5	0.2171	100119	26832	538106	144212	538106	144212	511862	137179
6	0.2171	69227	20837	372072	111994	372072	111994	353926	106532
7	0.2171	13675	4540	73498	24401	73498	24401	69914	23211
8	0.2171	10958	3781	58896	20319	58896	20319	56023	19328
9	0.2171	8151	2853	43807	15332	43807	15332	41670	14585
10	0.2171	7064	2536	37966	13630	37966	13630	36114	12965
11	0.2171	8694	3295	46727	17710	46727	17710	44448	16846
12	0.2171	1811	715	9735	3845	9735	3845	9260	3658
13	0.2171	444	184	2385	987	2385	987	2269	939
14	0.2171	118	49	633	266	633	266	602	253
Total		377897	94895	3561770	728413	2368372	597509	2252866	568368
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Year: 1996 F-factor: 0.6031 Reference F: 0.1834

						1 January		Spawning time	
rings	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	0.0253	14284	1028	600000	43200	0	0	0	0
2	0.0495	24315	3404	529323	74105	10586	1482	10070	1410
3	0.0989	40886	8259	455842	92080	423933	85634	403257	81458
4	0.1447	112240	26489	874193	206310	874193	206310	831558	196248
5	0.2171	26518	7107	142523	38196	142523	38196	135573	36333
6	0.2171	72911	21946	391874	117954	391874	117954	372762	112201
7	0.2171	50414	16738	270960	89959	270960	89959	257745	85571
8	0.2171	9959	3436	53525	18466	53525	18466	50914	17565
9	0.2171	7980	2793	42891	15012	42891	15012	40799	14280
10	0.2171	5936	2131	31902	11453	31902	11453	30346	10894
11	0.2171	5144	1950	27649	10479	27649	10479	26300	9968
12	0.2171	6331	2501	34029	13441	34029	13441	32369	12786
13	0.2171	1319	546	7089	2935	7089	2935	6744	2792
14	0.2171	323	136	1737	729	1737	729	1652	694
Total		378560	98463	3463537	734319	2312891	612051	2200090	582200
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

(cont.)

Table 2.11 Continued

Single option prediction: Detailed tables

(cont.)

Year: 1997 F-factor: 0.6031 Reference F: 0.2020

rings	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	1 January Sp.stock size	1 January Sp.stock biomass	Spawning time Sp.stock size	Spawning time Sp.stock biomass
1	0.0253	14284	1028	600000	43200	0	0	0	0
2	0.0495	24315	3404	529323	74105	10586	1482	10070	1410
3	0.0989	40886	8259	455842	92080	423933	85634	403257	81458
4	0.1447	47970	11321	373619	88174	373619	88174	355397	83874
5	0.2171	127340	34127	684410	183422	684410	183422	651031	174476
6	0.2171	19311	5813	103792	31241	103792	31241	98730	29718
7	0.2171	53097	17628	285381	94746	285381	94746	271462	90126
8	0.2171	36714	12666	197326	68077	197326	68077	187702	64757
9	0.2171	7252	2538	38979	13643	38979	13643	37078	12977
10	0.2171	5812	2086	31235	11213	31235	11213	29712	10666
11	0.2171	4323	1638	23233	8805	23233	8805	22100	8376
12	0.2171	3746	1480	20135	7953	20135	7953	19153	7565
13	0.2171	4611	1909	24781	10260	24781	10260	23573	9759
14	0.2171	961	403	5163	2168	5163	2168	4911	2063
Total		390622	104302	3373219	729089	2222573	606820	2114177	577225
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : PREDSNGLE
Date and time : 20OCT93:13:29
Computation of ref. F: Weighted mean, age 4 - 14
Prediction basis : F factors

Table 2.12 Herring, Summer Spawning at Iceland (Fishing Area Va).

Prediction with management option table: Input data

Year: 1993								
rings	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	1418.000	0.1000	0.0000	0.0000	0.5000	72.000	0.0420	0.072
2	263.376	0.1000	0.0200	0.0000	0.5000	140.000	0.0820	0.140
3	872.201	0.1000	0.9300	0.0000	0.5000	202.000	0.1640	0.202
4	690.713	0.1000	1.0000	0.0000	0.5000	236.000	0.2400	0.236
5	150.676	0.1000	1.0000	0.0000	0.5000	268.000	0.3600	0.268
6	120.750	0.1000	1.0000	0.0000	0.5000	301.000	0.3600	0.301
7	90.282	0.1000	1.0000	0.0000	0.5000	332.000	0.3600	0.332
8	77.992	0.1000	1.0000	0.0000	0.5000	345.000	0.3600	0.345
9	96.381	0.1000	1.0000	0.0000	0.5000	350.000	0.3600	0.350
10	19.903	0.1000	1.0000	0.0000	0.5000	359.000	0.3600	0.359
11	4.864	0.1000	1.0000	0.0000	0.5000	379.000	0.3600	0.379
12	1.253	0.1000	1.0000	0.0000	0.5000	395.000	0.3600	0.395
13	0.656	0.1000	1.0000	0.0000	0.5000	414.000	0.3600	0.414
14	0.437	0.1000	1.0000	0.0000	0.5000	420.000	0.3600	0.420
Unit	Millions	-	-	-	-	Grams	-	Kilograms

Year: 1994								
rings	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	72.000	0.0420	0.072
2	.	0.1000	0.0200	0.0000	0.5000	140.000	0.0820	0.140
3	.	0.1000	0.9300	0.0000	0.5000	202.000	0.1640	0.202
4	.	0.1000	1.0000	0.0000	0.5000	236.000	0.2400	0.236
5	.	0.1000	1.0000	0.0000	0.5000	268.000	0.3600	0.268
6	.	0.1000	1.0000	0.0000	0.5000	301.000	0.3600	0.301
7	.	0.1000	1.0000	0.0000	0.5000	332.000	0.3600	0.332
8	.	0.1000	1.0000	0.0000	0.5000	345.000	0.3600	0.345
9	.	0.1000	1.0000	0.0000	0.5000	350.000	0.3600	0.350
10	.	0.1000	1.0000	0.0000	0.5000	359.000	0.3600	0.359
11	.	0.1000	1.0000	0.0000	0.5000	379.000	0.3600	0.379
12	.	0.1000	1.0000	0.0000	0.5000	395.000	0.3600	0.395
13	.	0.1000	1.0000	0.0000	0.5000	414.000	0.3600	0.414
14	.	0.1000	1.0000	0.0000	0.5000	420.000	0.3600	0.420
Unit	Millions	-	-	-	-	Grams	-	Kilograms

Year: 1995								
rings	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	.	0.1000	0.0000	0.0000	0.5000	72.000	0.0420	0.072
2	.	0.1000	0.0200	0.0000	0.5000	140.000	0.0820	0.140
3	.	0.1000	0.9300	0.0000	0.5000	202.000	0.1640	0.202
4	.	0.1000	1.0000	0.0000	0.5000	236.000	0.2400	0.236
5	.	0.1000	1.0000	0.0000	0.5000	268.000	0.3600	0.268
6	.	0.1000	1.0000	0.0000	0.5000	301.000	0.3600	0.301
7	.	0.1000	1.0000	0.0000	0.5000	332.000	0.3600	0.332
8	.	0.1000	1.0000	0.0000	0.5000	345.000	0.3600	0.345
9	.	0.1000	1.0000	0.0000	0.5000	350.000	0.3600	0.350
10	.	0.1000	1.0000	0.0000	0.5000	359.000	0.3600	0.359
11	.	0.1000	1.0000	0.0000	0.5000	379.000	0.3600	0.379
12	.	0.1000	1.0000	0.0000	0.5000	395.000	0.3600	0.395
13	.	0.1000	1.0000	0.0000	0.5000	414.000	0.3600	0.414
14	.	0.1000	1.0000	0.0000	0.5000	420.000	0.3600	0.420
Unit	Millions	-	-	-	-	Grams	-	Kilograms

Notes: Run name : M1
Date and time: 20OCT93:14:34

Table 2.13 Herring, Summer Spawning at Iceland (Fishing Area Va).

Prediction with management option table

Year: 1993					Year: 1994					Year: 1995	
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
0.8418	0.2474	655441	480254	100000	0.0000	0.0000	686746	447534		775508	651760
.	.	.	.	.	0.1000	0.0308	.	447534	14730	759459	636914
.	.	.	.	.	0.2000	0.0615	.	447534	29043	743857	622490
.	.	.	.	.	0.3000	0.0923	.	447534	42954	728687	608476
.	.	.	.	.	0.4000	0.1230	.	447534	56475	713936	594857
.	.	.	.	.	0.5000	0.1538	.	447534	69618	699591	581623
.	.	.	.	.	0.6000	0.1846	.	447534	82395	685639	568760
.	.	.	.	.	0.7000	0.2153	.	447534	94817	672068	556258
.	.	.	.	.	0.8000	0.2461	.	447534	106895	658866	544105
.	.	.	.	.	0.9000	0.2768	.	447534	118641	646022	532289
.	.	.	.	.	1.0000	0.3076	.	447534	130064	633524	520801
.	.	.	.	.	1.1000	0.3384	.	447534	141174	621362	509631
.	.	.	.	.	1.2000	0.3691	.	447534	151982	609526	498768
.	.	.	.	.	1.3000	0.3999	.	447534	162496	598005	488203
.	.	.	.	.	1.4000	0.4306	.	447534	172726	586790	477926
.	.	.	.	.	1.5000	0.4614	.	447534	182679	575871	467930
.	.	.	.	.	1.6000	0.4922	.	447534	192366	565239	458204
.	.	.	.	.	1.7000	0.5229	.	447534	201794	554886	448742
.	.	.	.	.	1.8000	0.5537	.	447534	210970	544803	439534
.	.	.	.	.	1.9000	0.5844	.	447534	219904	534982	430573
.	.	.	.	.	2.0000	0.6152	.	447534	228601	525415	421852
-	-	Tonnes	Tonnes	Tonnes	-	-	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes

Notes: Run name : M1
Date and time : 20OCT93:14:34
Computation of ref. F: Weighted mean, age 4 - 14
Basis for 1993 : TAC constraints

Table 2.14 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: 20OCT93:14:50

Table 2.15 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	2067.925	5.973	1860.204	5.682	1769.481
0.1500	0.0509	0.230	68.725	6.821	1675.360	4.884	1468.633	4.645	1397.007
0.3000	0.1007	0.374	107.522	6.028	1397.553	4.097	1191.810	3.897	1133.685
0.4500	0.1493	0.467	129.478	5.439	1196.301	3.515	991.533	3.343	943.176
0.6000	0.1969	0.531	141.867	4.991	1046.994	3.074	843.192	2.924	802.069
0.7500	0.2434	0.576	148.764	4.642	933.571	2.731	730.728	2.598	695.090
0.9000	0.2889	0.610	152.468	4.364	845.409	2.459	643.516	2.339	612.131
1.0500	0.3336	0.636	154.292	4.137	775.373	2.238	574.422	2.129	546.407
1.2000	0.3774	0.656	154.993	3.948	718.599	2.056	518.581	1.955	493.289
1.3500	0.4205	0.673	155.014	3.789	671.714	1.902	472.621	1.810	449.571
1.5000	0.4629	0.688	154.620	3.652	632.342	1.771	434.166	1.685	412.992
1.6500	0.5046	0.700	153.969	3.532	598.781	1.658	401.515	1.577	381.933
1.8000	0.5459	0.711	153.160	3.427	569.792	1.559	373.427	1.483	355.214
1.9500	0.5866	0.721	152.256	3.333	544.455	1.471	348.983	1.399	331.963
2.1000	0.6268	0.729	151.295	3.249	522.079	1.393	327.493	1.325	311.521
2.2500	0.6666	0.737	150.303	3.172	502.138	1.322	308.430	1.258	293.388
2.4000	0.7059	0.744	149.298	3.102	484.220	1.258	291.383	1.197	277.172
2.5500	0.7449	0.751	148.290	3.038	468.006	1.200	276.032	1.141	262.570
2.7000	0.7836	0.757	147.288	2.979	453.240	1.146	262.122	1.090	249.338
2.8500	0.8219	0.762	146.295	2.924	439.715	1.097	249.446	1.044	237.281
3.0000	0.8599	0.768	145.316	2.873	427.265	1.052	237.838	1.000	226.238
3.1500	0.8977	0.772	144.353	2.825	415.752	1.009	227.159	0.960	216.081
3.3000	0.9351	0.777	143.406	2.780	405.062	0.970	217.296	0.923	206.699
3.4500	0.9723	0.781	142.477	2.738	395.099	0.933	208.154	0.888	198.002
3.6000	1.0093	0.785	141.566	2.698	385.782	0.899	199.651	0.855	189.914
3.7500	1.0461	0.789	140.673	2.660	377.044	0.866	191.719	0.824	182.368
3.9000	1.0826	0.793	139.797	2.624	368.824	0.836	184.299	0.795	175.311
4.0500	1.1190	0.797	138.940	2.590	361.073	0.807	177.342	0.768	168.693
4.2000	1.1552	0.800	138.100	2.557	353.747	0.780	170.803	0.742	162.473
4.3500	1.1912	0.803	137.276	2.526	346.808	0.754	164.644	0.717	156.614
4.5000	1.2271	0.806	136.469	2.496	340.222	0.729	158.832	0.694	151.085
-	-	Numbers	Grams	Numbers	Grams	Numbers	Grams	Numbers	Grams

Notes: Run name : Y1
Date and time : 20OCT93:14:50
Computation of ref. F: Weighted mean, age 4 - 14
F-0.1 factor : 0.6031
F-max factor : 1.2781
F-0.1 reference F : 0.1957
F-max reference F : 0.3944
Recruitment : Single recruit

Table 2.16

Run title : Herring, Summer Spawning at Iceland (Fishing Area Va) (run name: VL10)

At 22-Oct-93 14:35

Table 16 Summary (without SOP correction)

Traditional vpa using file input for terminal F

	RECRUITS,	TOTALBIO,	TOTSPBIO,	LANDINGS,	YIELD/SSB,	FBAR 6-10,
1947,	179506,	187248,	140720,	47800,	.3397,	.3464,
1948,	68007,	155807,	120358,	56800,	.4719,	2.5213,
1949,	77472,	109818,	90942,	5400,	.0594,	.0892,
1950,	197367,	117813,	86954,	13600,	.1564,	.3195,
1951,	116475,	128917,	87738,	15800,	.1801,	.3248,
1952,	323928,	148304,	100535,	10500,	.1044,	.1875,
1953,	197295,	174217,	108248,	17600,	.1626,	.2765,
1954,	167414,	195163,	147062,	11000,	.0748,	.1071,
1955,	191196,	216446,	169400,	20500,	.1210,	.0950,
1956,	469184,	242639,	169861,	20400,	.1201,	.1331,
1957,	791378,	318207,	179866,	22800,	.1268,	.2657,
1958,	369217,	331973,	199636,	33500,	.1678,	.2992,
1959,	555110,	382527,	278232,	35000,	.1258,	.2765,
1960,	712880,	371556,	258861,	28500,	.1101,	.0373,
1961,	531005,	393143,	286802,	74000,	.2580,	.2779,
1962,	525297,	411553,	310084,	92900,	.2996,	.4419,
1963,	467070,	350869,	267049,	130300,	.4879,	.8550,
1964,	585841,	259610,	189254,	86500,	.4571,	.8763,
1965,	507381,	265243,	156607,	122900,	.7848,	1.2144,
1966,	99674,	153782,	83727,	58400,	.6975,	.6623,
1967,	39279,	105861,	89307,	67700,	.7581,	1.2979,
1968,	178653,	47090,	27410,	16800,	.6129,	.7866,
1969,	47144,	43199,	16572,	20913,	1.2619,	.9864,
1970,	33805,	30085,	19816,	16445,	.8299,	1.0126,
1971,	70373,	23086,	13276,	11831,	.8912,	2.2446,
1972,	89677,	26806,	10694,	370,	.0346,	.2737,
1973,	418769,	74060,	28955,	255,	.0088,	.0598,
1974,	134222,	122023,	46179,	1274,	.0276,	.0036,
1975,	200239,	163808,	117438,	13280,	.1131,	.0986,
1976,	554112,	226117,	130191,	17168,	.1319,	.1744,
1977,	436442,	258946,	134036,	28924,	.2158,	.2501,
1978,	195360,	267279,	176745,	37333,	.2112,	.4532,
1979,	247634,	274698,	199447,	45072,	.2260,	.2564,
1980,	253191,	269067,	213929,	53269,	.2490,	.2996,
1981,	875512,	294117,	187323,	39544,	.2111,	.2293,
1982,	237500,	330391,	193617,	56528,	.2920,	.4098,
1983,	220154,	317852,	220128,	58665,	.2665,	.1968,
1984,	476995,	299721,	232878,	50293,	.2160,	.1014,
1985,	1280450,	397244,	250059,	49092,	.1963,	.1181,
1986,	608229,	475649,	260177,	65413,	.2514,	.3515,
1987,	376670,	532600,	372339,	75439,	.2026,	.5325,
1988,	509907,	551087,	429078,	91760,	.2139,	.8077,
1989,	372321,	506261,	401143,	100733,	.2511,	.4996,
1990,	1216705,	530347,	363510,	105593,	.2905,	.5818,
1991,	1195574,	580077,	310489,	109499,	.3527,	.4620,
1992,	301883,	598284,	399006,	106825,	.2677,	.3600,
Arith. Mean ,	384859,	266535,	179906,	46613,	.3019,	.4882,
Units,	(Thousands),	(Tonnes),	(Tonnes),	(Tonnes),		

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

Year	A	B[1]	C	D	Nominal catches	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	-	8,557	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	120,959[5]	19,023[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 19 September 1993

Table 3.2 Total catch of Norwegian spring-spawning herring (tonnes) from 1972-1993.

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	107,337[1]	32,645	

[1]Preliminary.

Table 3.3 Catch in numbers ('000) of Norwegian spring spawners. Unreported catches are included for age 3 and older herring. The catches in 1985, 1986 and 1987 are adjusted for by the effects of discards and the breaking of gear, as reported by the Working Group in 1988.

Age	1977	1978	1979	1980	1981	1982	1983	1984
0	43,000	20,100	32,600	6,900	8,300	22,600	127,000	33,857
1	6,200	2,400	3,800	800	1,100	1,100	4,679	1,700
2	3,100	1,200	1,900	400	11,900	200	1,675	2,489
3	22,103	3,019	6,352	6,407	4,166	13,817	3,183	4,483
4	23,595	12,164	1,866	5,814	4,591	7,892	21,191	5,388
5	336	20,315	6,865	2,278	8,596	4,507	9,521	61,543
6	-	870	11,216	8,165	2,200	6,258	6,181	18,202
7	419	-	326	15,838	4,512	1,960	6,823	12,638
8	10,766	620	-	441	8,280	5,075	1,293	15,608
9	-	5,027	-	8	345	6,047	4,598	7,215
10	-	-	2,534	-	103	121	7,329	16,338
11	-	-	-	2,688	114	37	143	6,478
12	-	-	-	-	964	37	40	-
13	-	-	-	-	-	121	143	-
14	-	-	-	-	-	-	862	-
15	-	-	-	-	-	-	-	1,652
16	-	-	-	-	-	-	-	-

Age	1985	1986	1987	1988	1989	1990	1991	1992
0	28,571	13,805	13,846	15,488	7,120	1,020	100	1,629
1	13,149	1,381	6,327	2,787	1,927	401	3,367	152
2	207,224[1]	3,091	35,770	9,112	25,203	15,542	3,333	1,343
3	21,500	539,785[2]	19,776	62,923	2,890	18,633	8,438	12,586
4	15,500	17,594	501,393	25,059	3,623	2,658	2,780	33,100
5	16,500	14,500	18,672	550,367	5,650	11,875	1,410	4,980
6	130,000	15,500	3,502	9,452	324,290	10,854	14,967	1,193
7	59,000	105,500	7,058	3,679	3,469	226,280	8,867	11,981
8	55,000	75,000	28,000	5,964	800	1,289	218,851	5,748
9	63,000	42,000	12,000	14,583	679	1,519	2,499	225,677
10	10,000	77,000	9,500	8,872	3,297	2,036	461	2,483
11	31,000	19,469	4,500	2,818	1,375	2,415	87	639
12	50,000	66,000	7,834	3,356	679	646	690	274
13	-	80,000	6,500	2,682	321	179	103	1,236
14	-	-	7,000	1,565	258	585	255	-
15	-	-	453	542	-	166	532	-
16	2,638	2,469	-	-	-	314	-	-

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

Table 3.4 Norwegian spring-spawners. Acoustic abundance (TS = 20 logL - 71.9) of 0-group herring in Norwegian coastal waters in 1975-1992 (numbers in millions).

Year	Area			Total
	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	1,993	621	2,891

Table 3.5 Abundance indices for 0-group herring in the Barents Sea, 1973-1993 (Anon., 1990).

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

Table 3.5A Acoustic estimates of immature herring in the Barents Sea.

BARENTS.XLS

Year	Yearclass	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1983	Jan/Feb											
	Mar/Apr											
	May/Jun											
	Jul/Aug											
	Sep/Oct											
	Nov/Dec	17900										
1984	Jan/Feb											
	Mar/Apr											
	May/Jun	21400										
	Jul/Aug											
	Sep/Oct											
	Nov/Dec		3800									
1985	Jan/Feb											
	Mar/Apr											
	May/Jun	19900										
	Jul/Aug											
	Sep/Oct			20800								
	Nov/Dec			2700								
1986	Jan/Feb	8100										
	Mar/Apr											
	May/Jun	3000										
	Jul/Aug											
	Sep/Oct				0							
	Nov/Dec											
1987	Jan/Feb											
	Mar/Apr											
	May/Jun											
	Jul/Aug											
	Sep/Oct					0						
	Nov/Dec											
1988	Jan/Feb											
	Mar/Apr											
	May/Jun											
	Jul/Aug											
	Sep/Oct											
	Nov/Dec						4900					
1989	Jan/Feb											
	Mar/Apr											
	May/Jun											
	Jul/Aug											
	Sep/Oct											
	Nov/Dec											
1990	Jan/Feb											
	Mar/Apr											
	May/Jun							4400				
	Jul/Aug											
	Sep/Oct						221	4748				
	Nov/Dec											
1991	Jan/Feb											
	Mar/Apr											
	May/Jun							5200	24300			
	Jul/Aug											
	Sep/Oct											
	Nov/Dec											
1992	Jan/Feb											
	Mar/Apr											
	May/Jun							5731	14027	32614		
	Jul/Aug											
	Sep/Oct										300000	
	Nov/Dec											
1993	Jan/Feb											
	Mar/Apr											
	May/Jun							0	1470	25790	102670	
	Jul/Aug											
	Sep/Oct											100000
	Nov/Dec											

Table 3.6

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

At 23-Oct-93 12:07

Table 2 Catch weights at age (kg)

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

Table 2 Catch weights at age (kg)

YEAR,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,
AGE										
3,	.2170,	.2180,	.2140,	.0550,	.1240,	.1240,	.1880,	.2300,	.2080,	.1910,
4,	.2650,	.2620,	.2770,	.2490,	.1730,	.1540,	.2640,	.2390,	.2500,	.2330,
5,	.3370,	.3250,	.2950,	.2940,	.2530,	.1940,	.2600,	.2660,	.2880,	.3040,
6,	.3780,	.3460,	.3380,	.3120,	.2320,	.2410,	.2820,	.3050,	.3120,	.3370,
7,	.4100,	.3810,	.3600,	.3520,	.3120,	.2650,	.3060,	.3080,	.3160,	.3650,
8,	.4260,	.4000,	.3810,	.3740,	.3280,	.3040,	.3090,	.3760,	.3300,	.3610,
9,	.4350,	.4130,	.3970,	.3980,	.3490,	.3050,	.3910,	.4070,	.3440,	.3710,
10,	.4440,	.4050,	.4090,	.4020,	.3530,	.3170,	.4220,	.4120,	.3720,	.4030,
11,	.4680,	.4260,	.4170,	.4010,	.3700,	.3080,	.3640,	.4240,	.3540,	.3650,
+gp,	.4610,	.4150,	.4350,	.4100,	.3850,	.3340,	.4290,	.4280,	.3980,	.4023,
SOPCOFAC,	1.0976,	1.0141,	1.0306,	1.0032,	1.0291,	1.0071,	1.0549,	1.0183,	1.0062,	1.0039,

Table 3.7

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

At 23-Oct-93 12:07

Table 3 Stock weights at age (kg)

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

Table 3 Stock weights at age (kg)

YEAR,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,
AGE										
3,	.1550,	.1400,	.1480,	.0540,	.0900,	.0980,	.1540,	.2190,	.1470,	.1280,
4,	.2490,	.2040,	.2340,	.2060,	.1430,	.1350,	.1750,	.1980,	.2100,	.2240,
5,	.3040,	.2950,	.2650,	.2650,	.2410,	.1970,	.2090,	.2580,	.2440,	.2960,
6,	.3680,	.3380,	.3120,	.2890,	.2790,	.2770,	.2520,	.2880,	.3000,	.3270,
7,	.4040,	.3760,	.3460,	.3390,	.2990,	.3150,	.3050,	.3090,	.3240,	.3550,
8,	.4240,	.3950,	.3700,	.3680,	.3160,	.3390,	.3670,	.4280,	.3360,	.3450,
9,	.4370,	.4070,	.3950,	.3910,	.3420,	.3430,	.3770,	.3700,	.3430,	.3670,
10,	.4360,	.4130,	.3970,	.3820,	.3430,	.3590,	.3590,	.4030,	.3820,	.3410,
11,	.4930,	.4220,	.4280,	.3880,	.3620,	.3650,	.3950,	.3870,	.3660,	.3610,
+gp,	.4950,	.4370,	.4280,	.3950,	.3760,	.3760,	.3960,	.4400,	.4250,	.4633,

Table 3.8

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

At 23-Oct-93 12:07

Table 5 Proportion mature at age

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

Table 5 Proportion mature at age

YEAR,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,
AGE										
3,	.1000,	.1000,	.1000,	.1000,	.1000,	.1000,	.1000,	.4000,	.1000,	.1000,
4,	.5000,	.5000,	.5000,	.2000,	.3000,	.3000,	.3000,	.8000,	.7000,	.2000,
5,	.6900,	.9000,	.9000,	.9000,	.9000,	.9000,	.9000,	.9000,	1.0000,	.8000,
6,	.7100,	.9500,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	.9000,	1.0000,	1.0000,
7,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	.9000,	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 3.9

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

At 23-Oct-93 12:07

Table 4 Natural Mortality (M) at age YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,
AGE									
3,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
4,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
5,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
6,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
7,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
8,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
9,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
10,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
11,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,
+gp,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,

Table 4 Natural Mortality (M) at age YEAR,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,
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,	.2300,	.2300,
6,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,
7,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,
8,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,
9,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,
10,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,
11,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,
+gp,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.1300,	.2300,	.2300,

Table 3.10

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

At 23-Oct-93 12:07

Traditional vpa using screen input for terminal F

Table 8 Fishing mortality (F) at age

YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,
AGE									
3,	.0249,	.1467,	.0300,	.0072,	.0218,	.0140,	.0213,	.0104,	.0236,
4,	.0194,	.0386,	.3549,	.0358,	.0045,	.0156,	.0148,	.0177,	.0228,
5,	.1009,	.0881,	.0003,	.0306,	.0364,	.0029,	.0221,	.0254,	.0202,
6,	1.6646,	.1640,	.0001,	.0004,	.0959,	.0236,	.0040,	.0249,	.0216,
7,	2.0959,	.1014,	.0907,	.0566,	.0004,	.0439,	.0391,	.0025,	.0259,
8,	.0452,	.0884,	.0246,	.0931,	.1032,	.0005,	.0716,	.0241,	.0032,
9,	.0541,	.0541,	.0541,	.0288,	.0533,	.0002,	.0046,	.0685,	.0205,
10,	.0653,	.0653,	.0653,	.0653,	.0339,	.0319,	.0002,	.0697,	.0287,
11,	.0800,	.0800,	.0800,	.0800,	.0800,	.0400,	.0400,	.0300,	.0300,
+gp,	.0800,	.0800,	.0800,	.0800,	.0800,	.0400,	.0400,	.0300,	.0300,
FBAR 5- 9,	.7921,	.0992,	.0340,	.0419,	.0578,	.0142,	.0283,	.0291,	.0183,

Table 8 Fishing mortality (F) at age

YEAR,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	FBAR 90-92
AGE											
3,	.0363,	.0419,	.0837,	.0351,	.0461,	.1177,	.0605,	.0595,	.0045,	.0022,	.0221,
4,	.0426,	.0739,	.1842,	.0849,	.0385,	.0705,	.0082,	.0675,	.0105,	.0203,	.0328,
5,	.0322,	.1551,	.3105,	.2425,	.1132,	.0503,	.0189,	.0313,	.0453,	.0228,	.0331,
6,	.0324,	.0739,	.5142,	.4923,	.0786,	.0716,	.0352,	.0427,	.0482,	.0506,	.0472,
7,	.0274,	.0796,	.3318,	.9558,	.4007,	.1030,	.0315,	.0289,	.0436,	.0520,	.0415,
8,	.0199,	.0752,	.5257,	.8360,	.6686,	.6407,	.0272,	.0137,	.0345,	.0370,	.0284,
9,	.0033,	.1368,	.4424,	.9138,	.2739,	.8287,	.1245,	.0616,	.0324,	.0466,	.0468,
10,	.0289,	.0136,	.2627,	1.4545,	.4885,	.3082,	.4061,	.5985,	.0233,	.0420,	.2213,
11,	.0400,	.0300,	.0300,	1.0800,	.2500,	.2400,	.0660,	.5400,	.0430,	.0420,	.2083,
+gp,	.0400,	.0300,	.0300,	1.0800,	.2500,	.2400,	.0660,	.5400,	.0430,	.0420,	
FBAR 5- 9,	.0231,	.1041,	.4249,	.6881,	.3070,	.3389,	.0475,	.0356,	.0408,	.0418,	

Table 3.11

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

At 23-Oct-93 12:07

Traditional vpa using screen input for terminal F

Table 10 Stock number at age (start of year)						Numbers*10**-4			
YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,
AGE									
3,	434,	2550,	83905,	329677,	14937,	48767,	32428,	42930,	63197,
4,	1335,	372,	1933,	71501,	287418,	12833,	42227,	27875,	37306,
5,	27190,	1150,	314,	1190,	60576,	251242,	11094,	36535,	24047,
6,	33,	21583,	925,	276,	1014,	51290,	219971,	9528,	31277,
7,	23,	6,	16085,	812,	242,	809,	43987,	192391,	8161,
8,	2,	3,	4,	12900,	674,	212,	680,	37143,	168515,
9,	2,	2,	2,	4,	10321,	534,	186,	556,	31840,
10,	2,	2,	2,	2,	3,	8592,	468,	163,	456,
11,	1,	1,	1,	1,	1,	3,	7307,	411,	133,
+gp,	7,	7,	7,	7,	7,	14,	14,	3492,	581,
TOTAL,	29030,	25674,	103179,	416370,	375192,	374294,	358363,	351023,	365512,

Table 10 Stock number at age (start of year)						Numbers*10**-4						
YEAR,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	GMST
AGE												
3,	9514,	11645,	28527,	1669487,	46781,	60364,	5249,	34382,	200895,	610739,	0,	281
4,	54199,	8056,	9806,	23038,	1415442,	39227,	47121,	4338,	28447,	175615,	535109,	219
5,	32020,	45609,	6570,	7162,	18583,	1195962,	32100,	41037,	3561,	24719,	151107,	176
6,	20693,	27225,	34295,	4229,	4935,	14572,	998660,	27658,	34923,	2704,	19197,	93
7,	26878,	17592,	22203,	18009,	2270,	4005,	11911,	846564,	23271,	26442,	2042,	34
8,	6982,	22963,	14265,	13991,	6080,	1335,	3173,	10134,	722181,	17701,	19944,	13
9,	147497,	6010,	18703,	7405,	5325,	2736,	618,	2711,	8778,	554346,	13553,	6
10,	27392,	129086,	4603,	10552,	2608,	3556,	1049,	479,	2239,	6752,	420392,	3
11,	389,	23367,	111820,	3108,	2164,	1405,	2294,	614,	231,	1738,	5144,	1
+gp,	2846,	5973,	189882,	23702,	10476,	4061,	2102,	480,	4225,	4041,	4403,	
TOTAL,	328412,	297527,	440675,	1780683,	1514663,	1327223,	1104277,	968398,	1028751,	1424797,	1170893,	

Table 3.12

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

At 23-Oct-93 12:07

Traditional vpa using screen input for terminal F

Table 13 Spawning stock biomass at age (spawning time) Tonnes

YEAR,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,	1982,
AGE									
3,	363,	2244,	74729,	429667,	3443,	8556,	13974,	21589,	10580,
4,	3066,	947,	4293,	162106,	750346,	18192,	58893,	30762,	35976,
5,	90866,	3848,	1060,	4018,	194219,	845546,	36777,	108779,	50243,
6,	107,	80478,	3505,	1045,	3677,	194456,	872517,	35463,	109362,
7,	76,	22,	64353,	3259,	977,	3339,	182081,	734753,	30772,
8,	11,	11,	19,	56014,	3034,	931,	3098,	149225,	656827,
9,	9,	9,	9,	17,	48234,	2660,	855,	2163,	129534,
10,	9,	9,	9,	9,	16,	43961,	2404,	831,	2031,
11,	7,	7,	7,	7,	7,	15,	38364,	2197,	615,
+gp,	33,	33,	33,	33,	34,	67,	67,	17594,	2892,
TOTSPBIO,	94547,	87608,	148018,	656175,	1003987,	1117722,	1209030,	1103356,	1028833,

Table 13 Spawning stock biomass at age (spawning time) Tonnes

YEAR,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,
AGE										
3,	1450,	1603,	4133,	88676,	4137,	5771,	793,	29554,	29137,	77148,
4,	66324,	8052,	11118,	9290,	597079,	15572,	24399,	6738,	41234,	77502,
5,	66084,	117688,	14995,	16457,	39339,	2082554,	59488,	93764,	8453,	57074,
6,	53197,	85655,	100326,	11486,	13483,	39558,	2475384,	70462,	101895,	8597,
7,	106891,	64775,	73356,	54768,	6437,	12327,	35746,	2317178,	73362,	91257,
8,	29165,	88861,	49432,	46747,	17739,	4191,	11463,	42755,	2363192,	59460,
9,	636026,	23818,	69767,	26084,	17491,	8526,	2271,	9842,	29329,	1978947,
10,	117547,	525526,	17570,	34401,	8407,	12217,	3569,	1795,	8338,	22408,
11,	1884,	97043,	470994,	10685,	7540,	4941,	8886,	2221,	823,	6105,
+gp,	13852,	25689,	799795,	82954,	37920,	14714,	8164,	1976,	17474,	18221,
TOTSPBIO,	1092420,	1038708,	1611487,	381547,	749573,	2200370,	2630162,	2576284,	2673237,	2396719,

Table 3.13

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

At 23-Oct-93 12:07

Table 16 Summary (without SOP correction)

Traditional vpa using screen input for terminal F

	RECRUITS,	TOTALBIO,	TOTSPBIO,	LANDINGS,	YIELD/SSB,	FBAR 5- 9,
1974,	4341,	97478,	94547,	7619,	.0806,	.7921,
1975,	25495,	92482,	87608,	13713,	.1565,	.0992,
1976,	839055,	227368,	148018,	10436,	.0705,	.0340,
1977,	3296769,	847709,	656175,	22706,	.0346,	.0419,
1978,	149366,	1126414,	1003987,	19824,	.0197,	.0578,
1979,	487668,	1267797,	1117722,	12864,	.0115,	.0142,
1980,	324276,	1329772,	1209030,	18577,	.0154,	.0283,
1981,	429297,	1213455,	1103356,	13736,	.0124,	.0291,
1982,	631966,	1201450,	1028833,	16655,	.0162,	.0183,
1983,	95143,	1241387,	1092420,	23054,	.0211,	.0231,
1984,	116451,	1098454,	1038708,	53532,	.0515,	.1041,
1985,	285267,	1702619,	1611487,	169872,	.1054,	.4249,
1986,	16694869,	1267665,	381547,	225256,	.5904,	.6881,
1987,	467806,	2225117,	749573,	127306,	.1698,	.3070,
1988,	603642,	2568210,	2200370,	135301,	.0615,	.3389,
1989,	52488,	2745713,	2630162,	103830,	.0395,	.0475,
1990,	343823,	2945126,	2576284,	86411,	.0335,	.0356,
1991,	2008946,	3027903,	2673237,	84683,	.0317,	.0408,
1992,	6107391,	3494542,	2396719,	104448,	.0436,	.0418,
Arith. Mean ,	1734951,	1564245,	1252620,	65780,	.0824,	.1667,
Units,	(Thousands),	(Tonnes),	(Tonnes),	(Tonnes),		

Table 3.14

Herring, Norwegian Spring Spawners

Herring, Norwegian Spring Spawners

Prediction with management option table: Input data

Year: 1993								
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	8298.000	0.2300	0.0100	0.1000	0.1000	0.114	0.0010	0.191
4	5351.000	0.2300	0.3000	0.1000	0.1000	0.201	0.0100	0.233
5	1511.000	0.2300	0.8000	0.1000	0.1000	0.265	0.0420	0.304
6	192.000	0.2300	1.0000	0.1000	0.1000	0.323	0.0420	0.337
7	20.000	0.2300	1.0000	0.1000	0.1000	0.354	0.0420	0.365
8	199.000	0.2300	1.0000	0.1000	0.1000	0.358	0.0420	0.361
9	136.000	0.2300	1.0000	0.1000	0.1000	0.381	0.0420	0.371
10	4204.000	0.2300	1.0000	0.1000	0.1000	0.369	0.0420	0.403
11	51.000	0.2300	1.0000	0.1000	0.1000	0.396	0.0420	0.365
12+	44.000	0.2300	1.0000	0.1000	0.1000	0.400	0.0420	0.402
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Year: 1994								
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	15256.000	0.2300	0.0100	0.1000	0.1000	0.121	0.0010	0.160
4	.	0.2300	0.3000	0.1000	0.1000	0.187	0.0100	0.223
5	.	0.2300	0.8000	0.1000	0.1000	0.247	0.0420	0.266
6	.	0.2300	1.0000	0.1000	0.1000	0.292	0.0420	0.289
7	.	0.2300	1.0000	0.1000	0.1000	0.325	0.0420	0.318
8	.	0.2300	1.0000	0.1000	0.1000	0.357	0.0420	0.340
9	.	0.2300	1.0000	0.1000	0.1000	0.364	0.0420	0.366
10	.	0.2300	1.0000	0.1000	0.1000	0.367	0.0420	0.383
11	.	0.2300	1.0000	0.1000	0.1000	0.378	0.0420	0.369
12+	.	0.2300	1.0000	0.1000	0.1000	0.404	0.0420	0.397
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	24693.000	0.2300	0.0100	0.1000	0.1000	0.121	0.0010	0.160
4	.	0.2300	0.3000	0.1000	0.1000	0.187	0.0100	0.223
5	.	0.2300	0.8000	0.1000	0.1000	0.247	0.0420	0.266
6	.	0.2300	1.0000	0.1000	0.1000	0.292	0.0420	0.289
7	.	0.2300	1.0000	0.1000	0.1000	0.325	0.0420	0.318
8	.	0.2300	1.0000	0.1000	0.1000	0.357	0.0420	0.340
9	.	0.2300	1.0000	0.1000	0.1000	0.364	0.0420	0.366
10	.	0.2300	1.0000	0.1000	0.1000	0.367	0.0420	0.383
11	.	0.2300	1.0000	0.1000	0.1000	0.378	0.0420	0.369
12+	.	0.2300	1.0000	0.1000	0.1000	0.404	0.0420	0.397
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Notes: Run name : REPORT
Date and time: 23OCT93:12:21

Table 3.15

Herring, Norwegian Spring Spawners

Herring, Norwegian Spring Spawners

Prediction with management option table

Year: 1993					Year: 1994					Year: 1995	
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
2.0869	0.0877	4203164	2359765	205000	0.0000	0.0000	5750433	2787877	0	8917780	4016629
.	.	.	.	.	0.5000	0.0210	.	2782641	58175	8860973	3955950
.	.	.	.	.	1.0000	0.0420	.	2777415	115308	8805222	3896528
.	.	.	.	.	1.5000	0.0630	.	2772200	171420	8750505	3838338
.	.	.	.	.	2.0000	0.0840	.	2766995	226531	8696802	3781351
.	.	.	.	.	2.5000	0.1050	.	2761801	280660	8644092	3725541
.	.	.	.	.	3.0000	0.1260	.	2756618	333829	8592354	3670881
.	.	.	.	.	3.5000	0.1470	.	2751445	386054	8541570	3617347
.	.	.	.	.	4.0000	0.1680	.	2746283	437356	8491720	3564912
.	.	.	.	.	4.5000	0.1890	.	2741132	487753	8442784	3513554
.	.	.	.	.	5.0000	0.2100	.	2735991	537261	8394746	3463248
.	.	.	.	.	5.5000	0.2310	.	2730860	585900	8347585	3413971
.	.	.	.	.	6.0000	0.2520	.	2725740	633687	8301285	3365699
.	.	.	.	.	6.5000	0.2730	.	2720631	680637	8255828	3318412
.	.	.	.	.	7.0000	0.2940	.	2715531	726768	8211197	3272087
.	.	.	.	.	7.5000	0.3150	.	2710443	772096	8167376	3226703
.	.	.	.	.	8.0000	0.3360	.	2705364	816637	8124347	3182239
.	.	.	.	.	8.5000	0.3570	.	2700296	860406	8082096	3138675
.	.	.	.	.	9.0000	0.3780	.	2695238	903418	8040607	3095991
.	.	.	.	.	9.5000	0.3990	.	2690191	945689	7999863	3054168
.	.	.	.	.	10.0000	0.4200	.	2685154	987233	7959851	3013186
-	-	Tonnes	Tonnes	Tonnes	-	-	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes

Notes: Run name : REPORT
Date and time : 23OCT93:12:21
Computation of ref. F: Simple mean, age 5 - 11
Basis for 1993 : TAC constraints

Table 4.1 International catch of Barents Sea CAPELIN ('000 t) in the years 1965 to 1993 as used by the Working Group.

Year	Winter				Summer-autumn			Total
	Norway	Russia	Other	Total	Norway	Russia	Total	
1965	217	7	0	224	0	0	0	224
1966	380	9	0	389	0	+	+	389
1967	403	6	0	408	0	+	+	408
1968	460	15	0	476	62	+	62	538
1969	436	1	0	436	243	+	243	680
1970	955	8	0	963	346	5	351	1314
1971	1300	14	0	1314	71	7	78	1392
1972	1208	25	0	1234	347	12	359	1593
1973	1078	34	0	1112	213	11	223	1336
1974	749	80	0	829	237	82	319	1148
1975	549	301	43	893	394	131	524	1417
1976	1230	230	0	1460	719	366	1085	2545
1977	1412	345	2	1758	704	477	1181	2940
1978	772	436	25	1233	350	311	661	1894
1979	539	342	5	886	569	327	896	1782
1980	539	253	9	801	459	388	847	1648
1981	784	429	28	1240	454	284	738	1978
1982	568	260	5	833	591	336	927	1760
1983	735	373	36	1145	758	439	1197	2342
1984	330	257	42	629	482	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	505	156	20	681	31	194	226	906
1992	620	247	24	887	73	159	232	1119
1993[1]	402	170	14	586	0	0	0	586

[1]Preliminary figures.

Table 4.2. Catch in numbers (millions) of Barents Sea CAPELIN in autumn 1992, by age groups and length, and catch in weight ('000 t) by age groups. Preliminary figures, only Norwegian and Russian catches are included.

Total length (cm)	Age					Sum	%
	1	2	3	4	5		
8 - 9	37.7					37.7	0.2
9 - 10	223.3					223.3	1.5
10 - 11	217.3	50.8				268.1	1.8
11 - 12	243.7	554.0	2.0			799.7	5.2
12 - 13	107.6	1682.2	417.6	9.4		2216.8	14.5
13 - 14	50.2	1955.6	1243.3	27.4		3276.5	21.4
14 - 15		1074.4	2222.6	82.8		3379.8	22.1
15 - 16		353.9	2215.1	146.9	4.0	2719.9	17.8
16 - 17		93.6	1357.1	304.8	4.0	1759.5	11.5
17 - 18		5.9	393.2	202.4	7.9	609.4	4.0
18 - 19			3.0	18.8	3.9	25.7	0.2
Total	879.8	5770.4	7853.9	792.5	19.8	15316.4	
%	5.7	37.7	51.3	5.2	0.1		100.0
Weight ('000 t)	5.4	66.6	141.6	17.6	0.5	231.7	

Table 4.3. Catch in numbers (millions) of Barents Sea CAPELIN in winter 1993, by age groups and length, and catch in weight ('000 t) by age groups. Preliminary figures, only Norwegian and Russian catches are included.

Total length (cm)	Age						Sum	%
	1	2	3	4	5	6		
8 - 9	3.1	30.8					33.9	0.1
9 - 10		50.7					50.7	0.2
10 - 11		190.4					190.4	0.6
11 - 12		98.9	79.2	9.6			187.7	0.6
12 - 13		91.3	502.9	329.0			923.2	2.8
13 - 14		29.4	1281.8	2520.7	25.5		3857.4	11.8
14 - 15		21.7	1513.6	5128.2	60.8		6724.3	20.5
15 - 16			847.4	7525.5	247.4		8620.3	26.3
16 - 17			454.1	6224.0	488.6		7166.7	21.9
17 - 18			65.0	3714.2	375.8	47.5	4202.5	12.8
18 - 19			9.0	691.8	96.0		796.8	2.4
19 - 20				16.0	23.0		39.0	0.1
Total	3.1	513.2	4753.0	26159.0	1317.1	47.5	32792.9	
%	+	1.6	14.5	79.8	4.0	0.1		100.0
Weight ('000 t)	+	2.9	63.8	473.0	31.1	1.3	572.1	

Table 4.4. Larval index for Barents Sea CAPELIN (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

Table 4.5. Acoustic estimate of Barents Sea Capelin, September-October 1993

Year class		Age (year class) 1992	1991	1990	1989	Total number (10^9)	Biomass (10^3 tons)	Mean weight (g)
Length (cm)		1	2	3	4			
7.0 -	7.5	0.05				0.05	0.1	1.1
7.5 -	8.0	0.09				0.09	0.1	1.6
8.0 -	8.5	0.08	0.01			0.09	0.2	1.9
8.5 -	9.0	0.30	0.01			0.32	0.7	2.3
9.0 -	9.5	0.50	0.04			0.54	1.6	2.9
9.5 -	10.0	0.52	0.08			0.60	2.0	3.3
10.0 -	10.5	0.38	0.36			0.74	3.0	4.0
10.5 -	11.0	0.18	0.80			0.99	4.7	4.8
11.0 -	11.5	0.02	2.64			2.66	14.6	5.5
11.5 -	12.0	0.04	5.85	0.04		5.93	38.7	6.5
12.0 -	12.5	0.06	10.31	0.32		10.69	79.8	7.5
12.5 -	13.0	0.01	11.60	0.75		12.36	105.2	8.5
13.0 -	13.5	+	10.21	1.36	0.02	11.59	116.0	10.0
13.5 -	14.0		5.87	2.58	0.18	8.63	100.1	11.6
14.0 -	14.5		3.20	2.82	0.37	6.40	86.7	13.5
14.5 -	15.0		1.64	3.75	0.44	5.82	89.8	15.4
15.0 -	15.5		0.60	2.63	0.38	3.54	60.6	17.1
15.5 -	16.0		0.14	1.40	0.26	1.80	35.0	19.5
16.0 -	16.5		0.03	0.97	0.23	1.25	26.9	21.6
16.5 -	17.0		0.04	0.52	0.29	0.84	19.7	23.4
17.0 -	17.5			0.07	0.10	0.17	4.6	26.5
17.5 -	18.0			0.07	0.01	0.08	2.0	27.1
18.0 -	18.5				0.13	0.13	4.0	32.0
Number (10^9)		2.24	53.38	17.28	2.40	75.28		
Biomass (10^3 tons)		7.7	482.4	261.3	44.9		796.3	
Mean length (cm)		9.61	12.81	14.59	15.46	13.21		
Mean weight (g)		3.4	9.0	15.1	18.8			10.6

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

Table 4.6 Stock size in numbers by age, total stock biomass and biomass of the maturing component of the Barents sea capelin 1973 to 1993. 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

Table 5.1 Preliminary TACs ('000 t) for the summer/autumn fishery, recommended TACs for the whole season, landings and remaining spawning stock in the 1983/84-1992/93 seasons.

Season	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93
Prelim. TAC	0	300	700	1100	500	900	900	600	0	500
Rec. TAC	640	920	1280	1290	1115	1065	-	250	740	900
Landings	573	897	1311	1333	1112	1022	799	318	677	787
Spawn. stock	440	460	460	420	400	445	115	330	475	500

Table 5.2 The international capelin catch 1964 - 1993 ('000 t)

	Winter season			Summer- and autumn season				
Year	Iceland	Norway	Faroes	Iceland	Norway	Faroes	Others	Total
1964	8.6	-	-	-	-	-	-	8.6
1965	49.7	-	-	-	-	-	-	49.7
1966	124.5	-	-	-	-	-	-	124.5
1967	97.2	-	-	-	-	-	-	97.2
1968	78.1	-	-	-	-	-	-	78.1
1969	170.6	-	-	-	-	-	-	170.6
1970	190.8	-	-	-	-	-	-	190.8
1971	182.9	-	-	-	-	-	-	182.9
1972	276.5	-	-	-	-	-	-	276.5
1973	440.9	-	-	-	-	-	-	440.9
1974	461.9	-	-	-	-	-	-	461.9
1975	457.1	-	-	3.1	-	-	-	460.2
1976	338.7	-	-	114.4	-	-	-	453.1
1977	549.2	-	24.3	259.7	-	-	-	833.2
1978	468.4	-	36.2	497.5	154.1	3.4	-	1,159.60
1979	521.7	-	18.2	442	124	22	-	1,127.90
1980	392.1	-	-	367.4	118.7	24.2	17.3	919.6
1981	156	-	-	484.6	91.4	16.2	20.8	769
1982	13.2	-	-	-	-	-	-	13.2
1983	-	-	-	133.4	-	-	-	133.4
1984	439.6	-	-	425.2	104.6	10.2	8.5	988.1
1985	348.5	-	-	644.8	193	65.9	16	1,268.20
1986	341.8	50	-	552.5	149.7	65.4	5.3	1,164.70
1987	500.6	59.9	-	311.3	82.1	65.2	-	1,019.10
1988	600.6	56.6	-	311.4	11.5	48.5	-	1,028.60
1989	609.1	56	-	53.9	14.4	52.7	-	786,1
1990	612	62.5	12.3	83.7	21.9	5.6	-	798
1991	258.4	-	-	56	-	-	-	314.4
1992	573.5	47.6	-	213.4	65.3	18.9	-	918.7
1993	489.1	-	-	*376.7	*127.5	*23.8	**9.3	

* Preliminary July-September
** 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) in the autumn season (August-December) 1978 - 1992

				Year				
Age	1978	1979	1980	1981	1982	1983	1984	1985
1	-	0.6	4.9	0.6	-	0.6	0.5	0.8
2	21.4	29.4	17.2	27.9	-	7.2	19.8	25.6
3	12.2	6.1	5.4	2.0	-	0.8	7.8	15.4
4	-	-	-	+	-	-	0.1	0.2
Total number	33.6	36.1	27.5	30.5	-	8.6	28.2	42.0
Total weight	655.0	588.0	527.6	613.0	-	133.4	548.5	919.7

				Year			
Age	1986	1987	1988	1989	1990	1991	1992
1	+	+	0.3	1.7	0.8	0.3	1.7
2	10.0	27.7	13.6	6.0	5.9	2.7	14.0
3	23.3	6.7	5.4	1.5	1.0	0.4	2.1
4	0.5	+	+	+	+	+	+
Total number	33.8	34.4	19.3	9.2	7.7	3.4	17.8
Total weight	772.9	458.6	371.4	121.0	112.4	56.0	297.6

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) in the winter season (January-March) 1979 - 1993

				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
2	+	+	0.1	1.4	0.6	2.7	0.2
3	6.9	23.4	22.9	24.8	7.7	29.4	20.1
4	15.5	7.2	7.8	9.6	1.6	2.8	2.5
5	-	0.3	+	0.1	+	+	+
Total number	22.4	30.9	30.8	35.9	9.9	34.9	22.8
Total weight	560.5	657.2	665.1	686.6	258.4	629.0	489.1

Table 5.5 The calculated number (billions) of capelin on 1 August 1978 - 1992 by age and maturity groups. The total number (billions) and weight ('000 t) of the immature and maturing (fishable) stock components are also given.

	Year							
Age/maturity	1978	1979	1980	1981	1982	1983	1984	1985
1 juvenile	163.9	60.3	65.9	49.1	147.3	125.1	252.1	99.1
2 immature	15.3	16.4	4.2	3.7	15.0	42.5	40.9	100.0
2 mature	81.9	91.3	35.4	39.7	17.1	53.7	40.7	64.6
3 mature	29.1	10.1	10.3	2.8	9.8	27.9	26.9	65.8
4 mature	0.4	0.3	+	+	+	0.1	0.4	0.4
Number immat.	179.2	76.7	70.1	52.8	162.3	167.6	293.0	199.1
Number mature	111.4	101.7	45.7	42.5	19.5	63.6	69.0	91.9
Weight immat	790	337	298	228	650	882	1343	1358
Weight mature	2147	1482	932	743	307	985	1270	1417

	Year							
Age/maturity	1986	1987	1988	1989	1990	1991	1992	1993
1 juvenile	157.1	143.5	80.8	64.2	117.8	148.5*	-	
2 immature	29.4	37.2	24.0	10.3	10.1	9.7	26.9*	
2 mature	35.6	65.4	70.3	42.8	31.9	67.7	70.7	99.9**
3 mature	65.8	20.0	24.4	15.8	6.8	6.7	6.4	17.7**
4 mature	0.7	0.1	0.4	+	+	+	+	
Number immat.	176.5	180.7	104.8	74.5	127.9	158.2*	-	
Number mature	101.4	85.4	95.1	58.6	38.7	74.4	77.1	117.6**
Weight immat	812	832	469	307	562	843*	-	
Weight mature	2116	1540	1528	1072	680	1146	1136	2138**

* Preliminary
** Predicted

Table 5.6 The calculated number (billions) of capelin on 1 January 1979 - 1993 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	11.7	14.3	39.8	25.2	34.5
4 mature	14.8	3.6	4.9	0.8	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	12.5	16.3	47.5	41.1	45.2
Weight immat	1028	502	527	292	685	984	1467	1414
Weight mature	1358	980	471	257	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
2 juvenile	131.9	120.5	67.8	53.9	98.9	124.8*	-
3 immature	25.6	31.2	20.1	8.6	8.6	8.1*	-
3 mature	22.1	34.1	48.8	31.2	22.3	54.8	46.5
4 mature	37.0	11.7	16.0	12.1	4.5	5.3	3.5
5 mature	0.2	+	0.3	+	+	+	+
Number immat.	157.5	151.3	87.9	62.5	107.5	132.9*	-
Number mature	59.1	45.8	64.8	43.3	26.8	60.1	50.0
Weight immat	1003.0	1083	434	291	501	695*	-
Weight mature	1355	993	1298	904	544	1106	1017
Number sp.st.	18.3	18.5	22.0	5.5	16.3	25.8	23.6
Weight sp. st.	420	400	440	115	330	475	499

* 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 N1	Age 2 Back-calc. Mature N2mat	Age 2 Acoustics Immature N2imm	Age 2 Back-calc. Total N2tot	Age 3 Back-calc. Mature N3tot
1980	23.7	17.1	1.7	32.0	9.8
1981	68.0	53.7	8.2	96.2	27.9
1982	44.1	40.7	4.6	81.7	27.0
1983	73.8	64.6	12.6	164.6	65.8
1984	33.8	35.6	1.4	66.2	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	42.3	6.7
1989	*39.2	67.7	5.2	77.2	6.4
1990	60.0	70.7	2.3	**73.1	
1991	104.6				

* 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 1978-1990 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	
Average	17.0	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	24.2	5.5	545	13	0
1983/84	81 - 80	65.6	0.3	1122	526	573
1984/85	82 - 81	43.3	27.5	1404	769	897
1985/86	83 - 82	71.1	21.4	1729	1049	1311
1986/87	84 - 83	33.6	56.6	1946	1236	1333
1987/88	85 - 84	56.8	14.8	1325	700	1115
1988/89	86 - 85	67.7	30.2	1885	1184	1036
1989/90	87 - 86	43.1	26.7	1381	749	550
1990/91	88 - 87	29.3	9.2	722	160	265
1991/92	89 - 88	38.7	4.6	770	216	740
1992/93	90 - 89	58.1	19.4	1459	816	*900
1993/94	91 - 90	99.9	17.7	2138	1390	

* 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 1992.

	Age/Year Class						
Total length (cm)	1 1991	2 1990	3 1989	4+ 1988	Total number (10^9)	Biomass (10^3 t)	Mean weight (g)
7.0 - 7.4	0.1	-	-	-	0.1	+	1.0
7.5 - 7.9	1.0	-	-	-	1.0	1.1	1.1
8.0 - 8.4	2.5	-	-	-	2.5	4.3	1.7
8.5 - 8.9	8.9	-	-	-	8.9	18.1	2.0
9.0 - 9.4	13.9	-	-	-	13.9	32.1	2.3
9.5 - 9.9	16.6	-	-	-	16.6	48.0	2.9
10.0 - 10.4	18.3	-	-	-	18.3	61.3	3.3
10.5 - 10.9	18.2	-	-	-	18.2	73.7	4.0
11.0 - 11.4	12.0	-	-	-	12.0	57.4	4.8
11.5 - 11.9	7.0	-	-	-	7.0	38.6	5.6
12.0 - 12.4	3.0	0.1	-	-	3.1	20.6	6.6
12.5 - 12.9	1.4	0.3	-	-	1.7	13.3	7.5
13.0 - 13.4	0.8	1.8	-	-	2.7	24.0	9.0
13.5 - 13.9	0.5	3.4	-	-	3.9	39.7	10.2
14.0 - 14.4	0.1	6.5	-	-	6.7	79.8	11.9
14.5 - 14.9	0.2	8.9	0.1	-	9.1	122.0	13.4
15.0 - 15.4	0.1	10.4	0.2	-	10.7	164.8	15.3
15.5 - 15.9	-	11.0	0.7	-	11.8	201.7	17.1
16.0 - 16.4	-	6.3	1.0	-	7.3	142.9	19.7
16.5 - 16.9	-	3.9	0.7	0.1	4.6	102.6	22.2
17.0 - 17.4	-	2.3	0.6	-	2.8	70.9	25.0
17.5 - 17.9	-	1.3	0.5	-	1.8	50.0	28.1
18.0 - 18.4	-	0.3	0.2	-	0.6	18.3	30.7
18.5 - 18.9	-	0.1	0.2	-	0.3	10.1	32.7
19.0 - 19.4	-	0.1	0.1	-	0.1	2.3	40.7
19.5 - 19.9	-	-	+	-	+	0.8	43.0
Number (10^9)	104.6	56.7	4.3	0.1	165.7	-	-
Biomass (10^3 t)	382.6	917.4	97.5	0.7	1398.3	1398.3	-
Mean length (cm)	10.3	15.4	16.7	16.8	12.2	-	-
Mean weight (g)	3.7	16.2	22.6	22.0	8.4	-	-

Table 5.11 The total international catch in numbers (millions) of capelin in the Iceland-east Greenland-Jan Mayen area in the autumn of 1992 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	Sum	%
9 - 10	304	-	-	-	304	1.7
10 - 11	772	-	-	-	772	4.3
11 - 12	497	51	-	-	548	3.1
12 - 13	89	986	-	-	1075	6.0
13 - 14	16	3595	-17	-	3628	20.4
14 - 15	-	4567	295	-	4862	27.3
15 - 16	-	3295	451	-	3747	21.0
16 - 17	-	1381	781	-	2162	12.1
17 - 18	-	124	469	-	593	3.3
18 - 19	-	-	87	-	87	0.5
Total	1700	14000	2100	-	17800	
%	9.6	78.7	11.8	-		100.0
Weight ('000 t)	9.4	234.9	53.3	-	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 1993 by age and length, and the catch in weight ('000 t) by age groups.

Total length (cm)	Age 2	Age 3	Age 4	Age 4	Sum	%
11 - 12	4	11	-	-	14	0.1
12 - 13	28	119	-	-	147	0.6
13 - 14	102	1262	13	-	1376	6.0
14 - 15	67	4207	188	-	4461	19.5
15 - 16	18	6337	682	-	7037	30.8
16 - 17	7	5107	732	-	5846	25.6
17 - 18	-	2653	604	+	3257	14.3
18 - 19	-	378	238	-	615	2.7
19 - 20	-	22	44	-	65	0.3
Total	225	20095	2500	+	22820	
%	1.0	88.1	10.9	+		100.0
Weight ('000 t)	3.0	421.7	64.3	0.1	489,1	

Table 5.13 The preliminary total international catch in number (millions) in July-September 1993 divided on age and length groups.

Length (cm)	Age 2	Age 3	Age 4	Total
12 - 13	1101	-	-	1101
13 - 14	6031	-	-	6031
14 - 15	7527	508	-	8035
15 - 16	4977	1628	+	6605
16 - 17	1899	2931	+	4830
17 - 18	165	981	+	1146
18 - 19	-	52	-	52
Total number	21700	6100	+	27800
%	78	22	+	100
Weight ('000 t)	384	153	+	537

Table 5.14 Abundance indices of 0-group capelin 1970-1993 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

Table 5.15 Estimated numbers of 1-group capelin in August 1982 - 1993

Year class	Number in 10^{-9}
1981	119
1982	155
1983	286
1984	31
1985	71
1986	101
1987	147
1988	111
1989	36
1990	50
1991	87
1992	*33

* Survey did not cover all of the distribution area.

Table 6.1.

Consumption by North-east Arctic cod of various prey species. 1984-1989 data from Bogstad and Mehl (1992), using the 1991 VPA for cod. 1992 data calculated in the same way, but using the 1993 VPA for cod and assuming that the mature cod stock is outside the Barents Sea for three months during the first half of the year. Consumption in '000 tonnes (% of total yearly consumption in parentheses).

Year Prey species	1984	1985	1986	1987	1988	1989	1992
Amphipods	16(1)	113(3)	721(25)	742(35)	1029(44)	646(27)	31(1)
Shrimp	417(19)	156(5)	125(4)	177(8)	128(5)	137(5)	332(6)
Capelin	867(40)	1938(56)	956(33)	226(11)	511(22)	783(31)	3064(59)
Herring	66(3)	161(5)	131(4)	30(1)	1(0)	4(0)	440(9)
Cod	33(2)	47(1)	103(4)	32(2)	10(1)	8(0)	67(1)
Haddock	45(2)	40(1)	79(3)	3(0)	5(0)	36(2)	191(4)
Redfish	331(15)	205(6)	251(8)	299(14)	190(8)	213(9)	222(4)
Others	371(17)	813(23)	565(19)	631(29)	482(20)	670(26)	803(16)
Total	2146(99)	3475(100)	2932(100)	2141(100)	2355(100)	2497(100)	5150(100)

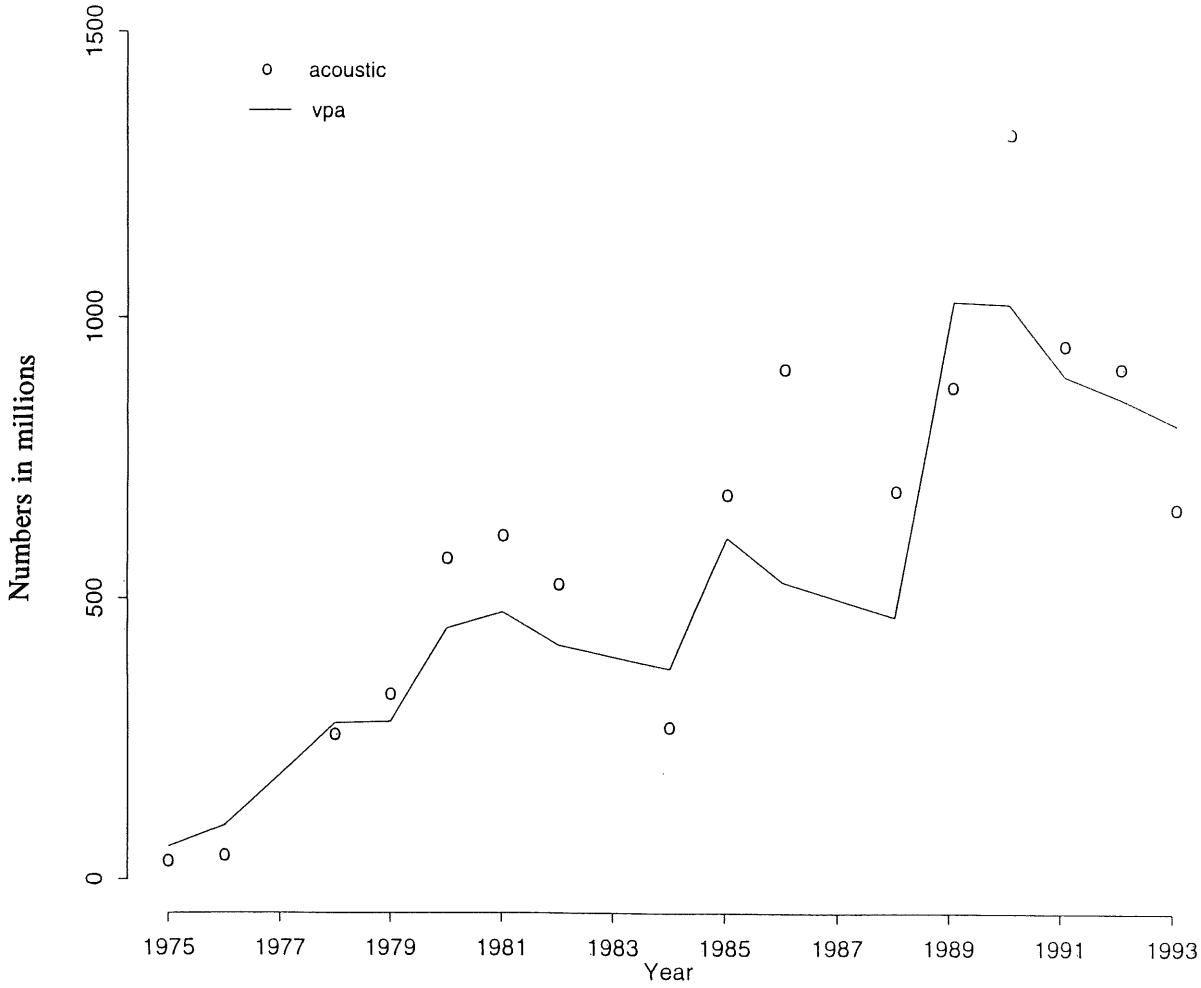


Figure 2.1a Trends in acoustics and VPA stock numbers, using TS=21.7 log(L)-75.5dB in acoustic estimate.

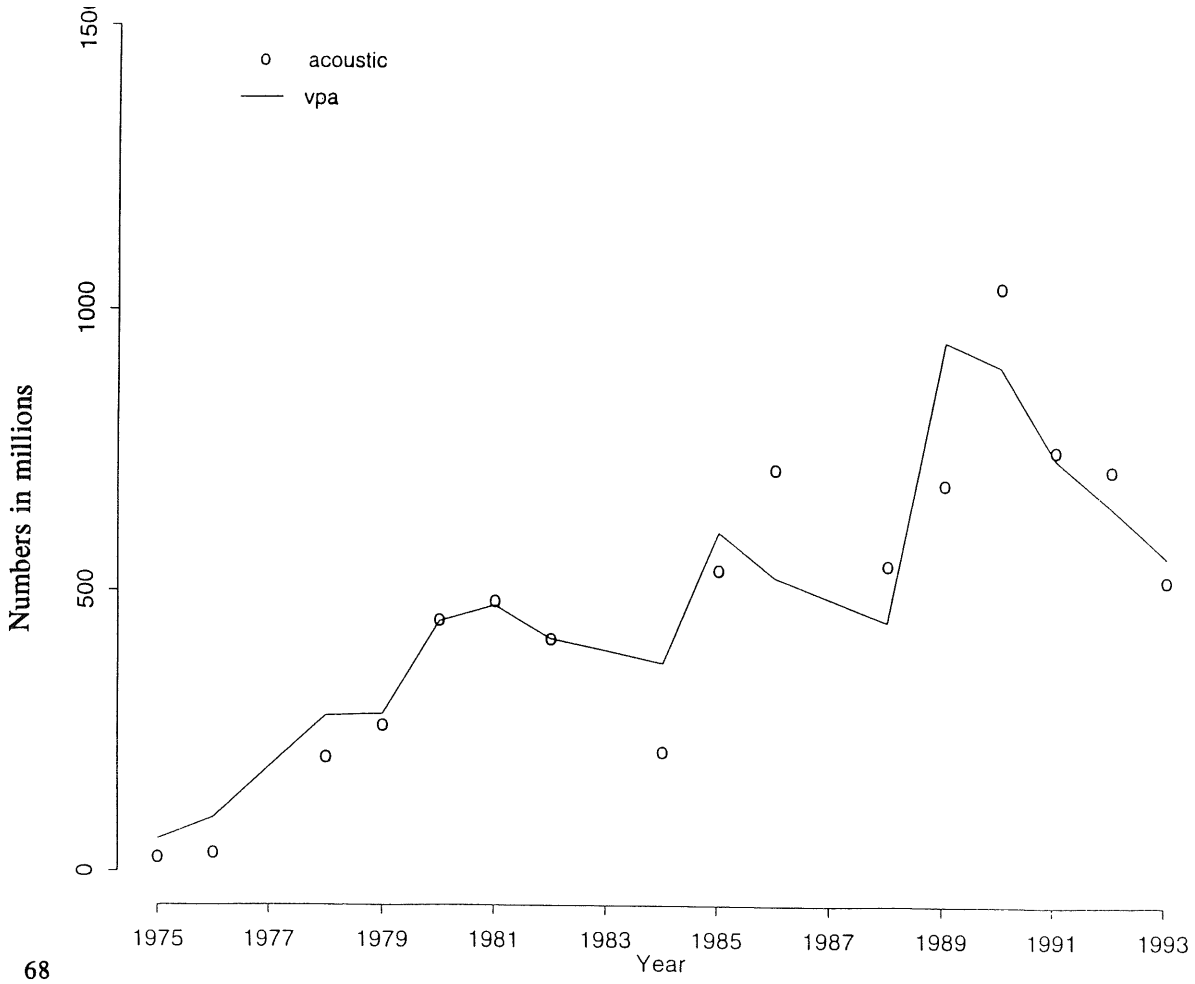


Figure 2.1b Trends in acoustics and VPA stock numbers, using TS=20 1og(L)-72dB in acoustic estimate.

Figure 2.2 Icelandic summer spawners. SSE for fit of VPA to acoustics.

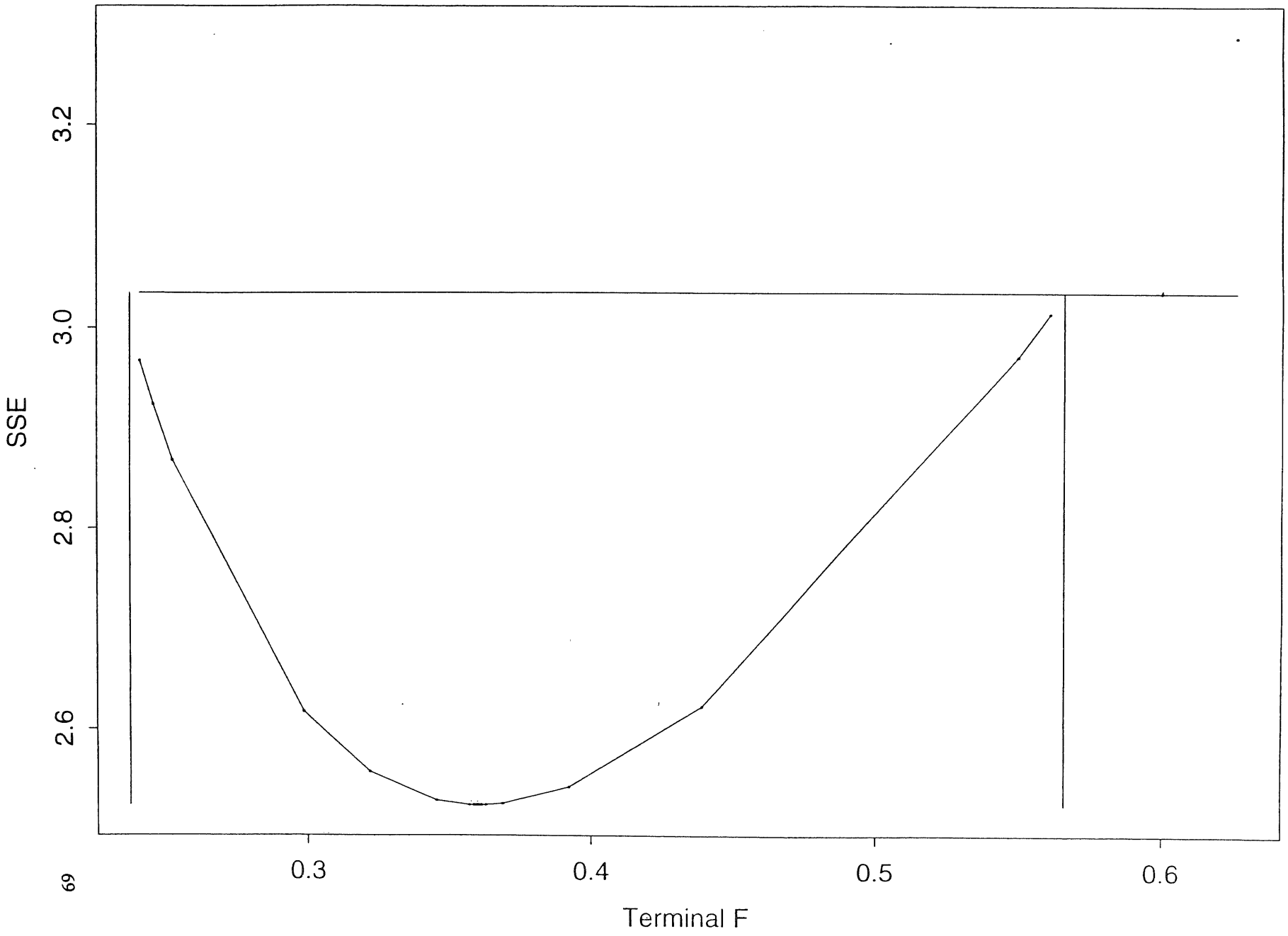


Figure 2.3 Acoustic estimates vs VPA stock numbers (millions), using TS=20log(L)-72 dB in acoustic estimate.

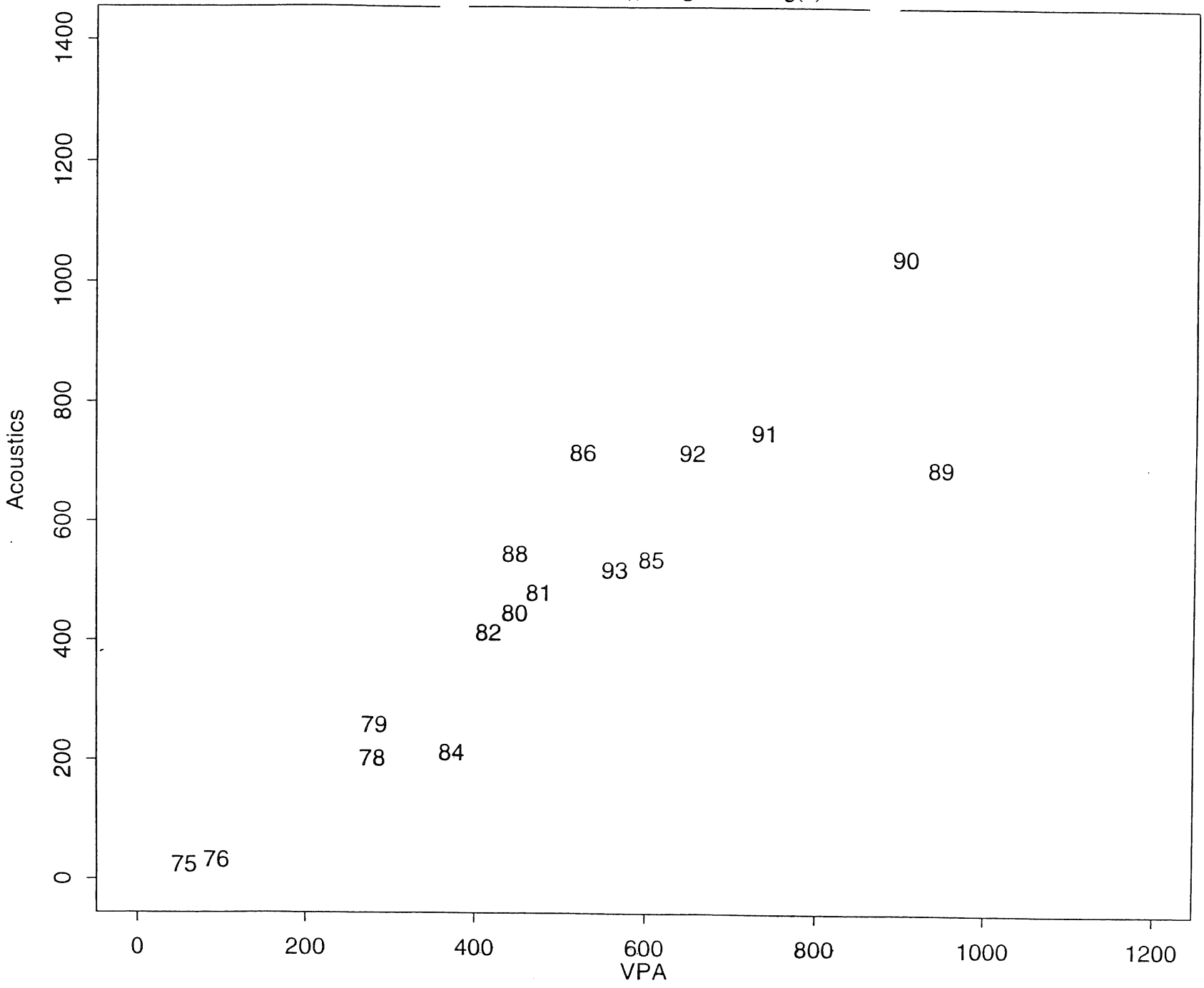
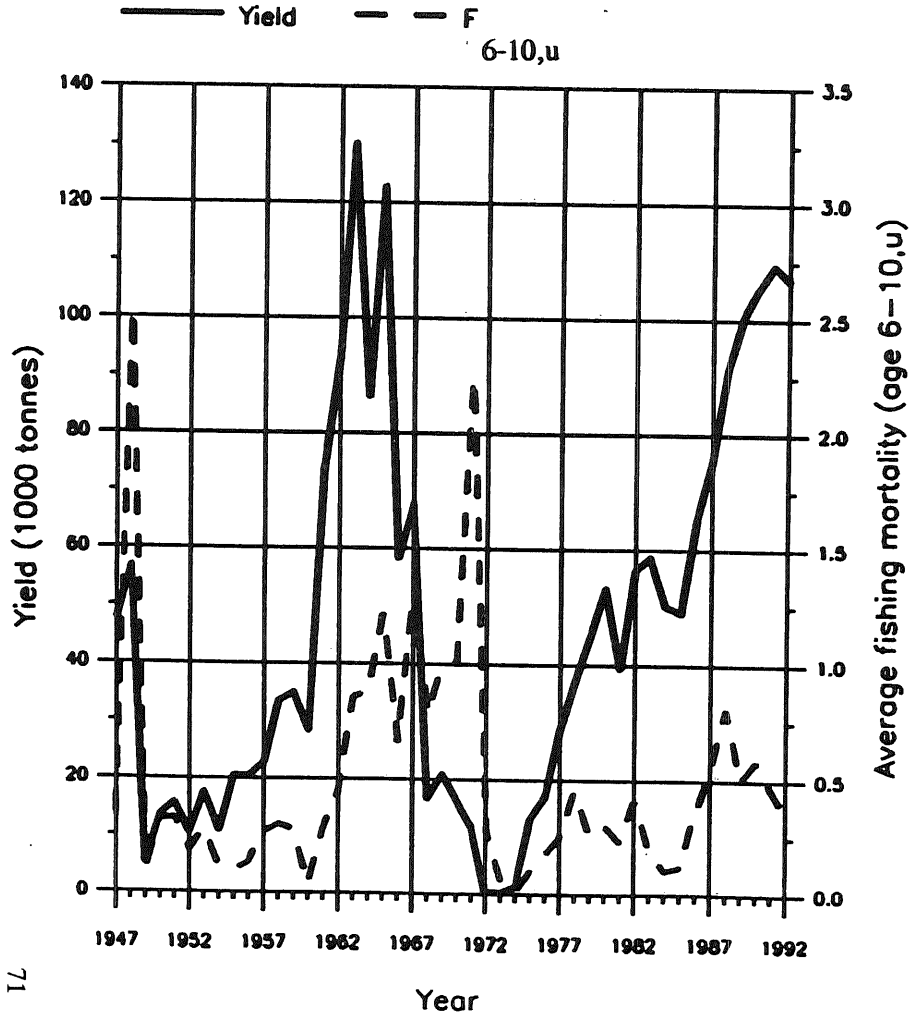


Figure 2.4

FISH STOCK SUMMARY
STOCK: Herring, Summer Spawning at Iceland (Fishing Area Va)
22–10–1993

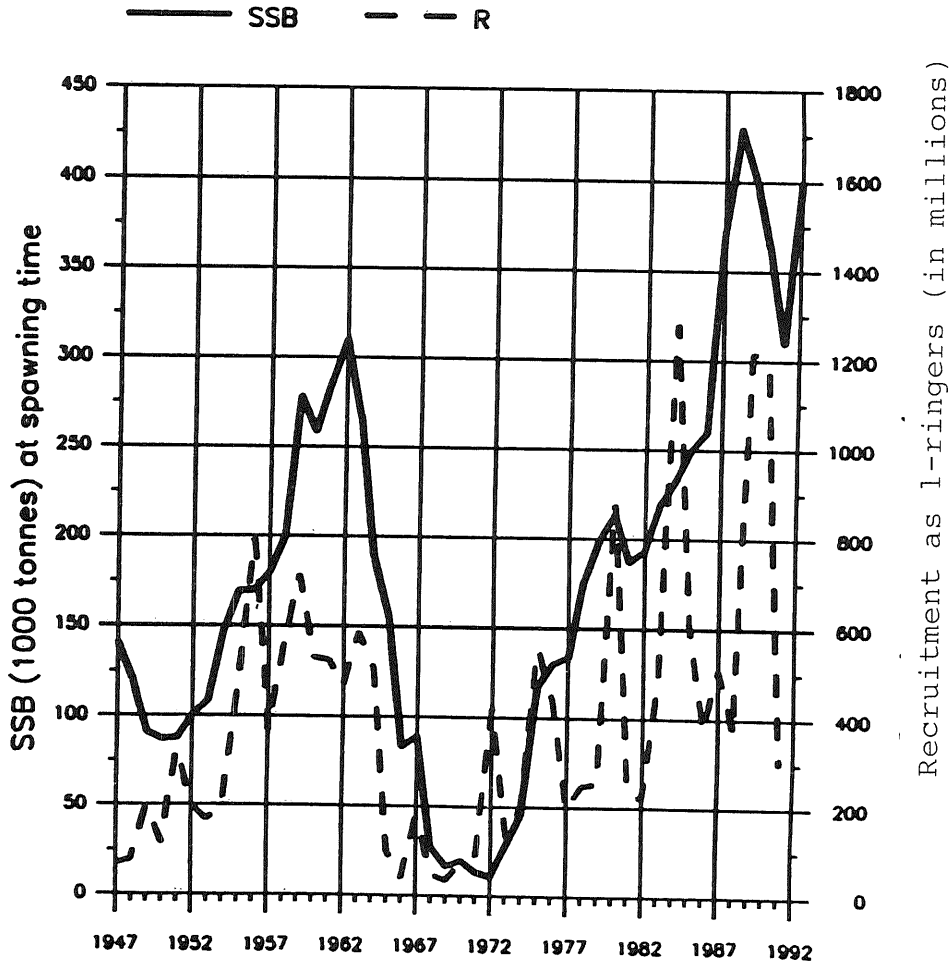
Trends in yield and fishing mortality (F)



(run: VL10)

A

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



(run: VL10)

B

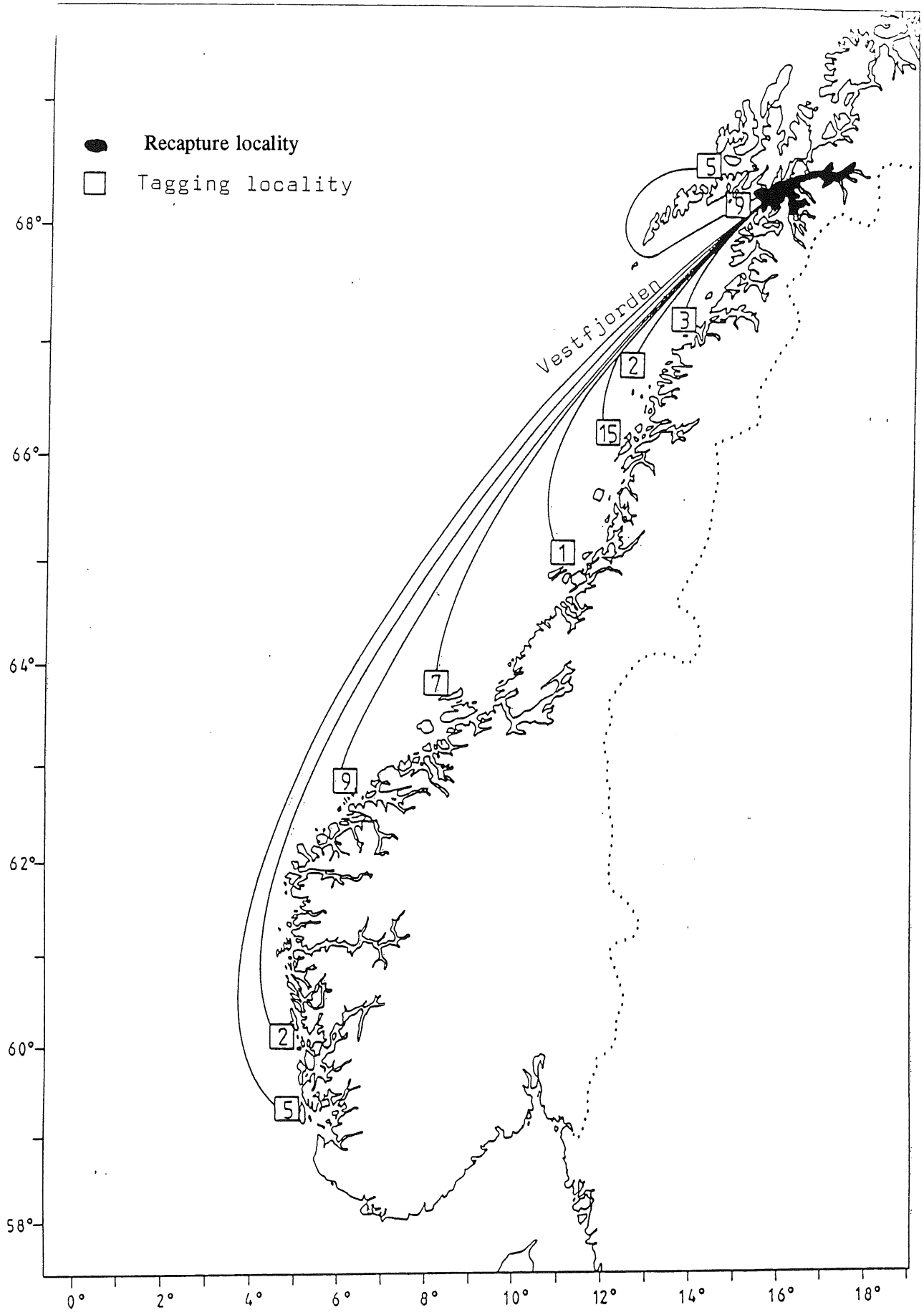


Figure 3.1 Norwegian spring spawners. Distribution of tag returns in 1993. The figure in the squares shows number of herring recaptured from that tagging locality.

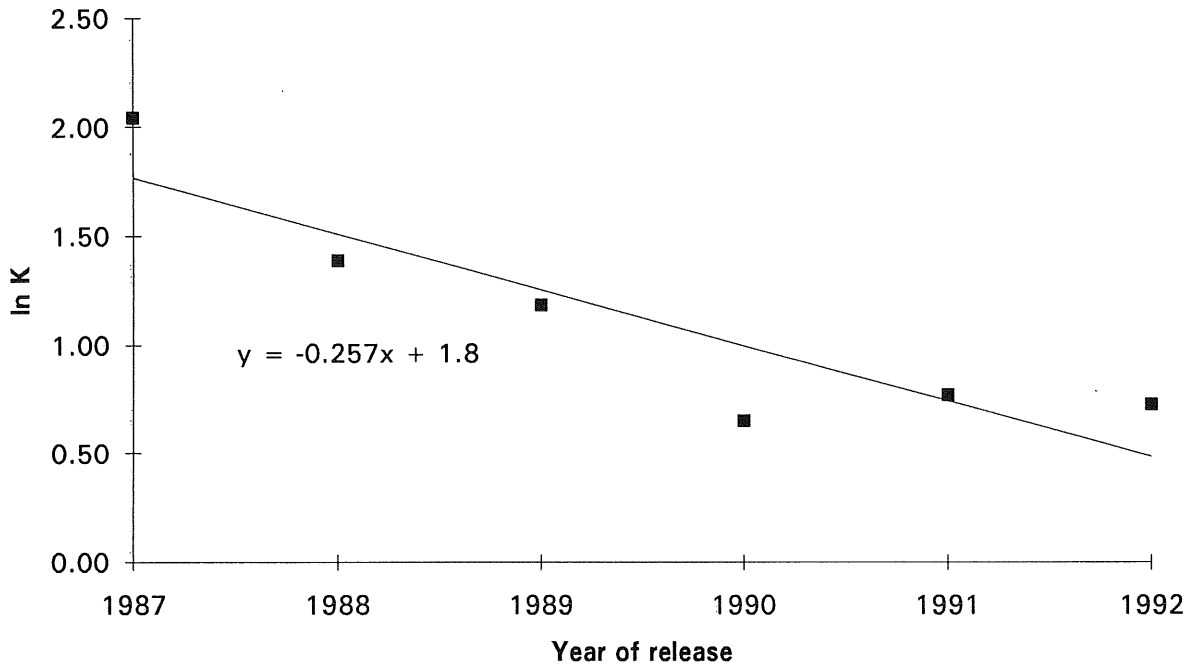


Figure 3.2 Norwegian spring spawning herring. Plot of ln K (see text) against years of release.

Figure 3.3 Norwegian spring spawners. Tuning of VPA to tagging and acoustic estimates.

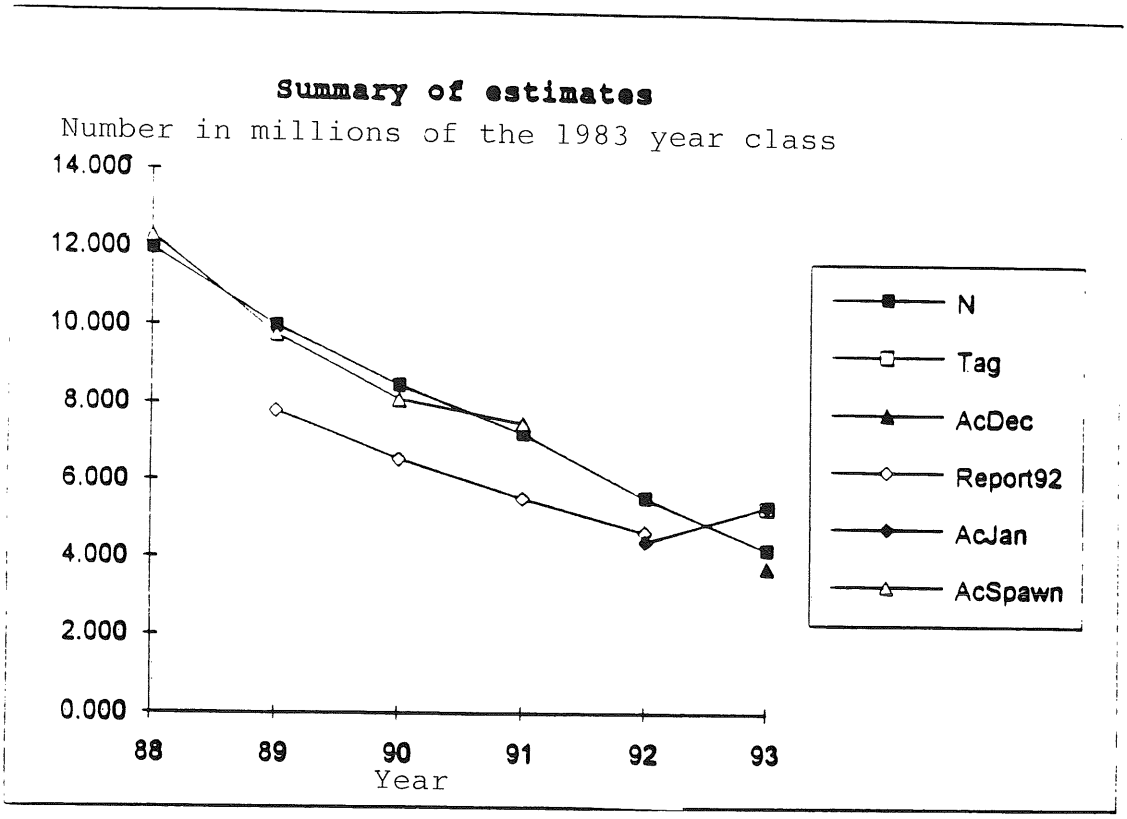


Figure 3.4 Distribution of Norwegian spring spawning herring. Spawning areas limited to Norwegian coastal waters.

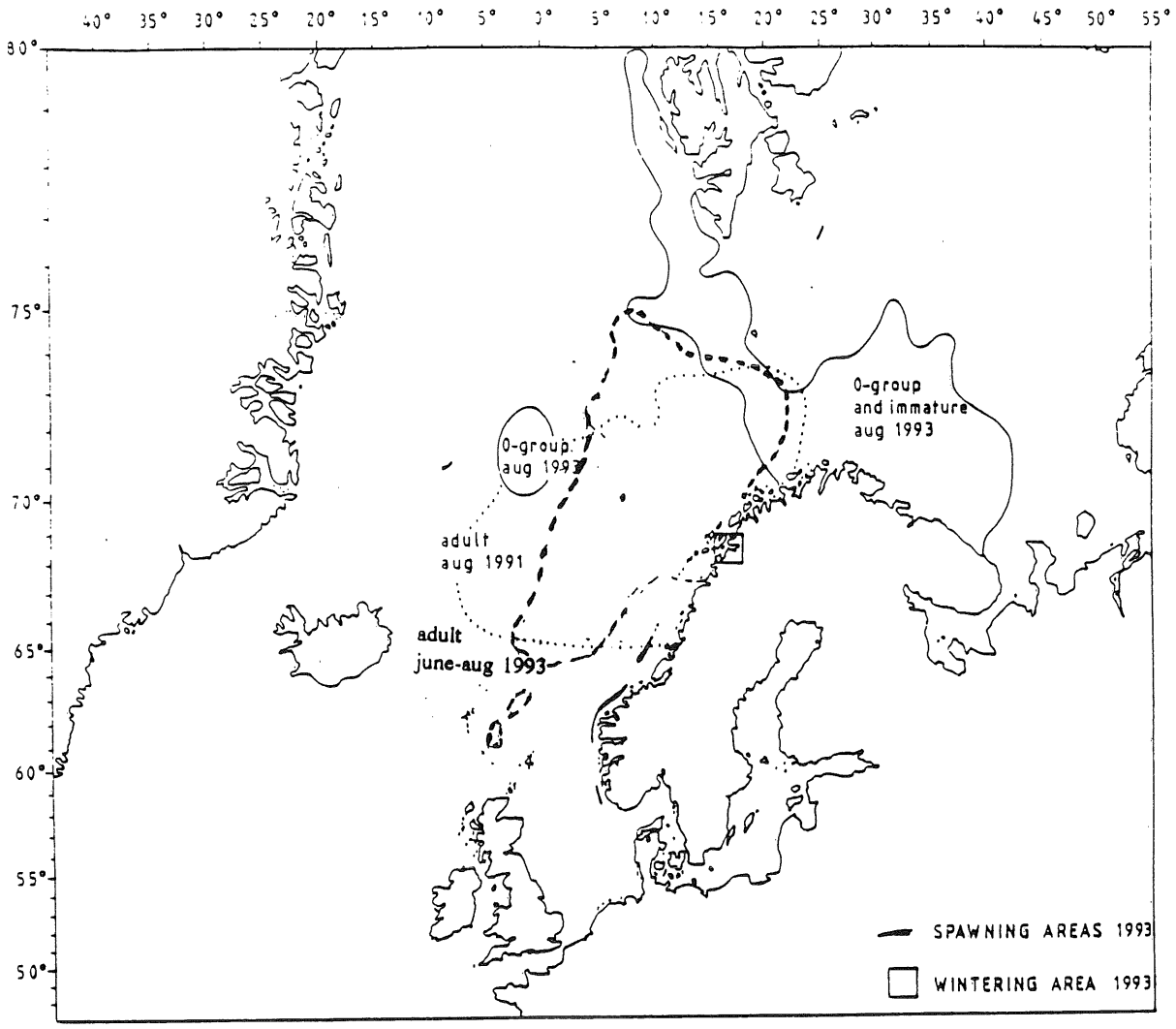
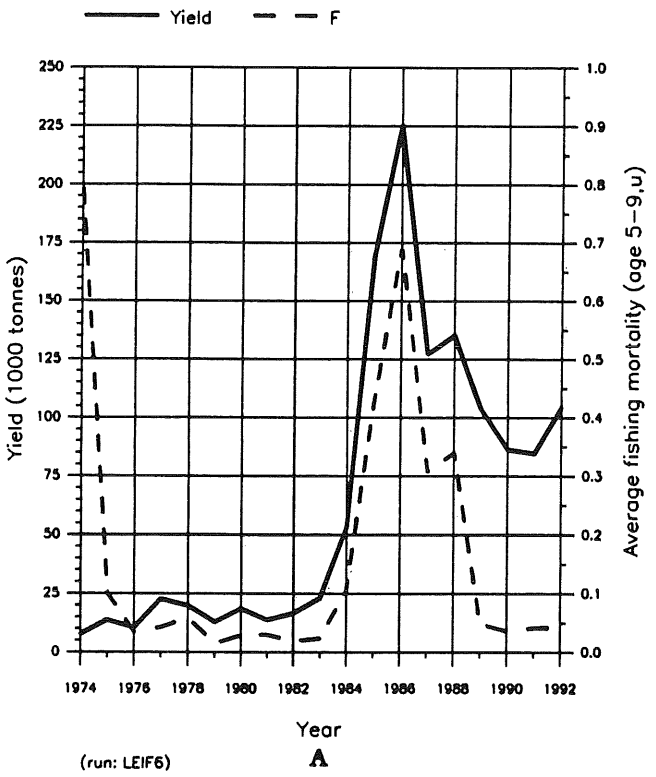


Figure 3.5

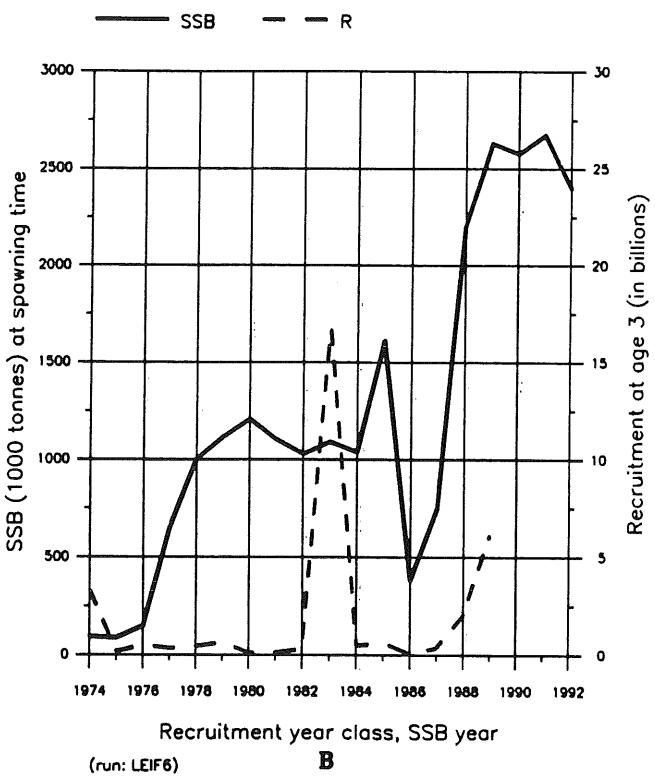
FISH STOCK SUMMARY
STOCK: Herring, Norwegian Spring Spawners
25–10–1993

Trends in yield and fishing mortality (F)



(run: LEIF6) **A**

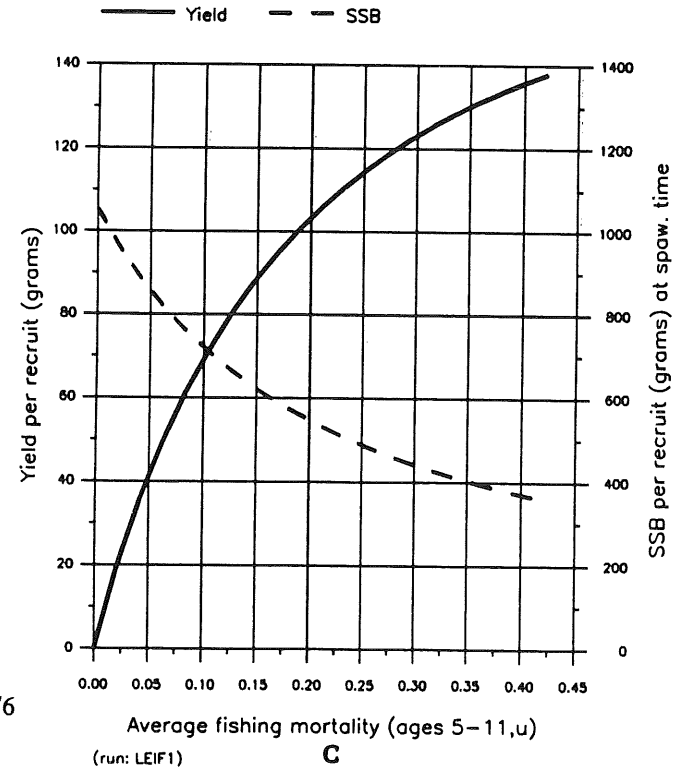
Trends in spawning stock biomass (SSB) and recruitment (R)



(run: LEIF6) **B**

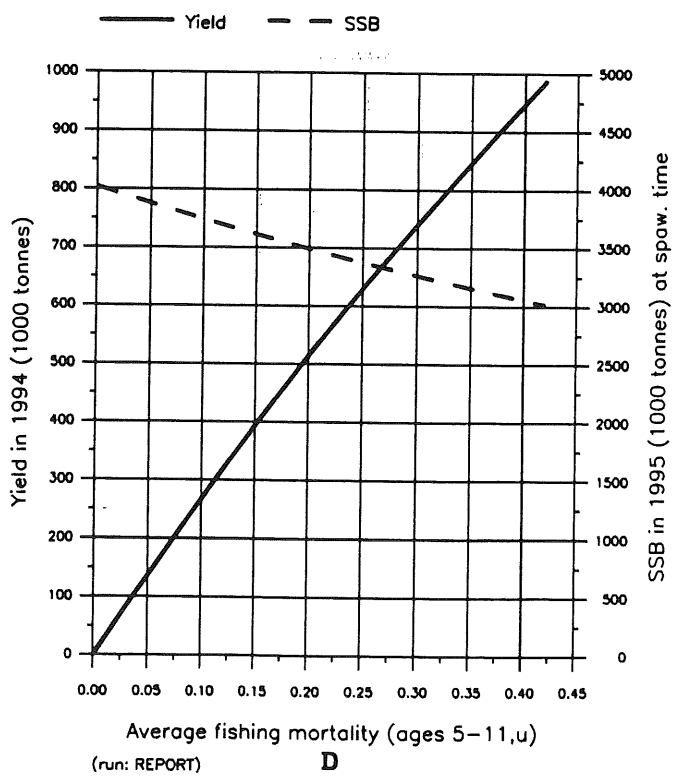
FISH STOCK SUMMARY
STOCK: Herring, Norwegian Spring Spawners
23–10–1993

Long term yield and spawning stock biomass



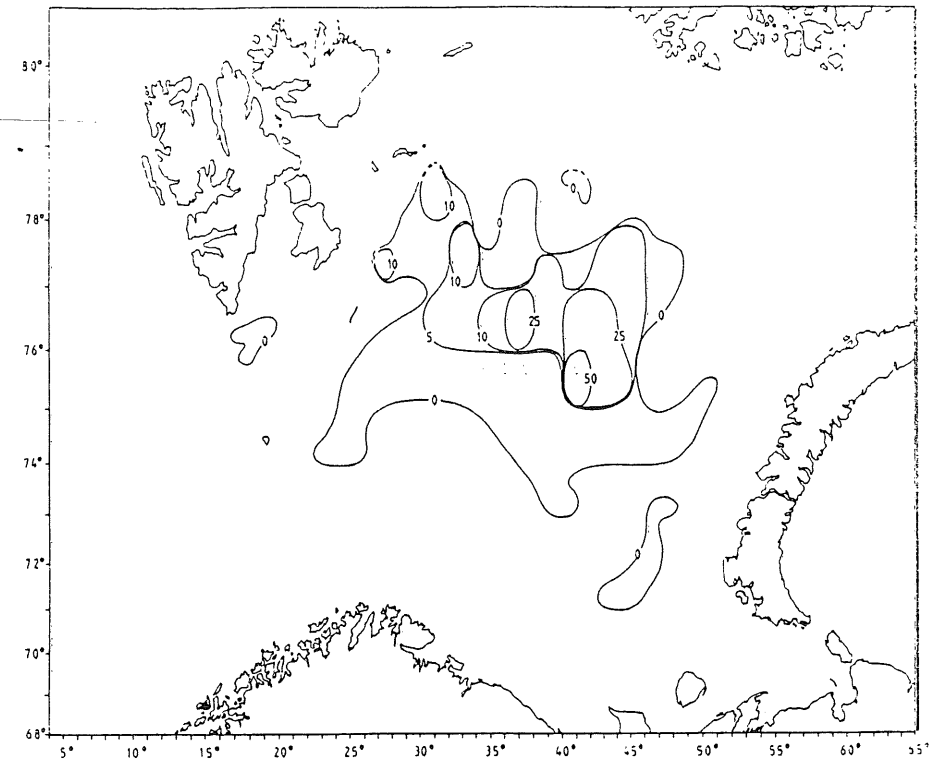
(run: LEIF1) **C**

Short–term yield and spawning stock biomass



(run: REPORT) **D**

Figure 4.1 Estimated total density distribution of capelin (tons/square nautical mile) in the acoustic survey autumn 1993.



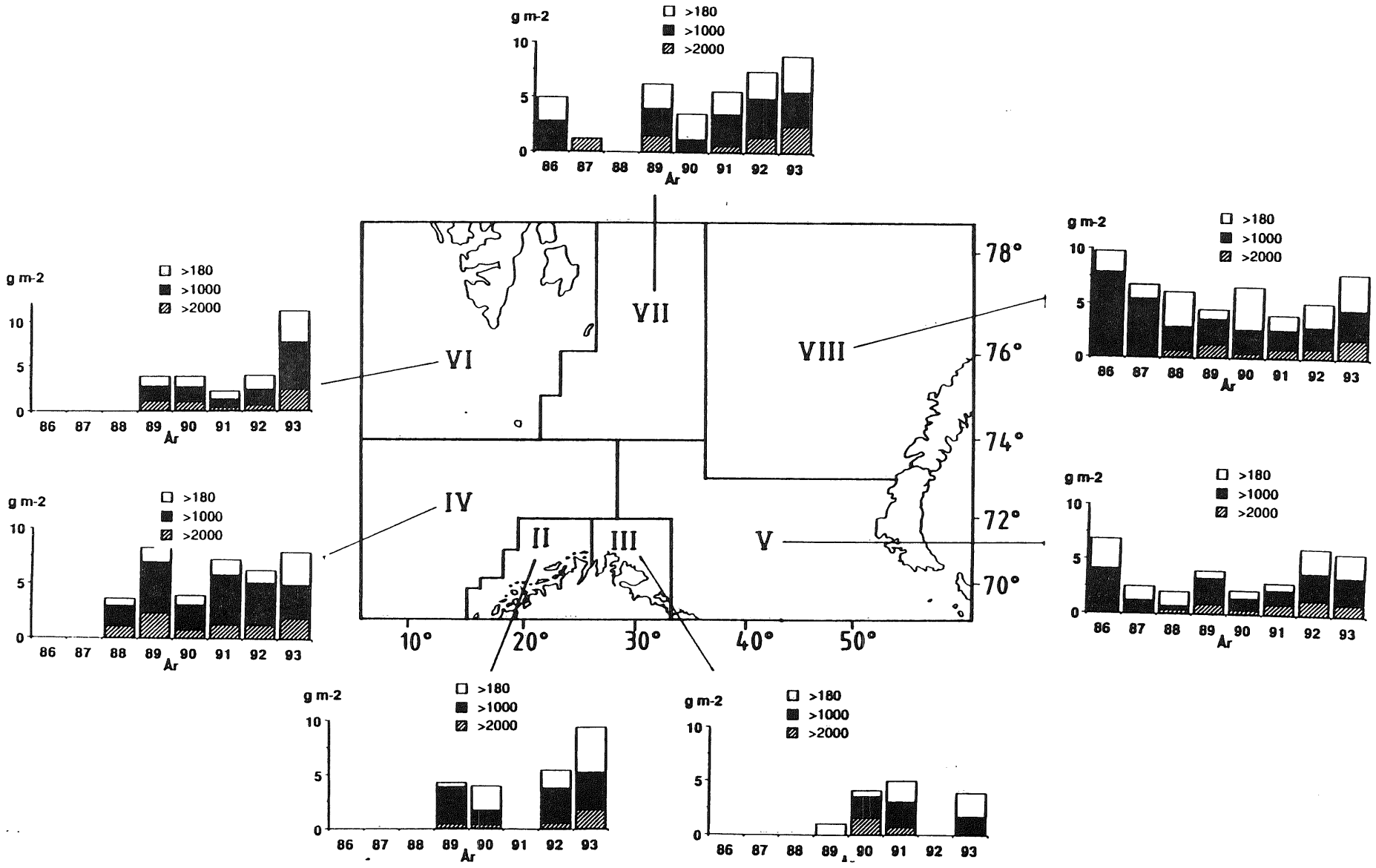


Figure 6.1 Average ash free dry weight (1985-1990) and dry weight (1991-1993, g m^{-2}, from bottom to surface in Barents Sea multispecies regions. Size fraction >180 and >1000 means 180-1000 and 1000-2000 μm respectively. Data based on WP2 net.