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



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1 INTRODUCTION

1.1 Terms of Reference

The Atlanto-Scandian Herring and Capelin Working Group (Chairman: Mr H.í Jákupsstovu, Faroe Islands) met at ICES Headquarters from 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

| | |
|---------------|--------|
| B. Bogstad | Norway |
| J. Carscadden | Canada |

| | |
|-----------------------------|-----------------------|
| H. Gjøsæter | Norway |
| J. Hamre | Norway |
| J. Jakobsson | Iceland |
| H. í Jákupsstovu (Chairman) | Faroe Islands |
| P. Kanneworff | Greenland (part-time) |
| A. Krysov | Russia |
| I. Røttingen | Norway |
| V. Shleinik | Russia |
| H. R. Skjoldal | Norway |
| G. Stefánsson | Iceland |

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 |

¹Recommended 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^I . 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 $TS = 20 \log L - 72 \text{ dB}$.

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 (F_{4-14w}) 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 $F_{4-14w} = 0.25$. 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 = $m/\Sigma r \times 500$

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 F_s 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 |

¹Back-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 quantities 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 (N_{2mat}) is a part of the survivors of the 1-group in the previous autumn (N_1), which is measured in October. Regressing the back-calculated maturing 2-group abundance against the 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 (N_{2imm}) in the year before are gross underestimates and will, therefore, not be used. Similarly, the January survey of this year class only estimates the part 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

(N_{2tot}); 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 (N_{2tot} and N_{3tot}) 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 Melrakkaslétta 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 euphausiids 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 MULT-SPEC 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 euphausiids 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 zooplankton 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 (Tøresen, 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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Working Documents

Icelandic summer-spawning herring

- J. Jakobsson. Icelandic summer-spawning herring.

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 | 48.240 | 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 | 332 | 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_{p92} is the exploitation pattern in 1992 (used in the prognoses) and F_{pav} is the average exploitation pattern for 1985-1988.

| Rings in 1992 | Year class | Acoustic | Catch 1992/93 | F^1 | F_{92} | F_{p92} | F_{pav} |
|------------------|---------------|-----------------------|------------------|-------|----------|-----------|-----------|
| | | estimate Dec. 1992 | | | | | |
| 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

| Year | F Factor | Reference F | Catch in numbers | Catch in weight | Stock size | Stock biomass | 1 January | | Spawning time | |
|------|-------------|----------------|---------------------|--------------------|---------------|------------------|------------------|---------------------|------------------|---------------------|
| | | | | | | | 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 | | | | | | 1 January | | Spawning time | |
|-------------------------------------------------|--------------|---------------------|--------------------|---------------|------------------|------------------|---------------------|------------------|---------------------|
| rings | bsolute 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 | 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 : PREDNGLE
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 | 1 | 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

| F Factor | Reference F | Catch in numbers | Catch in weight | Stock size | Stock biomass | 1 January | | Spawning time | |
|-------------|----------------|---------------------|--------------------|---------------|------------------|------------------|---------------------|------------------|---------------------|
| | | | | | | 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 : 200CT93:14:50
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 | |

¹Preliminary.

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 | Year class | 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, | .1300, |
| 4, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, |
| 5, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, |
| 6, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, |
| 7, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, |
| 8, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, |
| 9, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, |
| 10, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, |
| 11, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, |
| +gp, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, | .1300, |

| Table 4 | Natural Mortality (M) at age | | | | | | | | | |
|---------|------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| YEAR, | 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 YEAR, | Stock number at age (start of year) | | | | | Numbers*10**-4 | | | | |
|-------------------|-------------------------------------|--------|---------|---------|---------|----------------|---------|---------|---------|--|
| | 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

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 |

¹Preliminary 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) | | | | Total number (10 ⁹) | Biomass (10 ³ tons) | Mean weight (g) |
|-------------------------------------------------|------------------|-------|-------|-------|------------------------------------|-----------------------------------|-----------------|
| | 1992 | 1991 | 1990 | 1989 | | | |
| 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)

| Year | Winter season | | | Summer- and autumn season | | | | Total |
|------|---------------|--------|--------|---------------------------|--------|--------|--------|----------|
| | Iceland | Norway | Faroes | Iceland | Norway | Faroes | Others | |
| 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

| Age | 1978 | 1979 | 1980 | Year 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 |

| Age | 1986 | 1987 | 1988 | Year 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

| Age | 1979 | 1980 | 1981 | Year 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 |

| Age | 1987 | 1988 | 1989 | Year 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.

| | Age 1 Acoustics | Age 2 Back-calc. Mature | Age 2 Acoustics Immature | Age 2 Back-calc. Total | Age 3 Back-calc. Mature |
|---------------|--------------------|-------------------------------|--------------------------------|------------------------------|-------------------------------|
| Year class | N1 | N2mat | N2imm | N2tot | 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.

| Total length (cm) | Age/Year Class | | | | Total number (10 ⁹) | Biomass (10 ³ t) | Mean weight (g) |
|-----------------------------|----------------|-----------|-----------|------------|---------------------------------------|--------------------------------|-----------------------|
| | 1 1991 | 2 1990 | 3 1989 | 4+ 1988 | | | |
| 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) |

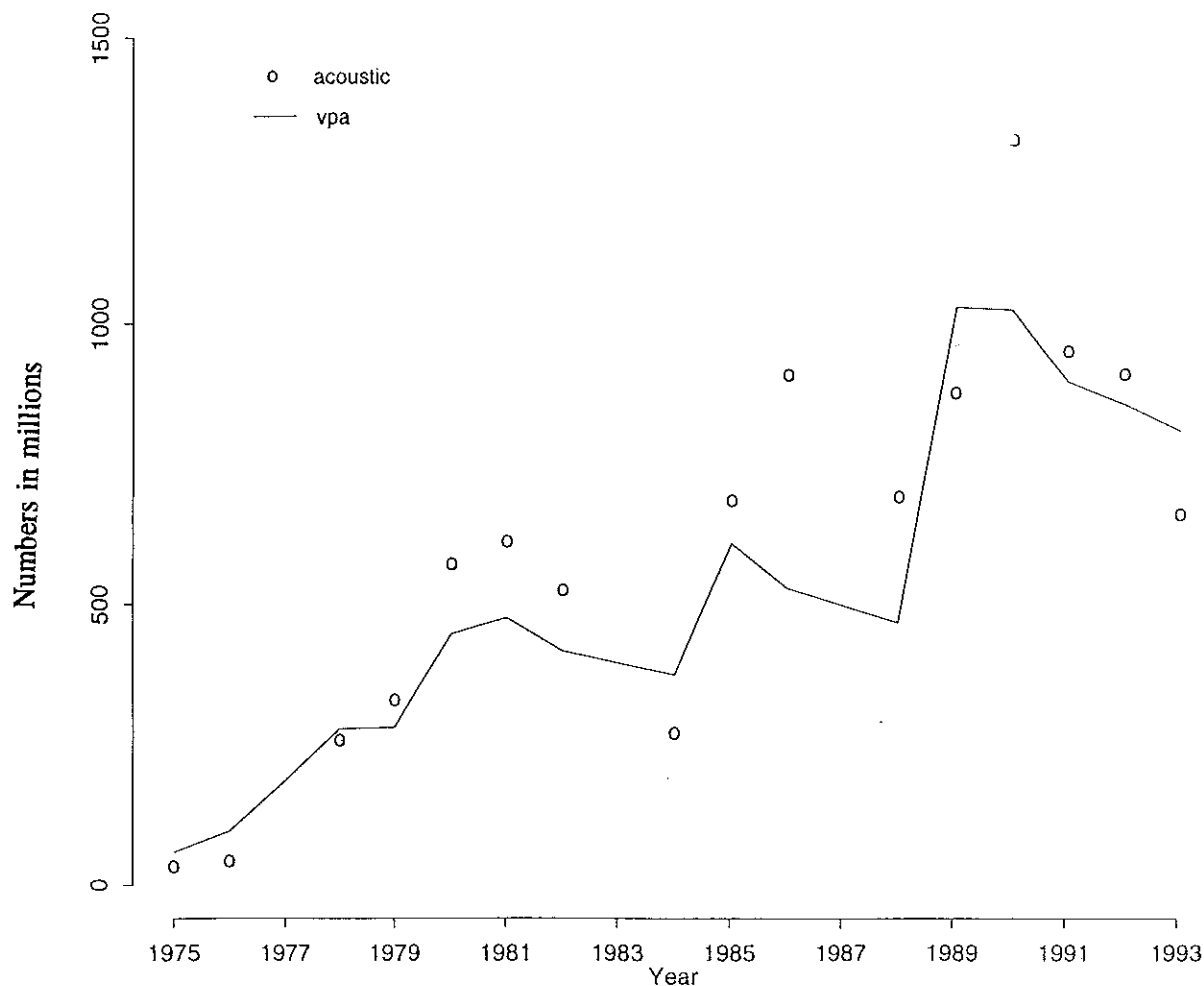


Figure 2.1a Trends in acoustics and VPA stock numbers, using $TS = 21.7 \log(L) - 75.5$ dB in acoustic estimate.

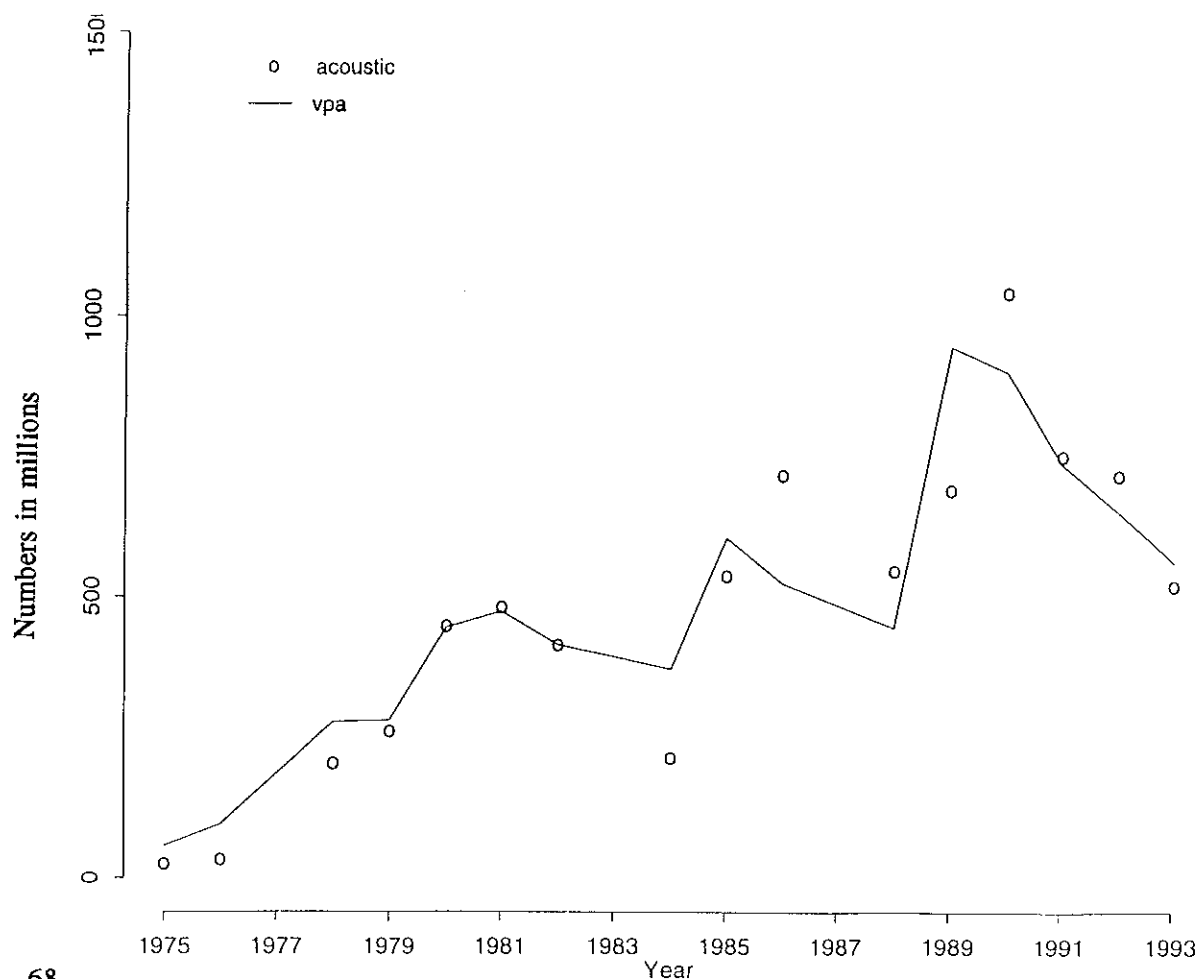


Figure 2.1b Trends in acoustics and VPA stock numbers, using $TS = 20 \log(L) - 72$ dB in acoustic estimate.

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

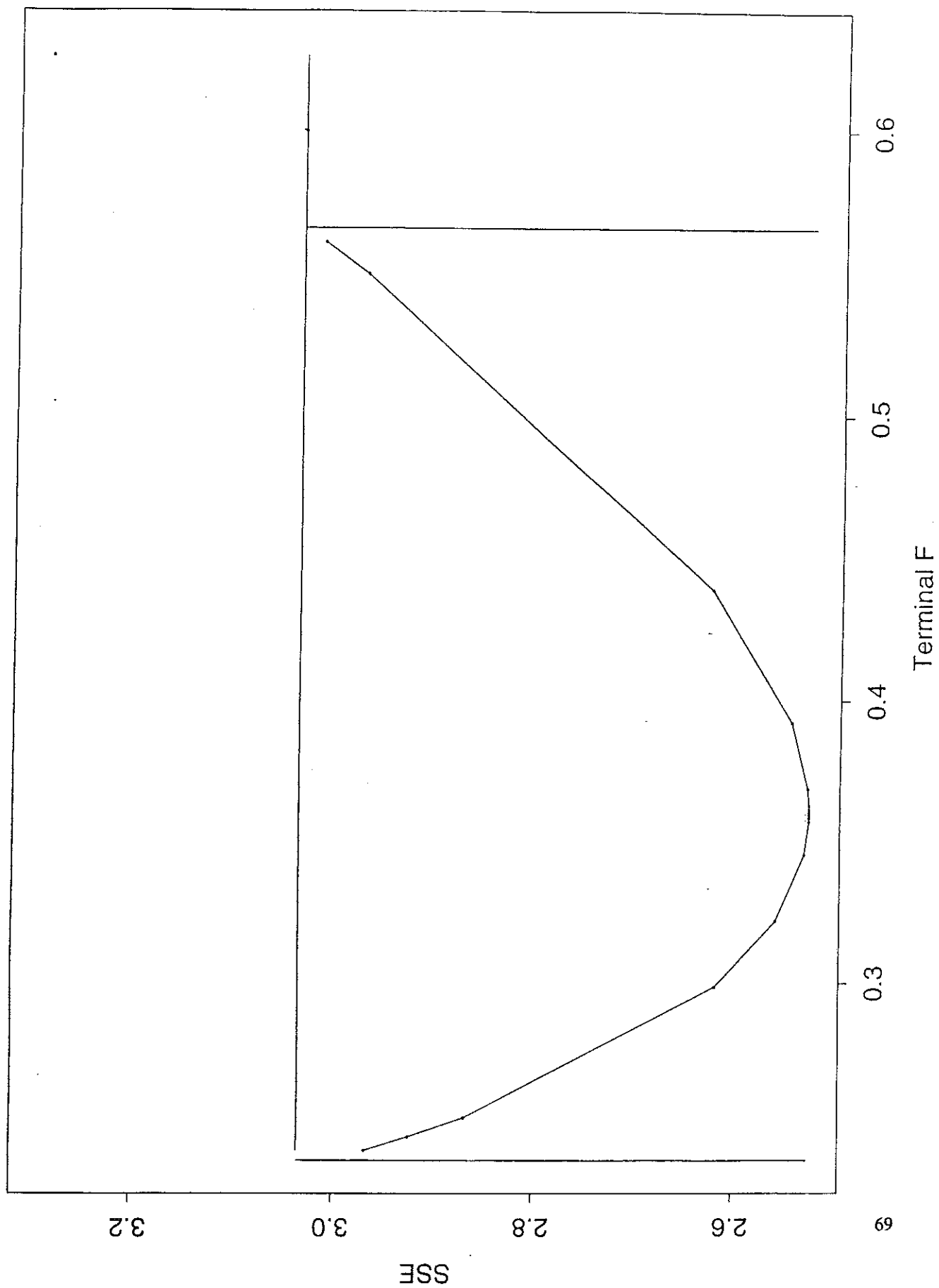


Figure 2.3 Acoustic estimates vs VPA stock numbers (millions), using $TS = 20 \log(L) - 72$ dB in acoustic estimate.

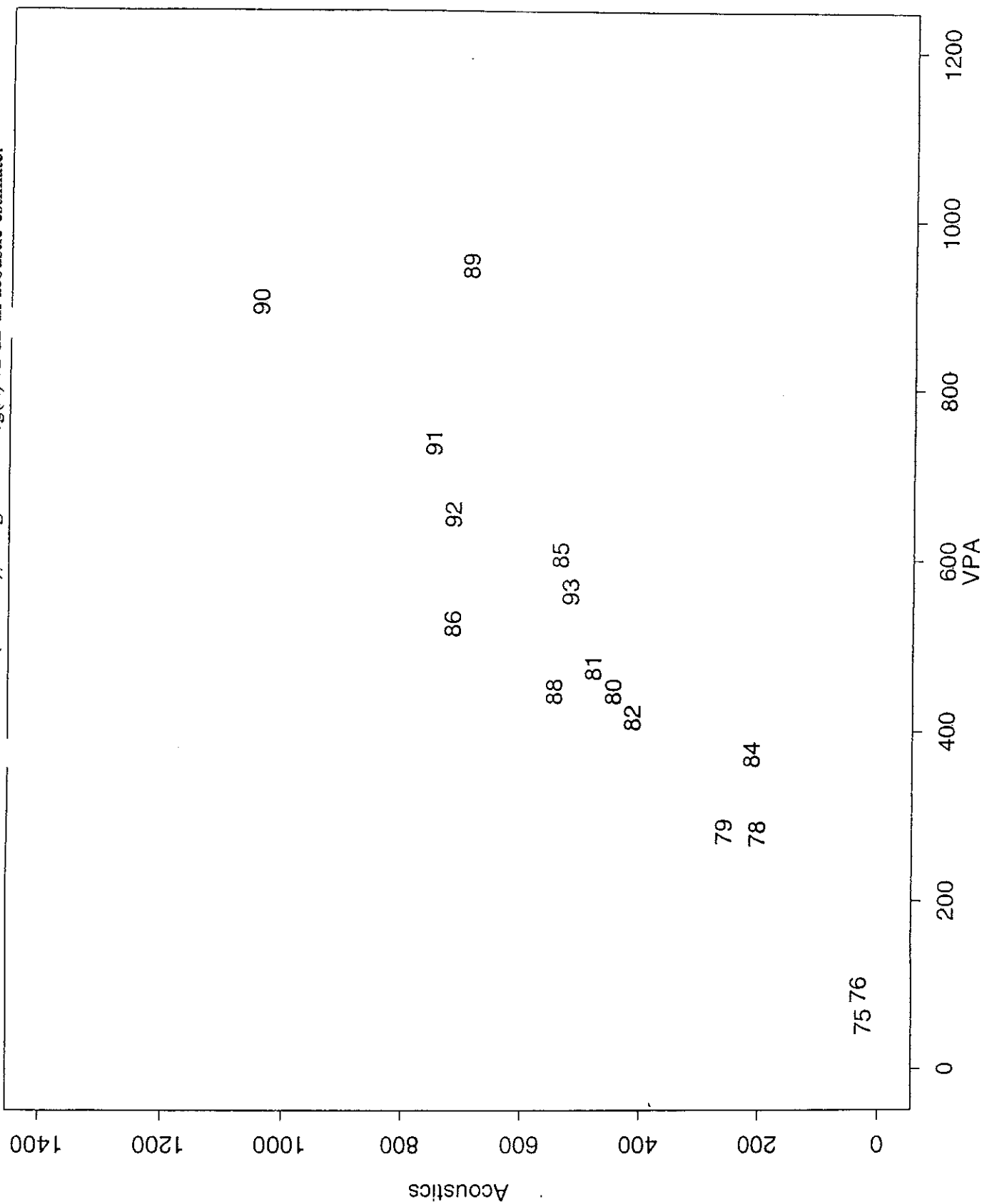
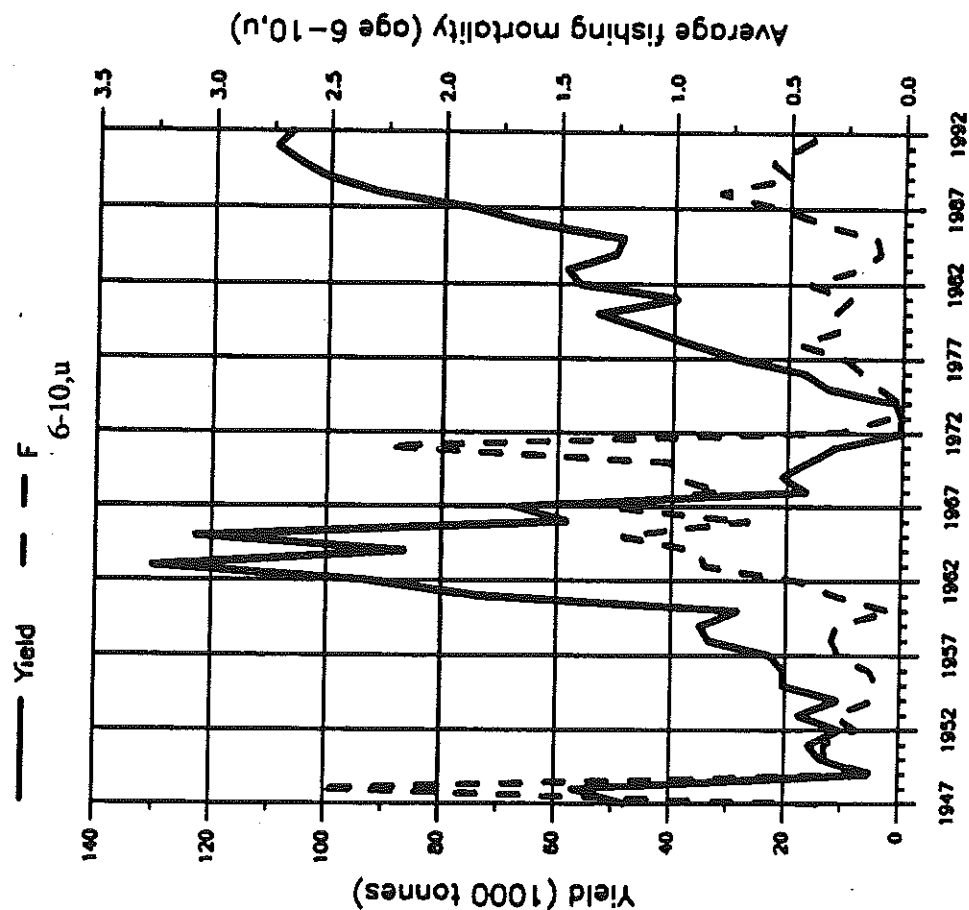


Figure 2.4

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

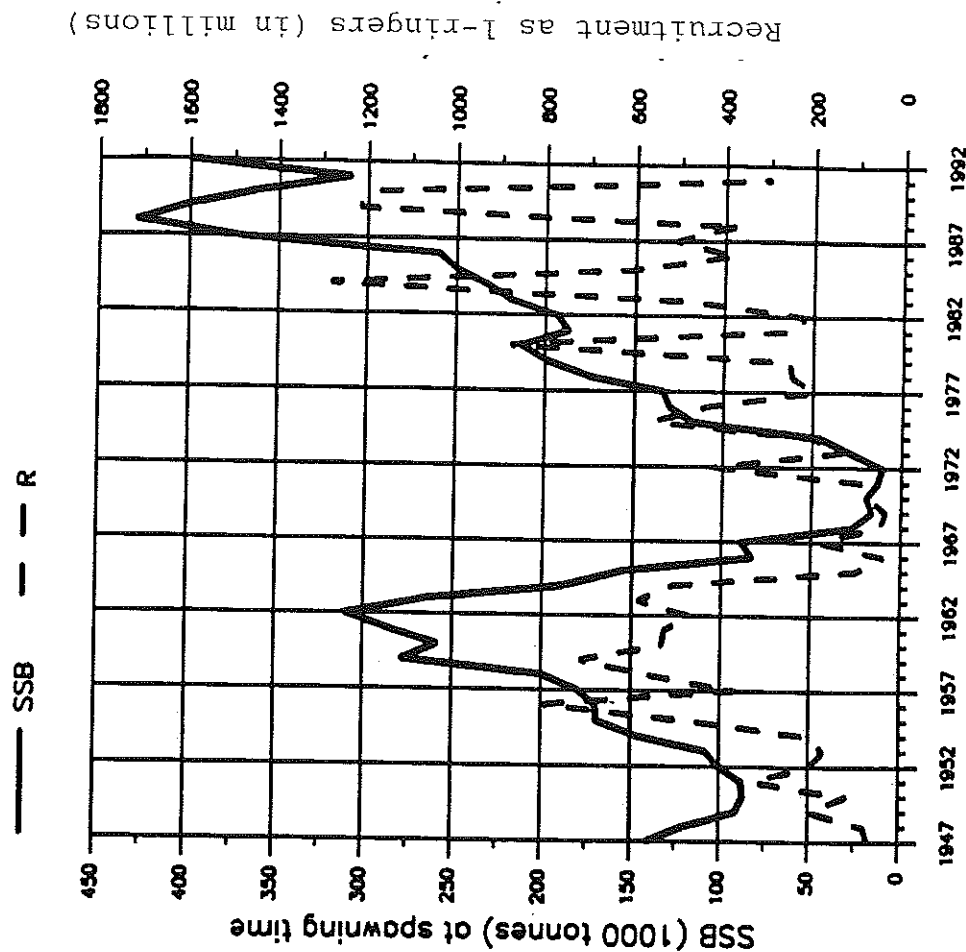
Trends in yield and fishing mortality (F)



(run: VL10)

A

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



(run: VL10)

B

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

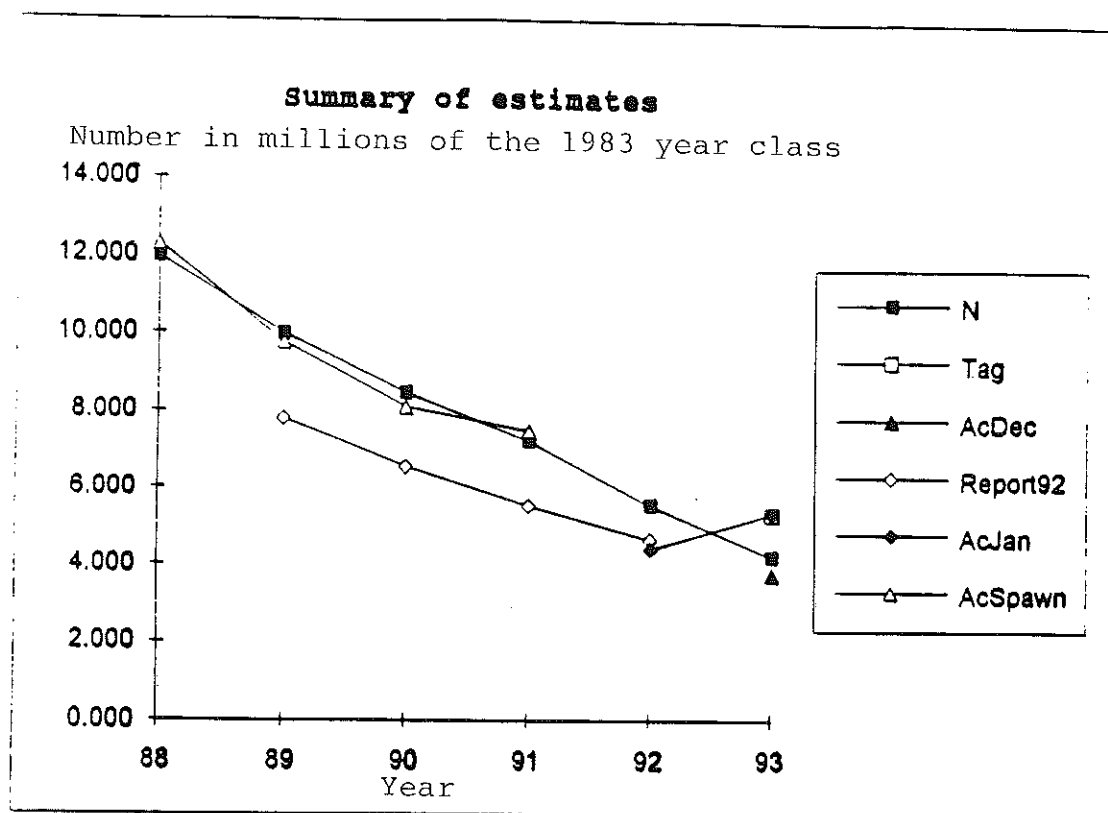


Figure 3.4 Distribution of Norwegian spring spawning herring. Spawning areas limited to Norwegian coastal waters.

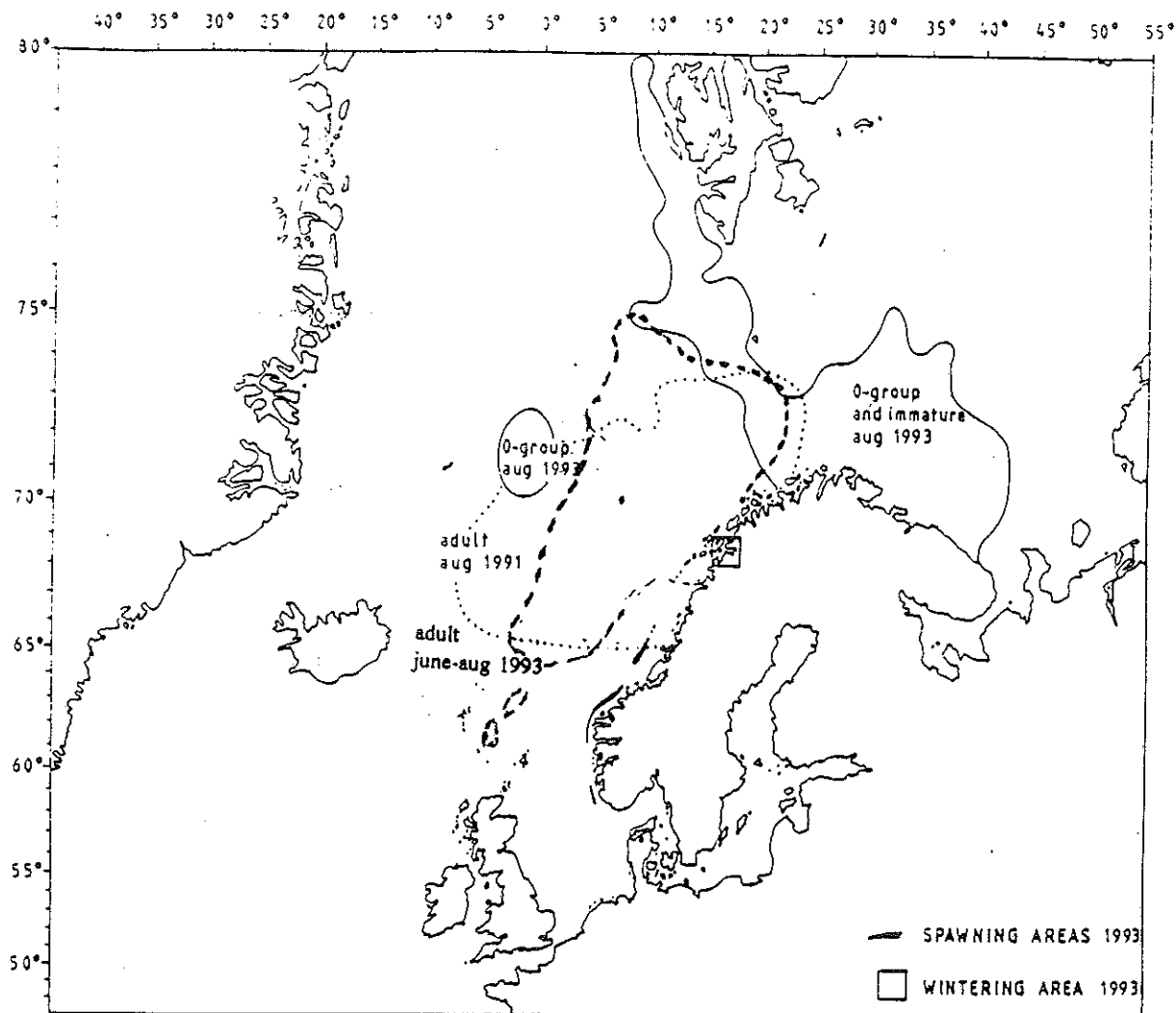
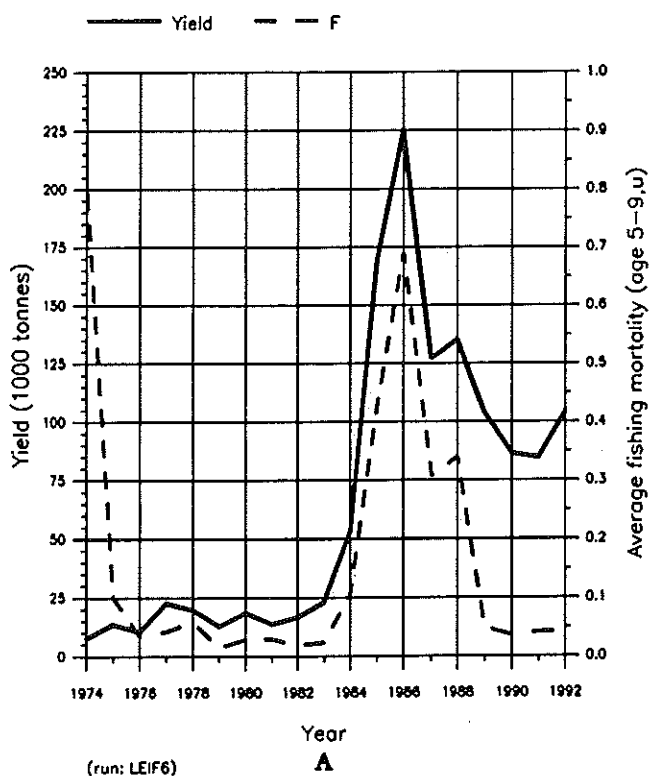


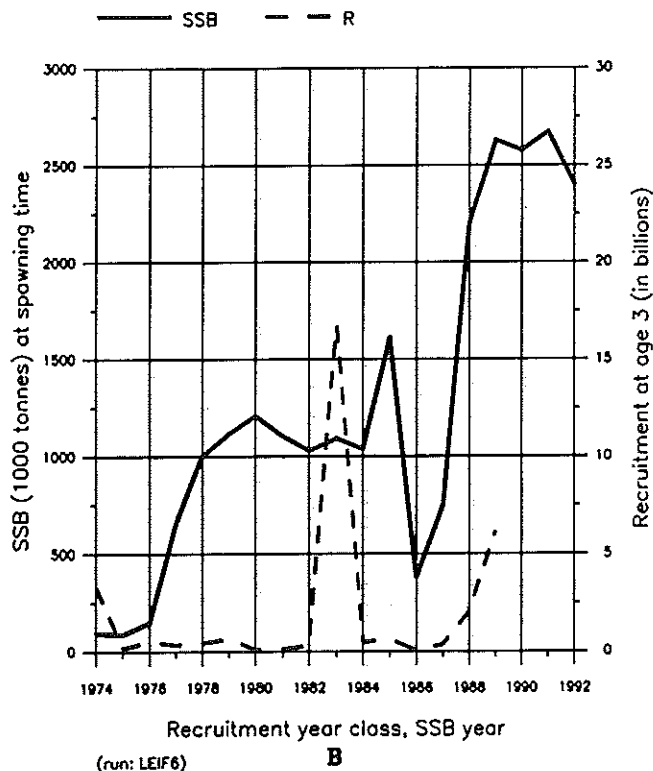
Figure 3.5

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

Trends in yield and fishing mortality (F)

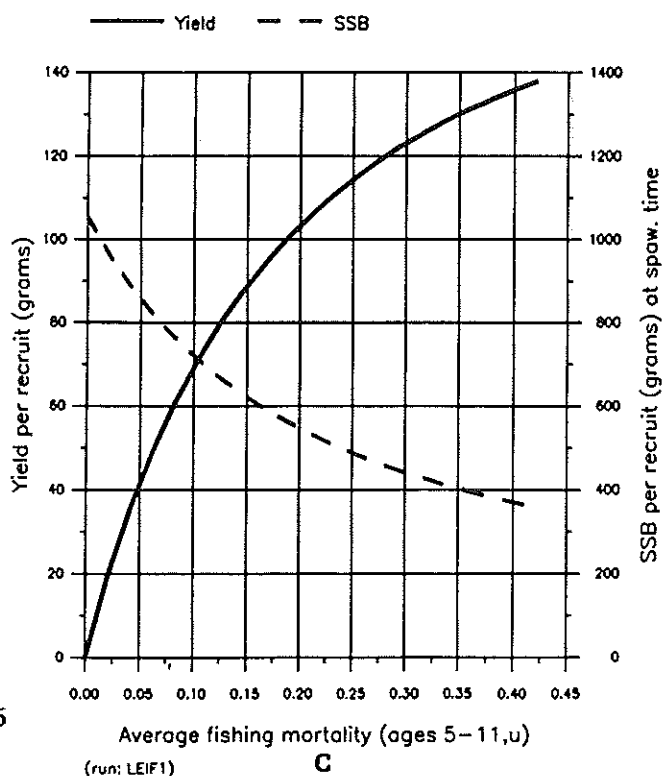


Trends in spawning stock biomass (SSB) and recruitment (R)



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

Long term yield and spawning stock biomass



Short-term yield and spawning stock biomass

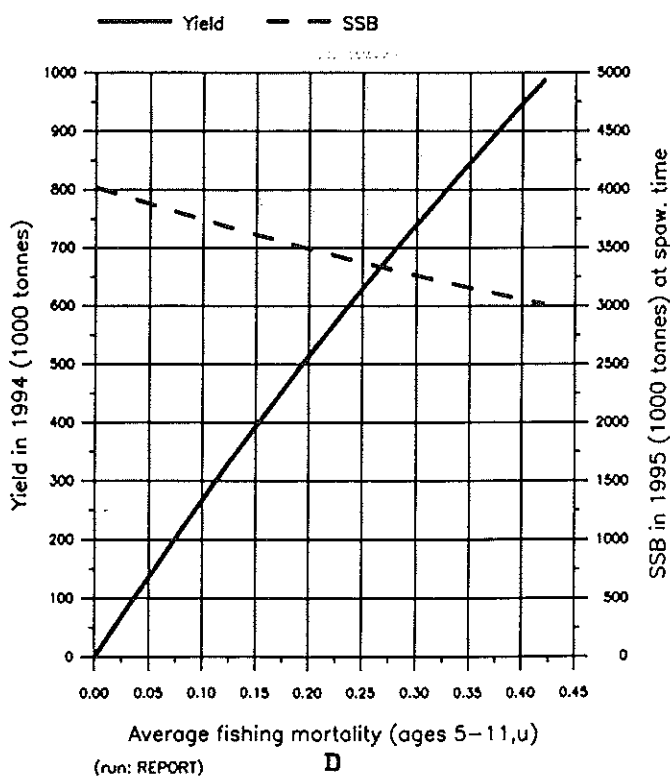
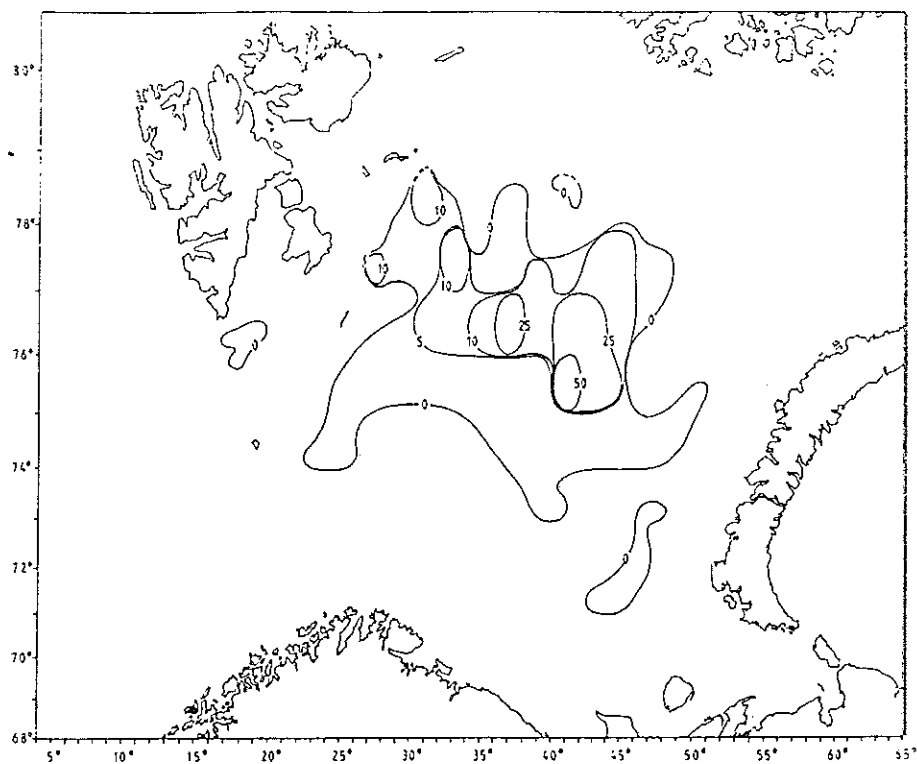


Figure 4.1 Estimated total density distribution of capelin (tons/square nautical mile) in the acoustic survey autumn 1993.



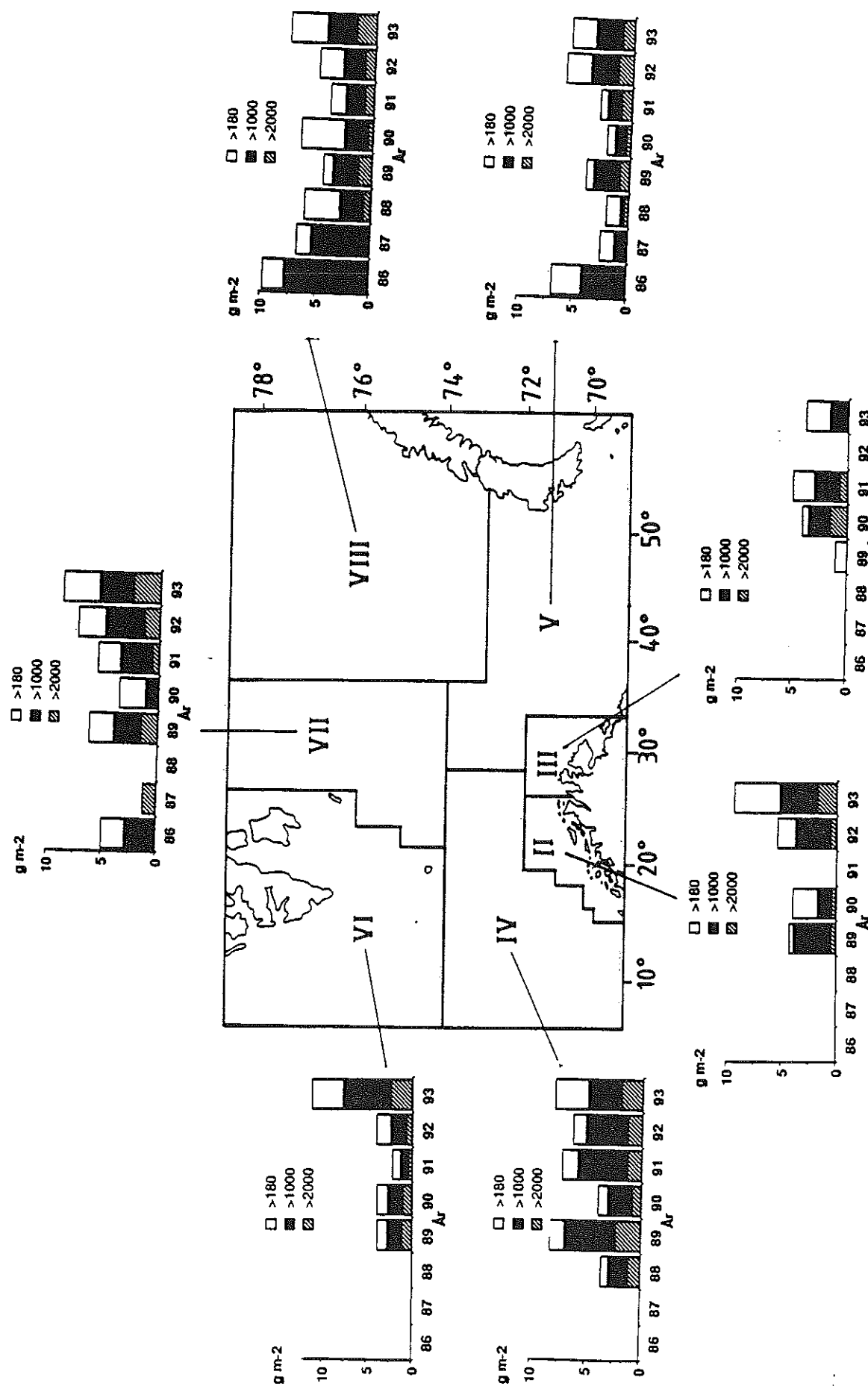


Figure 6.1 Average ash free dry weight (1985-1990) and dry weight (1991-1993, g m⁻², from bottom to surface in Barents Sea multispecies regions. Size fraction >180 and >1000 means 180-1000 and 1000-2000 μm respectively. Data based on WP2 net.

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