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REPORT OF THE ATLANTO-SCANDIAN HERRING AND CAPELIN WORKING GROUP

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CONTENTS

1 INTRODUCTION AND PARTICIPATION

1.1 Terms of Reference

The Atlanto-Scandian Herring and Capelin Working Group (Chairman: Mr H.í. Jakupsstovu, Faroes) met at ICES Headquarters from 19-23 October 1992 (C.Res.1991/2:7:20) with the following terms of reference:

a) assess the status of and provide catch options for 1993 and 1994 within safe biological limits for the Norwegian spring- and Icelandic summer-spawning herring stocks;

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

c) evaluate the expectation of re-building the spawning stock biomass of Norwegian spring-spawning herring to the target level of 2.5 million tonnes and review stock recovery policies in relation to this;

d) assess the status of capelin in Sub-areas V and XIV and provide catch options within safe biological limits for the winter 1992/1993 and summer/autumn 1993 seasons;

e) 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 1992/1993 and summer/autumn 1993 seasons;

f) evaluate differences between capelin stock assessments based on stomach data and acoustic surveys and make recommendations as to how these can be reconciled;

g) review and revise estimates of natural mortality of capelin in Sub-areas I, II (excluding Division IIa west of 5°W), V, and XIV;

h) evaluate the available data from multispecies studies and consider how they can be utilized in the assessments of capelin, herring, and cod stocks, and specify the format of the data required.

Additionally the following questions were considered:

i) Minimum landing size for capelin in an autumn fishery.

Based on a request from the Norwegian Ministry of Fisheries, the Group was asked by the ACFM chairman to "consider the optimum minimum landing size for capelin in an autumn fishery". The ACFM chairman envisages this question to be discussed in the mixed Norwegian-Russian fishery commission in October 1992, but he wants, however, this group to consider the question as well.

ii) The appropriateness of an area and time closure for a fishery on the capelin in the Iceland, East Greenland and Jan Mayen area.

In a Working Document by Hjalmar Vilhjálmsson to ACFM it is proposed that no fishery should take place south of 67°45'N in July-October. As there was no formal evaluation and accompanying analysis ACFM was not in a position to endorse this recommendation. ACFM, however, concluded that the Working Group evaluate this.

iii) The mean weight at age of cod used in the assessment of the amount of capelin set available for predators.

In a letter from Bjarte Bogstad and Harald Gjøsæter, Norway it is pointed out that in the calculations by the Arctic Assessment Working Group, which were used in this assessment in the last report, the average weight at age from the Norwegian and the Russian surveys was used, although there were great differences between the two sets of figures. Using either the Norwegian or the Russian figures alone would yield large deviations of the amount of capelin estimated to be consumed by cod the following year.

1.2 Participation

J. Hamre	Norway
J. Hunt	Canada
H.í. Jakupsstovu (Chairman)	Faroe Islands
J. Jakobsson	Iceland
I. Røttingen	Norway
V.N Shleinik	Russia
G. Stefansson	Iceland
K. Thyholt	Norway
S. Tjelmeland	Norway

2 ICELANDIC SUMMER-SPAWNING HERRING

2.1 The Fishery

The landings of summer spawning herring from 1968-1991 are given in Table 2.1. Until 1990 the herring fishery took place during the last three months of each calender year but in 1991 and 1992 the autumn fishery was continued in January and early February. Therefore, all references to the years 1990 and 1991 refer to the season starting in October of those years. These include estimated 9,200 t of discard for the 1991/1992 season. The fishery took place off the SE coast and 56% of the total catches were used for reduction while 44% were used for human consumption.

Year	Landings	TACs	Recommended TACs[1]
1984	50.3	50.0	50.0
1985	49.1	50.0	50.0
1986	65.5	65.0	65.0
1987	73.0	72.9	70.0
1988	92.8	90.0	100.0
1989	101.0[2]	90.0	90.0
1990/1991	105.6[2]	100.0	90.0
1991/1992	109.5[2]	110.0	79.0

1) Recommended by ACFM
2) Includes discard estimates (3,700 t in 1989, 3,250 t in 1990 and 9,200 t during the 1991/1992 season.

2.2 Catch in Number and Weight at Age

The catches in numbers at age for the Icelandic summer spawners for the period 1972-1991 are given in Table 2.1. As usual, age is given in rings, where the age in years equals the number of rings plus one. In the first years after the fishery was re-opened 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 very 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- to 10-ringed herring. In the period 1989-1991, the 1983 year class was dominating in the catch. The 1988 year class is also well represented in the 1991 catches.

The weights at age for each year are given in Table 2.2. The mean weight at age generally went down during the period from 1972 to about 1980, but has levelled off somewhat since then (Figure 2.1). Maturity at age is given in Table 2.3. These data for 1991 are based on 61 samples distributed throughout the 5 months' season. About 5,940 herring were analyzed in relation to sexual maturity, age, length, and weight.

2.3 Acoustic Surveys

The Icelandic summer-spawning herring stock has been monitored by acoustic surveys annually since 1973. These surveys have been carried on in November-December or January, usually after the fishery has been closed. The results are given in Table 2.4 along with the sum of the 5-ringers and older herring which has been used to calibrate the input F for the VPA. In some years (e.g., 1982) it is clear that the younger year classes have been outside the survey areas. In those cases, average recruitment was used in the assessment.

It should be noted, however, that the large variation observed in the estimates of the juvenile part of the stock have not affected the stock assessment seriously because this stock has been managed at a low rate of exploitation and, therefore, the recruiting year classes are only a small proportion of the fishable stock.

During a survey which took place during the period 3-15 December 1991, an estimate of all the age components of the stock was obtained. The stock was located in three areas off the SE coast of Iceland. Surveys outside these areas gave negative results. Therefore, the results of the December survey are the basis for the present assessment. The results are given in Table 2.5.

2.4 Stock Assessment

The results of the acoustic surveys together with the catch in numbers by age were used to calculate initial mortalities for the 1991/1992 seasons. Results are given in Table 2.5 as F'. In this analysis 6-ringers and older have been grouped for estimating the fishing mortality on the oldest herring. While the fishing mortality for the younger age groups are calculated for each year class. It is noted from the resulting F pattern based on the survey results that the F on 5-ringers is only 70% of the F on the older age groups. This was taken into account when the terminal Fs were fitted.

As in previous years, the estimation procedure of 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 data, rather than untransformed data, since there is increased variability in later years, coinciding with the increase in stock size. This has little effect on the final results (as indicated in the Appendix to *Anon.*, 1991a), but should make associated confidence intervals for the terminal fishing mortality more valid.

A series of VPAs were run using varying terminal Fs on ages 5+. For each terminal F a sum of squares (SSE(F)) of differences between the 5+ from the VPA and the acoustic is computed. A plot of these SSE-values is shown in Figure 2.2. From this series of VPAs it is clear that the best (giving the minimum value for SSE) one to one relation between the acoustic estimates and virtual population analysis was obtained with an input F of about 0.32. This is almost the same as the results from the latest survey results alone because that would give an input F for the 6-ringers and older herring of about 0.33. The confidence interval for the fitted terminal F is (0.19, 0.38). These are obtained as described in 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 (c.f., Figure 2.2).

The fishing mortalities on the 1-4 ringers in 1991, based on the 1991 survey, have been used without modification, since they cannot be estimated from a procedure using only 5+ ringers. This has very little effect on the results, since the survey estimate for the 5+ fishing mortality is 0.33 but the fitted terminal F is 0.316.

Using the catch data given in Table 2.1 and the fitted values of fishing mortalities given in the second last column of Table 2.5, 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 2.6 and 2.7, respectively, and the standard plots are shown in Figure 2.5. The resulting stock trend is plotted in Figure 2.3, and the correspondence with acoustic estimates is shown in Figure 2.4.

According to the current assessment, the spawning stock biomass was 427,000 t at 1 July, 1991, and had decreased by some 11% from its peak value of 478,000 t in 1988. Work is underway to complete a long-term stock assessment for this stock back to 1947.

2.5 Catch and Stock Projections

Catches have been calculated over a range of Fs for 1993 onwards, using the final exploitation pattern given in Table 2.6 as the 1984-1987 average, rescaled to the 1991 level. The 1991 stock in numbers data are given in Table 2.7.

As in previous years, a regression of weight increase has been used to predict the weights 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 1982-1991, except for the year 1985, which was considered an outlier and excluded from the regression. For 1-ringers and 9+ ringers, a simple average of mean weights at age for the period 1982-1991 was used for prediction (1985 excluded).

Weight at age for 2-8 ringers in the catch are thus obtained by using the relation:

$$W_{y+1} - W_y = -0.2428\, W_y + 91.08\ (g)$$

were W_y and W_{y+1} are the mean weight of the same year class in year y and y + 1, respectively. Appendix A describes some tests of this model.

In accordance with an increased level of recruitment during the 1980s (Figure 2.6), a predicted value of 600 million has been used. This indicates a steady-state yield of 87,000 t at $F_{0.1}$.

2.6 Prediction

Projections of spawning stocks biomass and catches ('000 t) for a range of values of Fs in 1993 are given in the management option table (Table 2.9). The predicted catch for 1992/1993 is 120,000 t which is equal to the TAC of 110,000 t plus a 10,000 t discard.

Detailed output for the prediction, assuming catches of fishing at a fishing mortality rate of $F_{0.1}$ = 0.21 are given in Table 2.10. A summary of these is given in Table 2.11. The input data for the yield-per-recruit calculation are given in Table 2.12 and the results in Table 2.13.

2.7 Management Considerations

Continued fishing at $F_{0.1}$ for the next two years corresponds to 112,000 t in 1993 and 117,000 t in 1994 giving an average catch of about 115,000 t in each year. This is a catch of about 25,000 t higher than calculated for fishing at $F_{0.1}$ in the 1991 report. The difference is entirely due to an acoustic estimate of two strong year classes (1988 and 1989) entering the fishery in the coming years.

Fishing at a higher fishing mortality rates which give a correspondingly higher short-term yield (e.g., 150,000 or 200 000 t) would reduce the stock sharply as soon as the effect these strong year classes has dwindled. Therefore, the Working Group stresses that managing this stock at exploitation rate at or near $F_{0.1}$ has been successful in the past and that this policy should be continued. These figures refer to catches including discards, and discard estimated should be subtracted to obtain the final TAC. Discard have been estimated as 4,000 - 9,000 t in the past two years and hence the $F_{0.1}$ catches correspond to a TAC of a little in excess of 100,000 t in terms of landings each year.

The Working Group noted that assessments and prediction for this stock has been stable (see Quality Control Table 2.14) and that it should be sufficient for ICES to give advice every other year, rather than annually.

3 NORWEGIAN SPRING SPAWNING HERRING

3.1 The Fisheries

The Norwegian fishery in 1991 started in the beginning of January in the wintering areas in the fjords in northern Norway. Approximately 14,500 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 on these spawning areas amounted to about 18,000 t. In addition, 850 t were caught on the spawning grounds off Karmøy. The Russian catch on the spawning areas was 11,000 t. The catches in late spring and summer were small, due to lower quality, price and availability of the herring which are distributed in very scattered concentrations in the Norwegian Sea. In September the herring again migrated into the winter areas, and in late autumn about 25,000 t were caught in this area.

So far, the same main features have prevailed in the fishery in 1992. The Norwegian catch by 30 August was 34,550 t. The Russian catch in the spawning period was 13,337 t.

3.2 Catch Statistics

The total annual catches of Norwegian spring-spawning herring during the period 1972-1992 in terms of weight in numbers are presented in Tables 3.1 and 3.2. Increasing awareness among fishermen and controlling authorities has probably reduced the previous problem of additional mortality in the fishery. Therefore, the amount which has been added to the reported catches in 1991 is reduced to 5,000 t compared to 8,000 tonnes in 1990.

3.3 The Adult Stock

3.3.1 Acoustic estimates

Since 1988 acoustic estimates of the adult stock have been made on the spawning grounds in February-March. Unfortunately, due to bad weather, it was not possible to obtain a corresponding estimate in February-March 1992. The text table below, taken from last year's Working Group report, gives the acoustic estimate from the spawning grounds in 1991:

Year class	Estimate (million indiv.)
1982 and older	102
1983	4,148
1984	122
1985	354
1986	12
1987	54
1988	59

However, as described in last year's Working Group report, results from acoustic surveys in the Ofotfjord indicated a larger spawning stock size than obtained from the spawning areas. The survey area was increased in 1992 to include the total wintering area. The text table below gives the results from the survey series in the wintering areas raised by 15% in the Ofotfjord to compensate for sound extinction (Toresen, 1991):

Year class	Ofotfjord (mill. indiv. 1 Jan 1991)	Total wintering area (mill. indiv. 1 Jan 1992)
1982+	440	30
1983	5500	5290
1984	150	140
1985	180	580
1986	20	70
1987	70	290
1988	220	930
1989	90	460

The estimated biomass in the wintering areas by 1 January 1992 was 2.582 million t, of which 1.965 million were located in Ofotfjord and 0.617 million in the neighbouring Tysfjord.

The conditions for acoustic surveying in the wintering areas seem to be very good. The herring are located in sheltered areas which can be surveyed within a very limited time span (approximately 24 hours). This in contrast to surveying on the spawning grounds where it takes several weeks to survey the total distribution area.

During that time interval new batches of herring may arrive to spawn while spent herring are leaving the area. The spawning area is spread over an area from north of Møre to south of Egersund, a distance of about 300 nautical miles. The weather conditions on the spawning grounds makes acoustic surveying impossible over longer or shorter time periods. Altogether, these factors makes it difficult to get a synoptic picture of the distribution of the herring on the spawning grounds.

A possible disadvantage of acoustic surveying in the wintering are the very dense schools of wintering herring. However, new advances in equipment (Simrad EK-500 and BEI-integrator) almost eliminate problems such as instrument saturation from strong reflected signals which was a feature of earlier equipment. Methodology which deals with the problem of the extinction of sound in dense herring concentrations (Toresen, 1991; Foote *et al.*, 1992), makes the acoustic estimates of such distributions more reliable than was the case previously.

The reason for the difference of the estimates may also in part be due to differences in the behaviour of the herring. When the estimates have been made in the wintering area in the January the herring has started on the spawning migration and are probably orientated in a different manner (i.e., the tilt angle distribution and thus the target strength) of the wintering areas compared to the spawning areas. Further, some of the herring recorded on the spawning area will be spawning or spent herring, with other gonad and/or swim bladder characteristics.

The Working Group concluded that the conditions for acoustic surveying are better on the wintering grounds than on the spawning grounds. On the other hand, the Working Group considered the uncertainties in target strength and sound extinction as possible sources of error in acoustic estimates of herring for the following reasons:

- The target strength/length relation which is in present use, TS=20logL-71.9 (Foote, 1987) is based on *in situ* measurements on herring from many geographical locations and during varying conditions. There are indications that the herring may have a higher target strength (for example, Kautsky *et al.*, 1990). If this is the case, an application of the TS/length relation given in Foote (1987) will lead to an overestimate of the herring stock in the wintering area.

- The principles of the methodology to deal with sound extinction has been documented in several papers (Toresen, 1991, Foote *et al.*, 1992). However, it is stated in the latter paper that the goal of further research is: "to get sufficient knowledge about the extinction cross section so that values can be assigned in an algorithm to remove the biasing effect of extinction from conventional echo integration measurements of fish density."

As these uncertainties might work in opposite direction the Working Group concluded that the survey on the wintering area in January 1992 should be the basis for the stock size assessment. Pending further research in these matters the Working Group was of the opinion that at present a correction for the extinction of sound should not be included in the area backscattering cross-section measurements. According to this the estimate of herring at the wintering area is as follows:

Year class	Estimate (million indiv.)
1982 and older	30
1983	4,690
1984	120
1985	510
1986	60
1987	260
1988	820
1989	410

3.3.2 The state of the stock and VPA

The input data in the VPA are as follows:

Total catch:	Table 3.1 (column "Total catch as used by the WG")
Catch in number per year:	Table 3.3
Catch weights at age:	Table 3.6
Weight at age in the stock:	Table 3.7
Proportions of maturity:	Table 3.8
Natural mortality:	0.13 (age 3 and older)

A terminal F for the 1983 year class was found by tuning to the estimate for the same year class from the wintering areas. This gave F=0.043.

The result of the VPA is given in Tables 3.9, 3.10, 3.11 and Figures 3.1A and B.

3.4 Recruitment

3.4.1 Stock estimates of immature herring

The nursery areas of the herring are the Norwegian fjords and coastal areas and the southern part of the Barents Sea. Since 1988, when the 1983 year class spawned for the first time, the latter area has increased in importance as a nursery area for the herring. Data on immature herring are obtained from 3 different investigations 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 3.5A).

3. Acoustic estimates of immature herring in the Barents Sea (Table 3.5B).

According to the acoustic estimates (Table 3.5B) the spawning in 1992 seems to have resulted in a year class of extraordinary strength.

It should be kept in mind that the estimates of the year classes 1989-1992 are made with new equipment (EK 500 echo sounder, BEI echo integrator). As described in the section on acoustic estimation of the adult stock, the new equipment eliminated the problem of instrument saturation when receiving strong signals. The young herring in the Barents sea in spring occurs in small dense schools. Signals from such schools *could* have saturated the equipment which was in use previous to 1990 with a corresponding underestimate as the result. Thus the acoustic estimates made prior to 1990 may not be directly comparable to the estimates made after that year.

3.4.2 Natural mortality of immature herring

Comparison of acoustic estimates for year classes 1983-1985 and 1988 (Table 3.5B), and the same year classes as 3 year old (VPA), gives the following annual M-values:

Year class	Acoustic estimate (mill. ind)	Estimate (mill. ind) VPA (3 years)	Duration between estimates (months)	Natural mortality
1983	25822	13477	18	0.43
	19900	13477	6	0.70
1984	3800	454	26	0.98
1985	20800	648	27	1.54
	2700	648	25	0.68
1988	4900	822	22	0.97

Average annual M = 0.88

In the first estimate of the 1983 year class (25822 mill ind) the 0-group estimate from the fjords (Table 3.4) is adjusted by the estimated average (M=0.88) to correspond to 1 June 1984 and added to the estimate of the year class in the Barents Sea (Table 3.5B).

An annual natural mortality for herring up to age 3 of 0.9 was used in the prognosis. This is the same value as used in the previous Working Group reports.

The natural mortality of the immature herring will in the period 1992-1996 depend on the situation in the nursery areas in the Barents Sea. The prognosis of the Northeast Arctic cod indicate a growing stock of young cod. Further, the year class strength of capelin show a decreasing trend since 1990, and especially the 1992 year class of capelin seem to be very weak (Section 4.3.1). This indicates that the natural mortality of the young herring may increase in the coming years. The stock situation for the young herring in the Barents Sea in the coming years should be investigated thoroughly to detect possible changes in mortality.

3.5 Catch and Stock Prognosis

The following estimates of year class strength (at 1 January 1992) of the immature herring were used as a basis for the prognosis:

1989 year class: The estimate from 1 June 1992 of 3-year old herring (Table 3.5B) has been raised by natural mortality of M=0.13, for 5 months to give the estimate of the component in the Barents Sea at 1 January 1992. In addition, some herring of this year class were present in the wintering areas in January 1992 (text table). This gives a total of 6,234 million individuals.

1990 year class: The estimate from 1 June 1992, raised by natural mortality of M=0.9 for 5 months is used as basis. By June most of the herring which were distributed in the fjords during their first winter have probably migrated to the Barents Sea, therefore no addition has been made for a costal component. This gives an estimate of 20260 million individuals.

1991 year class: The estimate from the Barents Sea from 1 June 1992, raised by natural mortality of M=0.9 for 5 months is used as a basis. In addition, the herring of this year class which spent the winter in the fjord areas in winter 1991/92 (Table 3.4) have been added. This gives a total of 50260 million individuals.

No development trends in weight in catch and weight in stock have been detected in the later years. Therefore an average for the last five years has been used in the prognosis. Further, a maturation ogive similar to the 1983 year class has been used in the prognosis. The input data to the prognosis is shown i Table 3.12.

3.5.1 Results of the stock prognosis

Table 3.13 and Figure 3.1D give the effects of different levels of fishing mortality in 1993 on catch, stock biomass and spawning stock biomass. The assessment shows that with an assumed catch of about 100,000 t in 1992 the spawning stock will increase to about 2.1 million t in 1993. If no fishery takes place in 1993 the spawning stock in 1994 will increase to just above 3 million t. If the present exploitation rate of F=0.05, giving a catch of about 125,000 t is continued in 1993, the resulting spawning stock biomass in 1994 will be 2.9 million tonnes. An increase in the exploitation rate to F=0.1 in 1993, will reduce the spawning stock in 1994 to 2.8 million t.

3.6 Stock Recovery Policies and Management Considerations

In 1979, ACFM requested the Working Group to consider the optimal range of spawning size for the Norwegian spring spawning herring. The Working Group noted that this had been estimated by Dragesund *et al.* (1980), which found that the recruitment was drastically reduced at spawning stock sizes below 2.5 million t. The Working Group agreed that it should be the aim to rebuild the stock to at least this order of abundance. The Working Group also considered the requirements in terms of spawning stock size which should be met before a directed fishery could be recommended, and agreed that a substantial increase in the spawning stock must be registered before a directed fishery could be recommended and that such a fishery should only be a fraction of that increase.

ACFM agreed to this general policy for rebuilding the stock and stressed that a substantial increase in the spawning stock as well as a much higher level of recruitment should be confirmed before even a limited fishery could be recommended. Care should then be taken that such a fishery only generates a very low fishing mortality, less than $F_{0.1}$, and that it does not appreciably delay further rebuilding of the stock. In light of the state of the stock and stock development, ACFM recommended that there should be no directed herring fishery in 1979-1980, and repeated this advice in 1980 to 1982.

The spawning stock increased gradually from a level of 100,000 t in the middle of the 1970s to about 500,000 t in 1983. The 1983 year class was much stronger than the previous ones since 1970. In view of this rebuilding of the stock and the anticipated continuation of stock increase due to the 1983 year class, ACFM recommended a cautious re-opening of the fishery in 1984 at a level of fishing mortality of $F = 0.05$. This level of F has been the guideline in the TAC assessment in later years.

The history shows that the recruitment to the herring stock is variable in strength and that strong year classes occur at time intervals of some 8 to 10 years (Marti and Fedorov, 1963), and is probably linked to increased inflow of warm Atlantic water into the Norwegian Sea - Barents Sea region. The current transports the herring fry northward and most of the strong year classes of herring will spend their first years of life in the southern parts of the Barents Sea. Here the juvenile herring is exposed to predation by the Northeast Arctic cod which has a similar recruitment pattern (Sætersdal and Loeng, 1984). The 1983-1985 year classes of herring and cod were recruited under such favourable recruitment conditions, but the herring year classes were considerably reduced by predation of cod in the Barents Sea, especially the year classes 1984-1985, which were depleted as juveniles (Mehl, 1987). In the period 1986-1990, the recruitment has been low and there has been no substantial growth in the spawning stock since the 1983 year class was recruited in 1988. At present, the spawning stock biomass is estimated to be at a level of 2 million t compared to an adult herring stock of 10 million t in the middle of the 1950s (Figure 3.1B).

The collapse of the Norwegian spring-spawning herring stock in the late 1960s was by far the largest loss of fishable biomass recorded in the North Atlantic. In addition, the lack of juvenile herring was probably the main reason for the starvation of fish and other predators in the Barents Sea in the middle of the 1980s (Hamre, 1988). The recovery policies and future management of the herring should, therefore, have two main aims, (a) to rebuild the adult stock in the Norwegian Sea to a stock level at which MSY can be expected and (b) to rebuild the spawning stock biomass to a level which is sufficiently high to secure recruitment and to feed the young cod and other predators in the area.

The assessment of the sustainable yield of the adult stock indicate that the yield approaches the MSY-level when the equilibrium state of the stock is above 6 million tonnes (Hamre, 1986).

The 1992 acoustic estimate of 0-group herring in the Barents Sea is in an order of magnitude of 300 billion individuals and the parent stock is some 2 million t. Compared to the estimated 0-group stock in 1950, the recruitment figure in 1992 indicates that the optimal biomass production of juveniles may be achieved at a lower spawning stock level than the MSY of the adults. There are, however, large sources of error in the acoustic estimates of 0-group herring which make it difficult to use the data for any firm conclusion in this respect. The predation pressure on herring in the Barents Sea is more over expected to increase considerably in the coming years due to an anticipated large growth in the stock of young cod and a possible new collapse of the capelin stock due to recruitment failure. According to Table 3.13 the spawning stock will be at a level of above 2.5 million t in 1994. However, the exploitation rate of the herring should not be increased above the present level before the recruitment to the spawning stock of the year classes 1989 and 1990 is confirmed. The fishing mortality could then, assuming the spawning stock is above 2.5 million tonnes,be increased gradually to reach $F_{0.1}$ when the stock approaches the MSY-level of about 6 million tonnes.

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

Until 1988, the herring spawned along the Norwegian coast from Stadt (approximately 62°N) and northwards to Lofoten. Since 1989, the herring has spawned at Karma (approximately 59°N), and in 1992, spawning herring of the 1983 year class were recorded at Egersund south of Stavanger and at Siragrunnen (58°15'N, 06°15'E), approximately 25 nautical miles from Lindesnes, the southernmost point of Norway. Thus, the later years have seen a southward extension of the spawning fields (Røttingen, 1992).

The adult herring at present have their feeding areas in the Norwegian Sea. A pair-trawl survey was carried out in the Norwegian Sea during August 1991, and herring was found over a wide area westwards to 6°W and northwards to 73°N (Holst and Iversen, 1992). Russian investigations in June-July 1992 confirmed that the herring were distributed over wide areas in the Norwegian Sea in summer.

Since 1986/1987, the herring has wintered in the Vestfjord and its tributary fjords in northern Norway. In 1987/1988, the herring wintered in several fjords between 67°N and 69°N, by 1991/1992 the wintering area was restricted to Ofotfjord and Tysfjord.

In the beginning of January the herring start the spawning migration from the wintering areas to spawning grounds on the Norwegian coast. A survey conducted in January-February 1990 showed that the migration routes were close to the shore. There has not been any records, neither from surveys nor fisheries, of herring migrating on the outer coastal banks or in open sea in January-February.

The most important nursery ground in 1988-1992 has been the Barents Sea. The present general distribution pattern for the Norwegian spring spawning herring is given in Figure 3.2.

3.8 *Ichthyophonus hoferi* Disease in Herring

Infection of the herring in the North-East Atlantic area was discovered during a survey in the Norwegian Sea in summer 1991. The disease has since been found in both North Sea and Baltic stocks. As yet, there have been no reported incidence of the disease in Icelandic herring. A diagnostic standard for epidemiologic studies were agreed upon at a special meeting in Lysekil in November 1991, using lesions in the heart as the main criterium. Based on pathological-anatomical evidence, the disease is believed to be near 100% lethal for herring. Precise data on the time course of the disease, which is necessary to estimate the mortality from population prevalence, are lacking, and experiments in that direction were recommended. The problem of *I. hoferi* disease in herring was again addressed by the Working Group on Pathology and Diseases of Marine Organisms in March 1992. But since data on the time course of the disease were still lacking, and since it was realized that different gears sample the diseased herring differently, this Working Group refrained from drawing conclusions on the impact of the disease on the population dynamics of the stocks.

During the January 1992 acoustic survey, herring samples were also collected and examined for evidence of *I. hoferi*. Initial samples taken from the upper layer of herring schools had an incidence of 1-24%. However, latter samples taken from oblique tows made through the entire school had only 1-2% occurrence. Samples taken in the Ofotfjorden after the majority of mature fish had left had a very high incidence at 80%. The Working Group concludes that only the sample taken from oblique tows is representative of the population rate of infestation. The other two samples may be biased by segregation of infested fish from the population, either vertically in case of schools or spatially in case of migration out of the fjords. Additional work was carried out between February and July 1992 in the Norwegian Sea and Barents sea on adult and juvenile herring. Approximately 1.5 thousand fish have been examined. There was no evidence of spores in February samples of spawning fish. Infestation was 100% in post-spawning herring taken in March from Halten Bank and a substantial number of samples were infested from June-July samples. The Working Group concludes from these analyses that infestation has mainly been confined to adult herring. However, in a survey in November 1991, the disease was also noted in 0-group herring in several of the fjords in Northern Norway. The Working Group encourages the continuation of studies to further define the extent and nature of infestations.

Acoustic estimates of Norwegian spring spawning herring in the wintering area do not indicate any substantial increase in mortality. During the survey on the wintering grounds in 1992, it was observed that within the dense concentrations of herring, which represent the major part of the herring in the area, the prevalence of the disease was in the order of 1-2%. Assuming a duration of the disease of 3-6 months, this corresponds to an annual mortality in the order of 0.02-0.08.

4 BARENTS SEA CAPELIN

4.1 Regulation of the Barents Sea Capelin Fishery

Since 1979, the Barents Sea capelin fishery has been regulated by a bilateral fishery management agreement between the USSR 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.

4.2 Catch Statistics

The international catch by country and season in the years 1965-1992 is given in Table 4.1. Statistics for the autumn season 1991 and the winter season 1992 are given in Tables 4.2 and 4.3, respectively. This year, the statistics are given in a more detailed form than previously, the number of individuals in the landings is distributed both on length and age. The TAC for the winter fishery 1991 was 850,000 t, and the total landings were 687,000 t. For the autumn fishery 1991, a TAC of 250,000 t was set, but only 226,000 t were landed. In winter 1992, 862,000 t were landed, while the TAC was set to 834,000 t + the amount of the autumn TAC which was not taken.

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 are shown in Table 4.4. The index in 1992 equals that of 1989, and shows that the larval production in 1992 was sufficient for a rich year class to emerge.

During the international 0-group survey in the Barents Sea in August 1992, practically no 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). Consequently, the recruitment from the 1992 year class seems to have failed.

4.3.2 Acoustic stock estimates

The 1992 acoustic survey was carried out jointly by two Russian and three Norwegian vessels in the period 10 September to 6 October. The distribution of capelin is shown in Figure 4.1. Table 4.5 gives the estimate as numbers by age and length, and the biomass at age. The results are summarized in the text table below (the estimates of the same age groups in 1991 are shown in brackets).

Year class		Age	Number (10^9)		Mean weight (g)		Biomass (10^3 t)	
1991	(1990)	1	351.3	(392.0)	3.6	(3.7)	1249.1	(1459.1)
1990	(1989)	2	196.3	(574.4)	8.6	(8.7)	1690.6	(4969.7)
1989	(1988)	3	128.8	(32.7)	16.9	(19.3)	2171.7	(630.9)
1988	(1987)	4	1.3	(1.2)	29.5	(30.1)	39.0	(35.9)
Total stock								
1992	(1991)	1-4	677.7	(1,003.3)	7.6	(7.1)	5,150.4	(7,095.6)

According to this estimate, the 1991 year class (1-group) is almost as abundant as the 1990 year class was at this stage. The mean weight is 3.6 g this year, (3.7 in 1991). The biomass of the 1-year-olds is about 15% lower than that of this age group last year.

The estimated number of fish in the 1990 year class (2-group) is only 196 billion individuals, as opposed to 575 billion in the 1989 year class measured last year. The mean weight of this age group is equal to last year; 8.6 g (8.7 g in 1991), and consequently the biomass of 2-year-old fish is only 1.7 million t, 34% of that of the 1989 year class at this stage. The mean weight of 8.6 g is lower than that in the 1970s, at the level of that measured in the period 1980-1985, but only 67% of that in the period 1986-1990.

The 1989 year class is estimated at approximately 129 billion individuals with a mean weight of 16.9 g, giving a biomass of 2.2 million t. This is by number approximately 4 times the size of this age group measured last year, and the most numerous year class at the 3-year-stage measured since the 1977 year class in 1980. The mean weight is low compared to the latest years, but equals the long-term mean. Although the 1989 year class is still a very strong year class, it has been considerably reduced from last year, see comments on mortality below.

Due to a weak 1988 year class, only a small amount of 4-year-old fish was detected, their number and biomass qual those for this age group measured last year.

The total stock size estimate of 5.2 million t is almost 2 million t less than that obtained last year. It is, however, the second largest estimate since 1981. It is also at the level of the mean stock size during the 1970s.

The biomass of fish larger than 14 cm, which is probably the part of the stock which is estimated to be the part of the stock which will spawn in 1993, is at present about 2.2 million t, and at the same level as in 1991. About 80% of this biomass stems from the 1989 year class.

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

Year: Year class:	83-84 1982	84-85 1983	85-86 1984	86-87 1985	87-88 1986	88-89 1987	89-90 1988	90-91 1989	91-92 1990
Age 1, Nos (10^9)	515.1	145.4	35.1	7.5	37.3	20.0	177.9	700.0	392.0
Age 2, Nos (10^9)	183.9	47.3	3.4	1.5	28.8	17.8	177.5	574.4	196.3
Total mortality (%)	64	68	90	80	33	12	.2	18	50

As there has been practically no fishing on these age groups, the figures for total mortality constitutes natural mortality only. In spite of the uncertainties in these values (illustrated by the low value for the 1988 year class) this probably reflects quite well the trend in predation on capelin. As can be seen from the table, the mortality increased up to 1985-1986, but then a substantial decrease occurred in 1987-1989, probably caused by a diminished predation pressure from cod. In 1990-1991 the mortality increases again, and it is almost 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 1973-1992 are shown in Table 4.6. The stock numbers are the survey results, i.e., by 1 October, with the following exceptions: The 1-year-olds were not properly covered during the surveys prior to 1982, and the numbers are, therefore, back-calculated from the number of 2-year-olds in the survey the following year. In this back-calculation, a mortality equal to that measured from age 2-3 the same year were used. In 1982, the autumn survey for unknown reasons gave highly improbable results. The number of fish in the various age groups this year were, therefore, back-calculated from the results in 1983. The stock biomasses given in the table are the survey results by 1 October, but for the years in which were the number of fish in one or more age groups were adjusted, the biomasses were adjusted accordingly, using the observed mean weights per age group. The biomass of the mature stock is taken to be the weight of all individuals above 14 cm length.

Some years, a fishery in September removed a quantity of fish prior to the survey. It is, however, difficult to compensate for this in Table 4.6, because the fishery and the acoustic coverage of the stock took place concurrently.

4.4 Management Considerations

In managing the Barents Sea fishery one of the main goals has been to allow a minimum target spawning stock biomass to spawn. In the period 1970-1982, this was set at 500,000 t and later at 400,000 t based on an analysis of 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 cod recruitment. Following the very good year classes of cod and herring in 1982-1985, the capelin recruitment failed completely in 1984 and 1985. In 1992 large quantities of young herring and cod were found in the Barents Sea coinciding with recruitment failure of capelin in that year. The situation may remain for at least 2 years. The prospects for capelin recruitment in 1993 may, therefore, be poor. In spite of this, the Working Group is of the opinion that a target spawning stock should be set at a relatively high level also in 1993. A large spawning stock may lead to a prolonged spawning period and utilization of a larger area for spawning which, in turn, may increase the probability that at least some components of the larvae will escape predators and survive.

4.4.1 TAC options for the winter fishery 1993

One of the most important questions in a TAC recommendation for the winter fishery in 1993 is assessing the consumption by the cod in the period from the autumn survey in 1992 to spawning in 1993. The consumption is affected by a number of factors that are difficult to predict. The Working Group was not able to select one combination of factors as the most likely and hence evaluated the catch/spawning stock options using the 9 most likely combinations. The considerations made are described in more detail in Appendix C. The resulting minimum and maximum spawning stock for TACs of 0, 300,000, 400,000, 500,000 and 600,000 t are given in the text table below.

Catch ('000 t)	Min. spawning stock ('000 t)	Max. spawning stock ('000 t)
0	1,032	1,297
300	753	1,057
400	660	964
500	567	870
600	474	777

The Working Group was seriously concerned about the uncertainties associated with cod mean weight at age (*Anon.*, 1993) and the implication for the above capelin SSB estimates derived from the consumption model (see Appendix C and Section 6).

4.4.2 TAC options for an autumn fishery 1993

The Working Group discussed the question of a summer-autumn fishery for capelin in the Barents Sea last year (*Anon.*, 1991b) and is still of the opinion that in general the Group is reluctant to recommend any summer-autumn fishery to take place irrespective of the stock situation.

The situation in the capelin stock is now one with serious danger of one or more years of recruitment failure. Additionally, the number of immature cod will continue to increase also next year, leading to high mortality on all age groups of capelin. In this situation, it is important for the preservation of the stock not to exploit immature fish, and any fishing should be restricted to the winter period. It is, therefore, strongly recommended not to allow a summer-autumn fishery in 1993.

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

5.1 Catch Regulations

The capelin comprising this stock are very short-lived and die upon spawning. The fishery depends for the most part upon maturing capelin, i.e., that part of each year class which spawns at age 3 as well as those fish, belonging to the next year class before, which did not reach maturity until in their 3rd year to spawn at age 4. The size of the immature 1- and 2-group 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) based on the results of surveys of the abundance of immature 1- (and 2-) group capelin carried out in August in the preceding year or January in the current year.

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

A summary of the above procedure and its consequences during the 1983/1984-1991/1992 seasons is given in Table 5.1.

5.2 Stock Prognosis, Assessments and Catch in the 1991/1992 Season

The total annual catches of capelin in the Iceland-East Greenland-Jan Mayen area by years and seasons are shown in Table 5.2.

Calculations of expected TACs for the 1989/1990 and 1990/1991 seasons gave very misleading results in comparison to TACs calculated from in-season surveys of fishable stock abundance. Since all evidence pointed to a relatively low abundance of the recruiting 1989 year class, it was recommended that the season should not be opened until after the result of surveys of actual fishable stock abundance had become available.

This advice was accepted by the authorities concerned and the season was not opened until after a survey, carried out in the first 3 weeks of October 1991. This survey gave an estimate of fishable stock abundance of 650,000 t. However, external surveying conditions and fish behaviour were not considered favourable in October and the survey was thought to have underestimated the fishable stock. Another survey was, therefore, carried out in November 1991. This latter survey yielded an estimate of total fishable stock abundance of 935,000 t. On the basis of this stock estimate a catch quota of 440,000 t was set for the 1991/1992 season, pending further surveying in early 1992.

In January 1992 the fishable stock was estimated to be 1,079,000 t. The TAC for all of the 1991/1992 season was subsequently set at 740,000 t, with the usual criteria of a monthly natural mortality rate of 0.035 and a remaining spawning stock of 400,000 t. This survey was more detailed than on previous occasions, carried out under good conditions with regard to weather and fish behaviour and, therefore, considered the most reliable of the three in-season estimates.

Due to area closures because of high concentrations of juvenile capelin in most of the distribution area of the adult stock in November and December 1991, and the generally scattered distribution of the capelin at that time as well as in January 1992, catch rates remained low throughout this period. In spite of the fact that catch rates improved greatly as soon as the spawning migraters arrived at SE-Iceland and remained high from then onwards this, however, resulted in part of the allocated catch quota not being fished. The total capelin catch during the 1991/1992 season amounted to only 677,000 t, the fishery thus leaving a residual spawning stock biomass of about 475,000 t.

5.3 New Method of Stock Prognoses

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

Available data include the survey estimates of the different age groups in August, October and January, where the August survey results have been found to be unreliable. Further, back-calculations can be used retrospectively to obtain more reliable estimates of the abundance of each year class.

The maturing part of the 3-group in fall 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 in the fall before are gross underestimates and will, therefore, not be used. Similarly, the January estimate of this year class only estimates the part which will spawn and thus is no indication of what will appear in fall. It is found, however, that maturity at age 2 is inversely related to abundance, hence the total abundance of the 2-group in fall is an indication of what will appear as the 3-group in the following fall. A regression relating the two back-calculated abundances of each year class as 2- and 3-year-olds results in an R2 value of 0.87 (P = 0.001).

The maturing part of the 2-group in fall (N2) is a part of the survivors of the 1-group in the previous fall (N1), which is measured in October. Regressing the back-calculated 2-group abundance against the 1-group acoustic estimates gives an R2 value of 0.88 (P = 0.002). This regression can now be used for predicting the abundance of mature 2-group in fall.

Year	Age 1 Acoustics N1	Age 2 Back-cal. mature N2	Age 2 Acoustics Total N2 tot.	Age 2 Back-cal. Total (N2 tot.)	Age 3 Back-cal. Mature N3
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	81.8	27.0
1983	73.8	64.6	12.6	164.7	65.8
1984	33.8	35.7	1.4	66.3	20.1
1985	58.6	65.4	5.4	102.5	24.4
1986	70.2	70.3	6.7	94.3	15.8
1987	43.9	42.8	1.8	51.2	6.8
1988	29.2	31.9	1.3	42.0	6.6
1989	39.2		5.2	74.3	
1990	60.0				

Details of the method are given in Appendix B.

5.4 Stock Prognosis and TAC for the 1992/1993 Season

The November 1991 survey gave an estimate of 60.0 billion capelin belonging to the 1990 year class and 5.2 billion of immature capelin belonging to the 1989 year class. A later survey, carried out in January 1992 gave an estimate of 53.3 billion mature capelin belonging to the 1990 year class. This, together with the immature component, estimated in November 1991 corresponds to a year class abundance of 74.3 billion 2-group capelin on 1 August 1991 when adjusted for catches and natural mortality.

The November 1991 estimate of the 1990 year class and the back-calculated estimate of the 1989 year class were used to forecast the abundance of maturing capelin of these year classes by number and weight on 1 August 1992, using the prediction model described above. The fishable stock biomass, estimated in this way, was then projected forward to spawning time in March 1993 with the usual prerequisites of a monthly mortality rate of 0.035 and a remaining spawning stock of 400,000 t. This calculation gave a predicted TAC of 810,000 t if spread evenly over the time period August 1992 - March 1993.

Although the new prediction model predicts roughly the same TAC or slightly lower than that finally recommended from acoustic assessments of fishable stock abundance in late autumn and/or winter, the series includes the notable exception of the 1989/1990 season. In this case the prediction proved to be optimistic by about one third. In view of this, as well as the short time series, it was recommended that a precautionary TAC for the 1992/1993 season should not exceed 500,000 t and 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 1992 and/or January 1993.

The first of the two planned in-season abundance assessment surveys is scheduled for the period 12-30 October 1992 and consequently there is as yet no available information for reconsidering the TAC for the 1992/1993 season. However, a survey of the area south of 68°N, carried out in August-September 1992, yielded an estimate of about 1.2 million tons of maturing capelin in that area. These survey results are not considered accurate, both because only part of the known distribution area of the adult stock was covered and due to the general tendency to underestimate adult capelin abundance in the summer. But for the same reasons the August survey indicates that the present fishable stock abundance is not below the predicted value.

In the period July-October 1992 the total capelin catch in the Iceland-East Greenland-Jan Mayen area amounted to about 155,000 t, about 2/3 of which had been taken in the Iceland Sea north of 68°N. Of this total catch, Iceland, Norway and Greenland (Faroes) took about 76,000 t, 47,000 t and 41,000 t, respectively.

5.5 Stock Abundance and TAC in the 1993-1994 Season

The main component of the fishable stock in the 1993/1994 season will be the 1991 year class. The 1991 0-group capelin index is one of the highest on record in the last 15 years (Table 5.3).

The August 1992 survey yielded an estimate of 86.6 billion capelin belonging to the 1991 year class, which in all probability is an underestimate due to trawl selection and the high abundance of older capelin in the distribution area of the 1-group juveniles at the time when the estimate was obtained. Estimates of the abundance of 1-group capelin in August 1982-1992 are given in Table 5.4.

Although the available evidence thus points to a rich 1991 year class, neither of these data is suitable for "reliable" predictions of stock abundance. The information necessary for predicting fishable stock abundance in the 1993/1994 season, using the method described in Section 5.3 and Appendix B, will not become available until after both the autumn 1992 survey and the winter 1992 survey have been completed. Advice on a preliminary TAC for the 1993/1994 season should, therefore, be postponed until the results of the above surveys have become available in late February or March 1993.

5.6 Closed Areas During the Summer-autumn Season

In the period July-October the capelin fishery has "traditionally" been conducted on that part of the stock which has migrated north to feed in the area between Greenland and Jan Mayen. These migrations consist almost exclusively of adult fish and this type of summer/autumn fishery has not taken juveniles. In 1988 the adult stock did not migrate to feed in this area but stayed in the region of the Iceland-Greenland Channel, south of Scoresby Sound until returning to the Icelandic area in November.

In the years 1989-1991 practically no capelin seem to have migrated to feed in the central and northern Iceland Sea. Instead the adult stock apparently stayed in or near the shelf area north of Iceland, feeding there together with the immatures. The same has in part been the case in 1992. In these years the summer fishery, and in fact the autumn fishery also, has been dependent upon mixed concentrations of adult and juvenile capelin. Although catches have mostly consisted of adult capelin by weight, there have been occasions when considerable parts of the catch by number have been juvenile fish. Furthermore, such fishery inevitably results in repeated escape of 1-group fish, which are generally not retained by the mesh used in capelin seines. While there are no measurements of mortalities caused by escapement it is likely that fishing for prolonged periods on such mixed concentrations can cause mass mortality of 1-group capelin which goes unnoticed.

Through acoustic surveying it is known that the main distribution area of juvenile 1-group capelin is usually in the shelf area north and northeast of Iceland. The distribution maps of this stock component based on the August-September surveys are shown in Figure 5.1. It seems advisable that in each season the boxed areas should remain closed to a commercial fishery, at least until surveying in August and/or October-November has identified the current situation, and the possible need for amendment of the boxes.

6 SIZE LIMITS FOR CAPELIN

In the summer-autumn fishery a minimum landing size of 11 cm has been enforced for several years with the aim of protecting the 1-year-old capelin.

The Working Group reviewed the request from ACFM for a recommended "optimum size limit" for capelin. It was agreed that such a limit would have application only when fisheries were active in areas of juvenile aggregations which have both temporal and spatial aspects. The Working Group also felt that the concept of "optimum" had to be placed in context and depending on context different factors would be relevant. For example, in the context of optimizing yield, factors influencing yield per recruit such as annual variability in maturation rates at age/length and loss in yield due to post-spawning mortality would have to be taken into consideration. This annual variation would result in year-specific optimum size limits. Conversely, in the context of minimizing exploitation, factors such as by-catch, mesh size, discards and segregation by size or maturity would have to be applied. It was concluded that the two aspects of optimization would not lead to the same estimate of optimum size limit. Evidence presented to the Working Group for the Icelandic capelin stock suggested that juvenile capelin were spatially segregated from adults during most of the year and that a closed area would reduce exploitation. For the Barents Sea capelin the catch of juveniles is limited to the autumn season and, therefore, a reduction of catches in this season would result in effective reduction in exploitation.

The Working Group concluded that it would be inappropriate to recommend or define an optimum size limit and that spatial or temporal reductions in exploitation of juvenile capelin would be more effective.

7 MULTISPECIES CONSIDERATIONS

7.1 Comparing Estimates of Capelin Abundance

7.1.1 Background

Capelin abundance is estimated from acoustic surveys in both regions. Analyses of cod stomach contents may indicate that consumption of capelin by cod is more than can be explained by the acoustic surveys (Magnússon and Pálsson, 1991).

In particular, there is currently a major difference in perceived natural mortality in the Icelandic region based on the two data sources, although this does not seem to be the case in the Barents Sea.

Clearly there is a need to reconcile the differences. Potential reasons for the differences include:

1) Errors in the TS value used in the acoustic survey and problems with the sound extinction can directly affect the acoustic estimate.

2) Incomplete coverage of the capelin stock or bad weather during the acoustic survey will lead to an underestimate of the biomass.

3) The potential exists for dispersed capelin or schools close to the bottom being missed by the acoustic survey.

4) Improper time and area coverage of stomach samples may lead to erroneous consumption estimates.

5) Cod stock biomass estimates are uncertain and the uncertainties directly affect the consumption estimates.

6) Several other model assumptions influence the consumption estimates. Different evacuation rate models can give considerably different estimates of consumption.

7.1.2 Consistency of Acoustic estimates

A working paper by Vilhjálmsson (WP 8) provided data on Icelandic acoustic surveys performed in October/November and January. These 11 pairs of estimates (Table 6.1) generally show consistency, except for 3 years where the autumn estimate is considerably lower than the winter estimate. In all 3 cases there had been notes in the fall survey reports that these years were unusual in some respects. The estimated CV based on the full data set is 13%, whereas it is about 3% when the 3 anomalous years are dropped (these 3 years are outliers when considered from a pure statistical viewpoint).

A likely interpretation of these results is that Icelandic winter measurements are quite accurate and the fall estimates are usually consistent with the later survey. In some instances, however, the fall survey provides underestimates.

It is highly unlikely that dispersed capelin is a major factor in terms of the acoustic survey becoming an underestimate. This view is based on information on the likely magnitude of this effect, given the strength of such acoustic signals and the corresponding area. It is unclear whether near-bottom capelin can be a serious source of bias on the acoustic abundance estimate.

7.1.3 Spatial distribution of cod consumption

Working paper 9 provided some information on the spatial distribution of cod consumption of capelin in October/November (Figure 6.1) and in March (Figure 6.2) in Icelandic waters.

From this figure it is evident that the consumption in March is heaviest off northwestern Iceland. The capelin in this area in March usually consist of post-spawners, which have arrived at these grounds by a clockwise migration around Iceland.

It follows that it is impossible to relate the consumption in March to consumption in earlier months by any simple interpolation, without further information on feeding and spatial distribution of both stocks in the previous months.

In particular, a consumption estimate of 100,000 t of capelin by cod in Icelandic waters in March is not inconsistent with the acoustic survey, if most of this consumption is based on post-spawners, as the post-spawners are usually about 400,000 t each year, according to the acoustic surveys.

From this it is clear that inclusion of spatial and temporal effects in the analysis of consumption is essential for reliable estimation of total consumption.

7.1.4 Conclusions regarding comparisons of estimates of capelin abundance

Based on the information presented in the previous sections, the Working Group noted that consumption estimates need not be inconsistent with the acoustic estimates.

The Working Group recommends that simultaneous surveys be conducted in order to estimate the overlap of the two species along with the estimated biomass of capelin and consumption by cod. Only in this way can it be ascertained whether the estimates of capelin consumption by cod and capelin biomass are consistent.

It is further recommended that acoustic equipment be used on all bottom trawl surveys in order to obtain some (rough) information on the distribution of capelin during the survey.

7.2 Natural Mortality

Natural mortality of capelin has been estimated in both regions. In the Barents Sea the mature natural mortality is estimated using a consumption model, since the mortality clearly varies with the size of the cod stock. For the immature capelin in the Barents Sea and for the Iceland-East Greenland-Jan Mayen capelin the natural mortality is estimated from acoustic surveys.

7.3 Data for Multispecies Modelling

7.3.1 Estimates of cod biomass

The Working Group noted that natural mortality of cod is traditionally assumed to be 0.2. Several attempts have been made to estimate this value (e.g., Jónsson, 1960, Stefánsson, 1992), but the resulting confidence limits are wide.

Different assumptions on natural mortality of cod can have significant implications on the estimates of consumption of capelin.

The Working Group, therefore, recommends that the Arctic Fisheries Working Group and the North-Western Working Group provide estimates of the stock sizes of Icelandic cod and NE Arctic cod using a reasonable range of natural mortalities. The resulting stock sizes need to include the number of recruits, the biomass of immatures and the SSB. Unless there is evidence to the contrary, using $M = 0.1$, 0.2 and 0.3 should be sufficient. The Working Group further recommends that the Arctic Fisheries Working Group and the North-Western Working Group provide information on the mean weights at age on the respective cod stocks by year as far back in time as possible.

The Working Group notes that problems in age determination for the NE Arctic cod seriously affect biomass estimates in a non-trivial fashion. The problems affect mean weights at age as well as stock estimates. The Working Group recommends that, if the discrepancies on age readings cannot be reconciled, the Arctic Fisheries Working Group provide bounds on the resulting biomass by age.

8 WORKING DOCUMENTS

Working documents made available to the meeting:

1. Bogstad, B. and H Gjøsæter. The consumption of Barents Sea capelin by cod - winter 1993.
2. Bogstad, B., H. Gjøsæter and S. Tjelmeland. Cap Tool: a versatile aid in Barents Sea capelin quota options calculations.
3. Gjøsæter, H. The Barents Sea capelin.
4. Hamre, J. Norwegian spring-spawning herring.
5. Jakobsson, J. and G. Stefánsson. Icelandic summer-spawning herring.
6. Kryssov. A. Norwegian spring-spawning herring.

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

Rings	1968	1969	1970	1971	1972	1973	1974	1975
1	18.183	4.520	2.003	8.774	0.147	0.001	0.001	1.518
2	10.945	79.410	22.344	13.071	0.322	0.159	3.760	2.049
3	14.102	8.274	33.965	5.439	0.131	0.678	0.832	31.975
4	30.821	5.178	4.500	13.688	0.163	0.104	0.993	6.493
5	10.927	10.015	2.734	3.040	0.264	0.017	0.092	7.905
6	4.386	2.841	4.419	1.563	0.047	0.013	0.046	0.863
7	2.362	1.389	1.145	3.276	0.028	0.006	0.002	0.442
8	0.902	1.179	0.531	0.748	0.024	0.006	0.001	0.345
9	0.811	0.609	0.604	0.250	0.013	0.003	0.001	0.114
10	0.490	0.424	0.195	0.103	0.009	0.003	0.001	0.004
11	0.082	0.286	0.103	0.120	0.003	0.001	0.001	0.001
12	0.262	0.139	0.076	0.001	0.001	0.001	0.001	0.001
13	0.227	0.109	0.061	0.001	0.003	0.001	0.001	0.001
14	0.009	0.074	0.051	0.001	0.001	0.001	0.001	0.001
Total	-	20.913	16.445	11.831	0.310	0.255	1.274	13.280

Rings	1976	1977	1978	1979	1980	1981	1982	1983
1	0.614	0.705	2.634	0.929	3.147	2.283	0.454	1.470
2	9.848	18.853	22.551	15.098	14.347	4.629	19.187	22.422
3	3.908	24.152	50.995	47.561	20.761	16.771	28.109	151.198
4	34.144	10.404	13.846	69.735	60.728	12.126	38.280	30.181
5	7.009	46.357	8.738	16.451	65.329	36.871	16.623	21.525
6	5.481	6.735	39.492	8.003	11.541	41.917	38.308	8.637
7	1.045	5.421	7.253	26.040	9.285	7.299	43.770	14.017
8	0.438	1.395	6.354	3.050	19.442	4.863	6.813	13.666
9	0.296	0.524	1.616	1.869	1.796	13.416	6.633	3.715
10	0.134	0.362	0.926	0.494	1.464	1.032	10.457	2.373
11	0.092	0.027	0.400	0.439	0.698	0.884	2.354	3.424
12	0.001	0.128	0.017	0.032	0.001	0.760	0.594	0.552
13	0.001	0.001	0.025	0.054	0.110	0.101	0.075	0.100
14	0.001	0.001	0.051	0.006	0.079	0.062	0.211	0.003
Total	17.168	28.294	37.333	45.072	53.269	39.544	56.528	58.665

Rings	1984	1985	1986	1987	1988	1989	1990/91	1991/92
1	0.421	0.111	0.100	0.029	0.869	3.963	11.061	35.872
2	18.011	12.800	8.161	3.144	4.702	22.568	14.413	92.766
3	32.237	24.521	33.893	44.590	40.855	26.578	57.293	51.052
4	141.324	21.535	23.421	60.285	98.222	77.618	34.509	87.614
5	17.039	84.733	20.654	20.622	68.533	188.155	78.187	33.439
6	7.111	11.836	77.526	19.751	22.691	43.000	152.955	54.845
7	3.915	5.708	18.228	46.240	19.899	8.095	32.417	109.428
8	4.112	2.323	10.971	15.232	31.830	5.881	8.754	9.252
9	4.516	4.339	8.583	13.963	12.207	7.273	4.453	3.796
10	1.828	4.030	9.662	10.179	10.132	4.767	4.307	2.634
11	0.202	2.758	7.174	13.216	7.293	3.440	2.529	1.826
12	0.255	0.970	3.677	6.224	7.200	1.406	1.232	0.516
13	0.260	0.477	2.914	4.723	4.752	0.842	1.024	0.262
14	0.003	0.578	1.786	2.280	1.935	0.347	0.613	0.298
Total	50.293	49.092	65.413	75.439	91.760	100.733	105.593	109.499

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

rings

Age	1968	1969	1970	1971	1972	1973	1974
1	82	82	82	82	96	90	80
2	153	153	153	153	177	199	189
3	210	210	210	210	278	257	262
4	260	260	260	260	332	278	297
5	290	290	290	290	358	337	340
6	320	320	320	320	379	381	332
7	341	341	341	341	410	380	379
8	370	370	370	370	419	397	356
9	380	380	380	380	470	385	407
10	390	390	390	390	500	450	410
11	408	408	408	408	500	450	410
12	408	408	408	408	500	450	423
13	408	408	408	408	500	450	423
14	408	408	408	408	500	450	423

Age	1975	1976	1977	1978	1979	1980	1981
1	110	103	84	73	75	69	61
2	179	189	157	128	145	115	141
3	241	243	217	196	182	202	190
4	291	281	261	247	231	232	246
5	319	305	285	295	285	269	269
6	339	335	313	314	316	317	298
7	365	351	326	339	334	352	330
8	364	355	347	359	350	360	356
9	407	395	364	360	367	380	368
10	389	363	362	376	368	383	405
11	430	396	358	380	371	393	382
12	416	396	355	425	350	390	400
13	416	396	400	425	350	390	400
14	416	396	420	425	450	390	400

Age	1982	1983	1984	1985	1986	1987	1988
1	65	59	49	53	60	60	75
2	141	132	131	146	140	168	157
3	186	180	189	219	200	200	221
4	217	218	217	266	252	240	239
5	274	260	245	285	282	278	271
6	293	309	277	315	298	304	298
7	323	329	315	335	320	325	319
8	354	356	322	365	334	339	334
9	385	370	351	388	373	356	354
10	389	407	334	400	380	378	352
11	400	437	362	453	394	400	371
12	394	459	446	469	408	404	390
13	390	430	417	433	405	424	408
14	420	472	392	447	439	430	437

Age	1989	1990	1991	1992
1	63	75	74	68
2	130	119	139	147
3	206	198	188	196
4	246	244	228	233
5	261	273	267	264
6	290	286	292	293
7	331	309	303	312
8	338	329	325	320
9	352	351	343	353
10	369	369	348	367
11	389	387	369	387
12	380	422	388	399
13	434	408	404	419
14	409	436	396	428

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.

Age	1968	1969	1970	1971	1972	1973	1974
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.290	0.640	0.140
3	1.000	1.000	1.000	1.000	1.000	0.990	0.940
4	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Age	1975	1976	1977	1978	1979	1980	1981
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.270	0.130	0.020	0.040	0.070	0.050	0.030
3	0.970	0.900	0.870	0.780	0.650	0.920	0.650
4	1.000	1.000	1.000	1.000	0.980	1.000	0.990
5	1.000	1.000	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Age	1982	1983	1984	1985	1986	1987	1988
1	0.020	0.000	0.000	0.000	0.000	0.000	0.000
2	0.050	0.000	0.010	0.000	0.030	0.010	0.045
3	0.850	0.640	0.820	0.900	0.890	0.870	0.900
4	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Age	1989	1990	1991	1992
1	0.000	0.000	0.000	0.000
2	0.060	0.000	0.013	0.013
3	0.930	0.780	0.720	0.720
4	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000

Table 2.4 Acoustic estimates (in millions) of herring of the Icelandic summer spawning herring 1974-1992.

Rings	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992[1]
1	-	-	-		-	-	-	968	5		-	-	312		607	442	8	740	635
2	211	7	184		293	216	26	500	23		235	39	911		174	983	244	1100	1015
3		179	26		563	444	234	620	99		410	88	274		465	236	782	305	1123
4		24	171		59	279	468	110	206		940	73	142		1081	319	228	396	458
5		27	21		24	63	325	218	54		102	461	110		366	486	385	175	350
6		3	13		176	25	65	232	157		49	83	539		67	216	683	223	119
7		2	4		23	140	52	41	205		19	40	85		46	53	233	489	102
8			4		23	38	117	36	30		34	20	51		95	29	-	50	265
9					12	38	13	72	10		33	21	21		31	38	-	12	40
10						25		13	57		12	23	34		26	20	-	3	14
11									12		6	11	33		18	12	22	-	-
12											15	9	20		21	11	-	-	21
13												5	8		10	6	-	-	-
14												6	7		8	4	-	-	-
15												6	1.4		4	3	-	-	-
5+		32	42		258	329	572	612	525		270	685	909		692	878	1323	952	911

[1]Adjusted for catch taken in Jan-Feb 1992 i.e., after the acoustic survey, to give an estimate of the stock size at the end of the season.

Table 2.5 Stock abundance and catches by age groups (millions) and fishing mortality rate for the Icelandic summer spawners. F'is the F calculated from the acoustic surveys. F_{ps} is the exploitation pattern in 1991 based on the surveys. F_{91} is fitted fishing mortality based on the fitting procedure for the 5+ and the 1992 acoustic estimates for the 1-4 ringers in 1991. $F_{p\,av}$ is the average exploitation pattern for 1984-1987 used in the prognosis.

Rings in 1991	Year class	Acoustic[1] estimates in Dec 1991	Catch 1991-1992	F'	F_{ps}	F_{91}	$F_{p\,av}$
0	1990	635					
1	1989	1015	35.9	0.03	.091	0.033	.001
2	1988	1123	92.8	0.075	.227	0.076	.124
3	1987	458	51.0	0.10	.303	0.101	.440
4	1986	350	87.6	0.21	.636	0.213	.852
5	1985	119	33.4	0.23	.697	0.220	.869
6+	1984-	442	182.8	0.33	1.000	0.316	1.000

[1]Adjusted for catch taken in Jan-Feb 1992 i.e., after the acoustic survey, to give an estimate of the stock size at the end of the seasc

Table 2.6 Icelandic summer spawners. Fishing mortality at age (M=0.1).

Age	1968	1969	1970	1971	1972	1973	1974
1	0.113	0.108	0.064	0.140	0.002	0.000	0.000
2	0.427	0.858	0.966	0.647	0.006	0.002	0.010
3	0.782	0.588	1.026	0.578	0.010	0.014	0.012
4	0.895	0.657	0.656	1.578	0.026	0.009	0.024
5	1.084	0.736	0.779	1.168	0.087	0.003	0.009
6	1.001	0.829	0.755	1.355	0.039	0.005	0.009
7	0.729	0.922	0.856	2.430	0.059	0.006	0.001
8	0.592	0.895	1.019	3.262	0.089	0.015	0.001
9	0.833	0.920	1.688	2.437	0.675	0.013	0.003
10	0.779	1.379	0.765	1.773	0.547	0.283	0.005
11	0.308	1.417	1.592	1.503	0.174	0.094	0.129
12	0.844	1.115	2.427	0.043	0.033	0.072	0.115
13	1.032	0.939	3.800	0.166	0.159	0.038	0.087
14	0.765	1.052	1.613	1.621	0.222	0.066	0.044
W.Av 4-14	0.920	0.767	0.784	1.656	0.050	0.007	0.019
Ave 4- 9	0.856	0.826	0.959	2.038	0.163	0.008	0.008
Ave 4-14	0.806	0.987	1.450	1.576	0.192	0.055	0.039

Age	1975	1976	1977	1978	1979	1980	1981
1	0.008	0.001	0.002	0.014	0.004	0.013	0.003
2	0.018	0.060	0.040	0.062	0.095	0.070	0.022
3	0.104	0.039	0.182	0.131	0.161	0.164	0.098
4	0.110	0.139	0.126	0.135	0.238	0.283	0.122
5	0.237	0.149	0.253	0.133	0.211	0.326	0.248
6	0.097	0.230	0.187	0.316	0.155	0.201	0.319
7	0.104	0.147	0.331	0.280	0.316	0.242	0.169
8	0.175	0.128	0.266	0.708	0.163	0.365	0.173
9	0.140	0.200	0.199	0.492	0.408	0.122	0.410
10	0.012	0.217	0.354	0.561	0.242	0.573	0.086
11	0.005	0.368	0.056	0.729	0.502	0.558	0.725
12	0.164	0.006	1.137	0.041	0.100	0.002	2.182
13	0.145	0.220	0.007	0.614	0.157	0.509	0.203
14	0.105	0.189	0.317	0.468	0.255	0.322	0.533
W.Av 4-14	0.150	0.148	0.219	0.243	0.238	0.293	0.245
Ave 4- 9	0.144	0.165	0.227	0.344	0.249	0.257	0.240
Ave 4-14	0.118	0.181	0.294	0.407	0.250	0.318	0.470

Age	1982	1983	1984	1985	1986	1987	1988
1	0.002	0.007	0.001	0.000	0.000	0.000	0.001
2	0.026	0.110	0.098	0.033	0.006	0.006	0.016
3	0.158	0.254	0.204	0.169	0.103	0.038	0.086
4	0.299	0.227	0.355	0.183	0.215	0.240	0.100
5	0.219	0.244	0.173	0.332	0.239	0.266	0.415
6	0.389	0.151	0.106	0.157	0.508	0.335	0.462
7	0.566	0.214	0.085	0.105	0.340	0.572	0.583
8	0.211	0.305	0.081	0.060	0.268	0.468	0.882
9	0.333	0.153	0.140	0.103	0.292	0.563	0.749
10	0.573	0.170	0.094	0.160	0.310	0.586	0.928
11	0.258	0.329	0.018	0.180	0.418	0.792	0.991
12	1.540	0.079	0.033	0.099	0.342	0.685	1.288
13	1.961	1.152	0.044	0.071	0.423	0.858	1.735
14	0.729	0.319	0.075	0.117	0.363	0.607	0.952
W.Av 4-14	0.364	0.222	0.252	0.221	0.346	0.381	0.244
Ave 4- 9	0.336	0.216	0.157	0.157	0.310	0.407	0.532
Ave 4-14	0.643	0.304	0.109	0.142	0.338	0.543	0.826

Age	1989	1990	1991	1984-1987
1	0.006	0.008	0.033	0.000
2	0.036	0.024	0.076	0.036
3	0.103	0.108	0.101	0.128
4	0.209	0.169	0.213	0.248
5	0.250	0.300	0.220	0.253
6	0.441	0.295	0.316	0.276
7	0.264	0.619	0.316	0.276
8	0.300	0.448	0.316	0.219
9	0.444	0.347	0.316	0.275
10	0.658	0.456	0.316	0.288
11	0.854	0.787	0.316	0.352
12	0.450	0.765	0.316	0.290
13	0.418	0.610	0.316	0.349
14	0.479	0.541	0.316	0.290
W.Av 4-14	0.264	0.300	0.267	0.250
Ave 4- 9	0.318	0.363	0.283	0.258
Ave 4-14	0.433	0.485	0.298	0.283

Table 2.7 Icelandic summer spawners. VPA stock size in numbers and spawning stock biomass in '000 tonnes at 1. July.

Age	1968	1969	1970	1971	1972	1973	1974
1	178.055	46.319	33.782	70.416	89.936	418.225	132.264
2	32.967	143.838	37.617	28.664	55.382	81.238	378.424
3	27.146	19.460	55.175	12.959	13.574	49.806	73.356
4	54.350	11.240	9.779	17.899	6.579	12.158	44.422
5	17.196	20.087	5.274	4.593	3.343	5.798	10.902
6	7.230	5.261	8.711	2.189	1.292	2.774	5.230
7	4.765	2.405	2.077	3.706	0.511	1.125	2.498
8	2.110	2.079	0.866	0.799	0.295	0.435	1.012
9	1.497	1.056	0.768	0.283	0.028	0.244	0.388
10	0.945	0.589	0.381	0.129	0.022	0.013	0.218
11	0.324	0.392	0.134	0.160	0.020	0.012	0.009
12	0.480	0.215	0.086	0.025	0.032	0.015	0.010
13	0.367	0.187	0.064	0.007	0.021	0.028	0.013
14	0.018	0.118	0.066	0.001	0.005	0.017	0.025
Total	29.450	16.276	19.080	10.657	10.353	28.672	45.938

Age	1975	1976	1977	1978	1979	1980	1981
1	198.905	554.231	436.752	196.520	248.850	255.308	886.652
2	119.676	178.534	500.905	394.519	175.314	224.285	228.020
3	338.838	106.340	152.185	435.318	335.544	144.286	189.308
4	65.584	276.216	92.505	114.773	345.457	258.451	110.842
5	39.250	53.175	217.503	73.820	90.700	246.407	176.250
6	9.777	28.014	41.458	152.820	58.496	66.454	161.009
7	4.689	8.027	20.146	31.119	100.825	45.330	49.175
8	2.258	3.823	6.271	13.089	21.277	66.536	32.205
9	0.915	1.716	3.043	4.350	5.837	16.357	41.774
10	0.350	0.719	1.272	2.256	2.406	3.510	13.094
11	0.196	0.313	0.524	0.807	1.165	1.708	1.791
12	0.007	0.177	0.196	0.448	0.352	0.638	0.885
13	0.008	0.005	0.159	0.057	0.389	0.289	0.577
14	0.010	0.006	0.004	0.143	0.028	0.301	0.157
Total	117.050	129.533	133.216	175.909	198.671	213.196	186.726

Age	1982	1983	1984	1985	1986	1987	1988
1	250.520	225.064	459.245	1536.194	638.195	353.209	746.583
2	800.105	226.249	202.248	415.141	1389.900	577.368	319.569
3	201.920	705.725	183.418	165.891	363.468	1249.874	519.435
4	155.359	156.013	495.106	135.364	126.821	296.681	1088.549
5	88.776	104.267	112.524	314.011	102.037	92.523	211.241
6	124.491	64.551	73.920	85.638	203.784	72.727	64.154
7	105.936	76.337	50.206	60.130	66.249	110.987	47.079
8	37.565	54.432	55.769	41.709	48.985	42.661	56.666
9	24.523	27.524	36.291	46.555	35.532	33.915	24.175
10	25.086	15.900	21.377	28.548	38.002	24.009	17.473
11	10.867	12.803	12.134	17.606	22.005	25.222	12.093
12	0.785	7.600	8.337	10.787	13.312	13.113	10.338
13	0.090	0.152	6.352	7.302	8.839	8.559	5.981
14	0.426	0.012	0.044	5.500	6.154	5.237	3.285
Total	194.091	221.172	236.262	255.601	264.149	409.650	478.216

Age	1989	1990	1991	1992
1	701.802	1486.157	1160.462	635.000
2	674.710	631.249	1334.214	1015.931
3	284.688	589.051	557.476	1119.098
4	431.185	232.346	478.568	455.924
5	891.644	316.479	177.470	349.868
6	126.199	628.261	212.205	128.845
7	36.556	73.453	423.395	139.999
8	23.769	25.397	35.798	279.329
9	21.227	15.929	14.687	23.617
10	10.339	12.317	10.191	9.690
11	6.250	4.847	7.065	6.724
12	4.064	2.407	1.996	4.661
13	2.579	2.345	1.014	1.317
14	0.955	1.536	1.153	0.669
Total	449.218	436.963	427.047	520.012

Table 2.8

Herring, Summer Spawning at Iceland (Fishing Area Va)

Single option prediction: Input data

Year: 1992								
Age	Stock size	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	635.000	0.1000	0.0000	0.0000	0.5000	68	0.0003	68
2	1015.931	0.1000	0.0216	0.0000	0.5000	147	0.0370	147
3	1119.098	0.1000	0.8513	0.0000	0.5000	196	0.1310	196
4	455.924	0.1000	1.0000	0.0000	0.5000	233	0.2540	233
5	349.868	0.1000	1.0000	0.0000	0.5000	264	0.2590	264
6	128.845	0.1000	1.0000	0.0000	0.5000	293	0.2980	293
7	139.999	0.1000	1.0000	0.0000	0.5000	312	0.2980	312
8	279.329	0.1000	1.0000	0.0000	0.5000	320	0.2980	320
9	23.617	0.1000	1.0000	0.0000	0.5000	353	0.2980	353
10	9.690	0.1000	1.0000	0.0000	0.5000	367	0.2980	367
11	6.724	0.1000	1.0000	0.0000	0.5000	387	0.2980	387
12	4.661	0.1000	1.0000	0.0000	0.5000	399	0.2980	399
13	1.317	0.1000	1.0000	0.0000	0.5000	419	0.2980	419
14	0.669	0.1000	1.0000	0.0000	0.5000	428	0.2980	428
Unit	Millions	-	-	-	-	Grams	-	Grams

Year: 1993								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	600.000	0.1000	0.0000	0.0000	0.5000	68	0.0003	68
2	.	0.1000	0.0216	0.0000	0.5000	147	0.0370	147
3	.	0.1000	0.8513	0.0000	0.5000	196	0.1310	196
4	.	0.1000	1.0000	0.0000	0.5000	233	0.2540	233
5	.	0.1000	1.0000	0.0000	0.5000	264	0.2590	264
6	.	0.1000	1.0000	0.0000	0.5000	293	0.2980	293
7	.	0.1000	1.0000	0.0000	0.5000	312	0.2980	312
8	.	0.1000	1.0000	0.0000	0.5000	320	0.2980	320
9	.	0.1000	1.0000	0.0000	0.5000	353	0.2980	353
10	.	0.1000	1.0000	0.0000	0.5000	367	0.2980	367
11	.	0.1000	1.0000	0.0000	0.5000	387	0.2980	387
12	.	0.1000	1.0000	0.0000	0.5000	399	0.2980	399
13	.	0.1000	1.0000	0.0000	0.5000	419	0.2980	419
14	.	0.1000	1.0000	0.0000	0.5000	428	0.2980	428
Unit	Millions	-	-	-	-	Grams	-	Grams

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
1	600.000	0.1000	0.0000	0.0000	0.5000	68	0.0003	68
2	.	0.1000	0.0216	0.0000	0.5000	147	0.0370	147
3	.	0.1000	0.8513	0.0000	0.5000	196	0.1310	196
4	.	0.1000	1.0000	0.0000	0.5000	233	0.2540	233
5	.	0.1000	1.0000	0.0000	0.5000	264	0.2590	264
6	.	0.1000	1.0000	0.0000	0.5000	293	0.2980	293
7	.	0.1000	1.0000	0.0000	0.5000	312	0.2980	312
8	.	0.1000	1.0000	0.0000	0.5000	320	0.2980	320
9	.	0.1000	1.0000	0.0000	0.5000	353	0.2980	353
10	.	0.1000	1.0000	0.0000	0.5000	367	0.2980	367
11	.	0.1000	1.0000	0.0000	0.5000	387	0.2980	387
12	.	0.1000	1.0000	0.0000	0.5000	399	0.2980	399
13	.	0.1000	1.0000	0.0000	0.5000	419	0.2980	419
14	.	0.1000	1.0000	0.0000	0.5000	428	0.2980	428
Unit	Millions	-	-	-	-	Grams	-	Grams

Herring, Summer Spawning at Iceland (Fishing Area Va)

Single option prediction: Input data

Year: 1995								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	600.000	0.1000	0.0000	0.0000	0.5000	68	0.0003	68
2	.	0.1000	0.0216	0.0000	0.5000	147	0.0370	147
3	.	0.1000	0.8513	0.0000	0.5000	196	0.1310	196
4	.	0.1000	1.0000	0.0000	0.5000	233	0.2540	233
5	.	0.1000	1.0000	0.0000	0.5000	264	0.2590	264
6	.	0.1000	1.0000	0.0000	0.5000	293	0.2980	293
7	.	0.1000	1.0000	0.0000	0.5000	312	0.2980	312
8	.	0.1000	1.0000	0.0000	0.5000	320	0.2980	320
9	.	0.1000	1.0000	0.0000	0.5000	353	0.2980	353
10	.	0.1000	1.0000	0.0000	0.5000	367	0.2980	367
11	.	0.1000	1.0000	0.0000	0.5000	387	0.2980	387
12	.	0.1000	1.0000	0.0000	0.5000	399	0.2980	399
13	.	0.1000	1.0000	0.0000	0.5000	419	0.2980	419
14	.	0.1000	1.0000	0.0000	0.5000	428	0.2980	428
Unit	Millions	-	-	-	-	Grams	-	Grams

Year: 1996								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	600.000	0.1000	0.0000	0.0000	0.5000	68	0.0003	68
2	.	0.1000	0.0216	0.0000	0.5000	147	0.0370	147
3	.	0.1000	0.8513	0.0000	0.5000	196	0.1310	196
4	.	0.1000	1.0000	0.0000	0.5000	233	0.2540	233
5	.	0.1000	1.0000	0.0000	0.5000	264	0.2590	264
6	.	0.1000	1.0000	0.0000	0.5000	293	0.2980	293
7	.	0.1000	1.0000	0.0000	0.5000	312	0.2980	312
8	.	0.1000	1.0000	0.0000	0.5000	320	0.2980	320
9	.	0.1000	1.0000	0.0000	0.5000	353	0.2980	353
10	.	0.1000	1.0000	0.0000	0.5000	367	0.2980	367
11	.	0.1000	1.0000	0.0000	0.5000	387	0.2980	387
12	.	0.1000	1.0000	0.0000	0.5000	399	0.2980	399
13	.	0.1000	1.0000	0.0000	0.5000	419	0.2980	419
14	.	0.1000	1.0000	0.0000	0.5000	428	0.2980	428
Unit	Millions	-	-	-	-	Grams	-	Grams

Notes: Run name : SNGL.PRED
Date and time: 21OCT92:15:31

Table 2.9

Herring, Summer Spawning at Iceland (Fishing Area Va)

Herring, Summer Spawning at Iceland (Fishing Area Va)

Prediction with management option table

Year: 1992					Year: 1993					Year: 1994	
F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	Stock biomass	Sp.stock biomass
1.0012	0.2743	798470	548432	120000	0.0000	0.0000	796924	616099	0	903337	731784
.	.	.	.	.	0.1000	0.0270	.	616099	15220	887250	716537
.	.	.	.	.	0.2000	0.0540	.	616099	30070	871556	701663
.	.	.	.	.	0.3000	0.0810	.	616099	44562	856243	687152
.	.	.	.	.	0.4000	0.1081	.	616099	58703	841302	672995
.	.	.	.	.	0.5000	0.1351	.	616099	72504	826723	659181
.	.	.	.	.	0.6000	0.1621	.	616099	85972	812496	645703
.	.	.	.	.	0.7000	0.1891	.	616099	99117	798614	632552
.	.	.	.	.	0.8000	0.2161	.	616099	111947	785066	619719
.	.	.	.	.	0.9000	0.2431	.	616099	124469	771844	607196
.	.	.	.	.	1.0000	0.2702	.	616099	136692	758940	594975
.	.	.	.	.	1.1000	0.2972	.	616099	148624	746345	583048
.	.	.	.	.	1.2000	0.3242	.	616099	160272	734052	571408
.	.	.	.	.	1.3000	0.3512	.	616099	171643	722053	560047
.	.	.	.	.	1.4000	0.3782	.	616099	182744	710340	548958
.	.	.	.	.	1.5000	0.4052	.	616099	193583	698906	538135
.	.	.	.	.	1.6000	0.4322	.	616099	204165	687744	527569
.	.	.	.	.	1.7000	0.4593	.	616099	214499	676846	517255
.	.	.	.	.	1.8000	0.4863	.	616099	224589	666206	507187
.	.	.	.	.	1.9000	0.5133	.	616099	234442	655818	497357
.	.	.	.	.	2.0000	0.5403	.	616099	244064	645675	487760
-	-	Tonnes	Tonnes	Tonnes	-	-	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes

Notes: Run name : MNGMNT PRED
Date and time : 21OCT92:15:52
Computation of ref. F: Weighted mean, age 4 - 14
Basis for 1992 : TAC constraints

Table 2.10

Herring, Summer Spawning at Iceland (Fishing Area Va)

Herring, Summer Spawning at Iceland (Fishing Area Va)

Single option prediction: Detailed tables

Year: 1992	F-factor: 1.0012		Reference F: 0.2743			1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0003	180	12	635000	43180	0	0	0	0
2	0.0370	35170	5170	1015931	149342	21970	3230	20898	3072
3	0.1312	131048	25685	1119098	219343	952632	186716	906172	177610
4	0.2543	97629	22748	455924	106230	455924	106230	433688	101049
5	0.2593	76214	20121	349868	92365	349868	92365	332805	87860
6	0.2984	31708	9290	128845	37752	128845	37752	122561	35910
7	0.2984	34453	10749	139999	43680	139999	43680	133171	41549
8	0.2984	68741	21997	279329	89385	279329	89385	265706	85026
9	0.2984	5812	2052	23617	8337	23617	8337	22465	7930
10	0.2984	2385	875	9690	3556	9690	3556	9217	3383
11	0.2984	1655	640	6724	2602	6724	2602	6396	2475
12	0.2984	1147	458	4661	1860	4661	1860	4434	1769
13	0.2984	324	136	1317	552	1317	552	1253	525
14	0.2984	165	70	669	286	669	286	636	272
Total		486631	120004	4170672	798470	2375245	576551	2259403	548432
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

(cont.)

Table 2.10 Continued

Herring, Summer Spawning at Iceland (Fishing Area Va)

Single option prediction: Detailed tables

(cont.)

Year: 1993 F-factor: 0.8000 Reference F: 0.2161

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0002	136	9	600000	40800	0	0	0	0
2	0.0296	15947	2344	574400	84437	12421	1826	11816	1737
3	0.1048	83945	16453	885822	173621	754056	147795	717280	140587
4	0.2032	155677	36273	888133	206935	888133	206935	844818	196843
5	0.2072	57070	15066	319904	84455	319904	84455	304302	80336
6	0.2384	49403	14475	244263	71569	244263	71569	232350	68079
7	0.2384	17497	5459	86509	26991	86509	26991	82290	25675
8	0.2384	19011	6084	93998	30079	93998	30079	89414	28612
9	0.2384	37932	13390	187548	66204	187548	66204	178401	62975
10	0.2384	3207	1177	15857	5820	15857	5820	15084	5536
11	0.2384	1316	509	6506	2518	6506	2518	6189	2395
12	0.2384	913	364	4515	1801	4515	1801	4294	1713
13	0.2384	633	265	3129	1311	3129	1311	2977	1247
14	0.2384	179	77	884	378	884	378	841	360
Total		442866	111946	3911469	796920	2617724	647683	2490056	616095
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Year: 1994 F-factor: 0.8000 Reference F: 0.2163

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0002	136	9	600000	40800	0	0	0	0
2	0.0296	15069	2215	542773	79788	11737	1725	11165	1641
3	0.1048	47817	9372	504580	98898	429524	84187	408576	80081
4	0.2032	126517	29479	721777	168174	721777	168174	686576	159972
5	0.2072	117001	30888	655843	173142	655843	173142	623857	164698
6	0.2384	47588	13943	235291	68940	235291	68940	223815	65578
7	0.2384	35220	10989	174137	54331	174137	54331	165645	51681
8	0.2384	12474	3992	61673	19735	61673	19735	58666	18773
9	0.2384	13553	4784	67012	23655	67012	23655	63744	22502
10	0.2384	27042	9924	133705	49070	133705	49070	127184	46676
11	0.2384	2286	885	11305	4375	11305	4375	10753	4162
12	0.2384	938	374	4638	1851	4638	1851	4412	1760
13	0.2384	651	273	3219	1349	3219	1349	3062	1283
14	0.2384	451	193	2231	955	2231	955	2122	908
Total		446743	117320	3718184	785062	2512092	651489	2389576	619716
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

(cont.)

Herring, Summer Spawning at Iceland (Fishing Area Va)

Single option prediction: Detailed tables

(cont.)

Year: 1995 F-factor: 0.8000 Reference F: 0.2222

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0002	136	9	600000	40800	0	0	0	0
2	0.0296	15069	2215	542773	79788	11737	1725	11165	1641
3	0.1048	45184	8856	476797	93452	405874	79551	386079	75671
4	0.2032	72067	16791	411137	95795	411137	95795	391086	91123
5	0.2072	95085	25103	532997	140711	532997	140711	507003	133849
6	0.2384	97561	28586	482375	141336	482375	141336	458849	134443
7	0.2384	33926	10585	167741	52335	167741	52335	159560	49783
8	0.2384	25109	8035	124144	39726	124144	39726	118090	37789
9	0.2384	8893	3139	43968	15521	43968	15521	41823	14764
10	0.2384	9662	3546	47774	17533	47774	17533	45444	16678
11	0.2384	19279	7461	95319	36889	95319	36889	90671	35090
12	0.2384	1630	650	8059	3216	8059	3216	7666	3059
13	0.2384	669	280	3307	1385	3307	1385	3145	1318
14	0.2384	464	199	2295	982	2295	982	2183	934
Total		424733	115455	3538686	759469	2336727	626705	2222763	596141
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Year: 1996 F-factor: 0.8000 Reference F: 0.2254

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0002	136	9	600000	40800	0	0	0	0
2	0.0296	15069	2215	542773	79788	11737	1725	11165	1641
3	0.1048	45184	8856	476797	93452	405874	79551	386079	75671
4	0.2032	68098	15867	388499	90520	388499	90520	369552	86106
5	0.2072	54162	14299	303605	80152	303605	80152	288798	76243
6	0.2384	79287	23231	392021	114862	392021	114862	372902	109260
7	0.2384	69553	21700	343890	107294	343890	107294	327118	102061
8	0.2384	24186	7740	119584	38267	119584	38267	113752	36401
9	0.2384	17900	6319	88504	31242	88504	31242	84187	29718
10	0.2384	6340	2327	31345	11504	31345	11504	29816	10943
11	0.2384	6888	2666	34058	13181	34058	13181	32397	12538
12	0.2384	13744	5484	67954	27114	67954	27114	64640	25791
13	0.2384	1162	487	5745	2407	5745	2407	5465	2290
14	0.2384	477	204	2357	1009	2357	1009	2242	960
Total		402186	111403	3397134	731591	2195174	598827	2088115	569622
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : SNGL.PRED
Date and time : 21OCT92:13:42
Computation of ref. F: Weighted mean, age 4 - 14
Prediction basis : F factors

Table 2.11

Herring, Summer Spawning at Iceland (Fishing Area Va)

Herring, Summer Spawning at Iceland (Fishing Area Va)

Single option prediction: Summary table

							1 January		Spawning time	
Year	F Factor	Reference F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1992	1.0012	0.2743	486631	120004	4170672	798470	2375245	576551	2259403	548432
1993	0.8000	0.2161	442866	111946	3911469	796920	2617724	647683	2490056	616095
1994	0.8000	0.2163	446743	117320	3718184	785062	2512092	651489	2389576	619716
1995	0.8000	0.2222	424733	115455	3538686	759469	2336727	626705	2222763	596141
1996	0.8000	0.2254	402186	111403	3397134	731591	2195174	598827	2088115	569622
Unit	-	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : SNGL.PRED
Date and time : 21OCT92:13:42
Computation of ref. F: Weighted mean, age 4 - 14
Prediction basis : F factors

Table 2.12

Herring, Summer Spawning at Iceland (Fishing Area Va)

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	64	0.0100	64
2	.	0.1000	0.0216	0.0000	0.5000	141	0.1240	141
3	.	0.1000	0.8513	0.0000	0.5000	203	0.4400	203
4	.	0.1000	1.0000	0.0000	0.5000	241	0.8520	241
5	.	0.1000	1.0000	0.0000	0.5000	270	0.8690	270
6	.	0.1000	1.0000	0.0000	0.5000	295	1.0000	295
7	.	0.1000	1.0000	0.0000	0.5000	320	1.0000	320
8	.	0.1000	1.0000	0.0000	0.5000	336	1.0000	336
9	.	0.1000	1.0000	0.0000	0.5000	358	1.0000	358
10	.	0.1000	1.0000	0.0000	0.5000	366	1.0000	366
11	.	0.1000	1.0000	0.0000	0.5000	391	1.0000	391
12	.	0.1000	1.0000	0.0000	0.5000	413	1.0000	413
13	.	0.1000	1.0000	0.0000	0.5000	417	1.0000	417
14	.	0.1000	1.0000	0.0000	0.5000	423	1.0000	423
Unit	Numbers	-	-	-	-	Grams	-	Grams

Notes: Run name : YIELD PER RECR
Date and time: 21OCT92:12:32

Table 2.13

Herring, Summer Spawning at Iceland (Fishing Area Va)

Yield per recruit: Summary table

						1 January		Spawning time	
F Factor	Reference F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
0.0000	0.0000	0.000	0	7.917	2070	5.910	1857	5.622	1766
0.0500	0.0478	0.210	65	6.938	1712	4.932	1499	4.691	1426
0.1000	0.0949	0.346	104	6.213	1452	4.208	1239	4.003	1179
0.1500	0.1413	0.438	127	5.665	1260	3.662	1047	3.484	996
0.2000	0.1871	0.500	141	5.244	1115	3.242	902	3.084	858
0.2500	0.2324	0.546	150	4.913	1003	2.912	791	2.770	753
0.3000	0.2771	0.579	155	4.648	916	2.649	704	2.519	670
0.3500	0.3214	0.605	158	4.432	847	2.434	635	2.315	604
0.4000	0.3653	0.625	160	4.254	790	2.257	579	2.146	550
0.4500	0.4089	0.641	161	4.103	744	2.107	532	2.005	506
0.5000	0.4521	0.655	162	3.975	705	1.981	493	1.884	469
0.5500	0.4952	0.667	162	3.865	672	1.871	461	1.780	438
0.6000	0.5380	0.677	163	3.768	643	1.776	433	1.689	411
0.6500	0.5807	0.685	163	3.683	619	1.692	408	1.609	388
0.7000	0.6232	0.693	162	3.607	597	1.617	387	1.539	368
0.7500	0.6656	0.700	162	3.540	578	1.551	368	1.475	350
0.8000	0.7079	0.707	162	3.478	561	1.491	351	1.418	334
0.8500	0.7501	0.712	162	3.423	546	1.436	336	1.366	320
0.9000	0.7922	0.718	161	3.372	532	1.386	322	1.319	307
0.9500	0.8343	0.722	161	3.325	519	1.341	310	1.275	295
1.0000	0.8763	0.727	161	3.282	508	1.299	299	1.236	284
-	-	Numbers	Grams	Numbers	Grams	Numbers	Grams	Numbers	Grams

Notes: Run name : YIELD PER RECR
Date and time : 21OCT92:12:32
Computation of ref. F: Weighted mean, age 4 - 14
F-0.1 factor : 0.2273
F-max factor : 0.6095
F-0.1 reference F : 0.2100
F-max reference F : 0.5445
Recruitment : Single recruit

Table 2.14

Stock: Icelandic summer-spawning herring.

Assessment Quality Control Diagram 1

Average F(4-14,w)					
Date of assessment	Year				
	1987	1988	1989	1990	1991
1988	.237				
1989	.278	.264			
1990	.326	.228	.252		
1991	.313	.228	.248	.246	
1992	.381	.244	.264	.300	.267

Remarks: The age range 4.14 refers to rings and is comparable to 5-15 years old herring.

Assessment Quality Control Diagram 2

Estimated total landings ('000 t) at *status quo* F							
Date of assessment	Year						
	1987	1988	1989	1990	1991	1992	1993
1988							
1989							
1990							
1991							
1992							
					Actual	Current	Forecast

$$\textit{Actual SQC} = \textit{Landings}(y) \times \frac{F(y-1)}{F(y)} \times \exp\left[-\frac{1}{2}\{F(y-1) - F(y)\}\right]$$

where F(y) and F(y−1) are as estimated in the assessment made in year (y+1).

Stock: Icelandic summer-spawning herring.

Assessment Quality Control Diagram 3

Recruitment (age 2) Unit: million					
Date of assessment	Year class				
	1985	1986	1987	1988	1989
1988	177				
1989	259	857			
1990	266	982	394		
1991	310	561	347	1102	
1992	320	675	631	1334	1016

Remarks:

Assessment Quality Control Diagram 4

Spawning stock biomass ('000 t)								
Date of assessment	Year							
	1987	1988	1989	1990	1991	1992	1993	1994
1988	486	539	483	468				
1989	394	422	386	432	445[1]			
1990	426	496	458	510	510[1]	490[1]		
1991	438	508	471	443	425[1]	503[1]	562[1]	
1992	410	478	449	437	427[1]	520[1]	590[1]	610[1]

[1]Forecast.

Remarks:

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	34.550[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 until 30 August 1992

Table 3.2 Total catch of Norwegian spring-spawning herring (tonnes) since 1972 as used by the Working Group.

Year	Norway	USSR	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[1]	34.550	13.337	

[1]Preliminary.

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

Age	1976	1977	1978	1979	1980	1981	1982	1983
0	20.100	43.000	20.100	32.600	6.900	8.300	22.600	127.000
1	2.400	6.200	2.400	3.800	800	1.100	1.100	4.679
2	1.200	3.100	1.200	1.900	400	11.900	200	1.675
3	23.248	22.103	3.019	6.352	6.407	4.166	13.817	3.183
4	5.436	23.595	12.164	1.866	5.814	4.591	7.892	21.191
5	-	336	20.315	6.865	2.278	8.596	4.507	9.521
6	-	-	870	11.216	8.165	2.200	6.258	6.181
7	13.086	419	-	326	15.838	4.512	1.960	6.823
8	-	10.766	620	-	441	8.280	5.075	1.293
9	-	-	5.027	-	8	345	6.047	4.598
10	-	-	-	2.534	-	103	121	7.329
11	-	-	-	-	2.688	114	37	143
12	-	-	-	-	-	964	37	40
13	-	-	-	-	-	-	121	143
14	-	-	-	-	-	-	-	862
15	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-

Age	1984	1985	1986	1987	1988	1989	1990	1991
0	33.857	28.571	13.805	13.846	15.488	7.120	1.020	100
1	1.700	13.149	1.381	6.327	2.787	1.927	401	3.367
2	2.489	207.224[1]	3.091	35.770	9.112	25.203	15.542	3.333
3	4.483	21.500	539.785[2]	19.776	62.923	2.890	18.633	8.438
4	5.388	15.500	17.594	501.393	25.059	3.623	2.658	2.780
5	61.543	16.500	14.500	18.672	550.367	5.650	11.875	1.410
6	18.202	130.000	15.500	3.502	9.452	324.290	10.854	14.967
7	12.638	59.000	105.500	7.058	3.679	3.469	226.280	8.867
8	15.608	55.000	75.000	28.000	5.964	800	1.289	218.851
9	7.215	63.000	42.000	12.000	14.583	679	1.519	2.499
10	16.338	10.000	77.000	9.500	8.872	3.297	2.036	461
11	6.478	31.000	19.469	4.500	2.818	1.375	2.415	87
12	-	50.000	66.000	7.834	3.356	679	646	690
13	-	-	80.000	6.500	2.682	321	179	103
14	-	-	-	7.000	1.565	258	585	255
15	1.652	-	-	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 1975-1991 (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

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

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

Table 3.5B Acoustic estimates (TS=20logL-71.9) of immature herring in the Barents Sea.

Year class	Time	Estimate (mill ind)
1983	Nov 1983	17900
	June 1984	21400
	May 1985	19900
	Jan 1986	8100
	May 1986	3000
1984	Nov 1984	3800
1985	Sept 1985	20800
	Nov 1985	2700
1986	Sept 1986	0
1987	Sept 1987	0
1988	Nov 1988	4900
	Sept 1990	221
1989	June 1990	4400
	Sept 1990	4748
	June 1991	5200
	June 1992	5731
1990	June 1991	24300
	June 1992	14027
1991	June 1992	32614
1992	Sept 1992	300000

Table 3.6

Run title : Herring, Norwegian Spring Spawners (run name: RUN1)

At 21/10/1992 12:15

Traditional vpa using screen input for terminal F

Table Catch weights at age (kg)

YEAR,	1973,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,
AGE									
3,	.2590,	.2590,	.5900,	.2590,	.2940,	.2320,	.2830,	.2240,	.2040,
4,	.3420,	.3420,	.3420,	.3430,	.3260,	.3590,	.3470,	.3360,	.3030,
5,	.3840,	.3840,	.3840,	.3840,	.3710,	.3850,	.4020,	.3780,	.3550,
6,	.4090,	.4090,	.4090,	.4090,	.4090,	.4200,	.4210,	.3870,	.3830,
7,	.4440,	.4440,	.4440,	.4440,	.4610,	.4440,	.4650,	.4080,	.3950,
8,	.4610,	.4610,	.4610,	.4610,	.4760,	.5050,	.4650,	.3970,	.4130,
9,	.5200,	.5200,	.5200,	.5200,	.5200,	.5200,	.5200,	.5200,	.4530,
10,	.5430,	.5430,	.5430,	.5430,	.5430,	.5510,	.5340,	.5430,	.4680,
11,	.4120,	.4120,	.4120,	.4120,	.5000,	.5000,	.5000,	.5120,	.5120,
+gp,	.4120,	.5000,	.5000,	.5000,	.5000,	.5000,	.5000,	.5000,	.5000,
SOPCOFAC,	.6757,	.7843,	.9220,	.7617,	1.1563,	1.2248,	1.1249,	.9887,	1.1367,

Table Catch weights at age (kg)

YEAR,	1982,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,
AGE										
3,	.2490,	.2040,	.2330,	.2260,	.0540,	.1210,	.1490,	.1890,	.2350,	.2150,
4,	.3040,	.2500,	.2810,	.2920,	.2440,	.1690,	.1860,	.2650,	.2440,	.2580,
5,	.3680,	.3170,	.3480,	.3110,	.2880,	.2480,	.2340,	.2610,	.2720,	.2970,
6,	.4040,	.3560,	.3710,	.3570,	.3060,	.2270,	.2910,	.2830,	.3110,	.3220,
7,	.4240,	.3860,	.4080,	.3800,	.3450,	.3060,	.3200,	.3070,	.3140,	.3260,
8,	.4370,	.4010,	.4280,	.4020,	.3670,	.3210,	.3670,	.3100,	.3840,	.3410,
9,	.4360,	.4100,	.4420,	.4190,	.3900,	.3420,	.3680,	.3920,	.4150,	.3550,
10,	.4930,	.4180,	.4340,	.4320,	.3940,	.3460,	.3820,	.4230,	.4210,	.3840,
11,	.4800,	.4410,	.4560,	.4400,	.3930,	.3620,	.3720,	.3650,	.4330,	.3660,
+gp,	.4856,	.4337,	.4450,	.4586,	.4022,	.3767,	.4027,	.4299,	.4372,	.4107,
SOPCOFAC,	1.0523,	1.1653,	.9437,	.9831,	1.0230,	1.0527,	.8351,	1.0512,	.9985,	1.0017,

Table 3.7

Run title : Herring, Norwegian Spring Spawners (run name: RUN1)

At 21/10/1992 12:15

Traditional vpa using screen input for terminal F

Table Stock weights at age (kg)

YEAR,	1973,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,
AGE									
3,	.1700,	.1700,	.1810,	.1810,	.1810,	.1800,	.1780,	.1750,	.1700,
4,	.2590,	.2590,	.2590,	.5900,	.2590,	.2940,	.2320,	.2830,	.2240,
5,	.3420,	.3420,	.3420,	.3420,	.3430,	.3260,	.3590,	.3470,	.3360,
6,	.3840,	.3840,	.3840,	.3840,	.3840,	.3710,	.3850,	.4020,	.3780,
7,	.4090,	.4090,	.4090,	.4090,	.4090,	.4090,	.4200,	.4210,	.3870,
8,	.4040,	.4440,	.4440,	.4440,	.4440,	.4610,	.4440,	.4650,	.4080,
9,	.4610,	.4610,	.4610,	.4610,	.4610,	.4760,	.5050,	.4650,	.3970,
10,	.5200,	.5200,	.5200,	.5200,	.5200,	.5200,	.5200,	.5200,	.5200,
11,	.5340,	.5430,	.5430,	.5430,	.5430,	.5430,	.5510,	.5340,	.5430,
+gp,	.4995,	.4824,	.4824,	.4824,	.4824,	.5000,	.5000,	.5000,	.5120,

Table Stock weights at age (kg)

YEAR,	1982,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,
AGE										
3,	.1700,	.1550,	.1400,	.1480,	.0540,	.0900,	.0980,	.1540,	.2190,	.1470,
4,	.2040,	.2490,	.2040,	.2340,	.2060,	.1430,	.1350,	.1750,	.1980,	.2100,
5,	.3030,	.3040,	.2950,	.2650,	.2650,	.2410,	.1970,	.2090,	.2580,	.2440,
6,	.3550,	.3680,	.3380,	.3120,	.2890,	.2790,	.2770,	.2520,	.2880,	.3000,
7,	.3830,	.4040,	.3760,	.3460,	.3390,	.2990,	.3150,	.3050,	.3090,	.3240,
8,	.3950,	.4240,	.3950,	.3700,	.3680,	.3160,	.3390,	.3670,	.4280,	.3360,
9,	.4130,	.4370,	.4070,	.3950,	.3910,	.3420,	.3430,	.3770,	.3700,	.3430,
10,	.4530,	.4360,	.4130,	.3970,	.3820,	.3430,	.3590,	.3590,	.4030,	.3820,
11,	.4680,	.4930,	.4220,	.4070,	.3880,	.3620,	.3650,	.3950,	.3870,	.3660,
+gp,	.5058,	.4951,	.4370,	.4278,	.3952,	.3763,	.3759,	.3955,	.4404,	.4249,

Table 3.8

Run title : Herring, Norwegian Spring Spawners (run name: RUN1)

At 21/10/1992 12:15

Traditional vpa using screen input for terminal F

Table Proportion mature at age

YEAR,	1973,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,
AGE									
3,	.5000,	.5000,	.5000,	.5000,	.7300,	.1300,	.1000,	.2500,	.3000,
4,	.9000,	.9000,	1.0000,	.9000,	.8900,	.9000,	.6200,	.5000,	.5000,
5,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	.9500,	.9700,	.9000,
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 Proportion mature at age

YEAR,	1982,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,
AGE										
3,	.1000,	.1000,	.1000,	.1000,	.1000,	.1000,	.1000,	.1000,	.4000,	.5000,
4,	.4800,	.5000,	.5000,	.5000,	.2000,	.3000,	.3000,	.3000,	.8000,	.9000,
5,	.7000,	.6900,	.9000,	.9000,	.9000,	.9000,	.9000,	.9000,	.9000,	1.0000,
6,	1.0000,	.7100,	.9500,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	.9000,	1.0000,
7,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	1.0000,	.9000,	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: RUN1)

At 21/10/1992 12:15

Traditional vpa using screen input for terminal F

Table Fishing mortality (F) at age

YEAR,	1973,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,
AGE									
3,	.0809,	.0010,	.0835,	.0315,	.0436,	.0229,	.0136,	.0213,	.0104,
4,	.0657,	.0097,	.0014,	.1800,	.0377,	.0284,	.0164,	.0397,	.0177,
5,	.9885,	.0782,	.0430,	.0000,	.0140,	.0384,	.0187,	.0233,	.0254,
6,	1.8066,	1.4079,	.1231,	.0001,	.0000,	.0425,	.0249,	.0258,	.0263,
7,	2.4452,	1.4153,	.0719,	.0658,	.0266,	.0000,	.0187,	.0415,	.0166,
8,	2.2029,	.0452,	.0374,	.0171,	.0659,	.0464,	.0000,	.0295,	.0255,
9,	.0541,	.0541,	.0541,	.0220,	.0199,	.0369,	.0001,	.0002,	.0270,
10,	.0653,	.0653,	.0653,	.0653,	.0256,	.0231,	.0218,	.0001,	.0024,
11,	.0800,	.0800,	.0800,	.0800,	.0800,	.0300,	.0270,	.0270,	.0130,
+gp,	.0800,	.0800,	.0800,	.0800,	.0800,	.0300,	.0270,	.0270,	.0130,
FBAR 5- 9,	1.4994,	.6001,	.0659,	.0210,	.0253,	.0328,	.0125,	.0241,	.0242,

Table Fishing mortality (F) at age

YEAR,	1982,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	FBAR 89-91
AGE											
3,	.0197,	.0364,	.0546,	.1040,	.0436,	.0475,	.1092,	.0327,	.0624,	.0110,	.0353,
4,	.0228,	.0354,	.0742,	.2502,	.1078,	.0483,	.0728,	.0076,	.0354,	.0110,	.0180,
5,	.0202,	.0322,	.1278,	.3118,	.3589,	.1479,	.0639,	.0196,	.0289,	.0220,	.0235,
6,	.0216,	.0324,	.0739,	.3916,	.4954,	.1268,	.0964,	.0453,	.0442,	.0430,	.0442,
7,	.0274,	.0274,	.0796,	.3318,	.5800,	.4047,	.1763,	.0433,	.0375,	.0430,	.0413,
8,	.0217,	.0211,	.0752,	.5257,	.8360,	.2738,	.6516,	.0490,	.0189,	.0430,	.0370,
9,	.0217,	.0229,	.1453,	.4424,	.9138,	.2739,	.2069,	.1276,	.1148,	.0430,	.0951,
10,	.0110,	.0308,	.0983,	.1976,	1.4545,	.4885,	.3082,	.0611,	.6203,	.0430,	.2415,
11,	.0010,	.0150,	.0320,	.2520,	1.0800,	.2500,	.2400,	.0660,	.0540,	.0430,	.0543,
+gp,	.0010,	.0150,	.0320,	.2520,	1.0800,	.2500,	.2400,	.0660,	.0540,	.0430,	
FBAR 5- 9,	.0225,	.0272,	.1004,	.4007,	.6368,	.2454,	.2390,	.0569,	.0489,	.0388,	

Run title : Herring, Norwegian Spring Spawners (run name: RUN1)

At 21/10/1992 12:15

Traditional vpa using screen input for terminal F

Table Stock number at age (start of year) Numbers*10**-4

YEAR,	1973,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,
AGE									
3,	3275,	11225,	4349,	79834,	55180,	14216,	49981,	32428,	42930,
4,	42225,	2652,	9847,	3513,	67925,	46385,	12200,	43293,	27875,
5,	109,	34720,	2306,	8635,	2577,	57436,	39591,	10538,	36535,
6,	189,	36,	28194,	1940,	7582,	2231,	48533,	34122,	9040,
7,	32,	27,	8,	21889,	1703,	6658,	1878,	41567,	29198,
8,	21,	2,	6,	6,	17997,	1456,	5846,	1618,	35017,
9,	2,	2,	2,	5,	5,	14795,	1221,	5133,	1380,
10,	2,	2,	2,	2,	4,	5,	12521,	1072,	4507,
11,	1,	1,	1,	1,	1,	4,	4,	10758,	941,
+gp,	252,	7,	7,	7,	7,	18,	20,	20,	7991,
TOTAL,	46108,	48674,	44722,	115832,	152982,	143204,	171795,	180549,	195414,

Table Stock number at age (start of year) Numbers*10**-4

YEAR,	1982,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	GMST 73-88	AMST 73-8
AGE													
3,	75540,	9483,	8985,	23181,	1347773,	45410,	64768,	9591,	32844,	82244,	0,	29918,	116785,
4,	37306,	65038,	8029,	7470,	18344,	1132952,	38024,	50988,	8151,	27096,	71428,	24814,	97692,
5,	24047,	32020,	55126,	6546,	5107,	14463,	947913,	31044,	44433,	6909,	23533,	14374,	79854,
6,	31277,	20693,	27225,	42600,	4208,	3132,	10954,	780857,	26731,	37905,	5934,	6499,	16997,
7,	7732,	26878,	17592,	22203,	25285,	2252,	2423,	8734,	655316,	22456,	31883,	2995,	12958,
8,	25217,	6606,	22963,	14265,	13991,	12432,	1319,	1784,	7345,	554249,	18889,	1392,	9923,
9,	29973,	21667,	5680,	18703,	7405,	5325,	8302,	604,	1491,	6329,	466200,	631,	7475,
10,	1179,	25753,	18596,	4313,	10552,	2608,	3556,	5927,	467,	1168,	5323,	288,	5292,
11,	3948,	1024,	21928,	14800,	3108,	2164,	1405,	2294,	4896,	220,	982,	133,	3756,
+gp,	8215,	7498,	5605,	25133,	23702,	10476,	4061,	2102,	3832,	4001,	3551,		
TOTAL,	244434,	216662,	191729,	179215,	1459477,	1231212,	1082724,	893925,	785504,	742577,	627723,		

Table 3.11

Run title : Herring, Norwegian Spring Spawners (run name: RUN1)

At 21/10/1992 12:15

Traditional vpa using screen input for terminal F

Table Spawning stock biomass at age (spawning time) Tonnes

YEAR,	1973,	1974,	1975,	1976,	1977,	1978,	1979,	1980,	1981,
AGE									
3,	2725,	9417,	3853,	71092,	71655,	3276,	8770,	13974,	21589,
4,	96519,	6096,	25172,	18084,	153970,	120806,	17294,	60229,	30762,
5,	335,	116295,	7751,	29149,	8711,	184115,	133034,	34931,	108779,
6,	597,	118,	105560,	7352,	28739,	8136,	183979,	135051,	33643,
7,	100,	95,	31,	87792,	6858,	26878,	7770,	172021,	111353,
8,	67,	11,	25,	27,	78355,	6596,	25621,	7406,	140665,
9,	9,	9,	9,	22,	25,	69260,	6085,	23561,	5392,
10,	9,	9,	9,	9,	22,	24,	64129,	5502,	23126,
11,	7,	7,	7,	7,	7,	19,	22,	56550,	5038,
+gp,	1234,	33,	33,	33,	33,	89,	98,	98,	40330,
TOTSPBIO,	101601,	132089,	142450,	213568,	348374,	419199,	446802,	509323,	520677,

Table Spawning stock biomass at age (spawning time) Tonnes

YEAR,	1982,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990,	1991,
AGE										
3,	12651,	1446,	1235,	3351,	71527,	4015,	6197,	1453,	28223,	59603,
4,	35976,	79644,	8024,	8414,	7380,	477446,	15090,	26403,	12699,	50495,
5,	50243,	66084,	142635,	14938,	11600,	30510,	1648381,	57526,	101546,	16602,
6,	109362,	53197,	85655,	126157,	11425,	8517,	29663,	1933571,	68089,	111763,
7,	29153,	106891,	64775,	73356,	79842,	6382,	7402,	26182,	1792160,	71510,
8,	98106,	27591,	88861,	49432,	46747,	37729,	4135,	6430,	30971,	1830337,
9,	121925,	93250,	22490,	69767,	26084,	17491,	27532,	2218,	5385,	21336,
10,	5267,	110493,	75067,	16571,	34401,	8407,	12217,	20876,	1744,	4383,
11,	18235,	4976,	91048,	57980,	10685,	7540,	4941,	8886,	18603,	793,
+gp,	41010,	36592,	24103,	103477,	83001,	37950,	14708,	8152,	16567,	16711,
TOTSPBIO,	521927,	580164,	603892,	523444,	382692,	635988,	1770268,	2091698,	2075989,	2183533,

Table 3.12

Herring, Norwegian Spring Spawners

Prediction with management option table: Input data

Year: 1992								
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	6234.000	0.1300	0.0000	0.3000	0.1000	0.126	0.0110	0.160
4	714.000	0.1300	0.3000	0.3000	0.1000	0.184	0.0110	0.228
5	235.000	0.1300	0.9000	0.3000	0.1000	0.244	0.0220	0.267
6	59.000	0.1300	0.9000	0.3000	0.1000	0.287	0.0430	0.290
7	319.000	0.1300	1.0000	0.3000	0.1000	0.321	0.0430	0.320
8	189.000	0.1300	1.0000	0.3000	0.1000	0.357	0.0430	0.348
9	4662.000	0.1300	1.0000	0.3000	0.1000	0.362	0.0430	0.377
10	53.000	0.1300	1.0000	0.3000	0.1000	0.370	0.0430	0.392
11	10.000	0.1300	1.0000	0.3000	0.1000	0.379	0.0430	0.382
12+	36.000	0.1300	1.0000	0.3000	0.1000	0.388	0.0430	0.400
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Year: 1993								
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	8237.000	0.1300	0.0000	0.3000	0.1000	0.126	0.0110	0.160
4	.	0.1300	0.3000	0.3000	0.1000	0.184	0.0110	0.228
5	.	0.1300	0.9000	0.3000	0.1000	0.244	0.0220	0.267
6	.	0.1300	0.9000	0.3000	0.1000	0.287	0.0430	0.290
7	.	0.1300	1.0000	0.3000	0.1000	0.321	0.0430	0.320
8	.	0.1300	1.0000	0.3000	0.1000	0.357	0.0430	0.348
9	.	0.1300	1.0000	0.3000	0.1000	0.362	0.0430	0.377
10	.	0.1300	1.0000	0.3000	0.1000	0.370	0.0430	0.392
11	.	0.1300	1.0000	0.3000	0.1000	0.379	0.0430	0.382
12+	.	0.1300	1.0000	0.3000	0.1000	0.388	0.0430	0.400
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	.	0.1300	0.0000	0.3000	0.1000	0.126	0.0110	0.160
4	.	0.1300	0.3000	0.3000	0.1000	0.184	0.0110	0.228
5	.	0.1300	0.9000	0.3000	0.1000	0.244	0.0220	0.267
6	.	0.1300	0.9000	0.3000	0.1000	0.287	0.0430	0.290
7	.	0.1300	1.0000	0.3000	0.1000	0.321	0.0430	0.320
8	.	0.1300	1.0000	0.3000	0.1000	0.357	0.0430	0.348
9	.	0.1300	1.0000	0.3000	0.1000	0.362	0.0430	0.377
10	.	0.1300	1.0000	0.3000	0.1000	0.370	0.0430	0.392
11	.	0.1300	1.0000	0.3000	0.1000	0.379	0.0430	0.382
12+	.	0.1300	1.0000	0.3000	0.1000	0.388	0.0430	0.400
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Notes: Run name : RUN02
Date and time: 21OCT92:12:46

Table 3.13

Herring, Norwegian Spring Spawners

Herring, Norwegian Spring Spawners

Prediction with management option table

Year: 1992					Year: 1993					Year: 1994	
F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	Stock biomass	Sp.stock biomass
1.1000	0.0463	2885107	1947468	100410	0.0000	0.0000	3884956	2103166	0	4180727	3078720
.	.	.	.	.	0.1000	0.0041	.	2100821	10170	4171056	3067410
.	.	.	.	.	0.2000	0.0081	.	2098480	20305	4161418	3056152
.	.	.	.	.	0.3000	0.0122	.	2096141	30407	4151811	3044947
.	.	.	.	.	0.4000	0.0162	.	2093805	40476	4142236	3033795
.	.	.	.	.	0.5000	0.0203	.	2091472	50511	4132693	3022694
.	.	.	.	.	0.6000	0.0243	.	2089142	60513	4123182	3011645
.	.	.	.	.	0.7000	0.0284	.	2086814	70482	4113702	3000648
.	.	.	.	.	0.8000	0.0324	.	2084490	80418	4104253	2989702
.	.	.	.	.	0.9000	0.0365	.	2082168	90321	4094835	2978806
.	.	.	.	.	1.0000	0.0405	.	2079849	100192	4085448	2967962
.	.	.	.	.	1.1000	0.0446	.	2077533	110029	4076093	2957167
.	.	.	.	.	1.2000	0.0486	.	2075220	119835	4066768	2946423
.	.	.	.	.	1.3000	0.0527	.	2072910	129608	4057474	2935728
.	.	.	.	.	1.4000	0.0568	.	2070602	139348	4048210	2925084
.	.	.	.	.	1.5000	0.0608	.	2068298	149057	4038977	2914488
.	.	.	.	.	1.6000	0.0649	.	2065996	158733	4029774	2903942
.	.	.	.	.	1.7000	0.0689	.	2063697	168378	4020601	2893444
.	.	.	.	.	1.8000	0.0730	.	2061401	177991	4011459	2882995
.	.	.	.	.	1.9000	0.0770	.	2059107	187573	4002346	2872594
.	.	.	.	.	2.0000	0.0811	.	2056817	197123	3993263	2862242
.	.	.	.	.	2.1000	0.0851	.	2054529	206642	3984210	2851937
.	.	.	.	.	2.2000	0.0892	.	2052244	216129	3975187	2841679
.	.	.	.	.	2.3000	0.0932	.	2049962	225586	3966193	2831469
.	.	.	.	.	2.4000	0.0973	.	2047682	235011	3957228	2821306
.	.	.	.	.	2.5000	0.1013	.	2045406	244405	3948293	2811190
.	.	.	.	.	2.6000	0.1054	.	2043132	253769	3939387	2801121
.	.	.	.	.	2.7000	0.1095	.	2040861	263103	3930510	2791098
.	.	.	.	.	2.8000	0.1135	.	2038593	272405	3921662	2781121
.	.	.	.	.	2.9000	0.1176	.	2036327	281678	3912842	2771189
.	.	.	.	.	3.0000	0.1216	.	2034065	290920	3904052	2761304
-	-	Tonnes	Tonnes	Tonnes	-	-	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes

Notes: Run name : RUN02
Date and time : 21OCT92:12:46
Computation of ref. F: Weighted mean, age 5 - 12
Basis for 1992 : F factors

Table 3.14

Stock: Norwegian spring-spawning herring.

Assessment Quality Control Diagram 1

Average F(4-9,u)					
Date of assessment	Year				
	1987	1988	1989	1990	1991
1988					
1989	.21	.20			
1990	.22	.19	.05		
1991	.14	.13	.04	.05	
1992	.21	.21	.05	.05	.03

Remarks: The age range 4.14 refers to rings and is comparable to 5-15 years old herring.

Assessment Quality Control Diagram 2

Estimated total landings ('000 t) at *status quo* F							
Date of assessment	Year						
	1987	1988	1989	1990	1991	1992	1993
1988							
1989							
1990							
1991							
1992							
					Actual	Current	Forecast

$$\textit{Actual SQC} = \textit{Landings}(y) \times \frac{F(y-1)}{F(y)} \times \exp\left[-\frac{1}{2}\{F(y-1) - F(y)\}\right]$$

where F(y) and F(y−1) are as estimated in the assessment made in year (y+1).

Stock: Norwegian spring-spawning herring.

Assessment Quality Control Diagram 3

Recruitment (age 3) Unit: million									
Date of assessment	Year class								
	1983	1984	1985	1986	1987	1988	1989	1990	1991
1987	2103								
1988	10259	191							
1989	10200	237	499						
1990	9935	446	289	156					
1991	10171	384	384	64	134				
1992	13478	454	647	96	382	822	6234	8237	8308

Remarks:

Assessment Quality Control Diagram 4

Spawning stock biomass ('000 t)							
Date of assessment	Year						
	1987	1988	1989	1990	1991	1992	1993[1]
1988	491						
1989	513	1336					
1990	506	1307	1497				
1991	532	1355	1547	1482			
1992	635	1770	2092	2076	2184	1947[1]	2103[1]

[1]Forecast.

Table 4.1 International catch of Barents Sea CAPELIN ('000 t) in the years 1965 to 1991 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[1]	620	243	24	887				

[1]Preliminary.

Table 4.2 Catch in numbers (millions) of Barents Sea CAPELIN in autumn 1991, 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							
	1	2	3	4	5	6	Sum	%
8 - 9	2.0						2.0	+
9 - 10	260.0	2.0					262.0	1.7
10 - 11	887.5	26.0					913.5	5.9
11 - 12	546.2	463.5					1009.7	6.5
12 - 13	368.7	1303.0	10.0				1681.7	10.8
13 - 14	81.2	2434.0	105.4				2620.4	16.9
14 - 15	30.0	2604.0	481.8	40.0			3155.4	20.3
15 - 16		1621.0	1141.0	180.0			2941.3	18.9
16 - 17		616.3	911.2	310.0	4.0		1841.5	11.9
17 - 18		184.6	381.5	220.0	40.0		826.1	5.3
18 - 19		41.1	62.9	100.0	20.0	20.0	244.0	1.6
19 - 20		6.0	7.1	20.0	1.0		34.1	0.2
20 - 21			1.0				1.0	+
Total	2175.6	9300.6	3101.5	870.0	65.0	20.0	15532.7	
%	14.0	59.9	20.0	5.6	0.4	0.1		100
Weight ('000 t)	12.06	126.41	63.69	21.57	1.72	0.65	225.83	

Table 4.3 Catch in numbers (millions) of Barents Sea CAPELIN in winter 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	%
	2	3	4	5	6		
9 - 10	20.0					20.0	
10 - 11	210.0	20.0				230.0	
11 - 12	260.0	162.0				422.0	
12 - 13		450.0				450.0	
13 - 14	40.0	1832.0	12.0			1884.0	
14 - 15	40.0	5708.0	1166.0			6914.0	
15 - 16		6893.0	3908.0	68.0		10869.0	
16 - 17		4778.0	5468.0	359.0		10605.0	
17 - 18		2125.0	4457.0	602.0		7184.0	
18 - 19		538.0	1554.0	781.0	40.0	2913.0	
19 - 20		222.0	155.0	128.0		505.0	
20 - 21			24.0	1.0		25.0	
Total	570.0	22728.0	16744.0	1939.0	40.0	42021.0	
%	1.4	54.1	39.9	4.6	0.1		100
Weight ('000 t)	2.50	409.84	392.10	56.92	1.31	862.7	

Table 4.4 Larval index for Barents Sea capelin

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

Table 4.5 Acoustic estimate of Barents Sea CAPELIN in autumn 1992.

Total length (cm)	Age (years) 1	2	3	4+	Total number (10^9)	Biomass (10^3 tons)	Mean weight (g)	Biomass (cum.) 10^3 tons
7.0 - 7.5	3.8				3.8	5.7	1.5	
7.5 - 8.0	8.8				8.8	18.2	2.1	
8.0 - 8.5	13.4				13.4	30.7	2.3	
8.5 - 9.0	34.0				34.0	88.7	2.6	
9.0 - 9.5	69.2				69.2	214.4	3.1	
9.5 - 10.0	91.6				91.6	308.8	3.4	
10.0 - 10.5	61.1	2.0			63.0	247.7	3.9	
10.5 - 11.0	47.9	7.5	0.2		55.6	253.6	4.6	
11.0 - 11.5	15.4	25.8	0.2		41.4	227.1	5.5	
11.5 - 12.0	4.0	34.7	1.0		39.6	253.5	6.4	
12.0 - 12.5	2.0	31.2	3.5		36.7	274.0	7.5	
12.5 - 13.0	0.1	28.5	6.1		34.7	298.7	8.6	
13.0 - 13.5		24.7	8.8		33.5	334.0	10.0	
13.5 - 14.0		18.0	13.8		31.8	367.2	11.5	
14.0 - 14.5		12.4	16.5		28.9	385.7	13.3	2200.9
14.5 - 15.0		7.0	16.6		23.6	351.2	14.9	1842.2
15.0 - 15.5		2.9	17.7		20.6	364.9	17.7	1491.0
15.5 - 16.0		1.1	14.2	0.1	15.4	311.3	20.3	1126.1
16.0 - 16.5		0.5	14.6	0.3	15.4	352.4	23.0	814.8
16.5 - 17.0		0.1	8.6	0.2	8.8	225.4	25.6	462.4
17.0 - 17.5			4.7	0.4	5.1	147.6	29.0	237.0
17.5 - 18.0			1.6	0.2	1.8	56.9	31.1	89.4
18.0 - 18.5			0.4	0.2	0.7	23.2	35.2	32.5
18.5 - 19.0			0.3		0.3	9.3	35.9	9.3
Number (10^9)	351.3	196.3	128.8	1.3	677.7			
Biomass (10^3 tons)	1249.1	1690.6	2171.7	39.0		5150.4		
Mean length (cm)	9.8	12.6	14.9	17.2	11.6			
Mean weight (g)	3.6	8.6	16.9	29.5			7.6	

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 1992. Stock in numbers (10^{-9}) at 1 October, stock and maturing stock biomass (10^{-3} tonnes) 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

Table 5.1 CAPELIN in the Iceland-East Greenland-Jan Mayen area. Preliminary TACs for the summer/autumn fishery, recommended TACS for the whole season, landings and remaining spawning stock in 1983/84-1991/92 in thousands of tonnes.

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

Table 5.2 Catches of CAPELIN in the Iceland-East Greenland-Jan Mayen area, 1964-1992 (thousand tonnes).

Year	Winter season			Summer & autumn season			Others	Total
	Iceland	Norway	Faroes	Iceland	Norway	Faroes		
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	-	1,159.6
1979	521.7	-	18.2	442.0	124.0	22.0	-	1,127.9
1980	392.1	-	-	367.4	118.7	24.2	17.3	919.6
1981	156.0	-	-	484.6	91.4	16.2	20.8	769.0
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	193.0	65.9	16.0	1,268.2
1986	341.8	50.0	-	552.5	149.7	65.4	5.3	1,164.7
1987	500.6	59.9	-	311.3	82.1	65.2	-	1,019.1
1988	600.6	56.6	-	311.4	11.5	48.5	-	1,028.6
1989	609.1	56.0	-	53.9	14.4	52.7	-	786.1
1990	612.0	62.5	12.3	83.7	21.9	21.9	-	798.0
1991	258.4	-	-	56.0	-	-	-	314.4
1992	573.5	47.6	-	-	-	-	-	-

Table 5.3 Abundance indices of 0-group CAPELIN 1972-1992 by areas.

Year	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
1977	+	2	29	+	31
1978	4	19	25	1	49
1979	3	18	19	1	41
1980	10	13	6	-	29
1981	+	8	5	+	13
1982	+	3	18	1	22
1983	+	2	17	9	28
1984	1	8	19	3	31
1985	+	16	17	4	37
1986	1	6	6	1	14
1987	3	22	26	1	52
1988	-	16	7	-	23
1990	+	7	12	2	21
1991	8	2	43	1	54
1992	3	11	20	+	35

Table 5.4 Acoustic abundance estimates of juvenile 1-group CAPELIN in number (billions) and biomass (thousand tonnes) by age groups in August 1982-1992. Vessels: BS = Bjarni Samundsson.

Year	Date	Vessel	Number	Biomass
1982	12/08-31/08	'AF BS	119.0	535.5
1983	13/08-31/08	'AF BS	154.6	649.9
1984	12/08-29/08	'AF BS	285.4	1,013.4
1985	08/08-27/08	'AF BS	30.9	117.4
1986	15/08-26/08	'AF BS	71.1	230.9
1987	15/08-10/09	'AF	101.5	306.1
1988	10/08-31/08	'AF	146.9	378.1
1989	11/08-08/09	'AF BS	110.6	371.7
1990	08/08-03/09	'AF BS	36.2	145.4
1991	06/08-05-09	'AF BS	49.6	251.6
1992	05/08-11/09	'AF BS	86.6	291.2

Table 6.1 Comparison of valid autumn/winter acoustic estimater of adult stock abundance by number. N_1=autumn stock estimate, C=catch in numbers between stock estimates, $N_{2calc}=(N_1-(C*e^{M/2}))*e^{-M}$ and N_{2est}=winter stock estimate.

Dates	N_1	C	N_{2calc}	N_{2est}
01/11/78-01/02/79	74.9	12.4	55.6	54.7
01/11/79-01/02/80	59.2	9.4	44.4	45.5
01/11/80-01/02/81	24.3	7.6	14.7	15.4
01/12/81-01/02/82	12.5	3.3	8.5	8.2
01/11/82-01/02/83	16.6	0.0	14.9	15.5
01/11/83-15/02/84	64.3	13.1	45.5	43.2
01/11/84-01/02/85	42.5	7.3	31.3	32.7
01/11/86-01/02/87	50.0	16.1	29.6	45.2
01/11/88-15-01/89	70.5	20.2	43.4	46.6
10/12/90-01/02/91	19.3	1.0	17.1	24.5
01/12/91-15/01/92	56.1	4.5	48.8	61.1

Fig. 2.1. Icelandic summer spawners.
Mean weight at age each year

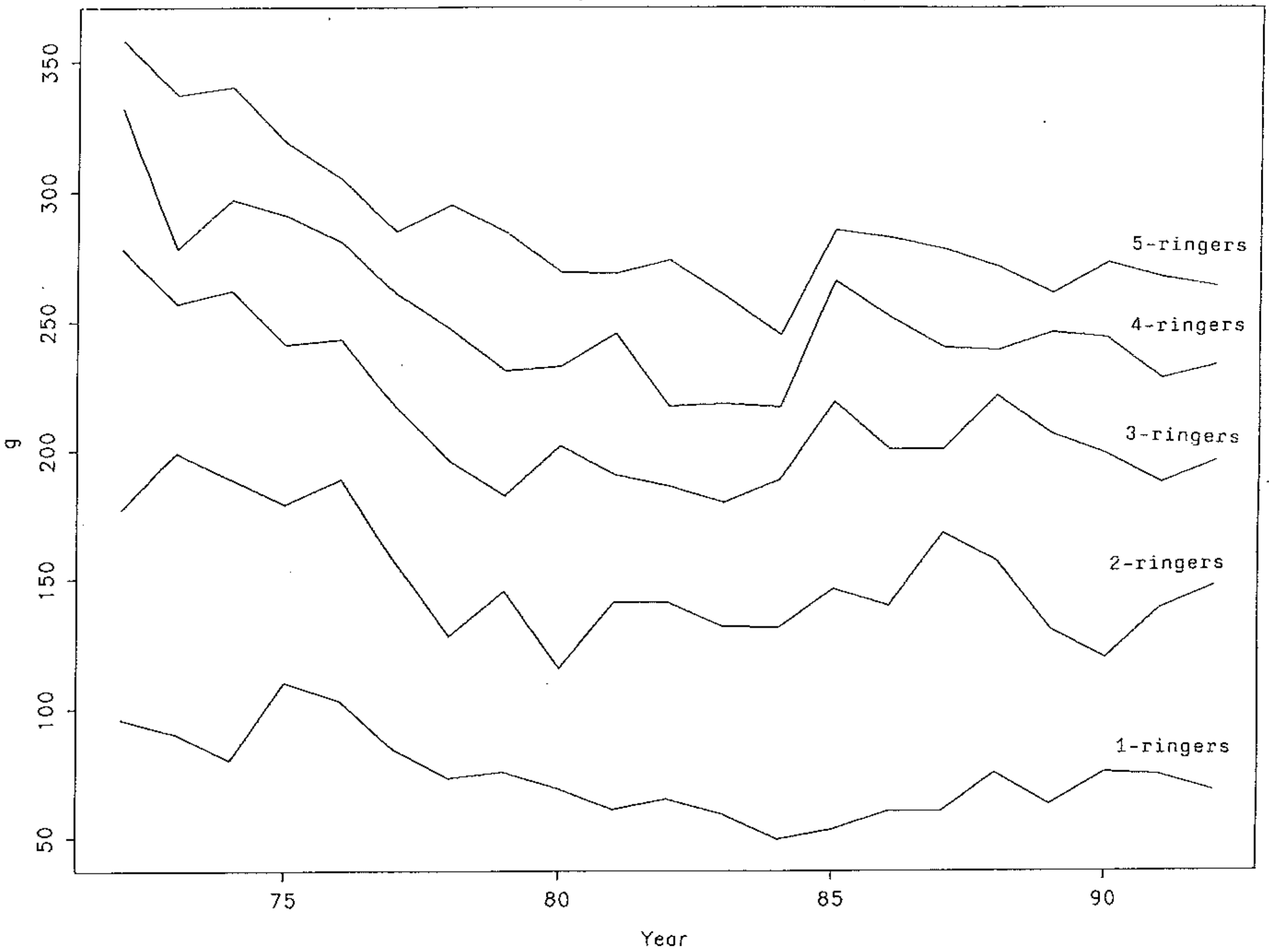


Fig. 2.2. Icelandic summer spawners.
SSE for fit of VPA to acoustics

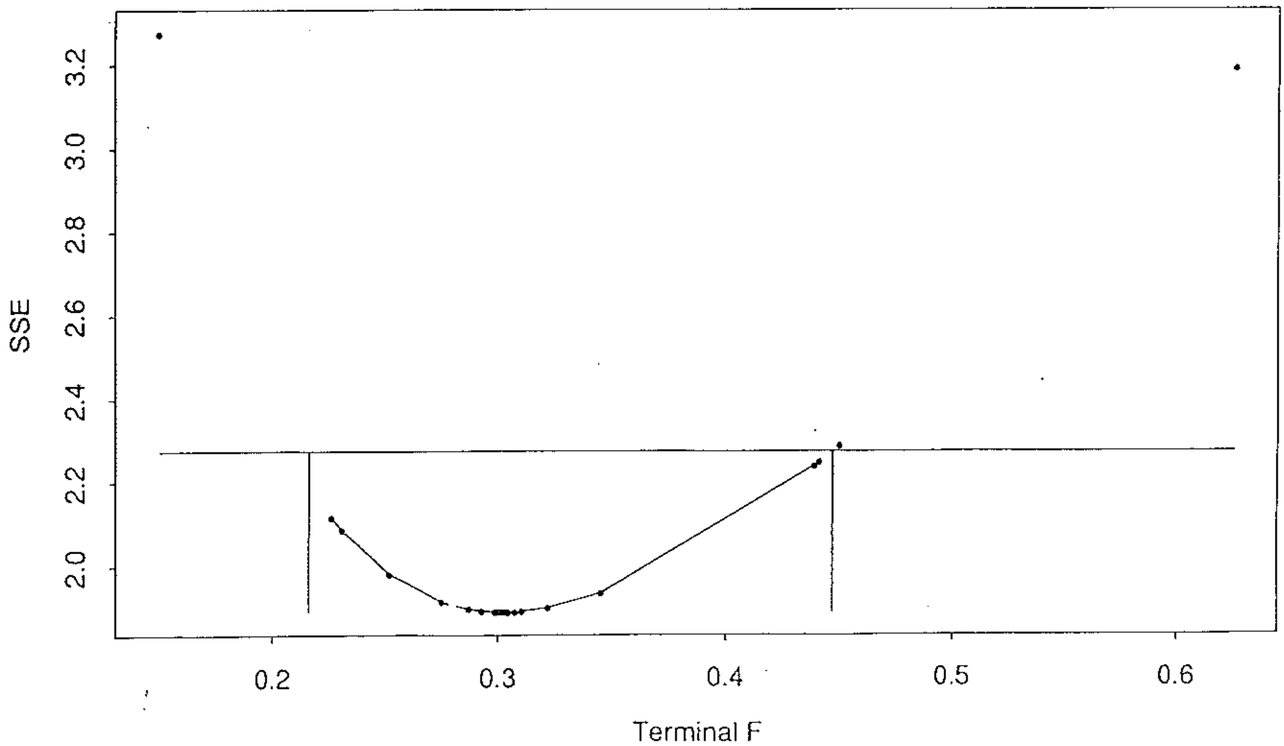


Fig. 2.3 Icelandic summer spawners.
Trends in acoustics and VPA stock numbers

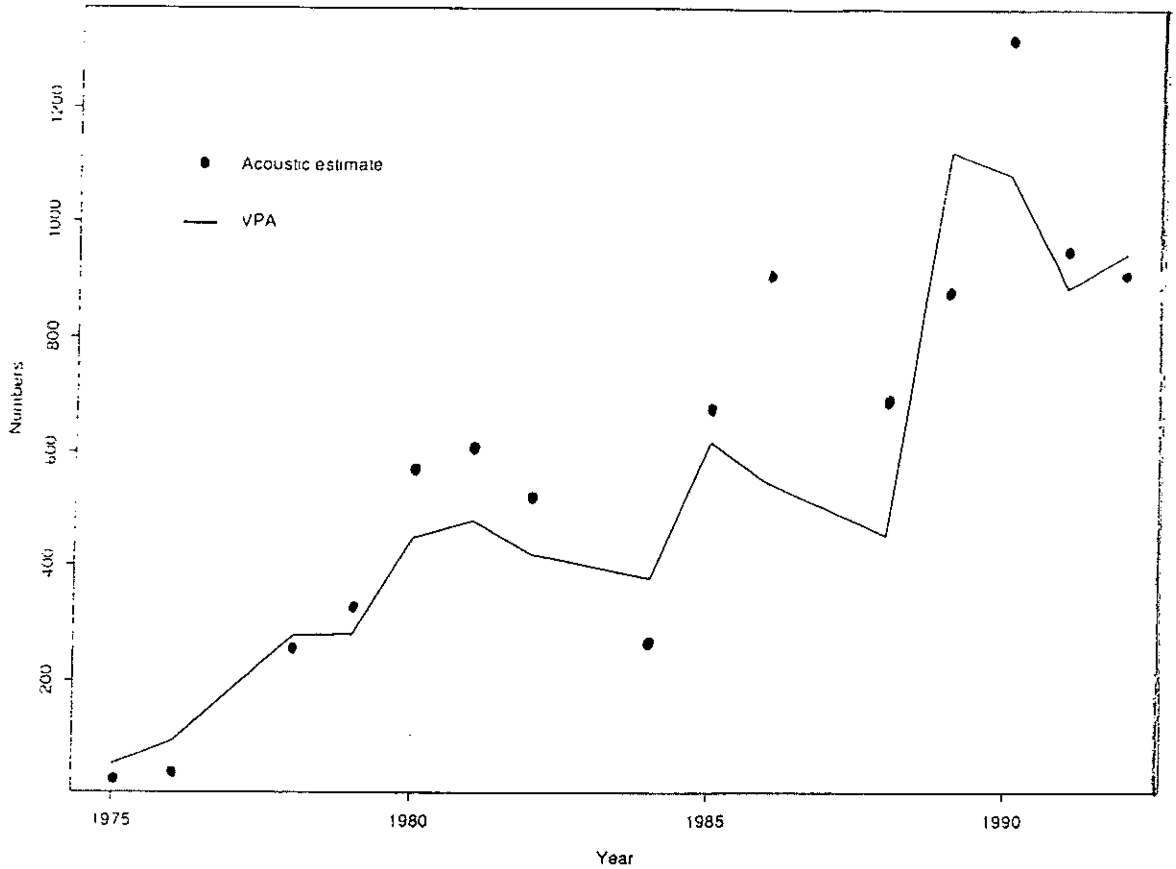


Fig. 2.4. Icelandic summer spawners.
Acoustic estimates vs VPA stock numbers

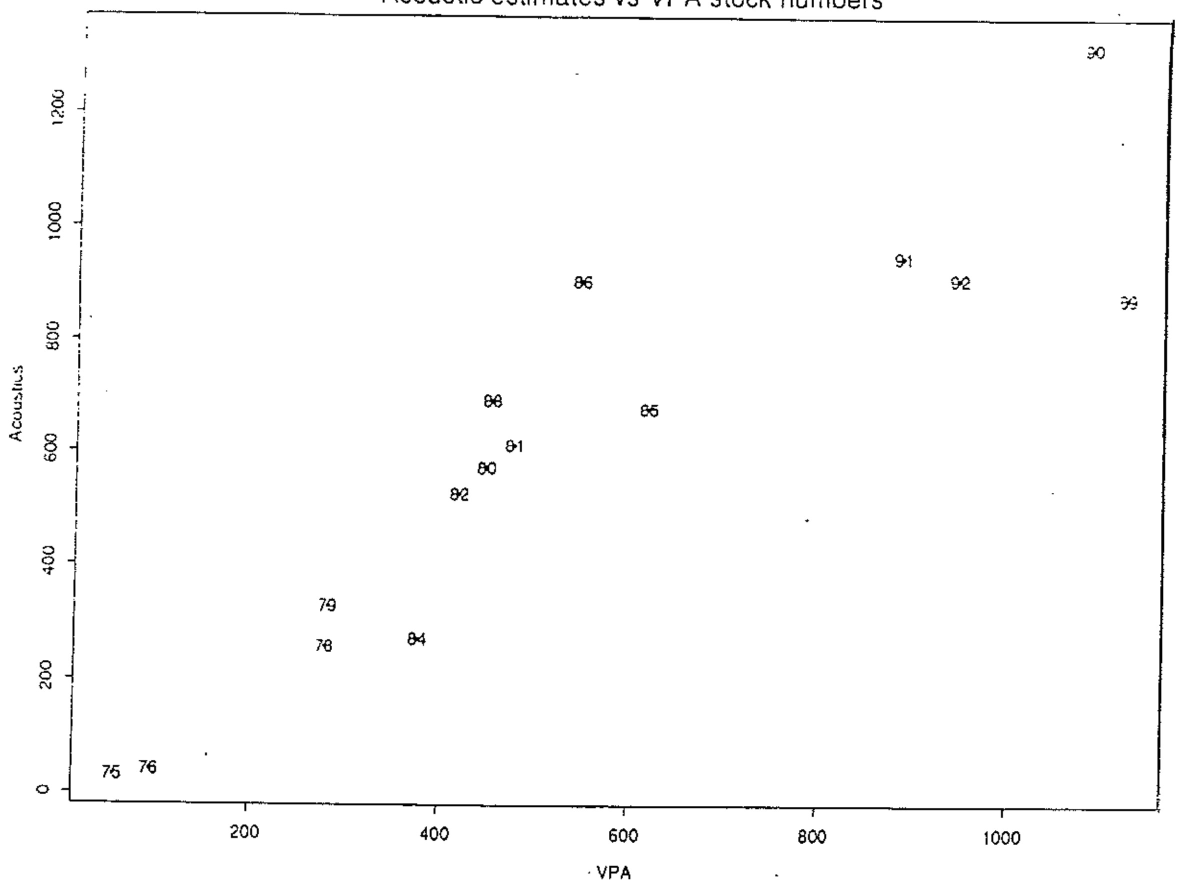
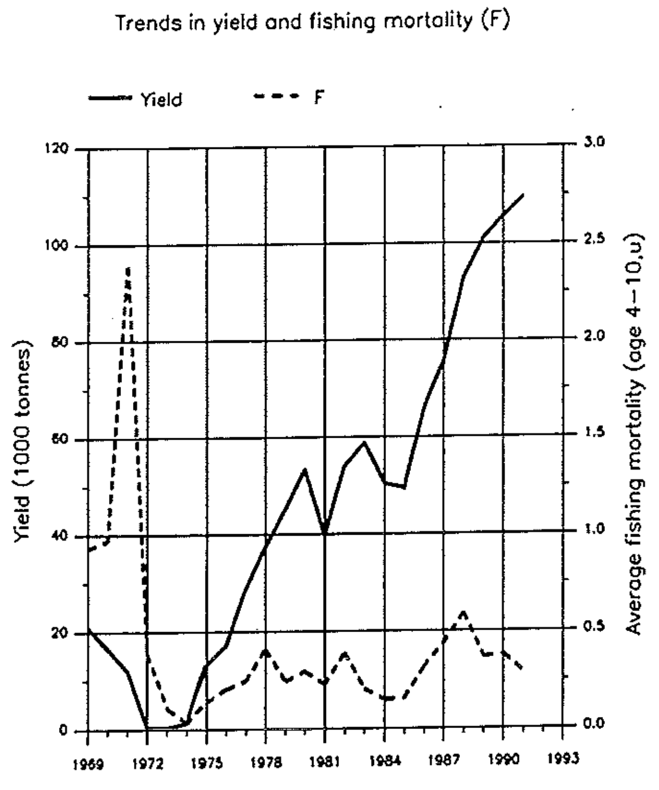
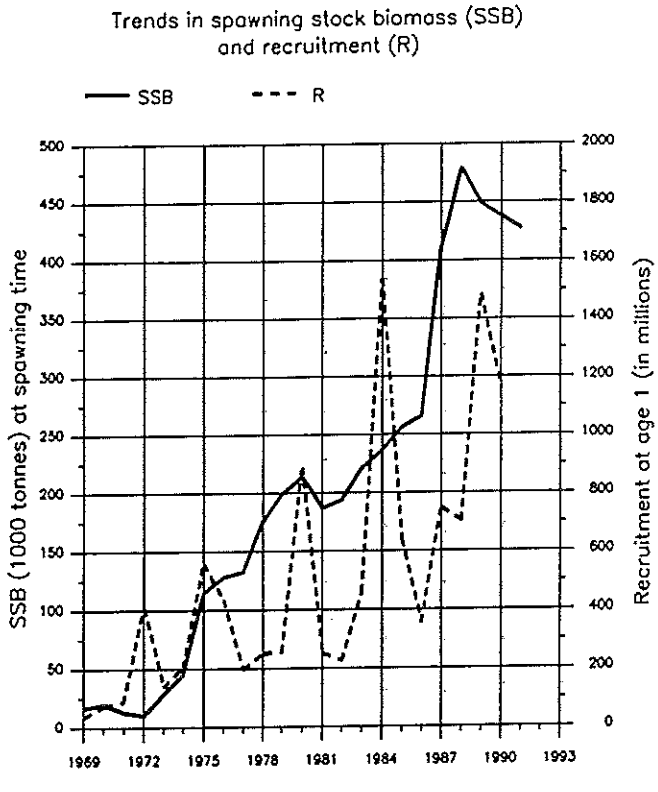


Figure 2.5

FISH STOCK SUMMARY
STOCK: Herring, Summer Spawning at Iceland (Fishing Area Va)
21-10-1992

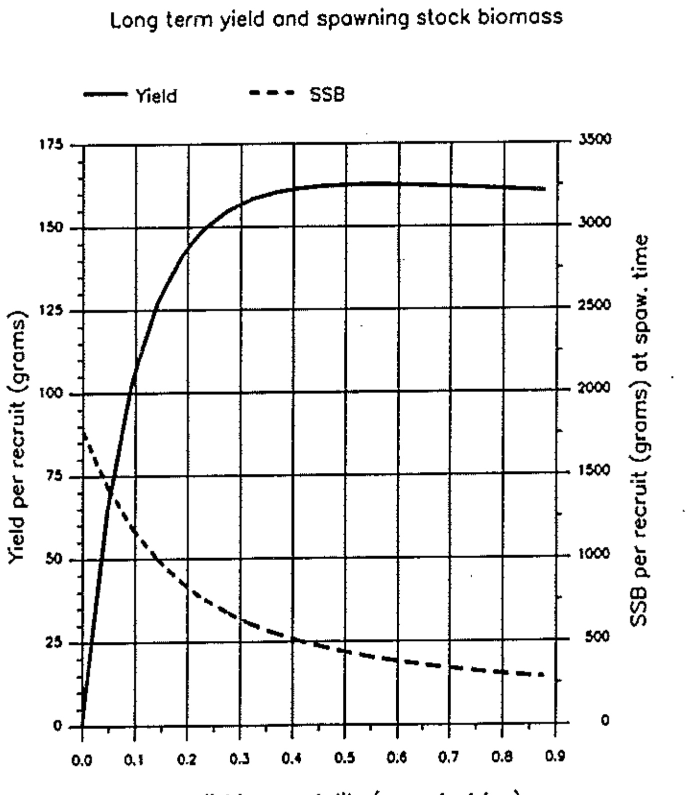


A



B

FISH STOCK SUMMARY
STOCK: Herring, Summer Spawning at Iceland (Fishing Area Va)
21-10-1992



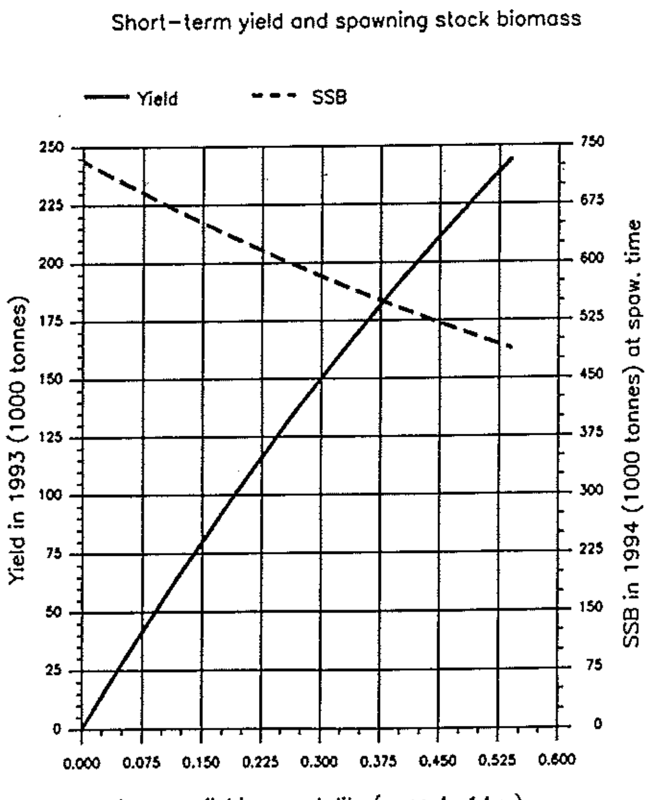


Fig. 2.6 Icelandic summer spawners.
Recruitment trend - actual and smoothed

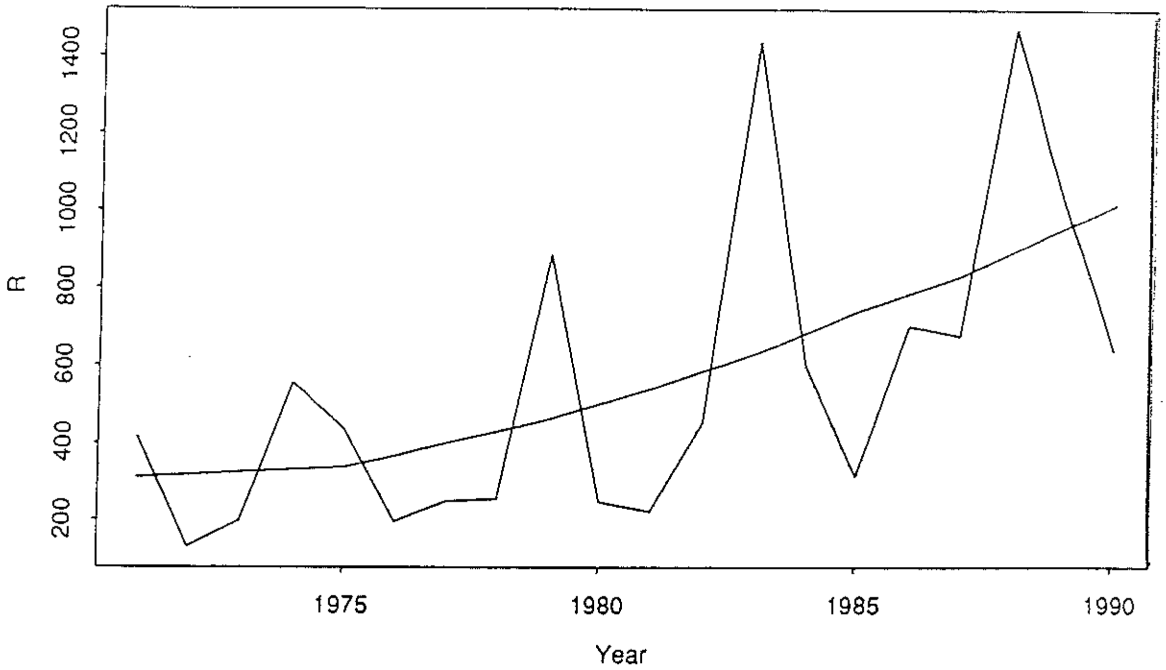


Figure 2.7

Icelandic Summer-spawning Herring

Long-term trends in SSB and recruitment

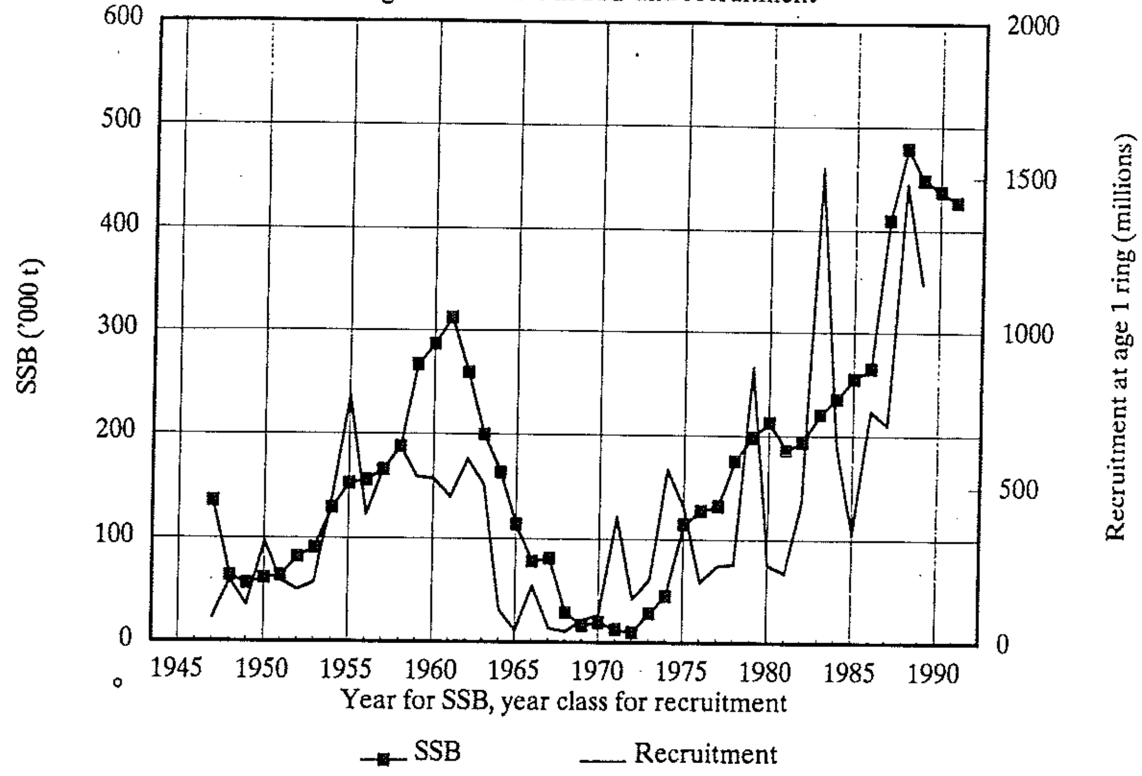
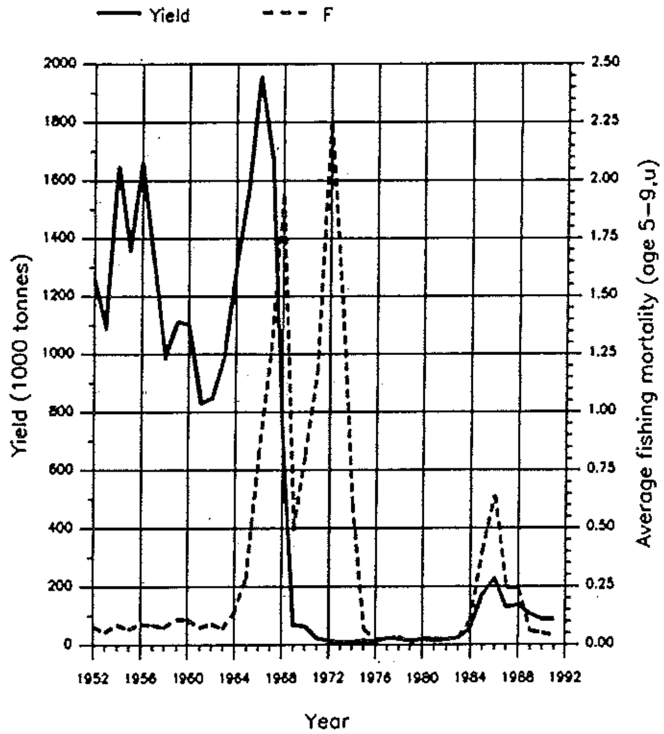


Figure 3.1

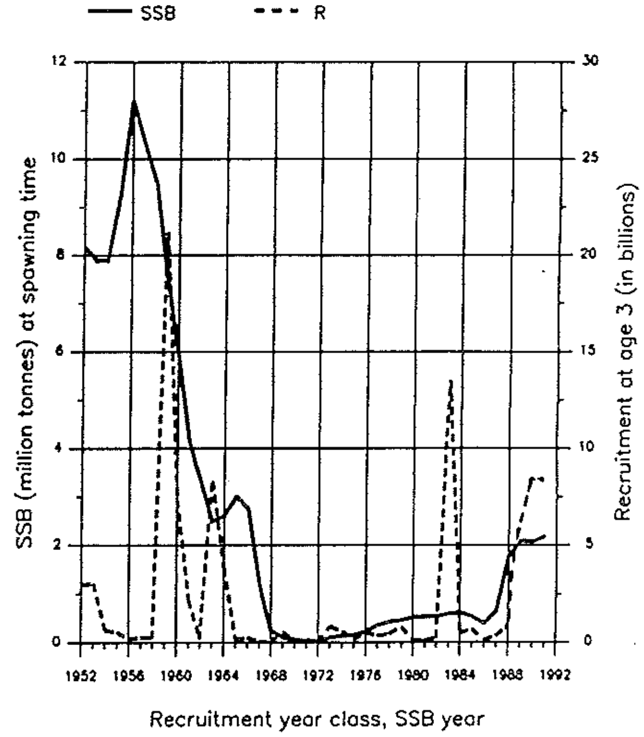
FISH STOCK SUMMARY
STOCK: Herring, Norwegian Spring Spawners
22-10-1992

Trends in yield and fishing mortality (F)



A

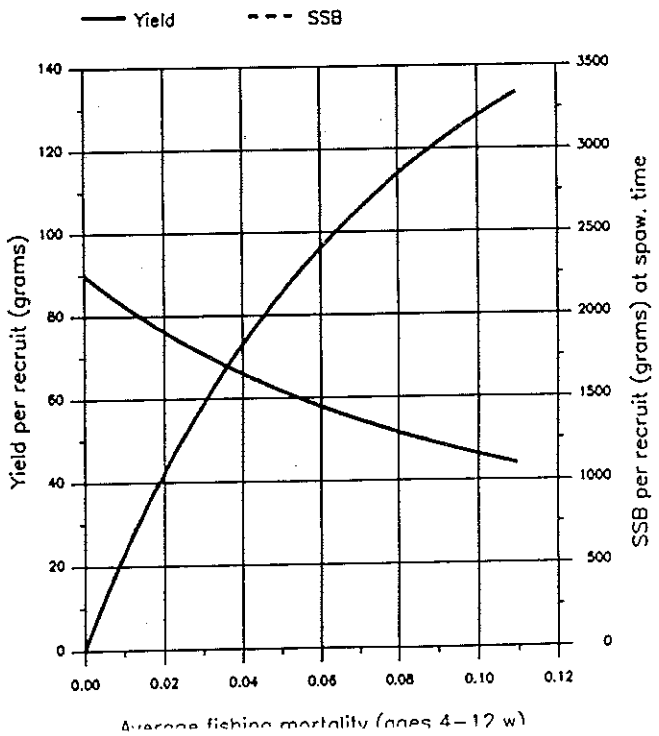
Trends in spawning stock biomass (SSB) and recruitment (R)



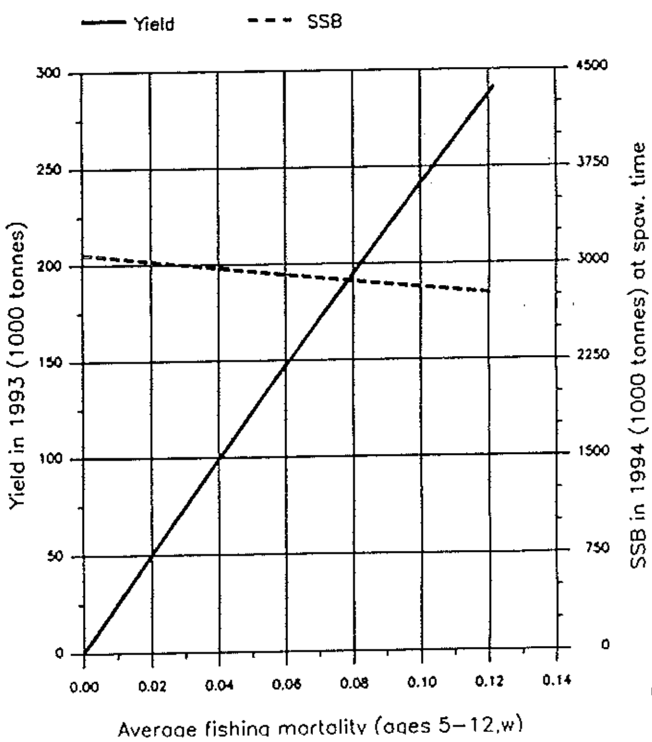
B

FISH STOCK SUMMARY
STOCK: Herring, Norwegian Spring Spawners
21-10-1992

Long term yield and spawning stock biomass



Short-term yield and spawning stock biomass



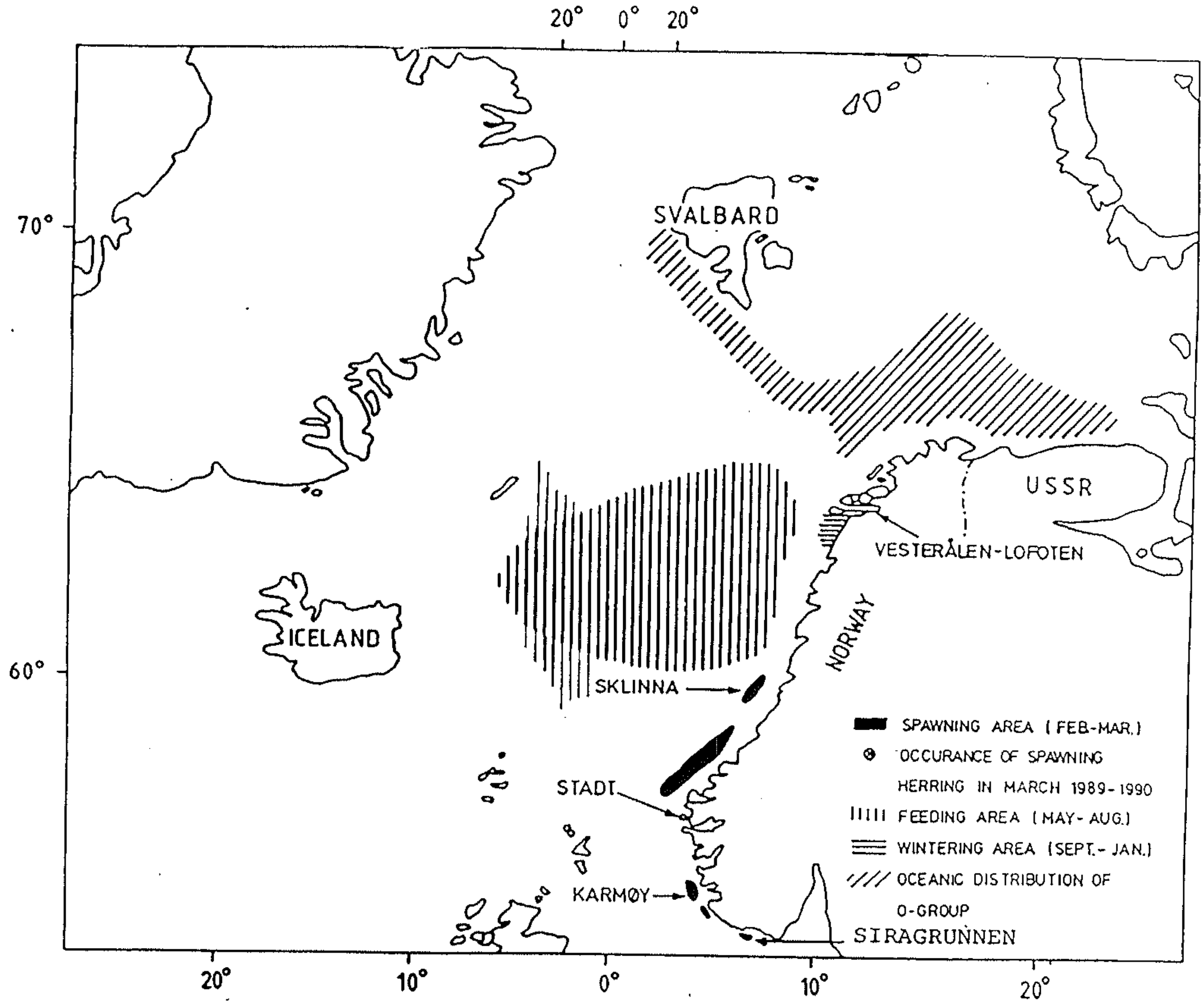


Figure 3.2 General distribution pattern of Norwegian spring-spawning herring in 1991 and 1992.

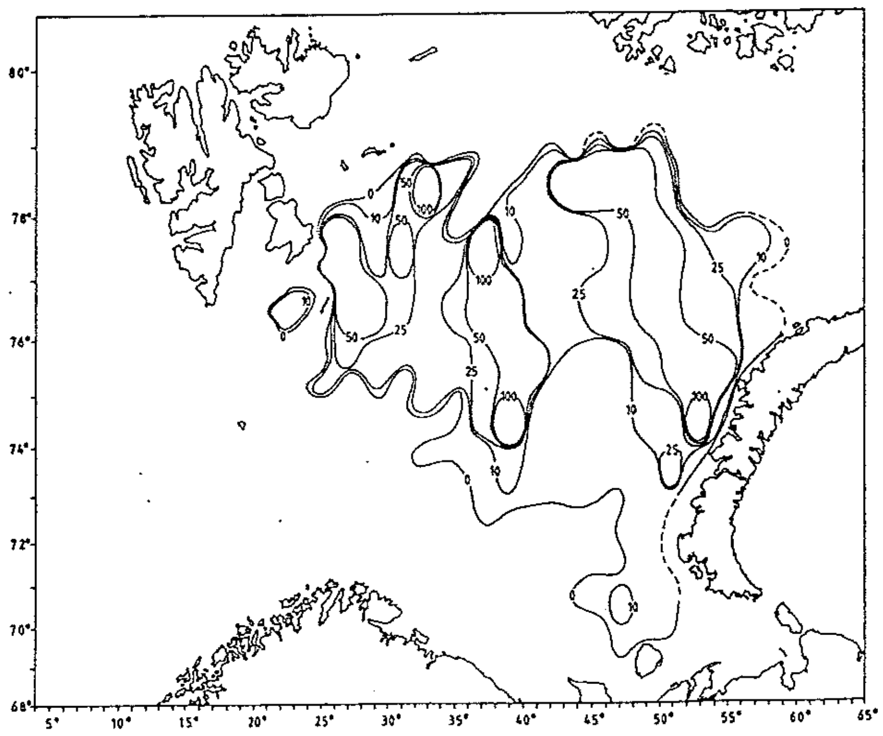
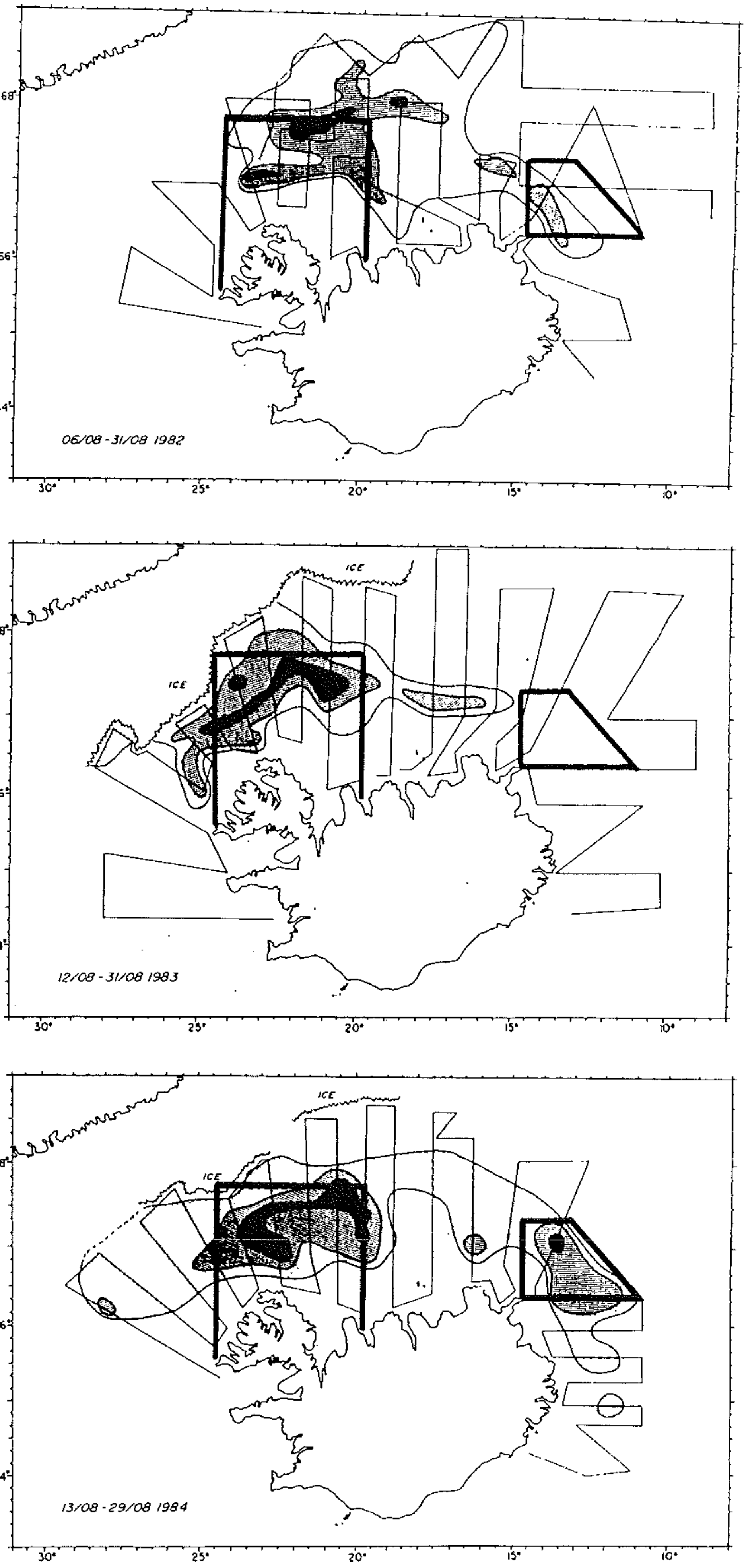


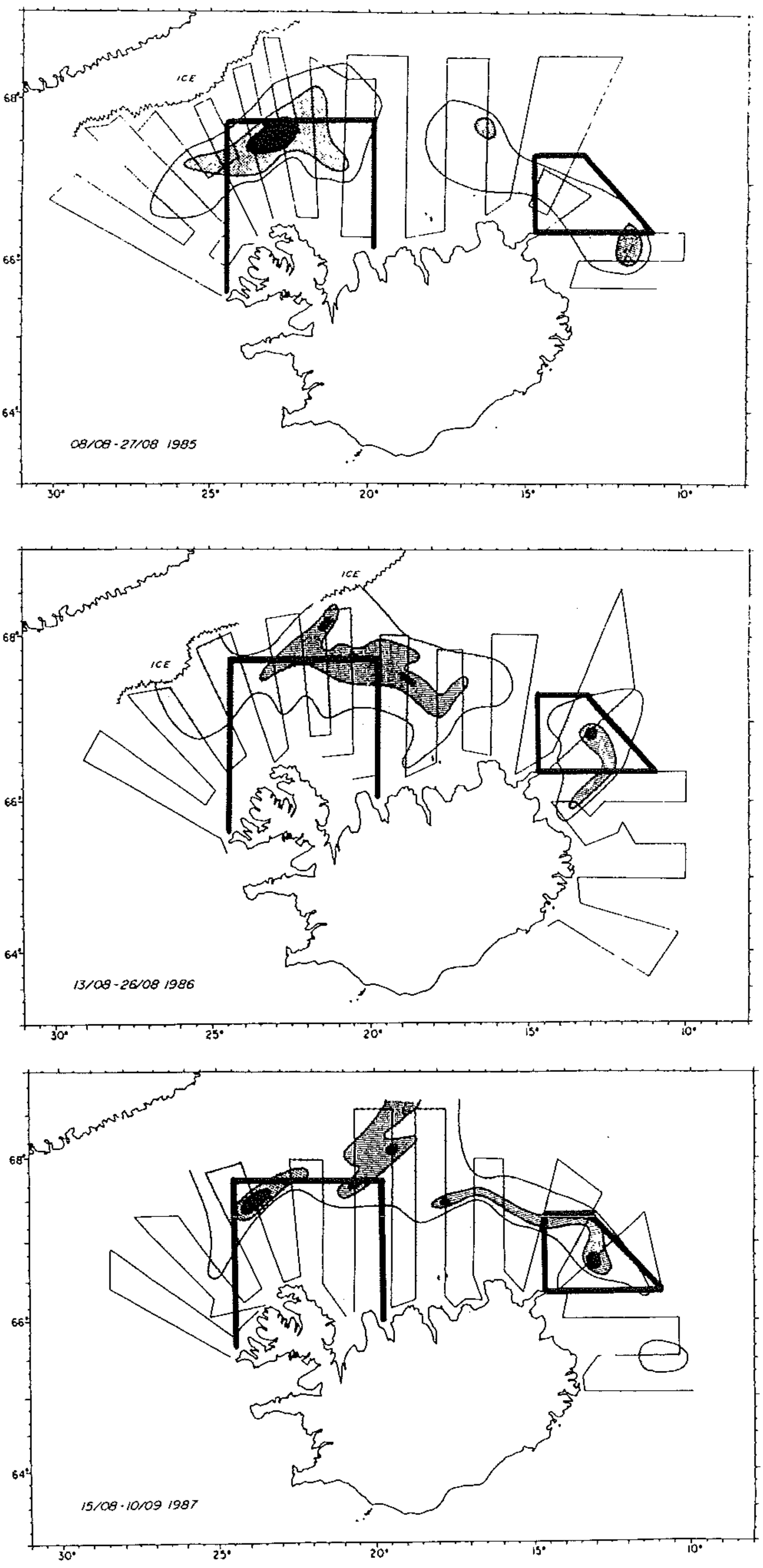
Figure 4.1 Estimated total density distribution of capelin (tons/square nautical mile)

Figure 5.1 Cruise tracks and distribution of immature capelin in August (1985-1987).



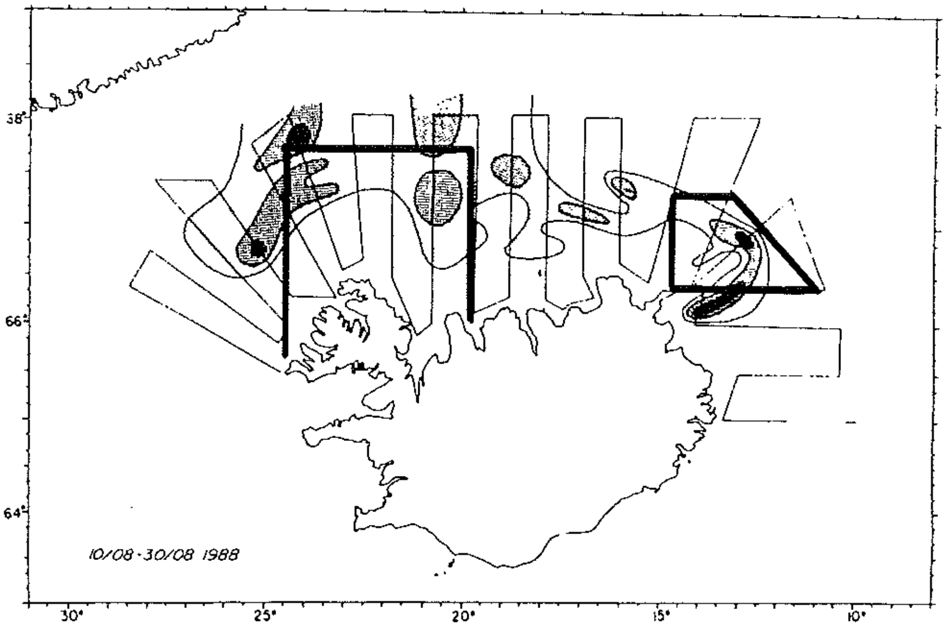
Continued

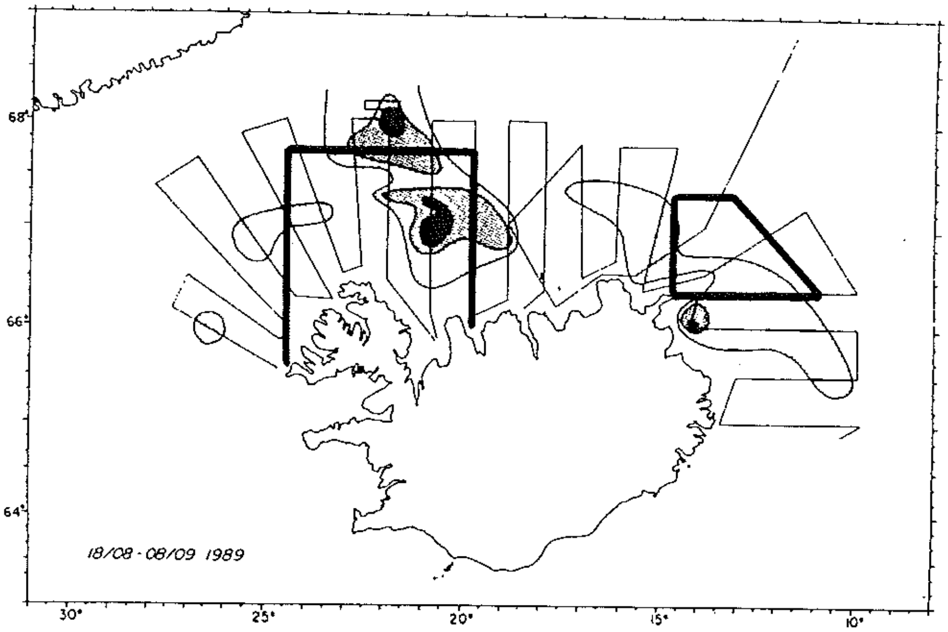
Figure 5.1 Continued



Continued

Figure 5.1 Continued





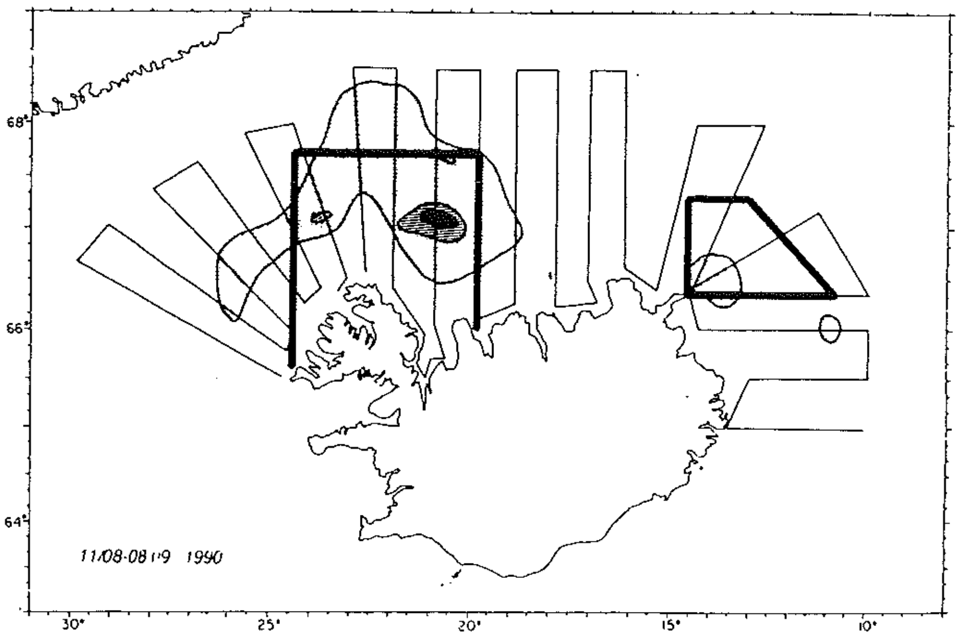


Figure 6.1 Icelandic Cod over 50 cm in March. Capelin in cod stomachs (grams per stomachs).

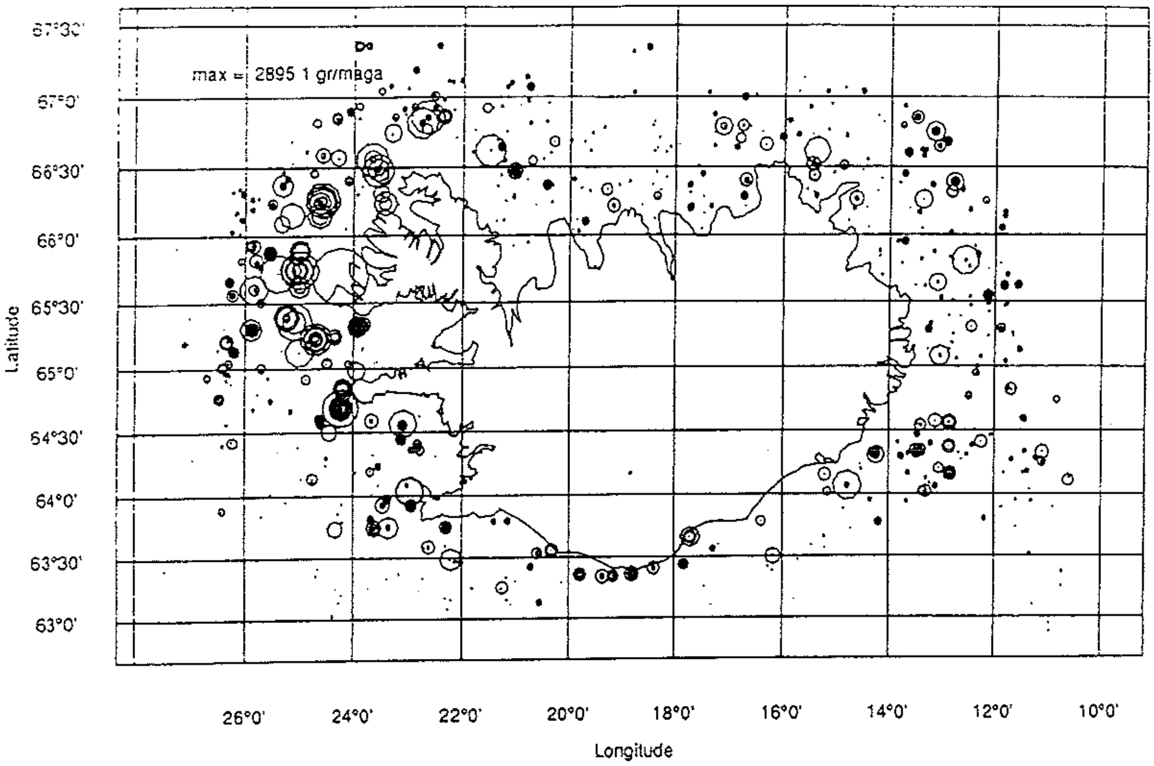
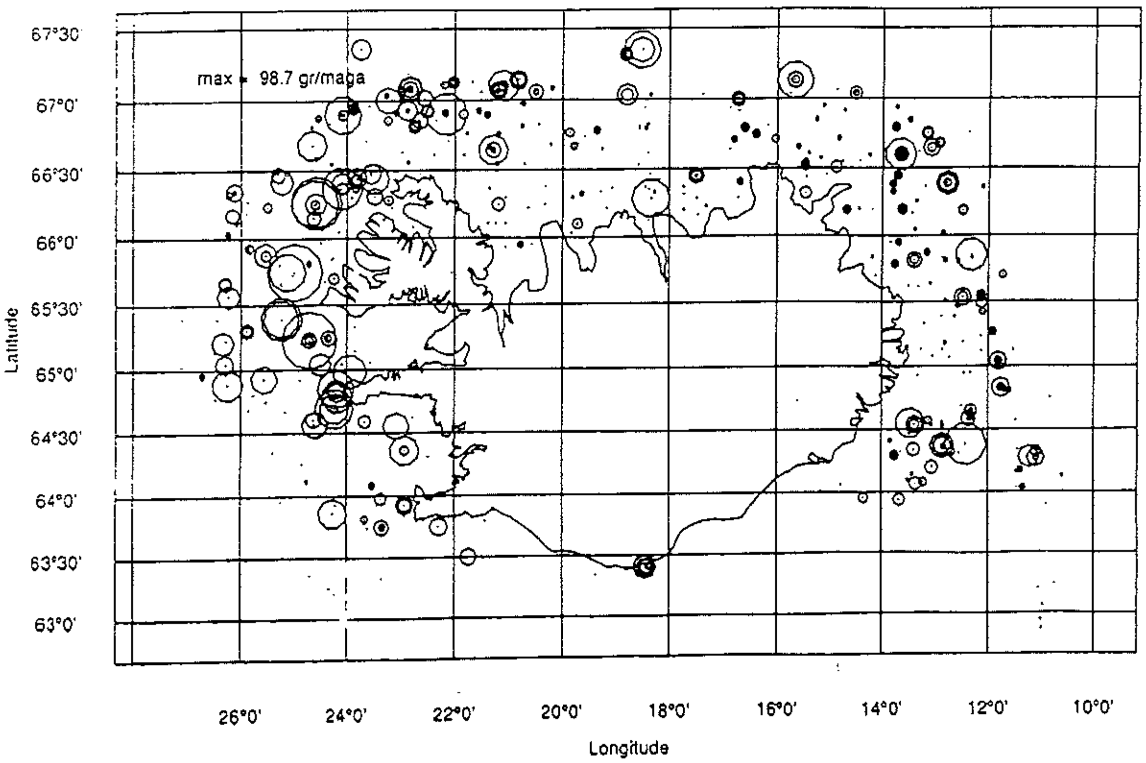


Figure 6.2 Icelandic Cod under 50 cm in March. Capelin in cod stomachs (grams per stomachs).



APPENDIX A

ICELANDIC SUMMER SPAWNERS - PREDICTING WEIGHTS AT AGE

Mean weights at age have been predicted by using a simple regression of the weight increase on the mean weight in the year before, i.e., by using

$$W_{a+1,y+1} - W_{ay} = \alpha + \beta' W_{ay} \qquad (1)$$

which is equivalent to fitting the model

$$W_{a+1,y+1} = \alpha + \beta W_{ay} \qquad (2)$$

where $1+\beta' = \beta$. Noticably, the same model has been used for age groups 2-8 and measurements for those ages have been used in a combined regression.

A preliminary analysis was undertaken in order to examine whether this model could be improved. Data in this analysis consisted of the mean weights at age (Table 2.2) for ages 1-7 in the years 1980-1990 growing to ages 2-8 in the years 1981-1991. Differences in growth between age groups were considered, as were differences between cohorts. The importance of density dependence in growth was also tested. The full class of models is described with:

$$W_{a+1,y+1} = \alpha_a + \beta_a W_{a,y} + \delta r_\tau + \chi_\tau + \gamma_y \qquad (3)$$

In the full model, both the intercept and slope in (2) are allowed to vary between age groups. If these were the sole components of the model, then it is equivalent to fitting a separate model for each age group.

In (3), τ denotes the year class (τ = y-a) and r is the size of the year class as 1-ringers. The parameter χ_τ estimates the possible difference in growth between cohorts, not due to their abundance. Since growth is obviously different between years, the parameter γ_y is included as an otherwise unexplained year effect.

Results from this analysis indicate that models (1)-(2) can be improved upon (Table A.1). The intercept (α_a) is significantly smaller for the older age groups than the younger ones. Thus the predictions can be slightly improved upon by using different intercepts in the regressions. The slopes (β_a) are not significantly different from each other and can therefore be collapsed into a single slope. The resulting term, βW_{ay}, can not be omitted from the model.

The cohort size is not significant in the model. The cohort effect is, however, significant when there is a year effect in the model.

The year effect is highly significant. Unfortunately the year effect is not known for the year which is to be predicted, so this term cannot be used in a prediction model.

The final model, which can be used in a predictive fashion is thus given by:

$$W_{a+1,y+1} - W_{a,y} = \alpha_a + \beta W_{a,y} \qquad (4)$$

It is clear, however, that measurements of an environmental parameter affecting the growth is desirable since the year effect explains about 60% of the variability left unexplained in (4).

The Working Group came to the conclusions that model (4) should be used in the future, pending some further testing. This testing should in particular attempt to identify important environmental variables such as appropriate zooplankton measures. Also, some further testing is required to verify the potential importance of density dependent growth, as indicated in Jakobsson and Halldórsson (1984).

Table A.1

```
*****************************************************************

Models with a year effect
*****************************************************************

> anova(lm(w~wm1+a+y+r+a*wm1+ycl,data=dat,singular.ok=T))
Analysis of Variance Table
```

Response: w $W_{ay} = \alpha_a + \beta_a W_{a-1,y-1} + \gamma_y + \delta r_r + \chi_r$

```
Terms added sequentially (first to last)  N.B.
          Df Sum of Sq Mean Sq F Value     Pr(F)
      wm1  1    331872  331872 8549.39 0.000000
        a  6      3281     547   14.09 0.000000
        y 10      6244     624   16.09 0.000000
        r  1        48      48    1.25 0.270917
      ycl 14      2736     195    5.03 0.000035
   a:wm1  6       159      27    0.68 0.664044  Not significant
Residuals 38      1475      39
> anova(lm(w~wm1+a+y+r+ycl,data=dat,singular.ok=T))
Analysis of Variance Table
```

Response: w $W_{ay} = \alpha_a + \beta W_{a-1,y-1} + \gamma_y + \delta r_r + \chi_r$

```
Terms added sequentially (first to last)
          Df Sum of Sq Mean Sq F Value     Pr(F)
      wm1  1    331872  331872 8935.21 0.000000
        a  6      3281     547   14.72 0.000000
        y 10      6244     624   16.81 0.000000
        r  1        48      48    1.30 0.259571
      ycl 14      2736     195    5.26 0.000011
Residuals 44      1634      37
> anova(lm(w~wm1+a+y+ycl,data=dat,singular.ok=T))
Analysis of Variance Table
```

Response: w $W_{ay} = \alpha_a + \beta W_{a-1,y-1} + \gamma_y + \chi_r$

```
Terms added sequentially (first to last)
          Df Sum of Sq Mean Sq F Value       Pr(F)
      wm1  1    331872  331872 8935.21 0.0000e+00
        a  6      3281     547   14.72 3.9000e-09
        y 10      6244     624   16.81 0.0000e+00
      ycl 15      2784     186    5.00 1.4435e-05
Residuals 44      1634      37
```

APPENDIX B

A NEW METHOD OF STOCK PROGNOSIS FOR THE ICELAND-EAST GREENLAND-JAN MAYEN CAPELIN STOCK

As stated in Section 5.9, stock prognoses, based on August estimates of juvenile capelin abundance, gave very misleading forecasts for the 1989/1990 and 1990/1991 seasons. In consequence, a new model for forecasting fishable stock abundance by number and biomass has been developed and works in the following way.

The new model for forecasting fishable stock abundance is based on the following facts and assumptions:

1. It is assumed that for all practical purposes that capelin belonging to this stock spawn only once and die thereafter.
2. There is practically no spawning of 2-group fish.
3. Each year class spawns only partly as 3-group fish. The remainder spawns as 4-group.
4. Maturity rate differs from one year class to another but appears to be in an approximately inverse relation to year class abundance.
5. It is possible to assess the number of fish in the fishable stock with a fair degree of accuracy by acoustic methods in autumn (October/November) and even more accurately in winter (January/February).
6. In the same way it is possible to assess the abundance of immature 1- and 2-group fish in autumn. However, the abundance of these stock components is always underestimated, especially that of the immature 2-group capelin. Useful information on the numbers of 1-group capelin may sometimes also be obtained in August and in the winter period.
7. The natural mortality rate (M) in the adult stock appears to be on average 0.035/month. The juvenile mortality rate (i.e., from 1- to the 2-group stage) is unknown, but for this purpose assumed to be the same.

The abundance of year classes 1980-1990 as 1-group was assessed in the autumn surveys with one exception. This was the 1986 year class which was partly inaccessible under ice at the time. The abundance of this year class was, however, successfully estimated at its 1-group stage in August.

Further, it is now clear that the 1989 year class has recruited to the 1991/1992 fishable stock in much larger numbers than the autumn 1990 survey results indicated. All data from that survey have now been scrutinized anew but in no way can it be ascertained whether the underestimate is due to an unusual behaviour pattern of the 1-group immatures in the survey area or simply because the survey did not cover all the distribution area of the 1989 year class. Due to the very low echo abundance in the 1990 autumn survey this underestimate cannot be explained by an incorrect distribution of trawl samples either. The fact remains, however, that the 1990 autumn acoustic estimate of 1-group capelin has failed (as did the August 1990 assessment also for that matter) and consequently we are left with 9 valid autumn 1-group estimates in the 1980-1989 year class series (Table B.1).

A regression of acoustic autumn estimates of the abundance of the 1980-1988 year classes as 1-group on that part of each year class for which back-calculations show matured and spawned at 3 years of age. Table B.2 gives $R^2=0.88$, $P=0.0002$ the slope and intercept being 0.89 and 2.9, respectively (regression 1). The relationship is illustrated in Figure B.1.

This comparison only deals with maturing capelin. Although the fishery will to some degree inevitably take immature 2-group capelin it is directed at the adult stock component. For the purpose of predicting fishable stock abundance it, therefore, seems reasonable to use the adult 2-group capelin measurement, i.e., the correlation between the autumn 1-group abundance estimates and the estimates of that part of the year class which matured and spawned at age 3.

Furthermore, acoustic estimates of the number of immature 2-group capelin, i.e., fish that will not mature and spawn until age 4, are also obtained during the autumn surveys. A comparison between such data to the number of 3-group capelin in the beginning of the season (1 August) gives $R^2=0.74$ and $P=0.003$. However, the numbers of immature 2-group fish are always grossly underestimated in the autumn surveys and consequently the regression is very sensitive to the availability of this component of the year class to acoustic surveying at that time of the year.

The total number of fish in each year class in the beginning of each fishing season (1 August) can be calculated, both for age groups 2 and 3, from acoustic abundance estimates, catches and natural mortality rates (Table B.2). As shown in Figure B.2, there is a very close correlation between these two pairs of estimates (R^2=0.87; P=0.0001, with a slope and intercept of 0.43 and -12.7). The explanation is that the maturity rate is closely but inversely related to year class size. This regression (regression 2) may, therefore, be used as reference when forecasting numbers of fish in the older year class in the fishable stock. This would then be done from the total acoustic estimate of 2-group fish obtained in the autumn or winter surveys in the preceding season. However, the immature part of the year class is also under-represented in such acoustic estimates of 2-group abundance and a forecast based upon such data will, consequently, always underestimate 3 group abundance to some degree. This forecast will on the other hand not be as sensitive to deviations from the "true" or relative abundance of immature 2-group fish as that using the immature 2-group component only.

As stated above, the capelin fishery in the summer and autumn season is mainly aimed at that part of the stock which is in the process of maturing and consists of individuals with high growth rate, feeding in the oceanic area between Iceland, Greenland and Jan Mayen. Indeed, areas known to contain a high proportion of juveniles have usually been closed to the fishery.

The rate of growth of maturing capelin is by far the highest in spring and summer but varies with feeding conditions and areas. In addition capelin continue to increase their weight almost until spawning commences in March. Although good catches have often been made in August and September the highest catch rates are normally not obtained until in October and onwards. In order to forecast mean weights for the summer and autumn season it seems, therefore, most reasonable to use mean average weights by age in the fishable stock (maturing capelin) in autumn. Such information is obtained in acoustic surveys in October/November are given for the year classes 1980(79)-1989(88) in Table B.3.

We may now forecast fishable stock biomass at the beginning of the season as follows:

$$W_{tot} = N_2 * w_2 + N_3 * w_3.$$

or in more detail:

$$W_{tot} = (N_1 * b_1 + a_1) * w_2 + (N_{2tot} * b_2 + a_2) * w_3,$$

where;

W_{tot} denotes the fishable stock biomass (maturing capelin on 1 August),

N_2 = numbers of maturing 2 group capelin in the fishable stock (regression 1),

N_3 is the number of mature 3 group capelin in the fishable stock (regression 2),

w_2 = 17.0 and w_3 = 24.5 are mean weights of 2 and 3 group capelin in autumn (Table B.3),

and

N_1 denotes the acoustic estimate of 1 group capelin by number in the autumn before,

N_{2tot} denotes the acoustic estimate of the total number of 2 group capelin in the autumn before,

a_1 = 2.9 and b_1 = 0.89 are intercept and slope of line in regression 1 (Fig. B.1),
a_2 = -12.7 and b_2 = 0.43 are intercept and slope of line in regression 2 (Fig. B.2).

In order to check the performance of the new model, fishable stock abundance and TACs have been calculated for the 1982/83 - 1991/92 seasons using the same criteria of remaining spawning stock, natural mortality rate and autumn assessments of the numbers of 1 and 2 group capelin. A comparison of stock abundance and TACs calculated in this way to actual advice on TACs set according to acoustic assessments of fishable stock abundance at the time is given in Table B.4.

As shown in Table B.4 the new model does indeed predicts changes in stock abundance along similar lines as those experienced in reality until the 1991/92 season. It was explained earlier that the quite dramatic recovery of the stock from its previous low is not indicated, but this is solely due the 1989 year class being much stronger than measured by acoustic surveys in the autumn (and summer) of 1990. As already mentioned there is absolutely no available information pointing in this direction and consequently no possibility to pinpoint the reason(s) why research failed. However, throughout the period of comparison the new model would otherwise have provided much better forecasts of fishable stock abundance, and consequently also of final TAC decisions, than the old one. Thus a regression of TACs, predicted by the new model, on recommended TACs gives a coefficient of determination, R2=0.82 (P=0.0008) with an intercept of 33.0 and a slope of 1.04 (Fig. B.3).

Table B.1

Acoustic abundance estimates of juvenile 1- and 2-group capelin in number (billions) and biomass (thousand tons) by age groups in autumn surveys 1980-1991. Ships: BS=Bjarni Sæmundsson; _F=_rni Fri_riksson; GOS=G. O. Sars; MS=Michael Sars.

Year	Dates	Vessels	Num/Bio	Age 1	Age 2
1981	03/11-29/11	BS	Number	23.7	1,4
			Biomass	89.8	15,1
1982	02/10-20/10	BS GOS	Number	68.0	1.7
			Biomass	260.4	14.4
1983	03/10-22/10	BS _F GOS	Number	44.1	8.2
			Biomass	224.5	77.9
1984	01/11-22/11	BS _F	Number	73.8	4.6
			Biomass	215.5	38.2
1985	08/10-29/10	BS _F	Number	33.8	12.6
			Biomass	129.0	107.1
1986	04/10-22/10	BS _F	Number	58.6	1,4
			Biomass	237.1	8,5
1987	18/11-04/12	BS	Number	*70.2	5,4
			Biomass	280.0	48.1
1988	06/10-24/10	BS _F	Number	43.9	6.7
			Biomass	133.5	52,3
1989	26/10-29/11	BS _F	Number	29.2	1.8
			Biomass	102.0	14.4
1990	08/11-27/11	BS	Number	**39.2	1.3
			Biomass	148.9	10.9
1991	15/11-26/11	BS _F	Number	60.0	5,2
			Biomass	282.1	45.8

* Invalid for 1-group due to ice. Estimated from August survey.
** Invalid for 1-group due to ice.

Table B.2

The calculated numbers of capelin (billions) of year classes 1976-1989 with reference to 1 August, divided on age groups and maturity stage.

Year class	Age group 2 immature	Age group 2 mature	Age group 2 total	Age group 3 mature
1976	15.3	81.9	97.2	10.1
1977	16.4	91.3	107.7	10.3
1978	4.2	35.4	39.6	2.8
1979	3.6	39.7	43,3	2,4
1980	15.0	17.1	32.1	9.8
1981	42.5	53.7	96,2	27.9
1982	40,9	40.7	81,6	26.9
1983	100.0	64.6	164.6	65.8
1984	29.4	35.6	65.0	20.0
1985	37.2	65.4	102.6	24.4
1986	24.0	70.3	94,3	15.8
1987	10.3	42.8	53.1	6.8
1988	10.3	31.9	42.2	6.7
1989	67.7	-	*74,3	-

* Total acoustic estimate (mature+immature), January 1992.

Table B.3

Mean weight (g) in autumn of the 1978-1989 year classes

Year class	Age groups 2 immature	2 mature	3 mature
1979			24.1
1980	11.0	16.5	22.6
1981	10.0	16.8	25.8
1982	11.8	15.8	23.8
1983	10.9	15.5	24.1
1984	11.1	18.1	25.8
1985	12.0	17.9	23.5
1986	12.0	15.5	25.5
1987	9.6	17.8	25.5
1988	9.8	18.1	25.3
1989	12.1	16.3	
Average	11.0	17.0	24.5

Table B.4

Predictions of fishable stock abundance and TACs for the 1982/83 - 1991/92 seasonsb based on autumn estimates of 1- and 2-group abundance. The last column gives contemporary advice on TAC_s for comparison.

Age 2 and age 3 are numbers in these age groups at the beginning of season. Fish.st. denotes calculated weight of maturing capelin on 1 August. TACpred denotes predicted TAC and TACadv denotes advised TAC. Mean weight of maturing age 2 and age 3 capelin in October/November 1981-1991 is 17.0 and 24.5 g, respectively. Numbers are billions; weights in thousand tons.

Season	Year classes	Age 2	Age 3	Fish.st.	TACpred	TACadv
1982/83	80 - 79	24.0	5.9	538	24	0
1983/84	81 - 80	63.4	1.1	1090	512	573
1984/85	82 - 81	42.1	28.7	1406	792	897
1985/86	83 - 82	68.5	22.4	1595	959	1311
1986/87	84 - 83	33.0	58.1	1997	1315	1333
1987/88	85 - 84	55.0	15.3	1373	763	1115
1988/89	86 - 85	*65.3	31.4	1750	1096	1036
1989/90	87 - 86	41.9	27.9	1457	837	550
1990/91	88 - 87	28.9	10.2	783	240	265
1991/92	89 - 88	37.7	5.5	754	215	740
1992/93	90 - 89	56.2	19.3	1428	811	

* 1 group not included in Autumn abundance estimate. The figure used represents an adjusted 1 group estimate from August in the same year.

Response: 2-group mature

Summary of Fit

Rsquare	,8790664
Root Mean Square Error	6,631252
Mean of Response	46,9
Observations (or Sum Wgts)	9

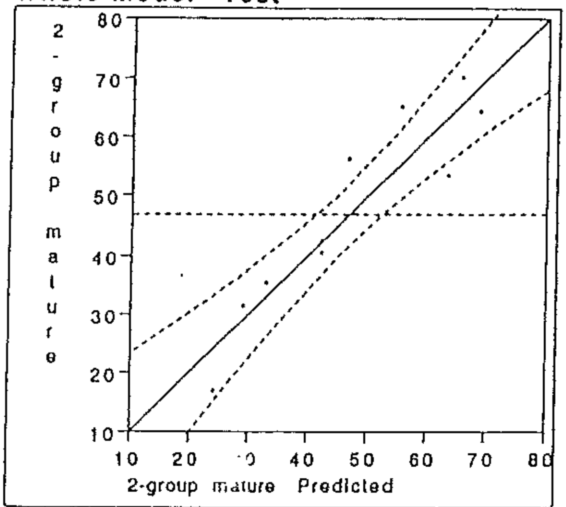
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2,8959158	6,55294	0,44	0,6719
1-group autumn	,88937066	,124679	7,13	0,0002

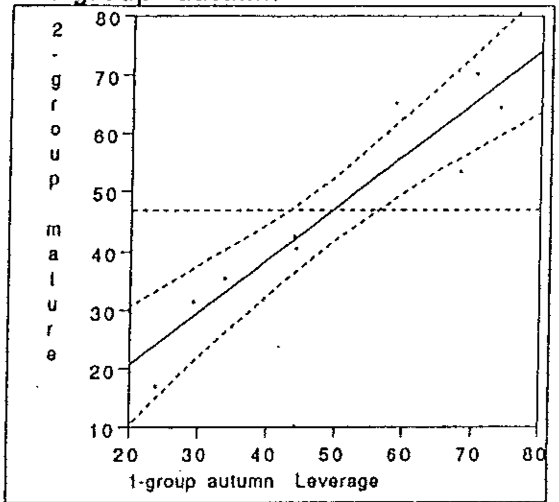
Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
1-group autumn	1	1	2237,5054	50,8830	0,0002

Whole-Model Test



1-group autumn



Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2237,5054	2237,51	50,8830
Error	7	307,8146	43,97	Prob > F
C Total	8	2545,3200		0,0002

Effect Test

Sum of Squares	F Ratio	DF	Prob > F
2237,5054	50,8830	1	0,0002

Figure B.1

Response: 3-group total

Summary of Fit

Rsquare	,8674824
Root Mean Square Error	7,055703
Mean of Response	20,65
Observations (or Sum Wgts)	10

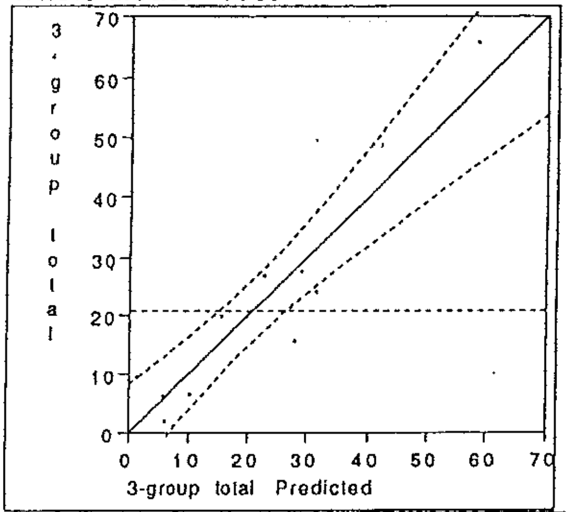
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-12,68256	5,11802	-2,48	0,0382
2-group total	,43009764	,059433	7,24	0,0001

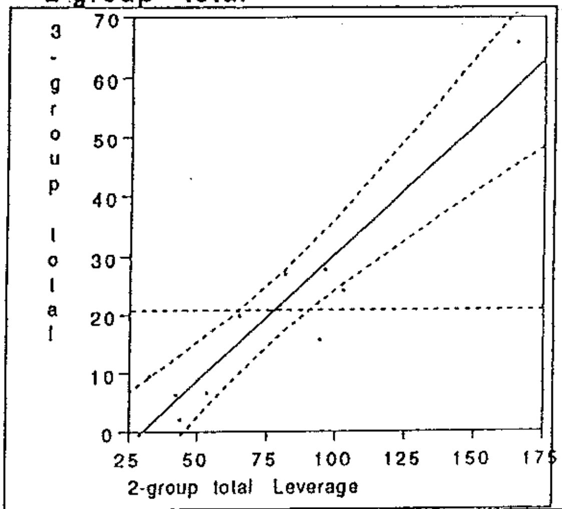
Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
2-group total	1	1	2607,1014	52,3694	0,0001

Whole-Model Test



2-group total



Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2607,1014	2607,10	52,3694
Error	8	398,2636	49,78	Prob > F
C Total	9	3005,3650		0,0001

Effect Test

Sum of Squares	F Ratio	DF	Prob > F
2607,1014	52,3694	1	0,0001

Figure B.2

Response: Advised TAC

Summary of Fit

Rsquare	,8195078
Root Mean Square Error	212,3122
Mean of Response	786,6666
Observations (or Sum Wgts)	9

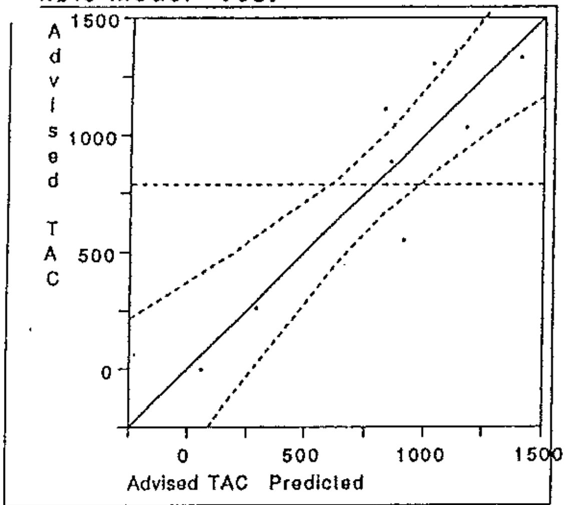
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	32,976474	151,265	0,22	0,8336
Predicted TAC	1,0375056	,184032	5,64	0,0008

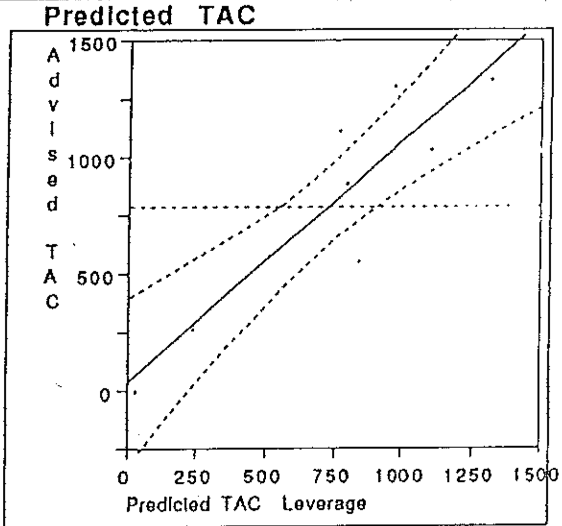
Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Predicted TAC	1	1	1432658,7	31,7828	0,0008

'hole-Model Test



Predicted TAC



Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
.odel	1	1432658,7	1432659	31,7828
Error	7	315535,3	45076	Prob > F
C Total	8	1748194,0		0,0008

Effect Test

Sum of Squares	F Ratio	DF	Prob > F
1432658,7	31,7828	1	0,0008

Figure B.3

APPENDIX C

CONSIDERATIONS ON THE ASSUMPTION UNDERLYING THE TAC OPTION CALCULATIONS FOR BARENTS SEA CAPELIN

Natural mortality and predation

The natural mortality has seemingly increased for all age groups. The reduction in number from age 1 as measured at the autumn survey in 1991 to age 2 as measured at the autumn survey this year, is 50% The corresponding quantity for age group 2-3 (only individuals below 14 cm at age 2) is 75%. These findings are well in accordance with the observations of cod feeding heavily on capelin over most of the capelin distribution area, but most intense in the central to northern areas where the adult capelin were distributed, in September-October this year. This high natural mortality will probably endure for the rest of this season.

For the winter period, a method introduced by Bogstad and Gjøsæter in 1990, calculating the consumption of prespawning capelin by young cod, were used (Working document by Bogstad and Gjøsæter, W.P.1): This method makes use of the data in the joint Russian-Norwegian cod stomach data base to estimate the amount of capelin removed from the stock by predation from cod. The results depend on mean evacuation rate for capelin in cod stomachs (found by experiments), number of individuals and mean weights of immature cod of various age groups, temperature in the relevant area, average amount of capelin in the cod stomachs, as percentage of cod body weight (estimated from the data in the cod stomach data base), and finally, mean overlap between the stocks of capelin and cod.

A new model "CapTool" (Working document to W.P.2 by Bjarte Bogstad, Harald Gjøsæter and Sigurd Tjelmeland) was used to calculate TAC options, based on the following input data.

The acoustic stock estimate 1992 (Table 4.5)
Length at maturity
Remaining catch autumn 1992
Consumption by cod January to March 1993
Additional natural mortality on mature capelin
Increase in weight for mature capelin (October to March)

Length at maturity

It was assumed that all capelin above 14.0 cm will mature and spawn in 1993.

Remaining catch autumn 1992

There are about 166 000 tonnes left to be taken from the catch quota set for the 1992 autumn fishery. It is assumed that 136 000 tonnes will be caught in October and 30 000 in November. The catch is distributed on age groups according to the age distribution of the biomass above 11.0 cm.

Consumption by cod January to March 1993

The expected consumption of mature capelin by cod from January to March 1993 was calculated using data from the joint PINRO-IMR stomach content data base. The procedure used this year was the same as that used by the WG in 1991. There is considerable uncertainty connected to the various inputs to the consumption model. The Working Group evaluated the consequences for the catch - spawning stock relation from several input assumptions.

Overlap between capelin and cod

The autumn distribution of the capelin in 1992 resembles that in 1991, as do the hydrographic situation. It is therefore assumed that a late spawning migration following an eastern route to the coast of Finnmark will dominate also next winter. An overlap between the stocks corresponding to 45 days is therefore considered most likely.

Mean stomach content

The mean stomach content/cod body weight ratio was extracted from the stomach content data base. In 1991, a year with intensive feeding on capelin, this ratio varied from 0.022 to 0.035. These values are in accordance with other years of intensive feeding on capelin: e.g. 1985. The cod stock is increasing and may graze down the mature capelin considerably during January-March. Therefore, the Working Group feels that an assumption of excess feeding during the whole period might not be fully justified and the values 0.02 and 0.03 are considered equally probable.

Initial meal size

The calculated consumption is dependent on which assumption is made on the initial meal size in the underlying gastric evacuation model. Setting the initial meal size equal to the mean stomach content implies continuous feeding, increasing the value implies a more pulse-like feeding. The Working Group investigated the consequences of an initial meal size equal to the mean stomach content and 50% higher than the average stomach content.

Temperature

An indication of what the ambient temperature for the cod might be during the capelin spawning migration in January-March might be found by looking at the decrease in temperature in the Kola section from September 1983 to February 1984 and applying the same decrease in the present situation. This gives a temperature of 3.1 degrees. However, if the cod stays close to the bottom during most of a 24 h period, the mean ambient temperature might be even lower. To find an appropriate mean temperature is an involved and, at the present state of knowledge, somewhat speculative task. The Working Group used both 3 and 4 degrees.

Maturity ogive for cod

The consumption is calculated assuming that only immature cod eats capelin during January-March. The maturity ogive used is the maturity ogive for 1992 taken from this year's report from the Arctic Fisheries Working Group (Anon. 1993).

Weight at age for cod

The Arctic Fisheries Working Group (Anon. 1993) made a forecast of weights based on the arithmetic mean of weight at age observed under a Russian survey in November-December 1991 and a Norwegian survey in February 1992. These observations differ considerably and the difference cannot be explained by growth during the intermediate time only. This discrepancy will influence the assessment of capelin because the consumption of mature capelin by immature cod is assumed to be directly related to cod biomass. If cod weight-at-age data from only one country is to be used the cod stock assessment should also be redone using the corresponding otolith readings, since it is likely that much of the discrepancy may stem from different age readings. The effect on the consumption calculations are unclear, and the Working Group decided to use the weight at age from the Arctic Fisheries Working Group. However, the Working Group feels that there is considerable uncertainty connected to this taking the most conservative approach, and carrying out the consumption calculation using Norwegian weights only and not redoing the cod stock assessment, the resulting spawning stock biomass of capelin would be reduced by 140,000-200,000 t, depending on which combination of assumptions and which catch option is used. This method does not provide the best consumption estimate, but it should provide seasonable upper limits on consumption. If the discrepancy in weight-at-age data cannot be sorted out, separate cod stock assessments should be available, to test the effect of this uncertainty.

Additional natural mortality for mature capelin

An M-value of 0.058 for six months is used.

Weight increase of mature capelin

It is observed that the mean weight of mature capelin at time of spawning generally is higher than the mean weight at October 1. Increase factors of 1.10, 1.15 and 1.00 for capelin 2-3, 3-4 and 4-5 years old, respectively, were used. These numbers are based on observed weights by age in the commercial catch in March 1991.