Advisory Committee on
Fishery Management

ICES CM 1998/Assess:6

REPORT OF THE

WORKING GROUP ON THE ASSESSMENT OF MACKEREL, HORSE MACKEREL, SARDINE AND ANCHOVY

ICES Headquarters
9–18 September 1997

PART 1 OF 2

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK-1261 Copenhagen K Denmark

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1 INTRODUCTION

1.1 Terms of Reference

At the 84th Statutory Meeting (1996 ICES Annual Science Conference) in Reykjavík, Iceland, it was decided in the terms of reference for this Working Group that we will meet at ICES Headquarters from 9–18 September 1997 to:

a) assess the status of and provide catch options for 1998 for the stocks of mackerel and horse mackerel (defining stocks as appropriate);

b) assess the status of and provide catch options for 1998 for the sardine stock in Divisions VIIIc and IXa, and the anchovy stocks in Sub-Area VIII, and Division IXa;

c) provide the data required to carry out multispecies assessments (quarterly catches and mean weights at age in the catch and stock for 1996 by statistical rectangle of the North Sea for mackerel and horse mackerel);

d) propose a definition of safe biological limits using target reference points based, where appropriate, on biomass, fishing mortality, maturity, growth, age structure, exploitation pattern, geographic distribution and other relevant parameters; based on the above parameters, propose limit reference points to be avoided with a high probability;

e) prepare medium-term forecasts of yield and SSB, taking into account uncertainties in data and assessments and assuming a stock-recruitment relationship, to indicate the probability of attaining target reference points and avoiding limit reference points;

f) quantify changes in sardine and anchovy recruitment in the Iberian Region and the Bay of Biscay and investigate possible relationships between any environmental parameters available and indices of recruitment;

g) provide information on quantities of discards by gear type and OSPAR area for stocks of fish and fisheries considered by this group [OSPAR 1997/5.3] and report to WGECO.

Additional request for advice

EU and Norway

Short and medium term levels of catches and spawning stock biomass, taking into account the risk of reduced recruitment at low stock sizes natural variability in recruitment and using the longest possible time series of recruitment. In particular, for the medium term analysis ICES is requested to provide 0-10 years stochastic projections at levels of F of 0.1, 0.15, 0.175, 0.2, 0.225, 0.25 and 0.3 and a plot of the spawning biomass in 10 years time for levels of F between 0.1 and 0.3 at percentiles of the distribution of 5, 10, 20, 30, 50, 80 and 90%.

Equilibrium spawning stock biomass and equilibrium yield for a full range of fishing mortality rates. These equilibrium calculations should be based on a stochastic stock recruitment relationship using the longest possible data set.

The analysis in a) and b) should used the longest possible time series of historical data to quantify stock and recruitment. If the combined stock assessment is of too limited extent, these analyses might be based on the Western stock only.

NEAFC

Indicate the seasonal and area distribution of mackerel in the NEAFC area for juvenile as well as parental components.

1.2 Participants

Pablo Abaunza	Spain
Sergei Belikov	Russia
Fátima Borges	Portugal
Pablo Carrera	Spain
Chris Darby	UK (England)
Guus Eltink	Netherlands
Svein A. Iversen	Norway
Michael Keating	Ireland
Maria Manuel Martins	Portugal
John Molloy	Ireland
Alberto Murta (Part-time)	Portugal
John Nichols	UK (England)
Kenneth Patterson	UK (Scotland)
Graça Pestana (Part-time)	Portugal
Carmela Porteiro (Chairperson)	Spain
Patrick Prouzet	France
Dave Reid	UK (Scotland)
Dankert Skagen	Norway
Eduardo Soares	Portugal
Karl-Johan Stæhr (Part-time)	Denmark
Andrés Uriarte	Spain
Begoña Villamor	Spain

1.3 Quality and Adequacy of Fishery and Sampling Data

1.3.1 Sampling data from commercial fishery

The Working Group again carried out a brief review of the sampling data and the level of sampling on the commercial fisheries. A short summary of the data, similar to that presented in recent Working Group is shown for each stock species. The overall sampling intensity is similar in recent years. Intensive sampling programmes continue to be carried out by Spain and Portugal. On the other hand sampling programmes on some of the large northern fisheries, particularly horse mackerel is very inadequate. Sampling programmes in Spain, Portugal, Ireland, England, France have been supported by an EU funded programme, 94/013.

The sampling programme on the various species is summarised as follows.

<u>Mackerel</u>

Year	Total catch	Catch covered by sampling programme	Samples	Measured	Aged
1996	563,600	446,085	1,492	171,830	14,130
1995	755,000	642,400	1,008	102,383	14,481
1994	822,000	657,000	807	72,541	13,360
1993	825,000	688,400	890	80,411	12,922
1992	760,000	645,000	92	77,000	11,800

In mackerel it appears that over 85% of the total catch was covered by sampling and in general the sampling level appears to have improved during 1996. Germany commenced a sampling programme and Portugal carried out an extremely intensive programme on their catches. There are still, however, a number of important mackerel catching countries which did not carry out any sampling programmes, e.g. Faroes, France and Sweden. The summarised details of the more important mackerel catching countries are shown in the following table.

Country	Catch	Catch covered by sampling programme	Samples	Measured	Aged
Norway	136,400	136,400	158	19,250	2,050
UK (Scotland)	108,700	106,300	78	7,329	2,716
Ireland	54,300	48,600	61	10,092	3,021
UK (Engl. + Wales)	36,200	15,750	29	3,670	655
Netherlands	48,175	39,045	60	5,141	1,500
Denmark	28,500	17,136	8	712	712
Russia	44,500	44,200	13	19,556	607
Spain	33,400	33,400	338	24,563	1,130
Germany	13,700	2,254	61	34,963	665
Faroes	16,800	0	0		
France	15,700	0	0		
Sweden	5,300	0	0		
Portugal	3,000	3,000	686	46,604	1,074
Estonia	3,700	0	0		
Others*	15,225	0	0		
Total	563,600	446,085	1,492	171,830	14,130

*Including discards.

Horse Mackerel

The following table shows a summary of the overall sampling intensity on horse mackerel catches in recent years.

Year	Total catch	Catch covered by sampling programme	Samples	Measured	Aged
1996	460,200	291,000	2,498	208,416	4,719
1995	580,000	275,516	2,041	177,803	5,885
1994	447,153	272,100	1,453	134,269	6,571
1993	504,190	379,000	1,178	158,954	7,476
1992	436,500	195,450	1,803	158,447	5,797

Although the overall numbers of horse mackerel measured during 1996, increased the detailed sampling of horse mackerel continued to be at a very low level. The only countries that carried out comprehensive sampling programmes were Netherlands, Portugal and Spain. Other countries, e.g. Ireland, Denmark and United Kingdom carry out no ageing programmes whatsoever. The lack of sampling data for large portions of the horse mackerel catch has a serious effect on the accuracy and reliability of the assessment, and the Working Group are concerned about the decreasing number of fish that have been aged during the last 4 years.

The following table shows the most important horse mackerel catching countries and the summarised details of their sampling programme in 1996.

Country	Catch	Catch covered by sampling programme	Samples	Measured	Aged
Ireland	127,500	63,000	26	3,076	0
Netherlands	136,000	164,000	76	9,105	1,900
Norway	15,500	14,600	5	564	142
Spain	35,800	35,800	621	49,051	663
England	33,700	330	1	101	0
Denmark	63,900	0			
Germany	21,200	0	2	941	
Portugal	14,000	14,000	1,767	145,578	2,014
Scotland	16,300	0			
Others*	-3,700	0			
Total	460,000	291,000	2,498	208,416	4,719

*Includes discards, small catches by other countries, and some misreported catches.

Sardines

The sampling programmes carried out on sardines in 1996 was again very similar to the programmes of recent years and is summarised as follows.

Year	Total catch	Catch covered by sampling programme	Samples	Measured	Aged
1996	126,926	11,431	833	73,220	4,830
1995	138,204	121,384	716	59,444	4,991
1994	162,900	134,700	748	63,788	4,253
1993	149,600	143,200	813	68,225	4,821
1992	164,000	130,000	788	66,346	4,086

In general the overall sampling intensity remains at a satisfactory level and good coverage is maintained throughout the year. No sampling programmes are carried out by France or Denmark or the United Kingdom.

The summarised details of individual sampling programmes in 1996 are shown below on the following page.

Country	Catch	Catch covered by sampling programme	Samples	Measured	Aged
Portugal	85,757	85,757	392	32,237	3,073
Spain	25,674	25,674	441	40,983	1,757
Denmark	2,921	0			
France	8,706	0			
UK (England)	6,868	0			

Anchovy

The sampling programmes carried out on anchovy in 1996 are summarised below. The sampling levels are very similar to those of 1994 and 1995 although the number of fish aged has increased considerably. However, sampling is stratified and appears to be satisfactory.

Year	Total catch	Catch covered by sampling programme	Samples	Measured	Aged
1996	38,773	36,053	214	17,800	4,029
1995	42,104	35,048	?	?	?
1994	34,600	34,400	281	17,111	2,923
1993	39,700	39,700	323	21,113	6,563
1992	40,800	37,700	289	17,112	3,805

Catches of anchovy were taken by Portugal in 1996 but were not subject to a sampling programme. The sampling data from Spain and France, who carry out comprehensive programmes are shown below.

Country	Catch	Catch covered by sampling programme	Samples	Measured	Aged
France	15,238	15,238	26	1,432	668
Spain	20,761	20,711	188	16,368	3,361
Portugal	2,775		?		

1.3.2 Catch data

The possible underestimation of the total mackerel catch has been discussed by a number of recent working groups. The 1996 Working Group expressed concern about the possible large scale misreporting of mackerel as horse mackerel in the northern areas. It has not however been able to clarify this situation and the Working Group therefore did not make any revisions to the catch data. The large decrease in mackerel catch recorded for 1996 appears to have been a genuine decrease caused by more effective control of the reduced TACs. As in recent years a number of countries which have substantial mackerel fisheries e.g. France, Faroes, Sweden, Estonia, have been unable to provide data on the distribution of the catches per statistical rectangle. The amounts of mackerel "misreported" to incorrect areas in 1996 decreased considerably.

Misreporting of mackerel by area continues to be a problem between Division VIa and Division IVa particularly during the month of January. The Working Group considers that this problem could be solved without endangering the North Sea stock by allowing fishing in Division IVa during January. There may be a problem of misreporting between IVa and IIa but the Working Group are unable to quantify the amounts involved.

1.3.3 Discards

Discarding of small mackerel has historically been a major problem in the mackerel fishery and was largely responsible for the introduction of the south west mackerel box. In the years prior to 1994 there was evidence of large-scale discarding and slipping of small mackerel in the fisheries in Division IIa and Sub-area IV, mainly because of the very high prices paid for larger mackerel (>600 g). This factor was put forward as a possible reason for the very low abundance of the 1991 year class in the 1993 catches in numbers at age. In some fisheries e.g. those in Sub-areas VI and VII mackerel is taken as a by catch in the horse mackerel fisheries. Reports from these fisheries have suggested that discarding may be significant because of the low mackerel quota relative to the high mackerel quota - particularly in those fisheries carried out by freezer trawlers. In the fisheries carried out in Divisions IIa and IVa the difference in prices paid for small and large mackerel has decreased since 1994 and the Working Group assumed that discarding may have been reduced in these areas. In autumn 1997 an EU funded programme involving Norway and Scotland commenced with the intention of studying the performance of the purse seine fisheries for herring and mackerel. This programme will provide data on discards for these fleets. At present only one country - the Netherlands -is providing information on mackerel discards but this information is not applied to any other fleets. The Working Group would also like to draw attention to the possibility that discarding of small mackerel may again become a problem in all areas if the 1996 year class is very strong as seems possible at present.

An EU programme carried out by Spain studied the rate of discards of all species taken by the Spanish fleets, fishing in Sub-areas VI, VII, VIIIc and IXa. The results of this study (Perez *et al.* 1994) showed that the discard rates varied by species , area and fishing fleet. The observed levels of discards were between 0.2%–25.7% for horse mackerel, between 0.1% and 8.1% for mackerel and less than 1% for sardine.

As with mackerel only the Netherlands provides information on discards in the horse mackerel fisheries.

No data is available on discards in the anchovy fisheries but the rate is assumed to be insignificant.

Because of the potential importance of significant discards levels on the mackerel and horse mackerel assessments the **Working Group recommends that observers should be placed on board vessels in those areas in which discarding may be a problem. This observer programme should be commenced as soon as possible.**

1.3.4 Fleet data

In 1993, the Working Group expressed concern that insufficient information was available about changes that may be taking place in the various national fleets. It was, therefore, decided that data should be collected about the different national fleets, particularly in relation to the introduction of new technical equipment, the improvement or increase in size of fishing nets and change in fleet capacity. It was felt that important information about the fishery effort was being lost without which it was difficult to determine changes in fish abundance. A certain amount of information on abundance was previously available from fluctuations in catches. However, this is not the case now because of the imposition of TACs and boat quotas. Decreases in stocks may therefore be difficult to detect because of rapid changes in efficiency. The Working Group therefore felt that data on fleet size and composition, e.g. size of vessels, type of vessel, overall horse power, size etc., should be updated each year.

This year's Working Group noted that the data as it is currently provided to the Working Group makes the desired comparison between years extremely difficult. This may be due to changes in the type of fishery a vessel may exploit. Many vessels, particularly the smaller ones, may be able to fish with a variety of different techniques, and hence different performance. Larger vessels e.g. purser/trawlers may switch preferences for one technique to the other. Vessels may also switch areas and stocks according to market conditions and changes in management criteria. These are likely to be difficult to document, and will be unclear or even misleading in the type of table previously produced. Additionally, it was felt that the data on lengths, horsepower, crew size etc. was not actually providing any useable profiles of the different fleets.

However, the Working Group felt that it remained useful to have information available profiling the different national fleets and, most importantly changes in the fleets and the way they perform. Therefore, the Working Group has asked the participating countries to prepare short profiles of their fleets and changes in them over the last 10 years. These will be assembled for next years report, and updated as felt necessary by the Working Group.

The information provided should include:

- target species
- areas worked
- gear and vessel types
- any major changes in gear, type of vessel, areas or species worked, number of vessels in the fleets etc.

1.3.5 Age reading

The quality of the age data for the various assessments depends on 1) the accuracy and precision of the age readings of each species, and 2) the sampling intensity which enables the catches to be converted into numbers at age. The Working Group examined the various species in respect to these factors. Factor 1 is dealt with in this Section, but factor 2 is dealt with in Section 1.3.1.

<u>Mackerel</u>

A mackerel otolith exchange in 1994 showed that the ageing were of a poor quality. Therefore an otolith workshop was held in February 1995 (ICES 1995/H:1). This improved the quality considerably and the precision of the age readings achieved was acceptable for the Working Group.

<u>Horse Mackerel</u>

A horse mackerel otolith exchange has been carried out in 1996. The results show that there is a considerable bias in the age readings. The results of the exchange are described in Section 4.7 and in Eltink (1997).

As in recent years, the only countries carrying out age readings on otoliths of horse mackerel are the Netherlands, Spain, Portugal and Norway. For the western area the catches of the non-sampling countries use the age compositions of either the Netherlands or Norway (only for the Divisions IIa and IVa area) to raise these to their own catches. In some cases this causes serious problems, e.g. where in a certain area/period the Netherlands took only one sample because of low Dutch catches and the Dutch age composition was then raised to the high catches of non-sampling countries. The quality of the catch in numbers at age would improve considerably, if the non-sampling countries, with relatively high catches would start to age horse mackerel and would take samples for ageing relative to their catches. It is therefore extremely important that countries like Ireland, Denmark and the

United Kingdom should initiate ageing programmes immediately (see Section 1.3.1). The text table below shows how the number of otolith readings relates to the catches by country for both the western and North Sea area in 1996.

Country	Catch (t)*	Otoliths read
Netherlands	136,000	1,900
Ireland	127,000	0
UK	47,000	0
Denmark	45,000	0
Spain	30,000	663
Portugal	14,000	2,000
Germany	17,000	0
Norway	15,500	142

*This includes discards.

Therefore the **Working Group strongly recommends that all countries with relatively high horse mackerel catches should sample for age at an adequate level.**

Sardine

In 1997 a Workshop on Sardine Otolith Age Reading was held in IEO, Vigo (Spain), following the sardine otolith exchange between Spain and Portugal carried out during 1996. Otolith samples collected in different areas and seasons off the Atlantic-Iberian coasts were analysed. It was concluded that there was a general good consistence between readings of the different readers involved and that the readings of the Spanish reader, who is responsible for the age length keys, was the most consistent and also that there was a reasonable good agreement with those readings performed by the most experienced Portuguese readers.

Besides several recommendations aiming to improve the age readings, this Workshop also adopted a protocol with the criteria for the standardisation of sardine age determination. It was also planned that this protocol will be complemented with a future guide that will assist the otolith readers.

Anchovy

The age readings of anchovy and the age sampling of all the catches appear to be satisfactory.

1.3.6 Biological data

The main problems in respect to the biological data (except age reading), which are identified by the Working Group for the various species, are:

Mackerel

The proportion mature of 1-, 2- and 3-year old mackerel appears to be overestimated in the present maturity ogive and therefore needs to be further investigated, because it affects the accuracy of the assessment (see Section 1.4 and 2.10).

Horse mackerel

The selection of an appropriate maturity ogive for the western horse mackerel stock still presents major difficulties. This affects the accuracy of the assessment (see Section 1.4 and 6.5). There exists uncertainty about the level of natural mortality (see Section 6.6).

Sardine

This years maturity ogive seems to be biased to the older ages compared to the maturity ogive of previous years.

Anchovy

The main biological problems for anchovy lies in understanding the migration of 0-group fish and their pre-recruit distribution. Information is also required about variations in natural mortality (M) as M may increase dramatically immediately after spawning has been completed. A better understanding is needed of seasonal growth in weight and length to modulate the time evolution over time of cohorts, because of the large seasonal changes in growth. The input of hydroclimatic conditions on the recruitment success needs to be studied more intensively since the physical conditions strongly affect the strength of the recruitment.

1.4 Review of the Mackerel and Horse Mackerel Egg Survey Working Group

The Working Group met in Lisbon from 3–7 February 1997. The main terms of reference were to plan the sampling, for both plankton and adult parameters, for the proposed egg surveys of the western and southern areas in 1998 and to review and report on previous estimates of mackerel fecundity, atresia and maturity. The conclusions and recommendations of the Working Group and the sampling plan for the 1998 surveys are presented in ICES (1997/H:4) and summarised below. The Working Group also considered the results of the 1996 North Sea mackerel egg surveys. These results are fully reported in Section 2.2.1.

1.4.1 1998 western and southern area egg surveys

A total of nine institutes from eight countries are committed to participate in the surveys. The survey area will be divided into southern and western components. Temporal coverage will be divided into seven sampling periods between 12 January and 20 July. Periods 1-3 will only cover the southern area, periods 6-7 will only cover the western area and during periods 4-5 both areas will be sampled. The only changes noted to the plan since the Egg Survey Working Group met are: the German survey (Walter Herwig) will now be from 13 March–8 April not 7–29 March and the English survey will be carried out on RV 'Corystes' not RV 'Cirolana' and will be extended by 4 days.

It has been requested that, where space is available, vessels should carry cetacean and seabird observers as part of an international programme organised by Mardik Leopold (Netherlands).

The plankton sampling strategy will be targeted at the Annual Egg Production method only for both mackerel and horse mackerel in the western and southern areas. The southern standard area will be the same as in the 1995 survey. The western standard area has been extended by a total of 27 rectangles on the western edge of the sampled area.

The Working Group was asked to consider ways of combining the western and southern area egg production estimates for mackerel. Because the peak of spawning occurs at different times in these areas, combining the egg production curves is not practical. Instead it was agreed that egg production estimates would be calculated separately for the western and southern areas and then added together to produce a combined estimate for the North East Atlantic mackerel.

Sample analysis will be completed by the end of September 1998 and the data submitted to Dave Reid, SOAEFD, Scotland, for the western area and Amor Sola, IEO, Spain. They will be responsible for subsequent analysis of the data and calculation of total annual egg production of both species.

Samples of adults for total fecundity analysis will be taken by England and Spain for mackerel and by The Netherlands and Portugal for horse mackerel. Samples for the estimation of atresia will be taken on all the egg surveys by all participants and subsequently analysed by either England, Scotland or Spain for mackerel and either Portugal, Spain or The Netherlands for horse mackerel. Samples for the estimation of maturity at age will only be taken at the peak of spawning. It is important that these samples are not only taken from the peak spawning areas of predominantly adult abundance but also from the areas juvenile distribution. In this context the Working Group requested information on the distribution of 1, 2 and 3 years old mackerel and horse mackerel, from the Assessment Working Group.

Further investigation is needed before the estimates of mackerel fecundity in the western and southern areas can be combined. There is a significant relationship between fish weight and eggs per gram in the southern area which may be related to a sampling problem. If this can be resolved then the estimates can be combined. The 1998 estimate of atresia will be the first estimate for the southern area.

For maturity ogive sampling in the 1998 egg surveys the areas for sampling, based on the distribution of 1, 2 and 3 year old mackerel need to be identified (see Section 13) This request also applies to horse mackerel sampling. In order to calculate the maturity ogive precisely it is vital that histological preparations of the ovaries are made and examined microscopically. A proposal for funding for this work has been submitted to the EU. Because of the cost of this sampling programme it is unlikely that it will be carried out unless financial support becomes available. The maturity ogives for the western and southern areas can be combined by weighting for the spawning fraction in each area.

Sample and data analysis for all the adult parameters required for the estimation of SSB from the annual egg production will be completed by 15 March 1999.

The Working Group concluded that they could not produce a provisional egg production or SSB estimate for either species in time for the 1998 Assessment Working Group meeting or the October ACFM meeting. Instead they recommended that the Egg Survey Working Group should meet from 13-19 April 1999 to produce these final estimates. They suggested that relevant stock assessment biologists should attend the last two days of that meeting in order to use the data to re-tune the VPA estimates of stock size in time for the May 1999 meeting of ACFM. For this reason it is important that the Egg Survey Working Group meeting does not coincide with the Herring Assessment Working Group meeting.

1.4.2 Review of mackerel fecundity and atresia

This Working Group had requested a review of the historic data series with particular reference to the significance of the inter-annual differences in the estimates of fecundity and atresia. These have led to a number of changes in the egg survey estimates of SSB over recent years. A comprehensive working document was produced for the Working Group (ICES 1997/H:4, Appendix 1).

Fecundity - It was concluded that there was a significant linear downward trend in potential fecundity, equivalent to a 3.5% decrease, over the three egg survey years 1989, 1992 and 1995 and that this should be incorporated into the biomass estimates. For the years 1977 to 1983 a mean potential fecundity from the 1986, 1989, 1992 and 1995 estimates (1526 oocytes/ gm. female) should be used. For the survey years 1986, 1989, 1992 and 1995 the observed values for those years should be used.

Atresia - this has only been estimated in the survey years from 1989. There was no evidence of a significant difference in the prevalence of atresia between the three years. There was significant evidence that the intensity of atresia in those fish with atresia was different between the three years. The Working Group concluded that for the survey years from 1977 to 1986 a mean atresia (as oocytes/g female) from the 1989, 1992 and 1995 observations should be applied retrospectively. For the years 1989, 1992 and 1995 the observed values should be used. Sampling in future survey years should ensure that this parameter can be calculated and used as a separate observation for that year.

The recalculated values of SSB based on the above advice on fecundity and atresia are given in Table 2.2.1.

1.4.3 Basis for the 1986 mackerel maturity ogive

The Working Group was asked to examine the basis for a different maturity ogive which has been used since 1986 for the 1984 year class.

Over the period 1977-1989 maturity ogives were based on maturity at age derived from fish examined over a wide area of their distribution. The ogive was constructed from the proportion of mature fish found irrespective of catch weights or the number of fish examined from different areas.

The 1984 year class, as two year olds in 1986, was considered to be exceptional (20% mature) from the long term average maturity ogive (2 year olds 60% mature). The conclusion was supported by two other observations:

1. Two year olds on the spawning ground in 1986 were 3 cm smaller than two year olds in 1985 (1983 year class).
2. The expected number of 1984 year class fish mature in 1986, as a proportion of the total mature population was 30%. The observed proportion was only 11%.

As a consequence, for the 1984 year class, the value of 20% mature at two years old was accepted and used.

With respect to the first point the 1984 year class was subsequently found to be above average numbers but it was not exceptional. The smaller mean size on the spawning ground was later seen as a change in the distribution of small fish rather than a change in mean size for the whole year class. At the 1987 and 1988 Assessment Working Group meetings (ICES 1987/Assess:12; ICES 1988/Assess:12), the weight at age of the 1984 year class, as two year olds, was revised upwards (300g) to greater than both the long term mean (275g) and the 1985 year class (250g).

With respect to the second point, a change in the basis for calculating the proportion of fish spawning on the grounds was made. The change was to include fish about to spawn and spent fish, as well as running females. This resulted in a revision upwards from 11% to 17% for the proportion of the population belonging to the 1984 year class which were spawning in 1986.

In conclusion, the observed reduced maturity of the 1984 year class in 1986 could have been generated by points 1 and 2 above. Equally it could have been generated by biased sampling related to changes in the population distribution as was the case with mean weight at age. The Egg Survey Working Group concluded that if the decision to change the mean weight at age was sound then it would be consistent to assume that the heavier fish were predominantly mature and therefore the general maturity ogive, applied since 1977, should be adopted for the 1984 year class from 1986.

1.4.4 Maturity ogive for the 1992 and 1995 egg surveys

In response to the request (ICES 1997/Assess:3) the Working Group were not able to provide a maturity ogive with a CV for either of these survey years. Sampling in these years was concentrated on the spawning grounds and did not adequately cover the areas of juvenile distribution where smaller less mature 2 year old fish may have been more abundant.

1.4.5 Future North Sea egg surveys

There is uncertainty about the origin of the exceptionally high numbers of 1996 year class mackerel observed in the IBTS in the North Sea as '0' groups (Figure 2.4.1) and as '1' groups (Figure 2.4.2). If these are North Sea stock mackerel then they should be fully mature by 1999 when the next egg survey of the North Sea could take place. The Working Group recommends that a survey of the North Sea spawning area is carried out in 1999.

1.5 Species Mixing

Scomber sp.

As in previous years, there was also a Spanish and Portuguese fishery for Spanish mackerel, *Scomber japonicus,* in the south of Division VIIIb, in Division VIIIc and Division IXa.

Table 1.5.1 shows the Spanish landings by Sub-division in the period 1982–1996. In 1996 the catch in Division VIIIb was 778 t, an increase with respect to 1994 and 1995. In Sub-division VIIIc East the catch was 2,633 t, similar to the catch in 1995. In Sub-division VIIIc West this is the first year in which a catch of this species has been registered, albeit only 47t. As has been the case since 1993, there was also a Spanish fishery of Spanish mackerel in Sub-division IXa North in 1996, mainly in the 3rd quarter, with a catch of 5,066 t. There is no error in the identification of mackerel species in the Spanish fishery in Divisions VIIIbc and Sub-division IXa North.

In Sub-division IXa South, the Gulf of Cadiz, there is a small Spanish fishery for mixed mackerel species which had a catch of 370 t in 1996, a fall in comparison with the period from 1992 to 1994 in which catches were around 1,000 tonnes, but similar to the 1995 catch of 364 tonnes. In the bottom trawl surveys carried out in the Gulf of Cadiz in 1996, catches of *S. scombrus* were scarce or even non-existent, with *S. japonicus* making up 99% of the total catch in weight of both species (M. Millán, pers. comm). Due to the uncertainties as to the proportion of *S. Scombrus* in landings for this area, they have never been included in the mackerel catches reported to this Working Group by Spain.

In Portugal the landings of Spanish mackerel from Division IXa (CN, CS and S) were 4,759 t in 1996, more abundant in the southern areas than those of the north (Table 1.5.1). These species are landed by all fleets but the purse seiners accounted for 76% of total weight. There is no error in the identification of mackerel species in the Portuguese fishery in Division IXa. Section 3 deals only with *S. scombrus*.

Trachurus sp.

Three species of *Trachurus* genus, *T. trachurus*, *T. mediterraneus* and *T. picturatus* are found together and are commercially exploited in the NE Atlantic waters. Studies about genetic differentiation showed three clear groups corresponding to each species of *Trachurus* with no intermediate principal components scores, excluding the possibility of hybrids between species (Soriano, M. and A. Sanjuan, WD 1997).

Following the Working Group recommendation (ICES 1996/Assess:2), special care was again taken to ensure that catch and length distributions and numbers at age of *T. trachurus* supplied to the Working Group did not include *T. mediterraneus* and *T. picturatus*. Spain provided data on *T. mediterraneus* and Portugal on *T. picturatus*.

In Divisions VIIIab and Sub-division VIIIc East, the total catch of *T. mediterraneus* was 4,618 t in 1996. In both areas the catch has fallen with respect to 1994 (Table 1.5.2).

As previous years, in both areas, more than 95% of the catches were obtained by purse seiners and the main catches were taken in the second half of the year, mainly in autumn, when the *T. trachurus* catches were lowest. *T. mediterraneus* catches were lowest in spring.

Catches and length distributions of *T. mediterraneus* in the Spanish fishery in Divisions VIIIa,b and c were reported separately from the catches and length distributions of *T. trachurus*.

A fishery for *T. picturatus* only occurred in the southern part of Division IXa, as in previous years. Data on *T. picturatus* in the Portuguese fishery for the period 1986–1996 are also given in Table 1.5.2. Catches and length distributions of *T. trachurus* for the Portuguese fishery in Division IXa do not include data for *T. picturatus*.

As information is available on the amounts and distribution of catches of *T. mediterraneus* and *T. picturatus* for at least eight years (ICES 1990/Assess:24; ICES 1991/Assess:22; ICES 1992/Assess:17; ICES 1993/Assess:19; ICES 1995/Assess:2; ICES 1996/Assess:7 and ICES 1997/Assess:3), and as the evaluations and assessments are only made for *T. trachurus*, the Working Group recommends that the TACs and any other management regulations which might be established in the future should be related only to *T. trachurus* and not to *T. trachurus spp.* in general, as is the case at present . It would then be appropriate to set TACs for the other species as well. Section 4.2.7 deals only with *T. trachurus*.

Table 1. 5. 1: Catches in tonnes of Scomber japonicus in Divisions VIIIb, VIIIc and IXa in the period 1982-1996.

Country	Sub-Divisions	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Spain	Division VIIIb	0	0	0	0	0	0	0	0	0	487	7	4	427	247	778
	VIIIc East	322	254	656	513	750	1150	1214	3091	1923	1502	859	1892	1903	2558	2633
	VIIIc west															47
	Total	322	254	656	513	750	1150	1214	3091	1923	1502	859	1892	1903	2558	2679
	IXa North												2557	7560	4705	5066
	IXa South											895	800	1013	364	370
	Total	0	0	0	0	0	0	0	0	0	0	895	3357	8573	5068	5437
	Total Spain	322	254	656	513	750	1150	1214	3091	1923	1989	1761	5253	10903	7872	8894
Portugal	IXa Central-North															785
	IXa Central-South															2224
	IXa South															1749
	Total Portugal	664	373	8059	9118	8184	8261	3816	6447	8567	10142	8942	7341	4438	3884	4759
TOTAL	**Division VIIIb**										487	7	4	427	247	778
	VIIIc East	322	254	656	513	750	1150	1214	3091	1923	1502	859	1892	1903	2558	2633
	VIIIc west															47
	Division VIIIc	322	254	656	513	750	1150	1214	3091	1923	1502	859	1892	1903	2558	2679
	IXa North												2557	7560	4705	5066
	IXa Central-North															785
	IXa Central-South															2224
	IXa South											895	800	1013	364	2120
	Division IXa	664	373	8059	9118	8184	8261	3816	6447	8567	10142	9837	10698	13011	8952	10195
	Total	986	627	8715	9631	8934	9411	5030	9538	10490	12131	10703	12594	15341	11756	13653

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Table 1. 5. 2 : Catches (t) of Trachurus mediterraneus in Divisions VIIIab, VIIIc and IXa in the period 1989-1996 and Trachurus picturatus in División IXa, Subarea X and in CECAF Division 34.1.1 in the period 1986-1996.

	Divisions	Sub-Divisions	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
T. mediterraneus	VIIIab		-	-	-	23	298	2122	1123	649	1573	2271	1175
	VIIIc	VIIIc East	-	-	-	3903	2943	5020	4804	5576	3344	4585	3443
		VIIIc West	-	-	-	0	0	0	0	0	0	0	
		Total	-	-	-	3903	2943	5020	4804	5576	3344	4585	3443
	IXa	IXa North	-	-	-	0	0	0	0	0	0	0	0
		IXa C, N & S	-	-	-	0	0	0	0	0	0	0	0
		Total	-	-	-	0	0	0	0	0	0	0	0
T. picturatus	IXa		367	181	2370	2394	2012	1700	1035	1028	1045	728	1009
	X Azorean Area		3331	3020	3079	2866	2510	1274	1255	1732	1778	1822	1715
	34.1.1 Madeira's area		2006	1533	1687	1564	1863	1161	792	530	297	206	393

(-) Not available

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2 MACKEREL - GENERAL

2.1 Stock Units

The mackerel caught in North East Atlantic waters were until 1995 treated as belonging to one of three stocks, Western, Southern and the North Sea stocks. Based on tagging experiments (Uriarte 1995) in the south east corner of the Bay of Biscay, in the North Sea and Western area (Bakken and Westgaard, 1986, Iversen and Skagen, 1989) and egg distributions the Working Group in 1995 (ICES 1996/Assess:7) decided to pool these units into one. The tagging experiments have demonstrated that mackerel from the different spawning areas are mixing in the North Sea and Norwegian Sea during the second half of the year (August-January). Since it is impossible to split the mackerel caught in these areas by stocks all the fish caught have been allocated to the Western stock. The catches of North Sea mackerel has been included in the assessment of Western mackerel since 1988 (ICES 1989/Assess:11). Due to big differences in stock size levels this has negligible impact on the assessment of the Western stock. The size of the North Sea stock is about 3% of the Western stock. In quarter 1 of 1997 there were unusually high catch rates of 1 group fish in the northern North Sea. As a result it has also become difficult to separate the juveniles of the western stock from the N. Sea stock. This provides a further rationale for treating the three stock as one. The total catches, estimated by the Working Group to have been taken from the various areas, are shown in Table 2.1.1.

Even if the three spawning units now are treated as one unit the Working Group considers it important to be able to follow the development of the egg production and spawning biomass in the Western, Southern and North Sea spawning area separately.

A joint EU/Norwegian mackerel tagging project (1996/035) involving Spain, Portugal, Ireland, and Norway has been carried out in 1997. 91,000 fish have so far been tagged using a combination of external and internal tags. The purpose of this project was 1) to study the migrations of adult and juvenile fish in the southern and western areas and 2) to obtain information on the recruitment patterns of juvenile fish from the Iberian peninsula and off north west Ireland. Preliminary results should be available for the 1998 meeting of the Working Group.

2.2 Spawning Stock Biomass Estimates from Egg Surveys

2.2.1 North Sea area

An egg survey of the North Sea was carried out between 6 June and 2 July 1996 with a total of three coverages of the spawning area by Denmark and Norway. A total of 30 ship days was deployed compared with 90 days in 1990 when the last egg survey was carried out. (ICES 1997/H:4).

On the first survey daily egg production was low (1.02 $x10^{12}$ eggs) but peak production occurred at the south-western corner of the surveyed area. It was possible that some production was missed on that survey.

The area coverage on the second and third surveys was adjusted to take into account the observed change in distribution. Daily egg production peaked on the second survey (2.01 $x10^{12}$ eggs) and declined to 1.07 $x10^{12}$ eggs on the final survey at the end of June.

A total seasonal egg production of 59 $x10^{12}$ eggs was calculated from these surveys based on spawning starting on 17 May and ending on 27 July, as used in the 1990 egg survey calculations. By applying the fecundity values from Iversen and Adoff (1983), a spawning stock biomass of 84,000 t is calculated. Using mean atresia data from the western area, 11.6%, this SSB estimate is increased to 110,000 t.

The Working Group recommends that the next North Sea egg survey should be carried out in 1999 (see Section 1.4.5).

2.2.2 Western Area

The Egg Survey Working Group recommended changes to the historic estimates of total potential fecundity and atresia (see Section 1.4.2). Those changes were accepted by this Working Group and have been incorporated into the current assessment. The estimates of fecundity, atresia and SSB of mackerel in ICES (1997/Assess:3; Table 2.1) have been updated and are given in Table 2.2.1.

The area will be surveyed again in 1998 (see Section 1.4.1).

2.2.3 Southern area

There is no new information to report. The area will be surveyed again in 1998 (see Section 1.4.1).

2.3 Allocation of Catches to Stock

Since 1987 all catches taken in the North Sea and Division IIIa have been assumed to belong to the Western stock. This assumption also applies to all the catches taken in the international waters. It has not been possible to calculate the total catch taken from the North Sea stock component separately but it has been believed to be less than 10,000 t for a number of years. This is because of the very low stock size and because of the low catches taken from Divisions IVb,c. This figure was originally based on a comparison of the age compositions of the spawning stock calculated at the time of the North Sea egg surveys This assumption has been continued in 1996 but it should be pointed out that if the North Sea stock should increase and the catches of "Western" mackerel continue to decrease then the figure may need to be reviewed. An international egg survey carried out in the North Sea during June 1996 provided a very low index of stock size in the area.

Prior to 1995 catches from Divisions VIIIc and IXa were all considered to belong to the southern mackerel stock, although no assessment had been carried out on the stock. In 1995 a combined assessment was carried out in which all catches from all areas were combined, i.e. the catches from the southern stock were combined with those from the western stock. The same procedure was carried out by the 1996 Working Group and again by the present Working Group; the new population unit again being called the North-east Atlantic mackerel unit.

The TAC for the Southern area applies to Divisions VIIIc and IXa. Since 1990, 3,000 t of this TAC, which has been fixed at 30,000 t, has been permitted to be taken from Division VIIIb in Spanish waters. This area is included in the "Western" management area. These catches (3,000 t) have always been included by the Working Group in the western component and are therefore included in the F values used in the assessment for the Western area.

2.4 Distribution of Juvenile Mackerel

2.4.1 Surveys in winter 1996/97

Fourth quarter 1996

High catch rates of 1996 year class fish were taken off the western Iberian coast, west of Ireland and in the Tampen/Viking banks area and the central North Sea (Figure 2.4.1). Lower catch rates than usual were recorded in the Hebrides NW Ireland area. For the 1995 year class there were small catches at the NW corner of Spain. The highest catch rates were recorded off NW Ireland and the Hebrides. However, these catches were substantially less than catches from either this year class or the 1994 year class in 1995. This may suggest that the high recruitment postulated in last years Working Group report was incorrect. The 1994 year class was found mainly concentrated in the NW Ireland/Hebrides area, with some reasonable catches in the Viking Bank area and in the southern North Sea.

First quarter 1997

No data are yet available for the 1994 and 1995 year classes. The bulk of the fish from the 1996 year class were caught in the Tampen/Viking Banks area of the North Sea (Figure 2.4.2). Smaller catches were also taken NW of Ireland and SW of Cornwall. Although not a bottom trawl survey it should be noted that the Spanish acoustic survey in March 1997 found large quantities of juvenile mackerel in layers close to the seabed.

It should also be mentioned that the Scottish bottom trawl survey on the Rockall Bank in August 1997 made large catches of juvenile mackerel which have not been observed here before. This was also confirmed by Irish commercial trawling operations in July.

2.4.2 Trends in age 0 fish in the fourth quarter surveys 1989–96 (Figure 2.4.3)

- West Iberia: There has been a consistent "hot-spot" around the area of the Spanish/Portuguese border except for 1990 and 91.
- Biscay: Although this area was not surveyed in all years there were moderate catches in all years surveyed in areas in the central part of the Bay.
- Cornwall & Western Approaches: Catch rates were very low from 1989 to 92 and then increased to moderate levels from 1993 to 96.
- West of Ireland/Hebrides: Generally high catch rates were recorded up to 1995, but were much reduced in 1996. Catch rates were higher in the Hebrides area in 1993 and 95.
- North Sea: Data have only been processed for 1995 and 96. Moderate catch rates were recorded in the central North Sea in 1995. In 1996 the catch rates increased considerably and the fish occupied a wider area to include Tampen and Viking Banks.

2.4.3 Trends in age 1 fish in the first quarter surveys 1986–97 (Figure 2.4.4)

There was no coverage south of 48°N except in 1992 and 1993.

- Cornwall & Western Approaches: Catch rates increased to high levels from 1986 to 94 and then decreased thereafter. The maximum catch rates were recorded in 1992.
- West of Ireland/Hebrides: The bulk of the age 1 fish were found in this area from 1990. The distribution tended to be more northerly (i.e. Hebrides area) during the good recruitment years of 1988, 90, 94 & 96. In years of poor recruitment the distribution was more even or tended to be higher in the areas off Cornwall. Very few age 1 fish were caught in this area in 1997.
- North Sea: Data have only been processed for 1996 and 97. There were two good catches in the Tampen area in 1996. Otherwise very little was caught in the rest of the North Sea. In 1997 the majority of all the age 1 fish were found in the area of the Tampen and Viking Banks. This is a highly unusual event, as can be seen from both the distribution maps and the North Sea recruit index (Table 3.1.1). The provenance of these fish is presently unknown and the Working Group feels that it is premature to consider whether these are North Sea or Western mackerel. This matter will be given further study.

2.4.4 Mackerel recruit indices

Some doubt has been expressed about the value of the mackerel recruit index derived from all the bottom trawl surveys in quarters 4 and 1 (ICES 1996/Assess:7; ICES 1995/Assess:2). Evidence was presented in the 1996 report (ICES 1997/Assess:3) that this might be explained by the more northerly distribution of the juvenile fish in recent years. The Working Group recommended that modelling and other studies be carried out to explore this.

To this end, studies have been carried out to compare the recruitment indices calculated for each individual survey series with the assessment index of recruitment. Two indices; one calculated from the Scottish west coast survey in the first quarter at age 1 (Figure 2.4.5) and one from the La Coruña fishery CPUE at age 1 (Spanish trawl fleet, VIIIc west) (Figure 2.4.6) show good fits with the assessment. As noted in last years report (ICES 1997/Assess:3) there appears to be a tendency in recent years for high catch rates to be taken at the extreme north and south ends of the range in good recruit years. Examination of the age 1 distribution maps from the quarter 1 bottom trawl surveys show that high catch rates were recorded in the Hebrides area in 1988, 90, 94 & 96, in each case following a peak in recruitment. There may be two possible explanations for this. First, that following a good recruit year the juvenile fish tend to spread out over a wider area, the so called "basin effect". Or secondly, that the conditions which lead to a good recruitment also tend to result in the a greater transport of the young fish into the Hebrides area. In either case there is good support from these data for the use of the West of Scotland surveys as an index of good vs. poor recruitment.

It is interesting to note that the index derived from all the surveys also showed up the good recruit years well. However, it also showed a high value for the 1991 year class which was not reflected in the assessment series. In 1992 there was a dramatic increase in catch rates around Cornwall, and this would have tended to produce a high overall index. There is still evidence of a general trend in the overall survey index which was also not reflected in the assessment series. The reasons for this remain unclear.

In quarter 1 1997 the fit between the assessment series and the Scottish west coast survey appeared to break down, with the survey index being much lower. As described above, the juvenile distribution maps (Figure 2.4.2) showed a dramatic increase in age 1 fish in the northern North Sea. Based on the assumption that these fish might belong to the Western "stock" rather than the North Sea "stock" they were then included in the west coast index. This resulted in a good fit with the assessment index.

The conclusion from these studies is that the two trawl indices can be used as reliable pointers to recruitment success or failure. However it continues to be important to collect recruit data from the other bottom trawl surveys in both quarters to retain an appreciation of changes in juvenile distribution and their potential impact on the validity of the indices.

As noted in last year's Working Group report (ICES 1997/Assess:3) and again this year, there have been marked interannual changes in the North/South distributions of juvenile mackerel which have cast doubt on the traditional method of calculating the recruit index. For this reason this index has not been calculated for 1996. The two indices mentioned above, the Scottish west coast survey at age 1 and the La Coruña fishery at age 1 will be used to indicate the pattern of recruitment.

2.5 The Fishery in 1996

The total catch estimated by the Working Group to have been taken from the various areas is shown in Table 2.1.1. This table shows the development of the fisheries since 1969. The total estimated catch in 1996 was about 563,600 t which was approximately 192,000t lower than the catch taken in 1995 and the lowest recorded from the fishery since 1973. The TACs set for 1996 amounted to 446,000 t (see Section 2.5.1.) The dramatic decrease was mainly due to the decrease in the TACs set as a result of the international agreements and the effective enforcement of the management measures. Estimates of discards are also shown in this table but these estimates apply to one fleet only.

During 1996 the highest catches (over 201,000 t) were again taken from Sub-area IV and Division IIIa - over 97% of these having been taken in Division IVa. There was, however, a considerable decrease in the catch taken from this area compared with that of 1995. A small decrease was also observed in the catches from Divisions IIa and Vb (103,000 t) where the international fisheries take place. Significant decreases also took place in the fisheries in Sub-areas VI and VII and Division VIIIa,b,d,e (213,000 t). The catches taken in Divisions VIIIc and IXa have slowly increased in recent years and the 1996 catch of over 34,000 t is the highest recorded since 1977. The amounts misreported during 1996 also decreased compared with previous years. Approximately 52,000 t of mackerel, taken in Division IVa, were reported as having been taken in Division VIa - the corresponding figure for 1995 was 107,000 t. This decrease was due to increased monitoring of the fisheries and also the decreased TACs. Catches from the fishery in the southern part of Division VIa which had developed considerably in recent years decreased in 1996 and fell from 20,000 t to 13,000 t.

The catches per quarter and per Sub-area and by Division are shown in Table 2.5.1 and also in Figures 2.5.1a–d. The quarterly distribution of the fisheries in 1996 was very similar to that of 1995. Over 37% of the total catch was taken during the 1st quarter as the shoals migrate through Sub-area VI to the main spawning areas in Sub-area VII. Only 8% of the total catch was taken in Quarter 2, most of it from Sub-areas VI and VII. During Quarter 3 the main catches were recorded from Division IIa and Division IVa from the shoals on the summer feeding areas. During Quarter 4 the main catches were recorded from the overwintering areas in Division IVa. The main catches from Divisions VIIIc and IXa were taken in Quarter 2 - over 57% of the total being taken in Quarter 2 from Division VIIIc. The quarterly distributions of the catches since 1990 are shown in the table below. Over this period there appears to have been a gradual change in the timing of the fisheries, with a decreasing amount of the catch being taken from Q4 and a corresponding increase in the catches from Q1.

Percentage distribution of the total catches from 1990–1996

Year	Q1	Q2	Q3	Q4
1990	28	6	26	40
1991	38	5	25	32
1992	34	5	24	37
1993	29	7	25	39
1994	32	6	28	34
1995	37	8	27	28
1996	37	8	32	23

National catches

The national catches recorded by the various countries for the different areas are shown in Tables 2.5.2–2.5.5. As has been stated before these figures should not be used to study trends in national figures because of the degree of misreporting, and the high "unallocated" catches due to some countries exceeding their quota. Some mistakes have been discovered in these tables - particularly for the earlier years and these have been corrected. These mistakes, however did not effect the catches in numbers at age used in the assessments The main mackerel catching countries in recent years continue to be Norway, United Kingdom, Ireland, Netherlands and Russia.

The total catch recorded from Divisions IIa and Vb (Table 2.5.2) was believed to be about 103,300 t, which was considerably lower than that for 1995 (135,493). Most of this catch was taken by Norway and Russia. The total catch believed to have been taken from "international" waters in this area was about 51,300 t. There appeared to have been no misreporting of catches from this area during 1996 but there is no data to support this assumption. High levels of misreporting were recorded in 1994 (109,600 t).

The total catch recorded from the North Sea (Sub-area IV and Division IIIa) (Table 2.5.3) was 212,800 t compared with 322,100 t in 1995. This figure is the lowest recorded from the area since 1986. This decrease was mainly a result of a decrease in fishing effort in Division IVa as a result of the reduced quota and more effective enforcement of the management measures? About 51,700t were believed to have been taken in Division IVa but were reported as having been taken in Division VIa. The main catches were recorded by Norway (88,000 t), while substantial catches, totalling 56,000 t were also recorded by Denmark, the United Kingdom and Faroe Islands.

The total catch estimated from the Western areas (Table 2.5.4) was 213,300 t , after correcting for unallocated and misreported catches (minus 41,800 t). The unallocated, misreported catches and discards are mainly made up of an unallocated catch of approximately 10,000 t together with catches of about 51,700 t believed to have been taken in Division IVa. The national catches have been very stable for a number of years - the main catches being recorded by the United Kingdom, Ireland and the Netherlands.

The total catch recorded from Divisions VIIIc and IXa (Table 2.5.5) was 34,100 which is the highest total recorded since before 1977 and continues the increasing trend in catches from this area observed in recent years. The increased catches were as a result of increased prices for mackerel. Most of the catch from this area is taken by Spain (>90%).

2.5.1 ACFM advice and management applicable to 1996 and 1997

The TACs agreed by the various management authorities and the advice given by ACFM for 1996 and 1997 were as follows:

	1996			1997	
Stock	Advice recommended by ACFM	Agreed TAC	Catch	Recommended TAC	Agreed TAC
North Sea Stock	Lowest possible level	52.8	?	LPL	52.8
Western Stock	Significant reduction of F	369.2	530	see text	363.2
Southern Stock	No advice given	30	34	see text	30.

[1]Assumed to be mainly Western stock mackerel, taken from Sub-area IV, Division IIIa and IIa, and included in the total agreed TAC for the western stock.

[2]Division VIIIc, Sub-areas IX and X and CECAF Division 34.1.1 (EU waters only).

The agreed TAC for 1997 for the Western and North Sea stocks combined amounts to 416,300t and this figure includes the agreements between EU, Norway and the Faroes. For 1997 ACFM recommended a significant reduction in fishing mortality in order to restore and maintain the SSB within the range observed in the time series available.

It is again important to stress that while the recommended TACs are meant to apply to the total catch of all mackerel over the total distribution area the actual agreed TACs do not apply to the catches taken in international waters. The total catches in international waters, which are mainly taken by Russia in the Norwegian Sea, have been increasing in recent years and amounted to over 51,000t in 1996. There are no restrictions on the amount of fish which can be taken in this fishery.

In addition to the TACs and the national quota the following are some of the more important additional management measures which were in force in 1996 and are again in force in 1997. These measures are mainly designed to afford maximum protection to the North Sea stock while it remains in it's present depleted state while at the same time allowing fishing on the western stock while it is present in the North Sea.

1. Prohibition of fishing in Division IVa during Quarters 1 and 2, and of a directed mackerel fishery in Divisions IVb and IVc throughout the year (Norway opened for a small fishery in Division IVa the first quarter of 1996 and 1997);
2. Prohibition of a directed mackerel fishery in the "Cornwall Box";
3. Minimum landing size of 30 cm for Sub-area IV, Division IIIa and 25 cm for Divisions VIIIc and IXa.

Various national measures such as closed seasons and boat quotas are also in operations in most of the major mackerel catching countries.

2.6 Distribution of the Mackerel Fisheries

The distribution of the mackerel catches taken in 1996 is shown per quarter and per Sub-area and Division in Table 2.5.1. More detailed information on catches, per statistical rectangle, based on logbook information is shown in Figures 2.5.1a–d. The information is incomplete because it is based only on catches from Netherlands, Norway, Ireland, Russia, Denmark, Spain, Portugal and United Kingdom. The catches represent over 400,000 t or about 70% of the total catch. In these figures the Spanish catches are not based on official data and the total catches have not been corrected for any misreporting.

First quarter 1996

Catches taken during this quarter totalled about 207,800 t. Misreporting of catches between Division IVa and VIa takes place particularly during the early part of this quarter and although the amounts have decreased during 1996 the distribution of the fishery shown in this quarter should be treated with caution. The distribution of the catches appear to be very similar to that of 1995 and reflects the migration of the shoals as they move away from the overwintering areas in the North Sea and IIa along the west of Scotland and Ireland towards the spawning grounds south-west of Ireland and England. Small catches are also taken during this quarter in the western English Channel and along the Iberian Peninsula. The distribution is shown in Figure 2.5.1.a.

Second quarter 1996

Catches during this quarter totalled about 47,000 t. The main catches were again taken from the spawning grounds west and south-west of Ireland. Small catches were again taken from the Iberian Peninsula, particularly in the south-eastern Section of the Bay of Biscay. Some catches were also reported from the international waters in the Norwegian sea. The distribution was again very similar to that of 1995 and is shown in Figure 2.5.1.b.

Third quarter 1996

Catches during this quarter totalled about 180,800 t. During this quarter the main catches were taken in the fisheries west of Norway where the distribution was again similar to 1995. Catches taken from the fishery in the international waters in the Norwegian Sea were distributed over a very wide area and the general distribution appeared to be similar to that in 1995. This fishery takes place in the early part of the quarter and the catches are taken in a more westerly area than the catches taken in the later part of the quarter. Small catches were again taken from around the Iberian Peninsula, particularly along the west coast of Portugal. The distribution is shown in Figure 2.5.1.c.

Fourth quarter 1996

Catches during this quarter totalled 128,800t. The main catches were again taken west of Norway. Catches were also taken from north-west of Ireland but on a more reduced scale than in 1995. Considerable catches were again taken from the western part of the English Channel. Small catches continued to be taken from around the Iberian Peninsula. The distribution is shown in Figure 2.5.1.d.

2.7 Length Compositions by Fleet and Country

Length distributions of some of the 1996 catches by some of the fleets were provided by Germany, Ireland, Netherlands, Norway, Portugal, Russia, Spain and United Kingdom. The length distributions were available from most of the major fishing fleets and account for about 75% of all catches. These distributions are only intended to give a very rough indication of the size of mackerel landed by the various fleets and they do not reflect the seasonal variations that occur in many of the landings More detailed information on a quarterly basis is available for some fleets on the Working Group files. The length distributions by country and by fleet for 1996 are shown in Table 2.7.1.

2.8 Catch in Numbers at Age

The catches in numbers at age by quarter for Divisions IIa; IIIa; IVa; IVb,c; VIa; VIIa,e,f,g,h; VIIb,c,j,k; VIId and VIIIa,b,d,e are shown in Table 2.8.1. The percentage catch by numbers at age from 1985 to 1995 is given in Figure 2.9.

The catch in number at age by quarter for mackerel from Divisions VIIIc and IXa for southern mackerel is given in Table 2.8.2 for 1996 and in Table 2.8.7 for the period 1984–1996.

The overall age composition for the catches from the Western areas is mainly composed of 2–7 year old fish. These age groups constitute 72% of the total catches. Three year old fish i.e. the 1993 year dominated the catches throughout most areas. Fish belonging to the 1995 year class were dominant in the catches in Q3 in Division VIa. The overall age compositions are reasonably consistent throughout most areas with the exceptions of Divisions IVb,c and Divisions VIIa,e,f,g,h and Division VIId. These three areas contain much higher numbers of 0 and 1 year old fish. In most areas catches of 0 and 1 group mackerel are insignificant and less than 1%. However, in Division IVb,c they amount to 50%; mainly being taken in the Quarter 4. In Divisions VIIa,e,f,g, VIa and VIId the respective percentages are 26%, 11.6% and 12.8%.

Catches from Divisions VIIIc and IXa were again dominated by young mackerel. Mackerel belonging to 0/1 groups constituted 44% of the catch compared with 24% for 1995. Fish in the age groups 2–6 constituted 35% while those in the older groups constituted 21%. These percentages are very similar to the averages over the period 1990–1996 when the respective figures were 38%, 43% and 19%.

Age distributions of catches were provided by Denmark, Ireland, Netherlands, Norway, Portugal, Russia, Spain and United Kingdom. There were again some serious deficiencies in the overall sampling of the catches. No age distributions were available from a number of countries who take substantial catches, e.g. the Faroes, France, and Sweden who together take nearly 38,000 t. Russian age data has been used to cover the catches taken from "international" waters in Divisions IIa and Vb (51,000 t) but it is by no means certain that this is appropriate because of lack of information on the gears used by other fleets fishing in these areas. Catches by pelagic trawlers fishing in Division IVa have not been adequately sampled and have been converted to numbers at age using samples from purse seine catches. In addition, there were no samples to cover the entire catch from Division VIId (4,000 t) and very limited data to cover the catches taken from Division IIIa. Catches for which there was no sampling data were converted into numbers at age using data from the most appropriate fleets. As in 1995 this procedure was not considered satisfactory because of possible differences between fishing gears in the different areas.

The sampling intensity is further discussed in Section 1.3.1.

2.9 Mean Lengths at Age and Mean Weights at Age

Mean lengths

The mean lengths at age per quarter for 1996 for the Western area and for the Southern area are shown in Tables 2.8.3 and 2.8.4 respectively. A long series of these data are available on mean lengths for both these areas and should be investigated for possible changes in relation to changes in stock sizes.

Mean weights

The mean weights at age in the catches per quarter for 1996 for the western and southern areas are shown in Tables 2.8.5 and 2 8.6 respectively. The mean weights at age in the stock for the western mackerel is shown in Table 3.2.3. These are based on a combination of samples obtained from Dutch freezer trawlers fishing on the spawning grounds west of Ireland, together with data from the Irish fisheries during the same period. The mean weights at age in the stock for the southern mackerel are based on samples obtained during Quarter 1 and Quarter 4 . The same data set has been used since 1984 and the data is shown below.

Stock Weights at Age (kg) for Southern Mackerel

Age in Years														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
.161	.248	.305	.354	.385	.427	.455	.493	.511	.545	.548	.617	.622	656	.716

Mean weights at age in the catches for the southern areas for the period 1984–1996 are shown in Table 2.8.8.

2.10 Maturity Ogive

A comprehensive review of the problems related to the estimation of maturity at age was given in the report of this Working Group in 1996 (ICES 1997Assess:3). Some of the question raised in that review were addressed to the Mackerel and Horse Mackerel Egg Survey Working Group which met in February 1997 to plan the 1998 egg surveys. Their response is summarised in Sections 1.4.3 and 1.4.4. As a result this Working Group has now revised the maturity at age 2 of the 1984 year class from 20% mature to 60% mature in line with the general maturity ogive applied since 1997.

It is important for assessment purposes that the maturity ogive represents the proportions of fish by age group that actually spawn, because the assessment is tuned to the SSB obtained from egg surveys. This is particularly important when a strong year class recruits to the stock. For the 1992 and 1995 egg survey years it was not possible to provide a maturity ogive because of poor sampling of the population distribution. This problem will be addressed in the 1998 surveys when fish sampling will be distributed across both predominantly adult and juvenile distribution areas. The maturity ogive for 1998 will be based on histological examination of the ovaries rather than the macroscopic examination used in previous survey years. In this context a proposal has been submitted to the EU for funding this aspect of the 1998 surveys. Unless some financial support becomes available it is unlikely that this part of the programme will be able to proceed. Histological maturity data indicate that proportions mature based on macroscopic examination tend to overestimate the proportions mature in the 1 to 3 age groups. This is because a large proportion of the younger age group which start to produce vittellogenic oocytes never actually spawn and those oocytes become atretic.

Table 2.1.1 Catches of MACKEREL by area. Discards not estimated prior to 1978. (Data submitted by Working Group members.)

Year	Sub-area VI			Sub-area VII and Divisions VIIIa,b,d,e			Sub-area IV and Division IIIa			Divs. IIa,Vb[1]	Divs. VIIIc, IXa	Total		
	Landings	Discards	Catch	Landings	Discards	Catch	Landings	Discards	Catch	Landings	Landings	Landings	Discards	Catch
1969	4,800		4,800	66,300		66,300	739,182		739,182			810,282		810,282
1970	3,900		3,900	100,300		100,300	322,451		322,451	163		426,814		426,814
1971	10,200		10,200	122,600		122,600	243,673		243,673	358		376,831		376,831
1972	10,000		10,000	157,800		157,800	188,599		188,599	88		356,487		356,487
1973	52,200		52,200	167,300		167,300	326,519		326,519	21,600		567,619		567,619
1974	64,100		64,100	234,100		234,100	298,391		298,391	6,800		603,391		603,391
1975	64,800		64,800	416,500		416,500	263,062		263,062	34,700		779,062		779,062
1976	67,800		67,800	439,400		439,400	303,842		303,842	10,500		821,542		821,542
1977	74,800		74,800	259,100		259,100	258,131		258,131	1,400	27,417	620,848		620,848
1978	151,700	15,100	166,900	355,500	35,500	391,000	148,817		148,817	4,200	26,508	686,725	50,700	737,425
1979	203,300	20,300	223,600	398,000	39,800	437,800	152,323	500	152,823	7,000	22,475	783,098	60,600	843,698
1980	218,700	6,000	224,700	386,100	15,600	401,700	87,391		87,391	8,300	15,964	716,455	21,600	738,055
1981	335,100	2,500	337,600	274,300	39,800	314,100	64,172	3,216	67,388	18,700	18,053	710,325	45,516	755,841
1982	340,400	4,100	344,500	257,800	20,800	278,600	35,033	450	35,483	37,600	21,076	691,909	25,350	717,259
1983	315,100	22,300	337,400	245,400	9,000	254,400	40,889	96	40,985	49,000	14,853	665,242	31,396	696,638
1984	306,100	1,600	307,700	176,100	10,500	186,600	39,374	202	39,576	93,900	20,308	635,782	12,302	648,084
1985	388,140	2,735	390,875	75,043	1,800	76,843	46,790	3,656	50,446	78,000	18,111	606,084	8,191	614,275
1986	104,100		104,100	128,499		128,499	236,309	7,431	243,740	101,000	24,789	594,697	7,431	602,128
1987	183,700		183,700	100,300		100,300	290,829	10,789	301,618	47,000	22,187	644,016	10,789	654,805
1988	115,600	3,100	118,700	75,600	2,700	78,300	308,550	29,766	338,316	116,200	24,772	640,722	35,566	676,288
1989	121,300	2,600	123,900	72,900	2,300	75,200	279,410	2,190	281,600	86,900	18,321	578,831	7,090	585,921
1990	114,800	5,800	120,600	56,300	5,500	61,800	300,800	4,300	305,100	116,800	21,311	610,011	15,600	625,611
1991	109,500	10,700	120,200	50,500	12,800	63,300	358,700	7,200	365,900	97,800	20,683	637,183	30,700	667,883
1992	141,906	9,620	151,526	72,153	12,400	84,553	364,184	2,980	367,164	139,062	18,046	735,351	25,000	760,351
1993	133,497	2,670	136,167	99,828	12,790	112,618	387,838	2,720	390,558	165,973	19,720	806,856	18,180	825,036
1994	134,338	1,390	135,728	113,088	2,830	115,918	474,830	1,150	475,980	69,900	25,043	817,198	5,370	822,568
1995	145,626	74	145,700	117,883	6,917	124,800	322,670	730	323,400	134,100	27,600	747,879	7,721	755,600
1996	129,895	255	130,150	73,351	9,773	83,124	211,451	1,387	212,838	103,376	34,123	552,196	11,415	563,611

[1]For 1976-1985 only Division IIa.
[2]Discards estimated only for one fleet in recent years.

NB: Landings from 1969–1978 were taken from the 1978 Working Group report (Tables 2.1, 2.2 and 2.5).

Table 2.2.1 Spawning stock biomass for the western mackerel and western horse mackerel. Spawning stock biomass estimates are corrected for atresia. A sex ratio of 1:1 is assumed. The SSB was calculated from the total egg production based on arithmetic mean of unsampled rectangles if available.

Mackerel:

Year	Total egg production (10^{-15}) (Mean used for unsampled rectangles) Geometric	Arithmetic	Total fecundity eggs/g female [atresia oocytes/gm female]	Total fecundity corrected for atresia (eggs/g female)	Pre-spawning stock biomass ($x10^{-6}$ tonnes)	Spawning stock biomass ($x10^{-6}$ tonnes) (conv. f.x1.08)
Annual egg production method - western mackerel						
1977	1.98		1526 [211]	1315	3.01	3.25
1980	1.48 a		1526 [211]	1315	2.25	2.43
1980	1.84 b		1526 [211]	1315	2.80	3.02
1983	1.50	1.53	1526 [211]	1315	2.33	2.51
1986	1.15	1.24	1457 [211]	1246	1.99	2.15
1989	1.45	1.52	1608 [326]	1282	2.37	2.56
1992	1.83	1.94	1569 [138]	1431	2.71	2.93
1995	-	1.49	1473 [171]	1302	2.28	2.47

Horse Mackerel:

Year	Total egg production (10^{-15}) (Mean used for unsampled rectangles) Geometric	Arithmetic	Total fecundity (eggs/g female)	Total fecundity corrected for 3.4% atresia (eggs/g female)	Pre-spawning stock biomass ($x10^{-6}$ tonnes)	Spawning stock biomass ($x10^{-6}$ tonnes) (conv. f.x1.05)
Annual egg production method - western horse mackerel						
1977	0.533 c		1557	1504	0.71	0.74
1980	0.635 c		1557	1504	0.84	0.89
1983	0.381 c		1557	1504	0.51	0.53
1986	0.508 c		1557	1504	0.68	0.71
1989	1.54	1.63	1557	1504	2.17	2.28
1992	1.37	1.58	1557	1504	2.10	2.21
1995	-	1.226	1557	1504	1.63	1.71

a Egg survey data for period 3 included
b Egg survey data for period 3 excluded
c Eaton (1989). Incomplete coverage in 1977

Estimates by Generalized Additive Modelling (from Augustin et al WD 1996)

Year	Area	Mackerel GAM (no bc)	Mackerel GAM (with bc)		Horse mackerel GAM (no bc)	Horse mackerel GAM (with bc)
		Egg Production x 10^{-15}				
1995	Western	0.854	1.623		0.886	1.554
		0.02	*0.05*		*0.09*	*0.24*
		[2.7]	[2.9]		[10.2]	[15.4]
	Southern	0.136	0.202		0.396	0.553
1992	Western	1.744	2.366		1.44	1.804
		0.05	*0.07*		*0.11*	*0.21*
		[2.6]	2.9		[7.5]	[11.9
1989	Western	1.373	3.027		1.308	1.635
		0.09	*0.12*		*0.09*	*0.14*
		[6.5]	[3.8]		[6.7]	[9.2]

bc = bias correction
Figures in italics are standard errors
Figures in brackets are %cv's

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Table 2.5.1 Catches of mackerel by Division and Sub-area in 1996.
(Data submitted by Working Group members.)

Quarter	1	2	3	4	Total
IIa + Vb	3100	5,500	93800	1000	103400
IIIa	500	500	2700	2400	6100
IVa	55900	300	63200	83900	203300
IVb,c			900	2500	3400
VI	103000	2200	13100	11800	130100
VII	36100	16200	2700	24900	79900
VIIIa,b,d,e	500	2100		500	3100
Sub-total	199100	26800	176400	127000	529300
VIIIc	7000	18700	2000	600	28300
IXa	700	1500	2300	1200	5700
Grand total	206800	47000	180700	128800	563300

Catches rounded to nearest 100.

Table 2.5.2 Catches (t) of MACKEREL in the Norwegian Sea (Division IIa) and off the Faroes (Division Vb). (Data submitted by Working Group members.)

	1984	1985	1986	1987[1]	1988[1]	1989
Denmark	11,787	7,610	1,653	3,133	4,265	6,433
Faroe Islands	137				22	1,247
France		16				11
Germany, Fed. Rep.			99		380	
German Dem. Rep.			16	292		2,409
Norway	82,005	61,065	85,400	25,000	86,400	68,300
Poland						
United Kingdom			2,131	157	1,413	
USSR	4,293	9,405	11,813	18,604	27,924	12,088
Discards						
Total	98,222	78,096	101,112	47,186	120,404	90,488

Country	1990	1991	1992	1993[2]	1994[2]	1995	1996[1]
Denmark	6,800	1,098	251			4,746	3,198
Estonia			216		3,302	1,925	3,741
Faroe Islands	3,100	5,793	3,347	1,167	6,258	9,032	2,965
France		23	6	6	5	5	0
Germany							1
Iceland							92
Latvia			100	4,700	1,508	389	233
Netherlands							561
Norway	77,200	76,760	91,900	110,500	140,708	93,315	47,992
Russia			42,440	49,600	28,041	44,537	44,545
United Kingdom	400	514	802		1,706	194	48
USSR[2]	28,900	13,631[3]					
Misreported (IVa)					-109,625	-18,647	
Discards	2,300						
Total	118,700	97,819	139,062	165,973	71,903	135,496	103,376

[1]Preliminary.
[2]Russia.

Table 2.5.3 Catch (t) of MACKEREL in the North Sea, Skagerrak, and Kattegat (Sub-area IV and Division IIIa). (Data submitted by Working Group members).

Country	1984	1985	1986	1987	1988	1989
Belgium	68		49	14	20	37
Denmark	10,088	12,424	23,368	28,217	32,588	26,831
Faroe Islands		1,356				2,685
France		322	1,200	2,146	1,806	2,200
Germany, Fed. Rep.	112	217	1,853	474	177	6,312
Ireland						8,880
Netherlands	340	726	1,949	2,761	2,564	7,343
Norway	27,311	30,835	50,600	108,250	59,750	81,400
Sweden	1,440	760	1,300	3,162	1,003	6,601
United Kingdom	15	170	559	19857	1,002	38,660
USSR						
Misreported (IIa)						
Misreported (VIa)			148,000	117,000	180,000	92,000
Unallocated & Discards	202	3,656	14,822	19,737	59,406	8,651
Total	39,576	50,466	243,700	301,618	338,316	281,600

Country	1990	1991	1992	1993	1994	1995	1996[1]
Belgium		125	102	191	351	106	62
Denmark	29,000	38,834	41,719	42,502	47,852	30,891	24,057
Estonia			400				
Faroe Islands	5,900	5,338		11,408	11,027	17,883	13,886
France	1,600	2,362	956	1,480	1,570	1,599	1,316
Germany, Fed. Rep.	3,500	4,173	4,610	4,940	1,479	712	542
Ireland	12,800	13,000	13,136	13,206	9,032	5,607	5,280
Latvia			211				
Netherlands	13,700	4,591	6,547	7,770	3,637	1,275	1,996
Norway	74,500	102,350	115,700	112,700	115,741	108,785	88,444
Sweden	6,400	4,227	5,100	5,934	7,099	6,285	5,307
United Kingdom	30,800	36,917	35,137	41,010	27,479	21,609	18,545
Russia							
Romania					2,903		
Misreported (IIa)					109,625	18,647	
Misreported (VIa)	126,000	130,000	127,000	146,697	134,765	106,987	51,781
Unallocated & Discards	900	23,958	16,546	2,720	1,417	1,713	1,623
Total	305,100	365,875	367,164	390,558	473,977	322,099	212,839

[1] Preliminary.

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Table 2.5.4 Catch (t) of MACKEREL in the Western area (Sub-areas VI and VII and Divisions VIIIa,b,d,e). (Data submitted by Working Group members).

Country	1984	1985	1986	1987	1988	1989
Belgium						
Denmark	200	400	300	100		1,000
Faroe Islands	9,200	9,900	1,400	7,100	2,600	1,100
France	12,500	7,400	11,200	11,100	8,900	12,700
Germany	11,200	11,800	7,700	13,300	15,900	16,200
Ireland	84,100	91,400	74,500	89,500	85,800	61,100
Netherlands	99,000	37,000	58,900	31,700	26,100	24,000
Norway	34,700	24,300	21,000	21,600	17,300	700
Poland						
Spain	100				1,500	1,400
United Kingdom	198,300	205,900	156,300	200,700	208,400	149,100
USSR	200					
Unallocated	18000	75100	49299	26000	4700	18900
Misreported (IVa)			-148,000	-117,000	-180,000	-92,000
Discards	12,100	4,500			5,800	4,900
Grand Total	479,600	467,700	232,599	284,100	197,000	199,100

Country	1990	1991	1992	1993	1994	1995	1996
Belgium							
Denmark		1,573	194		2,239	1,443	1,271
Estonia						361	
Faroe Islands	1,000	4,095		2,350	4,283	4,248	
France	17,400	10,364	9,109	8,296	9,998	10,178	14,347
Germany	18,100	17,138	21,952	23,776	25,011	23,703	15,685
Ireland	61,500	64,827	76,313	81,773	79,996	72,927	49,033
Netherlands	24,500	29,156	32,365	44,600	40,698	34,514	34,203
Norway				600	2,552		
Spain	400	4,020	2,764	3,162	4,126	4,509	2,271
United Kingdom	162,700	162,588	196,890	215,265	208,656	190,344	127,612
Unallocated	11,500	-3,802	1,472	0	4,632	28,245	10,603
Misreported (IVa)	-126,000	-130,000	-127,000	-146,697	-134,765	-106,987	-51,781
Discards	11,300	23,550	22,020	15,660	4,220	6,991	10,028
Grand Total	182,400	183,509	236,079	248,785	251,646	270,476	213,272

Table 2.5.5 Landing (tonnes) of Mackerel in Divisions VIIIc and IXa, 1977 - 1996.

(Data submitted by Working Group members).

	Division VIIIc	Division IXa					
Years	Spain	Portugal	Spain	Poland	USSR	Total	TOTAL
1977	19,852	1,743	2,935	8	2,879	7,565	27,417
1978	18,543	1,555	6,221	-	189	7,965	26,508
1979	15,013	1,071	6,280	-	111	7,462	22,475
1980	11,316	1,929	2,719	-	-	4,648	15,964
1981	12,834	3,108	2,111	-	-	5,219	18,053
1982	15,621	3,018	2,437	-	-	5,455	21,076
1983	10,390	2,239	2,224	-	-	4,463	14,853
1984	13,852	2,250	4,206	-	-	6,456	20,308
1985	11,810	4,178	2,123	-	-	6,301	18,111
1986	16,533	6,419	1,837	-	-	8,256	24,789
1987	15,982	5,714	491	-	-	6,205	22,187
1988	16,844	4,388	3,540	-	-	7,928	24,772
1989	13,446	3,112	1,763	-	-	4,875	18,321
1990	16,086	3,819	1,406	-	-	5,225	21,311
1991	16,940	2,789	1,051	-	-	3,840	20,780
1992	12,043	3,576	2,427	-	-	6,003	18,046
1993	16,675	2,015	1,027	-	-	3,042	19,719
1994	21,146	2,158	1,741	-	-	3,899	25,045
1995	23,631	2,893	1,025	-	-	3,918	27,549
1996	28,386	3,023	2,714	-	-	6,737	34,123

Table 2.7.1 Length distribution in 1996 catches (thousands) by various fleets.

	Scotland			Norway*	Netherlands	Spain			Ireland	UK (England & Wales)		Russia	Portugal			Germany
Length cm	P. Seine	Other	P. Trawl	P. Seine	Pelagic Trawl	P. Seine	Artisanal	Trawl	P. Trawl	Trawl	Handline	Commercial	P.seine	Artisanal	Trawl	
14						45										
15						445										
16						1,436										
17					325	1,214				0.00						1
18				0	367	1,723				0.00						3
19				1	934	6,196		100		0.00			1			167
20				0	1,485	5,472		587	21	0.00			98	2		1,451
21				0	1,627	5,673		3,798		0.00			184	19	5	1,633
22			6	17	1,437	5,716		4,183	62	0.00			604	36	34	1,098
23	20		6	4	1,631	1,463		620		0.00			455	9	62	452
24	1			0	536	525		179	143	0.00	9	1	90	2	69	112
25				0	850	2,867		46	566	0.00	64	78	146	31	67	23
26				22	2,444	7,155		102	1,102	0.00	216	371	147	54	206	3
27		70	2	75	5,784	6,948	2	179	1,155	0.00	267	1,367	145	50	381	23
28	5	23	30	2,188	8,475	5,712	8	292	2,363	0.00	403	2,703	96	29	418	74
29	112	178	50	6,472	5,196	1,001	31	281	5,164	0.03	578	4,629	149	29	203	173
30	545	410	357	8,121	6,139	581	45	314	8,466	0.26	755	8,072	203	17	114	509
31	1,692	747	392	10,182	6,508	669	119	632	9,733	0.62	687	11,693	425	11	96	970
32	3,005	1,164	504	21,193	7,667	1,689	665	987	11,829	0.94	563	15,765	654	29	126	1,377
33	5,222	1,506	919	34,732	11,577	2,436	989	1,011	14,010	1.04	592	12,546	678	62	180	2,052
34	6,555	1,570	1,421	45,708	11,223	2,293	1,332	1,022	16,768	1.10	499	10,614	479	51	184	2,707
35	8,154	1,858	1,770	44,422	12,736	2,144	1,915	927	14,266	1.17	249	7,983	480	51	166	2,467
36	6,727	2,131	1,957	37,464	10,020	1,509	2,183	684	11,561	1.68	114	6,006	369	81	118	1,961
37	6,484	2,214	1,484	29,796	7,897	1,422	2,748	455	8,444	1.26	104	5,464	204	80	154	2,050
38	5,863	2,562	1,613	25,764	7,664	1,528	4,670	406	9,195	0.53	55	2,981	176	425	89	1,955
39	5,760	2,346	1,579	20,419	5,794	2,428	5,288	438	7,667	0.32	86	1,993	54	156	139	2,043
40	3,489	1,572	2,091	12,515	4,977	2,803	6,150	327	7,056	0.09	50	922	51	333	128	1,639
41	2,434	898	1,559	6,788	3,213	2,451	3,286	162	4,452	0.09	35	318	7	55	94	1,010
42	1,111	852	894	4,586	1,523	1,332	2,901	132	3,046	0.09	4	183	2	40	61	665
43	667	169	308	1,452	675	732	1,358	72	1,735		1			172	23	302
44	189	215	104	237	295	304	410	35	540					44	7	121
45	96	88	49	71	83	126	135	9	415	0.03				28	2	78
46	107		6	21		103	66	3	83					10		18
47				15		25	5	2						5		4
48						5	9							2		5
49					202	5								3		3
50														3		
Total No.	482,979	20,576	16,840	312,265	129,284	78,176	34,315	17,985	139,842	9.2	5,330.4	93,689	5,897	1,919	3,126	27,149
Tonnes	28,717	8,976	7,356	136,436	39,045	14,771	15,307	3,292	48,894	4	1,317	44,545	1,231	755	1,038	13,193

*ICES Divsions IIa,IIIa and IVa combined

Table 2.8.1 Catch in numbers ('000) at age by quarter and by Division for mackerel in sub-divisions II-VIII in 1996.

	Quarter 1 (Catch '000)									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	0	0	0	0	0	0
1	16	10	115	0	183	26	437	39	1	827
2	774	93	2,358	0	2,727	337	8,383	3,353	17	18,043
3	2,983	733	20,945	0	33,933	20,932	9,726	4,833	148	94,233
4	1,606	168	24,724	0	53,944	21,770	2,212	887	259	105,571
5	1,168	180	22,694	0	43,456	16,781	618	206	151	85,255
6	592	109	11,139	0	20,673	7,686	190	78	132	40,597
7	623	28	17,985	0	33,681	7,407	57	14	174	59,969
8	365	0	7,661	0	14,767	2,568	47	31	124	25,564
9	355	0	10,945	0	18,418	2,874	49	15	122	32,778
10	232	0	3,810	0	7,723	1,484	0	0	71	13,320
11	130	13	3,389	0	6,410	1,029	19	3	42	11,034
12	133	0	2,228	0	5,941	196	11	0	22	8,531
13	0	0	467	0	634	170	0	0	6	1,278
14	0	3	434	0	966	527	45	7	8	1,990
15+	55	4	859	0	2,009	511	36	6	3	3,484
Total	9,032	1,341	129,752	0	245,465	84,299	21,831	9,471	1,282	502,474
Tonnes	3,129	530	55,890	0	102,981	31,077	3,525	1,477	540	199,149

	Quarter 2 (Catch '000)									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	0	0	0	0	0	0
1	0	9	2	0	0	0	55	0	0	66
2	257	80	82	0	794	5,419	1,038	0	9	7,679
3	3,679	626	311	1	1,587	10,836	1,178	118	234	18,571
4	2,240	144	165	0	1,755	11,977	262	237	657	17,438
5	1,649	154	118	0	753	5,133	74	118	480	8,479
6	1,134	93	59	0	711	4,847	23	276	502	7,646
7	1,048	24	61	0	376	2,568	8	39	745	4,869
8	715	0	35	0	42	286	6	39	551	1,675
9	801	0	33	0	125	855	6	0	559	2,379
10	334	0	20	0	84	569	1	0	352	1,360
11	257	11	12	0	42	286	3	158	193	961
12	210	0	11	0	0	0	1	0	93	315
13	0	0	0	0	0	0	0	0	28	29
14	38	3	0	0	0	0	5	0	26	72
15+	0	3	5	0	0	0	4	0	9	22
Total	12,361	1,146	915	2	6,270	42,776	2,663	987	4,439	71,560
Tonnes	5,480	453	311	12	2,246	15,331	425	448	2,092	26,799

	Quarter 3 (Catch '000)									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	969	0	0	0	0	969
1	34	53	2,399	1,881	35,308	269	431	4	0	40,379
2	8,855	482	14,090	814	19,925	5,101	4,742	28	0	54,038
3	48,903	3,790	37,007	688	8,408	2,909	216	28	1	101,951
4	53,569	871	31,732	280	1,432	82	0	6	2	87,975
5	27,874	929	19,689	1	571	403	0	2	1	49,470
6	16,042	563	10,324	32	522	0	0	1	2	27,487
7	18,787	143	10,290	31	635	0	0	0	2	29,889
8	8,879	0	4,864	64	153	0	0	0	2	13,961
9	8,291	0	4,947	0	209	0	0	0	2	13,449
10	2,604	0	1,169	0	40	0	0	0	1	3,814
11	2,080	65	407	0	72	0	0	0	1	2,626
12	3,435	0	4,025	0	24	0	0	0	0	7,484
13	389	0	409	0	40	0	0	0	0	839
14	0	15	88	0	0	0	0	0	0	103
15+	688	20	699	0	16	0	0	0	0	1,423
Total	200,432	6,932	142,138	3,792	68,325	8,765	5,389	71	14	435,858
Tonnes	93,772	2,741	63,177	859	13,126	1,620	1,093	20	6	176,414

	Quarter 4 (Catch '000)									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	0	0	2,268	0	3,861	6,129
1	0	47	2,316	5,795	5,778	6,059	26,188	2,330	1,041	49,554
2	68	429	25,558	2,829	10,150	5,512	31,257	2,309	459	78,571
3	585	3,374	58,621	1,754	18,461	7,628	15,666	2,433	12	108,534
4	642	776	39,605	342	4,879	1,531	4,349	744	23	52,892
5	273	827	24,014	51	1,541	334	1,029	79	15	28,164
6	121	501	13,338	147	483	104	776	47	14	15,531
7	168	127	13,773	457	170	178	542	9	29	15,452
8	114	0	7,514	0	25	15	738	0	19	8,425
9	82	0	4,524	0	92	0	306	0	20	5,023
10	41	0	4,223	0	80	30	104	11	10	4,499
11	21	58	1,316	0	8	0	133	9	8	1,552
12	47	0	2,190	0	16	0	3	0	3	2,260
13	8	0	317	0	3	42	5	0	1	375
14	0	13	279	0	0	17	0	0	1	311
15+	4	18	419	0	0	0	0	0	1	441
Total	2,173	6,171	198,007	11,375	41,686	21,450	83,364	7,970	5,517	377,713
Tonnes	994	2,440	83,879	2,547	11,794	5,251	17,551	2,129	518	127,103

	Quarter 1 - 4 (Catch '000)									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	969	0	2,268	0	3,861	7,098
1	50	120	4,831	7,676	41,269	6,354	27,111	2,373	1,042	90,826
2	9,955	1,083	42,088	3,643	33,596	16,370	45,421	5,689	485	158,331
3	56,150	8,523	116,884	2,443	62,389	42,306	26,785	7,413	395	323,289
4	58,057	1,960	96,226	622	62,011	35,361	6,824	1,874	942	263,876
5	30,964	2,091	66,515	52	46,321	22,651	1,721	406	647	171,368
6	17,889	1,265	34,860	180	22,389	12,637	989	403	650	91,262
7	20,626	322	42,109	488	34,862	10,153	606	62	951	110,179
8	10,072	0	20,074	64	14,987	2,869	792	71	696	49,625
9	9,528	0	20,448	0	18,844	3,729	361	15	703	53,629
10	3,210	0	9,223	0	7,927	2,083	104	11	434	22,993
11	2,489	147	5,124	0	6,532	1,314	154	170	244	16,174
12	3,825	0	8,454	0	5,981	196	15	0	118	18,590
13	397	0	1,193	0	677	212	5	0	35	2,520
14	38	34	801	0	967	544	50	7	35	2,476
15+	747	45	1,981	0	2,026	511	41	6	13	5,369
Total	223,998	15,589	470,812	15,170	361,746	157,291	113,247	18,500	11,252	1,387,604
Tonnes	103,375	6,164	203,257	3,418	130,147	53,279	22,594	4,074	3,156	529,464

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Table 2.8.2 Catch in numbers ('000) at age by quarter and by Division for mackerel in sub-divisions VIIIC & IXa in 1996.

	Quarter 1		
Age	VIIIc	IXa	All Divisions
0	0	0	0
1	9,417	492	9,909
2	411	862	1,273
3	3,405	914	4,320
4	5,573	495	6,069
5	1,428	66	1,494
6	931	35	965
7	1,735	59	1,794
8	1,052	37	1,089
9	1,080	20	1,099
10	507	13	521
11	388	6	394
12	165	5	171
13	27	2	29
14	47	0	48
15+	40	1	40
Total	26,207	3,008	29,215
Tonnes	7,037	732	7,769

	Quarter 2		
Age	VIIIc	IXa	All Divisions
0	0	0	0
1	7,049	1,544	8,593
2	1,776	992	2,768
3	3,226	952	4,178
4	7,559	622	8,181
5	4,296	187	4,483
6	3,656	133	3,789
7	7,252	339	7,591
8	4,555	234	4,789
9	4,591	195	4,786
10	2,038	140	2,178
11	1,658	73	1,731
12	703	49	751
13	156	15	171
14	192	5	198
15+	219	9	228
Total	48,926	5,488	54,414
Tonnes	18,713	1,496	20,209

	Quarter 3		
Age	VIIIc	IXa	All Divisions
0	0	18,506	18,506
1	6,551	1,952	8,503
2	5,121	872	5,993
3	850	495	1,345
4	303	505	809
5	56	186	242
6	25	203	228
7	36	141	177
8	16	238	254
9	12	210	221
10	5	55	60
11	3	9	12
12	1	0	1
13	0	0	0
14	0	0	0
15+	0	0	0
Total	12,980	23,372	36,352
Tonnes	2,074	2,343	4,417

	Quarter 4		
Age	VIIIc	IXa	All Divisions
0	690	11,662	12,351
1	885	1,136	2,021
2	308	209	517
3	155	79	234
4	185	64	249
5	59	22	81
6	38	20	59
7	77	12	89
8	48	7	55
9	59	6	65
10	50	3	52
11	40	2	42
12	16	0	16
13	7	0	7
14	5	0	5
15+	27	0	27
Total	2,649	13,223	15,872
Tonnes	560	1,166	1,726

	Quarter 1-4		
Age	VIIIc	IXa	All Divisions
0	690	30,168	30,858
1	23,902	5,124	29,026
2	7,616	2,935	10,551
3	7,636	2,441	10,077
4	13,620	1,687	15,307
5	5,840	460	6,300
6	4,650	391	5,041
7	9,100	552	9,652
8	5,671	516	6,187
9	5,741	431	6,172
10	2,600	211	2,811
11	2,089	89	2,179
12	885	54	939
13	190	17	208
14	245	6	251
15+	286	9	295
Total	90,762	45,091	135,853
Tonnes	28,384	5,737	34,121

Table 2.8.3 Length (cm) at age by quarter and by Division for mackerel in sub-divisions II-VIII in 1996.

	Quarter 1									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	0	0	0	0	0	0.0
1	21.6	23	22.6	0	22.6	22.5	21.2	21.5	29.3	21.8
2	29.6	30.6	30.2	0	30.5	27.3	27.5	28	32.3	28.5
3	32.6	33.8	33.2	0	33.1	32.9	29.8	29.9	34.3	32.6
4	34.7	36.6	35.2	0	35.2	35.2	32.9	32.3	36	35.1
5	36	37.9	36.3	0	36.4	36.6	33.5	32.6	38.2	36.4
6	37.1	39.3	37.4	0	37.8	38.8	34.9	35	39.3	37.8
7	38.7	39.9	39	0	38.9	39.1	35.1	33.9	40	38.9
8	38.9	0	39.7	0	39.5	40.2	36.6	37.3	40.2	39.6
9	39.8	0	40.5	0	40.4	41	35.3	34.1	40.7	40.4
10	40.8	0	41.1	0	40.5	40.8	0	0	41.4	40.7
11	39.5	42.5	40.9	0	41	41.3	36.5	36.5	42.1	40.9
12	42.2	0	41.8	0	41.9	41.7	38.5	0	43.1	41.9
13	0	0	42.7	0	43.1	44.4	0	0	44.1	43.1
14	0	43.5	42	0	41.7	45.8	34.5	34.5	45.1	42.7
15+	43.1	44.4	42.9	0	42.5	42.4	36.5	36.5	44.8	42.5
All ages	34.9	35.1	36.9	0	37	36.2	29.3	29.6	38.5	36.3

	Quarter 2									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	0	0	0	0	0	0.0
1	0	23	21.6	0	0	0	21.2	0	0	21.5
2	30.2	30.6	29.6	31.5	32.5	32.5	27.5	0	33.8	31.7
3	33.1	33.8	32.6	34.2	35.3	35.3	29.8	36.2	36.1	34.4
4	35.8	36.6	34.6	35.8	36.7	36.7	32.9	36.2	36.7	36.5
5	37.7	37.9	36	36.3	37.3	37.3	33.6	38.8	38.7	37.4
6	39	39.3	37	37.7	39.2	39.2	35.1	39.2	39.7	39.2
7	40.1	39.9	38.7	38.4	39.4	39.4	35.9	37.5	40.5	39.7
8	41.2	0	38.9	38	40.5	40.5	37.2	38.5	40.7	40.8
9	40.8	0	39.7	40.4	40.8	40.8	36.1	0	41	40.8
10	41.4	0	40.6	41.6	40	40	41.7	0	41.7	40.8
11	43	42.5	39.4	41.4	40.5	40.5	37.2	41.5	42.4	41.7
12	41.6	0	42.1	0	40.9	0	39.6	0	42.8	42.0
13	0	0	0	0	40.4	0	43.9	0	44	44.0
14	41.3	43.5	0	0	38.4	0	34.6	0	44.2	41.9
15+	0	44.4	43.2	0	40	0	36.5	0	43.8	42.3
All ages	36.8	35.1	34.7	34.9	36.5	36.5	29.3	38.3	39.8	36.5

	Quarter 3									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	17.2	0	0	0	0	17.2
1	29.5	23	24.3	28.6	25.7	27	28	28.7	0	25.8
2	31.1	30.6	31.3	30.5	29.4	28.3	28.8	30.5	0	30.1
3	34	33.8	34	31.9	31.5	30.3	32.5	33.2	36.1	33.7
4	35.6	36.6	35.5	34	34.8	35.5	0	34.8	36.7	35.5
5	37.3	37.9	37	36.3	36.9	33.8	0	36.6	38.7	37.2
6	38.4	39.3	38	34.6	38.3	0	0	36.8	39.7	38.3
7	39.4	39.9	39	34.5	38.7	0	0	36.5	40.5	39.2
8	40.2	0	39.7	37	39	0	0	0	40.7	40.0
9	40.1	0	40.1	0	39.9	0	0	0	41	40.1
10	40.7	0	40.1	0	40.3	0	0	33.5	41.7	40.5
11	41.8	42.5	41	0	41.7	0	0	36.5	42.4	41.7
12	41.9	0	41.8	0	39.5	0	0	0	0	41.9
13	39.4	0	41.7	0	41.9	0	0	0	0	40.6
14	0	43.5	44.8	0	0	0	0	0	0	44.6
15+	42.9	44.4	42.8	0	43.5	0	0	0	43.5	42.9
All ages	36.5	35.1	35.7	30.2	28	29.2	28.9	32.2	39.7	34.6

	Quarter 4									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	0	0	20.6	0	21	20.9
1	0	23	29.6	28.8	29.6	28.3	27	29.4	26.8	27.9
2	31.3	30.6	32.2	30.7	31.3	31	29.3	31.2	28	30.7
3	34	33.8	34.4	32.3	33.4	33.4	32	33.4	32.8	33.7
4	35.3	36.6	35.6	36.5	34.7	34.8	34	35.3	36.5	35.4
5	36.7	37.9	36.7	32.2	34.8	35.6	37.1	36.5	38.7	36.6
6	37.8	39.3	38.3	35.5	36.2	37	37	36.8	39.7	38.1
7	38.7	39.9	38.7	36.9	38.4	35.2	39.6	36.5	40.1	38.7
8	39.4	0	39.6	38	38.5	38.5	39.8	0	40.7	39.6
9	39.9	0	39.9	40.4	37.4	0	38.1	0	41	39.8
10	40.6	0	41.1	41.6	38.8	39	33.7	33.5	42.1	40.9
11	40	42.5	41.5	41.4	41.2	0	37.2	36.5	42.2	41.1
12	41.5	0	41.1	39.5	42	0	36.5	0	42.3	41.1
13	39.4	0	41.8	40.5	40.8	36.9	38.5	0	44.5	41.2
14	0	43.5	43.1	0	38.5	37.5	0	0	43.8	42.8
15+	44.4	44.4	42.9	0	42.2	0	0	0	43.5	43.0
All ages	36.1	35.1	35.8	30.5	32.6	31.5	29.5	31.8	23.2	33.4

	Quarter 1-4									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	17.2	0	20.6	0	21	20.4
1	27	23	26.8	28.7	26.2	28.2	26.9	29.2	26.8	26.9
2	31	30.6	31.8	30.7	30.1	30.6	28.9	29.3	28.2	30.3
3	33.9	33.8	34	32.2	33	33.4	31.1	31.2	35.3	33.4
4	35.6	36.6	35.5	35.4	35.2	35.7	33.6	34	36.5	35.4
5	37.3	37.9	36.6	32.3	36.4	36.7	35.7	35.2	38.6	36.7
6	38.4	39.3	37.9	35.3	37.8	38.9	36.6	38.1	39.6	38.1
7	39.4	39.9	38.9	36.7	38.9	39.1	39.1	36.6	40.4	39.0
8	40.2	0	39.7	37	39.5	40.2	39.6	38	40.6	39.8
9	40.1	0	40.3	40.4	40.4	40.9	37.7	34.1	41	40.3
10	40.8	0	41	41.6	40.5	40.5	33.8	33.5	41.7	40.7
11	41.8	42.5	41	41.4	41	41.1	37.1	41.2	42.3	41.1
12	41.9	0	41.6	39.5	41.9	41.7	38.1	0	42.8	41.8
13	39.4	0	42.1	40.5	43	42.9	38.5	0	44	42.0
14	41.3	43.5	42.7	0	41.7	45.5	34.5	34.5	44.4	42.7
15+	42.9	44.4	42.9	0	42.6	42.4	36.5	36.5	44	42.7
All ages	36.4	35.1	36.1	30.4	34.8	35.3	29.4	31	31.5	35.0

Table 2.8.4 Length [cm] at age by quarter and by Division for mackerel in sub-divisions VIIIC & IXa in 1996.

	Quarter 1		
Age	VIIIc	IXa	All Divisions
0	0	0	0
1	22.1	23.9	22.2
2	32.4	31.4	31.7
3	33.6	33	33.4
4	35.1	34.1	35
5	37.5	36.1	37.5
6	39	37.1	38.9
7	39.7	38.4	39.7
8	40.4	38.9	40.3
9	41	40.4	41
10	41.8	41.8	41.8
11	41.9	42.6	41.9
12	42.2	42.9	42.2
13	43.8	44.6	43.9
14	43.7	45.5	43.7
15+	43.8	47.1	43.8
All ages	31.5	31.7	31.6

	Quarter 2		
Age	VIIIc	IXa	All Divisions
0	0	0	0
1	26.5	25.8	26.4
2	28.3	30.1	28.9
3	34.1	33.1	33.9
4	36	34.7	35.9
5	38.6	37	38.5
6	39.5	37.9	39.5
7	39.9	38.9	39.9
8	40.4	39.8	40.4
9	40.9	40.8	40.9
10	41.7	42.1	41.8
11	41.7	42.9	41.8
12	42.1	42.9	42.2
13	44.4	44.3	44.4
14	43.7	45.2	43.7
15+	44.4	44.6	44.4
All ages	36.8	32.4	36.3

	Quarter 3		
Age	VIIIc	IXa	All Divisions
0	0	19.6	19.6
1	27.6	27.7	27.6
2	28.2	29.7	28.4
3	31	34.8	32.4
4	35	35.9	35.6
5	36.7	36.9	36.8
6	37.6	38.4	38.3
7	38.3	39	38.9
8	38.9	41.5	41.3
9	39.5	40.3	40.2
10	39.2	40.5	40.4
11	40.3	41.5	41.2
12	40.7	45.4	41.3
13	44.3	49.5	46.5
14	43.6	0	43.6
15+	44.3	0	44.3
All ages	28.4	22.2	24.4

	Quarter 4		
Age	VIIIc	IXa	All Divisions
0	21.4	22.1	22.1
1	28.6	28.6	28.6
2	28.9	30.2	29.4
3	32.7	34.5	33.3
4	35.4	36	35.5
5	37.9	36.7	37.5
6	39.2	38.2	38.9
7	39.9	39.1	39.8
8	40.6	40	40.5
9	41.6	40.3	41.4
10	43.1	43.5	43.2
11	43.6	42.6	43.6
12	43.3	46.5	43.3
13	44.9	0	44.9
14	43.8	0	43.8
15+	46.8	0	46.8
All ages	29.5	23	24.1

	Quarter 1-4		
Age	VIIIc	IXa	All Divisions
0	21.4	20.6	20.6
1	25.2	26.9	25.5
2	28.5	30.4	29
3	33.5	33.4	33.5
4	35.6	34.9	35.5
5	38.3	36.8	38.2
6	39.4	38.1	39.3
7	39.9	38.9	39.8
8	40.4	40.5	40.4
9	40.9	40.5	40.9
10	41.8	41.7	41.8
11	41.8	42.8	41.9
12	42.2	42.9	42.2
13	44.3	44.3	44.3
14	43.7	45.2	43.7
15+	44.5	44.8	44.5
All ages	33.9	24.3	30.7

Table 2.8.5 Weight (g) at age by quarter and by Division for mackerel in sub-divisions II-VIII in 1996.

	Quarter 1									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	0	0	0	0	0	0
1	54	101	77	0	75	62	59	59	177	66
2	178	257	205	0	211	135	131	132	242	156
3	252	352	289	0	277	252	167	160	296	257
4	322	436	358	0	342	320	225	200	342	337
5	380	478	398	0	388	368	238	207	414	385
6	425	546	440	0	437	468	268	258	450	443
7	497	544	508	0	487	473	271	230	474	491
8	507	0	542	0	519	535	315	312	486	527
9	547	0	573	0	556	564	279	236	502	562
10	594	0	608	0	567	572	0	0	533	580
11	537	638	594	0	585	584	303	288	563	586
12	666	0	643	0	635	594	404	0	608	637
13	0	0	691	0	690	751	0	0	648	698
14	0	680	656	0	632	817	257	243	698	677
15+	724	728	698	0	674	663	302	288	685	675
All ages	347	395	430	0	420	368	161	156	429	396

	Quarter 2									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	0	0	0	0	0	0
1	0	101	58	0	0	0	59	0	0	65
2	241	257	178	237	227	227	130	0	277	214
3	317	352	252	311	306	306	165	376	342	301
4	398	436	322	360	356	356	223	350	362	360
5	457	478	380	379	397	397	237	449	428	411
6	503	546	425	430	454	454	271	489	462	463
7	560	544	495	455	484	484	300	459	490	501
8	616	0	505	441	518	518	336	469	499	551
9	589	0	543	540	501	501	306	0	511	533
10	610	0	588	592	514	514	543	0	542	546
11	703	638	530	578	476	476	331	596	570	577
12	589	0	663	0	578	0	413	0	587	591
13	0	0	0	0	557	0	635	0	640	640
14	572	680	0	0	476	0	257	0	651	581
15+	0	728	731	0	537	0	301	0	629	599
All ages	443	395	340	336	358	358	160	452	469	373

	Quarter 3									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	33	0	0	0	0	33
1	201	101	107	189	134	141	165	196	0	135
2	269	258	279	231	213	172	207	237	0	236
3	363	352	367	254	276	197	317	308	341	351
4	431	436	423	331	390	327	0	355	361	427
5	488	478	489	442	466	266	0	410	428	486
6	544	546	535	306	523	0	0	419	462	540
7	581	544	584	312	541	0	0	402	491	581
8	607	0	611	412	557	0	0	0	499	607
9	650	0	630	0	600	0	0	0	511	642
10	660	0	631	0	618	0	0	311	543	651
11	707	638	676	0	694	0	0	402	571	700
12	720	0	697	0	577	0	0	0	0	707
13	592	0	689	0	703	0	0	0	0	645
14	0	680	797	0	0	0	0	0	0	780
15+	779	728	742	0	790	0	0	0	614	760
All ages	468	395	444	226	192	185	208	283	467	405

	Quarter 4									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	0	0	56	0	60	59
1	0	101	209	182	193	165	153	190	135	167
2	292	258	303	219	236	225	201	246	159	243
3	371	352	365	267	304	291	263	316	258	332
4	421	436	410	388	351	337	318	383	354	395
5	477	478	453	432	358	363	415	405	428	446
6	524	546	525	340	422	417	419	419	462	514
7	563	544	545	401	510	359	523	402	478	538
8	595	0	583	514	542	478	506	0	498	576
9	617	0	605	631	459	0	432	0	513	591
10	653	0	657	691	503	500	303	311	557	644
11	632	638	681	675	676	0	396	402	562	652
12	701	0	641	580	663	0	392	0	566	642
13	593	0	711	630	655	418	488	0	661	672
14	0	680	735	0	450	436	0	0	632	716
15+	820	728	750	0	783	0	0	0	646	749
All ages	457	395	425	223	283	245	210	267	94	337

	Quarter 1-4									
Age	IIa	IIIa	IVa	IVbc	VIa	VIIbcjk	VIIaefgh	VIId	VIIIabde	All Divisions
0	0	0	0	0	33	0	56	0	60	55
1	155	101	156	184	142	164	152	188	135	152
2	261	258	289	222	220	207	187	179	164	229
3	354	352	352	263	286	269	224	215	322	314
4	427	436	401	363	344	333	284	292	356	380
5	482	478	445	432	389	372	344	317	425	426
6	538	546	500	334	440	462	386	436	460	486
7	578	544	539	395	488	474	497	400	487	522
8	604	0	574	412	520	533	493	400	497	558
9	641	0	594	572	556	550	409	236	510	583
10	650	0	633	634	566	555	305	311	541	602
11	697	638	623	608	585	560	383	580	569	611
12	710	0	668	580	635	594	402	0	590	665
13	592	0	695	630	690	685	489	0	642	676
14	572	680	699	0	632	805	257	243	661	683
15+	775	728	724	0	675	663	301	288	643	703
All ages	461	395	432	224	360	338	200	220	280	382

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Table 2.8.6 Weight (g) at age by quarter and by Division for mackerel in sub-divisions VIIIC & IXa in 1996.

	Quarter 1		
Age	VIIIc	IXa	All Divisions
0	0	0	0
1	72	96	73
2	241	231	234
3	270	260	268
4	312	287	310
5	387	352	385
6	436	388	434
7	460	433	459
8	485	455	484
9	508	512	508
10	541	569	542
11	547	603	548
12	560	624	562
13	629	709	634
14	622	741	623
15+	626	843	630
All ages	263	243	261

	Quarter 2		
Age	VIIIc	IXa	All Divisions
0	0	0	0
1	126	118	125
2	158	201	174
3	286	264	281
4	336	307	334
5	420	381	419
6	454	415	452
7	468	451	467
8	487	489	487
9	506	524	507
10	541	579	543
11	541	614	544
12	556	620	560
13	656	692	659
14	624	717	626
15+	655	695	656
All ages	384	273	373

	Quarter 3		
Age	VIIIc	IXa	All Divisions
0	0	50	50
1	145	155	147
2	154	207	162
3	209	345	259
4	308	381	354
5	356	424	408
6	387	489	477
7	409	515	494
8	428	651	637
9	450	579	572
10	440	590	577
11	481	643	603
12	494	888	547
13	651	1,202	888
14	618	0	618
15+	651	0	651
All ages	160	100	121

	Quarter 4		
Age	VIIIc	IXa	All Divisions
0	65	72	71
1	162	174	169
2	167	215	186
3	250	339	280
4	318	390	336
5	396	417	402
6	440	481	455
7	466	523	474
8	490	568	501
9	529	582	534
10	596	765	604
11	616	712	620
12	600	963	600
13	670	0	670
14	620	0	620
15+	770	0	770
All ages	212	88	109

	Quarter 1-4		
Age	VIIIc	IXa	All Divisions
0	65	59	59
1	111	142	117
2	161	213	175
3	269	281	272
4	326	327	326
5	411	396	410
6	450	454	450
7	466	467	466
8	487	562	493
9	507	551	510
10	542	584	545
11	543	619	546
12	557	621	561
13	652	696	656
14	623	719	626
15+	662	706	663
All ages	312	127	251

Table 2.8.7 **Catch numbers ('000) at age of the Southern Mackerel.**

AGE/YEAR	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	287,887	81,221	30,419	4,927	54,829	40,961	18,896	5,118	41,728	6,234	24,899	11,027	30,858
1	15,285	30,856	27,323	16,783	46,960	21,433	31,935	11,339	8,634	13,484	2,876	7,436	29,026
2	3,788	3,046	13,324	8,040	4,347	5,880	7,518	9,842	5,372	7,549	7,650	5,870	10,551
3	8,599	1,934	4,862	10,580	6,652	4,360	2,662	11,552	8,889	2,477	7,949	9,249	10,077
4	4,679	10,506	5,402	4,660	9,719	4,159	2,876	12,671	5,482	10,810	7,920	6,757	15,307
5	6,475	3,333	13,251	9,464	3,220	6,010	4,683	6,813	7,813	4,435	13,126	5,069	6,300
6	1,643	2,050	3,727	7,019	5,588	2,767	6,615	4,136	3,430	8,242	9,425	7,255	5,041
7	931	722	377	1,707	12,975	4,106	1,929	5,609	2,060	4,352	6,608	6,907	9,652
8	1,583	524	1,522	1,818	5,610	5,532	4,718	1,337	2,908	2,106	2,899	6,944	6,187
9	1,540	1,024	638	1,082	1,824	1,581	5,468	1,405	868	2,260	2,735	3,759	6,172
10	608	941	525	1,626	543	819	1,532	2,899	1,053	1,424	1,393	2,611	2,811
11	732	775	198	917	291	334	697	523	1,186	917	957	2,226	2,179
12	348	528	3,224	483	764	291	596	56	428	542	623	1,243	939
13	500	364	1,714	461	716	292	58	111	195	643	275	644	208
14	360	313	0	115	125	85	137	79	14	279	336	642	251
15+	4	558	3,237	241	940	346	145	361	68	1,183	148	623	295
TOTAL	334,962	138,694	109,745	69,921	155,105	98,956	90,465	73,851	90,128	66,937	89,819	78,261	135,853
CATCH (t)	20,308	18,111	24,789	22,187	24,773	18,321	21,312	20,781	18,046	19,719	25,045	27,549	34,121
SOP (t)	20,045	17,833	25,378	23,026	24,931	18,358	20,852	20,724	17,993	19,704	25,107	27,518	34,060
%	99	98	102	104	101	100	98	100	100	100	100	100	100

Table 2.8.8 **Catch weights at age (kg) for the Southern Mackerel .**

AGE/YEAR	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	0.031	0.055	0.063	0.089	0.055	0.042	0.092	0.075	0.051	0.077	0.046	0.071	0.059
1	0.059	0.092	0.122	0.183	0.081	0.100	0.118	0.160	0.190	0.116	0.167	0.160	0.117
2	0.228	0.189	0.249	0.251	0.218	0.197	0.207	0.208	0.265	0.200	0.205	0.246	0.175
3	0.248	0.299	0.289	0.291	0.251	0.267	0.256	0.242	0.279	0.307	0.262	0.303	0.272
4	0.303	0.339	0.390	0.398	0.286	0.357	0.310	0.294	0.325	0.326	0.352	0.370	0.326
5	0.344	0.408	0.401	0.442	0.326	0.392	0.365	0.333	0.366	0.360	0.379	0.409	0.410
6	0.378	0.484	0.404	0.474	0.342	0.472	0.401	0.400	0.404	0.401	0.422	0.443	0.450
7	0.392	0.502	0.567	0.560	0.388	0.499	0.475	0.439	0.435	0.443	0.457	0.478	0.466
8	0.457	0.593	0.512	0.602	0.395	0.511	0.494	0.485	0.463	0.469	0.498	0.507	0.493
9	0.451	0.596	0.417	0.638	0.406	0.544	0.525	0.508	0.480	0.499	0.525	0.530	0.510
10	0.441	0.609	0.567	0.624	0.480	0.545	0.507	0.521	0.537	0.491	0.536	0.556	0.545
11	0.465	0.607	0.649	0.652	0.494	0.591	0.565	0.517	0.544	0.518	0.579	0.560	0.546
12	0.345	0.646	0.528	0.449	0.492	0.565	0.540	0.746	0.595	0.597	0.626	0.619	0.561
13	0.406	0.636	0.526	0.519	0.543	0.626	0.729	0.674	0.523	0.590	0.629	0.657	0.656
14	0.504	0.679	0.000	0.663	0.549	0.579	0.553	0.667	0.718	0.578	0.625	0.616	0.626
15+	0.708	0.667	0.679	0.769	0.567	0.735	0.724	0.720	0.708	0.744	0.722	0.675	0.663
0-15+	0.060	0.153	0.286	0.329	0.161	0.186	0.231	0.281	0.200	0.294	0.280	0.352	0.251

Figure 2.4.1 Juvenile Mackerel catch rates: Quarter 4 1996

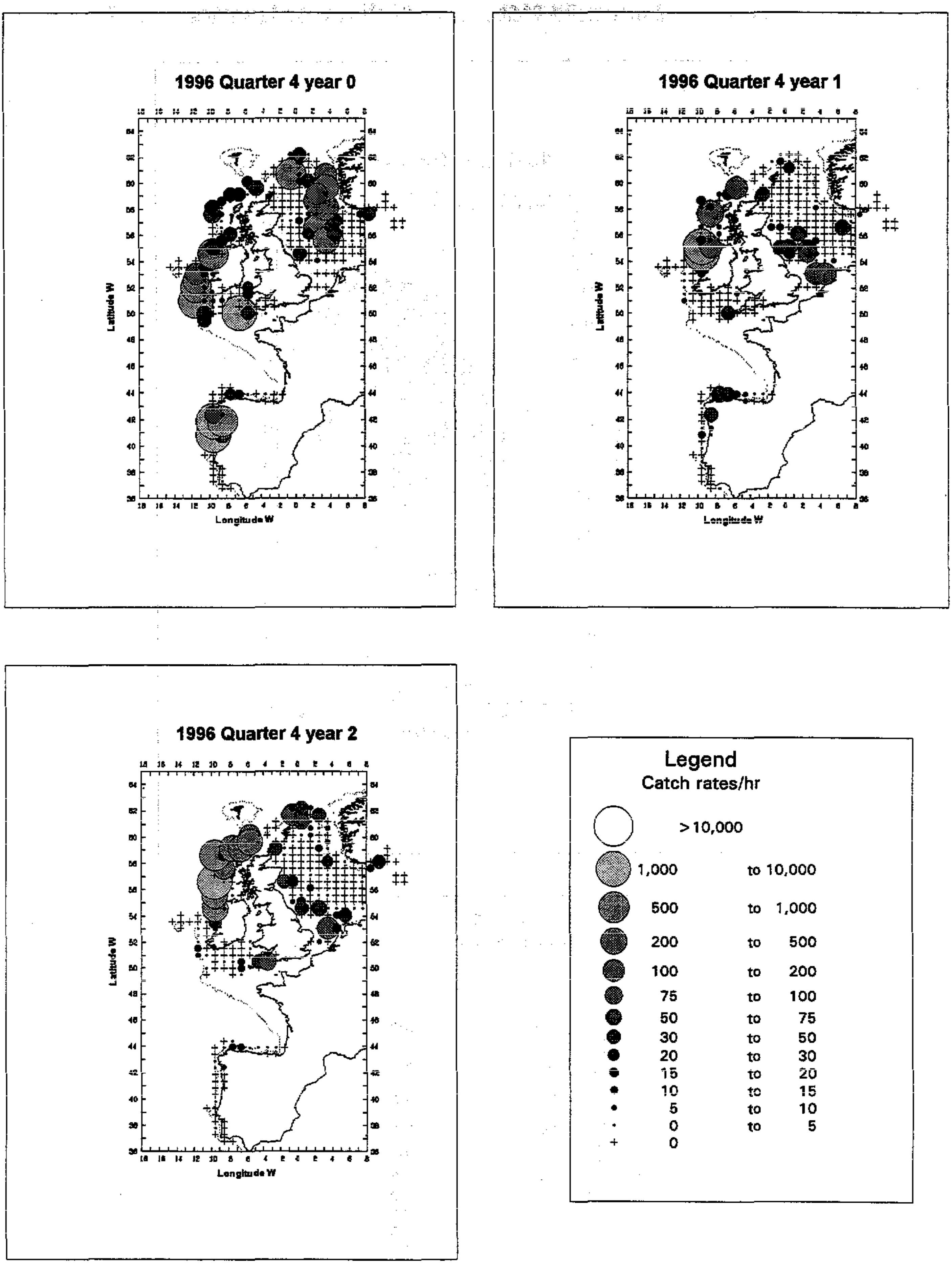
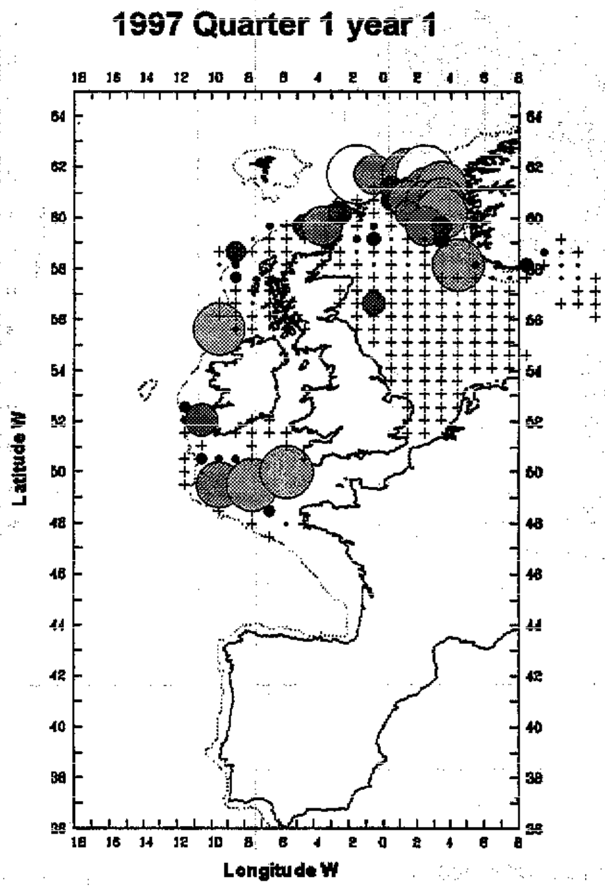


Figure 2.4.2 Juvenile Mackerel catch rates: Quarter 1 1997



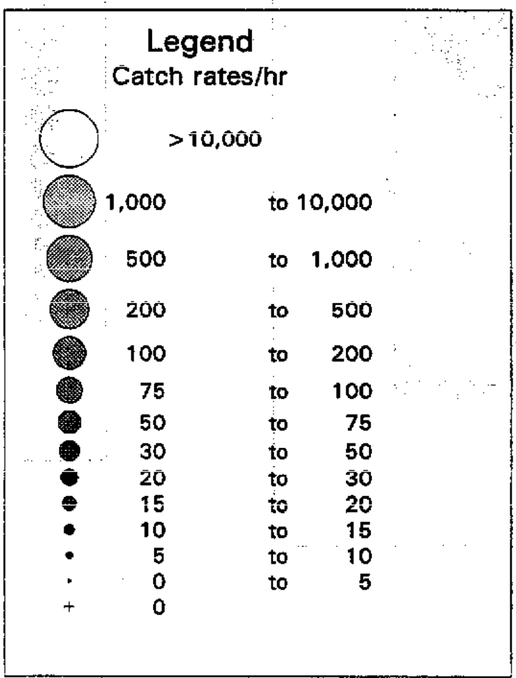


Figure 2.4.3. Mackerel juvenile distributions (age 0) 1993-96

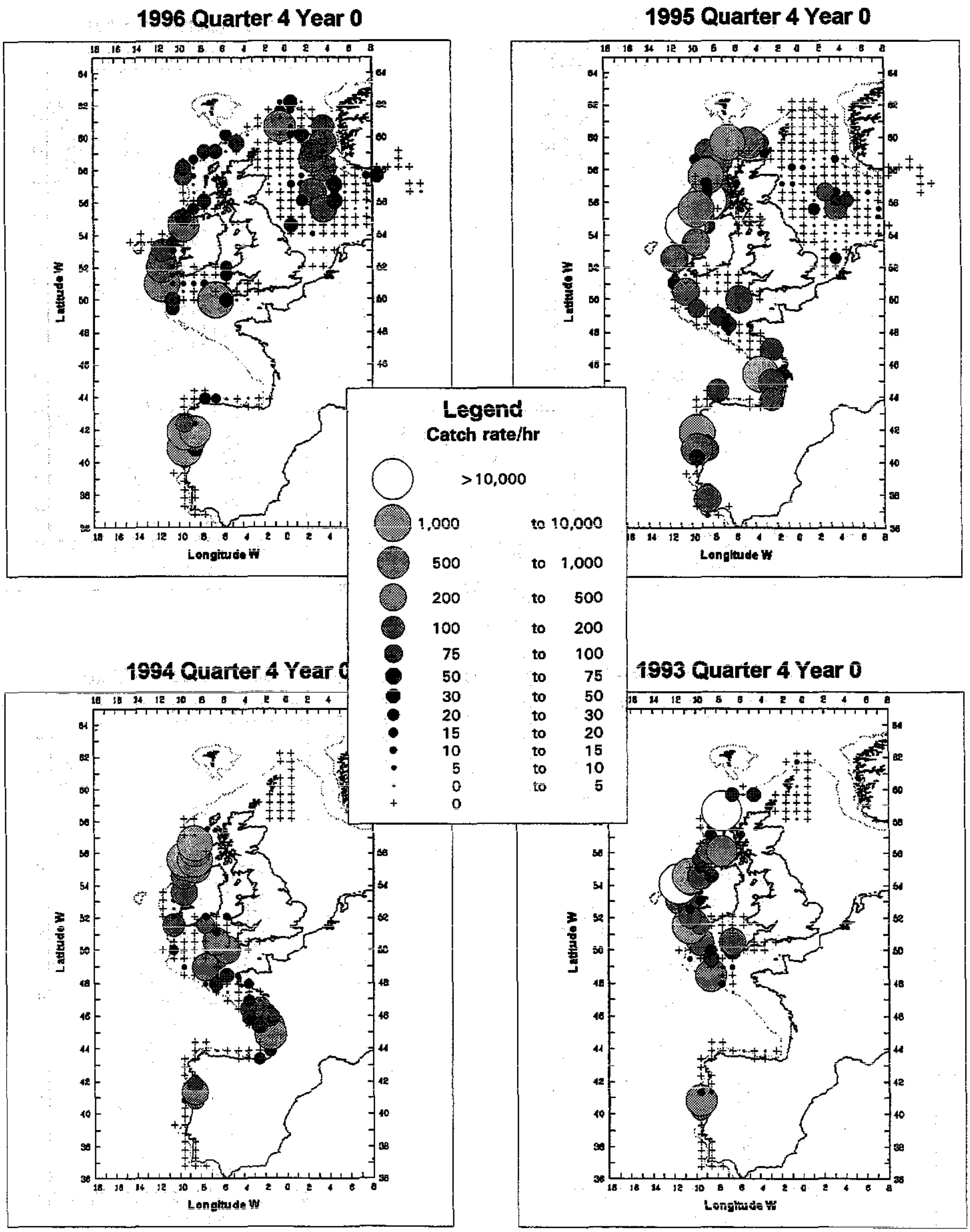


Figure 2.4.3 (cont.) Mackerel juvenile distribution at age 0 1989-92

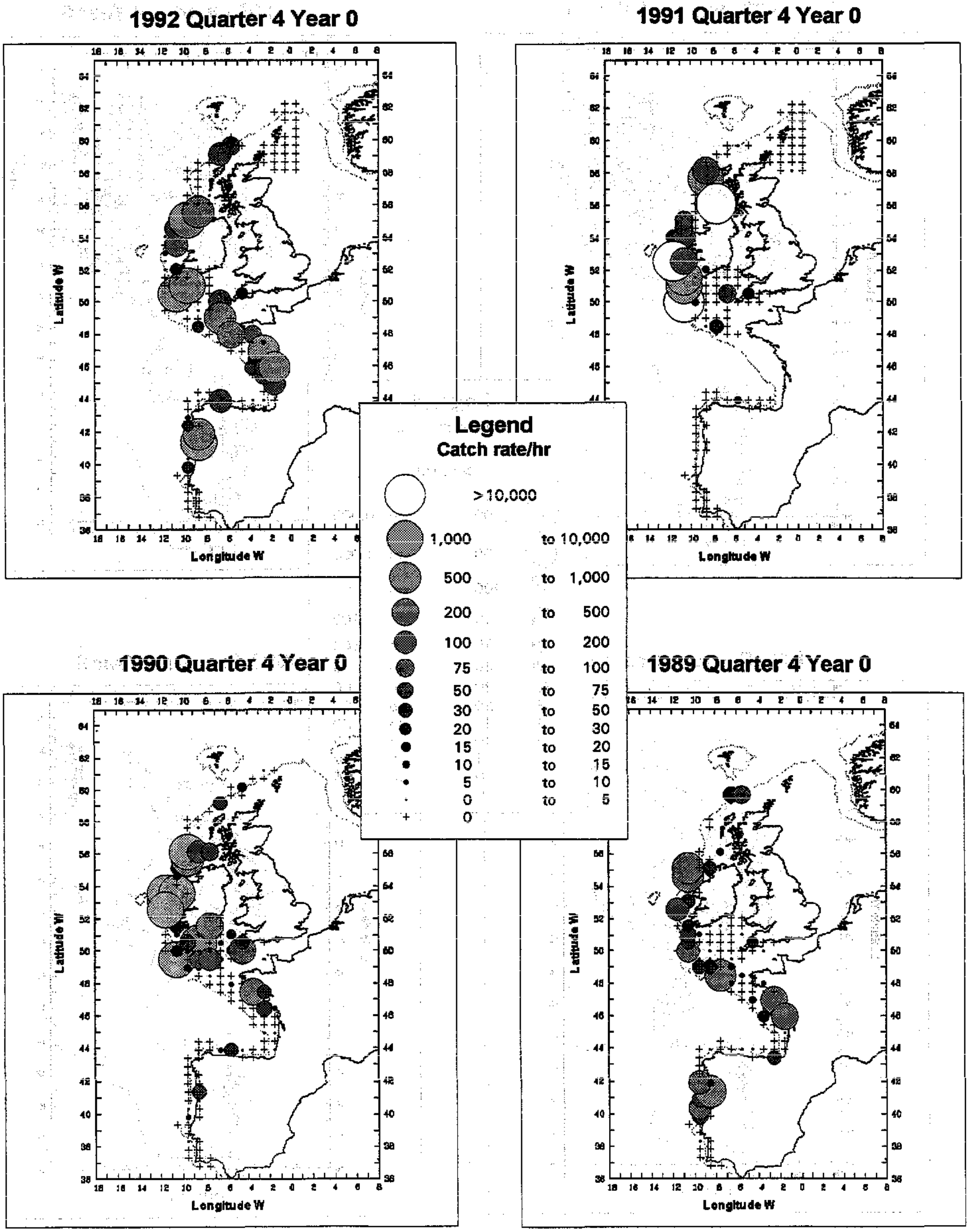


Figure 2.4.4 Juvenile mackerel distributions age 1 1994-97

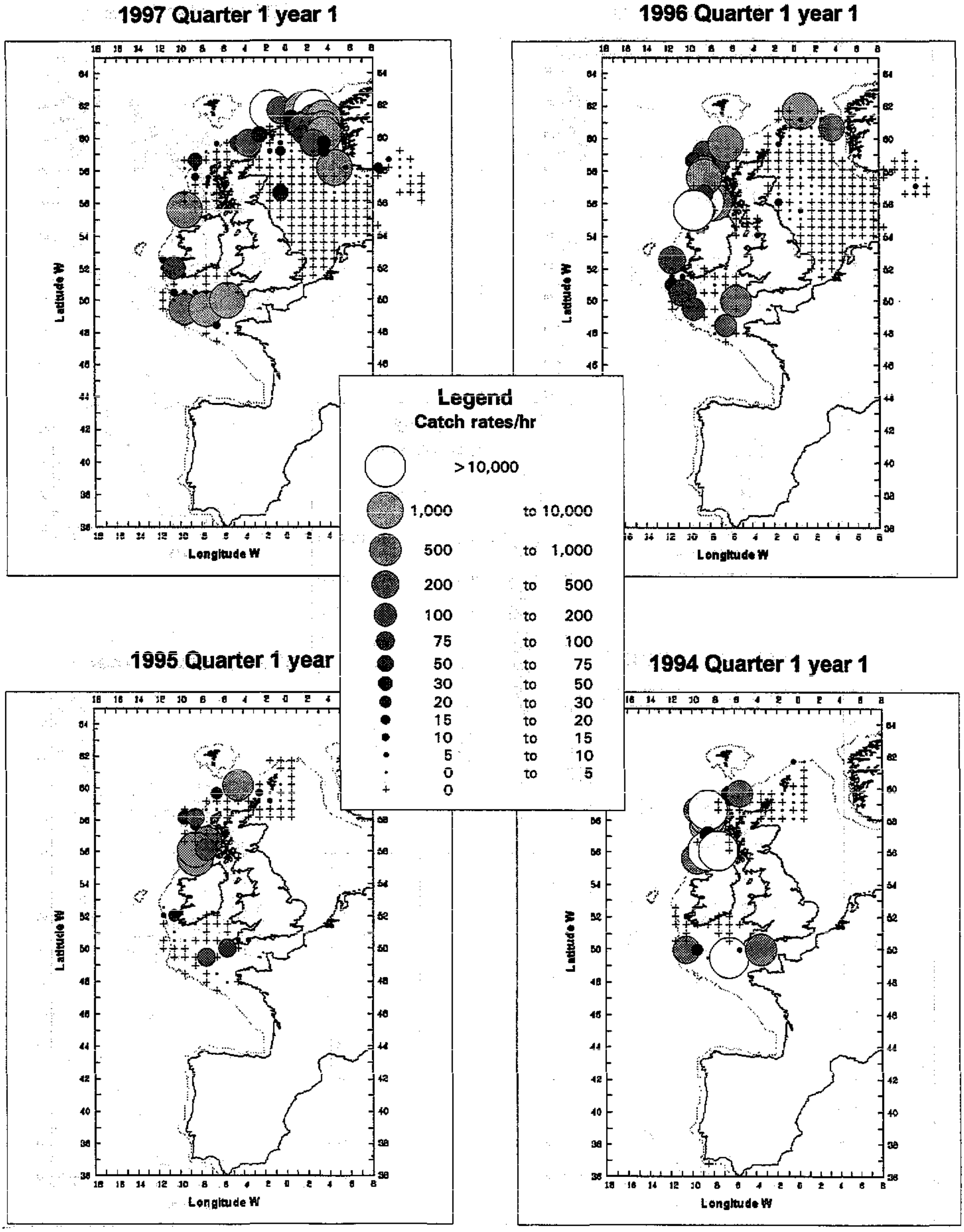


Figure 2.4.4 (cont.) Juvenile mackerel distributions at age 1 1990-1993

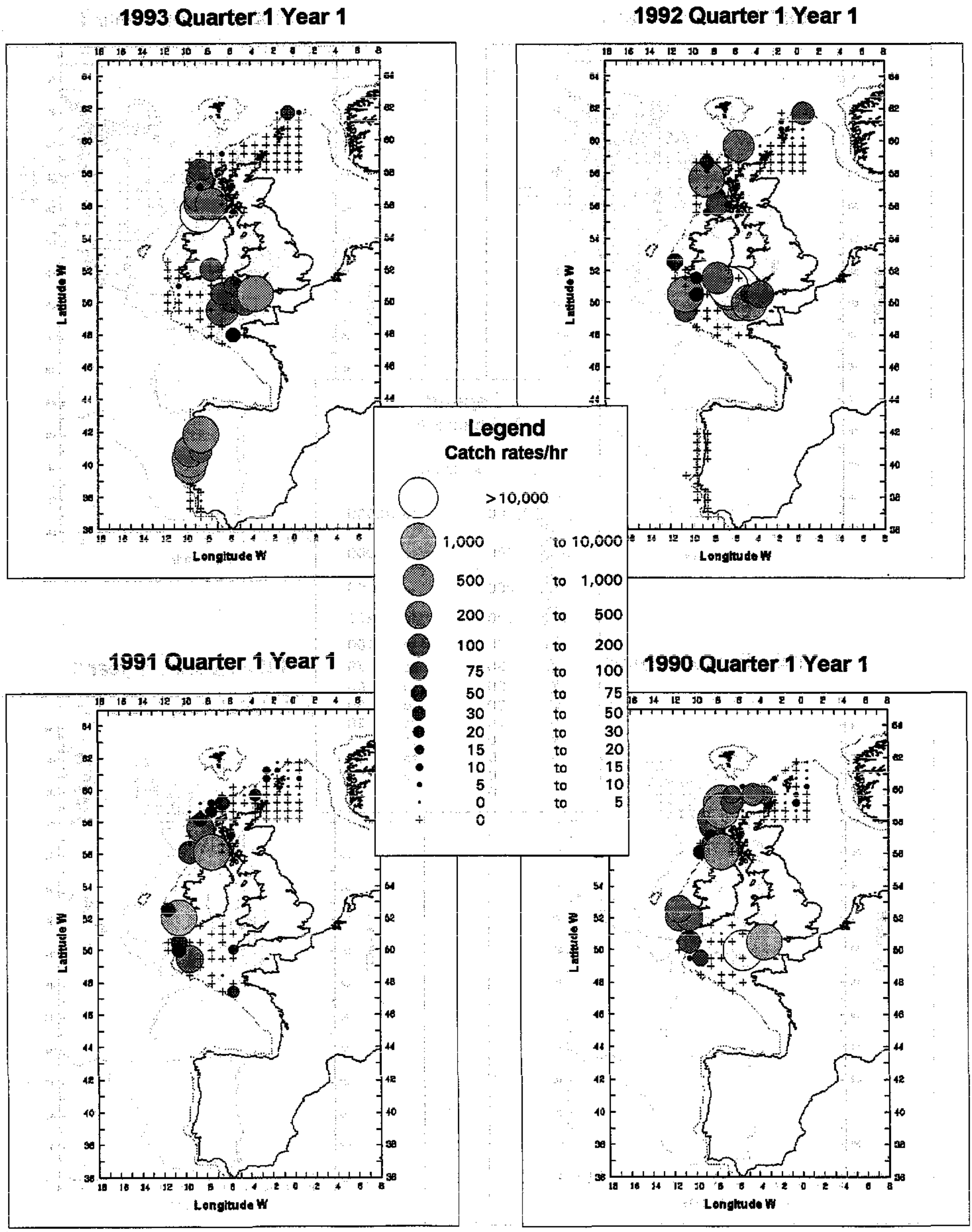


Figure 2.4.4 (cont) Juvenile mackerel distributions age 1 1986-89

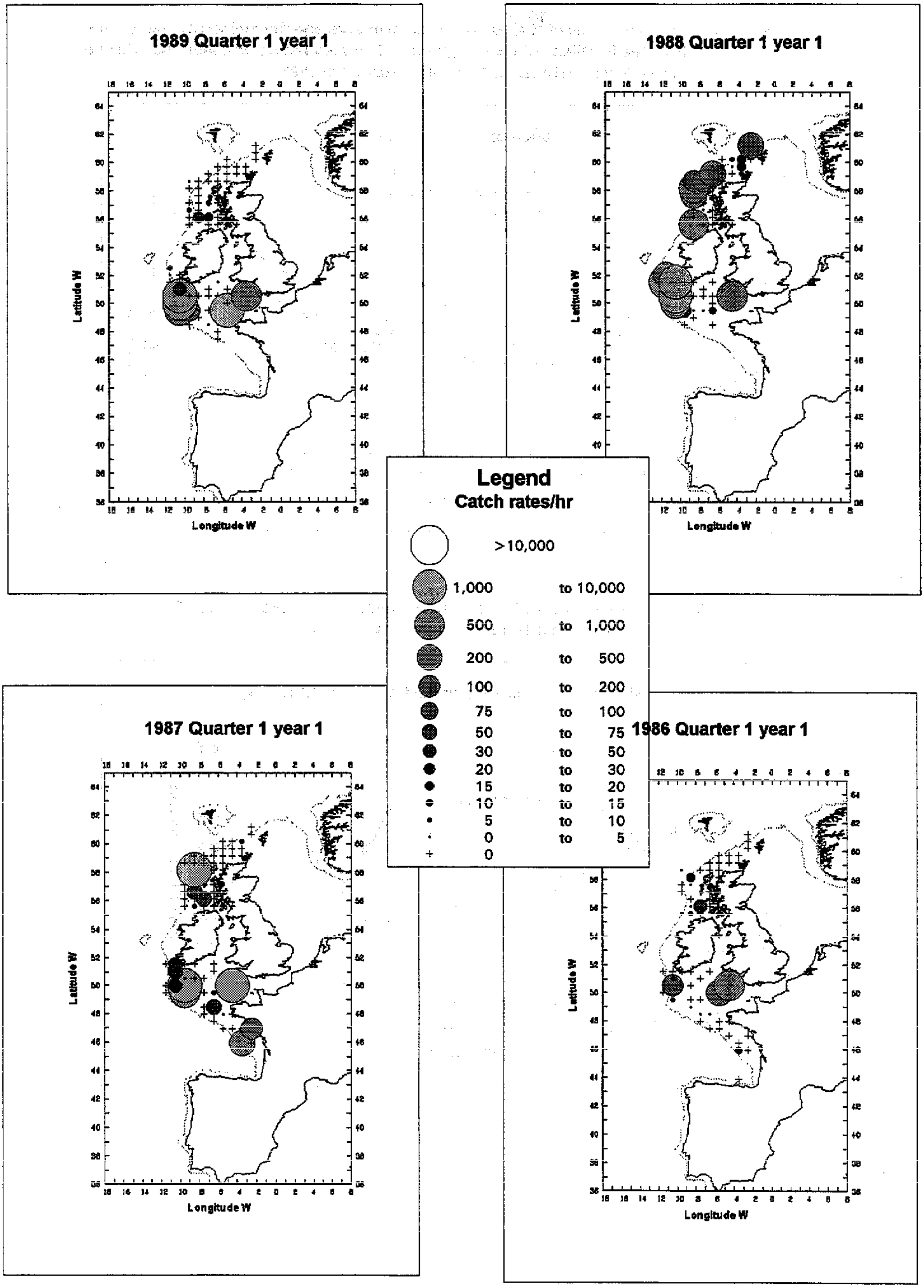


Figure 2.4.5 The time series of ICA estimated recruitments and the indices of abundance from the Scottish 1st quarter groundfish survey before and after the addition of the North sea index of 1year old mackerel in 1996

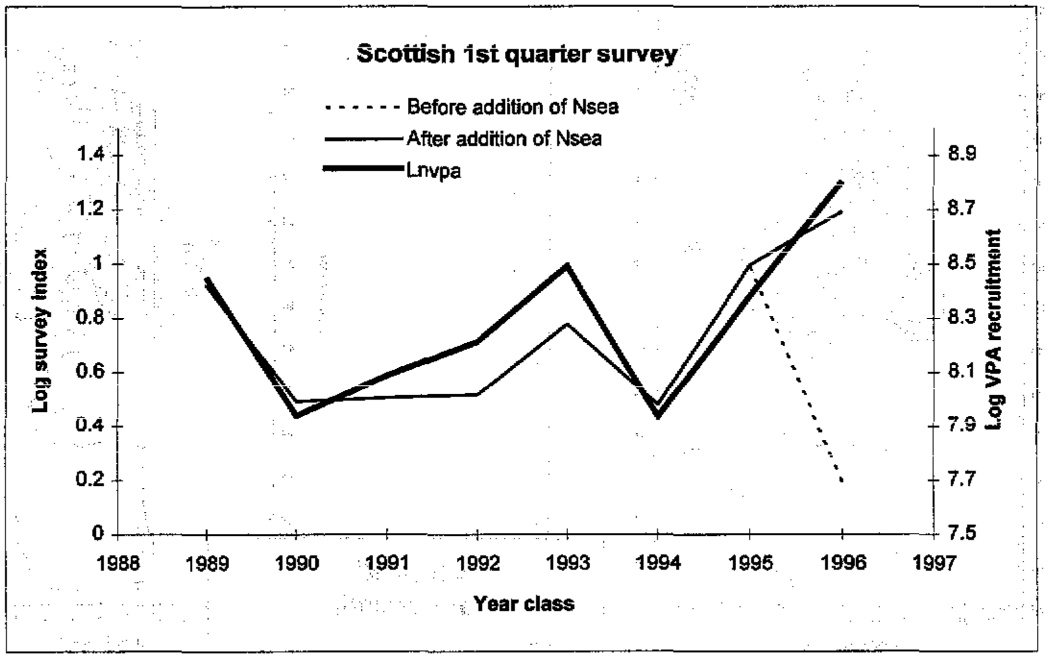
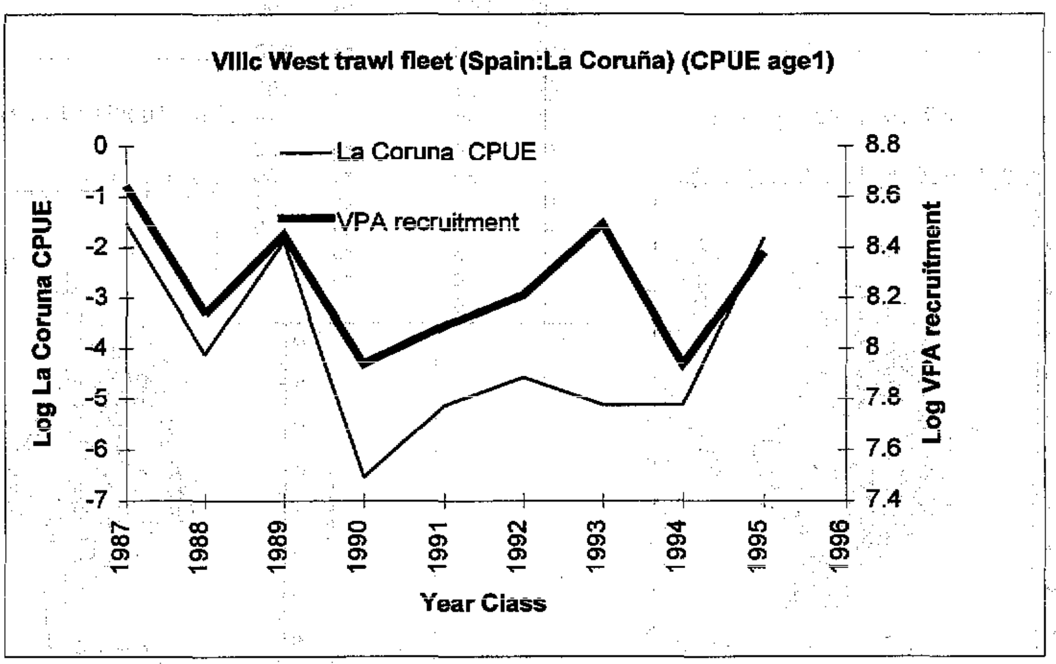


Figure 2.4.6 The time series of ICA estimated recruitments and the indices of age 1 catch per unit effort from the La Coruna fleet



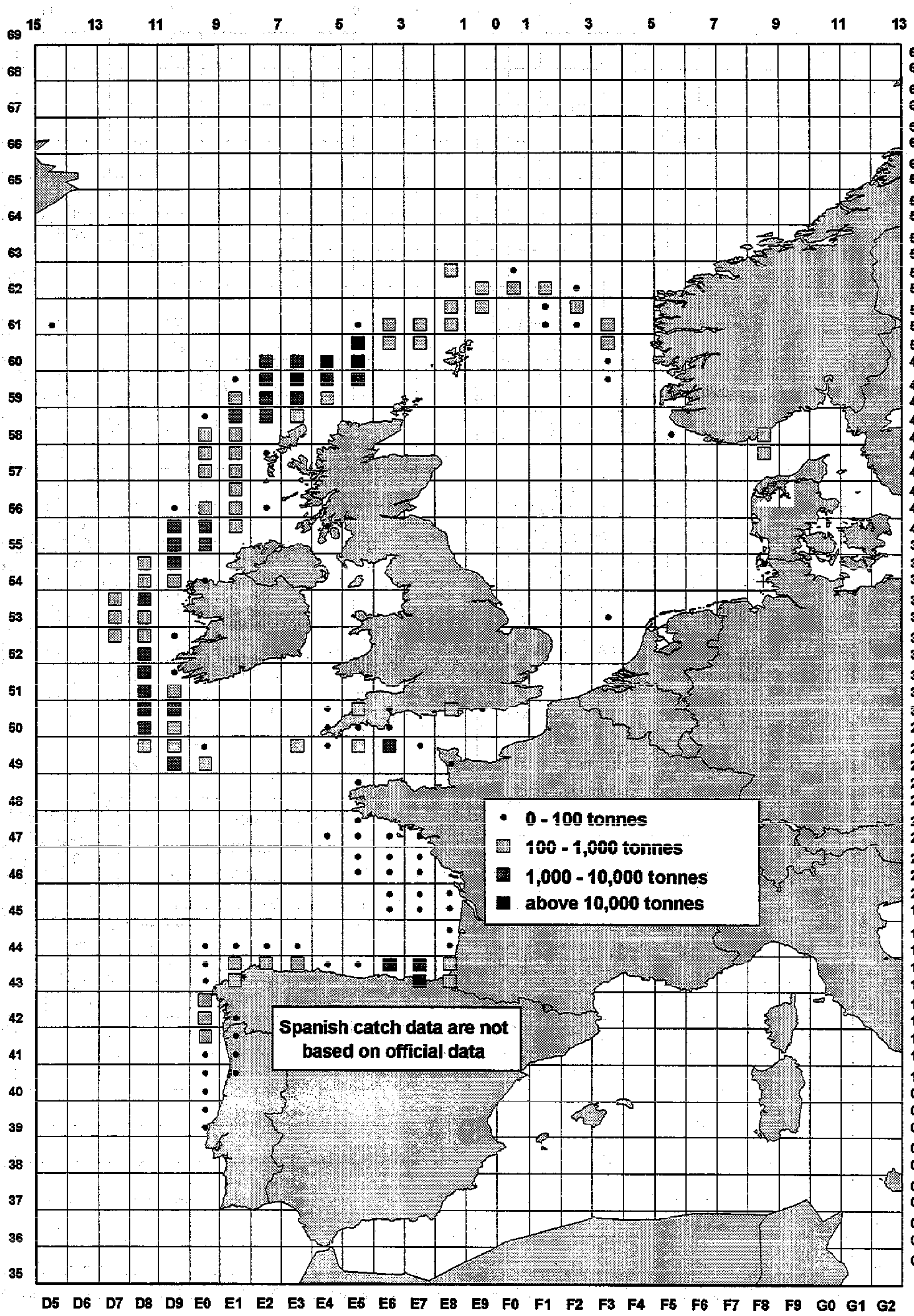


Fig. 2.5.1a Distribution of mackerel catches: Quarter 1 1996

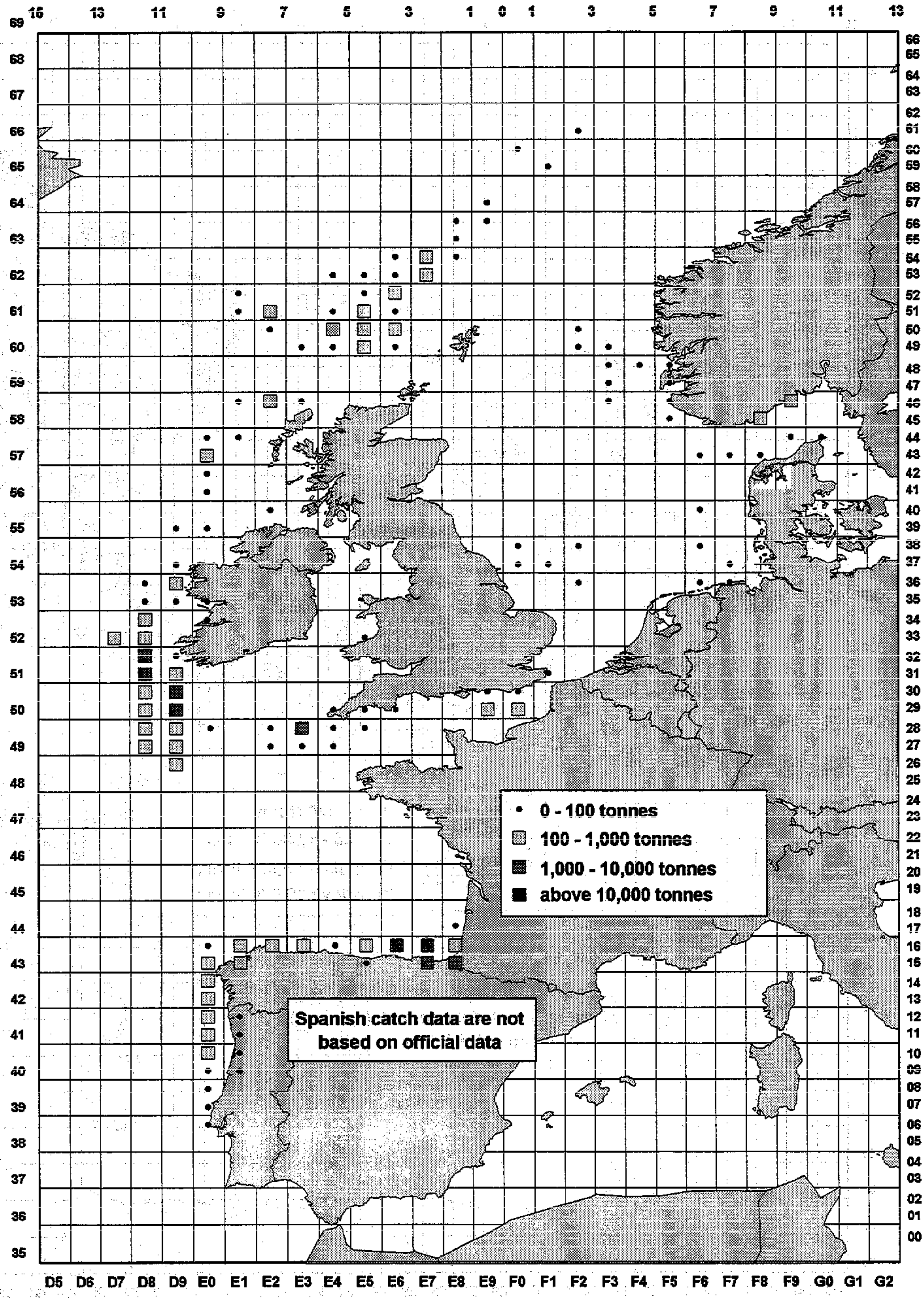


Fig. 2.5.1b Distribution of mackerel catches: Quarter 2 1996

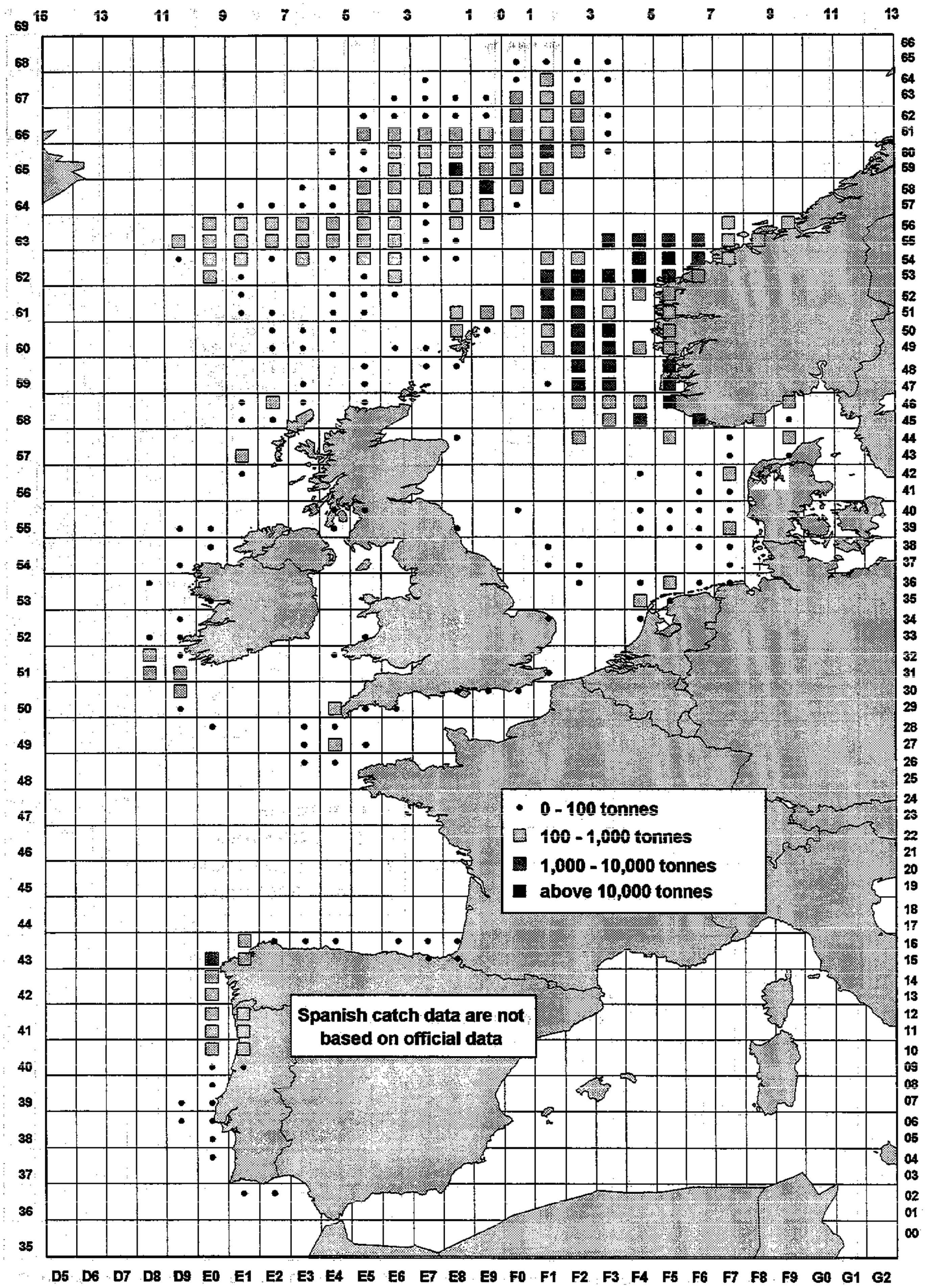


Fig. 2.5.1c Distribution of mackerel catches: Quarter 3 1996

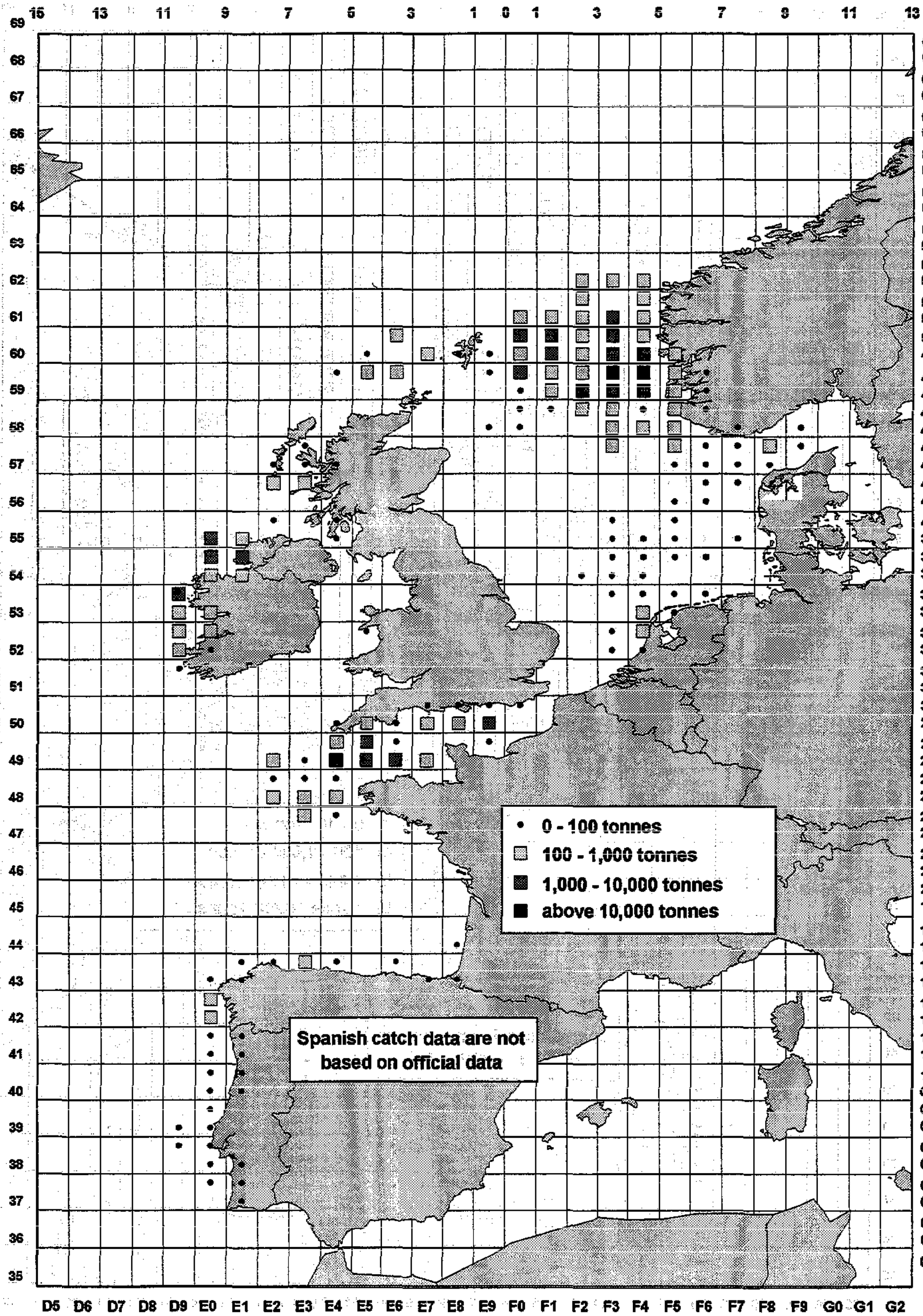


Fig. 2.5.1d Distribution of mackerel catches: Quarter 4 1996

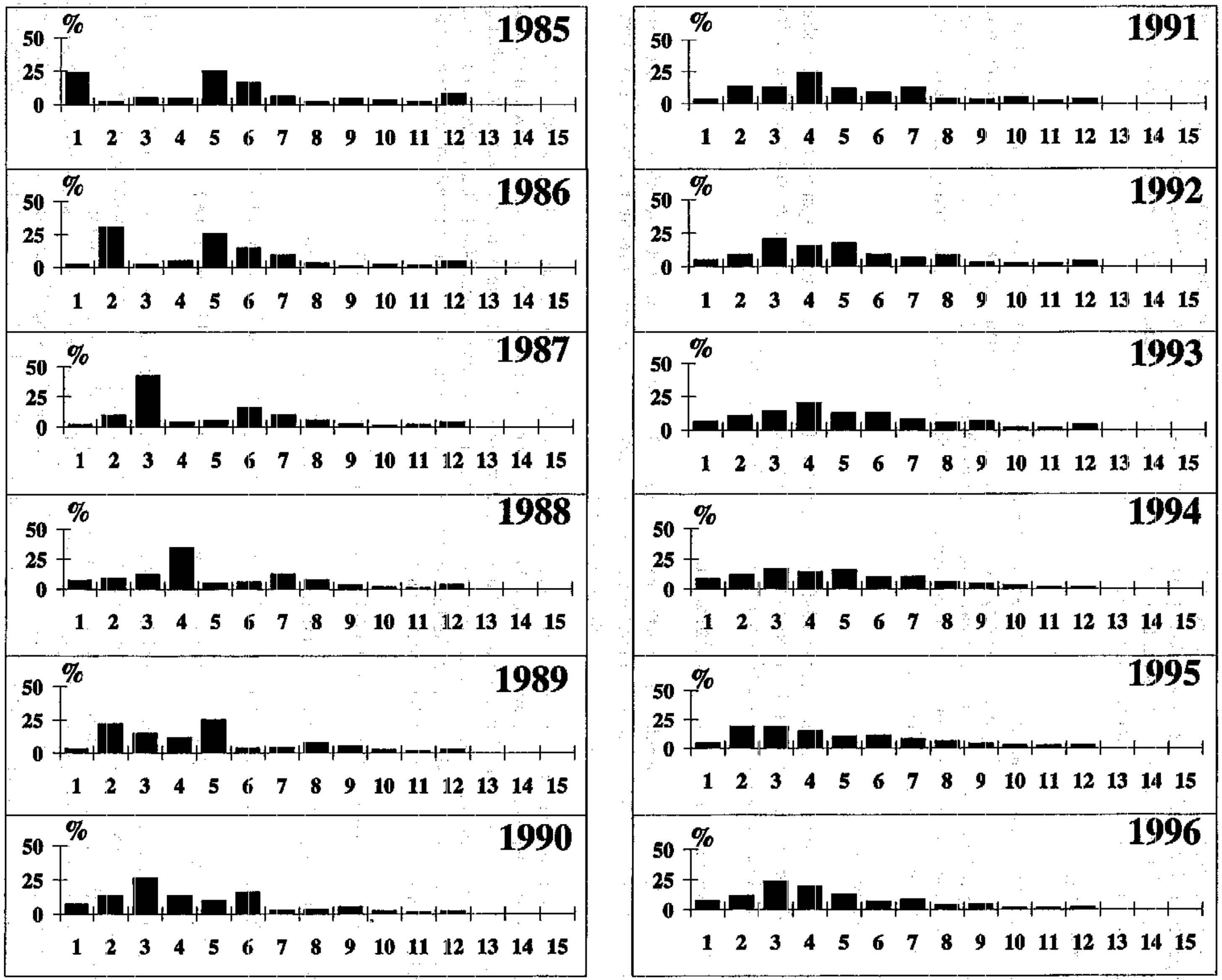


Figure 2.9 **The age composition of the western mackerel in the international catches from 1985-1995. Age 12 is a plus group.**

a:\acfm\wgmhsa97\f-2-9.xls

3 NORTH SEA, WESTERN AND SOUTHERN MACKEREL (DIVISIONS IIa, IIIa, IVa–c, Vb, VIa–b, VIIa–k, VIIIa,b,c,e AND IXa)

3.1 North Sea Mackerel

3.1.1 Fishery independent information from egg surveys

An egg survey of the North Sea was carried out in 1996, the first since 1990 (see Section 2.2.1). Temporal and spatial coverage was poor compared with the 1990 with only three surveys of the spawning area. The limited coverage resulted in some egg production being missed on the first survey. A total seasonal production of stage 1 eggs of 59 x 10^{12} was calculated equivalent to a SSB of 84,000 t. Using a mean atresia correction of 11.6%, from the western area, increases the estimate of SSB to 110,000 t.

3.1.2 Recruitment

For the first time in many years there was mackerel juvenile in the North Sea and Skagerrak during the autumn 1996 (0-group) and in 1997 (1-group). The origin of this mackerel is at present unclear. Preliminary results from genetic studies indicate that the fish might have mixed origins (Nesboe *et al.* WD, 1997). Also the abundance index of the 1996 year class as preliminary calculated from the North Sea International Young Fish Survey, first quarter of 1997, is very high (Table 3.1.1).

3.1.3 Assessment

The estimated SSB from the egg surveys in 1996 was 110,000 t. There seemed to be a slight increase in the SSB since the estimate of 78,000 t based on the surveys in 1990 (Table 3.1.2). This estimate was not adjusted for atresia so it might compare with the unadjusted estimate in 1996 of 84,000 t.

3.1.4 Management measures and considerations

The Working Group still considers the North Sea mackerel to be severely depleted. Therefore the North Sea mackerel still need maximum protection until the spawning stock show evidence of recovery, while at the same time allowing fishing on the western and southern mackerel.

ACFM has for several years recommended the closure of Division IVa for fishing during the first half of the year until the Western Mackerel stock enter the North Sea in July early August to stay there until late December and in January the following year. There are restrictions for fishing in the North Sea and this has particularly during the first quarter resulted in large scale misreporting from the Northern part of the North Sea (Division IVa) to Division VIa. To allow a fishery during the first quarter might solve the misreporting problem. However, this would have implications for North Sea mackerel in this area.

The Working Group endorses the recommendations made by ACFM for several years:

- There should be no fishing for mackerel in Divisions IIIa and IVb,c at any time of the year;

- There should be no fishing for mackerel in Division IVa during the period 1 January–31 July;

- The 30 cm minimum landing size at present in force in Sub-area IV should be maintained.

The closure of the mackerel fishery in Divisions IVb,c and IIIa the whole year will protect the North Sea stock in this area and the juvenile Western fish which are numerous particularly in Division IVb,c during the second half of the year. This closure has unfortunately resulted in increased discards of mackerel in the non-directed fisheries in the these area as vessels at present are permitted to take only 10% of their catch as mackerel by-catch. No data on the actual size of mackerel by-catch have been available for the Working Group concerning 1996 but the reported landings of Mackerel in Divisions IIIa and IVb,c for 1996 might be seriously under-estimated due to discarded by-catch.

3.2 Western Mackerel

An ICA model has been fitted to the western component of the mackerel stock in order to maintain the long time series of information on trends in SSB and recruitment which are not available for the combined stock.

3.2.1 Fishery independent information

The Egg Survey Working Group recommended that the time series of spawning stock biomasses used for fitting of the ICA separable VPA models to the Western and North East Atlantic catch data be revised to take into account significant between year variation in the rate of atresia (ICES 1997/H:4). The effect of the revisions on the time series is discussed Section 2.2, which also includes a complete time series of egg survey biomass estimates (Table 2.2.1).

Over the last few years a time series of catches from the CEFAS Western Approaches March ground fish survey has been utilised within an XSA assessment for comparison with the ICA results. The survey was completed in 1997. However, until the potential effects of changes in the spatial distribution of the mackerel (Section 2.4) on the survey's catchability have been investigated, it was considered that this time series should be omitted from the current analysis.

3.2.2 Recruitment

Spatial changes in the distributions of juvenile mackerel have resulted in trends in the survey times series of recruitment indices, these are discussed in Sections 2.4 and 3.4.2.

3.2.3 Maturity at age

The assumptions made about maturity, by the Working Group in previous years, were retained with the exception of the reduced maturity at age 2 of the 1984 year class (see Section 1.4.3). Maturity at age is now constant for each year of the assessment. The values are given in the text table below:

Age 0	1	2	3	4	5	6	7	8+
% 0	8	60	90	97	97	99	100	100

An estimation of the maturity ogive in 1998 will be obtained as part of the egg survey of the western area. In this context samples will be taken over areas of predominantly juvenile distribution as well as on the spawning grounds (see Section 13.1). Samples will be analysed by histological examination to provide a more accurate estimate of the numbers of fish which will actually spawn in that year (see Section 2.10).

3.2.4 Stock assessment

Tables 3.2.1 to 3.2.3 show the catches in number, mean weights at age in the catch and mean weights at age in the stock. Due to the recent extension of the number of years that ICA can use in an assessment, the new assessment time series now includes the all of the available data from the years 1972–1996. In 1996, low sample numbers in the Dutch sampling scheme resulted in low values for the stock weights at the older ages. Weight at age data available from the Irish catches in March and April 1996 were used to estimate new values for the older ages. This data set will be explored further during the next year in order to evaluate its potential use in estimating stock weights at age. The catch at age data were screened using a preliminary ICA fit. There were no large residuals or aberrant patterns, indicating selection pattern changes, within the residuals from the fit to the recent years.

ICA fits to the catch at age data and the egg production estimates were used to examine the relationship between the indices and the catch at age data as estimated by a separable VPA. As in previous years, two selection patterns were used in order to model an apparent change in selection that took place in 1989 (1986–1988 and 1989–1996, Figure 3.2.3). The short time span for the first period was selected in order to exclude the 1985 catch data, which includes a zero catch of 0-group. The zero value introduces a large residual to the analysis and its omission from the model fit reduces the variance and bias of the log catch residuals from the separable fit. In this years assessment a terminal selection of 1.2 was used for both periods as there is no evidence for a difference between the values estimated for the oldest ages. Both selection patterns were calculated relative to the reference fishing mortality at age 5.

The model was fitted by a non-linear minimisation of:

$$\sum_{a=0}^{a=11}\sum_{y=1986}^{y=1988}\lambda_a(\ln(C_{a,y})-\ln(F_y.S1_a.\overline{N}_{a,y}))^2+$$

$$\sum_{a=0}^{a=11}\sum_{y=1989}^{y=1996}\lambda_a(\ln(C_{a,y}-\ln(F_y.S2_a.\overline{N}_{a,y}))^2+$$

$$\sum_{y=1977}^{y=1986}\Sigma(\ln(EPB_y)-\ln(\Sigma_a N_{a,y}.O_{a,y}.W_{a,y}.\exp(-PF.F_y.S1_a-PM.M))^2+$$

$$\sum_{y=1989}^{y=1995}\Sigma(\ln(EPB_y)-\ln(\Sigma_a N_{a,y}.O_{a,y}.W_{a,y}.\exp(-PF.F_y.S2_a-PM.M))^2$$

subject to the constraints

$S1_5 = S2_5 = 1.0$
$S1_{11} = S2_{11} = 1.2$

where

Nbar - mean exploited population abundance over the year.
N - population abundance on 1 January.
O - percentage maturity.
M - natural mortality.
F - fishing mortality at age 5.
S1, S2 - selection at age over the time periods 1986–1988 and 1989–1996, referenced to age 5.
λ - weighting factor set to 0.1 for age 0, 1.0 for all other ages.
a,y - age and year subscripts.
PF, PM - proportion of fishing and natural mortality occurring before spawning.
EPB - Egg production estimates of mackerel spawning biomass.
C - Catches in number at age and year.

Tables 3.2.4 a,b,c,d and Figures 3.2.1–3.2.4 present the ICA diagnostic output. Tables 3.2.5, 3.2.6 and 3.2.7 present the estimated fishing mortalities and population numbers-at-age and the stock summary.

3.2.5 Comments on the assessment

Mean F on ages 4-8 is estimated to have been 0.220 in 1996 and 0.294 in 1995 (4% lower than estimated in last year's assessment (F_{95} = 0.307). This results from both the addition of the new catch data and also the revisions to the egg production estimates of spawning stock biomass. However, mean F over the period 1992 to 1995 (0.287) is unchanged. Since no new tuning data has been added to the assessment time series these results are conditional on the assumption of a constant selection pattern during the last few years. The assessment for the years after the last survey would be very sensitive to deviations from the historic selection pattern.

Figure 3.2.2 shows that whilst the yield remained relatively stable between 1980 and 1990, the spawning stock biomass increased slowly. This resulted from a sustained level of good recruitment. Between 1990 and 1993 the yield and fishing mortality increased rapidly, they remained stable at a high level in 1994 and 1995, well above the long term mean. Fishing mortality is estimated to have decreased in 1996. Since 1992 the SSB has declined sharply, last years assessment estimated the SSB in 1995 to be at a historical low of 2.12 million tonnes, just below the estimate for 1994 (2.14). This years assessment has increased both estimates by 4% (1995: 2.25 and 1994: 2.21 million tonnes). The most recent estimate, at 2.13 million tonnes, is close to the historical low. Given the errors inherent within the assessment data sets the 1996 SSB is at an equivalent level to that of the previous two years and it appears that the decreasing trend may have been slowed or halted.

The 1995 year class was estimated to be extremely low by last years assessment, the revised 1995 ICA estimate is for a year class of average strength.

3.2.6 Comparative assessments

In previous years the ICA assessment was compared to the results from an XSA assessment tuned to the Western Approaches ground fish survey and two simple biomass-dynamic models (ICES 1997/Assess:3, ICES 1995/Assess:2). No comparative assessments have been made this year. Due to the spatial changes in the distribution of mackerel affecting the ground fish survey it was considered that no runs of XSA should be made this year without an analysis of the effects of distributional changes on catchability.

3.2.7 Consequences of using GAM estimates of egg production

The Working Group has previously explored the sensitivity of the Western Mackerel assessment to the method used to calculate estimates of egg production from the egg surveys: either the estimates calculated by the traditional method, or estimates calculated using a GAM approach (ICES 1997/Assess:3). The assessment was found to be highly sensitive: Using the GAM-based stock size estimates and allowing a proportional catchability relationship for the surveys, a stock size approximately 50% lower than the Working Group's conventional assessment could plausibly be calculated. The concomitant fishing mortality estimate was approximately 0.6 compared to the conventional estimate of 0.2.

As no new information on the GAM -based approach has been presented, this analysis has not been repeated. Instead for convenience Figure 3.2.5 has been reproduced from the comparison made previously and mentioned above.

The Working Group notes with concern that a plausible alternative interpretation of the data, using an alternative structural model, leads to a much lower perception of stock size.

3.3 Southern Mackerel Component

3.3.1 Effort and catch per unit effort

Table 3.3.1 shows the fishing effort data from Spanish and Portuguese commercial fleets. The table includes Spanish effort of the hand-line fleets from Santona and Santander (Sub-division VIIIc East) from 1989 to 1996 and from 1990 to 1996 respectively, for which mackerel is the target species from March to May. The table also shows the effort of the Aviles and La Coruña trawl fleets (Sub-division VIIIc East and VIIIc West) from 1983 to 1996 and the Vigo purse-seine fleet (Sub-division IXa North) from 1983 to 1992 for which mackerel is a by catch. The Spanish trawl fleet effort corresponds to the total annual effort of the fleet for which demersal species is the main target. Portuguese Mackerel effort from the trawl fleet (Sub-division IXa Central-North, Central-South and South) during 1988–1996 is also included and as in Spain mackerel is a by-catch.

Table 3.3.2 shows the CPUE corresponding to the fleets referred to in Table 3.3.1. The Spanish trawl fleets in 1996 showed again fluctuations in different trends compared with the ones from 1995, while the hand-line fleets are relatively stable, although a considerable increase was observed for the fleet of Santander in 1994 and 1995. The Portuguese trawl fleet shows a relative stability. The catches per effort, expressed as the numbers fish at each age group, for the various fleets is shown in Table 3.3.3.

The series of the Spanish CPUE of the commercial fleets indicate that there are seasonal fluctuations in the abundance of adults and juveniles mackerel in Division VIIIc and Subdivision IXa North and also confirm that seasonal and spatial variation of the fishery is related to the spatial variation of the abundance of this species in that area (Villamor *et al.*, in press).

3.3.2 Surveys

Mackerel egg surveys carried out in the Spanish and Portuguese area are discussed in Section 2.1.

Table 3.3.4 shows the numbers at age per half hour trawl from the Spanish bottom trawl surveys from 1984 to 1995 in September-October and the numbers at age per hour trawl (* 1000) Portuguese bottom trawl autumn surveys from 1986 to 1995.

The two sets of autumn surveys covered Sub-divisions VIIIc East, VIIIc West and IXa North (Spain) from 20–500 m depth and Sub-divisions IXa Central North, Central South and South (Portugal), from 20–750 m depth. The same sampling methodology was used in both surveys but there were differences in the gear design.

The data of the bottom trawl surveys indicate that mackerel were very scarce. This may be explained because of the gear used in these surveys, in which the main aim was to obtain the hake recruitment index, and also because the season in which these surveys are carried out is a time when abundance of the species is very low in this area (Villamor *et al.*, submitted). The catches of these autumn surveys consist mainly on juveniles, both on the Spanish coast and Portuguese coast (Martins *et al op. cit*).

3.4 North East Atlantic (NEA) Mackerel

3.4.1 Fishery independent information

As in previous years the western area egg survey estimates of spawning stock biomass since 1984 were raised by 15% to provide a spawning stock biomass series for the combined stock. The raising factor is based on the ratio of the spawning stock biomass estimates for the two components in the 1995 and 1992 surveys.

During the last few years a time series of catches from the CEFAS Western Approaches March ground fish survey has been utilised within an XSA assessment to provide a comparison with the ICA results. The survey was completed in 1997, however, until the potential effects of changes in the spatial distribution of the mackerel (Section 2.4) on the survey's catchability have been investigated, it was considered that this time series should be omitted from the current analysis.

3.4.2 Recruitment

ICES (1997/Assess:3) and ICES (1995/Assess:2) compared estimates of recruitment derived from the recruitment index for the Western stock with the estimates derived from an ICA analysis which incorporated all available assessment information. The results established that the index values have an increasing trend with time, whereas the estimates of recruitment have recently been declining. The discrepancy appears to have been caused by variation in the spatial distribution of juvenile mackerel (Section 2.4). Until the causes of the change are investigated further, the series can only be used qualitatively. In the present assessment the first quarter Scottish ground fish survey and the La Coruña age 1 CPUE time series have been used as qualitative measures of the abundance of the 1995 and 1996 year classes (Figures 2.4.5 and 2.4.6).

3.4.3 Combining data

A combined data set for the North East Atlantic mackerel was calculated as in previous years. The analysis was restricted to the years 1984–1996. The data series for the southern area is only available for this period and the stock spawning in the North Sea had been reduced to near the present low level by 1984, so its contribution to the catch at age data was negligible. For the North Sea stock, only data for 1984–87 were included, since data for the North Sea have been included in the data for the Western stock from 1988 onwards.

Mean weight in the catch was obtained as a catch number weighted average of the weights used for the three stocks. Catch weights for the 0 and 1 groups are determined primarily from the southern area and those for all other ages primarily from the western area.

Weights in the stock and maturity ogives were obtained as averages weighted by the relative proportion of the egg production spawning stock biomass within the respective areas. For the North Sea spawners, the biomass estimates by egg surveys since 1984 range from 37 to 133 thousand tonnes (ICES 1989/Assess:?), which corresponds to approximately 1.5% to 4.5% of the combined North Sea and western spawners. Thus, for combining the North Sea and western stock data, weighting factors of 0.03 and 0.97 respectively were applied. In 1996, low sample numbers in the Dutch sampling scheme resulted in low values for the stock weights at the older ages of the western mackerel. Weight at age data available from the Irish catches in March and April 1996 were used to estimate new values for the older ages. This data set will be explored further during the next year in order to evaluate its potential use in estimating stock weights at age. Weighting factors of 0.15 and 0.85 were used for the southern and western data. Similar weights were applied to the maturity at age, the resulting maturity ogive is given on the following page:

Age	0	1	2	3	4	5	6	7	8+
Maturity	0	0.14	0.65	0.91	0.97	0.97	0.99	1	1

Natural mortality was taken as 0.15 and the proportions of F and M before spawning were 0.4.

3.4.4 Stock assessment

Tables 3.4.1 to 3.4.3 show the catches in number, mean weights at age in the catch and mean weights at age in the stock. The catch at age data were screened using a preliminary ICA fit. There were no large residuals or aberrant patterns, indicating selection pattern changes, within the residuals from the fit to the recent years.

ICA fits to the catch at age data and the egg production estimates were used to examine the relationship between the indices and the catch at age data as estimated by a separable VPA. As in previous years, two selection patterns were used in order to model an apparent change in selection that took place in 1989 (1986–1988 and 1989–1996, Figure 3.4.3). The short time span for the first period was selected in order to exclude the 1985 catch data, which includes a zero catch of 0-group. The zero value introduces a large residual to the analysis and its omission from the model fit reduces the variance and bias of the log catch residuals from the separable fit. In this years assessment a terminal selection of 1.2 was used for both periods as there is no evidence for a difference between the values estimated for the oldest ages. Both selection patterns were calculated relative to the reference fishing mortality at age 5.

The model was fitted by a non-linear minimisation of:

$$\sum_{a=0}^{a=11}\sum_{y=1986}^{y=1988}\lambda_a(\ln(C_{a,y}) - \ln(F_y.S1_a.\overline{N}_{a,y}))^2 +$$
$$\sum_{a=0}^{a=11}\sum_{y=1989}^{y=1996}\lambda_a(\ln(C_{a,y} - \ln(F_y.S2_a.\overline{N}_{a,y}))^2 +$$
$$\sum_{y=1984}^{y=1988}\Sigma(\ln(EPB_y) - \ln(\Sigma_a N_{a,y}.O_{a,y}.W_{a,y}.\exp(-PF.F_y.S1_a - PM.M))^2 +$$
$$\sum_{y=1992}^{y=1995}\Sigma(\ln(EPB_y) - \ln(\Sigma_a N_{a,y}.O_{a,y}.W_{a,y}.\exp(-PF.F_y.S2_a - PM.M))^2$$

subject to the constraints:

$S1_5 = S2_5 = 1.0$
$S1_{11} = \quad S2_{11} = 1.2$

where

N bar - mean exploited population abundance over the year.
N - population abundance on 1 January.
O - proportion of fish mature at each age.
M - Natural mortality.
F - fishing mortality at age 5.
S1, S2 - selection at age over the time periods 1986–1989 and 1990–1995, referenced to age 5.
λ - weighting factor set to 0.1 for age 0, 1.0 for all other ages.
a,y - age and year subscripts.
PF, PM, proportion of fishing and natural mortality occurring before spawning.
EPB - Egg production estimates of mackerel spawning biomass.
C - Catches in number at age and year.

Parameter estimates and their standard deviations are listed in Tables 3.4.4a–f and illustrated in Figures 3.4.1–3.4.4. Tables 3.4.5, 3.4.6 and 3.4.7 present the estimated fishing mortalities, population numbers-at-age and stock summary.

3.4.5 Comments on the assessment

Figure 3.4.5 compares the assessments for the Western mackerel with the combined assessment and also the combined assessment carried out in 1996 with this years. The new assessment has only made minor revisions to the perception of the recruitment, SSB and fishing mortality time series. Since no new tuning data have been added to the assessment time series these results are conditional on the assumption of a constant selection pattern during the last few years. The assessment for the years after the last survey would be very sensitive to deviations from the historic selection pattern.

Mean F on ages 4–8 is estimated to have been 0.21 in 1996 and 0.27 in 1995 the same as estimated in last year's assessment (F_{95} = 0.27). Mean F over the period 1992 to 1995 (0.265) is unchanged. Figure 3.4.2 shows that as with the Western mackerel the yield remained relatively stable between 1984 and 1990, with a slow increase in spawning stock biomass. This resulted from a sustained sequence of good recruitment. Between 1990 and 1993 the yield and reference F increased rapidly, they remained stable at a high level in 1994 and 1995, well above the long term mean. Fishing mortality is estimated to have decreased in 1996. Since 1992 the SSB has declined sharply, last years assessment estimated the SSB in 1995 to be at a historical low of 2.54 million tonnes, just below the estimate for 1994 (2.55). The differences between this years and last years assessments for these values are negligible. The most recent estimate, at 2.46 million tonnes, is at the historical low for this restricted time series. However, given the errors inherent within the assessment data sets the 1996 SSB is at an equivalent level to that of the previous two years and it appears that the decreasing trend may have been slowed or halted.

ICES (1991/Assess:?) performed a sensitivity analysis for *status quo* forecasts made using data from this stock. The results revealed that the forecasts were sensitive to the estimates of the strength of the year class that recruited two years before the year of the assessment. The forecast made this year will be sensitive to the estimate of recruitment in 1995. The 1995 year class was estimated to be extremely low in last years assessment but there were indications from survey and CPUE data that it may have been at least of average strength; in forecasts the geometric mean of the time series was used. Both of the new ICA fit and the index of abundance derived from the Scottish 1st quarter groundfish survey and the La Coruña age 1 CPUE time series confirm that the 1995 recruitment was of average strength (Figures 2.4.5 and 2.4.6). The estimate for the 1994 recruitment has not altered substantially from the low value estimated last year (Figure 3.4.5). The 1996 year class is estimated to be strong by the ICA fit but this is not considered to be reliable as it is based on one catch at age value from the 1996 0-group.

3.4.6 Catch predictions

Table 3.4.8 presents the input values for the catch forecasts. Apart from the recruitment in 1996, the ICA-estimated abundances at all ages were used as the starting populations in the prediction. The recruitment for 1996 is estimated to be 6,757 million. The index from the Scottish groundfish survey, with the addition of the North Sea catches indicates that the year class may be at least of average strength. However, the predictive value of these data series is, as yet, unknown. A precautionary approach is to assume that the 1996 year class is of average strength. Therefore, the geometric mean was used for the 1996 recruitment, the value is calculated from the geometric mean (1972–1995) of the recruitment to the Western mackerel, raised by the average ratio (1.09) of the estimated Western and Southern area recruitments for the period 1984–1994.

Catch forecasts have been calculated for the provision of area based TACs. Two "fleets" have been defined, corresponding to the exploitation of the western area, including the North Sea and the unregulated catches taken in international waters, Division IIa (Northern), and the southern area (Southern).

The exploitation pattern used in the prediction was the separable ICA Fs for the final year. These were subdivided into partial Fs for each fleet using the average ratio of the fleet catch at each age and the total catch at each age for the years 1994–1996. Weight at age in the catch was taken as an average of the values for the period 1994–1996 for each area. Weight at age in the stock was calculated from an average (1994–1996) of the combined data.

The TACs for 1997, in each area, are the same as those for 1996. For the Northern area it is 350,000 tonnes (including unregulated catches taken in International waters, Division IIa). The Southern area has a TAC of 30,000 tonnes. Catches in the Southern area have recently been increasing and exceeded the quota for the first time in 1996. Catches in international waters which are not subject to a TAC, have recently averaged 45,000 tonnes. The combined over-shoot of the 1996 TAC was 23% (560kt).

Four single option summary tables are presented (Tables 3.4.9 a–d) and summarised in the text table below. The tables illustrate *status quo* fishing mortality and 560kt constant catch options for 1997. These are followed by three options: *status quo* fishing mortality, F98 = F99 = 0.15 the agreed between the EU and Norway for 1998, and constant catch options.

Year	*Status quo* (F96)		Catch 97 = 96 Catch 98,99=560 kt		Catch 97 = 96 F= 0.15, 98,99		Catch 97 = 96 SqF 98, 99	
	Ref F	SSB	Ref F	SSB	Ref F	SSB	Ref F	SSB
1997	0.20	2.56	0.20	2.57	0.20	2.57	0.2	2.57
1998	0.20	2.67	0.19	2.70	0.15	2.74	0.2	2.68
1999	0.20	2.71	0.17	2.78	0.15	2.90	0.2	2.72

The forecasts predict that SSB will begin to recover, as predicted last year, to an average of 2.8 million tonnes. However, the recovery is sensitive to the estimate of the 1996 year class abundance, which has been taken to be the geometric mean for the time series.

Two management option tables are presented. Table 3.4.10 presents the option for *Status quo* F in 1997, Table 3.4.11 presents a constant catch for each fleet in 1997; each is followed by a range of F98 values for both areas. The forecasts for the two scenarios are in close agreement for the predicted SSB values. This results from the dominant effect of the exploitation in the Western area on the forecast SSB estimates. The reference Fs in the Southern area are so low that for the range of F multipliers used in the forecast their catches make no significant impact on the predicted SSB in the short term.

3.4.7 Medium-term predictions

Medium-term predictions were made using the methodology described in ICES (1997/Assess:7). The input parameters were estimated as follows:

- Stock population parameters (Fishing mortality, selection, population abundance at age) were taken directly from the ICA fit (Section 3.4.4), apart from the 1996 year class at age 0. This value was replaced by the geometric mean as described in Section 3.4.6.
- Due to the down-weighting of the 0 group during the fitting of ICA the estimated variance gave an 800% coefficient of variation. The variance of the estimate in the ICA covariance matrix was replaced by the variance of the geometric mean of the full recruitment time series. The adjusted variance-covariance matrix was then used as the estimate of uncertainty in the stock population parameters.
- Mean weights at age in the catches and the fleet partial-F ratio at age were calculated as from the average proportions in the 1994–1996 catches.
- The mean of the maturity ogive and weights in the stock were estimated from observations from 1994 to 1996.
- Recruitment Function.

A simple, robust and precautionary approach to modelling recruitment was adopted. It is assumed that if spawning stock biomass falls below the lowest spawning stock biomass estimate, then a linear dependency is assumed to hold. Uncertainty about such a relationship was also modelled.

This model was formulated on the basis of making the simplest assumptions about recruitment that are consistent with the available data and with obvious constraints that are necessary from theoretical grounds. Firstly, there is no detectable dependency of recruitment on stock size over the range of stock size estimates available. Attempts to fit such functions having proved unsuccessful, it becomes necessary to retain the assumption that, over the observed range of stock sizes, the recruitment is independent of stock size. A geometric mean recruitment has been used as the estimate of central tendency over this range of stock sizes. An additional necessary constraint is that when stock size is zero, recruitment is also zero. The dependency of recruitment on stock size in the region between the lowest observed stock size (Recruitment = Geometric mean) and stock size = zero (Recruitment = zero), has been chosen by Ockham's razor, a simple linear dependency of recruits on stock size in this region.

Stochastic variation of recruitment about the model for medium-term prediction purposes was modelled in different ways separately for the regions of stock size above and below the lowest observed stock size. In the region over which stock sizes have been observed and recruitment is assumed to be stock-independent, pseudo-recruitments R' were drawn from a distribution as:

$$R' = \exp(\frac{1}{n}\Sigma_y(\ln(R_y)) + \varepsilon')$$

where R_y are the estimated recruitments over the n years, and the epsilon' are re-sampled with replacement from the historic distribution of recruitments about their geometric mean.

For lower stock sizes, a different approach was used. For each pseudo recruitment, a new estimate of the inflection point of the stock-recruit relationship (the recruitment at the lowest observed stock size) was drawn from a distribution having as its mean the geometric mean of observed recruitments, and with variance equal to the estimated variance of the observed recruitments. A pseudo recruitment was then generated using the generated inflection point (and assuming a linear dependency of recruitment on stock size down to the origin) and perturbed with an error re-sampled from log residuals with replacement, as above.

Bias in the medium term projections (differences between the mean values of F from the stochastic simulations from the deterministic trajectory from the stock assessment least squares estimates), were corrected by adjusting F-multiplier values in the stochastic projections so that the mean values in the projections conformed to the desired F-values. The predictions have been calculated for the following F - constraint options for 10 years ahead:

F96	F as in 1996 (0.208)
F15	F = 0.15, which has been agreed by EU and Norway as a TAC that is consistent with a fishing mortality of 0.15 in 1998 unless future scientific advice requires modification of the agreement. Brussels 9th Dec. 1995.

An MBAL of 2,300,000 tonnes was used (see Section 3.4.9).

The *status quo* F constraint led to a gradual reduction in the risk of SSB falling below MBAL (Figure 3.4.8), starting from around 30% and falling to 20% in 10 years. At the lower agreed fishing mortality this risk was considerably lower (≈5%, Figure 3.4.11). Under these options the catches increased to a range of 350–1,000,000 tonnes, slightly higher for F = 0.2 (Figure 3.4.7) than for F = 0.15 (Figure 3.4.10).

3.4.8 Long-term yield

Table 3.4.12 and Figure 3.4.12 present the yield per recruit forecasts for the both areas. F_{max} is poorly defined at a combined reference F of about 0.5. However, for pelagic species F_{max} is generally estimated to be at levels of F well beyond sustainable levels and should not be used as a fishing mortality target. F0.1 was estimated last year using the same selection pattern, the full age range and a 12 plus group, to be 0.175.

The time series of stock and recruitment estimates for this management unit are short and the estimation of F_{med}, F_{high} and F_{low} for short time series will be biased if the stock has previously been reduced to a low level. For this reason the F reference points have been calculated from the Western mackerel assessment time series of recruitment and SSB raised by the ratio of the respective series with the combined assessment time series. Figure 3.4.13 presents the results, F_{low} is estimated to be 0.08, F_{med} 0.28 and F_{high} 0.765; currently F is estimated to be between F_{med} and F_{low}. The fishing mortality forecast for 1997 under the constant catch restriction is 0.2 (= F96).

3.4.9 Reference points for management purpose

Even when the period back to 1977 is included, the SSB only spans the range of about 2.5–3.5 million tonnes. Within this range, there is no evidence that the stock size influences the recruitment. One would expect that the recruitment would be reduced at some level of SSB, but there is nothing in the present experience to indicate what this level would be. In recent years, the trend in SSB has been downwards. The Working Group has previously recommended that this development should be reversed. This is both because of the uncertainty as to what the dangerous level of SSB would be, but also because the present fishing mortality is well above F0.1, which implies that the fishing mortality could be reduced without any appreciable loss in long term yield.

Since the shape of the stock-recruit relation below the historical low SSB is unknown, a precautionary assumption about this relation would be a linear decrease in recruitment with decreasing SSB below the historical low, and a constant recruitment at the geometrical mean above it, as has been used within the stochastic projections.

However, this declining line in the stock recruit plane would represent the replacement line corresponding to the historical low SSB and the mean recruitment, and any higher F than the one corresponding to this replacement line would lead to depletion of the stock in long term simulations. Thus, under these assumptions, the lowest historical SSB has the properties of a limit biomass since the corresponding F would appear as an F_{crash}.

The level of 2.3 million tonnes has been regarded as the lower bound of the experienced SSB-range by the Working Group for several years. This is not to be taken as a B_{lim}, and the corresponding F as an F_{lim}, as is the usual interpretation of these concepts. In the present context, they represent the lower end of the range where by experience, the recruitment is largely independent on the stock biomass, but not necessarily the beginning of a range where poorer recruitment is to be expected. However, since this biomass level is well below that corresponding to F0.1 at equilibrium, an exploitation which leads to a lower SSB cannot be justified on the grounds that it would increase the long term equilibrium catch appreciably. In this case, the argument sometimes put forward, that using the lowest experienced SSB as a limit would preclude full exploitation of a stock, does not apply. Thus, until better insight in the stock recruitment dynamics is achieved, the level of 2.3 million tonnes is a candidate reference point for the biomass that it would be advisable to remain above.

Simulations made by the Comprehensive Working Group (ICES 1997/Assess:15) indicate F0.1 as a default candidate for F_{pa} under a wide range of stock dynamics. As such, it should imply a good trade-off between yield and risk. To explore this specifically for this stock, the long-term equilibrium distribution of SSB at various levels of F was computed. The model used is similar to the one used by (ICES 1997/Assess:8). It estimates the stationary distribution of SSB and recruitment at a fixed F, taking into account variations in recruitment and weights at age. The stock-recruitment function used was:

$R = f(SSB)*\exp(\varepsilon)$,

where

f(SSB)	= 3872	for SSB>2.3 million tonnes
	=SSB/2.3*3872	for SSB<2.3 million tonnes

and ε is normally distributed with expectation = 0 and s = 0.485. The parameters represent the geometric mean and the standard deviation of the log residuals of the recruitments in the years 1972–1995, as described in Section 3.4.6. The stochastic weights at age were obtained by drawing a year randomly each time a weight was needed by the model, and using the weights at age from that year. The year range used was 1984–1996. A selection of percentiles for the SSB-distribution is shown in Figure 3.4.14.

As a reference point representing the precautionary exploitation (F_{pa}), an F at about 0.185, which is slightly above F0.1, appears to be the highest F that is acceptable in terms of a less than 5% probability for the biomass to be below 2.3 million tonnes. The mean biomass at this level of F is close to 3.0 million tonnes, and the median 2.75 million tonnes.

The choice of reference points, in particular B_{pa} and F_{pa}, will to some extent depend on the harvest control law to which they are to be applied. Some exploratory simulations of a harvest control law was done using a medium-term simulation model. The harvest control law used was:

At	$B>B_{pa}$:	$F = F_{pa}$
At	$B_{low}<B<B_{pa}$:	$F=(F_{pa}-F1)*(B-B_{low})/(B_{pa}-B_{low})+F1$

Where F1 is a fishing mortality admitted when $B<B_{low}$, and B_{low} is the biomass which should be avoided. For the NEA mackerel stock, where the SSB is close to the assumed B_{low} of 2.3 million tonnes, and the assumed B_{low} is somewhat arbitrary and does not represent a limit below which the recruitment is known to be reduced, less drastic measures than closing the fishery should be permissible. A guideline in this case would be to apply a fishing mortality well below that represented by the replacement line through the mean recruitment and the 2.3 million tonnes. As an example, F corresponding to a replacement line at 2.3 million tonnes and one standard deviation below the geometric mean recruitment was used. This F-value is 0.122. As another example, a very low F of 0.05 was used. For 1997, a catch of 560,000 tonnes was assumed, and for F_{pa}, the F0.1 = 0.175 was used.

The medium-term simulation is a stochastic projection model, run over 10 years, with the same input data as the equilibrium model described above. The projection starts with the stock numbers from the last assessment year, and includes the uncertainty in these as specified by the variance-covariance matrix estimated in the ICA assessment. The model includes a decision rule, where next years F is determined according to the biomass it would lead to in the next year. The model allows for uncertainty in future assessment by multiplying the actual biomass with a stochastic multiplier, which is normally distributed and specified as a mean and standard deviation. Likewise, deviation of the realized catches from the TAC are also modelled with a similar catch multiplier. These options allow for testing the robustness of the model to these sources of errors.

Table 3.4.13 shows the results for a selection of runs. Three measures of performance are shown:

- The probability that the stock will reach the 2.3 million tonnes level at least once in the 10 years period.
- A measure of year to year variation of the catches, which is the range of catches divided by the mean in the last 5 years in each trajectory. This is a stochastic measure, and the median is shown here.
- The median total catch over the 10 year, expressed as average catch per year.

The results indicate that in order to be robust towards uncertain assessment or overfishing of TACs, a fairly high B_{pa} is helpful. This will increase the year to year variation in the catches to some extent. A lower value of the F1 will also be helpful, but will also increase the year to year variation.

Possible harvest control laws would need far more extensive evaluation before they can be recommended. In particular, one should be aware that the results are sensitive to the selection pattern. For the NEA mackerel, this is to a large extent assumed, and the sensitivity of a harvest control law performance to this has not been investigated.

In consequence the Working Group invite comments on the appropriateness for management purposes of a harvest control law as defined above, with B_{low} = 2.3 million tonnes, F_{pa} = F0.1 and F1 = 0.122.

3.4.10 Management measures and considerations

In 1995 ACFM recommended that to restore and maintain the spawning stock biomass above the historical low in 1997, the fishing mortality in 1996 should be reduced by 80% compared to 1994. Also that a reduction of 60% in 1996 would bring the SSB above this level by the time of spawning in 1998. This assessment has estimated that catch resulting from the overshot 1996 TAC has resulted in a reduction by 26% compared to 1994. The TAC for 1997 is the same as that of 1996 and if the resulting catch is equivalent to that for 1996, the fishing mortality will remain at this level. Short- and medium-term forecasts predict that the recent decline in SSB has been halted and continued fishing at this level will lead to gradual recovery to 2.7 million tonnes in 1998 and 2.8 million tonnes in 1999.

The Working Group points out that catches have consistently exceeded the TAC and this forecast is therefore considered to be optimistic. In addition, the forecast recovery is sensitive to the estimate of the 1996 year class abundance, which has been taken to be the geometric mean for the time series.

In the longer term, F in the order of 0.15–0.2 will result in a low risk of going below the MBAL level and is likely to improve the long term yield. Fs at the recent higher (1993–1995) levels would imply a far greater risk of the stock falling below the current MBAL.

The catches from this management unit have been increasing, with those of the period 1993–1995 the highest on record. This year's assessment has confirmed the previously, relatively high levels of F and the recent rapid decline in the spawning stock biomass. The reductions in quota imposed in 1996 have reduced fishing mortality and stabilised the decline in SSB. Minor revisions to the egg survey estimates have had no effect on the perception of the state of the stock.

The management of the Western component in recent years has reflected the need to protect the North Sea spawning stock by recommending that there should be no fishing for mackerel in Divisions IIIa and IVb,c at any time of year and in Division IVa for the first seven months of the year (see Section 3.1).

The TAC should take into account catches from **all** areas including those in international waters.

Table 3.1.1 Mackerel abundance indices from the North Sea International Young Fish Surveys. Values are mean numbers per 10 hr.

Year	First winter	Second winter
1970	6536	13
1971	3250	576
1972	13	226
1973	28	2
1974	14	12
1975	165	1
1976	4	2
1977	14	<.5
1978	23	<.5
1979	2	<.5
1980	<.5	<.5
1981	1	<.5
1982	1	1
1983	19	52
1984	1	4
1985	7	0
1986	5	21
1987	89*	<.5
1988	13	1
1989	11	17
1990	350	12
1991	69*	2
1992	160*	4
1993	10	8
1994	22	1
1995	+	+
1996	104	7
1997	7200**	36**

Notes: Data for survey years 1970-1974 based on standard area south of 59°30'N, 1975-1992 based on standard area south of 61°30'N; *Values dominated by catch in one or two rectangles only; ** Preliminary

Table 3.1.2 North Sea Mackerel (Weight in '000 t).

Year	Spawning Stock Biomass	Landings
1965	2850 $	208
1966	2700 $	530 *
1967	1900 $	930 *
1968	1500 $	822 *
1969	1113 "	739 *
1970	550 "	323 *
1971	580 "	243 *
1972	1249 "	125 +
1973	1097 "	226 +
1974	1036 "	190 +
1975	826 +	138 +
1976	700 +	165 +
1977	583 +	188 +
1978	436 +	103 +
1979	336 +	66 +
1980	258 +	61 +
1981	189 +	60 +
1982	162 +	40 +
1983	168 +	43 +
1984	133 #	67 +
1985		35 +
1986	45 #	25 +
1987		3 +
1988	37 #	6
1989		7
1990	78 #	10
1991		- **
1992		- **
1993		- **
1994		- **
1995		- **
1996	110 #	- **

$ Hamre, J. 1980 Rapp.P.-v. Reun.Cons.Int.Explor.Mer. 177:212–242
* Report of the Mackerel Working Group 1975. ICES CM 1975/H:3
" Report of the Mackerel Working Group 1981. ICES CM 1981/H:7
\+ Report of the Mackerel Working Group 1989. ICES CM 1989/Assess:11
\# Estimations based on Mackerel Egg Surveys
** Since 1990 assumed by the Working Group to be 10,000 t

Table 3.2.1 The Western mackerel catch numbers at age.

Mackerel West (run: ICACDD03/I03)

Catch in number

Age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	1.6	.0	1.3	1.0	34.2	2.0	10.3	79.5	19.5	38.3	2.0	.0	.5	.0	18.1
1	12.4	33.8	87.0	52.5	279.4	153.5	31.3	351.1	484.5	266.1	203.0	43.6	15.2	234.3	25.7
2	12.1	49.4	24.3	104.0	184.9	289.5	563.8	61.6	468.7	506.4	435.9	712.7	79.5	16.0	397.8
3	29.4	64.0	123.5	94.5	322.3	154.0	425.0	602.5	75.2	225.1	483.6	444.6	661.8	49.1	29.9
4	507.7	115.5	108.5	306.3	170.6	166.0	243.7	365.5	381.3	31.7	184.1	391.6	374.6	420.3	63.6
5	.0	582.3	191.8	192.2	288.8	51.0	258.3	217.2	282.0	174.8	24.7	130.4	238.2	242.6	331.9
6	.0	.0	567.0	143.8	118.6	140.0	71.9	233.1	145.2	158.5	136.6	20.2	92.0	158.4	193.9
7	.0	.0	.0	1246.2	279.7	64.4	151.9	86.8	158.4	99.5	108.6	91.3	15.5	58.9	119.5
8	.0	.0	.0	.0	438.8	89.4	56.7	154.2	52.4	116.6	84.5	70.9	51.5	16.2	38.3
9	.0	.0	.0	.0	.0	158.5	83.2	70.5	139.6	35.3	87.0	47.1	39.3	42.0	11.1
10	.0	.0	.0	.0	.0	.0	210.8	74.6	43.6	138.7	24.4	48.9	25.1	33.0	28.6
11	.0	.0	.0	.0	.0	.0	.0	189.1	47.9	29.4	90.3	19.1	21.4	20.4	20.2
12	.0	.0	.0	.0	.0	.0	.0	.0	115.4	176.1	147.6	126.2	44.2	80.3	60.1

Thousands

Catch in number

Age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	2.5	.3	24.4	5.4	4.9	1.7	13.1	.5	3.7	7.1
1	22.9	99.0	42.8	108.6	47.1	75.0	114.7	144.5	74.1	90.8
2	148.4	127.3	306.9	202.3	202.7	150.9	202.8	215.1	335.0	158.3
3	653.6	175.4	203.3	408.1	194.9	347.3	264.2	301.1	331.0	323.3
4	51.9	505.1	163.4	205.3	362.8	261.1	387.4	261.0	268.3	263.9
5	79.3	66.5	356.5	152.1	181.8	298.3	239.9	289.7	181.8	171.4
6	237.4	77.9	45.9	247.4	125.0	152.6	247.2	176.3	190.6	91.3
7	148.8	179.2	54.0	40.6	192.3	111.8	145.6	183.8	135.4	110.2
8	83.9	111.5	105.7	45.0	49.7	135.6	95.6	103.5	106.5	49.6
9	33.0	51.6	66.7	80.0	42.0	50.3	119.1	77.5	65.4	53.6
10	18.0	19.3	31.4	31.5	67.9	35.6	37.4	56.4	39.8	23.0
11	24.7	12.3	13.6	15.9	29.2	39.8	28.2	19.6	35.7	16.2
12	60.8	52.4	34.8	27.0	52.4	67.5	65.6	56.4	36.6	29.0

Thousands

Table 3.2.2 The Western mackerel catch weights at age.

Weights at age in the catches (Kg)

Age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	.06600	.06600	.06600	.06600	.06600	.06600	.00000	.00000	.06600	.06600	.06600	.06600	.06900	.00000	.00000
1	.13700	.13700	.13700	.13700	.13700	.13700	.13700	.13700	.13100	.13100	.13100	.17800	.13700	.15100	.16600
2	.15800	.15800	.15800	.15800	.15800	.15800	.15800	.15800	.24800	.24800	.24800	.21600	.17600	.27300	.24500
3	.24100	.24100	.24100	.24100	.24100	.24100	.24100	.24100	.28300	.28300	.28300	.27000	.29400	.34900	.33900
4	.41600	.31400	.31400	.31400	.31400	.31400	.31400	.31400	.34300	.34300	.34300	.30600	.32400	.41800	.42100
5	.00000	.43700	.33400	.33400	.33400	.33400	.33400	.33400	.37300	.37300	.37300	.38300	.34100	.41600	.47300
6	.00000	.00000	.47200	.39800	.39800	.39800	.39800	.39800	.45500	.45500	.45500	.42500	.42900	.43400	.44400
7	.00000	.00000	.00000	.48000	.41000	.41000	.41000	.41000	.49700	.49700	.49700	.43000	.53800	.52000	.45600
8	.00000	.00000	.00000	.00000	.50800	.50300	.50300	.50300	.50800	.50800	.50800	.49100	.46800	.54400	.54100
9	.00000	.00000	.00000	.00000	.00000	.51100	.51100	.51100	.53900	.53900	.53900	.54200	.56100	.56200	.59300
10	.00000	.00000	.00000	.00000	.00000	.51100	.51100	.51100	.57300	.57300	.57300	.60800	.61900	.62700	.54600
11	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.51100	.57300	.57300	.57300	.60800	.63600	.66600	.69200
12	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.57300	.57300	.57300	.60800	.63600	.70400	.69200

Units

Weights at age in the catches (Kg)

Age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	.04900	.07100	.06100	.06100	.06000	.05500	.05300	.05400	.07300	.05500
1	.17600	.15700	.15400	.16700	.15500	.16400	.13600	.13500	.14100	.15200
2	.22200	.26000	.23800	.23400	.25500	.23800	.24100	.25700	.23400	.22900
3	.31800	.32600	.32100	.33700	.33200	.33400	.31700	.34100	.33400	.31400
4	.39900	.39000	.37700	.38000	.39700	.39800	.37700	.39100	.39000	.38000
5	.47800	.46200	.43400	.42500	.42600	.46200	.43700	.45100	.45300	.42600
6	.51300	.53700	.45500	.46900	.47100	.49700	.48600	.51700	.50300	.48600
7	.49200	.56700	.54600	.53000	.50800	.53400	.53000	.54600	.54200	.52200
8	.49600	.56300	.59600	.55800	.55600	.55700	.55000	.59300	.58200	.55800
9	.57700	.56800	.57900	.61200	.61200	.59900	.58500	.58500	.59800	.58300
10	.63500	.61700	.58200	.61100	.63500	.65400	.59900	.62900	.60900	.60200
11	.63400	.62700	.64900	.59200	.65100	.66700	.65100	.68300	.63500	.61100
12	.72100	.70500	.74200	.71700	.70800	.67000	.68000	.71400	.67500	.67500

Units

Table 3.2.3 The Western mackerel stock weights age age.

Weights at age in the stock (Kg)

Age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1	.11300	.11300	.11300	.11300	.11300	.11300	.09500	.09500	.09500	.07000	.07000	.07000	.07000	.07000	.07000
2	.13100	.13100	.13100	.13100	.13100	.13100	.15000	.15000	.15000	.17200	.10800	.15600	.18700	.15000	.16400
3	.20100	.20100	.20100	.20100	.20100	.20100	.21500	.21500	.21500	.24100	.20200	.22000	.24600	.29200	.26100
4	.38000	.25100	.25100	.25100	.25100	.25100	.27500	.27500	.27500	.30000	.26000	.26100	.28300	.30000	.29000
5	.00000	.41000	.26400	.26400	.26400	.26400	.32000	.32000	.32000	.30000	.37900	.32200	.30500	.32800	.34500
6	.00000	.00000	.44000	.31600	.31600	.31600	.35500	.35500	.35500	.35900	.32900	.36000	.37900	.36600	.33700
7	.00000	.00000	.00000	.47000	.38000	.38000	.38000	.38000	.38000	.40100	.38800	.38400	.42900	.42100	.39500
8	.00000	.00000	.00000	.00000	.49000	.41200	.40000	.40000	.40000	.41200	.41700	.42000	.42100	.44000	.46700
9	.00000	.00000	.00000	.00000	.00000	.51100	.42000	.42000	.42000	.42700	.42500	.49700	.46500	.44800	.44100
10	.00000	.00000	.00000	.00000	.00000	.51100	.48500	.48500	.48500	.41300	.46000	.45300	.51500	.55400	.45100
11	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.48500	.48500	.50900	.51300	.55000	.49700	.57900	.47200
12	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.48500	.50900	.51300	.55000	.54900	.59900	.56800

Units

Weights at age in the stock (Kg)

Age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1	.07000	.07000	.07000	.07000	.07000	.07000	.07000	.07000	.07000	.07000
2	.13900	.14600	.17600	.12800	.14900	.21600	.19300	.17500	.15100	.12200
3	.23300	.23300	.23800	.21300	.22700	.25700	.26400	.23000	.25900	.24400
4	.26800	.30200	.29900	.28000	.30700	.30900	.31100	.28900	.31600	.31400
5	.36300	.32700	.34200	.33100	.35600	.35900	.35700	.35300	.39200	.35600
6	.37100	.43400	.36300	.36500	.40800	.40000	.41600	.40700	.44500	.44300
7	.39200	.45500	.41900	.40500	.43100	.42400	.45800	.46800	.49300	.46400
8	.40200	.43600	.46800	.39300	.50600	.46400	.46400	.46400	.50600	.50500
9	.45900	.46000	.44100	.42000	.54700	.48900	.48000	.47200	.54600	.57600
10	.48300	.52800	.45100	.51400	.57400	.52300	.51200	.55000	.50200	.58000
11	.44200	.60600	.49600	.51400	.57400	.55600	.59700	.61200	.62700	.62400
12	.54700	.64500	.58500	.51400	.57400	.58200	.56100	.56800	.63300	.63800

Units

Table 3.2.4a The ICA diagnostic output for the Western mackerel.

IFAP run code: I03

No of years for separable analysis : 11
Age range in the analysis : 0 12
Year range in the analysis : 1972 1996
Number of indices of SSB : 1
Number of age-structured indices : 0
Parameters to estimate : 53
Number of observations : 139

Two selection vectors to be fitted .
Abrupt change in selection specified.
Selection assumed constant up to and including 1988

PARAMETER ESTIMATES

Parm No.		Maximum Likelih. Estimate	CV (%)	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. distrib.
Separable Model: Reference F by year								
1	1986	.1321	16	.0960	.1818	.1122	.1554	.1338
2	1987	.1651	15	.1219	.2234	.1414	.1926	.1671
3	1988	.1788	14	.1337	.2392	.1541	.2074	.1808
4	1989	.1718	12	.1337	.2207	.1512	.1952	.1732
5	1990	.1793	12	.1392	.2309	.1576	.2040	.1808
6	1991	.1975	13	.1525	.2558	.1731	.2254	.1992
7	1992	.2352	14	.1787	.3097	.2044	.2706	.2375
8	1993	.3051	15	.2235	.4163	.2603	.3575	.3089
9	1994	.3028	19	.2076	.4416	.2497	.3670	.3084
10	1995	.2906	24	.1796	.4701	.2274	.3714	.2995
11	1996	.2170	30	.1188	.3967	.1596	.2952	.2276
Separable Model: Selection (S1) by age from 1986 to 1988								
12	0	.0041	145	.0002	.0712	.0010	.0176	.0119
13	1	.0818	20	.0546	.1225	.0665	.1005	.0835
14	2	.4682	20	.3149	.6961	.3824	.5732	.4778
15	3	.6011	20	.4049	.8925	.4913	.7354	.6135
16	4	.7135	20	.4810	1.0583	.5835	.8724	.7281
	5	1.0000			Fixed : Reference age			
17	6	1.2779	19	.8642	1.8896	1.0467	1.5601	1.3036
18	7	1.6337	19	1.1075	2.4098	1.3398	1.9921	1.6662
19	8	1.6174	19	1.0951	2.3887	1.3256	1.9734	1.6497
20	9	1.2163	19	.8262	1.7906	.9985	1.4816	1.2402
21	10	1.2934	19	.8832	1.8942	1.0647	1.5713	1.3182
	11	1.2000			Fixed : last true age			

Table 3.2.4b The ICA diagnostic output for the Western mackerel.

Separable Model: Selection (S2) by age from 1989 to 1996

22	0	.0053	95	.0008	.0348	.0020	.0139	.0084
23	1	.1212	15	.0888	.1655	.1034	.1421	.1227
24	2	.3842	14	.2910	.5072	.3334	.4427	.3881
25	3	.6610	13	.5093	.8578	.5786	.7550	.6668
26	4	.8759	12	.6822	1.1246	.7710	.9950	.8830
	5	1.0000			Fixed : Reference age			
27	6	.9729	11	.7694	1.2303	.8631	1.0967	.9799
28	7	1.0774	11	.8578	1.3532	.9591	1.2103	1.0847
29	8	1.1306	11	.9070	1.4093	1.0104	1.2651	1.1378
30	9	1.3674	10	1.1049	1.6922	1.2264	1.5245	1.3755
31	10	1.2733	11	1.0234	1.5842	1.1390	1.4234	1.2812
	11	1.2000			Fixed : last true age			

Separable Model: Populations in year 1996

32	0	.6637E+07	270	.3294E+05	.1337E+10	.4429E+06	.9945E+08	.2590E+09
33	1	3746385	44	1563648	8976064	2398852	5850883	4137786
34	2	1997494	35	992238	4021194	1397816	2854441	2128913
35	3	2675214	30	1473689	4856366	1973512	3626414	2801914
36	4	1431225	28	823390	2487769	1079460	1897619	1489309
37	5	841618	27	489647	1446597	638408	1109511	874376
38	6	475924	27	277504	816218	361421	626704	494294
39	7	541157	26	319507	916571	413587	708076	561071
40	8	270016	27	158632	459607	205842	354197	280144
41	9	300065	26	177159	508239	229326	392624	311108
42	10	109933	28	62570	193147	82462	146557	114573
43	11	73620	29	40915	132469	54555	99348	77002

Separable Model: Populations at age 11

44	1986	147726	29	83385	261714	110342	197777	154150
45	1987	144490	23	91318	228621	114331	182604	148504
46	1988	58026	20	38686	87034	47184	71360	59281
47	1989	77295	19	53121	112470	63833	93595	78723
48	1990	119888	17	84901	169293	100535	142967	121761
49	1991	146193	17	104734	204063	123319	173309	148324
50	1992	199708	16	144523	275964	169330	235536	202445
51	1993	73985	17	53013	103251	62415	87699	75062
52	1994	48637	19	33227	71193	40044	59073	49564
53	1995	180477	23	113513	286947	142455	228648	185599

SSB Index catchabilities
INDEX1
Used as absolute estimator.
No fitted catchability for this index.

Table 3.2.4c The ICA diagnostic output for the Western mackerel.

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals

Age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	2.423	-.334	-2.089	1.820	.771	.435	-.909	.583	-2.186	-.514	.000
1	-.045	-.395	.439	-.274	.302	-.116	.027	.070	.030	-.042	.005
2	.412	-.066	-.308	.252	.276	-.127	-.075	-.171	-.222	-.019	.064
3	-.710	.665	.013	.104	.193	-.152	-.041	-.024	-.004	.010	-.028
4	-.165	-.305	.419	-.116	.073	-.008	.000	-.116	.071	.016	.135
5	.444	-.227	-.178	.071	-.050	.049	-.159	-.075	-.098	.045	.114
6	.276	-.040	-.225	-.158	.014	.021	.089	-.165	.102	-.004	.079
7	.189	-.092	-.247	-.022	-.096	-.095	.003	.105	-.096	.231	.047
8	-.078	.012	-.021	.029	.047	.319	-.280	-.015	.208	-.172	-.098
9	-.348	.192	.125	.086	-.115	.076	.385	-.373	.117	.118	-.292
10	-.017	.185	-.122	-.010	-.253	.095	.240	.401	-.489	.109	-.073
11	.003	.021	.165	.012	-.308	.017	-.140	.286	.350	-.327	.028

Units

SPAWNING BIOMASS INDEX RESIDUALS

INDEX1

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	.213	-1.000	-1.000	.135	-1.000	-1.000	.056	-1.000	-1.000	-.107	-1.000	-1.000	-.017	-1.000	-1.000

Units

INDEX1

	1992	1993	1994	1995
1	.031	-1.000	-1.000	.092

Units

Table 3.2.4d The ICA diagnostic output for the Western mackerel.

PARAMETERS OF THE DISTRIBUTION OF ln CATCHES AT AGE

Separable model fitted from 1986 to 1996

Variance	:	.0672
Skewness test statistic	:	.2645
Kurtosis test statistic	:	2.9749
Partial chi-square	:	.4773
Significance in fit	:	.0000
Degrees of freedom	:	89

PARAMETERS OF THE DISTRIBUTION OF THE SSB INDICES

DISTRIBUTION STATISTICS FOR INDEX1

Index used as absolute measure of abundance.

Variance	:	.0126
Skewness test statistic	:	1.2999
Kurtosis test statistic	:	-.3504
Partial chi-square	:	.0060
Significance in fit	:	.0000
Number of observations	:	7
Degrees of freedom	:	7
Weight in the analysis	:	1.0000

ANALYSIS OF VARIANCE TABLE

Unweighted Statistics

		SSQ	Data	Params	d.f.	
Variance						
	Total for Model	25.8362	139	53	86	.3004
	Catches at Age	25.7483	132	53	79	.3259
SSB Indices						
INDEX1		.0879	7	0	7	.0126

Weighted Statistics

		SSQ	Data	Params	d.f.	
Variance						
	Total for Model	5.3932	139	53	86	.0627
	Catches at Age	5.3054	132	53	79	.0672
SSB Indices						
INDEX1		.0879	7	0	7	.0126

Table 3.2.5 The Western mackerel fishing mortality at age.

Fishing Mortality (per year)

Age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	.00085	.00000	.00041	.00022	.00725	.00221	.00331	.01560	.00381	.00576	.00114	.00000	.00008	.00000	.00054
1	.00252	.02111	.02482	.01920	.07337	.03869	.04110	.14052	.11785	.06235	.03620	.02932	.01384	.04486	.01080
2	.00681	.01173	.01798	.03552	.08258	.09609	.18397	.10078	.26611	.16463	.13050	.16265	.06508	.01714	.06183
3	.01352	.04288	.03486	.08548	.13929	.08698	.18853	.28828	.16285	.18667	.22117	.18042	.21128	.04946	.07938
4	.07580	.06410	.09018	.10772	.20689	.09375	.18257	.23217	.28196	.09069	.21684	.26495	.21502	.19070	.09422
5	.00000	.11081	.13651	.21559	.13303	.08333	.19535	.23228	.26678	.19078	.08985	.22222	.24138	.19910	.13206
6	.00000	.14160	.14216	.13629	.18940	.08358	.15340	.25621	.22703	.22286	.21170	.09357	.22810	.23691	.16876
7	.00000	.18103	.22302	.49166	.39883	.14114	.11636	.26426	.26206	.22679	.22156	.20225	.09176	.21149	.21575
8	.00000	.17922	.22079	.34868	.30164	.20143	.16843	.15720	.23852	.29589	.28900	.20845	.15888	.12369	.21359
9	.00000	.13477	.16604	.26222	.16180	.16019	.27583	.30726	.19719	.23678	.35421	.24478	.16162	.17818	.16062
10	.00000	.14332	.17657	.27885	.17206	.10778	.31190	.40104	.29905	.28946	.24149	.32528	.18871	.18778	.17081
11	.00000	.13297	.16381	.25871	.15963	.10000	.23442	.47915	.45854	.31886	.29291	.28540	.21770	.21802	.15847
12	.00000	.13297	.16381	.25871	.15963	.10000	.23442	.47915	.45854	.31886	.29291	.28540	.21770	.21802	.15847

Units

Fishing Mortality (per year)

Age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	.00068	.00074	.00091	.00095	.00105	.00125	.00162	.00161	.00154	.00115
1	.01350	.01462	.02082	.02173	.02394	.02851	.03698	.03670	.03522	.02631
2	.07728	.08370	.06600	.06889	.07588	.09037	.11720	.11632	.11165	.08339
3	.09923	.10747	.11355	.11852	.13054	.15547	.20163	.20011	.19208	.14346
4	.11777	.12756	.15048	.15705	.17298	.20603	.26720	.26517	.25454	.19011
5	.16507	.17879	.17180	.17931	.19749	.23522	.30506	.30275	.29061	.21705
6	.21094	.22847	.16714	.17445	.19214	.22885	.29679	.29455	.28273	.21117
7	.26968	.29208	.18510	.19319	.21278	.25343	.32867	.32619	.31311	.23385
8	.26698	.28916	.19423	.20273	.22329	.26594	.34490	.34229	.32856	.24539
9	.20077	.21745	.23491	.24518	.27005	.32163	.41712	.41397	.39737	.29678
10	.21351	.23125	.21875	.22832	.25147	.29951	.38843	.38549	.37003	.27637
11	.19808	.21454	.20616	.21517	.23699	.28227	.36607	.36330	.34873	.26046
12	.19808	.21454	.20616	.21517	.23699	.28227	.36607	.36330	.34873	.26046

Units

Table 3.2.6 The Western mackerel population numbers at age.

Population Abundance (1 January)

Age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
0	2025.3	4439.0	3454.4	4938.3	5094.8	974.1	3356.0	5530.3	5524.5	7182.6	1889.4	1387.2	6679.2	3129.9	3174.5
1	5313.2	1741.7	3820.7	2972.0	4249.5	4353.5	836.6	2879.0	4686.3	4736.9	6146.6	1624.4	1193.9	5748.4	2693.9
2	1919.9	4561.6	1467.8	3207.9	2509.4	3398.8	3604.8	691.1	2153.1	3585.2	3830.6	5102.4	1357.7	1013.5	4730.6
3	2357.3	1641.3	3880.4	1240.8	2664.7	1988.7	2657.4	2581.3	537.8	1420.2	2617.4	2893.7	3732.4	1095.0	857.5
4	7482.4	2001.7	1353.3	3225.5	980.5	1995.3	1569.1	1894.2	1665.3	393.3	1014.2	1805.8	2079.5	2600.7	897.0
5	.0	5970.1	1615.9	1064.4	2492.7	686.2	1563.7	1125.2	1292.6	1081.2	309.2	702.8	1192.5	1443.5	1849.8
6	.0	.0	4599.5	1213.3	738.5	1878.2	543.4	1107.1	767.7	852.0	769.0	243.2	484.4	806.3	1018.2
7	.0	.0	.0	3434.2	911.3	525.9	1487.0	401.2	737.5	526.6	586.9	535.6	190.7	331.9	547.6
8	.0	.0	.0	.0	1807.8	526.4	393.1	1139.3	265.1	488.4	361.3	404.7	376.6	149.7	231.2
9	.0	.0	.0	.0	.0	1150.8	370.4	285.9	837.9	179.8	312.7	232.9	282.8	276.5	113.9
10	.0	.0	.0	.0	.0	.0	843.9	242.0	181.0	592.2	122.1	188.9	156.9	207.1	199.1
11	.0	.0	.0	.0	.0	.0	.0	531.7	139.4	115.5	381.6	82.5	117.4	111.8	147.7
12	.0	.0	.0	.0	.0	.0	.0	.0	336.0	691.8	623.7	545.4	242.9	440.2	440.7

Thousands

Population Abundance (1 January)

Age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	5505.9	3422.8	4676.9	2801.6	3251.1	3688.3	4874.4	2797.5	4359.4	6637.0	3035.7
1	2730.8	4735.7	2943.9	4021.8	2409.1	2795.3	3170.6	4188.6	2404.0	3746.4	5705.9
2	2293.8	2318.9	4016.9	2481.6	3387.1	2024.4	2338.3	2629.9	3475.3	1997.5	3140.8
3	3827.6	1827.4	1835.7	3236.6	1993.7	2702.3	1591.9	1790.0	2015.0	2675.2	1581.7
4	681.7	2983.2	1412.6	1410.4	2474.4	1506.0	1991.0	1120.0	1261.3	1431.2	1994.9
5	702.6	521.6	2260.2	1046.0	1037.5	1791.4	1054.9	1311.9	739.4	841.6	1018.6
6	1395.2	512.7	375.4	1638.3	752.5	732.9	1218.7	669.2	834.2	475.9	583.1
7	740.3	972.5	351.2	273.4	1184.4	534.5	501.8	779.6	429.1	541.2	331.7
8	379.8	486.5	625.0	251.2	194.0	824.0	357.0	310.9	484.2	270.0	368.7
9	160.7	250.3	313.6	443.0	176.5	133.5	543.6	217.7	190.0	300.1	181.8
10	83.5	113.2	173.4	213.4	298.4	116.0	83.3	308.3	123.8	109.9	191.9
11	144.5	58.0	77.3	119.9	146.2	199.7	74.0	48.6	180.5	73.6	71.8
12	363.3	291.6	200.6	149.6	266.5	294.6	229.3	198.4	133.3	135.5	138.7

Thousands

Table 3.2.7 The Western mackerel stock summary.

STOCK SUMMARY

Year	Recruits Age 0 thousands	Total Biomass tonnes	Spawning Biomass tonnes	Landings tonnes	Yield/ SSB ratio	Mean F Ages 4- 8	SoP (%)
1972	2025310	4169035	3106189	170775	.0550	.0152	129
1973	4439000	4074425	3212076	219445	.0683	.1353	145
1974	3454420	4194057	3242893	298054	.0919	.1625	138
1975	4938250	4093581	2994589	491380	.1641	.2600	175
1976	5094810	3714176	2640334	507178	.1921	.2460	134
1977	974120	3617208	2627487	325974	.1241	.1206	116
1978	3356000	3603484	2814991	503913	.1790	.1632	124
1979	5530340	3309601	2485863	605744	.2437	.2284	126
1980	5524490	3084500	2122118	604761	.2850	.2553	132
1981	7182580	3183374	2220708	661762	.2980	.2054	105
1982	1889410	3089671	2116151	623819	.2948	.2058	112
1983	1387150	3253802	2372638	614287	.2589	.1983	110
1984	6679210	3035758	2378906	550929	.2316	.1870	102
1985	3129870	3195576	2363152	561292	.2375	.1924	99
1986	3174500	3213985	2392909	537615	.2247	.1649	99
1987	5505870	3176714	2438347	615380	.2524	.2061	102
1988	3422780	3442641	2564421	628000	.2449	.2232	99
1989	4676890	3493412	2604335	567400	.2179	.1737	100
1990	2801580	3271368	2461098	605937	.2462	.1813	99
1991	3251060	3675238	2834169	646169	.2280	.1997	101
1992	3688250	3746484	2840649	742305	.2613	.2379	100
1993	4874400	3468166	2529635	805039	.3182	.3085	99
1994	2797490	3148143	2213471	797688	.3604	.3062	99
1995	4359400	3094567	2253114	728637	.3234	.2939	100
1996	6637000	2875022	2129666	529464	.2486	.2195	99

Table 3.3.1 **SOUTHERN MACKEREL. Effort data by fleets.**

	SPAIN					PORTUGAL
	TRAWL		HOOCK (HAND-LINE)		PURSE SEINE	TRAWL
	AVILES (Subdiv.VIIIc East) (HP*fishing days*10^-2)	LA CORUÑA (Subdiv.VIIIc West) (Av. HP*fishing days*10^-2)	SANTANDER (Subdiv.VIIIc East) (Nº fishing trips)	SANTOÑA (Subdiv.VIIIc East) (Nº fishing trips)	VIGO (Subdiv.IXa North) (Nº fishing trips)	(Subdiv.IXa CN,CS &S) (Fishing hours)
YEAR	ANUAL	ANUAL	MARCH to MAY	MARCH to MAY	ANUAL	ANUAL
1983	12568	33999	-	-	20	-
1984	10815	32427	-	-	700	-
1985	9856	30255	-	-	215	-
1986	10845	26540	-	-	157	-
1987	8309	23122	-	-	92	-
1988	9047	28119	-	-	374	60601
1989	8063	29628	-	605	153	53428
1990	8492	29578	322	509	161	49532
1991	7677	26959	209	724	66	45467
1992	12693	26199	70	698	286	78272
1993	7635	29670	151	1216	-	48565
1994	9620	39590	130	1926	-	39062
1995	6146	41452	217	1696	-	44463
1996	4525	35728	560	2007	-	36002

- Not available

Table 3.3.2 **SOUTHERN MACKEREL. CPUE series in commercial fisheries.**

	SPAIN					PORTUGAL
	TRAWL		HOOCK (HAND-LINE)		PURSE SEINE	TRAWL
	AVILES (Subdiv.VIIIc East) (Kg/HP*fishing days*10^-2)	LA CORUÑA (Subdiv.VIIIc West) (Kg/Av. HP*fishing days*10^-2)	SANTANDER (Subdiv.VIIIc East) Kg/Nº fishing trips	SANTOÑA (Subdiv.VIIIc East) Kg/Nº fishing trips	VIGO (Subdiv.IXa North) (t/Nº fishing trips)	(Subdiv.IXa CN,CS &S) (Kg/Fishing hours)
YEAR	ANUAL	ANUAL	MARCH to MAY	MARCH to MAY	ANUAL	ANUAL
1983	14.2	34.2	-	-	1.3	-
1984	24.1	40.1	-	-	5.6	-
1985	17.6	38.1	-	-	4.2	-
1986	41.1	34.2	-	-	5.0	-
1987	13.0	36.5	-	-	2.1	-
1988	15.9	48.0	-	-	3.7	33.1
1989	19.0	43.0	-	1427.5	2.1	26.4
1990	82.7	59.0	739.6	1924.4	2.7	39.6
1991	68.2	54.6	632.9	1394.4	2.0	38.6
1992	35.1	19.7	905.6	856.4	3.9	20.3
1993	12.8	19.2	613.3	1790.9	-	16.6
1994	57.2	41.4	2388.5	1590.6	-	20.7
1995	94.9	34.0	3136.1	1987.9	-	24.6
1996	124.5	29.1	1165.7	1508.9	-	28.8

- Not available

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Table 3.3.3 SOUTHERN MACKEREL. CPUE at age from fleets.

VIIIc East handline fleet (Spain:Santoña) (Catch thousands)

Year	Effort	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10	Catch age 11	Catch age 12	Catch age 13	Catch age 14	Catch age 15+
1989	605	0	0	3	74	142	299	197	309	441	134	67	27	23	19	7	27
1990	509	0	0	0	17	71	210	465	177	384	378	127	40	51	2	7	5
1991	724	0	0	52	435	785	473	309	323	100	98	150	29	3	7	7	18
1992	698	0	0	35	568	442	477	139	69	77	20	15	17	4	4	0	1
1993	1216	0	0	40	65	1043	621	1487	771	345	339	215	126	59	66	30	52
1994	1926	0	23	168	526	1060	2005	1443	1003	406	360	176	98	54	24	24	9
1995	1696	0	41	83	793	1001	789	1092	998	928	519	339	300	159	83	81	63
1996	2007	0	0	28	401	1234	865	701	1361	802	773	330	288	105	13	28	18

VIIIc East handline fleet (Spain:Santander) (Catch thousands)

Year	Effort	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10	Catch age 11	Catch age 12	Catch age 13	Catch age 14	Catch age 15+
1990	322	0	0	0	6	25	66	132	41	86	83	28	8	11	0	2	2
1991	209	0	0	5	45	96	60	39	43	14	14	23	4	1	1	1	4
1992	70	0	0	4	60	47	51	15	7	8	2	2	2	0	0	0	0
1993	151	0	0	1	2	43	26	63	33	15	15	9	5	3	3	1	2
1994	130	0	2	18	56	110	205	146	101	40	36	18	10	5	2	2	1
1995	217	0	3	33	171	168	144	225	227	222	107	70	56	22	9	11	9
1996	560	0	0	6	89	276	191	152	293	171	164	70	60	22	3	6	4

VIIIc East trawl fleet (Spain:Aviles) (Catch thousands)

Year	Effort	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10	Catch age 11	Catch age 12	Catch age 13	Catch age 14	Catch age 15+
1988	9047	0	333	25	78	126	28	34	31	15	6	1	0	1	2	0	1
1989	8063	0	535	201	66	38	53	17	23	29	7	3	2	2	2	0	4
1990	8492	1834	6690	145	123	147	158	181	21	24	17	6	1	2	3	5	24
1991	7677	95	2419	592	205	108	99	57	55	16	14	26	4	3	2	1	13
1992	12693	236	1495	329	122	65	115	56	38	52	16	19	27	13	4	0	2
1993	7635	3	31	48	8	49	20	37	20	11	13	7	6	9	5	3	9
1994	9620	0	83	317	299	180	302	204	144	56	45	21	12	7	3	4	1
1995	6146	0	9	139	261	168	125	177	156	147	74	50	44	20	10	11	9
1996	4525	0	327	126	274	527	149	81	134	70	63	27	21	8	1	2	3

VIIIc West trawl fleet (Spain:La Coruña) (Catch thousands)

Year	Effort	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10	Catch age 11	Catch age 12	Catch age 13	Catch age 14	Catch age 15+
1988	28119	0	6095	584	625	594	167	239	444	195	53	12	8	21	26	0	7
1989	29628	462	482	719	345	289	541	231	355	444	117	63	24	22	22	6	15
1990	29578	27	4535	939	175	235	370	624	184	409	405	145	45	69	5	9	5
1991	26959	1	39	454	573	839	551	445	504	165	165	266	53	4	10	11	23
1992	26199	1	154	102	298	251	355	128	61	84	25	32	38	14	6	0	2
1993	29670	0	307	440	118	528	188	265	98	41	33	21	11	3	4	2	3
1994	39590	0	237	1531	1085	821	1156	575	264	63	40	17	6	1	1	1	0
1995	41452	735	249	400	624	324	251	381	376	402	175	116	104	44	17	19	20
1996	35728	54	5865	104	562	695	148	77	127	65	59	27	20	8	1	2	2

IXa trawl fleet (Portugal) (Catch thousands)

Year	Effort	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10	Catch age 11	Catch age 12	Catch age 13	Catch age 14	Catch age 15+
1988	60601	8076	4510	536	457	76	14	3	0	1	5	0	0	0	0	0	0
1989	53428	6092	6468	1080	572	185	51	15	4	7	4	3	0	0	0	0	0
1990	49532	2840	5729	1967	137	36	11	4	4	0	0	0	0	0	0	0	0
1991	45467	1695	2397	1904	1090	138	85	65	24	3	5	0	0	0	0	0	0
1992	78272	498	2211	1015	664	263	100	45	22	17	10	70	0	0	0	0	0
1993	48565	1010	2365	442	172	155	32	8	5	1	0	1	0	0	0	0	0
1994	39062	650	1128	1447	342	125	94	65	21	4	1	2	0	1	0	0	0
1995	44463	1001	2690	983	295	99	59	46	40	25	17	16	8	5	0	0	1
1996	36002	423	1293	778	490	269	86	88	129	98	109	66	34	17	6	0	1

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Table 3.3.4 SOUTHERN MACKEREL. CPUE at age from surveys.

October Spain Survey, Bottom trawl survey (Catch: numbers)

Year	Effort	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10+
1984	1	1.467	0.200	0.106	0.371	0.149	0.209	0.039	0.013	0.029	0.018	0.065
1985	1	2.653	1.598	0.016	0.055	0.370	0.138	0.085	0.030	0.017	0.029	0.084
1986	1	0.026	0.174	0.140	0.022	0.026	0.060	0.025	0.002	0.000	0.004	0.029
1987												
1988	1	0.286	0.028	0.027	0.014	0.021	0.005	0.010	0.012	0.004	0.001	0.001
1989	1	0.510	0.000	0.020	0.000	0.040	0.020	0.000	0.010	0.000	0.000	0.000
1990	1	0.400	0.940	0.040	0.000	0.010	0.020	0.000	0.000	0.000	0.000	0.000
1991	1	0.130	0.270	0.220	0.270	0.340	0.070	0.030	0.010	0.030	0.000	0.010
1992	1	19.900	0.480	0.160	0.150	0.090	0.030	0.010	0.000	0.000	0.000	0.000
1993	1	0.071	1.256	0.789	0.026	0.063	0.018	0.008	0.002	0.002	0.002	0.005
1994	1	0.468	0.106	0.122	0.145	0.043	0.040	0.012	0.006	0.002	0.001	0.000
1995	1	0.916	0.031	0.187	0.164	0.049	0.013	0.011	0.003	0.002	0.001	0.000
1996	1	46.092	6.396	1.316	0.074	0.101	0.019	0.000	0.007	0.010	0.000	0.000

October Portugal Survey, Bottom trawl survey (Catch: number * 1000)

Year	Effort	Catch age 0	Catch age 1	Catch age 2	Catch age 3	Catch age 4	Catch age 5	Catch age 6	Catch age 7	Catch age 8	Catch age 9	Catch age 10+
1986	1	515	2759	1004	512	36	14	9	4	0	0	0
1987	1	1026	23280	14792	2939	545	0	0	0	0	0	0
1988	1	86467	24547	354	328	35	11	0	0	0	0	0
1989	1	11643	28427	4707	3452	22	9	0	0	0	0	0
1990	1	1344	2991	1753	89	5	1	0	0	0	0	0
1991	1	309	374	288	185	32	19	15	6	1	1	0
1992	1	123551	2738	664	302	57	14	5	0	0	0	0
1993	1	52323	385	115	47	75	0	0	0	0	0	0
1994	1	12211	771	297	106	42	49	18	14	0	0	0
1995	1	318598	9076	282	110	31	10	5	2	0	0	0
1996*	1	235262	2157	216	22	4	1	0	0	0	0	0

* DIFFERENT SHIP

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Table 3.4.1 The North East Atlantic mackerel catch numbers at age.

Mackerel NE Atlantic (run: ICACDD06/I06)

Catch in number

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	288.40	81.22	48.52	7.42	55.12	65.40	24.25	10.01	43.45	19.35	25.37	14.76	37.96
1	32.02	267.06	56.42	40.20	145.97	64.26	140.53	58.46	83.58	128.14	147.32	81.53	119.85
2	86.40	20.75	412.12	156.97	131.61	312.74	209.85	212.52	156.29	210.32	221.49	340.90	168.88
3	685.13	57.93	37.26	664.65	182.06	207.69	410.75	206.42	356.21	266.68	306.98	340.22	333.37
4	389.08	442.21	74.30	56.79	514.81	167.59	208.15	375.45	266.59	398.24	267.42	275.03	279.18
5	252.48	250.43	353.45	89.17	69.72	362.47	156.74	188.62	306.14	244.29	301.35	186.86	177.67
6	98.44	164.05	201.93	245.04	83.50	48.70	254.02	129.15	156.07	255.47	184.93	197.86	96.30
7	22.17	61.92	122.48	150.88	192.22	58.12	42.55	197.89	113.90	149.93	189.85	142.34	119.83
8	62.05	19.42	41.32	86.03	117.13	111.25	49.70	51.08	138.46	97.75	106.11	113.41	55.81
9	48.11	47.22	13.14	34.86	53.46	68.24	85.45	43.42	51.21	121.40	80.05	69.19	59.80
10	37.63	37.34	31.83	19.70	19.80	32.23	33.04	70.84	36.61	38.79	57.62	42.44	25.80
11	30.22	26.77	22.30	25.80	12.60	13.90	16.59	29.74	40.96	29.07	20.41	37.96	18.35
12	69.45	96.96	78.78	63.27	54.98	35.81	27.91	52.99	68.21	68.22	57.55	39.75	30.65

Thousands

INDICES OF SPAWNING BIOMASS

INDEX1

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	1.0	1.0	2470.0	1.0	1.0	2940.0	1.0	1.0	3370.0	1.0	1.0	2840.0

Thousands

Table 3.4.2 The North East Atlantic mackerel catch weights at age.

Weights at age in the catches (Kg)

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	.03100	.05500	.03900	.07600	.05500	.04900	.08500	.06800	.05100	.06100	.04600	.07200	.05800
1	.10200	.14400	.14600	.17900	.13300	.13600	.15600	.15600	.16700	.13400	.13600	.14300	.14300
2	.18400	.26200	.24500	.22300	.25900	.23700	.23300	.25300	.23900	.24000	.25500	.23400	.22600
3	.29500	.35700	.33500	.31800	.32300	.32000	.33600	.32700	.33300	.31700	.33900	.33300	.31300
4	.32600	.41800	.42300	.39900	.38800	.37700	.37900	.39400	.39700	.37600	.39000	.39000	.37700
5	.34400	.41700	.47100	.47400	.45600	.43300	.42300	.42300	.46000	.43600	.44800	.45200	.42500
6	.43100	.43600	.44400	.51200	.52400	.45600	.46700	.46900	.49500	.48300	.51200	.50100	.48400
7	.54200	.52100	.45700	.49300	.55500	.54300	.52800	.50600	.53200	.52700	.54300	.53900	.51800
8	.48000	.55500	.54300	.49800	.55500	.59200	.55200	.55400	.55500	.54800	.59000	.57700	.55100
9	.56900	.56400	.59100	.58000	.56200	.57800	.60600	.60900	.59700	.58300	.58300	.59400	.57600
10	.62800	.62900	.55200	.63400	.61300	.58100	.60600	.63000	.65100	.59500	.62700	.60600	.59600
11	.63600	.67900	.69400	.63500	.62400	.64800	.59100	.64900	.66300	.64700	.67800	.63100	.60300
12	.66300	.71000	.68800	.71800	.69700	.73900	.71300	.70800	.66900	.67900	.71300	.67200	.67000

Units

Table 3.4.3 The North East Atlantic mackerel stock weights age age.

Weights at age in the stock (Kg)

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
1	.08700	.08700	.08700	.08600	.08400	.08400	.08400	.08400	.08400	.08400	.08400	.08400	.08400
2	.19800	.16800	.18000	.15800	.16100	.18700	.14600	.16400	.22100	.20100	.18600	.16600	.14100
3	.25700	.29500	.27000	.24600	.24400	.24800	.22700	.23900	.26400	.27000	.24100	.26600	.25300
4	.29700	.31100	.30200	.28400	.31000	.30700	.29100	.31400	.31600	.31800	.29900	.32200	.32000
5	.32100	.34000	.35300	.36800	.33600	.34800	.33900	.36000	.36300	.36100	.35800	.39100	.36000
6	.38900	.37800	.35400	.38200	.43300	.37300	.37400	.41100	.40400	.41800	.41000	.44200	.44000
7	.43500	.42900	.40700	.40400	.45500	.42400	.41200	.43500	.42900	.45800	.46600	.48700	.46300
8	.43500	.45100	.47300	.41900	.44500	.47200	.40800	.50400	.46800	.46800	.46800	.50400	.50300
9	.47400	.46000	.45500	.47000	.46800	.45200	.43400	.54200	.49200	.48500	.47800	.54100	.56600
10	.52100	.55400	.46900	.49500	.53100	.46500	.51900	.57000	.52600	.51700	.54900	.50800	.57500
11	.50800	.57500	.48800	.46200	.59700	.50400	.51900	.57000	.55500	.59000	.60200	.61500	.61300
12	.57300	.61100	.58600	.56900	.64700	.59700	.53700	.58600	.59200	.57400	.57900	.63500	.63800

Units

Table 3.4.4a The ICA diagnostic output for the North East Atlantic mackerel.

Predicted Catch in Number

Age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	19.15	38.62	26.81	23.64	14.51	18.02	24.13	38.80	22.85	37.71	37.96
1	51.05	59.87	108.32	72.26	99.85	64.25	85.38	125.41	154.69	89.23	118.73
2	284.80	166.58	174.79	250.92	169.51	245.05	167.95	242.62	272.59	329.87	154.62
3	71.14	356.37	185.55	193.65	345.20	243.34	372.51	274.27	300.77	332.20	329.70
4	87.56	76.36	339.65	195.72	198.01	367.50	272.95	444.21	246.16	265.84	242.61
5	238.77	107.79	83.24	339.73	167.42	176.11	343.25	269.22	327.52	178.94	160.38
6	158.23	255.05	101.48	57.38	248.46	127.28	140.52	288.85	168.67	202.35	91.76
7	105.43	164.58	232.69	60.06	47.26	212.60	114.17	132.60	203.15	117.03	116.85
8	45.34	85.02	115.86	110.08	46.46	37.96	178.70	100.62	86.80	131.27	63.07
9	18.42	28.74	47.10	63.75	94.77	41.46	35.32	173.10	72.28	61.63	78.24
10	32.76	16.25	22.26	32.36	41.88	64.53	29.42	26.06	93.94	38.78	27.72
11	22.24	24.98	10.87	13.63	21.88	29.37	47.25	22.48	14.69	52.32	18.06

Thousands

Weighting factors for the catches in number

Age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	.0100	.0100	.0100	.0100	.0100	.0100	.0100	.0100	.0100	.0100	.0100
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	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	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	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	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Units

Table 3.4.4b The ICA diagnostic output for the North East Atlantic mackerel.

Predicted SSB Index values

INDEX1

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	1.0	1.0	2736.8	1.0	1.0	2883.1	1.0	1.0	3157.6	1.0	1.0	2598.0

Thousands

Predicted Age-Structured Index Values

Fitted Selection Pattern

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	.1771	.1295	.0437	.0437	.0437	.0296	.0296	.0296	.0296	.0296	.0296	.0296	.0296
1	.1083	.2487	.1366	.1366	.1366	.1429	.1429	.1429	.1429	.1429	.1429	.1429	.1429
2	.2621	.1040	.4604	.4604	.4604	.3954	.3954	.3954	.3954	.3954	.3954	.3954	.3954
3	.8394	.2700	.6166	.6166	.6166	.6711	.6711	.6711	.6711	.6711	.6711	.6711	.6711
4	.8727	.9565	.7226	.7226	.7226	.8830	.8830	.8830	.8830	.8830	.8830	.8830	.8830
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	.9460	1.1979	1.2494	1.2494	1.2494	.9764	.9764	.9764	.9764	.9764	.9764	.9764	.9764
7	.4779	1.0772	1.5895	1.5895	1.5895	1.0809	1.0809	1.0809	1.0809	1.0809	1.0809	1.0809	1.0809
8	.7257	.6878	1.6101	1.6101	1.6101	1.1398	1.1398	1.1398	1.1398	1.1398	1.1398	1.1398	1.1398
9	.7488	.9611	1.2487	1.2487	1.2487	1.3703	1.3703	1.3703	1.3703	1.3703	1.3703	1.3703	1.3703
10	.8036	1.0199	1.3191	1.3191	1.3191	1.2734	1.2734	1.2734	1.2734	1.2734	1.2734	1.2734	1.2734
11	.9178	1.0097	1.2000	1.2000	1.2000	1.2000	1.2000	1.2000	1.2000	1.2000	1.2000	1.2000	1.2000
12	.9178	1.0097	1.2000	1.2000	1.2000	1.2000	1.2000	1.2000	1.2000	1.2000	1.2000	1.2000	1.2000

Units

Table 3.4.4c The ICA diagnostic output for the North East Atlantic mackerel.

IFAP run code: I06

No of years for separable analysis : 11
Age range in the analysis : 0 12
Year range in the analysis : 1984 1996
Number of indices of SSB : 1
Number of age-structured indices : 0
Parameters to estimate : 53
Number of observations : 136

Two selection vectors to be fitted .
Abrupt change in selection specified.
Selection assumed constant up to and including 1988

PARAMETER ESTIMATES

Parm No.		Maximum Likelih. Estimate	CV (%)	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. distrib.
Separable Model: Reference F by year								
1	1986	.1398	15	.1039	.1881	.1201	.1626	.1414
2	1987	.1647	14	.1242	.2185	.1426	.1903	.1664
3	1988	.1743	13	.1328	.2289	.1517	.2003	.1760
4	1989	.1695	12	.1338	.2148	.1502	.1913	.1707
5	1990	.1748	12	.1375	.2223	.1547	.1976	.1762
6	1991	.1893	12	.1479	.2422	.1669	.2147	.1908
7	1992	.2197	13	.1690	.2858	.1922	.2513	.2217
8	1993	.2812	15	.2091	.3781	.2418	.3271	.2844
9	1994	.2762	18	.1938	.3938	.2305	.3310	.2808
10	1995	.2656	22	.1706	.4133	.2119	.3328	.2724
11	1996	.2050	27	.1187	.3539	.1551	.2708	.2131
Separable Model: Selection (S1) by age from 1986 to 1988								
12	0	.0437	134	.0031	.6107	.0114	.1678	.1080
13	1	.1366	19	.0939	.1987	.1128	.1654	.1391
14	2	.4604	18	.3185	.6656	.3815	.5556	.4686
15	3	.6166	18	.4274	.8897	.5115	.7435	.6275
16	4	.7226	18	.5012	1.0416	.5996	.8708	.7352
	5	1.0000			Fixed : Reference age			
17	6	1.2494	18	.8692	1.7960	1.0383	1.5035	1.2710
18	7	1.5895	18	1.1079	2.2805	1.3221	1.9109	1.6167
19	8	1.6101	18	1.1211	2.3124	1.3386	1.9367	1.6378
20	9	1.2487	18	.8726	1.7868	1.0401	1.4992	1.2697
21	10	1.3191	18	.9263	1.8785	1.1014	1.5799	1.3407
	11	1.2000			Fixed : last true age			

Table 3.4.4d The ICA diagnostic output for the North East Atlantic mackerel.

Separable Model: Selection (S2) by age from 1989 to 1996

22	0	.0296	88	.0052	.1688	.0122	.0720	.0439
23	1	.1429	14	.1070	.1908	.1233	.1656	.1445
24	2	.3954	13	.3051	.5124	.3464	.4513	.3988
25	3	.6711	12	.5263	.8559	.5928	.7598	.6763
26	4	.8830	11	.6996	1.1144	.7841	.9944	.8893
	5	1.0000			Fixed : Reference age			
27	6	.9764	11	.7853	1.2141	.8737	1.0912	.9825
28	7	1.0809	10	.8748	1.3354	.9703	1.2040	1.0872
29	8	1.1398	10	.9289	1.3985	1.0268	1.2652	1.1460
30	9	1.3703	10	1.1235	1.6714	1.2382	1.5165	1.3774
31	10	1.2734	10	1.0385	1.5615	1.1476	1.4130	1.2803
	11	1.2000			Fixed : last true age			

Separable Model: Populations in year 1996

32	0	6757009	251	49217	927652633	548436	83249668	158191007
33	1	4427881	40	1995866	9823370	2948712	6649048	4809358
34	2	2136963	32	1127010	4051970	1541796	2961877	2253909
35	3	2758000	27	1596581	4764281	2086749	3645174	2867377
36	4	1574604	25	947618	2616431	1215212	2040285	1628349
37	5	929602	25	566246	1526121	721862	1197126	959816
38	6	543446	25	332524	888156	422973	698232	560784
39	7	631483	24	391083	1019659	494529	806365	650638
40	8	325082	24	200566	526902	254088	415912	335101
41	9	342873	24	212272	553825	268465	437903	353288
42	10	129534	26	77681	216000	99789	168146	134018
43	11	88942	27	52239	151431	67794	116686	92281

Separable Model: Populations at age 11

44	1986	154788	27	91049	263146	118074	202917	160566
45	1987	149614	21	97566	229427	120293	186081	153216
46	1988	61875	19	42375	90349	51007	75058	63040
47	1989	79556	17	56018	112986	66519	95149	80841
48	1990	124179	16	89761	171794	105228	146544	125894
49	1991	155225	16	113251	212757	132162	182314	157247
50	1992	218790	15	160914	297483	187046	255921	221495
51	1993	84157	16	61293	115549	71589	98931	85265
52	1994	55844	18	38981	80001	46486	67085	56791
53	1995	205644	21	133823	316010	165166	256043	210644

SSB Index catchabilities
INDEX1
Used as absolute estimator.
No fitted catchability for this index.

Table 3.4.4e The ICA diagnostic output for the North East Atlantic mackerel.

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals

Age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	.930	-1.650	.721	1.018	.513	-.588	.588	-.695	.105	-.938	.000
1	.100	-.398	.298	-.117	.342	-.094	-.021	.022	-.049	-.090	.009
2	.370	-.059	-.284	.220	.213	-.142	-.072	-.143	-.208	.033	.088
3	-.647	.623	-.019	.070	.174	-.165	-.045	-.028	.020	.024	.011
4	-.164	-.296	.416	-.155	.050	.021	-.024	-.109	.083	.034	.140
5	.392	-.190	-.177	.065	-.066	.069	-.114	-.097	-.083	.043	.102
6	.244	-.040	-.195	-.164	.022	.015	.105	-.123	.092	-.022	.048
7	.150	-.087	-.191	-.033	-.105	-.072	-.002	.123	-.068	.196	.025
8	-.093	.012	.011	.011	.067	.297	-.255	-.029	.201	-.146	-.122
9	-.338	.193	.127	.068	-.104	.046	.371	-.355	.102	.116	-.269
10	-.029	.193	-.117	-.004	-.237	.093	.219	.398	-.489	.090	-.072
11	.002	.032	.147	.020	-.277	.013	-.143	.257	.329	-.321	.016

Units

SPAWNING BIOMASS INDEX RESIDUALS

INDEX1

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	-1.000	-1.000	-.103	-1.000	-1.000	.020	-1.000	-1.000	.065	-1.000	-1.000	.089

Units

Table 3.4.4f The ICA diagnostic output for the North East Atlantic mackerel.

PARAMETERS OF THE DISTRIBUTION OF ln CATCHES AT AGE

Separable model fitted from 1986 to 1996

Variance	:	.0566
Skewness test statistic	:	.0962
Kurtosis test statistic	:	3.4479
Partial chi-square	:	.3933
Significance in fit	:	.0000
Degrees of freedom	:	89

PARAMETERS OF THE DISTRIBUTION OF THE SSB INDICES

DISTRIBUTION STATISTICS FOR INDEX1

Index used as absolute measure of abundance.

Variance	:	.0058
Skewness test statistic	:	-.0418
Kurtosis test statistic	:	-.6366
Partial chi-square	:	.0016
Significance in fit	:	.0000
Number of observations	:	4
Degrees of freedom	:	4
Weight in the analysis	:	1.0000

ANALYSIS OF VARIANCE TABLE

Unweighted Statistics

		SSQ	Data	Params	d.f.	
Variance						
	Total for Model	11.8886	136	53	83	.1432
	Catches at Age	11.8656	132	53	79	.1502
SSB Indices						
INDEX1		.0231	4	0	4	.0058

Weighted Statistics

		SSQ	Data	Params	d.f.	
Variance						
	Total for Model	4.4916	136	53	83	.0541
	Catches at Age	4.4686	132	53	79	.0566
SSB Indices						
INDEX1		.0231	4	0	4	.0058

Table 3.4.6 The North East Atlantic mackerel population numbers at age.

Population Abundance (1 January)

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	7281.3	3463.6	3386.5	5799.2	3805.1	5086.0	3026.8	3473.2	4007.4	5039.5	3020.8	5185.1	6757.0	3369.8
1	1311.2	5999.9	2905.9	2897.0	4955.6	3250.2	4355.7	2591.7	2972.7	3426.9	4301.6	2578.8	4427.9	5780.6
2	1488.7	1098.9	4916.8	2453.9	2438.0	4164.9	2730.5	3656.4	2171.2	2479.6	2833.3	3559.1	2137.0	3701.1
3	3944.0	1201.4	926.6	3968.2	1957.8	1936.6	3352.4	2193.2	2920.2	1713.3	1909.6	2186.4	2758.0	1696.1
4	2162.7	2761.2	980.4	731.7	3085.5	1513.3	1487.6	2566.0	1662.5	2168.8	1221.0	1365.5	1574.6	2068.8
5	1242.8	1501.8	1967.7	762.7	559.1	2341.4	1121.5	1097.2	1868.6	1178.6	1456.3	823.5	929.6	1130.9
6	509.1	836.4	1061.0	1472.7	556.8	404.2	1701.1	810.4	781.5	1291.1	765.8	950.9	543.4	651.8
7	214.9	347.2	568.3	766.9	1031.8	385.4	294.9	1234.3	579.8	542.8	844.4	503.3	631.5	382.9
8	407.8	164.5	241.6	391.7	508.0	673.1	276.2	210.1	865.8	393.6	344.7	539.2	325.1	435.5
9	307.2	293.6	123.6	166.0	258.6	330.2	477.6	194.8	145.7	580.1	245.8	216.6	342.9	221.5
10	225.3	220.0	209.0	89.3	116.3	179.0	225.3	323.5	129.3	92.8	339.6	144.9	129.5	222.9
11	160.6	159.2	154.8	149.6	61.9	79.6	124.2	155.2	218.8	84.2	55.8	205.6	88.9	85.9
12	369.0	576.4	548.2	378.9	312.8	209.0	158.4	280.0	315.8	255.4	218.8	156.2	150.9	161.4

Thousands

Fishing Mortality (per year)

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	.04356	.02557	.00611	.00720	.00762	.00502	.00518	.00560	.00650	.00832	.00818	.00786	.00607
1	.02664	.04909	.01909	.02250	.02381	.02422	.02499	.02705	.03140	.04019	.03948	.03795	.02929
2	.06448	.02053	.06435	.07584	.08026	.06702	.06913	.07483	.08688	.11118	.10921	.10500	.08103
3	.20652	.05329	.08619	.10158	.10750	.11376	.11735	.12703	.14748	.18873	.18539	.17824	.13755
4	.21470	.18881	.10100	.11902	.12596	.14968	.15439	.16713	.19403	.24831	.24392	.23451	.18098
5	.24602	.19740	.13978	.16473	.17433	.16951	.17485	.18927	.21974	.28120	.27623	.26558	.20496
6	.23274	.23647	.17464	.20582	.21782	.16551	.17073	.18481	.21456	.27458	.26972	.25932	.20013
7	.11757	.21265	.22217	.26183	.27710	.18321	.18899	.20458	.23751	.30394	.29857	.28705	.22153
8	.17854	.13578	.22506	.26523	.28070	.19321	.19930	.21574	.25046	.32052	.31485	.30271	.23361
9	.18421	.18972	.17453	.20569	.21768	.23228	.23960	.25936	.30111	.38534	.37852	.36392	.28086
10	.19770	.20134	.18438	.21729	.22996	.21585	.22265	.24102	.27982	.35808	.35175	.33818	.26099
11	.22580	.19932	.16773	.19767	.20920	.20341	.20982	.22713	.26369	.33745	.33148	.31869	.24595
12	.22580	.19932	.16773	.19767	.20920	.20341	.20982	.22713	.26369	.33745	.33148	.31869	.24595

Units

Table 3.4.5 The North East Atlantic mackerel fishing mortality at age.

Table 3.4.7 The North East Atlantic mackerel stock summary.

STOCK SUMMARY

Year	Recruits Age 0 thousands	Total Biomass tonnes	Spawning Biomass tonnes	Landings tonnes	Yield/ SSB ratio	Mean F Ages 4- 8	SoP (%)
1984	7281310	3488632	2748697	648084	.2358	.1979	99
1985	3463640	3670211	2708072	614275	.2268	.1942	99
1986	3386450	3650931	2736806	602128	.2200	.1725	97
1987	5799150	3545016	2725600	654805	.2402	.2033	100
1988	3805090	3789610	2827004	676288	.2392	.2152	96
1989	5086000	3840867	2883121	585921	.2032	.1722	99
1990	3026780	3682675	2768656	625611	.2260	.1777	100
1991	3473230	4060674	3144915	667883	.2124	.1923	101
1992	4007420	4121989	3157600	760351	.2408	.2233	100
1993	5039500	3862019	2853050	825036	.2892	.2857	99
1994	3020780	3568013	2556340	822570	.3218	.2807	99
1995	5185060	3504273	2598039	756186	.2911	.2698	100
1996	6757010	3323920	2456109	563585	.2295	.2082	99

Table 3.4.8

Mackerel in the North East Atlantic

Multi fleet prediction: Input data

1997	Northern		Southern							
Age	Exploit. pattern	Weight in catch	Exploit. pattern	Weight in catch	Stock size	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock
0	0.0010	0.056	0.0050	0.059	3872.000	0.1500	0.0000	0.4000	0.4000	0.000
1	0.0260	0.141	0.0030	0.148	3312.000	0.1500	0.1400	0.4000	0.4000	0.084
2	0.0780	0.244	0.0030	0.209	3701.000	0.1500	0.6500	0.4000	0.4000	0.164
3	0.1340	0.329	0.0040	0.279	1696.000	0.1500	0.9100	0.4000	0.4000	0.253
4	0.1740	0.386	0.0070	0.349	2069.000	0.1500	0.9700	0.4000	0.4000	0.314
5	0.1980	0.441	0.0070	0.400	1131.000	0.1500	0.9700	0.4000	0.4000	0.370
6	0.1910	0.502	0.0090	0.438	652.000	0.1500	0.9900	0.4000	0.4000	0.431
7	0.2100	0.536	0.0120	0.467	383.000	0.1500	1.0000	0.4000	0.4000	0.472
8	0.2180	0.575	0.0160	0.499	436.000	0.1500	1.0000	0.4000	0.4000	0.492
9	0.2630	0.586	0.0180	0.521	222.000	0.1500	1.0000	0.4000	0.4000	0.528
10	0.2440	0.615	0.0170	0.546	223.000	0.1500	1.0000	0.4000	0.4000	0.544
11	0.2280	0.650	0.0180	0.562	86.000	0.1500	1.0000	0.4000	0.4000	0.610
12+	0.2330	0.691	0.0130	0.624	161.000	0.1500	1.0000	0.4000	0.4000	0.617
Unit	-	Kilograms	-	Kilograms	Millions	-	-	-	-	Kilograms

1998	Northern		Southern							
Age	Exploit. pattern	Weight in catch	Exploit. pattern	Weight in catch	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock
0	0.0010	0.056	0.0050	0.059	3872.000	0.1500	0.0000	0.4000	0.4000	0.000
1	0.0260	0.141	0.0030	0.148	.	0.1500	0.1400	0.4000	0.4000	0.084
2	0.0780	0.244	0.0030	0.209	.	0.1500	0.6500	0.4000	0.4000	0.164
3	0.1340	0.329	0.0040	0.279	.	0.1500	0.9100	0.4000	0.4000	0.253
4	0.1740	0.386	0.0070	0.349	.	0.1500	0.9700	0.4000	0.4000	0.314
5	0.1980	0.441	0.0070	0.400	.	0.1500	0.9700	0.4000	0.4000	0.370
6	0.1910	0.502	0.0090	0.438	.	0.1500	0.9900	0.4000	0.4000	0.431
7	0.2100	0.536	0.0120	0.467	.	0.1500	1.0000	0.4000	0.4000	0.472
8	0.2180	0.575	0.0160	0.499	.	0.1500	1.0000	0.4000	0.4000	0.492
9	0.2630	0.586	0.0180	0.521	.	0.1500	1.0000	0.4000	0.4000	0.528
10	0.2440	0.615	0.0170	0.546	.	0.1500	1.0000	0.4000	0.4000	0.544
11	0.2280	0.650	0.0180	0.562	.	0.1500	1.0000	0.4000	0.4000	0.610
12+	0.2330	0.691	0.0130	0.624	.	0.1500	1.0000	0.4000	0.4000	0.617
Unit	-	Kilograms	-	Kilograms	Millions	-	-	-	-	Kilograms

(cont.)

(cont.)

1999	Northern		Southern							
Age	Exploit. pattern	Weight in catch	Exploit. pattern	Weight in catch	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock
0	0.0010	0.056	0.0050	0.059	3872.000	0.1500	0.0000	0.4000	0.4000	0.000
1	0.0260	0.141	0.0030	0.148	.	0.1500	0.1400	0.4000	0.4000	0.084
2	0.0780	0.244	0.0030	0.209	.	0.1500	0.6500	0.4000	0.4000	0.164
3	0.1340	0.329	0.0040	0.279	.	0.1500	0.9100	0.4000	0.4000	0.253
4	0.1740	0.386	0.0070	0.349	.	0.1500	0.9700	0.4000	0.4000	0.314
5	0.1980	0.441	0.0070	0.400	.	0.1500	0.9700	0.4000	0.4000	0.370
6	0.1910	0.502	0.0090	0.438	.	0.1500	0.9900	0.4000	0.4000	0.431
7	0.2100	0.536	0.0120	0.467	.	0.1500	1.0000	0.4000	0.4000	0.472
8	0.2180	0.575	0.0160	0.499	.	0.1500	1.0000	0.4000	0.4000	0.492
9	0.2630	0.586	0.0180	0.521	.	0.1500	1.0000	0.4000	0.4000	0.528
10	0.2440	0.615	0.0170	0.546	.	0.1500	1.0000	0.4000	0.4000	0.544
11	0.2280	0.650	0.0180	0.562	.	0.1500	1.0000	0.4000	0.4000	0.610
12+	0.2330	0.691	0.0130	0.624	.	0.1500	1.0000	0.4000	0.4000	0.617
Unit	-	Kilograms	-	Kilograms	Millions	-	-	-	-	Kilograms

Notes: Run name : SPRCDD02
Date and time: 15SEP97:21:27

Table 3.4.9a Multifleet prediction summary table for the Mackerel in the North East Atlantic, a status quo F constraint for each fleet in 1997 and status quo F in 1998 and 1999

The SAS System 18:55 Sunday, September 14, 1997

Mackerel in the North East Atlantic

Multi fleet prediction: Summary table

	Northern				Southern				Total				1 January		Spawning time	
Year	F Factor	Reference F	Catch in numbers	Catch in weight	F Factor	Reference F	Catch in numbers	Catch in weight	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1997	1.0000	0.1982	1423031	561906	1.0000	0.0102	85769	25126	1508800	587032	17944000	3449021	9673170	2923853	8562262	2560899
1998	1.0000	0.1982	1461673	582788	1.0000	0.0102	85456	25197	1547129	607986	17920927	3541317	9875726	3044274	8731574	2665657
1999	1.0000	0.1982	1468709	591508	1.0000	0.0102	87322	26054	1556031	617563	17865648	3575485	9873565	3091763	8722935	2706025
Unit	-	-	Thousands	Tonnes	-	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : SPRCDD02
Date and time : 16SEP97:08:35
Computation of ref. F: Northern: Simple mean, age 4 - 8
Southern: Simple mean, age 4 - 8
Prediction basis : F factors

Table 3.4.9b Multifleet prediction summary table for the Mackerel in the North East Atlantic, assuming a status quo catch constraint for each fleet in 1997 and status quo F in 1998 and 1999

The SAS System 18:55 Sunday, September 14, 1997

Mackerel in the North East Atlantic

Multi fleet prediction: Summary table

	Northern				Southern				Total				1 January		Spawning time	
Year	F Factor	Reference F	Catch in numbers	Catch in weight	F Factor	Reference F	Catch in numbers	Catch in weight	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1997	0.9400	0.1863	1342048	530103	1.3400	0.0137	115194	33783	1457242	563886	17944000	3449021	9673170	2923853	8584853	2568605
1998	1.0000	0.1982	1469777	586606	1.0000	0.0102	85819	25360	1555596	611966	17968492	3560840	9925774	3063612	8775134	2682432
1999	1.0000	0.1982	1474688	594589	1.0000	0.0102	87628	26198	1562315	620787	17898760	3590653	9907648	3106984	8752316	2719154
Unit	-	-	Thousands	Tonnes	-	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : SPRCDD02
Date and time : 15SEP97:20:20
Computation of ref. F: Northern: Simple mean, age 4 - 8
Southern: Simple mean, age 4 - 8
Prediction basis : F factors

Table 3.4.9c Multifleet prediction summary table for the Mackerel in the North East Atlantic, assuming a status quo catch constraint for each fleet in 1997 a 560kt catch in 1998 and 1999

The SAS System 18:55 Sunday, September 14, 1997

Mackerel in the North East Atlantic

Multi fleet prediction: Summary table

	Northern				Southern				Total				1 January		Spawning time	
Year	F Factor	Reference F	Catch in numbers	Catch in weight	F Factor	Reference F	Catch in numbers	Catch in weight	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1997	0.9569	0.1897	1366352	539752	0.9569	0.0098	82295	24135	1448647	563886	17944000	3449021	9673170	2923853	8585031	2568882
1998	0.9074	0.1798	1343774	536789	0.9074	0.0093	78358	23211	1422132	560000	17976451	3562041	9927733	3064273	8828208	2701111
1999	0.8790	0.1742	1326039	536365	0.8790	0.0090	78446	23636	1404485	560000	18028811	3638584	10028550	3153126	8926543	2783762
Unit	-	-	Thousands	Tonnes	-	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : SPRCDD02
Date and time : 15SEP97:20:20
Computation of ref. F: Northern: Simple mean, age 4 - 8
Southern: Simple mean, age 4 - 8
Prediction basis : TAC constraints

Table 3.4.9d Multifleet prediction summary table for the Mackerel in the North East Atlantic, assuming a status quo catch constraint for each fleet in 1997 and F= 0.15 in 1998 and 1999

The SAS System 18:55 Sunday, September 14, 1997

Mackerel in the North East Atlantic

Multi fleet prediction: Summary table

	Northern				Southern				Total				1 January		Spawning time	
Year	F Factor	Reference F	Catch in numbers	Catch in weight	F Factor	Reference F	Catch in numbers	Catch in weight	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1997	0.9400	0.1863	1342048	530103	1.3400	0.0137	115194	33783	1457242	563886	17944000	3449021	9673170	2923853	8584853	2568605
1998	0.7203	0.1428	1082566	433172	0.7023	0.0072	61348	18255	1143914	451426	17968492	3560840	9925774	3063612	8931554	2737694
1999	0.7175	0.1422	1125105	457750	0.7175	0.0073	66080	20178	1191185	477928	18278942	3734054	10265635	3245890	9230237	2899237
Unit	-	-	Thousands	Tonnes	-	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : SPRCDD02
Date and time : 15SEP97:21:07
Computation of ref. F: Northern: Simple mean, age 4 - 8
Southern: Simple mean, age 4 - 8
Prediction basis : F factors

Table 3.4.10 Multifleet management option table for the Mackerel in the North East Atlantic, assuming a status quo F 1997.

Multi fleet prediction with mangement option table

Year: 1997								
Northern			Southern			Total		
F Factor	Reference F	Catch in weight	F Factor	Reference F	Catch in weight	Catch in weight	Stock biomass	Sp.stock biomass
1.0000	0.1982	561906	1.0000	0.0102	25126	587032	3449021	2560899
-	-	Tonnes	-	-	Tonnes	Tonnes	Tonnes	Tonnes

Year: 1998									Year: 1999	
Northern			Southern			Total				
F Factor	Reference F	Catch in weight	F Factor	Reference F	Catch in weight	Catch in weight	Stock biomass	Sp.stock biomass	Stock biomass	Sp.stock biomass
0.0000	0.0000	0	0.0000	0.0000	0	0	3541317	2866989	4119009	3408098
0.1000	0.0198	63183	0.1000	0.0010	2730	65913	.	2846128	4060008	3329183
0.2000	0.0396	125217	0.2000	0.0020	5411	130628	.	2825433	4002097	3252352
0.3000	0.0595	186126	0.3000	0.0031	8044	194169	.	2804901	3945254	3177547
0.4000	0.0793	245930	0.4000	0.0041	10629	256559	.	2784532	3889456	3104711
0.5000	0.0991	304654	0.5000	0.0051	13167	317821	.	2764324	3834683	3033787
0.6000	0.1189	362318	0.6000	0.0061	15660	377978	.	2744276	3780914	2964722
0.7000	0.1387	418942	0.7000	0.0071	18109	437051	.	2724387	3728130	2897463
0.8000	0.1586	474549	0.8000	0.0082	20514	495063	.	2704655	3676310	2831960
0.9000	0.1784	529158	0.9000	0.0092	22877	552034	.	2685079	3625434	2768163
1.0000	0.1982	582788	1.0000	0.0102	25197	607986	.	2665657	3575485	2706025
1.1000	0.2180	635460	1.1000	0.0112	27477	662937	.	2646389	3526443	2645499
1.2000	0.2378	687191	1.2000	0.0122	29717	716909	.	2627273	3478290	2586540
1.3000	0.2577	738002	1.3000	0.0133	31918	769919	.	2608307	3431009	2529104
1.4000	0.2775	787909	1.4000	0.0143	34080	821989	.	2589491	3384582	2473149
1.5000	0.2973	836931	1.5000	0.0153	36205	873135	.	2570823	3338992	2418633
1.6000	0.3171	885084	1.6000	0.0163	38292	923377	.	2552303	3294222	2365517
1.7000	0.3369	932387	1.7000	0.0173	40344	972731	.	2533928	3250257	2313762
1.8000	0.3568	978856	1.8000	0.0184	42360	1021216	.	2515698	3207080	2263329
1.9000	0.3766	1024507	1.9000	0.0194	44342	1068849	.	2497611	3164676	2214183
2.0000	0.3964	1069356	2.0000	0.0204	46290	1115646	.	2479666	3123028	2166287
-	-	Tonnes	-	-	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes

Notes: Run name : MANCDD03
Date and time : 16SEP97:08:14
Computation of ref. F: Northern: Simple mean, age 4 - 8
Southern: Simple mean, age 4 - 8
Basis for 1997 : F factors

Table 3.4.11 Multifleet management option table for the Mackerel in the North East Atlantic, assuming a status quo catch constraint for each fleet in 1997.

Multi fleet prediction with mangement option table

Year: 1997								
Northern			Southern			Total		
F Factor	Reference F	Catch in weight	F Factor	Reference F	Catch in weight	Catch in weight	Stock biomass	Sp.stock biomass
0.9400	0.1863	530103	1.3400	0.0137	33783	563886	3449021	2568605
-	-	Tonnes	-	-	Tonnes	Tonnes	Tonnes	Tonnes

Year: 1998									Year: 1999	
Northern			Southern			Total				
F Factor	Reference F	Catch in weight	F Factor	Reference F	Catch in weight	Catch in weight	Stock biomass	Sp.stock biomass	Stock biomass	Sp.stock biomass
0.0000	0.0000	0	0.0000	0.0000	0	0	3560840	2885201	4137684	3425709
0.1000	0.0198	63601	0.1000	0.0010	2748	66349	.	2864191	4078299	3346284
0.2000	0.0396	126044	0.2000	0.0020	5446	131491	.	2843347	4020011	3268958
0.3000	0.0595	187354	0.3000	0.0031	8096	195450	.	2822669	3962798	3193672
0.4000	0.0793	247552	0.4000	0.0041	10698	258249	.	2802154	3906639	3120368
0.5000	0.0991	306660	0.5000	0.0051	13253	319913	.	2781802	3851513	3048991
0.6000	0.1189	364701	0.6000	0.0061	15762	380463	.	2761611	3797398	2979486
0.7000	0.1387	421696	0.7000	0.0071	18226	439922	.	2741580	3744274	2911800
0.8000	0.1586	477664	0.8000	0.0082	20647	498311	.	2721707	3692121	2845882
0.9000	0.1784	532628	0.9000	0.0092	23024	555652	.	2701992	3640921	2781683
1.0000	0.1982	586606	1.0000	0.0102	25360	611966	.	2682432	3590653	2719154
1.1000	0.2180	639619	1.1000	0.0112	27654	667273	.	2663027	3541299	2658249
1.2000	0.2378	691684	1.2000	0.0122	29908	721592	.	2643774	3492840	2598922
1.3000	0.2577	742822	1.3000	0.0133	32122	774944	.	2624674	3445260	2541128
1.4000	0.2775	793050	1.4000	0.0143	34298	827348	.	2605724	3398540	2484826
1.5000	0.2973	842386	1.5000	0.0153	36436	878822	.	2586924	3352663	2429973
1.6000	0.3171	890848	1.6000	0.0163	38537	929384	.	2568272	3307612	2376530
1.7000	0.3369	938452	1.7000	0.0173	40601	979053	.	2549767	3263372	2324457
1.8000	0.3568	985217	1.8000	0.0184	42630	1027847	.	2531407	3219925	2273716
1.9000	0.3766	1031157	1.9000	0.0194	44624	1075781	.	2513192	3177257	2224270
2.0000	0.3964	1076290	2.0000	0.0204	46584	1122874	.	2495121	3135351	2176084
-	-	Tonnes	-	-	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes

Notes: Run name : MANCDD03
Date and time : 16SEP97:08:14
Computation of ref. F: Northern: Simple mean, age 4 - 8
Southern: Simple mean, age 4 - 8
Basis for 1997 : F factors

Table 3.4.12 Multifleet yield per recruit table for the Mackerel in the North East Atlantic.

Multi fleet yield per recruit: Summary table

Northern			Southern			Total			1 January		Spawning time	
F Factor	Reference F	Catch in weight	F Factor	Reference F	Catch in weight	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	0.0000	0.0000	0.000	0.000	7.179	2298.416	5.088	2167.032	4.791	2040.834
0.2000	0.0396	70.508	0.2000	0.0020	3.446	73.954	6.169	1735.619	4.084	1605.842	3.789	1486.868
0.4000	0.0793	107.967	0.4000	0.0041	5.161	113.129	5.544	1402.799	3.465	1274.545	3.171	1161.619
0.6000	0.1189	129.942	0.6000	0.0061	6.074	136.017	5.114	1183.953	3.041	1057.145	2.748	949.357
0.8000	0.1586	143.694	0.8000	0.0082	6.577	150.270	4.796	1029.426	2.729	903.994	2.437	800.630
1.0000	0.1982	152.684	1.0000	0.0102	6.856	159.540	4.550	914.558	2.489	790.435	2.198	690.926
1.2000	0.2378	158.734	1.2000	0.0122	7.012	165.746	4.352	825.780	2.296	702.907	2.006	606.797
1.4000	0.2775	162.875	1.4000	0.0143	7.099	169.974	4.189	755.047	2.138	633.368	1.849	540.283
1.6000	0.3171	165.727	1.6000	0.0163	7.147	172.874	4.051	697.301	2.005	576.764	1.717	486.398
1.8000	0.3568	167.679	1.8000	0.0184	7.175	174.853	3.932	649.211	1.891	529.769	1.605	441.865
2.0000	0.3964	168.984	2.0000	0.0204	7.193	176.177	3.828	608.496	1.793	490.105	1.507	404.447
2.2000	0.4360	169.817	2.2000	0.0224	7.208	177.024	3.737	573.544	1.706	456.163	1.422	372.566
2.4000	0.4757	170.296	2.4000	0.0245	7.223	177.519	3.656	543.183	1.629	426.774	1.347	345.081
2.6000	0.5153	170.508	2.6000	0.0265	7.241	177.749	3.582	516.541	1.561	401.068	1.279	321.142
2.8000	0.5550	170.515	2.8000	0.0286	7.263	177.778	3.516	492.955	1.499	378.386	1.218	300.106
3.0000	0.5946	170.364	3.0000	0.0306	7.288	177.652	3.456	471.912	1.443	358.216	1.164	281.478
3.2000	0.6342	170.090	3.2000	0.0326	7.317	177.407	3.400	453.009	1.391	340.157	1.114	264.867
3.4000	0.6739	169.720	3.4000	0.0347	7.351	177.070	3.349	435.924	1.344	323.889	1.068	249.965
3.6000	0.7135	169.274	3.6000	0.0367	7.388	176.661	3.302	420.397	1.301	309.155	1.026	236.522
3.8000	0.7532	168.768	3.8000	0.0388	7.428	176.196	3.258	406.216	1.261	295.742	0.987	224.335
4.0000	0.7928	168.216	4.0000	0.0408	7.472	175.688	3.217	393.206	1.224	283.479	0.951	213.236
-	-	Grams	-	-	Grams	Grams	Numbers	Grams	Numbers	Grams	Numbers	Grams

Notes: Run name : YLDCDD03
Date and time : 17SEP97:08:19
Computation of ref. F: Northern: Simple mean, age 4 - 8
Southern: Simple mean, age 4 - 8
Recruitment : Single recruit

Table 3.4.13 The medium term simulation harvest control rules for North East Atlantic mackerel

Medium term simulations harverst control rules for mackerel

Fixed parameters:
Lower limit of SSB: 2300
F above upper limit of SSB: 0.175

Stock assessment SD	Catch multiplier	Catch mult. SD	F lower level	Upper limit SSB	Prob 2=>1 (%)	Catch variation	Avg. catch
0	1	0	0.05	2500	0.9	20	584
				3000	0.9	20	584
			0.122	2500	3.7	20	584
				3000	1.4	23	574
0.1	1	0	0.05	2500	1.7	42	580
				3000	0.5	64	558
			0.122	2500	3.7	41	583
				3000	1.5	51	572
0.3	1	0	0.05	2500	6.6	150	567
				3000	7.4	160	550
			0.122	2500	11.2	116	583
				3000	12.5	121	574
0.1	1.1	0.1	0.05	2500	4.4	62	609
				3000	1.3	88	581
			0.122	2500	11.3	59	613
				3000	6.6	67	598
0.1	1.2	0.1	0.05	2500	12.7	74	632
				3000	3.3	99	601
			0.122	2500	21.8	65	639
				3000	16.3	70	622

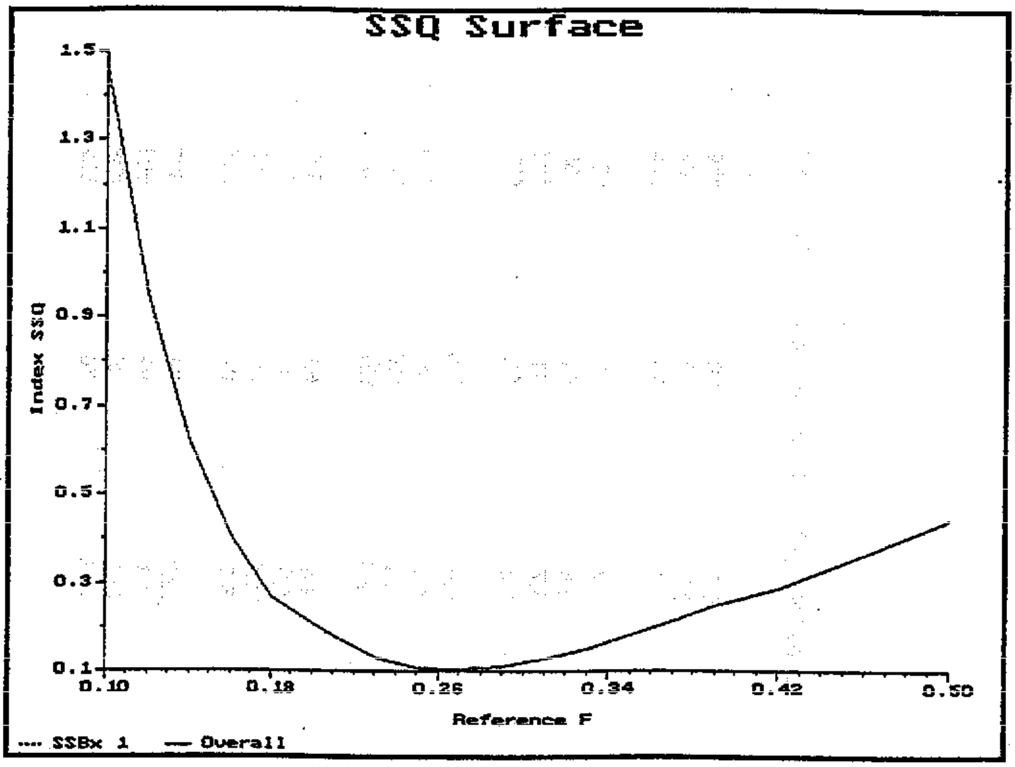


Figure 3.2.1 The sum of squares surface for the ICA separable VPA fit to the Western mackerel egg survey spawning stock biomass estimates.

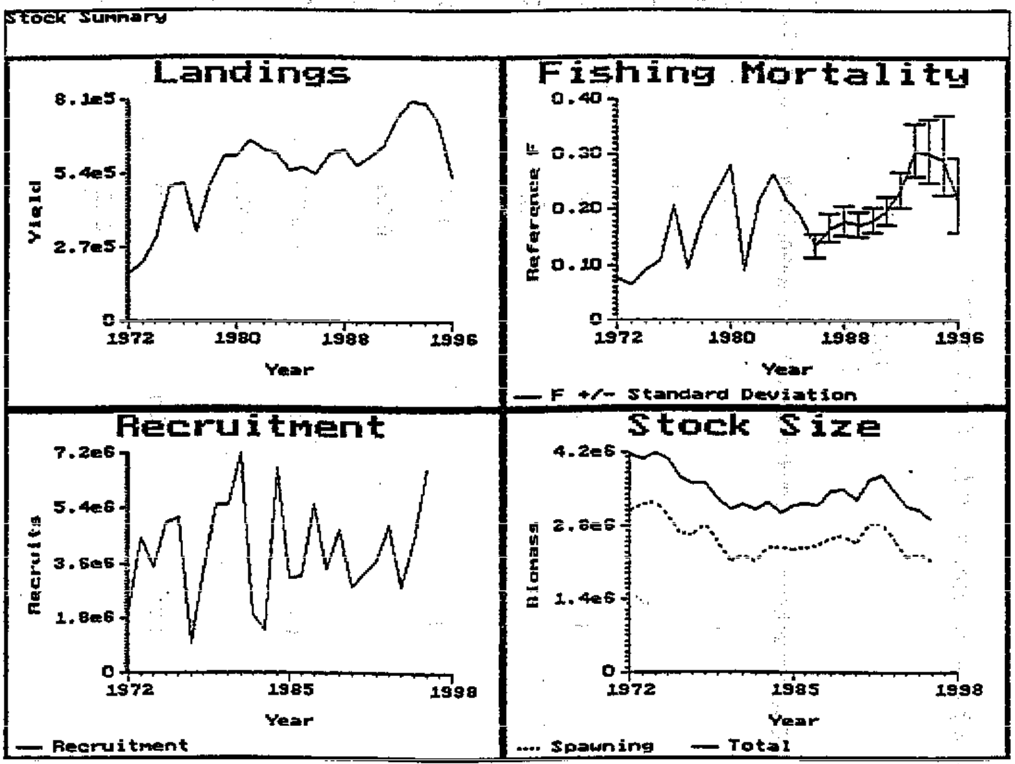


Figure 3.2.2 The long term trends in stock parameters for the Western mackerel.

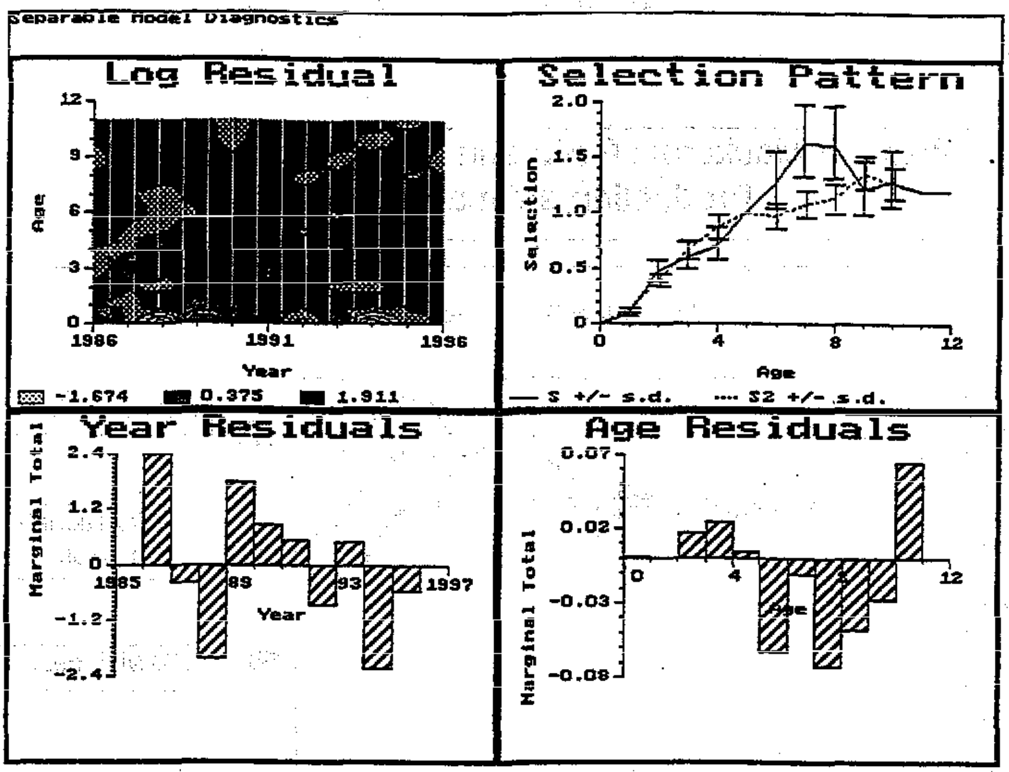


Figure 3.2.3 The catch at age residuals and selection at age as fitted by ICA to the Western mackerel data.

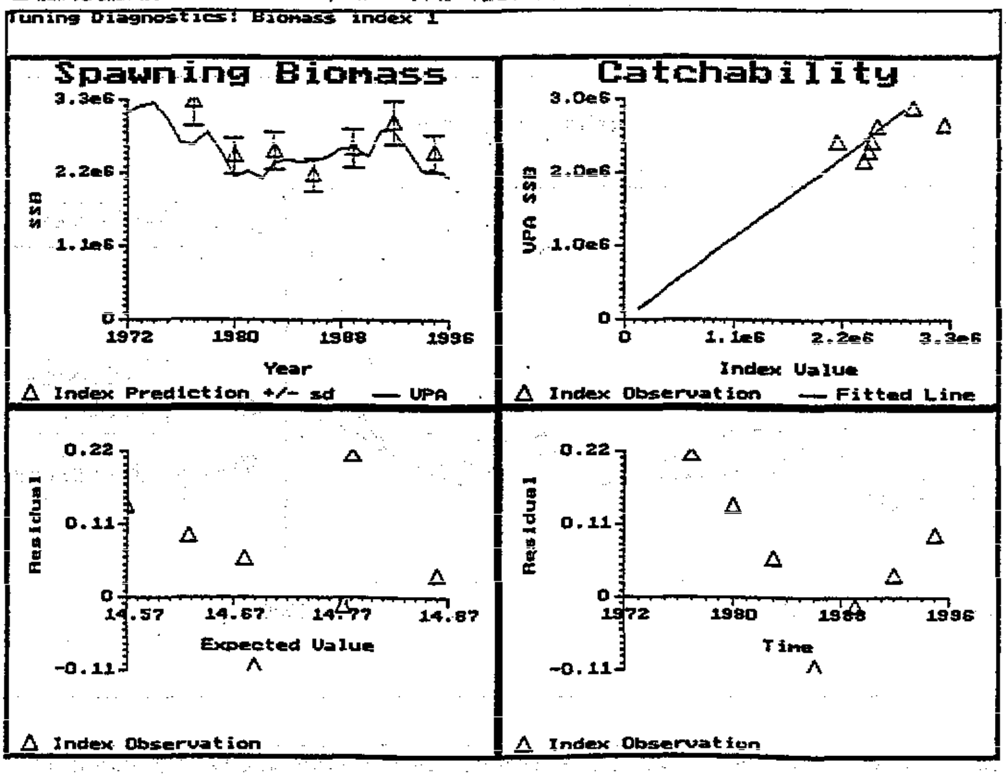
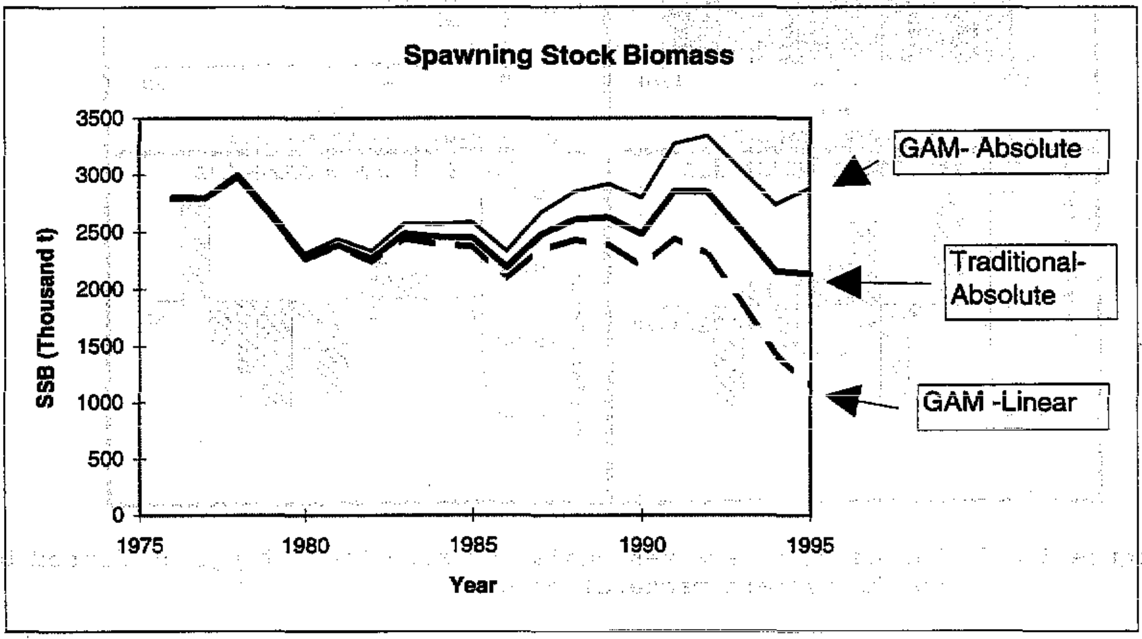


Figure 3.2.4 The diagniostics for the egg production index as fitted by ICA to the Western mackerel data.

Western Mackerel : GAM and Traditional Egg Production estimates



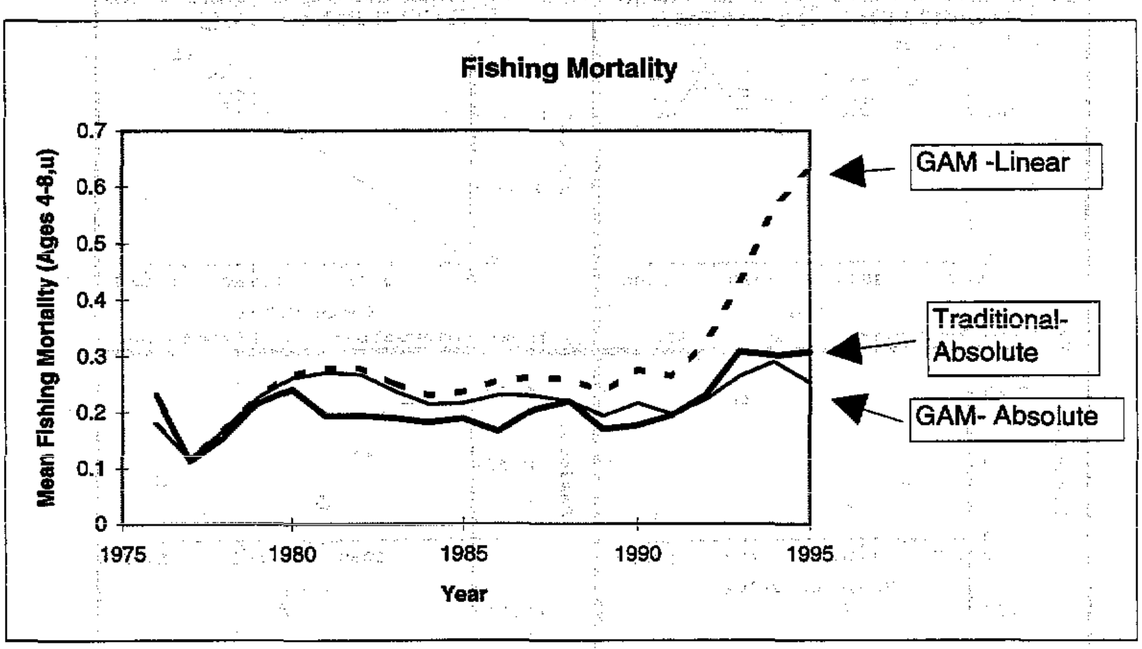


Figure 3.2.5*.Western Mackerel. Comparison of stock assessment calculations made by the Working Group in 1996, using either the traditional egg production estimates (as absolute measures of stock size), or the GAM-based estimates of stock size. The GAM estimates were tested as either absolute or linear proportional estimates of stock size.

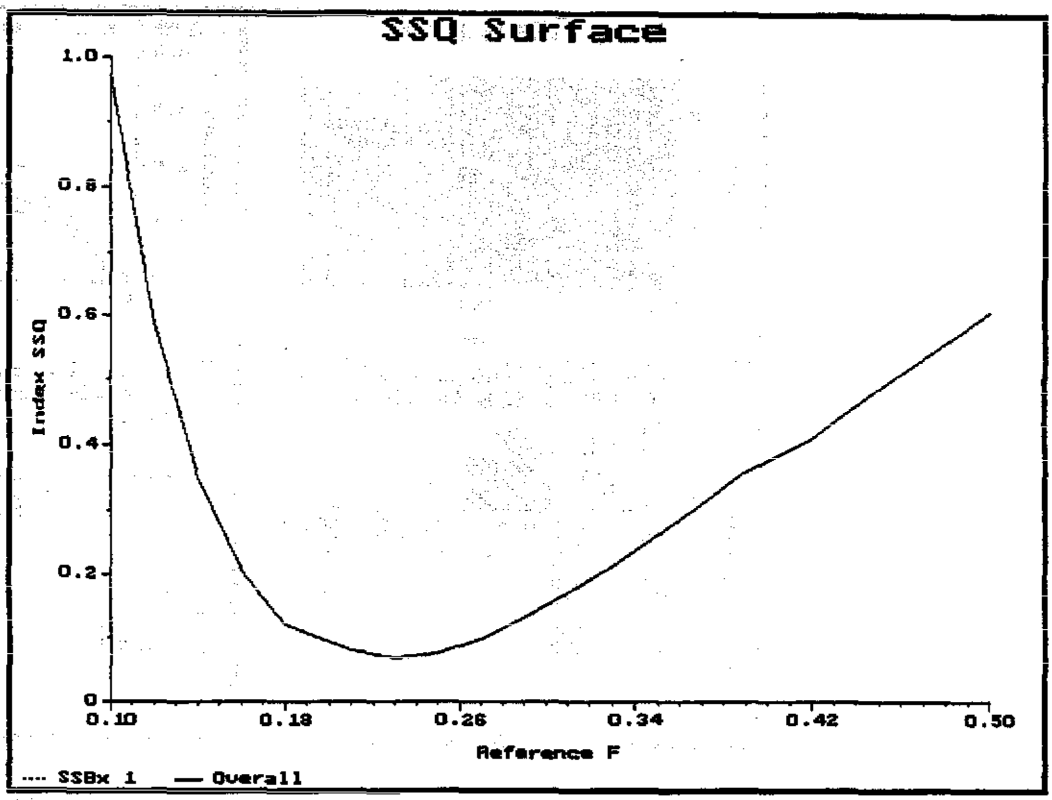


Figure 3.4.1 The sum of squares surface for the ICA separable VPA fit to the North East Atlantic mackerel egg survey spawning stock biomass estimates.

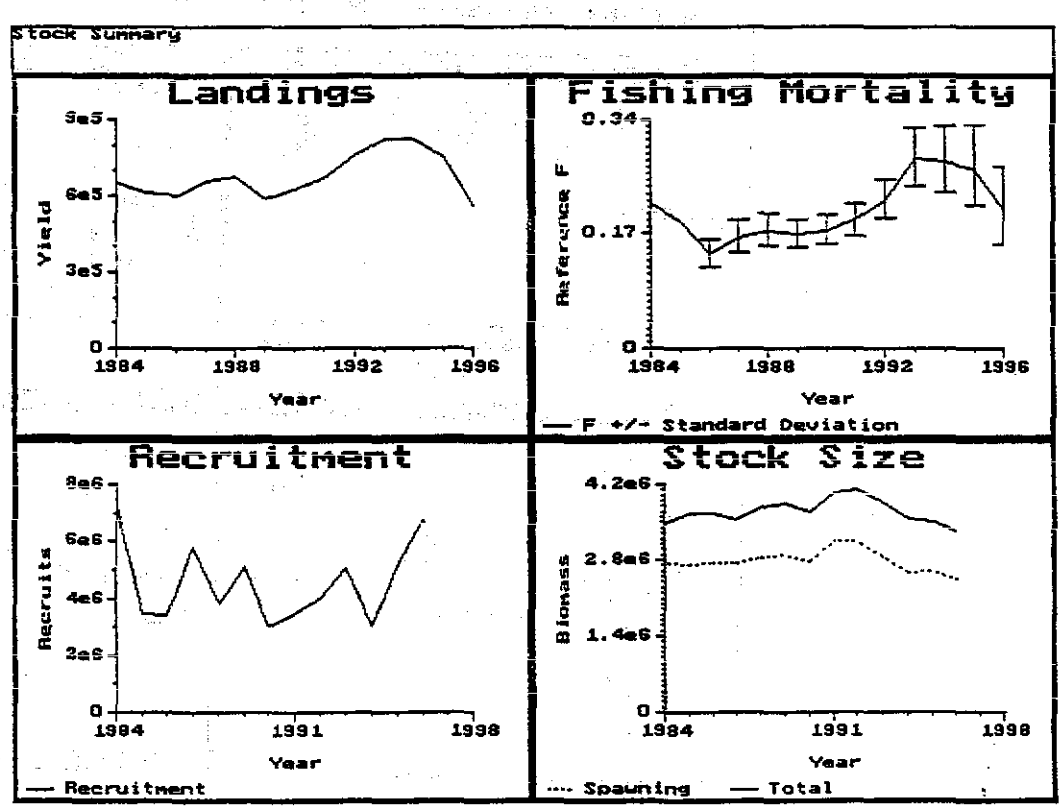


Figure 3.4.2 The long term trends in stock parameters for the North East Atlantic mackerel.

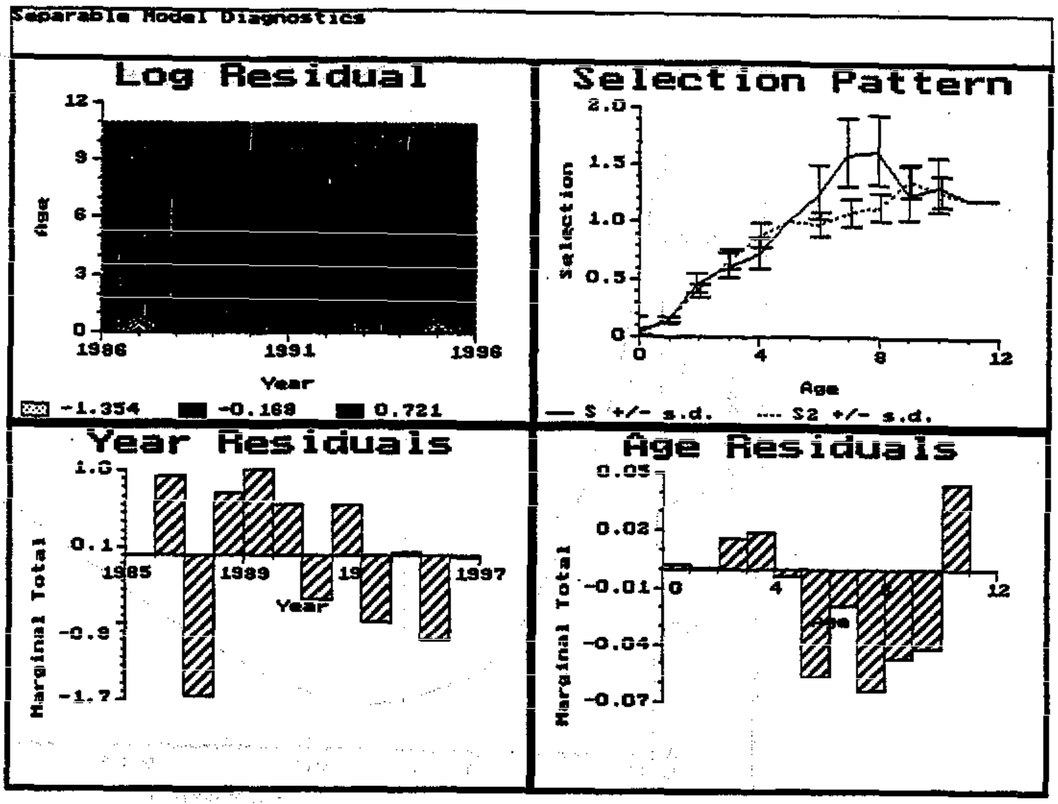


Figure 3.4.3 The catch at age residuals and selection at age as fitted by ICA to the North East Atlantic mackerel data.

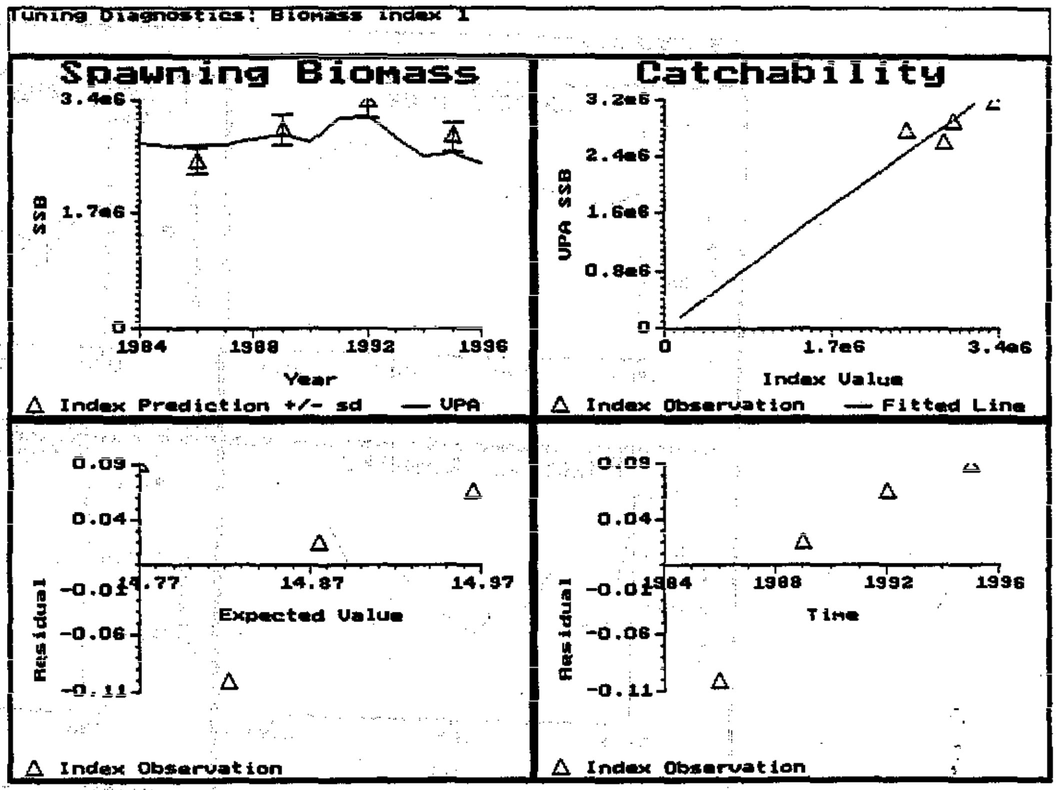


Figure 3.4.4 The diagniostics for the egg production index as fitted by ICA to the North East Atlantic mackerel data.

Figure 3.4.5 **Comparisons between the Western and North East Atlantic mackerel assessments .**

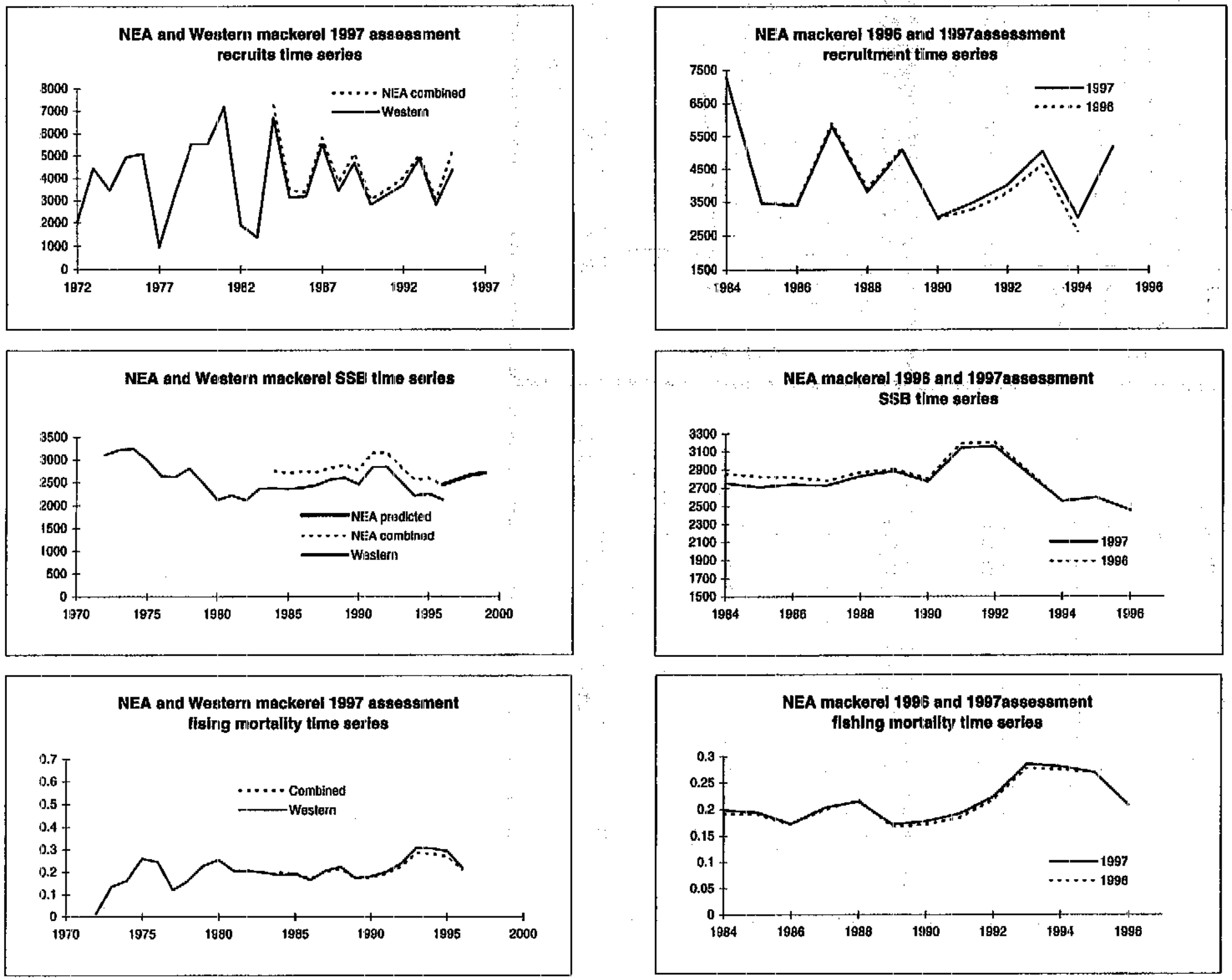


Figure 3.4.6 The medium term projection results for status quo (F96) fishing mortality for North East Atlantic mackerel. Total landings, fishing mortality, recruitment and stock size.

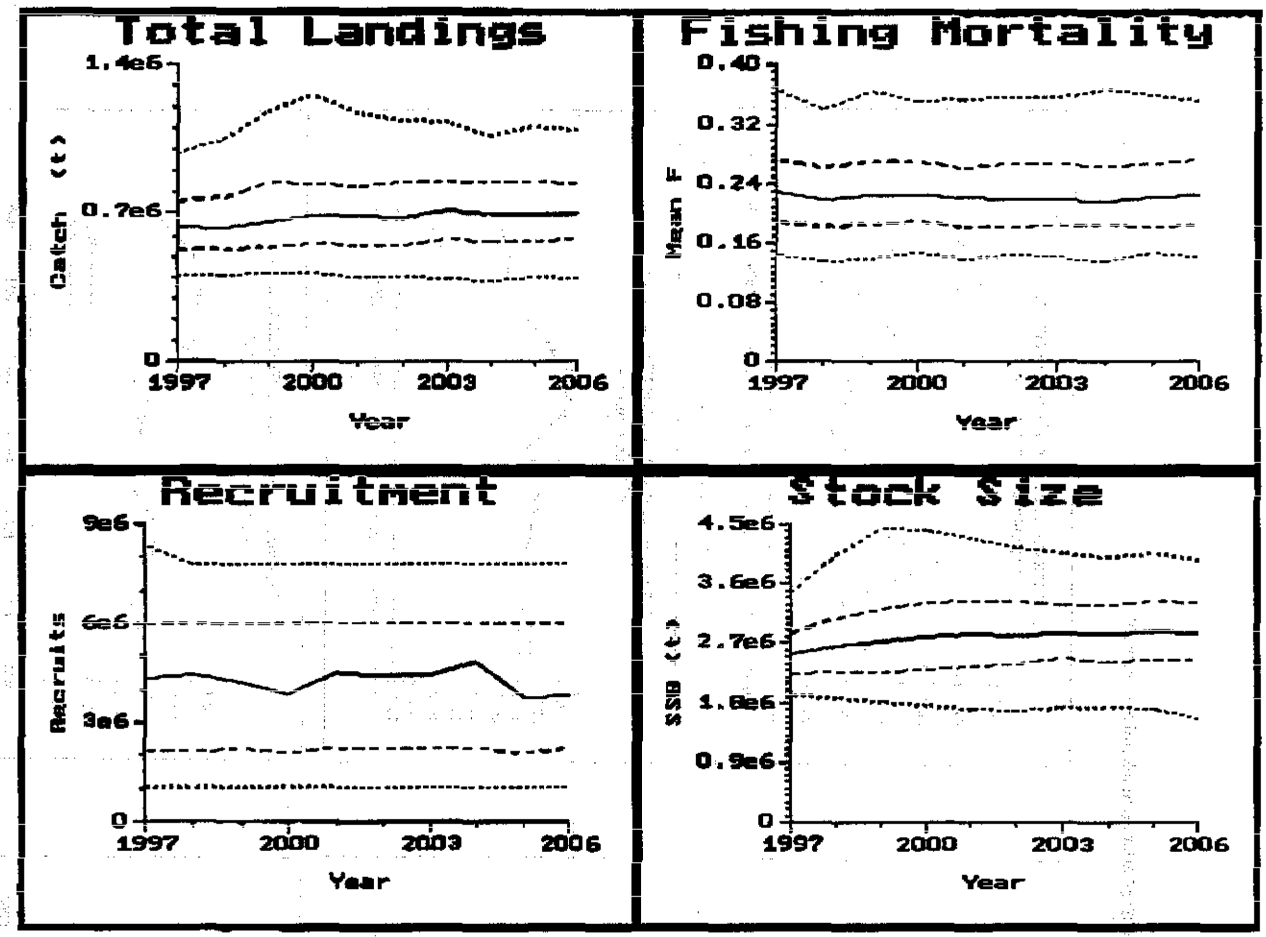


Figure 3.4.7 The medium term projection results for status quo (F96) fishing mortality for North East Atlantic mackerel. Fleet catches.

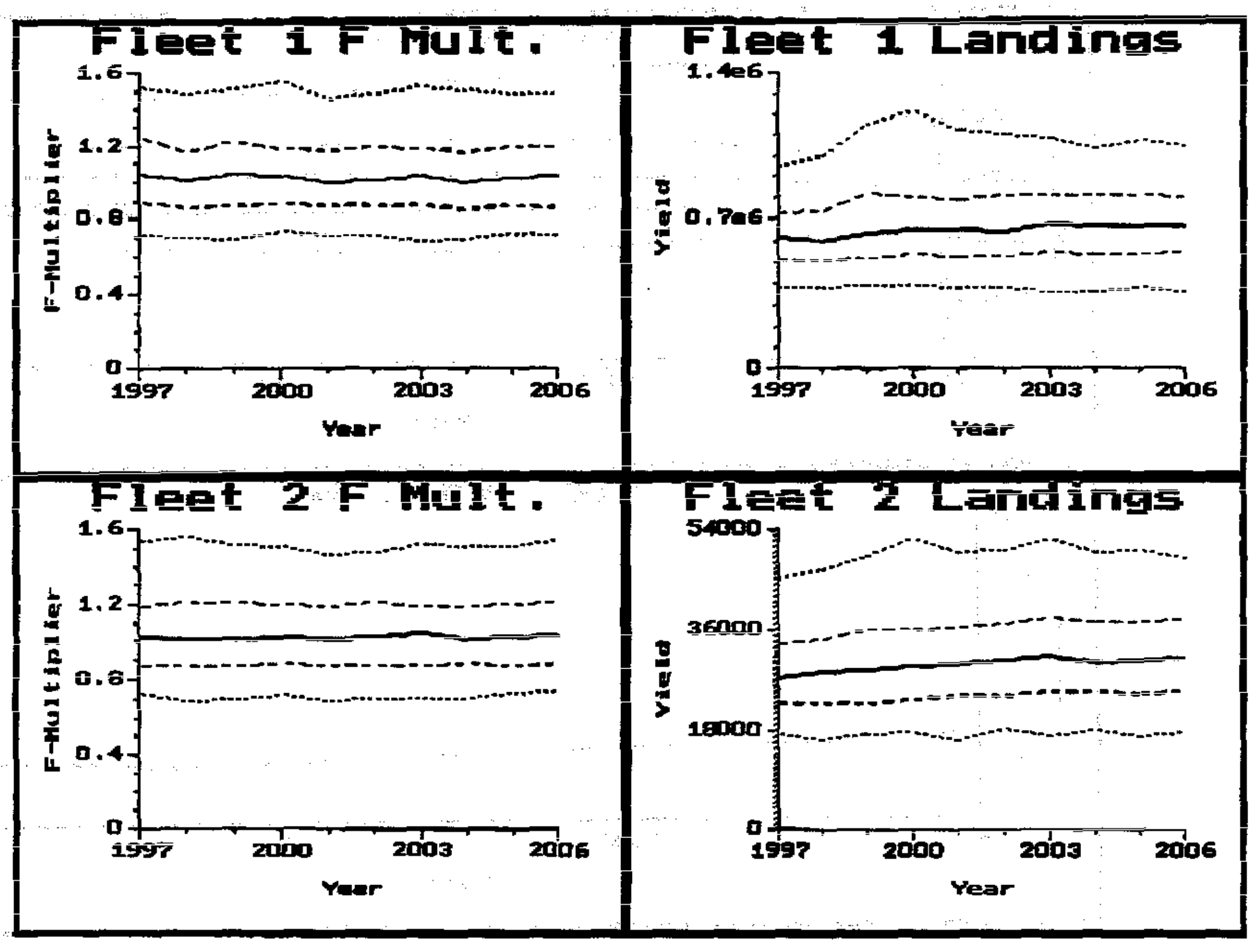


Figure 3.4.8 The medium term projection results for status quo (F96) fishing mortality for North East Atlantic mackerel. Stock size and risk of going below MBAL.

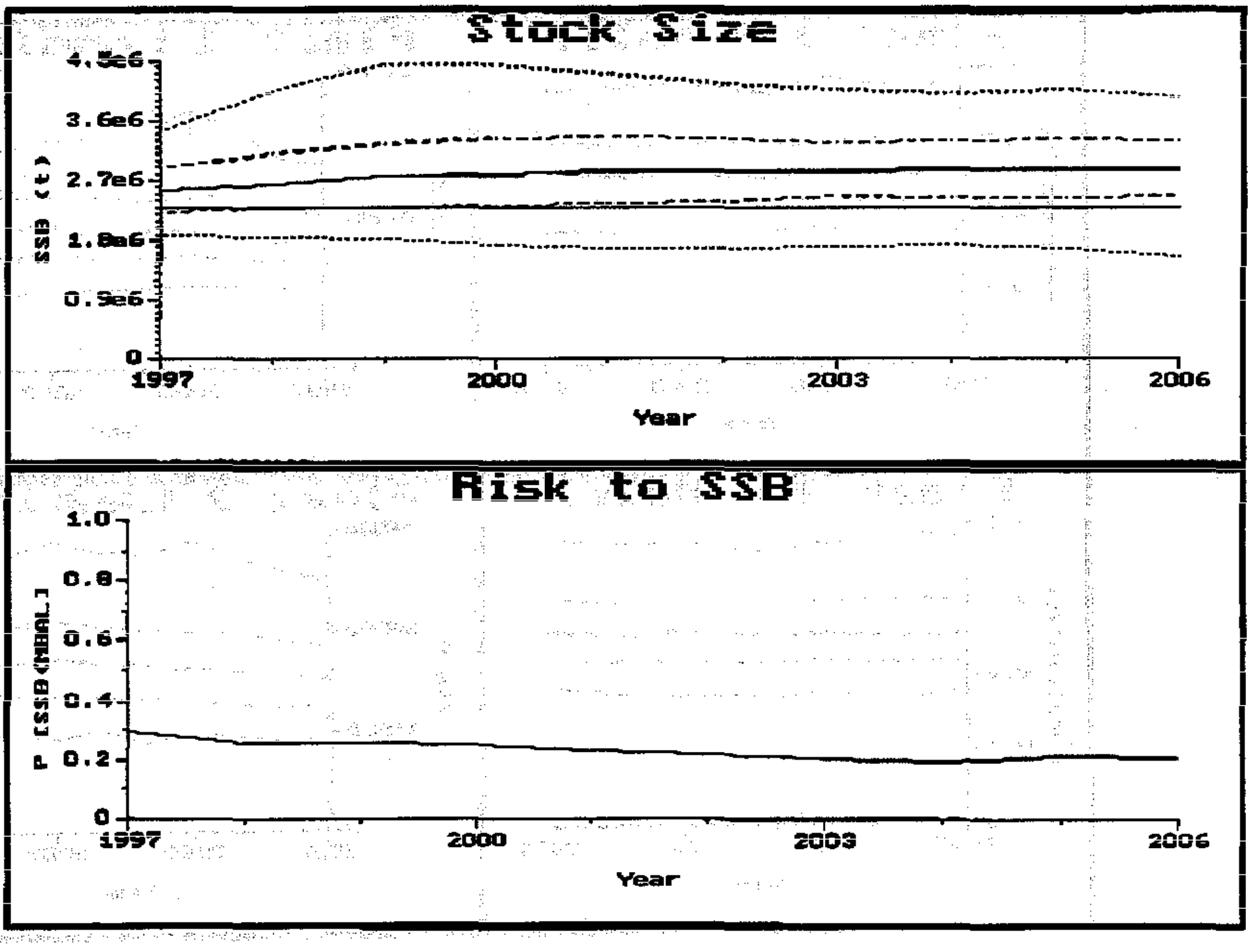


Figure 3.4.9 The medium term projection results for an F = 0.15 fishing mortality for North East Atlantic mackerel. Total landings, fishing mortality , recruitment and stock size.

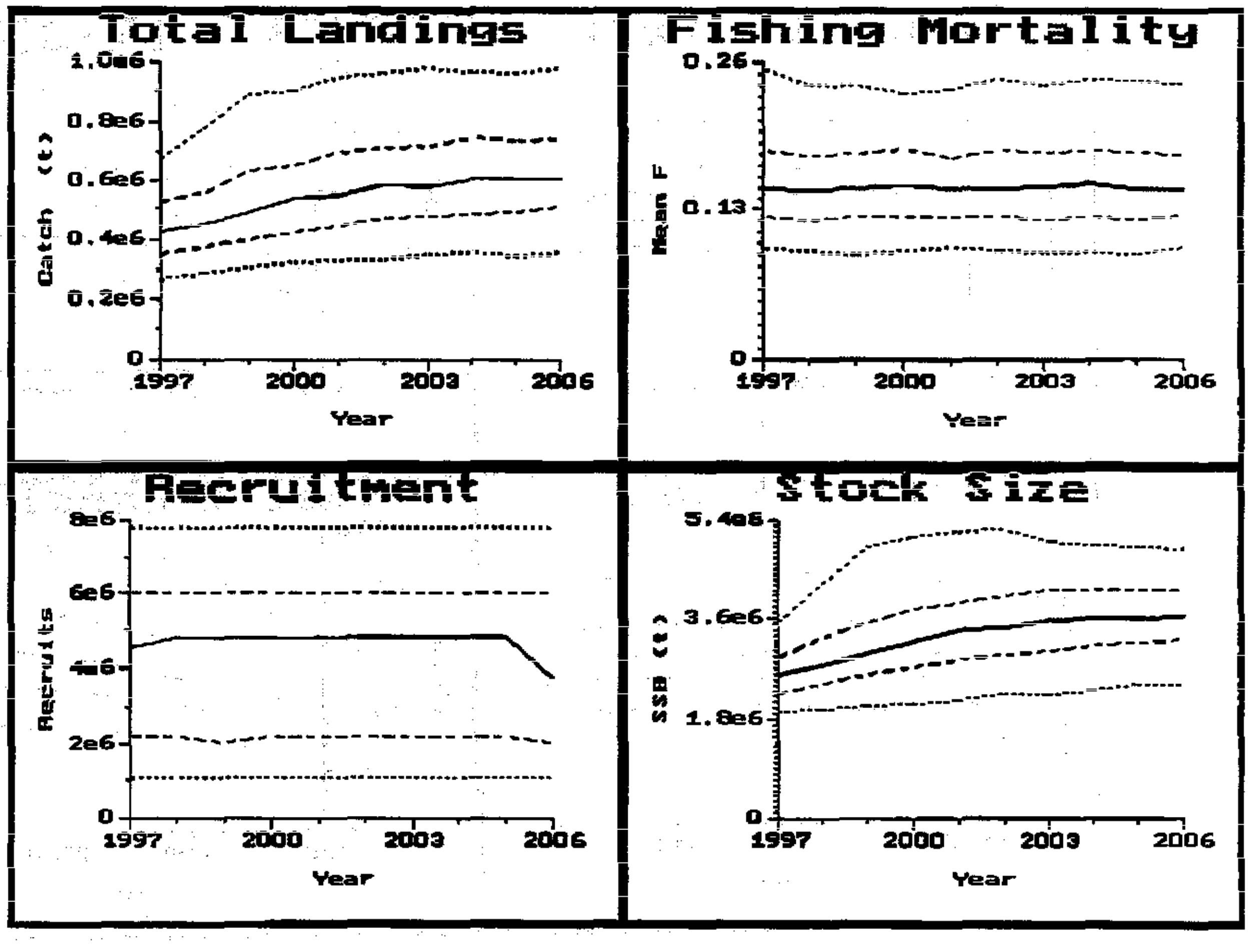


Figure 3.4.10 The medium term projection results for an F = 0.15 fishing mortality for North East Atlantic mackerel. Fleet catches.

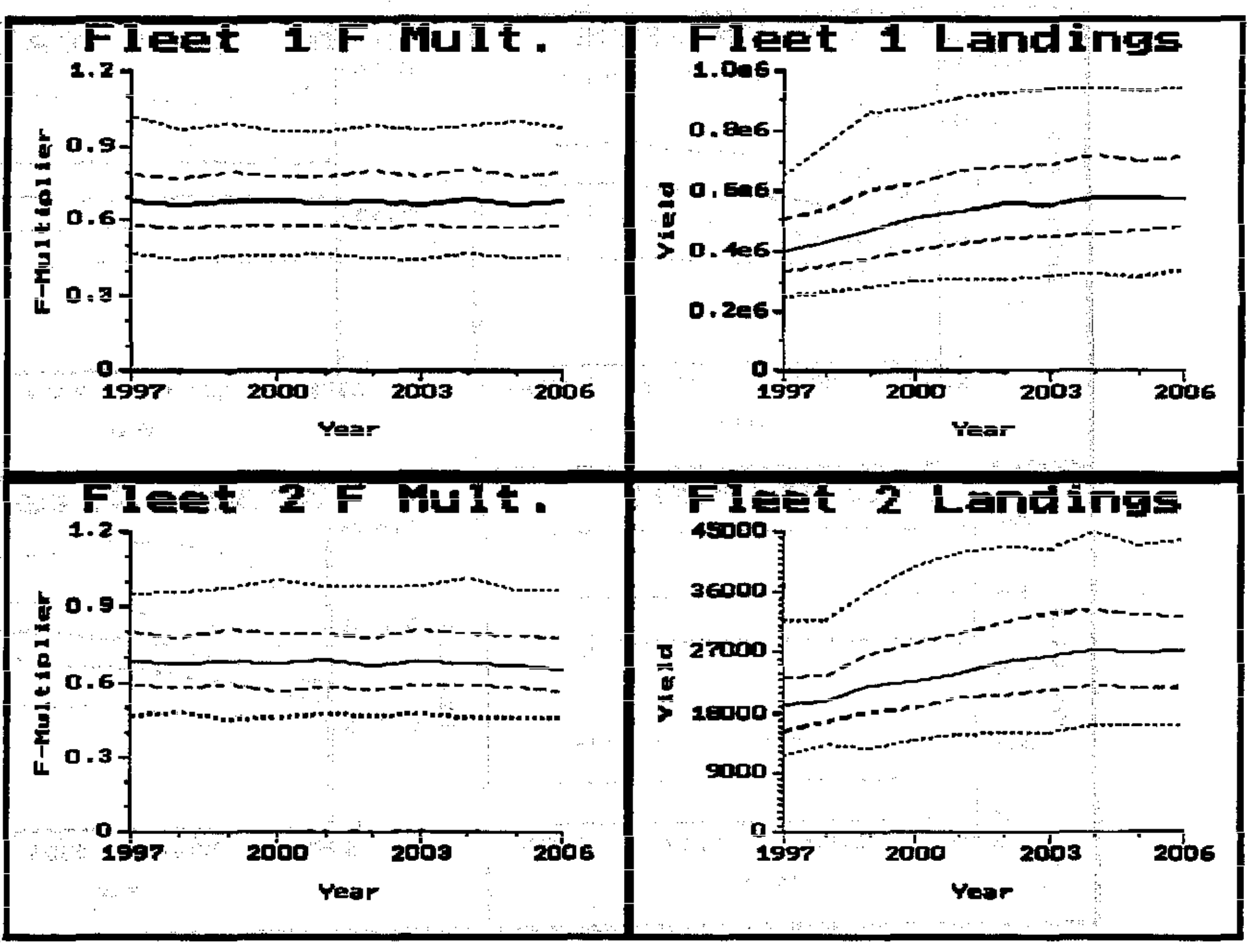


Figure 3.4.11 The medium term projection results for an F = 0.15 fishing mortality for North East Atlantic mackerel. Stock size and risk of going below MBAL.

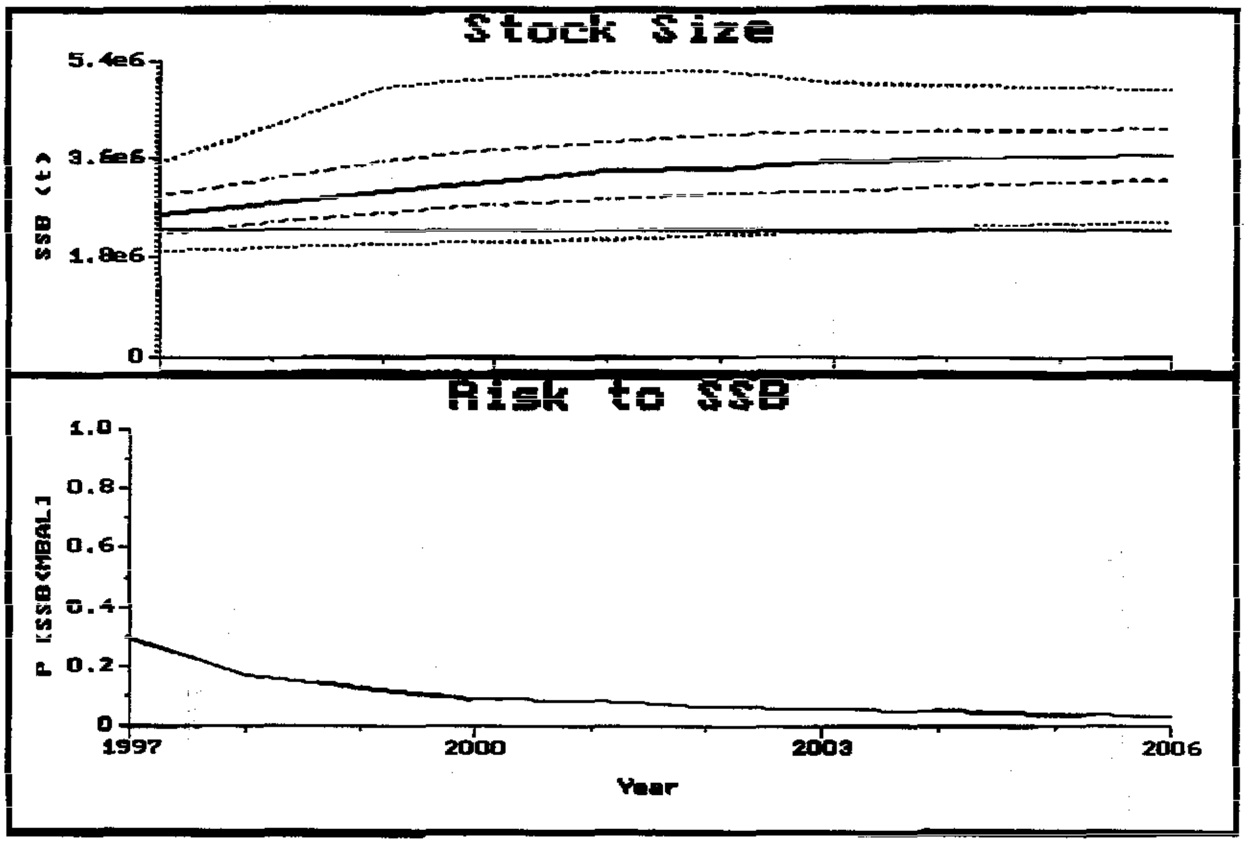


Figure 3.4.12 NEA mackerel multifleet yield per recruit

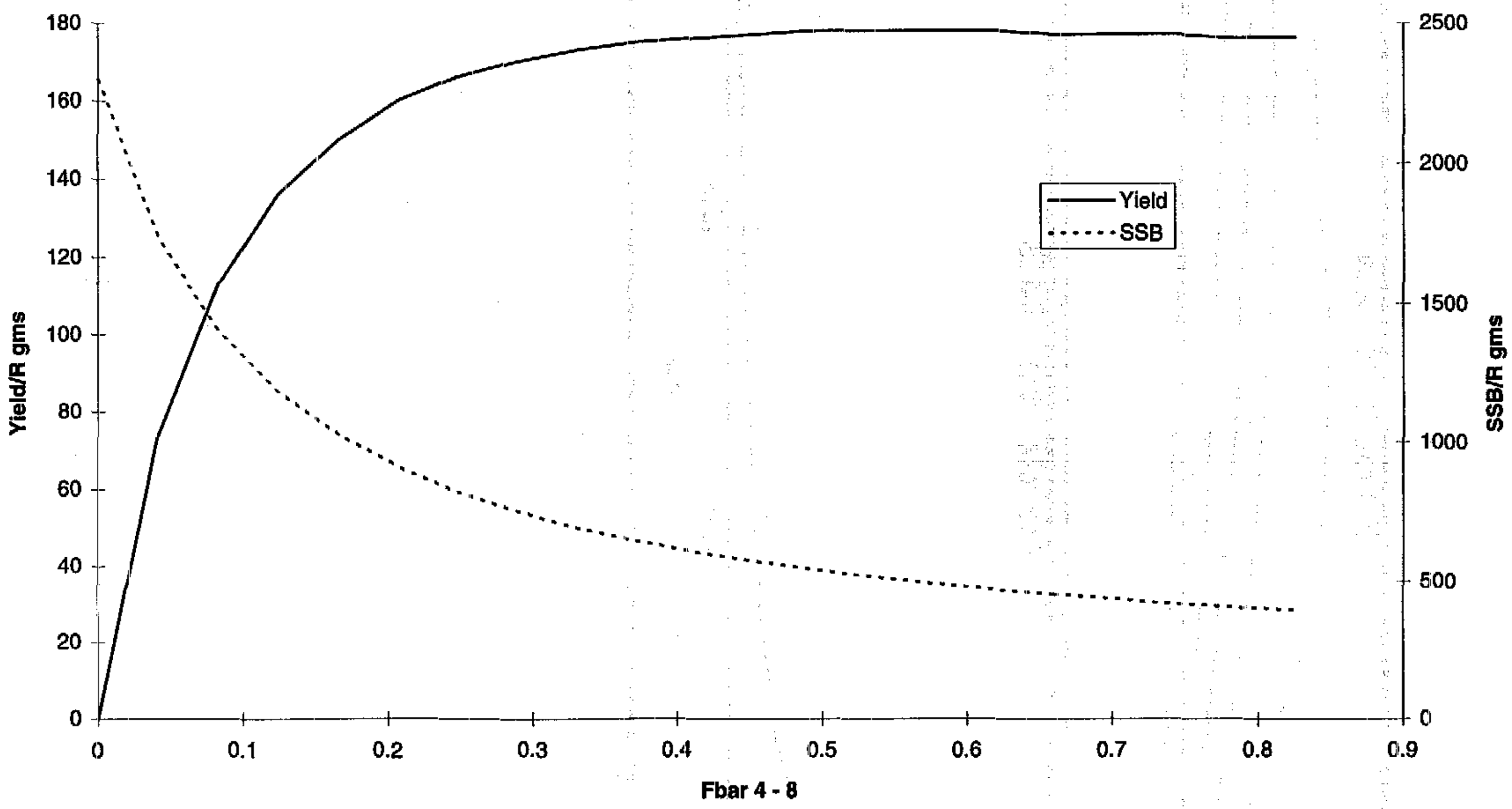


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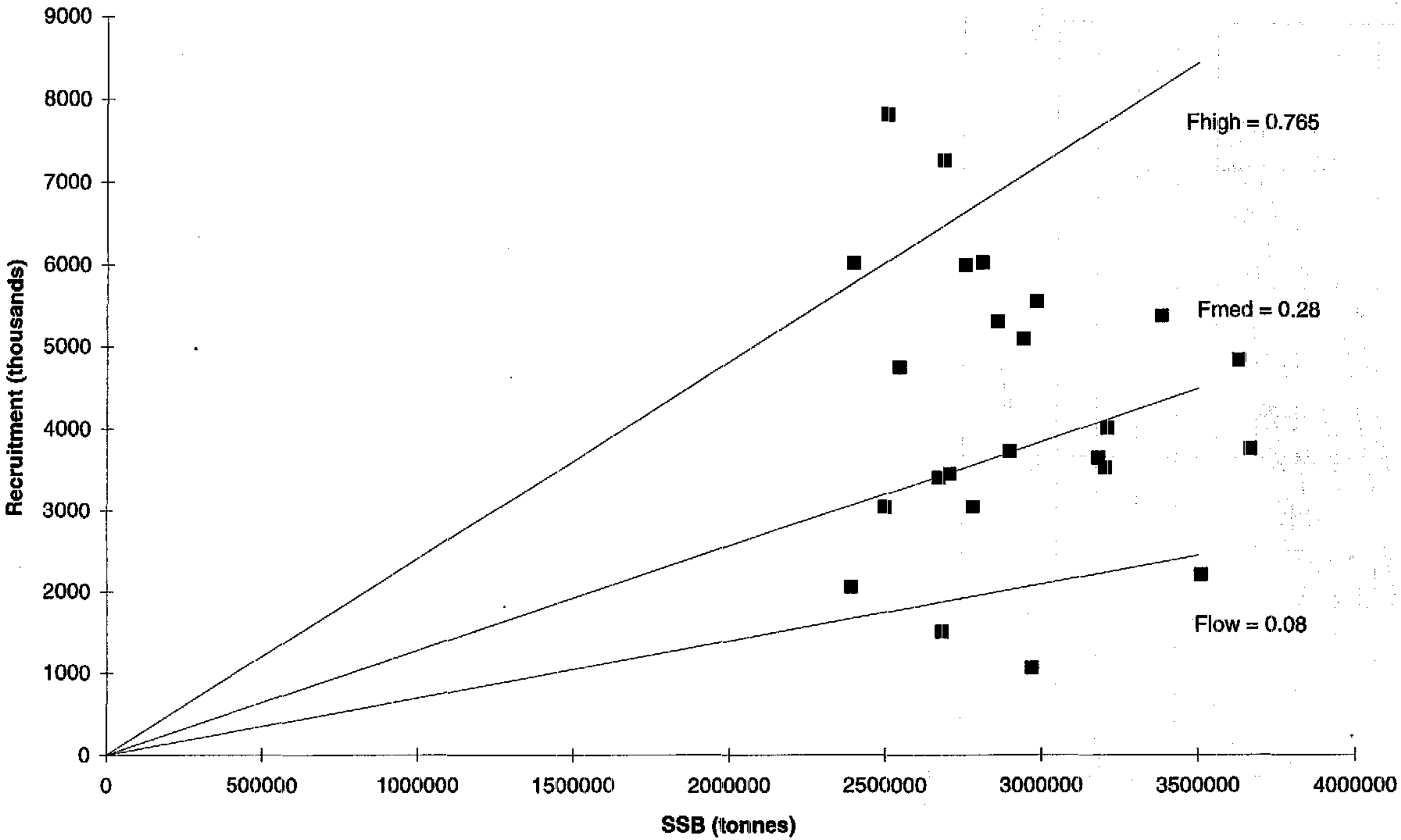
Figure 3.4.13 The NEA mackerel stock-recruitment relationship



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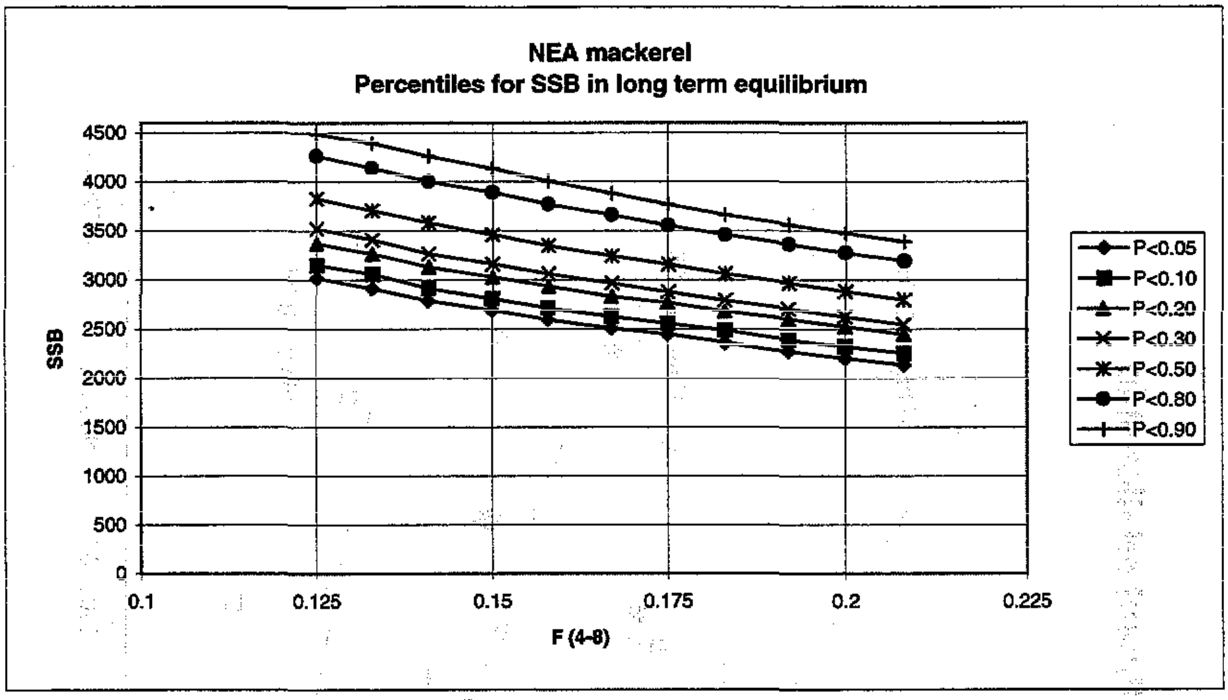
NEA mackerel
Percentiles for SSB in long term equilibrium
4500
4000
3500
3000
2500
2000
1500
1000
500
0
SSB
0.1
0.125
0.15
0.175
0.2
0.225
F (4-8)
P<0.05
P<0.10
P<0.20
P<0.30
P<0.50
P<0.80
P<0.90

Figure 3.4.14

4 HORSE MACKEREL - GENERAL

4.1 Stock Units

The last 8 years the Working Group has considered the horse mackerel in the north east Atlantic as separated into three management stocks, the North Sea, the Southern and the Western stock (ICES 1990/Assess:24, ICES 1991/Assess:22). Since little information from research surveys are available this separation is based on the observed egg distributions and the temporal and spatial distribution of the fishery. The Southern and Western horse mackerel are thought to have similar migration patterns to the mackerel from the same areas. As for mackerel the egg surveys have demonstrated that it is difficult to determine a realistic border between a western and southern spawning area. In later years some horse mackerel have been tagged in Portuguese and Spanish waters, but so far no tags have been recovered (Borges and Porteiro pers. comm.).

Until recently little has been done to study stock identity problems for horse mackerel. Two studies are now available; one on allozyme differentiation (Soriano and Sanjuan, WD 1997), and one of morphometric characters of horse mackerel in the southern region (Murta and Borges, WD 1997). However, none of these studies indicate that there are basis to change the stock separation used previously. Therefore the Working Group still consider horse mackerel in the north east Atlantic to consist of three units, the North Sea, the Southern and the Western horse mackerel.

4.2 Spawning Stock Biomass Estimates from Egg Surveys

4.2.1 North Sea area

No new egg surveys covering the spawning of horse mackerel have been carried out since 1991 and none are currently planned for the future.

4.2.2 Western area

There is no new information to report since the 1995 egg survey. The estimates of egg production and SSB from that survey (Table 2.2.1) remain unchanged. The area will be surveyed again in 1998 (see Section 1.4.1).

4.2.3 Southern area

There is no new information to report since the 1995 egg survey. The area will be surveyed again in 1998 (see Section 1.4.1).

4.3 Allocations of Catches to Stock

Usually, the catches in the Western part of Division IIIa (third and fourth quarters) are closer to the catch distributions in Division IVa than in Divisions IVb,c both spatially and temporally. Therefore these catches have been allocated to the western stock. However, in 1996 the catches in Division IIIa were taken in the eastern part (Figures 4.3.2a–d) and were not taken in an area close to the fishery in Division IVa. Therefore these catches were allocated to the North Sea stock.

Except for the catches in IIIa the distribution of the fishery in 1996 was similar to previous years and thereby the catches were allocated to the different stocks as:

Western stock: Divisions IIa, Vb, IVa, VIIa–c,e-k and VIII a,b,d,e

North Sea stock: Divisions IVb,c, VIId and IIIa

Southern stock: Divisions VIIIc and IXa

The catches by stock are given in Table 4.3.1 and Figure 4.3.1.

4.4 The Fishery in 1996

The total international catches of horse mackerel in the North East Atlantic are shown in Table 4.4.1 and Figure 4.3.1. The total catch from all areas in 1996 is 460,000 t which 120,000 t lower than the record high catches in 1995. Ireland, Denmark and the Netherlands have a directed trawl fishery and Norway a directed purse seine fishery for horse mackerel. Spain and Portugal have a directed trawl and purse seine fishery. Only one country provides data for discards. Therefore the amount of discards given in Table 4.3.1 are not representative for the total fishery.

4.5 Distribution of the Horse Mackerel Fisheries

The distribution of the fisheries in 1996 are given in Figure 4.3.2a-d. The figures are based on data provided by Denmark, Ireland, the Netherlands, Norway, Portugal, Spain and UK (England and Wales) covering 91% of the total catch. The total catch was allocated to quarters according to the data from the above countries and are given in Table 4.5.1. As usual the main catches were taken in Divisions VIIa–c,e-k. and the main seasons were the first and fourth quarters.

First quarter, 163,000 t. This is 42,000 t more than 1995. The distribution of the catches are similar to previous years. The main catches were taken along the western continental shelf west of Ireland and the British Isles, in the western Channel, in the Bay of Biscay and along the Portuguese and Spanish west coast (Figure 4.3.2a).

Second quarter, 58,000 t. This is 34,000 t less than last year. The fishery was as in previous years, mainly carried out south west of Ireland, south of Cornwall, in the Bay of Biscay, along the west coast of the Iberian peninsula (Figure 4.3.2b).

Third quarter, 86,000 t. This is 21,000 t less than in 1996. The fishery is similar to the second quarter but in addition the fishery increased slightly in the North Sea and Skagerrak (Figure 4.3.2c).

Fourth quarter, 153,000 t. This is considerable lower (107,000 t) than in 1997. This is mainly due to a reduced fishery in the northern part of the North Sea (Division IVa). The main fishery is carried out west of Ireland, in the western Channel and to some extent in the Bay of Biscay and along the Iberian west coast (Figure 4.3.2d).

4.6 Length Compositions by Fleet and by Country

The 1996 annual length compositions by fleet were provided by Germany, Ireland (third and fourth quarter), England and Wales (second quarter), the Netherlands, Norway, Portugal and Spain. These length distributions cover about 65% of the total landings in 1996. The length distributions by country and fleet are shown in Table 4.6.1.

4.7 Otolith Exchange in 1996

Last years Working Group recommended that a new horse mackerel otolith exchange be carried out in 1996 to estimate the precision of the age readings of the otolith readers in the northeast Atlantic area (ICES, 1997/Assess:3). The results of this 1996 otolith exchange are presented in Eltink (1997).

Two earlier horse mackerel otolith exchanges have been carried out in 1984 and 1988 (Eltink, 1985 and Borges, 1989). However, this 1996 otolith exchange differs from the two earlier exchanges, because now one exchange set contained otoliths of 'known' age. This enables the estimation of both accuracy and precision.

During the 1996 horse mackerel otolith exchange three sets of otoliths were circulated among 7 readers from 6 countries. Set A contained otoliths of 'known' or 'actual' age, which were only otoliths of the extremely strong 1982 year class collected during the period 1985–1995 of which the original ageings had a very high probability to agree with the true age. Set B contained otoliths of fish caught in the first half of the year (only translucent edges) and set C contained otoliths of fish caught during the second half of the year (mixture of translucent and opaque edges). Set A has been used to validate the age reading method of each otolith reader. Based on this validation the age readings of set B and C of each otolith reader have been evaluated. Difficulties in the interpretation of the edge of the otolith were analysed by comparing ageing results of set B and C. The age readings of the three sets were analysed for the age range 0-15, in addition set B was analysed over the age range 10–25 in order to get information on the relative bias in the ageings of especially the older fish. The accuracy and the precision of the age readings as well as the bias in the ageings are discussed by otolith set. Precision by reader differed considerably and appeared to be related to experience in otolith reading. When ageings were compared to 'actual' age, validation set A showed that all readers had a bias in the age readings (see Figure 4.7.1). But, when the ageings were compared to modal age, validation set A showed that the bias was much less (Figure 4.7.2). The percentage of agreement in the age readings of all readers obtained from comparisons to the 'actual' age decreased from 75% to 20% over age range 3 to 13, but from comparisons to the modal age it decreased only from 80% to 50% (see Figure 4.7.3). In general it can be said that the modal or average age are good representations of the true age if no bias occurs in the age readings. However, if bias occurs, than the modal age provides a far too optimistic view. In this case, in which the bias starts at age 6 and increases up to one year of underestimation at age 13, the agreement with 'actual' age is roughly 25%–50% lower for the ages 6–13 than as indicated by the modal age. In future age comparisons it is therefore essential that calcified structures of known age are available to show presence of absence or bias. If bias can be excluded than the agreement to modal or average age can be regarded as the agreement to the true age.

The absolute bias in ageing was estimated for each age group (see Figure 4.7.4).

The following conclusions were drawn:

1. All seven otolith readers appeared to have a bias in their age readings based on age reading comparisons from otoliths of "known" or "actual" age. Six readers underestimated the ages; this bias started in general at age 6 and increased with age. The bias is an underestimation of approximately one year at age 13. One of the readers appeared to overestimate the ages, especially the ages 7–9.

2. Interpretation of the outer edge (translucent/opaque) appeared to cause problems in the age determination.

3. There is no reason to change the age range (ages 0–14 with a 15+ group) for data to be supplied to the ICES Assessment Working Group.

4. Both the bias and the outer edge problem in ageing horse mackerel otoliths should be solved as soon as possible. This could be done by the use of the 1982 year class otoliths (both with translucent and opaque edges). Discussions on how to read and interpret the ring structures could help to improve the precision and accuracy.

The Mackerel, Horse Mackerel, Sardine and Anchovy Working Group recommends that a horse mackerel otolith workshop be held in 1998 in ... from ... to ... 1998 to be organised by A. Eltink, Netherlands to improve the quality of the age readings.

The workshop is requested to provide:

a) a synopsis of the biology of the species (stocks, migrations, spawning, feeding, maturity, growth, etc.).
b) an overview on how the ageing technique was validated.
c) a review of sample processing methods.
d) a manual for age reading (date of birth, interpretation of rings and edges, guide-lines on how the best ageings can be achieved, etc.).
e) available information on when translucent and opaque otolith edge structures occur by month and by age group for both western and southern horse mackerel stocks.
f) an exercise to estimate the precision, accuracy and bias from an age readings comparisons on otoliths of known age to be carried out at the end of the workshop to demonstrate the improvements.
g) recommendations on how to improve the age reading quality.

Table 4.3.1 Landings and discards of HORSE MACKEREL (t) by year and division, for the North Sea, Western and Southern horse mackerel. (Data submitted by Working Group members.)

Year	North Sea horse mackerel					Western horse mackerel							Southern horse mackerel			Total
	IIIa	IVb,c	Discards	VIId	Total	IIa	IVa	VIa	VIIa-c,e-k	VIIIa,b,d,e	Discards	Total	VIIIc	IXa	Total	All stocks
1982	- 2,788[3]	-		1,247	4,035	-	-	6,283	32,231	3,073	-	41,587	19,610	39,726	59,336	104,958
1983	- 4,420[3]	-		3,600	8,020	412	-	24,881	36,926	2,643	-	64,862	25,580	48,733	74,313	147,195
1984	- 25,893[3]	-		3,585	29,478	23	94	31,716	38,782	2,510	500	73,625	23,119	23,178	46,297	149,400
1985	1,138	22,897		2,715	26,750	79	203	33,025	35,296	4,448	7,500	80,551	23,292	20,237	43,529	150,830
1986	396	19,496		4,756	24,648	214	776	20,343	72,761	3,071	8,500	105,665	40,334	31,159	71,493	201,806
1987	436	9,477		1,721	11,634	3,311	11,185	35,197	99,942	7,605	-	157,240	30,098	24,540	54,638	223,512
1988	2,261	18,290		3,120	23,671	6,818	42,174	45,842	81,978	7,548	3,740	188,100	26,629	29,763	56,392	268,163
1989	913	25,830		6,522	33,265	4,809	85,304[2]	34,870	131,218	11,516	1,150	268,867	27,170	29,231	56,401	358,533
1990	14,872[1]	17,437		1,325	18,762	11,414	112,753[2]	20,794	182,580	21,120	9,930	373,463	25,182	24,023	49,205	441,430
1991	2,725[1]	11,400		600	12,000	4,487	63,869[2]	34,415	196,926	25,693	5,440	333,555	23,733	21,778	45,511	391,066
1992	2,374[1]	13,955	400	688	15,043	13,457	101,752	40,881	180,937	29,329	1,820	370,550	24,243	26,713	50,955	436,548
1993	850[1]	3,895	930	8,792	13,617	3,168	134,908	53,782	204,318	27,519	8,600	433,145	25,483	31,945	57,428	504,190
1994	2,492[1]	2,496	630	2,503	5,689	759	106,911	69,546	194,188	11,044	3,935	388,875	24,147	28,442	52,589	447,153
1995	240	7,948	30	8,666	16,756	13,133	90,527	83,486	320,102	1,175	2,046	510,597	27,534	25,147	52,681	580,034
1996	1,657	7,558	212	9,416	18,843	3,366	18,356	81,259	252,823	23,978	16,870	396,652	24,290	20,400	44,690	460,185

[1]Norwegian and Danish catches are included in the Western horse mackerel.
[2]Norwegian catches in Division IVb included in the Western horse mackerel.
[3]Divisions IIIa and IVb,c combined.

Table 4.4.1 Landings (t) of HORSE MACKEREL by Sub-area. Data as submitted by Working Group members.

Sub-area	1979	1980	1981	1982	1983	1984
II	2	-	+	-	412	23
IV + IIIa	1,412	2,151	7,245	2,788	4,420	25,987
VI	7,791	8,724	11,134	6,283	24,881	31,716
VII	43,525	45,697	34,749	33,478	40,526	42,952
VIII	47,155	37,495	40,073	22,683	28,223	25,629
IX	37,619	36,903	35,873	39,726	48,733	23,178
Total	137,504	130,970	129,074	104,958	147,195	149,485

Sub-area	1985	1986	1987	1988	1989	1990
II	79	214	3,311	6,818	4,809	11,414
IV + IIIa	24,238	20,746	20,895	62,892	112,047	145,062
VI	33,025	20,455	35,157	45,842	34,870	20,904
VII	39,034	77,628	100,734	90,253	138,890	192,196
VIII	27,740	43,405	37,703	34,177	38,686	46,302
IX	20,237	31,159	24,540	29,763	29,231	24,023
Total	144,353	193,607	222,340	269,745	358,533	439,901

Sub-area	1991	1992	1993	1994	1995[1]	1996[1]
II + Vb	4,487	13,457	3,168	759	13,133	3,366
IV + IIIa	77,994	113,141	140,383	112,580	98,745	27,782
VI	34,455	40,921	53,822	69,616	83,595	81,259
VII	201,326	188,135	221,120	200,256	330,705	279,109
VIII	49,426	54,186	53,753	35,500	28,709	48,269
IX	21,778	26,713	31,944	28,442	25,147	20,400
Total	389,466	436,553	504,190	447,153	580,034	460,185

[1]Preliminary.

Table 4.5.1 Quarterly catches (1000 t) of HORSE MACKEREL by Division and Sub-division in 1996.

Division	1Q	2Q	3Q	4Q	TOTAL
IIa+Vb	0	0	0	3.4	3.4
IIIa	+	0	0.7	1.0	1.7
IVa	1.6	+	0	16.8	18.4
IVbc, VIId	3.6	1.3	3.1	9.2	17.2
VIa	33.7	1.1	35.9	10.5	81.2
VIIa-c,e-k	114.1	42.4	32.1	81.1	269.7
VIIIabde	0.6	1.7	1.5	20.2	24.0
VIIIc	5.4	7.0	7.0	4.9	24.3
IXa	4.4	4.9	5.3	5.8	20.4
Sum	163.4	58.4	85.6	152.9	460.3

Table 4.6.1 Annual length distributions (in millions) of HORSE MACKEREL catches by fleet and country in 1996.

cm	Netherlands Pelagic trawl	Eng.&Wales Pel.trawl UK landings	Norway Purse seine	Germany Pel.trawl	Spain Purse seine	Spain Demersal trawl	Spain Gill net	Spain Hook	Portugal Artisan	Portugal Trawl	Portugal Purse	Ireland Pel.trawl
		2 Q										3+4 Q
5												
6					0.15							
7					3.35							
8					6.63	0.00						
9					3.76	0.00				0.61		
10					3.31	0.01				2.81		
11					9.66	0.01				12.83	1.31	
12					13.55	0.80				9.68	3.44	
13					9.17	1.78				3.99	0.65	
14					4.96	2.55				7.27	0.08	
15					4.44	5.11				4.63	0.00	
16					11.92	8.66				1.79	0.00	
17	6.07				16.55	10.63			0.00	2.06	0.00	
18	14.14				14.89	9.82		0.00	0.04	2.94	0.02	
19	55.53				14.85	4.60		0.00	0.24	4.68	0.04	
20	74.20				13.54	2.21	0.00	0.00	0.75	7.75	0.77	
21	130.18				9.96	0.73	0.00	0.01	1.49	9.43	2.14	
22	134.02				6.63	1.00	0.01	0.01	2.95	9.55	5.56	
23	148.34				7.55	1.10	0.01	0.02	7.07	8.71	4.13	0.67
24	98.28			0.00	12.19	1.31	0.03	0.04	8.96	6.33	2.52	5.96
25	84.01			0.00	16.65	1.39	0.04	0.05	6.94	3.14	0.78	15.78
26	64.05			0.00	17.02	1.85	0.06	0.05	6.85	1.92	0.14	35.05
27	83.71			0.00	13.83	3.19	0.06	0.06	5.04	1.37	0.11	40.38
28	60.01		0.13	0.00	10.58	4.77	0.05	0.08	3.85	1.01	0.00	49.81
29	74.11	0.35	0.06	0.01	7.08	6.15	0.05	0.09	3.80	0.79	1.20	66.61
30	53.94	1.54	0.33	0.02	6.24	6.33	0.04	0.07	3.11	0.63	7.17	43.42
31	41.28	2.01	0.72	0.05	3.58	4.22	0.04	0.08	2.96	0.52	13.15	22.18
32	26.39	2.25	2.94	0.10	2.13	4.12	0.04	0.07	3.04	0.43	7.57	8.57
33	23.29	2.13	8.37	0.22	0.78	3.02	0.04	0.06	3.07	0.37	1.59	4.93
34	16.13	0.59	10.61	0.25	0.45	2.61	0.03	0.08	3.36	0.35	0.40	4.30
35	9.66	0.83	8.05	0.26	0.37	1.78	0.03	0.05	3.21	0.23		2.59
36	7.01	1.18	5.81	0.14	0.23	1.21	0.02	0.03	2.76	0.17		1.32
37	3.51	0.47	2.11	0.07	0.17	1.03	0.02	0.01	2.15	0.10		1.43
38	0.37	0.35	0.76	0.05	0.26	0.54	0.01	0.01	1.69	0.04		0.58
39	0.74	0.12	0.19	0.01	0.18	0.50	0.01	0.01	1.74	0.02		0.12
40	0.05	0.00	0.13	0.02	0.27	0.19	0.01	0.01	1.22	0.01		0.17
41		0.12		0.00	0.22	0.12	0.01	0.01	0.55	0.00		0.06
42+		0.00			0.00	0.08	0.00	0.01	0.37	0.00		
Numbers	1209.01	11.94	40.20	1.19	247.10	93.43	0.60	0.90	77.23	106.17	52.76	303.92
1000 tons	166.21	3.55	15.53	0.41	22.64	12.81	0.15	0.22	4.39	7.58	2.09	63.13

0.00=<5000

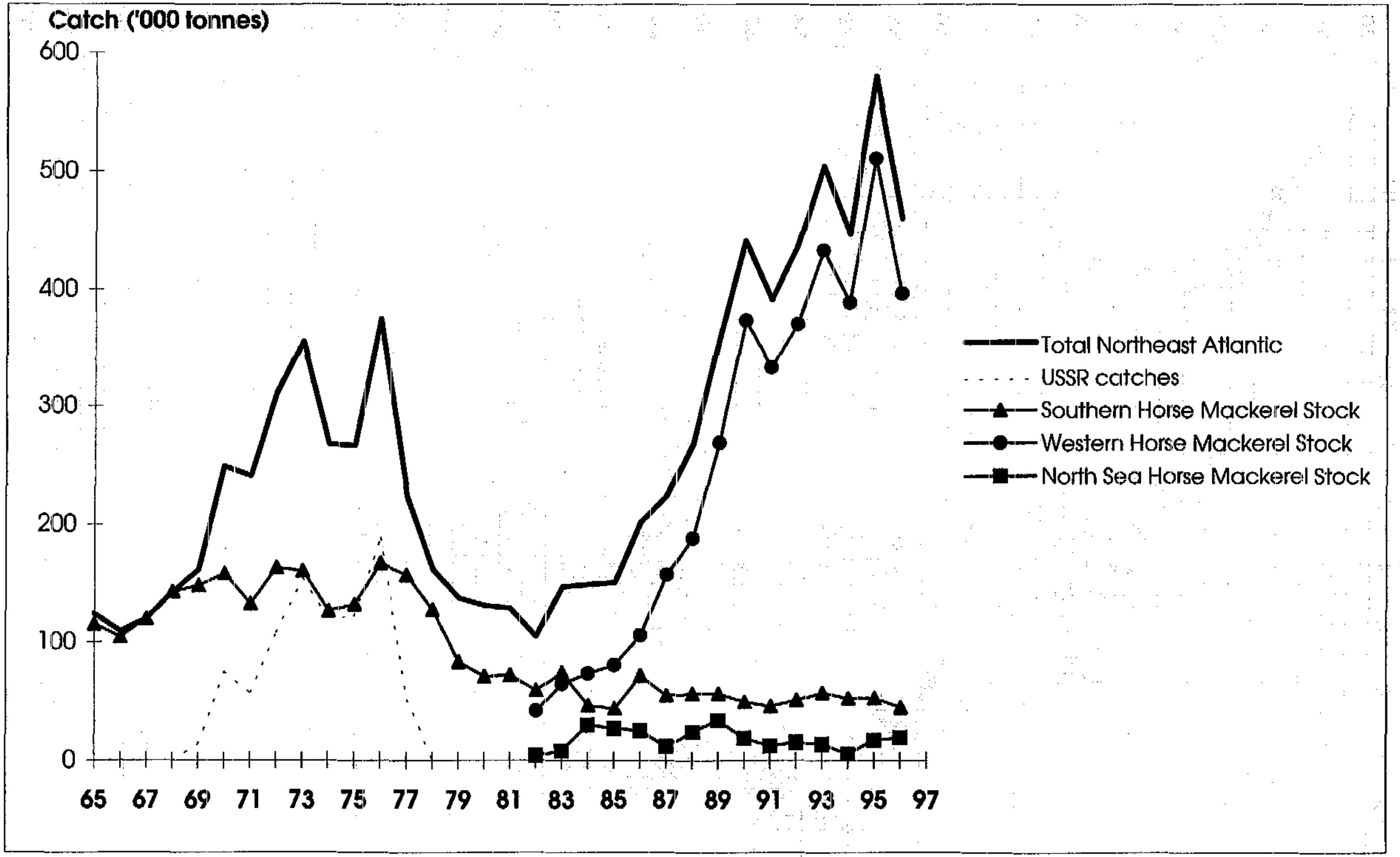

Figure 4.3.1 Total catches of horse mackerel in the northeast Atlantic during the period 1965 - 1996. The catches taken by the USSR and catches taken from the southern, western and North Sea horse mackerel stocks are shown in relation to the total catches in the northeast Atlantic.

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Horse Mackerel Quarter 1 1996

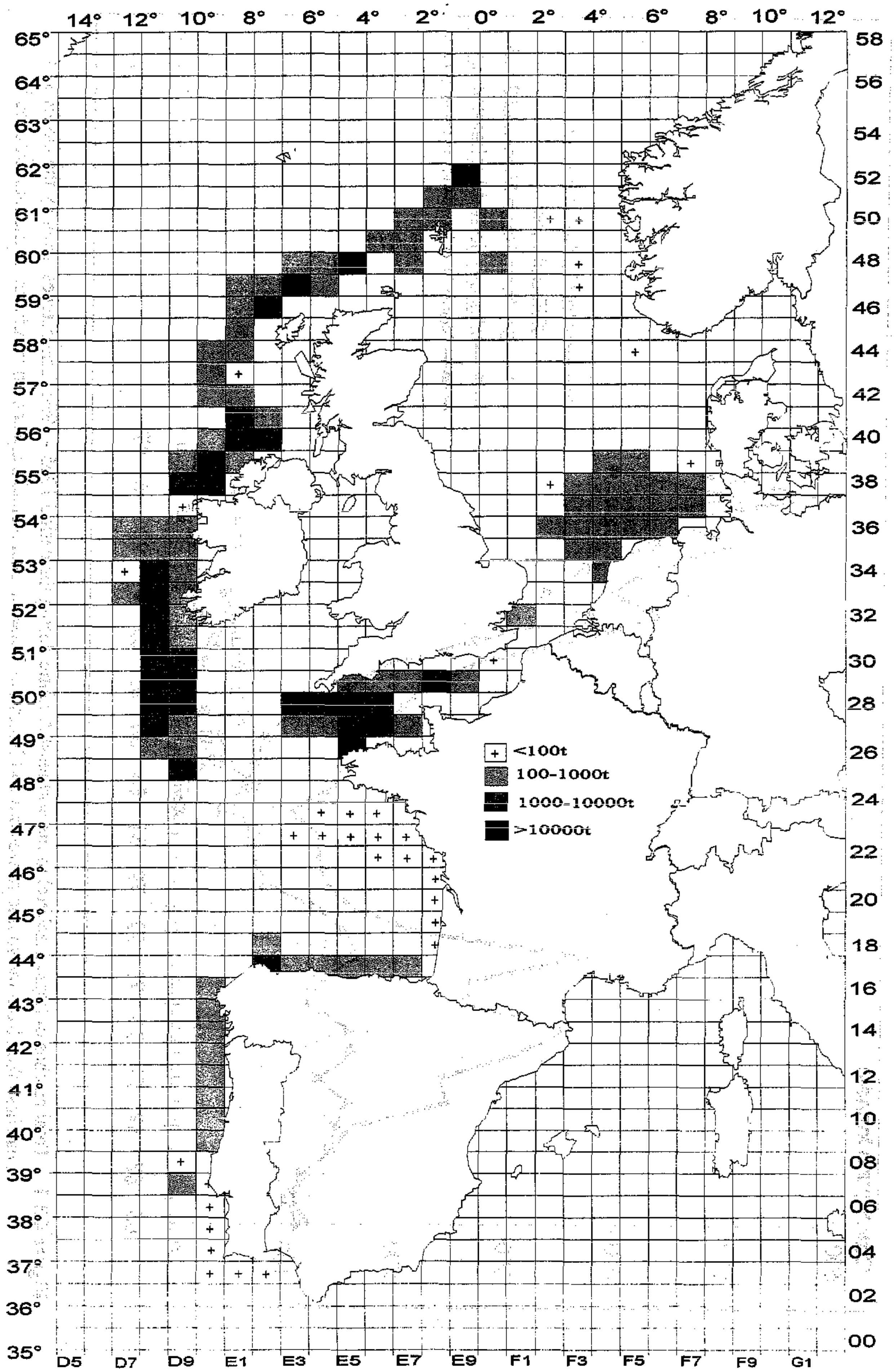

Figure 4.3.2.a

Horse Mackerel Quarter 2 1996

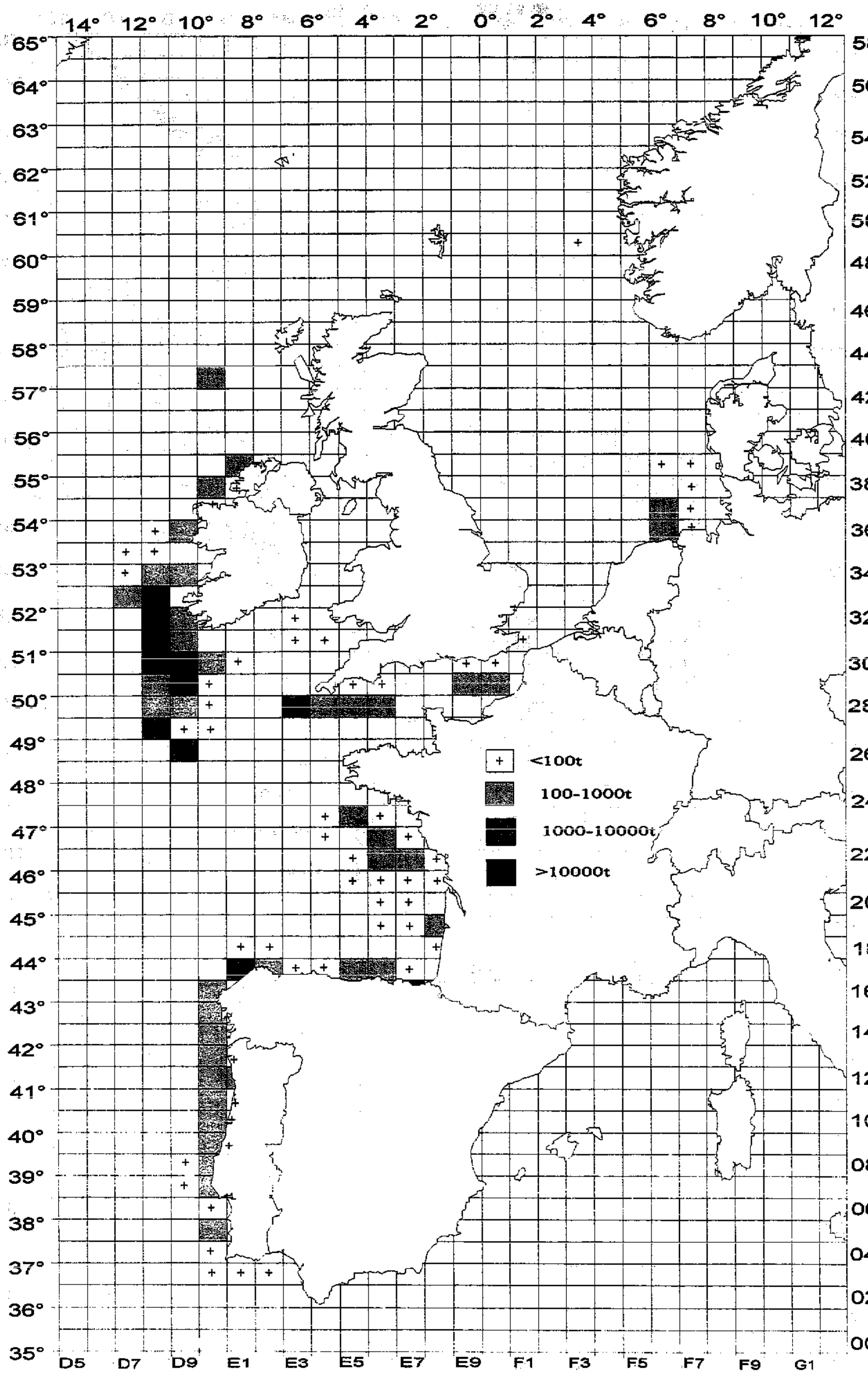

Figure 4.3.2.b

Horse Mackerel Quarter 3 1996

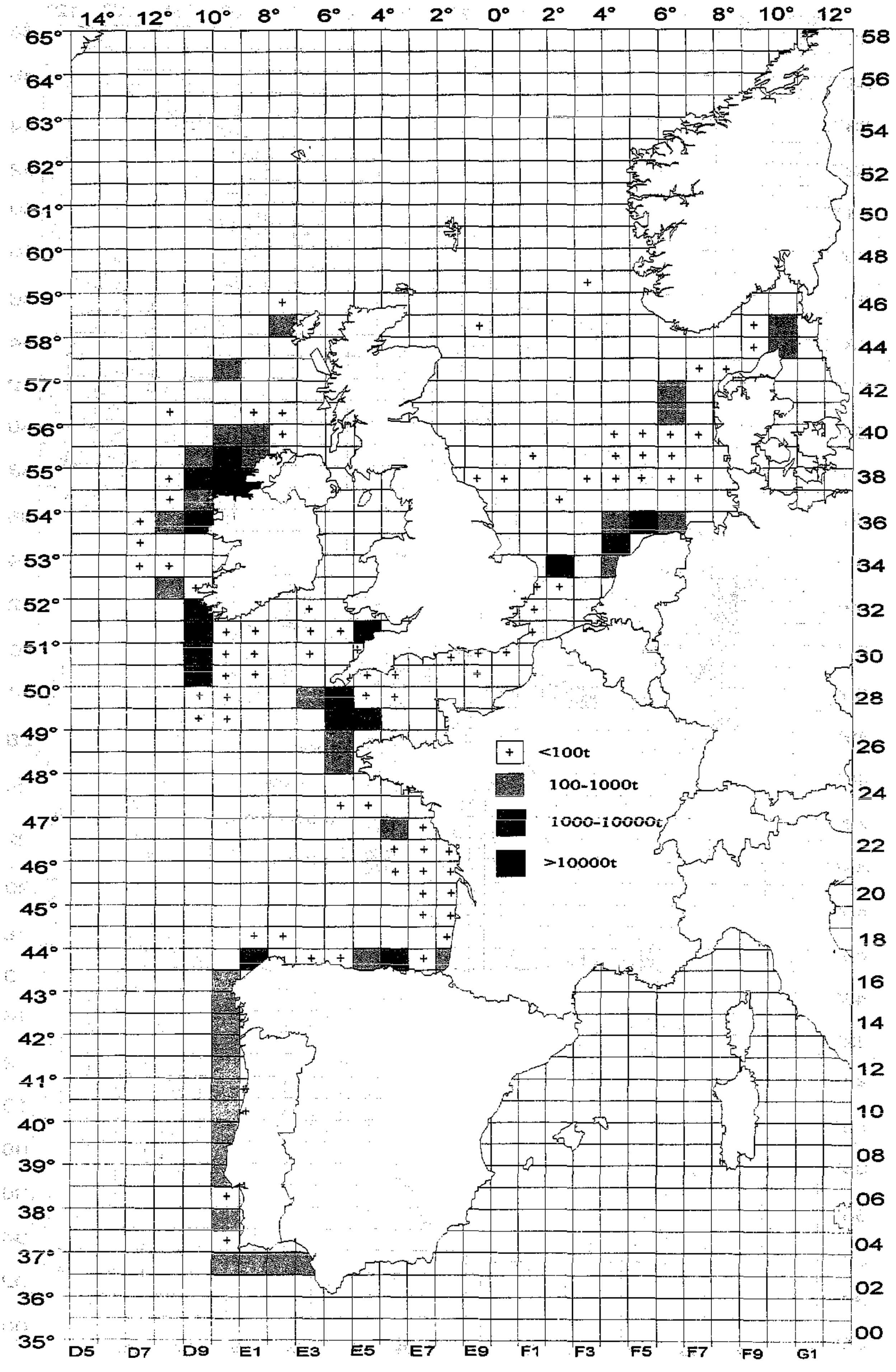

Figure 4.3.2.c

Horse Mackerel Quarter 4 1996

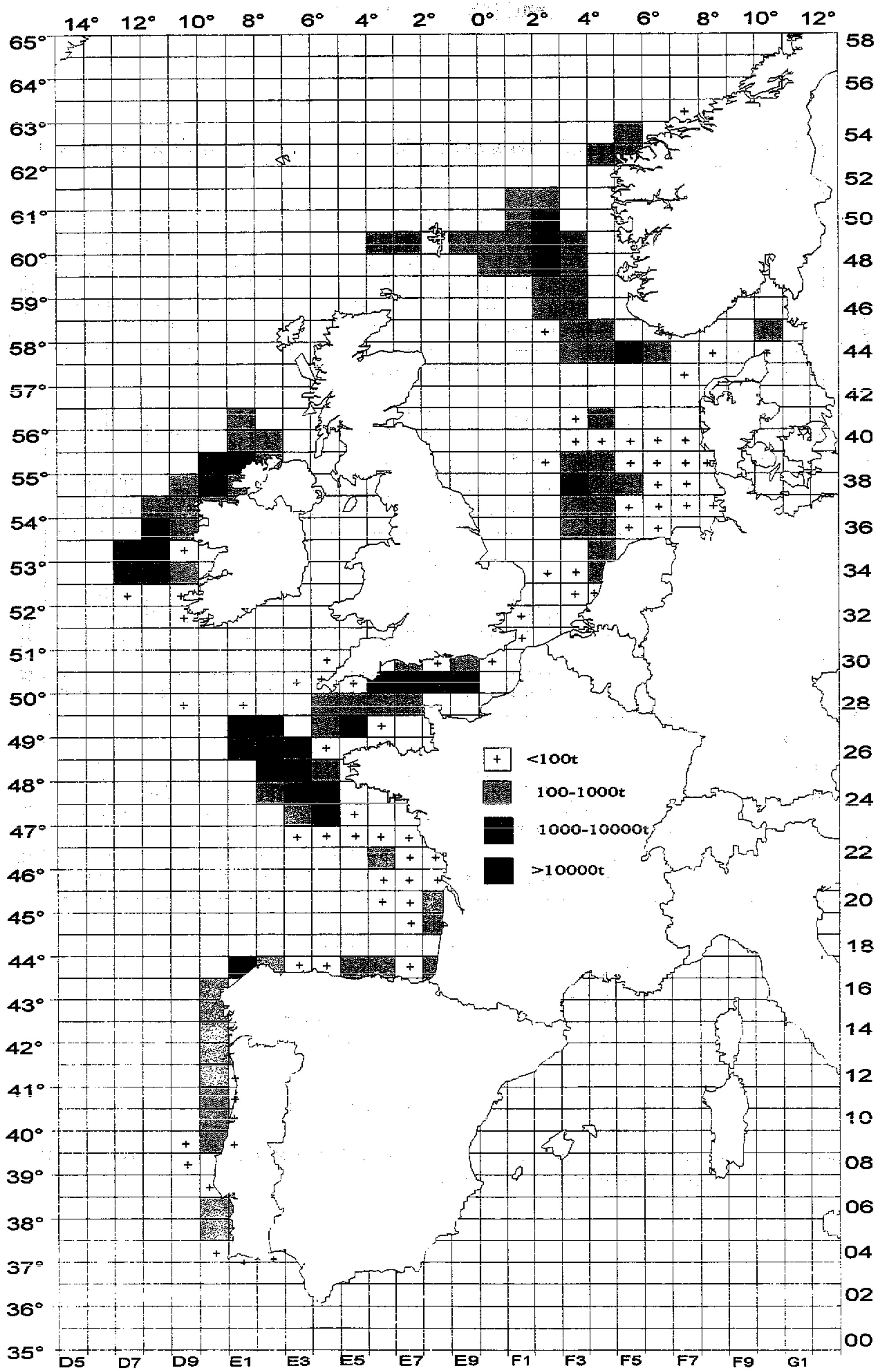

Figure 4.3.2.d

HORSE MACKEREL OTOLITH EXCHANGE 1996 SET A (against 'actual' age)

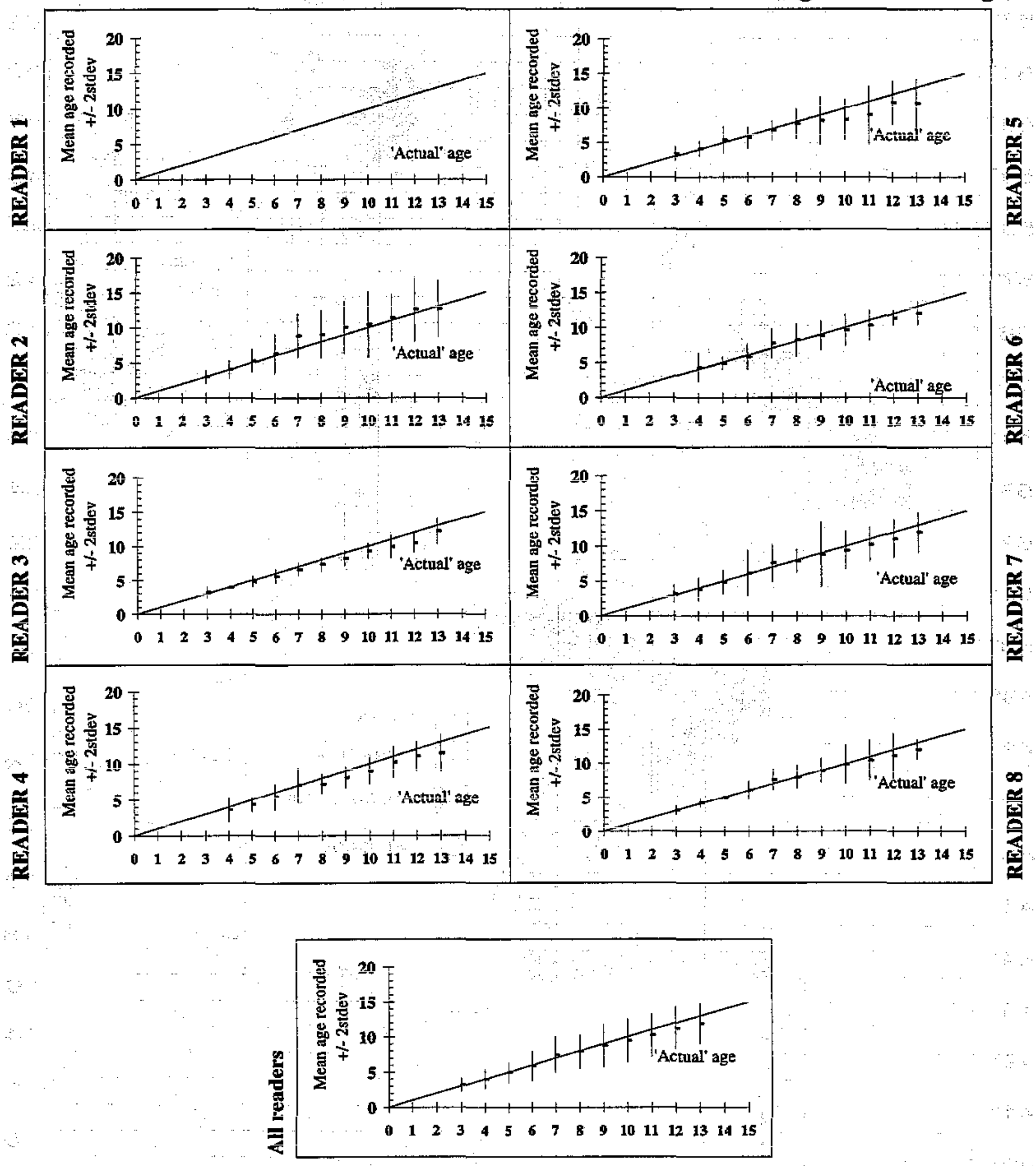

Figure 4.7.1 In above age bias plots the mean age recorded +/- 2stdev of each reader and of all readers combined is plotted against the 'actual' age.

HORSE MACKEREL OTOLITH EXCHANGE 1996 SET A (against modal age)

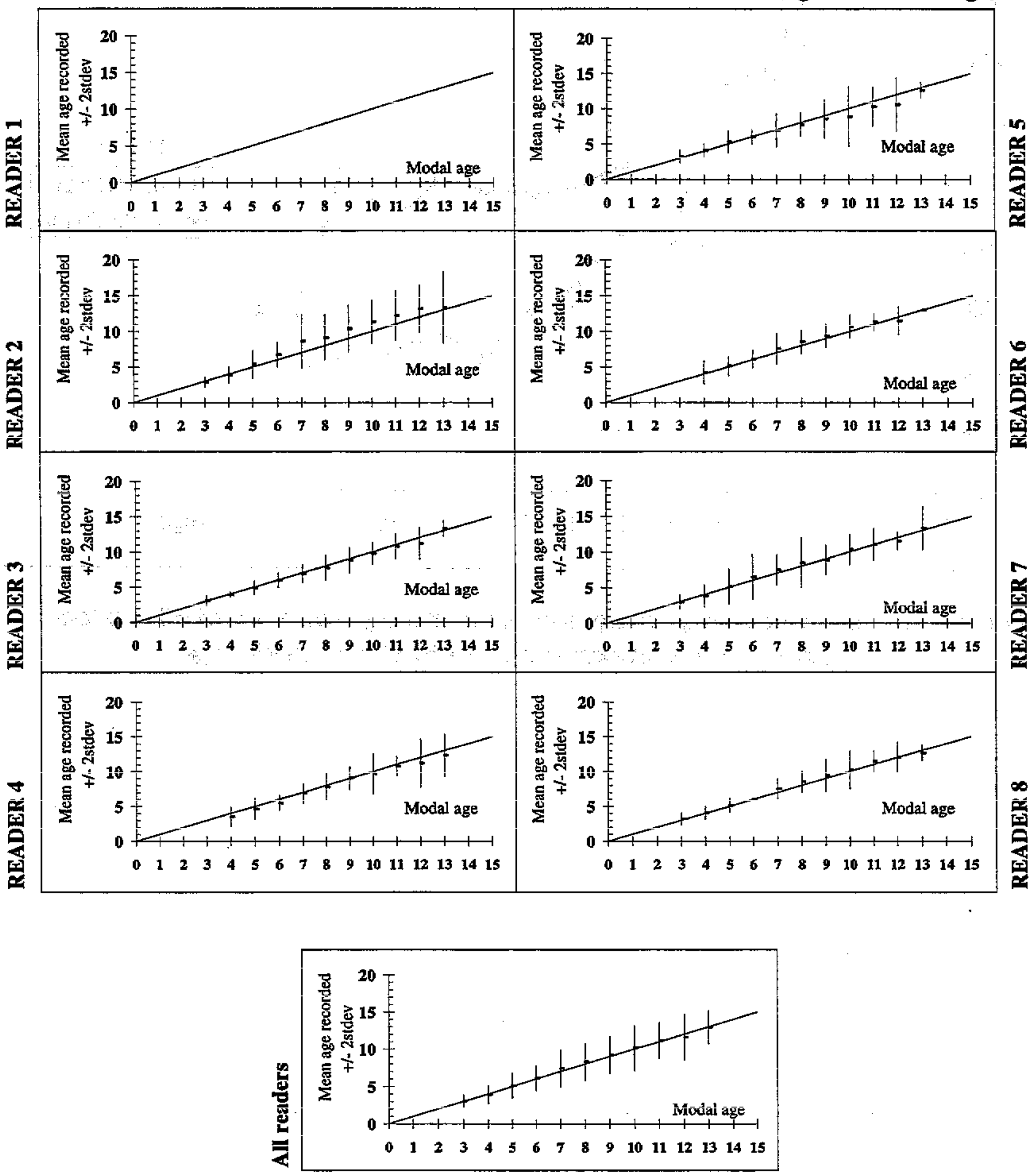

Figure 4.7.2 In above age bias plots the mean age recorded +/- 2stdev of each reader and of all readers combined is plotted against the 'actual' age.

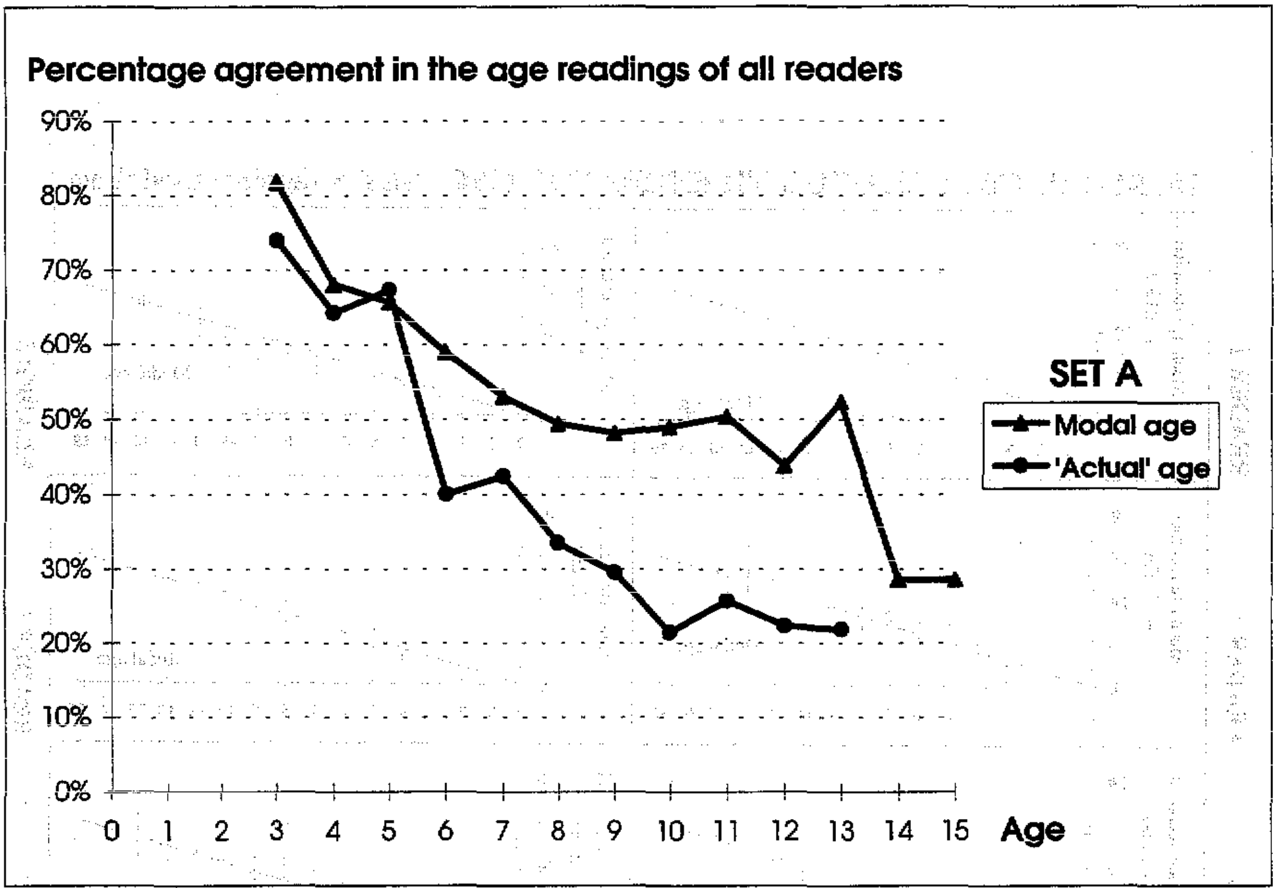

Figure 4.7.3 The percentage of agreement in the age readings of all readers obtained from comparisons to 'actual' and modal age.

e:\acfm\wgmhsa98\F-473.xls

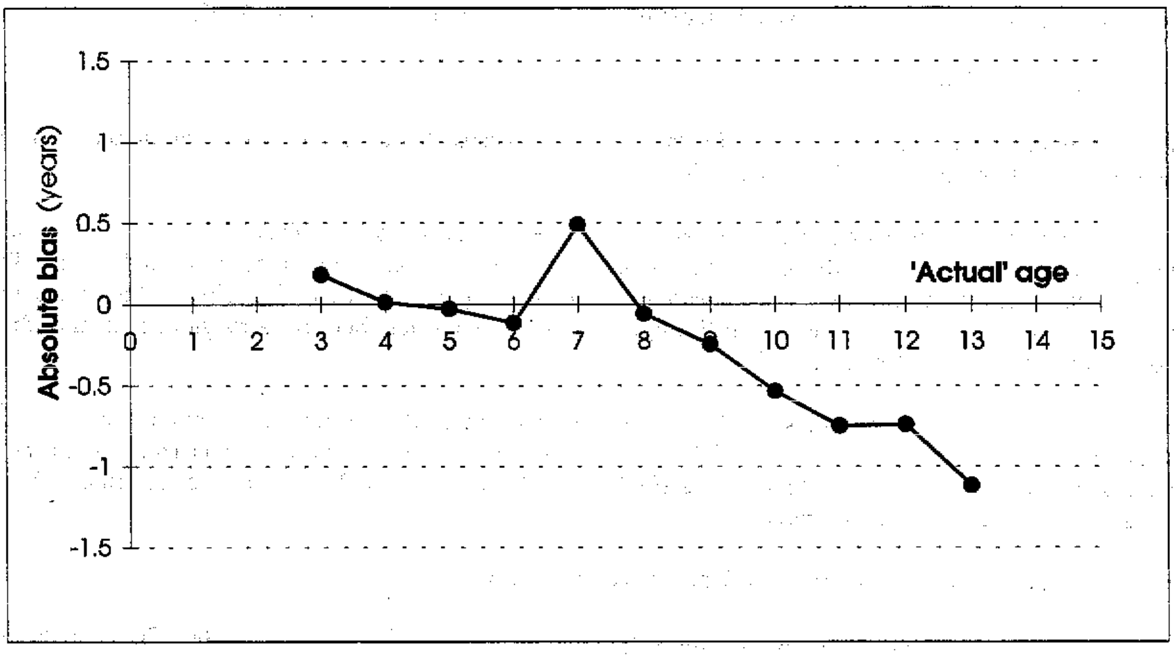

Figure 4.7.4 **The absolute bias is plotted as obtained from the mean of ages recorded compared to the 'actual' age (horse mackerel otolith exchange set A). Absolute bias is the bias in a comparison to true age.**

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5 NORTH SEA HORSE MACKEREL (DIVISIONS IIIa - EXCEPT WESTERN PART OF SKAGERRAK - IVb,c AND VIId)

5.1 The Fishery in 1996

The total catch taken from the North Sea and Division IIIa decreased considerably from 99,000 t in 1995 to 26,000 t in 1996. However, only catches taken in Divisions IIIa - except western part of Skagerrak - IVb,c and VIId are regarded as belonging to the North Sea horse mackerel stock (see Section 4.3). Table 4.3.1 shows the catches of this stock from 1982–1996. The total catch taken from this stock in 1996 was about 19,000 t, which is about the same as to the catch of about 17,000 t taken in 1995. In the latest years most of the catches from the North Sea stock were taken as a by-catch in the small mesh industrial fisheries in the fourth quarter carried out mainly in Divisions IVb and VIId. However, in 1995 and 1996 at least 70% of the catch has been taken for human consumption.

5.2 Fishery Independent Information

Horse mackerel egg surveys in the North Sea were carried out from 1988 to 1991 and the spawning stock biomass estimated were respectively 120, 217, 255 and 247 thousand tonnes (Eltink, 1992). The 1988 estimate was regarded as an underestimate. No egg surveys were carried out in the years 1992–1997.

5.3 Catch in Numbers at Age

Catch in number data are now provided for the first time, because the catch for human consumption increased above 70% both in 1995 and 1996 (Table 5.3.1).

Catch in number data were not provided in earlier years, because the majority of the catch was used for industrial purposes. For these earlier only age compositions were presented based on samples taken from the Dutch commercial catches and research vessel catches. These are available for the period 1987–1996. In the earlier years the Dutch samples cover only a small proportion of the total catch, but give a rough indication of the age composition of the stock (Figure 5.3.1).

The strength of the 1982 year class in the central and southern North Sea does not seem as strong as in the western area (compare Figure 5.3.1 with 6.3.1) and the 1987 year class can not be recognized as the strong year class that is in the western area. Year classes 1993 and 1994 are very abundant in the western catches, but year class 1993 only in the North Sea catches.

5.4 Mean Weight and Mean Length at Age in the Catch

Table 5.3.1 provides information on the mean length and mean weight in the catch in 1996. These are based on only Dutch samples from commercial and research vessels.

5.5 Assessment

As the available biological samples are not considered to be representative of the total catch, no estimates of the catch in numbers were made and it was not possible to do an analytical assessment.

The egg surveys carried out in 1989, 1990 and 1991 resulted in an average spawning stock biomass of 240,000 t over this period (Eltink, 1992).

The strong 1982 year class and relatively strong 1986 and 1989 year classes are recognized in the structure of the stock (Figure 5.3.1).

This stock appears to be underexploited based on the following evidence. The catch ranged from 4,000–33,000 t during the period 1982–1996, while the average SSB from the egg surveys from 1989–1991 was estimated at 240,000 t. There is a high catch of the 15 plus group (Figure 5.3.1). The Y/SSB ratio during the period of the 1989–1991 is only 0.09.

The Working Group recommends that more research be carried out on the North Sea horse mackerel stock in order to be able to assess this stock.

5.6 Reference Points for Management Purpose

Reference points and limits can not be defined with the very little current information about this stock.

5.7 Management Measures and Considerations

No forecast is available for 1998.

The Working Group recommends, that if a TAC is set for this stock, it should apply only to those areas where North Sea horse mackerel are fished, i.e. Divisions IVb,c, VIId, and Division IIIa.

Table 5.3.1 Catch in numbers ('000), mean length (cm) and mean weight (g) at age of NORTH SEA HORSE MACKEREL by quarter and by Division(s) in 1996.

1996 Age	IIIa 1'st Q catch('000)	IVb,c 1'st Q catch('000)	VIId 1'st Q catch('000)	All areas 1'st Q catch('000)
0	0	0	0	0
1	0	0	0	0
2	0	815	0	815
3	0	2,038	0	2,038
4	0	1,020	0	1,020
5	0	1,427	0	1,427
6	0	1,427	466	1,893
7	0	1,020	935	1,955
8	0	408	935	1,343
9	0	408	1,869	2,277
10	0	204	0	204
11	0	612	935	1,547
12	0	0	0	0
13	0	0	466	466
14	0	612	2,802	3,414
15+	0	204	3,270	3,474
Total	0	10,193	11,679	21,872
Tonnes	0	1,737	2,742	4,479

1996 Age	IIIa 1'st Q length(cm)	IVb,c 1'st Q length(cm)	VIId 1'st Q length(cm)	All areas 1'st Q length(cm)
0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0
2	0.0	22.5	0.0	22.5
3	0.0	24.0	0.0	24.0
4	0.0	25.3	0.0	25.3
5	0.0	25.9	0.0	25.9
6	0.0	26.8	26.5	26.7
7	0.0	27.1	27.0	27.1
8	0.0	28.0	27.5	27.7
9	0.0	28.0	28.8	28.7
10	0.0	28.5	0.0	28.5
11	0.0	30.2	29.5	29.8
12	0.0	0.0	0.0	0.0
13	0.0	0.0	29.5	29.5
14	0.0	31.2	31.0	31.0
15+	0.0	32.5	32.1	32.1
0-15+	0.0	26.4	30.0	28.3

1996 Age	IIIa 1'st Q weight(g)	IVb,c 1'st Q weight(g)	VIId 1'st Q weight(g)	All areas 1'st Q weight(g)
0	0	0	0	0
1	0	0	0	0
2	0	102	0	102
3	0	123	0	123
4	0	142	0	142
5	0	162	0	162
6	0	177	183	178
7	0	179	188	183
8	0	202	182	188
9	0	190	203	201
10	0	194	0	194
11	0	252	244	247
12	0	0	0	0
13	0	0	219	219
14	0	284	258	263
15+	0	325	268	271
0-15+	0	171	235	205

Age	IIIa 2'nd Q catch('000)	IVb,c 2'nd Q catch('000)	VIId 2'nd Q catch('000)	All areas 2'nd Q catch('000)
0	0	0	0	0
1	0	0	0	0
2	0	153	0	153
3	0	384	0	384
4	0	192	0	192
5	0	269	0	269
6	0	269	235	504
7	0	192	471	663
8	0	77	471	548
9	0	77	943	1,020
10	0	38	0	38
11	0	115	471	586
12	0	0	0	0
13	0	0	235	235
14	0	115	1,413	1,528
15+	0	38	1,650	1,688
Total	0	1,919	5,890	7,808
Tonnes	0	327	1,383	1,710

Age	IIIa 2'nd Q length(cm)	IVb,c 2'nd Q length(cm)	VIId 2'nd Q length(cm)	All areas 2'nd Q length(cm)
0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0
2	0.0	22.5	0.0	22.5
3	0.0	24.0	0.0	24.0
4	0.0	25.3	0.0	25.3
5	0.0	25.9	0.0	25.9
6	0.0	26.8	26.5	26.7
7	0.0	27.1	27.0	27.0
8	0.0	28.0	27.5	27.6
9	0.0	28.0	28.8	28.7
10	0.0	28.5	0.0	28.5
11	0.0	30.2	29.5	29.6
12	0.0	0.0	0.0	0.0
13	0.0	0.0	29.5	29.5
14	0.0	31.2	31.0	31.0
15+	0.0	32.5	32.1	32.1
0-15+	0.0	26.4	30.0	29.1

Age	IIIa 2'nd Q weight(g)	IVb,c 2'nd Q weight(g)	VIId 2'nd Q weight(g)	All areas 2'nd Q weight(g)
0	0	0	0	0
1	0	0	0	0
2	0	102	0	102
3	0	123	0	123
4	0	142	0	142
5	0	162	0	162
6	0	177	183	180
7	0	179	188	185
8	0	202	182	185
9	0	190	203	202
10	0	194	0	194
11	0	252	244	246
12	0	0	0	0
13	0	0	219	219
14	0	284	258	260
15+	0	325	268	269
0-15+	0	0	235	219

Age	IIIa 3'rd Q catch('000)	IVb,c 3'rd Q catch('000)	VIId 3'rd Q catch('000)	All areas 3'rd Q catch('000)
0	0	0	0	0
1	0	0	0	0
2	379	2,158	0	2,158
3	1,325	6,528	2	7,854
4	1,230	4,962	2	6,194
5	852	4,342	12	5,206
6	284	2,645	12	2,942
7	284	2,133	28	2,445
8	189	1,080	20	1,289
9	95	797	11	902
10	0	256	4	260
11	0	770	11	781
12	0	0	2	2
13	0	0	4	4
14	95	1,053	12	1,160
15+	0	256	14	271
Total	4,735	26,981	133	31,846
Tonnes	687	4,241	28	4,956

Age	IIIa 3'rd Q length (cm)	IVb,c 3'rd Q length (cm)	VIId 3'rd Q length (cm)	All areas 3'rd Q length(cm)
0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0
2	22.5	22.5	0.0	22.5
3	23.6	23.8	22.5	23.7
4	25.3	25.3	25.5	25.3
5	25.7	25.8	25.9	25.8
6	26.8	26.8	26.5	26.8
7	27.5	27.3	27.8	27.3
8	28.5	28.3	28.8	28.3
9	27.5	27.8	28.3	27.8
10	0.0	28.5	29.5	28.5
11	0.0	30.2	29.7	30.2
12	0.0	0.0	33.5	33.5
13	0.0	0.0	29.5	29.5
14	25.5	29.7	31.2	29.3
15+	0.0	32.5	32.4	32.5
0-15+	25.1	25.7	28.7	25.6

Age	IIIa 3'rd Q weight (g)	IVb,c 3'rd Q weight (g)	VIId 3'rd Q weight (g)	All areas 3'rd Q weight(g)
0	0	0	0	0
1	0	0	0	0
2	113	108	0	128
3	124	124	101	124
4	144	143	116	143
5	153	157	151	156
6	175	176	170	176
7	185	181	194	182
8	219	211	211	212
9	168	182	193	181
10	0	194	246	195
11	0	252	230	252
12	0	0	307	307
13	0	0	201	201
14	155	249	264	241
15+	0	325	285	322
0-15+	146	146	210	146

Age	IIIa 4'th Q catch('000)	IVb,c 4'th Q catch('000)	VIId 4'th Q catch('000)	All areas 4'th Q catch('000)
0	0	0	0	0
1	0	0	0	0
2	535	538	0	1,073
3	1,871	1,344	288	3,503
4	1,737	1,613	288	3,637
5	1,202	1,747	2,016	4,965
6	401	1,881	2,016	4,298
7	401	2,419	4,609	7,429
8	267	1,344	3,168	4,779
9	134	538	1,728	2,400
10	0	403	576	979
11	0	672	1,728	2,400
12	0	0	288	288
13	0	0	576	576
14	134	672	2,016	2,822
15+	0	269	2,304	2,573
Total	6,681	13,441	21,600	41,722
Tonnes	970	2,392	4,542	7,904

Age	IIIa 4'th Q length(cm)	IVb,c 4'th Q length(cm)	VIId 4'th Q length(cm)	All areas 4'th Q length(cm)
0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0
2	22.5	22.5	0.0	22.5
3	23.6	24.0	22.5	23.7
4	25.3	25.5	25.5	25.4
5	25.7	26.1	25.9	25.9
6	26.8	27.2	26.5	26.8
7	27.5	27.3	27.8	27.6
8	28.5	28.1	28.4	28.3
9	27.5	28.3	29.2	28.9
10	0.0	28.2	29.7	29.1
11	0.0	29.7	32.6	31.8
12	0.0	0.0	30.5	30.5
13	0.0	0.0	30.8	30.8
14	25.5	30.1	32.1	31.3
15+	0.0	31.5	29.6	29.8
0-15+	25.1	26.9	28.7	27.6

Age	IIIa 4'th Q weight(g)	IVb,c 4'th Q weight(g)	VIId 4'th Q weight(g)	All areas 4'th Q weight(g)
0	0	0	0	0
1	0	0	0	0
2	113	102	0	107
3	124	123	101	122
4	144	147	116	143
5	153	161	151	155
6	175	184	170	177
7	185	183	194	190
8	219	197	211	208
9	168	200	193	193
10	0	206	246	230
11	0	236	230	232
12	0	0	307	307
13	0	0	201	201
14	155	262	264	258
15+	0	286	285	285
0-15+	146	178	210	189

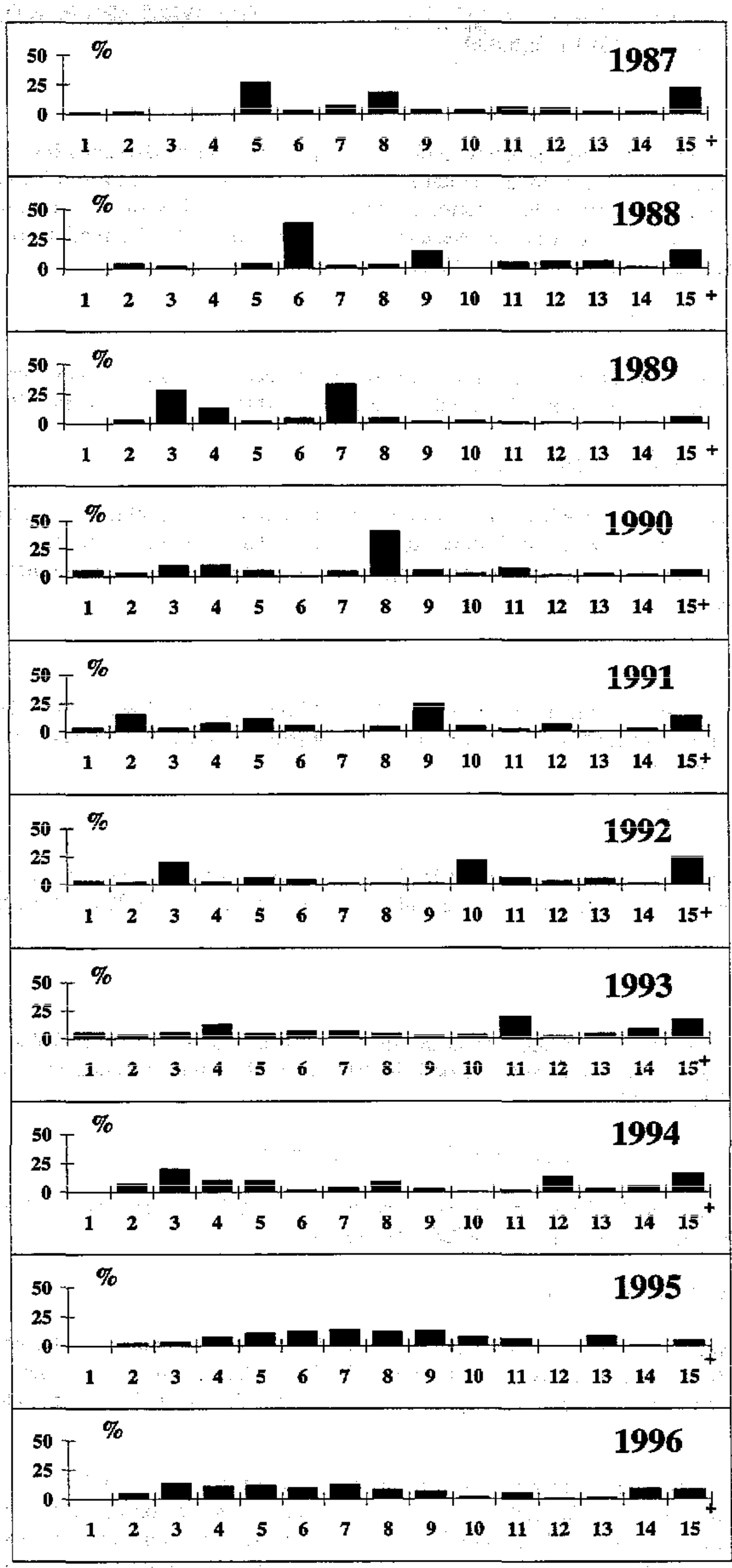

Figure 5.3.1 The age composition of the NORTH SEA HORSE MACKEREL based on commercial and research vessel samples from 1987-1996.

6 WESTERN HORSE MACKEREL (DIVISIONS IIa, IIIa (WESTERN PART), IVa, Vb, VIa, VIIa–c, VIIe-k, AND VIIIa,b,d,e)

6.1 The Fishery

The fishery for the western horse mackerel stock is mainly carried out in Divisions IIa, IVa, VIa, VIIe,g,h and VIIIa. The national catches taken by the countries fishing these areas are shown in Tables 6.1.1–6.1.5, while information on the development of the fisheries by quarter and division is shown in Table 4.4.1, Table 4.5.1 and in Figures 4.3.2a–d. Usually catches in the western part of Division IIIa has been allocated to the western stock. In 1996 no catches were taken in this part of that Division.

Sub-areas II and Division Vb

The national catches in this area are shown in Table 6.1.1. The catches in this area have varied from year to year. The catches dropped from the record high catch in 1995 of 14,000 t to about 3,400 t in 1996.

Sub-area IV and Division IIIa (western part)

The total catches in this area have been above or close to 100,000 t since 1989 to 1995 (Table 6.1.2). In 1996 the catches dropped by about 75%, mainly because considerable reduction in the Norwegian purse seine catch. This reduction might be caused by a lesser extensive migration into these areas due to environmental changes (Iversen *et al.* WD, 1997).

Sub-area VI

The catches in this area have increased from 21,000 t in 1990 to historical high level of 84,000 t in 1995 with a slight decline in 1996 to 81,000 t. (Table 6.1.3). The main part of the catches are taken in a directed Irish trawl fishery for horse mackerel.

Sub-area VII

The catches from this area are mainly taken in directed Dutch and Irish trawl fisheries in Divisions VIIb,e,h,j (Table 6.1.4). The catches increased to a historical high level in 1995 of 330,000 t and dropped by about 50,000 t in 1996.

Sub-area VIII

The catches from this area are mainly taken in Divisions VIIIa,b,d,e and given in Table 6.1.5. Historical high catches of more than 53,000 t were taken both in 1992 and 1993, then dropped to 29,000 tons in 1995 and increased to 48,000 t in 1996.

6.2 Fishery Independent Information from Egg -Surveys

As mentioned in Section 4.2.2 there are no new revisions of the SSB estimations based on egg surveys used by the assessment Working Group last year (ICES 1997/Assess:3).

6.3 Catch in Numbers at Age

As in previous years only two countries provide sample data with age readings, the Netherlands (Divisions VIa, Sub-areas IV, VII and VIII) and Norway (Division IIa, IVa). Catches from other countries were converted to numbers at age using the Dutch and Norwegian data. This means that about 57% of the catches were not sampled at all.

The catch in numbers at age by quarters and Divisions for western horse mackerel are shown in Table 6.3.1. The total annual catch in numbers for 1996 is shown in Table 6.4.3. The sampling intensity is discussed in Section 1.3. The 1982 year class has until last year (Figure 6.3.1) been the most numerous in the catches from the western stock. The age distributions of the catches in 1996 demonstrate that the relative proportion of the 1982 year class in the western catches is considerably reduced compared with previous years. The proportions of the 1993 and 1994 year classes are also relatively strong in the 1996 catches, indicating that these year classes might be strong.

6.4 Mean Length at Age and Mean Weight at Age

Mean weight and mean length at age in the catches in 1996

Mean weights and mean lengths at age in the catches by quarters in 1996 were provided only by Netherlands and Norway. These data were applied to the catches from other countries. The mean weight and mean length at age in the catches are shown in Tables 6.4.1, 6.4.2 and 6.4.3.

Mean weight at age in the stock

As for previous years the mean weight at age is based on all mature fish sampled from Dutch freezer trawlers the first and second quarter in Divisions VIIj,k. (Table 6.4.3).

Projected weights at age in catches and in the stock 1997–2002

Projected weights at age in the catches and weights at age in the stock are needed for the forecasts. The mean weights at age in the catch and in the stock for the period 1997–2002 for all ages except for the 1982 and 1987 year classes were set as the mean weights from 1994, 1995 and 1996. The weights at age in the catch and in the stock of the 1982 and 1987 year classes were obtained from extrapolated growth curves over the period 1997-2002. The mean weights at age in the catch and in the stock of the 1982 year class have been used for the 15+ group since the majority of this group consists of the 1982 year class. The projected weights at age in catches and stock for 1997–2002 are given in Table 6.7.2 and Table 6.7.3 respectively.

6.5 Maturity at Age

Fish which are mature were assumed to be either maturing prior to spawning, to be spawning or to have spawned in the current spawning season. Immature fish were not expected to do so. The definition of mature fish is changed because in the assessment the tuning takes place to the spawning stock biomass as estimated from the egg surveys. In this context the spawning stock biomass only includes fish which contribute to the annual egg production. Therefore fish, which are apparently maturing but which do not produce any eggs because of mass atresia, should not be included as mature fish. This will reduce the proportion mature of especially the ages 2 and 3.

The sampling for the proportion mature at age should be equally distributed over the total distribution area. In most cases the sampling scheme should be different for younger age groups since the distribution over the juvenile/adult areas differs by age group. However, the proportion mature at age for most species is estimated from fish samples from the commercial fleet, where no weighting of the fish samples by juvenile/adult area and by age group is applied. The proportion mature at age of the younger age groups is often overestimated because relatively too many samples are taken from the adult areas and not enough from the juvenile areas. Relatively more samples should be taken from the adult area when fish are older.

The maturity ogives of different species are in most cases based on macroscopically estimated maturity stages. However, histological analysis of the ovaries of younger fish shows that the macroscopically estimated proportion mature might be overestimated (ICES 1996/H:2, 1997/H:4).

Annual changes in the mean weights at age are expected to be related to annual changes in the maturity ogive. Therefore, the maturity ogive should be estimated for each year to take into account possible differences in growth rates.

The extremely abundant 1982 year class showed a very much retarded growth itself, but in addition it reduced the growth of all other year classes as well. In the earlier years the proportion mature at age of western horse mackerel was estimated from commercial samples, but in 1988 the maturity at age data set was revised based on mean length-at-age data taking into account that fish mature at 23–24 cm (ICES 1988/Assess:22). In 1990 the Working Group decided not to change the maturity at age, although the proportion mature of the 1982 year class in 1986 should be reduced from 0.6 to 0.1 if the spawning stock is to correspond with the estimate from the egg survey (ICES 1990/Assess:24). From 1987 onwards the proportion mature at age was not changed, because it could not be replaced by a more reliable data set. For the assessment and prediction the proportion mature at age was kept the same for the period 1996–2002 as for the period 1987–1995 (Table 6.7.4).

During the mackerel/horse mackerel egg surveys in 1998 horse mackerel will be collected to estimate the proportion mature by histological analysis to improve the maturity ogive (see Section 13).

6.6 Natural Mortality

For the first assessments of both western and southern horse mackerel a natural mortality of M = 0.2 was used in 1987 (ICES 1987/Assess:23). In 1989 M was reduced to 0.15 only for western horse mackerel, because of its longevity up to 30 years based on the ageing technique of counting each translucent ring as an annual ring in the broken/burnt otoliths (ICES 1989/Assess:19). However, M remained 0.2 for southern horse mackerel, because a large proportion of the Iberian catches consisted of juvenile fish and therefore were expected to suffer a much higher natural mortality than older fish. Furthermore M was kept high for southern horse mackerel because of a different ageing technique by which two translucent rings in an annual growth zone were counted once fish were spawning (ICES 1989/Assess:19). The age readings of older fish according to this technique were approximately a factor of 2 times lower. From 1992 onwards a natural mortality of 0.15 was also adopted for the assessment of the southern horse mackerel after the revision of the catch in numbers at age data series according to the ageing technique of counting each translucent ring as an annual ring (ICES 1992/Assess:17). A natural mortality of 0.15 has since been used for the assessments for both southern and western horse mackerel. The natural mortality of 0.15 may have been chosen too high for a fish with a present maximum observed age of 37 years. Horse mackerel is probably a less preferred prey by predators compared to mackerel. Stomach samples of white-sided dolphins obtained from catches in the Dutch mackerel and horse mackerel fisheries southwest of Ireland, indicate that there is a preference for mackerel compared to horse mackerel (Couperus, 1997). Mackerel is a species which lives in the same area as horse mackerel and which carries out similar migrations. Therefore, comparison of natural mortalities for both species seems appropriate. For the assessment of the northeast Atlantic mackerel an M of 0.15 is used, where the maximum age is approximately 20 years. This level of natural mortality agrees with estimates from the Norwegian tagging experiments (Hamre, 1978).

The natural mortality of horse mackerel is expected to be at least lower than that of mackerel. At last years Working Group meeting a the potential magnitude of bias for assumptions of the M of 50% higher and lower than the routinely used value of M = 0.15 was investigated (ICES 1997/Assess:3). These preliminary sensitivity results indicated that a lower M rate would reduce the substantial discrepancies between the model estimate of spawning stock biomass and the egg survey biomass estimate in 1983.

On account of this the Working Group decided to admit uncertainties in M in the range of 0.05 to 0.15. A longer time series of egg surveys would show more clearly how the discrepancies, that might exist between the estimates of spawning stock biomass estimates from the model and those obtained from the 1983, 1992, 1995 and 1998 egg surveys. Furthermore it was considered difficult to assume natural mortalities for the younger age groups (0- and 1-group), which are regarded to have a higher M. This is regarded to be more important for the assessment of the southern horse mackerel, since this is a directed fishery on the 1- and 2-group fish and regarded less important for the assessment of the western horse mackerel, which is mainly concentrated on 2-year and older fish.

6.7 Stock Assessment

A Bayesian approach has been used to calculate the stock assessment. This has been chosen as being an appropriate method of admitting perceived uncertainties in assumptions in the assessment, and of estimating uncertainties in the perceptions of stock size, and in short and medium-term forecasts. An accessible introduction to Bayesian methodology in a fisheries context is given by Hilborn and Walters (1992). Estimates calculated by this approach can reflect uncertainty in assumptions as well as noise in the data around a given structural model. One difference between the Bayesian and conventional approach is that no attempt is made to find a 'best' set of parameter estimates or 'best' VPA. Instead, over a wide range of plausible prior assumptions, the data are compared with the assessment model using a likelihood function. For any particular parameter such as spawning stock size or a future catch under a particular catch option, the perceived ('posterior') probability of each stock size or catch option can be calculated. It is not necessarily the case that the likeliest estimates of all the parameters, or even their expected values, should be consistent through a single calculation of the assessment model. This can happen because of nonlinearities and parameter correlations in the assessment model. The Working Group does not therefore provide a single 'final' VPA, but instead provides expected values and distribution percentiles for quantities judged to be of management interest.

The calculating mechanism is described briefly in Appendix 1 to this report, which is a summary of a description given in Patterson (1997).

As has been noted in two previous Assessment Working Group Reports (ICES 1996/H:2, ICES 1997/Assess:3) the assessment of Western Horse Mackerel presents peculiar and special difficulties. The stock is dominated by two cohorts, the extremely strong 1982 and the much less abundant 1987 recruitments comprising the bulk of the catches in recent years. Although there exist plausible catch-at-age data for the period 1982 to 1996 and there also exists a time-series of egg survey estimates of spawning biomass (ICES 1996/H:2) it is not a straightforward task to use the egg survey estimates to 'tune' a population model to the egg survey estimates. This is because maturation of horse mackerel appears to be density-dependent, and also because sampling for maturation is subject to unknown bias due to migration effects. Lastly, the assumption of natural mortality, M = 0.15 was made arbitrarily. Alternative choices of M were explored briefly by ICES (1997/Assess: 3) which suggested that lower rather than higher values of M may provide better fits of VPA-derived population models to egg survey biomass estimates.

The problematic nature of the assessment has led to rather poor consistency in advice. Estimates of the abundance of the 1982 year-class have been revised upwards successively by successive working groups, and as new egg survey estimates were added to the time-series, the perception of the precision of the earlier surveys was diminished.

Here an attempt is made to make a more comprehensive assessment of uncertainty in some quantities used for management purposes (spawning stock size, fishing mortality, F-status-quo catch) that includes uncertainty in some critical quantities (maturity ogive, natural mortality) that has up to now proven impossible for this stock. A Bayesian VPA-based method based on a Markov Chain Monte Carlo method similar to that used for Norwegian Spring-Spawning Herring (Patterson, 1997) is used. In addition to the age-structured observation data set, this requires the specification of prior distributions for quantities about which limited or subjective knowledge is available.

6.7.1 Model

6.7.1.1 Structural model for assessment

The underlying structural population model is of 'ADAPT' type structured so as to make all historic and recent population abundances and mortalities dependent on two parameters, being the abundance of fish aged 13 on 1 January 1997 and the natural mortality. The model is similar to that described by ICES (1997/Assess:3), albeit with slightly different exploitation pattern assumptions. The following constraints were imposed:

- Selection (relative fishing mortality) in 1996 and later years is constrained = 1 on ages 4 and older.
- Selection on ages 0 to 3 in 1996 is calculated by linear interpolation between 1 at age 4 and 0 at age 0.
- Fishing mortality on the oldest age taken as the arithmetic mean from age 6 to the penultimate true age in the catch at age matrix.
- Recruitments from 1993 to 1996 were modelled as a geometric mean of recruitments in the years 1981, 1983–1986 and 1988–1992 (see Section 6.8) in order to avoid inferring recent recruitments from a selection pattern assumption.

6.7.1.2 Probability model

The likelihood function is defined analogously to that for the conventional assessment, based on the lognormal distribution. With usual notation indexed by year y and age a, (Egg surveys U_y, Population abundance $N_{a,y}$, Maturity ogive O, fishing mortality F, natural mortality M, survey variance sigma and the proportions of fishing and natural mortality experienced before the time of the survey PF and PM):

$$P(\text{Data} \setminus \text{Model}) = \Pi_y \left(\frac{1}{U_y \sigma (2\pi)^{1/2}} \exp\left(-\frac{[\log(U_y / \Sigma_a N_{a,y} O_{a,y} W_{a,y} \exp(-PF.F_{a,y} - PM.M_{a,y}))]^2}{2\sigma^2} \right) \right)$$

6.7.2 Data and priors

6.7.2.1 Data assumed known precisely

Estimates of landings and estimates of catches at age in numbers, weights at age in the catches and weights at age in the stock were as described in Sections 6.3–6.5 and given in Tables 6.7.1 to 6.7.4.

6.7.2.2 Uncertainty in maturity

Relatively few proportions mature at age are relevant in the assessment, because of the existence of one extremely abundant cohort (1982 year class) and because of the availability of only triennial estimates of spawning stock biomass from egg surveys (1983, 1986, 1989, 1992 and 1995). The following assumptions for the prior distributions for maturity have been made, based on hypotheses about plausible maturities that are described in Section 6.5:

1. The strongest year class before the 1982 year class was the 1979 year class, which did not show a retarded growth until 1983. The percentage mature is assumed to be in the range of 75% to 100% with equal probability for all values.
2. Fish of the 1982 year class in 1983 at age 1 are assumed to be all immature, no uncertainty admitted.
3. Because of the retarded growth, the fish of the 1982 year class in 1986 and 1989 at respectively ages 4 and 7 are assumed to have a completely unknown maturity in the range of 0 to 100% with equal probability. It is assumed that the maturity in 1989 must be greater than in 1986.
4. Fish of the 1982 year class in 1992 at age 10 are assumed in the range of 80 to 100% mature with equal probability.
5. Fish of the year class 1992 in 1995 at age 3 are assumed to have a maturity in the range of 0 to 100%, but less mature than the 1979 year class in 1983.
6. Fish of the 1982 year class in 1995 at age 13 are assumed to be all mature with no uncertainty admitted.

These maturity assumptions described above were parameterised as follows, and depending on five parameters $X_{1\text{-}5}$:

$$MO(1983,4)=X_1$$
$$MO(1986,4)=X_2$$
$$MO(1989,7)=X_3(1-X_2)+X_2$$
$$MO(1992,10)=X_4$$
$$MO(1995,3)=X_5.X_1$$

In the 1996 assessment of this stock trials with M in the region +/- 50% around M=0.15 were made. Here we consider admissible hypotheses for M in the range 0.05 to 0.15, for reasons given in Section 6.6. No attempt was made to explore uncertainty about possible differences in natural mortality at age.

6.7.2.3 Egg survey precision

The coefficient of variation of the 1992 western horse mackerel egg survey estimates was estimated at between 18 and 22% depending on the analytic method used (ICES 1994/H:4).For present purposes the egg survey abundances estimates were assumed to be estimated with a CV of 25% on a lognormal distribution. No uncertainty was admitted in this variance estimate.

6.7.2.4 Summary of prior assumptions

The prior distributions are summarised in the text table below. All prior distributions are uniform.

Parameter		Lower Bound	Upper Bound	Comment
$N_{1997,14}$	Population Abundance (thousands)	1000	$8 . 10^9$	Unrestrictive, reference parameter for VPA
M	Natural Mortality	0.05	0.15	Range from long-lived species to mackerel assumptions
X_1	Maturity 1983 age 4	0.75	1.0	
X_2	Maturity 1986 age 4	0	1.0	
X_3	Maturity 1989 age 7, additional to maturity 1986 age 4	0	1.0	
X_4	Maturity 1992 age 10	0.8	1.0	
X_5	Relative Maturity 1995 age 3	0	1.0	

6.7.3 Perception of state of the stock

Posterior distributions for population abundance, natural mortality and spawning biomass in 1996 and 1997 (the latter predicated on an assumption of a catch of 400,000 t in 1997) are shown in Figure 6.7.1. The distribution of the ratio F/M is plotted because as both F and M are uncertain parameters, the distribution of F alone has an uncertain meaning. This shows that:

1. The data and model indicate values of natural mortality higher than 0.12 are improbable (P<0.95).
2. The lower limit of natural mortality is constrained by the prior assumptions, and the data and model do not give information about this lower limit.
3. Spawning stock size estimates of 936,000 t to 1,795,000 t (25th and 75th percentiles) in 1996 are calculated.
4. Estimates of the ratio of fishing mortality to natural mortality in 1996 1.67 to 3.30 (25th and 75th percentiles) are calculated.
5. The distribution of the estimate of spawning stock biomass in 1983, which has been used for reference purposes, is 705,000 t to 907,000t 30 (25th and 75th percentiles).

Perceptions of maturity parameter estimates (X_1 to X_5) are given in Figure 6.7.2. This shows that there is little information in the model and data about these parameters, with the exception that lower values of maturity of the age 4 fish in 1986 appear more likely.

Estimates of the historic development of the stock parameters are plotted in Figure 6.7.3, and the expectations and 5th, 25th, 50th, 75th and 95th percentiles of these distributions are given in Table 6.7.5. From Figure 6.7.3. it can be seen that the 1983 and 1986 egg survey observations lie outside the 95th percentile of the SSB distribution, indicating that even with the relaxation of assumptions allowed in this assessment compared with the conventional assessment procedure, the egg survey time series does not appear to be compatible with the reported catches, the VPA assumptions and the assumption of a 25% CV in egg survey estimates.

6.8 Short-Term Catch Prediction

A calculation of the consequences of different short-term catch options can be made from the Bayesian assessment, but a different presentation is necessary to take account of the fact that most of the important variables (stock size, natural mortality, fishing mortality etc.) are treated as stochastic and no attempt is made to find a joint maximum-likelihood solution: There is no 'final VPA' in the usual sense. Consequently, a stochastic version of the conventional catch option table has been calculated here.

The following assumptions were made in the calculations:

1. Recruitments in 1993 and later were treated as lognormal variates with mean and variance estimated from the mean and variance of the recruitments in 1981, 1983–1986 and 1988–1992. This treatment is as used by ICES (1997/Assess:3) and represents a cautious approach to modelling recruitment as the mean and variance of the weak year classes, ignoring the few stronger year classes.

2. Exploitation in 1997 and later was assumed to follow the selection pattern assumed for 1996.

3. Catches in 1997 were assumed to be 400,000 t, on the basis of a TAC of 300,000 t to be taken by EU countries and an additional catch of 100,000 t assumed to be taken by non-EU countries. A Norwegian catch was predicted of about 70,000 t in 1997 based on a correlation between the amount of fish entering Norwegian fishing areas and the influx of Atlantic water (Iversen *et al.*, 1997 WD). The assumption of 400,000 t in 1997 was thought preferable to an assumption of *status quo* fishing mortality, because such a mortality would imply much lower catches than those which are expected from this stock. Recent fishery statistics reported to the EU indicate that about 210,000 t had been taken by 1 August 1997, which leads to a belief that by October the full 300,000 t will be taken by the EU countries, and the total international catch may reach 400,000 t by the end of the year.

4. Weights at age in the stock and in the catch, and maturity in years 1997 and later, were taken as values as given in Tables 6.7.2, 6.7.3 and 6.7.4.

5. Options of F=M, and of Catch (1998) = Catch (1999) = 50, 100, 200, 300 and 400 thousand tonnes were simulated.

6. In the simulations, an upper bound restriction was placed on fishing mortality = 1.5, in order to avoid simulations of extreme fishing mortalities when a catch constraint is imposed on a stock size which has a stochastic distribution which may extend to low values (possibly lower than the putative catch constraint).

For each option, the expectation of spawning stock size in 1998 and 1999, and the 25th, 50th and 75th percentiles of the SSB distribution are tabulated. The risk that the stock size may fall under each of two reference levels. These reference levels are the model estimate of SSB in 1983 and a value of 500,000 t.

Presentation of the F=M-based option is somewhat complex, as both M and the F=M catch are here considered as uncertain. Here, for the F=M option, the distribution of corresponding SSB has been tabulated, and also the distribution of the corresponding catch. However, it would be incorrect to interpret the former as being conditional on the expectation of the latter.

This form of Bayesian catch option table is given as Table 6.8.1.

6.9 Medium-Term Projections

The outcome of some simple harvest strategies in the medium-term was evaluated by taking samples from the multivariate posterior distribution of parameters for the stock assessment, and projecting from each drawn parameter sample under the harvest control from 1998 until 2002.

The assumptions described in Section 6.7 were retained for all cases. The following scenarios were modelled, applying from 1998 onwards:

(1) Constant catch = 50, 100, 200, 300 or 400 thousand tonnes by year.
(2) Constant fishing mortality=natural mortality.

Some percentiles of the distribution of fishing mortality, recruitment, spawning stock size and landings, calculated under these assumptions, are given in Figures 6.9.1 to 6.9.6.

A calculation of risk was made for some levels of fishing mortality between 0.1M and 3M, expressed as the probability of the stock being under 500,000 t at spawning time in 2002. This calculation was made from estimates of the probability distribution of spawning stock size using the assumptions given above, but assuming exploitation between 1998 and 2002 = 0.1M, 0.25M, ... 3M. Risk so calculated is given in Figure 6.9.7.

6.10 Comparative Assessments

6.10.1 ADAPT maximum-likelihood assessment

A method to assess this stock is the 'ADAPT'-type method (Gavaris, 1988) in which an arbitrary choice of selection pattern is made. This method has been used at earlier Working Group meetings in 1994–1996 to estimate the size of this stock and associated mortality rates. This method is again used at this year's Working Group meeting for comparability with last years maximum-likelihood ADAPT assessment and with this years new Bayesian assessment (see Section 6.7). The Working Group considers that the Bayesian VPA provides an improved perception of uncertainty in the assessment compared to the traditional maximum-likelihood ADAPT. The use of this maximum-likelihood ADAPT method also allows estimation of some of the uncertainty in the assessment, and of the sensitivity of the assessment to the assumed selection pattern. As fishing mortality has historically been rather low in this stock, VPA 'convergence' does not help stabilise the analysis rapidly and hence the population model is likely to be strongly dependent on starting assumptions.

The model is a conventional VPA which is fitted by a non-linear minimisation of the sum of squares. Given population abundance N, fishing mortality F, natural mortality M, weights at age W, and maturity at age O, egg survey estimates of SSB U, and the proportion of fishing and natural mortality exerted before spawning PF and PM respectively, the VPA is fitted by minimising:

$$\sum_y (\ln(U_y) - \ln(\sum_{a,y} N_{a,y} . O_{a,y} . W_{a,y} . \exp(-PF. F_{a,y} - PM. M_{a,y}))^2$$

where subscripts a and y denote age and year respectively.

The model is fitted to the traditional egg production estimates of biomass (Table 6.10.3) only for the 1992 and 1995 estimates. At last year's meeting (ICES 1997/Assess:3) a calculation was made for illustrative purposes using GAM estimates of egg production (ICES 1996/H:2), but as these estimates have not yet been shown to be more accurate than traditional estimates of egg production, this calculation has been provided only to show the sensitivity of the assessment to the choice of method for calculating egg production (see Section 6.10.2).

Given the lack of age-structured surveys it is necessary to impose some constraints about the exploitation pattern on the model. Although some of these constraints are not very realistic there are insufficient observations available to make objective parameter estimations. These constraints are somewhat arbitrary:

- Selection pattern in 1996 and later years is equal to 1 on ages 4 and older (based on exploratory runs);
- Selection on ages 0 to 4 in 1995 and later years set to mean from previous 5 years 1991 to 1995 (the same as in last years assessment);
- Natural mortality, weights at age in the stock and in the catch are assumed to be known precisely;
- Maturity ogive is assumed to be known precisely;
- Fishing mortality on the oldest age taken as an arithmetic mean from age 6 to the penultimate true age in the catch at age matrix.

The choices made about constraints listed above were made after a number of exploratory model fits, which are documented in ICES (1996/Assess:7). As before, egg survey information prior to 1992 was excluded on account of uncertainty introduced by the unknown maturity of the 1982 cohort.

Input data for the assessment and projections is given in Table 6.7.1–6.7.4 and the fitted populations, fishing mortalities and stock sizes are given in Tables 6.10.1 and 6.10.2. Figure 6.10.1 shows the estimates of spawning stock biomass with egg survey estimates of 1992 and 1995, recruitment, catch and fishing mortality over the period 1982–1996. These data are also listed in Table 6.10.3.

<u>Short- and Medium-Term Predictions</u>

A very simple parametric bootstrap approach to the assessment of the consequences of management action under uncertainty is used here. Only uncertainty in the egg survey biomass estimates is considered, and all other parameters and observations are assumed to be known precisely and the model is assumed to be correctly formulated. This approach considerably underestimates the uncertainty in the stock projections, but is considered preferable to presenting a purely deterministic view of stock dynamics.

A catch of 400,000 t was assumed for 1997 (arguments for this are given in Section 6.8).

The ADAPT assessment model described above was used to fit 500 VPA populations to the catch at age data for each of 500 Monte-Carlo simulations of pseudo-egg surveys, assuming a lognormal error distribution and a coefficient of variation of 20%. The population vectors were then projected forwards through 1998 to 2002 under five constant-catch options ranging from 50,000 t to 400,000t annually and under a fishing mortality constraint of F = M = 0.15.

The conservative approach to modelling forthcoming recruitment used by ICES (1996/Assess:7) and ICES (1997/Assess:3) was retained here. Recruitments in 1996 and later years were assumed equal to the geometric mean of the weak year classes (1981, 1983–1986, 1988–1992) as estimated in the ADAPT procedure (= 1860 million), because the weak recruitments occur far more frequent than the strong ones.

Percentiles of the simulations of stock size falling above and below the 500,000 t (see Section 6.13) were used as estimates of the risk of the stock falling below this level. Results of these simulations are given in Figures 6.10.2–6.10.6. An additional simulation was calculated with a constant fishing mortality multiplier constraint (relative to 1996) corresponding to fishing at a target mortality of F = M = 0.15, beginning in 1998 (Figure 6.10.7). Table 6.10.4 shows the predicted spawning stock biomass and catches (medians) for the period 1998–2002.

The simulations indicate that for constant catch levels of 300,000 t or 400,000 t, both stock size and catch will decline rapidly in the forthcoming few years. If catches were to be reduced to 50,000 t to 200,000 t annually or if fishing mortality would be kept constant at F = M = 0.15, the decline would be somewhat slower. The associated risks to the stock, in terms of the probability that the stock will fall below 500,000 t in each forthcoming year, are plotted in Figures 6.10.2–6.10.7.

Fishing at a target fishing mortality rate of 0.15 leads to a slower decline in stock size and a lower risk of falling below 500,000 t, at a cost of a progressive reduction in catches from 221,000 t in 1998 down to 138,000 t in 2002 (Table 6.10.4). However, these calculations are sensitive to the assumed value for maximum fishing mortality imposed on the stock. This is particularly the case for higher levels of catch constraint, which cannot be maintained unless extremely high values of fishing mortality (in excess of 1.5) are allowed in the projections. Such values may not be feasible in practice. The consequences of attempting to remove catches exceeding 200,000 t cannot therefore be predicted in the medium term, but it appears likely that a rapid depletion in stock size would occur.

Table 6.10.4 shows for the fishing mortality constraint and for the different catch constraints in what year over the period 1998 to 2002 the spawning stock biomass is expected to have a 50% probability of falling below 500,000 t. This table also shows the corresponding catches related to the option of fishing mortality constraint F = M = 0.15. The calculations are also of course highly sensitive to the assumed values of natural mortality, which is not known for this stock. The probabilities of stock falling below 500,000 t are lower than those from the simulations from the Bayesian assessment (see Sections 6.7–6.9), because in the ADAPT based simulations only uncertainty was included in the biomass estimates from the egg surveys. The year classes 1993 and 1994 appear to be relatively strong according to the ADAPT analysis, however it should be taken into account that the calculations are very sensitive to the assumed exploitation pattern of 1996. Similarly the 1992 year class, which seemed to be strong in 1994 (Figure 6.3.1) appears both in the 1996 catches and in this assessment much weaker.

6.10.2 Comparison with GAM egg production estimate

Population parameter estimates obtained using GAM estimates of egg production were presented in last years report (ICES 1997/Assess:3, Figure 6.2). The assessment calculation was clearly very robust to the choice of either the traditional or the GAM estimates of egg production and the comparison was not carried out again at this year's meeting.

6.11 Long-Term Yield

Given the uncertainty, both to the mortalities and to the future recruitment, long-term yield has not been computed.

6.12 Uncertainty in Assessment

The assessment calculation expressed in Section 6.7 and concomitant forecasts in Sections 6.8 and 6.9. are made with an explicit consideration of perceived uncertainty in natural mortality, egg survey biomass estimates and in some maturity parameters. Distribution percentiles for various quantities from the assessment and short-term projection are given in Tables 6.7.5 and 6.8.1, which represents the best available estimates of quantified uncertainty. Distribution percentiles in medium-term forecasts are given in Section 6.9.1 to 6.9.6.

Additional, unquantified uncertainty exists. The following sources of uncertainty have not been taken into account in the assessment:

1. Uncertainty about reported catches;
2. Uncertainty about selection pattern assumptions, which have a strong effect on the estimation of recent recruitments;
3. Uncertainty in maturity, except for the years and ages mentioned in Section 6.7.2.2;
4. Uncertainty in stock weights and catch weights at age, either for the historic, measured values of for future, projected values;
5. Uncertainty in sampling and ageing commercial catches.

Despite the inclusion of many sources of uncertainty, the assessment model appears to be in conflict with the 1983 egg survey estimate (Figure 6.7.3).The causes for this are not known, but could be sought within (1) to (4) above.

6.13 Reference Points for Management Purposes

6.13.1 MBAL

This stock is characterised by infrequent, extremely large recruitments. As only a short time series of data are available, it is not possible to quantify stock-recruit relationships, but one may make the precautionary assumption that the likelihood of a strong year class appearing would decline if stock size were to fall lower than the stock size at which the only such event has been observed. This has been the basis for the historic assumption of the MBAL being the stock size in 1983.

As noted above, population model estimates of the SSB in 1983 differ from the egg survey biomass estimate. The model estimates are in the range 739 to 2,479 thousand t with 90% confidence, yet the egg survey biomass estimate was 530,000 t. In Section 6.12. it is noted that the assessment of uncertainty in the population model estimates is incomplete, and therefore it is proposed to retain the use of the egg survey biomass estimate as the reference value for MBAL. Conventionally this has been rounded to 500,000 t.

6.13.2 Fishing mortality reference points

The stock is at present in a transition from harvesting the large 1982 year class to a conservation strategy. At a later stage, a harvesting strategy will need to be provided, which can be applied when a new large year class appears.

Given the extreme dynamics of the stock it is inappropriate to attempt to calculate F_{msy}, F_{med} or F_{low} reference points over the short time-series available. Possibly useful reference points for management purposes might be F=M, F=2/3M or $F_{0.1}$. A probability distribution for estimates of $F_{0.1}$ and $F_{0.1}$ relative to M from the stock assessment is shown in Figure 6.13.1. The percentiles of the distribution $F_{0.1}$ relative to M are given in the text table below:

Expected	5%	25%	50%	75%	95%
1.21	0.99	1.10	1.21	1.34	1.45

This illustrates that even these measures may be problematic as management tools, due to the uncertainty of their estimates in this assessment.

6.13.3 B_{lim}, B_{pa} and F_{pa}

Given the extremely limited knowledge about parameters of stock dynamics the Working Group believes there exists insufficient basis in data to propose values of B_{pa}, B_{lim} or F_{pa}. The MBAL may continue to be a useful reference point which marks the region of wholly unknown stock dynamics.

6.14 Management considerations

Given the poor state of knowledge about the long-term dynamics of this stock, the Working Group suggests that management may wish to consider constant fishing mortality options in the range below natural mortality. According to the medium term predictions (Figures 6.9.1–6.9.7), this will imply a gradual decrease in the risk for the stock of falling below MBAL of 500,000 t in the years immediately after 1998. Both the medium-term projections and comparisons with other stocks suggest that fishing with F/M=1 would lead to precautionary management. Even in this range, however, it is estimated (based on the assumption of continued low recruitment) that the spawning stock size has a probability around 10% of falling under MBAL by 2002. The ADAPT-based predictions give a largely similar impression.

TAC has been overshot considerably since 1988 (ICES 1997/Assess:3). The Working Group advises that if a TAC is set for this stock, it should apply to all areas where western horse mackerel are caught, i.e. Divisions IIa, IIIa (western part), IVa, Vb, VIa, VIIa–c, VII e–k and VIIIa,b,d,e.

Table 6.1.1 Landings (t) of HORSE MACKEREL in Sub-area II. (Data as submitted by Working Group members.)

Country	1980	1981	1982	1983	1984
Denmark	-	-	-	-	-
France	-	-	-	-	1
Germany, Fed.Rep.	-	+	-	-	-
Norway	-	-	-	412	22
USSR	-	-	-	-	-
Total	-	+	-	412	23

Country	1985	1986	1987	1988	1989	1990
Faroe Islands	-	-	-	-	-	964[3]
Denmark	-	-	39	-	-	-
France	1	-[2]	-[2]	-[2]	-	-
Germany, Fed.Rep.	-	-	-	64	12	+
Norway	78	214	3,272	6,285	4,770	9,135
USSR	-	-	-	469	27	1,298
UK (England + Wales)	-	-	-	-	-	17
Total	79	214	3,311	6,818	4,809	11,414

	1991	1992	1993	1994	1995	1996[1]
	1,115[3]	9,157[3]	1,068	-	950	1,598
Denmark	-	-	-	-	200	-
France	-	-	-	55	-	-
Germany	-	-	-	-	-	-
Norway	3,200	4,300	2,100	4	11,300	887
Russia	172	-	-	700	1,633	881
UK (England + Wales)	-	-	-	-	-	-
Total	4,487	13,457	3,168	759	14,083	3,366

[1]Preliminary.
[2]Included in Sub-area IV.
[3]Includes catches in Division Vb.

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Table 6.1.2 Landings (t) of HORSE MACKEREL in Sub-area IV by country. (Data submitted by Working Group members).

Country	1980	1981	1982	1983	1984
Belgium	8	34	7	55	20
Denmark	199	3,576	1,612	1,590	23,730
Faroe Islands	260	-	-	-	-
France	292	421	567	366	827
Germany, Fed.Rep.	+	139	30	52	+
Ireland	1,161	412	-	-	-
Netherlands	101	355	559	2,029[4]	824
Norway	119	2,292	7	322	[4]
Poland	-	-	-	2	94
Sweden	-	-	-	-	-
UK (Engl. + Wales)	11	15	6	4	-
UK (Scotland)	-	-	-	-	3
USSR	-	-	-	-	489
Total	2,151	7,245	2,788	4,420	25,987

Country	1985	1986	1987	1988	1989
Belgium	13	13	9	10	10
Denmark	22,495	18,652[2]	7,290[2]	20,323[2]	23,329[2]
Estonia	-	-	-	-	-
Faroe Islands	-	-	-	-	-
France	298	231[3]	189[3]	784[3]	248
Germany, Fed.Rep.	+	-	3	153	506
Ireland	-	-	-	-	-
Netherlands	160[4]	600[4]	850[4]	1,060[4]	14,172
Norway[2]	203	776	11,728[5]	34,425[5]	84,161
Poland	-	-	-	-	-
Sweden	-	2[2]	-	-	-
UK (Engl. + Wales)	71	3	339	373	10
UK (N. Ireland)	-	-	-	-	-
UK (Scotland)	998	531	487	5,749	2,093
USSR	-	-	-	-	-
Unallocated + discards	-	-	-	-	-12,482[5]
Total	24,238	20,808	20,895	62,877	112,047

Country	1990	1991	1992[7]	1993	1994	1995	1996[1]
Belgium	13	-	+	74	57	51	28
Denmark	20,605[2]	6,982[2]	7,755	6,120	3,921	2,432	1,433
Estonia	-	-	293	-		17	-
Faroe Islands	942	340	-	360	275	-	-
France	220	174	162	302		-	-
Germany, Fed.Rep.	2,469[6]	5,995	2,801	1,570	1,014	1,600	7
Ireland	687	2,657	2,600	4,086	415	220	1,100
Netherlands	1,970	3,852	3,000	2,470	1,329	5,285	6,205
Norway[2]	117,903[2]	50,000[2]	96,000	126,800	94,000	84,747	14,639
Poland	-	-	-	-		-	-
Sweden	102	953[2]	800	697	2,087	-	95
UK (Engl. + Wales)	10	132	4	115	389	478	40
UK (N. Ireland)	-	350	-	-		-	-
UK (Scotland)	458	7,309	996	1,059	7,582	3,650	2,442
USSR	-	-	-	-		-	-
Unallocated + discards	-317[5]	-750[5]	-278	-3,270	1,511	-28	136
Total	145,062	77,994	114,133	140,383	112,580	98,505	26,125

[1]Preliminary. [2]Includes Division IIIa. [3]Includes Division IIa. [4]Estimated from biological sampling. [5]Assumed to be misreported. [6]Includes 13 t from the German Democratic Republic. [7]Includes a negative unallocated catch of -4,000 t.

Table 6.1.3 Landings (t) of HORSE MACKEREL in Sub-area VI by country. (Data submitted by Working Group members).

Country	1980	1981	1982	1983	1984	1985
Denmark	734	341	2,785	7	-	-
Faroe Islands	-	-	1,248	-	-	4,014
France	45	454	4	10	14	13
Germany, Fed. Rep.	5,550	10,212	2,113	4,146	130	191
Ireland	-	-	-	15,086	13,858	27,102
Netherlands	2,385	100	50	94	17,500	18,450
Norway	-	5	-	-	-	
Spain	-	-	-	-	-	
UK (Engl. + Wales)	9	5	+	38	+	996
UK (N. Ireland)						-
UK (Scotland)	1	17	83	-	214	1,427
USSR	-	-	-		-	-
Unallocated + discards						-19,168
Total	8,724	11,134	6,283	24,881	31,716	33,025

Country	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996[1]
Denmark	-	769	1,655	973	615	-	42	-	294	106	114
Faroe Islands	1,992	4,450[3]	4,000[3]	3,059	628	255	-	820	80	-	-
France	12	20	10	2	17	4	3	+	-	-	-
Germany, Fed. Rep.	354	174	615	1,162	2,474	2,500	6,281	10,023	1,430	1,368	943
Ireland	28,125	29,743	27,872	19,493	15,911	24,766	32,994	44,802	65,564	120,124	87,872
Netherlands	3,450	5,750	3,340	1,907	660	3,369	2,150	590	341	2,326	572
Norway	83	75	41	-	-	-	-	-	-	-	-
Spain	-[2]	-[2]	-[2]	-[2]	-[2]	1	3	-	-	-	-
UK (Engl. + Wales)	198	404	475	44	145	1,229	577	144	109	208	612
UK (N.Ireland	-	-	-	-	-	1,970	723	-	-	-	-
UK (Scotland)	138	1,027	7,834	1,737	267	1,640	86	4,523	1,760	789	2,669
USSR	-	-	-	-	44	-	-	-	-	-	-
Unallocated + discards	-13,897	-7,255	-	6,493	143	-1,278	-1,940	-6,960[4]	-51	-41,326	-11,523
Total	20,455	35,157	45,842	34,870	20,904	34,456	40,469	53,942	69,527	83,595	81,259

[1]Preliminary.
[2]Included in Sub-area VII.
[3]Includes Divisions IIIa, IVa,b and VIb.
[4]Includes a negative unallocated catch of -7,000 t.

Table 6.1.4 Landings (t) of HORSE MACKEREL in Sub-area VII by country. Data submitted by the Working Group members).

Country	1980	1981	1982	1983	1984
Belgium	-	1	1	-	-
Denmark	5,045	3,099	877	993	732
France	1,983	2,800	2,314	1,834	2,387
Germany, Fed.Rep.	2,289	1,079	12	1,977	228
Ireland	-	16	-	-	65
Netherlands	23,002	25,000	27,500[2]	34,350	38,700
Norway	394	-	-	-	-
Spain	50	234	104	142	560
UK (Engl. + Wales)	12,933	2,520	2,670	1,230	279
UK (Scotland)	1	-	-	-	1
USSR	-	-	-	-	-
Total	45,697	34,749	33,478	40,526	42,952

Country	1985	1986	1987	1988	1989
Faroe Islands	-	-	-	-	-
Belgium	+	+	2	-	-
Denmark	1,477[2]	30,408[2]	27,368	33,202	34,474
France	1,881	3,801	2,197	1,523	4,576
Germany, Fed.Rep.	-	5	374	4,705	7,743
Ireland	100	703	15	481	12,645
Netherlands	33,550	40,750	69,400	43,560	43,582
Norway	-	-	-	-	-
Spain	275	137	148	150	14
UK (Engl. + Wales)	1,630	1,824	1,228	3,759	4,488
UK (N.Ireland)	-	-	-	-	-
UK (Scotland)	1	+	2	2,873	+
USSR	120	-	-	-	-
Unallocated + discards	-	-	-	-	28,368
Total	39,034	77,628	100,734	90,253	135,890

Country	1990	1991	1992	1993	1994	1995	1996[1]
Faroe Islands	28	-	-	-	-	-	-
Belgium	+	-	-	-	1	-	-
Denmark	30,594	28,888	18,984	16,978	41,605	28,300	43,330
France	2,538	1,230	1,198	1,001	-	-	-
Germany, Fed.Rep.	8,109	12,919	12,951	15,684	14,828	17,436	15,949
Ireland	17,887	19,074	15,568	16,363	15,281	58,011	38,455
Netherlands	111,900	104,107	109,197	157,110	92,903	116,126	114,692
Norway	-	-	-	-	-	-	-
Spain	16	113	106	54	29	25	33
UK (Engl. + Wales)	13,371	6,436	7,870	6,090	12,418	31,641	28,605
UK (N.Ireland)	-	2,026	1,690	587	119	-	-
UK (Scotland)	139	1,992	5,008	3,123	9,015	10,522	11,241
USSR	-	-	-	-	-	-	-
Unallocated + discards	7,614	24,541	15,563	4,010[3]	14,057	68,644	26,795
Total	192,196	201,326	188,135	221,000	200,256	330,705	279,100

[1]Provisional.
[2]Includes Sub-area VI.
[3]Includes a negative unallocated catch of -4,000 t.

Table 6.1.5 Landings (t) of HORSE MACKEREL in Sub-area VIII by country. (Data submitted by Working Group members).

Country	1980	1981	1982	1983	1984
Denmark	-	-	-	-	-
France	3,361	3,711	3.073	2,643	2,489
Netherlands	-	-	-	-	-[2]
Spain	34,134	36,362	19,610	25,580	23,119
UK (Engl. + Wales)	-	+	1	-	1
USSR	-	-	-	-	20
Total	37,495	40,073	22,683	28,223	25,629

Country	1985	1986	1987	1988	1989
Denmark	-	446	3,283	2,793	6,729
France	4,305	3,534	3,983	4,502	4,719
Germany	-	-	-	-	-
Netherlands	-[2]	-[2]	-[2]	-	-
Spain	23,292	40,334	30,098	26,629	27,170
UK (Engl. + Wales)	143	392	339	253	68
USSR	-	656	-	-	-
Unallocated + discards	-	-	-	-	-
Total	27,740	45,362	37,703	34,177	38,686

Country	1990	1991	1992	1993	1994	1995	1996[1]
Denmark	5,726	1,349	5,778	1,955	-	340	140
France	5,082	6,164	6,220	4,010	28	-	7
Germany	-	80	62	-		-	-
Netherlands	6,000	12,437	9,339	19,000	7,272	-	14,187
Spain	25,182	23,733	27,688	27,921	25,409	28,349	29,428
UK (Engl. + Wales)	6	70	88	123	753	20	924
USSR	-	-	-	-		-	-
Unallocated + discards	1,500	2,563	5,011	700	2,038	-	3,583
Total	43,496	46,396	54,186	53,709	35,500	28,709	48,269

[1]Preliminary.
[2]Included in Sub-area VII.

Table 6.3.1 Catch in numbers ('000) at age of WESTERN HORSE MACKEREL by quarter and by Division(s) in 1996.

1996 Age	IIa 1'st Q catch('000)	IVa 1'st Q catch('000)	VIa 1'st Q catch('000)	VIIb,c,j,k 1'st Q catch('000)	VIIa,e,f,g,h 1'st Q catch('000)	VIIIa,b,d,e 1'st Q catch('000)	All areas 1'st Q catch ('000)
0	0	0	0	0	0	0	0
1	0	0	0	0	0	103	103
2	0	0	0	0	176,982	3,751	180,733
3	0	0	0	3,650	265,470	2,335	271,454
4	0	0	0	3,471	0	299	3,771
5	0	0	0	4,656	0	154	4,810
6	0	0	0	6,603	0	121	6,725
7	0	0	0	13,213	0	0	13,213
8	0	0	0	16,161	0	70	16,231
9	0	0	0	21,566	0	0	21,566
10	0	0	0	33,187	0	0	33,187
11	0	0	0	51,813	0	0	51,813
12	0	0	0	45,178	0	0	45,178
13	0	0	0	41,404	0	0	41,404
14	0	0	32,180	78,071	0	51	110,301
15+	0	0	57,258	20,180	0	0	77,438
Total	0	0	89,438	339,154	442,452	6,885	877,929
Tonnes	0	0	33,340	76,186	38,228	612	148,366

Age	IIa 2'nd Q catch('000)	IVa 2'nd Q catch('000)	VIa 2'nd Q catch('000)	VIIb,c,j,k 2'nd Q catch('000)	VIIa,e,f,g,h 2'nd Q catch('000)	VIIIa,b,d,e 2'nd Q catch('000)	All areas 2'nd Q catch ('000)
0	0	0	0	0	0	0	0
1	0	0	0	0	0	279	279
2	0	0	0	804	74,912	10,186	85,902
3	0	0	0	3,222	112,367	6,341	121,930
4	0	0	0	1,611	0	813	2,424
5	0	0	0	804	0	418	1,222
6	0	0	0	804	0	330	1,134
7	0	0	0	1,611	0	0	1,611
8	0	0	0	1,611	0	190	1,802
9	0	0	0	5,637	0	0	5,637
10	0	0	0	4,833	0	0	4,833
11	0	0	0	5,637	0	0	5,637
12	0	0	0	8,859	0	0	8,859
13	0	0	0	7,248	0	0	7,248
14	0	0	1,520	54,759	0	139	56,419
15+	0	0	2,705	23,355	0	0	26,060
Total	0	0	4,225	120,796	187,279	18,696	330,997
Tonnes	0	0	1,575	26,140	16,181	1,662	45,558

Age	IIa 3'rd Q catch('000)	IVa 3'rd Q catch('000)	VIa 3'rd Q catch('000)	VIIb,c,j,k 3'rd Q catch('000)	VIIa,e,f,g,h 3'rd Q catch('000)	VIIIa,b,d,e 3'rd Q catch('000)	All areas 3'rd Q catch ('000)
0	0	0	0	0	0	0	0
1	0	0	0	0	0	260	260
2	0	0	0	554	86,809	9,499	96,863
3	0	0	0	7,746	83,207	5,914	96,867
4	0	0	0	11,492	2,001	758	14,251
5	0	0	0	11,874	0	390	12,264
6	0	0	0	17,718	0	308	18,025
7	0	0	0	13,787	0	0	13,787
8	0	0	0	4,837	0	178	5,014
9	0	0	0	6,779	0	0	6,779
10	0	0	0	6,750	0	0	6,750
11	0	0	8,714	4,314	0	0	13,028
12	0	0	4,446	1,976	0	0	6,421
13	0	0	0	455	0	0	455
14	0	0	61,530	19,868	0	130	81,528
15+	0	0	35,211	2,485	0	0	37,696
Total	0	0	109,900	110,635	172,017	17,436	409,988
Tonnes	0	0	35,922	19,086	13,042	1,550	69,600

Age	IIa 4'th Q catch('000)	IVa 4'th Q catch('000)	VIa 4'th Q catch('000)	VIIb,c,j,k 4'th Q catch('000)	VIIa,e,f,g,h 4'th Q catch('000)	VIIIa,b,d,e 4'th Q catch('000)	All areas 4'th Q catch ('000)
0	0	0	0	0	0	0	0
1	0	0	0	0	0	3,395	3,395
2	0	0	0	0	128,187	124,075	252,262
3	0	0	0	582	273,231	77,240	351,053
4	0	0	0	1,152	125,550	9,905	136,607
5	0	0	0	0	44,536	5,092	49,628
6	5	96	0	582	15,354	4,018	20,055
7	0	0	0	1,722	18,264	0	19,986
8	8	144	0	2,304	21,268	2,320	26,044
9	12	226	0	1,152	8,821	0	10,211
10	100	1,900	0	0	1,668	0	3,668
11	33	616	2,540	6,330	9,050	0	18,568
12	60	1,144	1,296	582	1,668	0	4,750
13	6	122	0	582	5,097	0	5,807
14	1,702	32,195	17,935	10,356	31,697	1,697	95,582
15+	371	7,018	10,264	3,456	2771	0	23,880
Total	2,297	43,461	32,035	28,797	687,161	227,743	1,021,494
Tonnes	3,366	16,763	10,474	5,634	76,422	20,245	132,904

Table 6.4.1 Length (cm) at age of WESTERN HORSE MACKEREL by quarter and Division in 1996

1996 Age	IIa 1'st Q length(cm)	IVa 1'st Q length(cm)	VIa 1'st Q length(cm)	VIIb,c,j,k 1'st Q length(cm)	VIIa,e,f,g,h 1'st Q length(cm)	VIIIa,b,d,e 1'st Q length(cm)	All areas 1'st Q length(cm)
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	19.5	19.5
2	0.0	0.0	0.0	0.0	21.1	21.3	21.1
3	0.0	0.0	0.0	23.5	22.2	23.0	22.2
4	0.0	0.0	0.0	25.4	0.0	25.0	25.4
5	0.0	0.0	0.0	26.1	0.0	25.5	26.0
6	0.0	0.0	0.0	27.3	0.0	26.5	27.3
7	0.0	0.0	0.0	28.1	0.0	0.0	28.1
8	0.0	0.0	0.0	29.6	0.0	27.5	29.6
9	0.0	0.0	0.0	29.8	0.0	0.0	29.8
10	0.0	0.0	0.0	30.3	0.0	0.0	30.3
11	0.0	0.0	0.0	30.8	0.0	0.0	30.8
12	0.0	0.0	0.0	31.4	0.0	0.0	31.4
13	0.0	0.0	0.0	31.5	0.0	0.0	31.5
14	0.0	0.0	37.1	32.1	0.0	27.5	33.5
15+	0.0	0.0	37.3	33.6	0.0	0.0	36.3
0-15+	0.0	0.0	37.2	30.9	21.8	22.3	26.9

Age	IIa 2'nd Q length(cm)	IVa 2'nd Q length(cm)	VIa 2'nd Q length(cm)	VIIb,c,j,k 2'nd Q length(cm)	VIIa,e,f,g,h 2'nd Q length(cm)	VIIIa,b,d,e 2'nd Q length(cm)	All areas 2'nd Q length(cm)
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	19.5	19.5
2	0.0	0.0	0.0	23.5	21.1	21.3	21.1
3	0.0	0.0	0.0	24.0	22.2	23.0	22.3
4	0.0	0.0	0.0	25.0	0.0	25.0	25.0
5	0.0	0.0	0.0	25.5	0.0	25.5	25.5
6	0.0	0.0	0.0	26.5	0.0	26.5	26.5
7	0.0	0.0	0.0	27.5	0.0	0.0	27.5
8	0.0	0.0	0.0	28.0	0.0	27.5	27.9
9	0.0	0.0	0.0	28.4	0.0	0.0	28.4
10	0.0	0.0	0.0	28.7	0.0	0.0	28.7
11	0.0	0.0	0.0	29.9	0.0	0.0	29.9
12	0.0	0.0	0.0	30.8	0.0	0.0	30.8
13	0.0	0.0	0.0	30.8	0.0	0.0	30.8
14	0.0	0.0	37.1	31.2	0.0	27.5	31.3
15+	0.0	0.0	37.3	33.1	0.0	0.0	33.5
0-15+	0.0	0.0	37.2	30.7	21.8	22.3	25.3

Age	IIa 3'rd Q length (cm)	IVa 3'rd Q length (cm)	VIa 3'rd Q length (cm)	VIIb,c,j,k 3'rd Q length (cm)	VIIa,e,f,g,h 3'rd Q length (cm)	VIIIa,b,d,e 3'rd Q length (cm)	All areas 3'rd Q length(cm)
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	19.5	19.5
2	0.0	0.0	0.0	23.3	20.4	21.3	20.5
3	0.0	0.0	0.0	24.3	21.8	23.0	22.0
4	0.0	0.0	0.0	25.3	24.5	25.0	25.2
5	0.0	0.0	0.0	26.6	0.0	25.5	26.6
6	0.0	0.0	0.0	26.7	0.0	26.5	26.7
7	0.0	0.0	0.0	27.8	0.0	0.0	27.8
8	0.0	0.0	0.0	27.9	0.0	27.5	27.9
9	0.0	0.0	0.0	28.3	0.0	0.0	28.3
10	0.0	0.0	0.0	28.2	0.0	0.0	28.2
11	0.0	0.0	32.5	29.1	0.0	0.0	31.4
12	0.0	0.0	31.5	29.4	0.0	0.0	30.9
13	0.0	0.0	0.0	29.9	0.0	0.0	29.9
14	0.0	0.0	35.0	28.9	0.0	27.5	33.5
15+	0.0	0.0	34.4	29.2	0.0	0.0	34.1
0-15+	0.0	0.0	34.5	27.3	21.1	22.3	26.4

Age	IIa 4'th Q length(cm)	IVa 4'th Q length(cm)	VIa 4'th Q length(cm)	VIIb,c,j,k 4'th Q length(cm)	VIIa,e,f,g,h 4'th Q length(cm)	VIIIa,b,d,e 4'th Q length(cm)	All areas 4'th Q length(cm)
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	19.5	19.5
2	0.0	0.0	0.0	0.0	21.5	21.3	21.4
3	0.0	0.0	0.0	24.5	22.8	23.0	22.8
4	0.0	0.0	0.0	25.5	25.1	25.0	25.1
5	0.0	0.0	0.0	0.0	25.8	25.5	25.8
6	30.9	30.9	0.0	26.5	26.5	26.5	26.5
7	0.0	0.0	0.0	26.8	27.2	0.0	27.1
8	28.5	28.5	0.0	27.8	27.5	27.5	27.5
9	31.9	31.9	0.0	29.0	28.8	0.0	28.9
10	33.5	33.5	0.0	0.0	28.6	0.0	31.3
11	32.7	32.7	32.5	29.0	28.9	0.0	29.6
12	34.2	34.2	31.5	30.5	27.0	0.0	30.5
13	32.5	32.5	0.0	30.5	27.7	0.0	28.1
14	34.6	34.6	35.0	29.3	28.3	27.5	31.9
15+	36.4	36.4	34.4	28.8	31.3	0.0	33.8
0-15+	34.8	34.8	34.5	26.8	24.0	22.3	24.6

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Table 6.4.2 Weight (g) at age of WESTERN HORSE MACKEREL by quarter and by Division(s) in 1996.

1996 Age	IIa 1'st Q weight(g)	IVa 1'st Q weight(g)	VIa 1'st Q weight(g)	VIIb,c,j,k 1'st Q weight(g)	VIIa,e,f,g,h 1'st Q weight(g)	VIIIa,b,d,e 1'st Q weight(g)	All areas 1'st Q weight(g)
0	0	0	0	0	0	0	0
1	0	0	0	0	0	59	59
2	0	0	0	0	81	78	81
3	0	0	0	93	90	94	90
4	0	0	0	120	0	125	120
5	0	0	0	126	0	139	126
6	0	0	0	152	0	152	152
7	0	0	0	166	0	0	166
8	0	0	0	200	0	149	199
9	0	0	0	199	0	0	199
10	0	0	0	209	0	0	209
11	0	0	0	224	0	0	224
12	0	0	0	233	0	0	233
13	0	0	0	239	0	0	239
14	0	0	373	253	0	148	288
15+	0	0	376	299	0	0	356
0-15+	0	0	375	226	86	89	170

Age	IIa 2'nd Q weight(g)	IVa 2'nd Q weight(g)	VIa 2'nd Q weight(g)	VIIb,c,j,k 2'nd Q weight(g)	VIIa,e,f,g,h 2'nd Q weight(g)	VIIIa,b,d,e 2'nd Q weight(g)	All areas 2'nd Q weight(g)
0	0	0	0	0	0	0	0
1	0	0	0	0	0	59	59
2	0	0	0	87	81	78	81
3	0	0	0	90	90	94	90
4	0	0	0	104	0	125	111
5	0	0	0	107	0	139	118
6	0	0	0	121	0	152	130
7	0	0	0	151	0	0	151
8	0	0	0	139	0	149	140
9	0	0	0	161	0	0	161
10	0	0	0	178	0	0	178
11	0	0	0	196	0	0	196
12	0	0	0	213	0	0	213
13	0	0	0	215	0	0	215
14	0	0	373	224	0	148	228
15+	0	0	376	270	0	0	281
0-15+	0	0	375	216	86	89	137

Age	IIa 3'rd Q weight (g)	IVa 3'rd Q weight (g)	VIa 3'rd Q weight (g)	VIIb,c,j,k 3'rd Q weight (g)	VIIa,e,f,g,h 3'rd Q weight (g)	VIIIa,b,d,e 3'rd Q weight (g)	All areas 3'rd Q weight(g)
0	0	0	0	0	0	0	0
1	0	0	0	0	0	59	59
2	0	0	0	124	69	78	70
3	0	0	0	128	83	94	87
4	0	0	0	144	102	125	137
5	0	0	0	163	0	139	162
6	0	0	0	163	0	152	163
7	0	0	0	179	0	0	179
8	0	0	0	185	0	149	184
9	0	0	0	196	0	0	196
10	0	0	0	181	0	0	181
11	0	0	284	192	0	0	254
12	0	0	278	194	0	0	252
13	0	0	0	211	0	0	211
14	0	0	338	195	0	148	303
15+	0	0	326	193	0	0	317
0-15+	0	0	327	173	76	89	170

Age	IIa 4'th Q weight(g)	IVa 4'th Q weight(g)	VIa 4'th Q weight(g)	VIIb,c,j,k 4'th Q weight(g)	VIIa,e,f,g,h 4'th Q weight(g)	VIIIa,b,d,e 4'th Q weight(g)	All areas 4'th Q weight(g)
0	0	0	0	0	0	0	0
1	0	0	0	0	0	59	59
2	0	0	0	0	78	78	78
3	0	0	0	145	91	94	92
4	0	0	0	153	124	125	125
5	0	0	0	0	138	139	138
6	291	291	0	170	147	152	149
7	0	0	0	167	159	0	159
8	275	275	0	185	162	149	163
9	309	309	0	210	181	0	187
10	343	343	0	0	172	0	265
11	317	317	284	199	192	0	211
12	371	371	278	229	138	0	246
13	319	319	0	211	172	0	179
14	381	381	338	207	181	148	284
15+	437	437	326	192	241	0	331
0-15+	386	386	327	196	111	89	128

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Table 6.4.3 Catch i numbers, mean length and mean weight in catch and mean weight in stock of western horse mackerel 1996.

Age	Catch in numbers (millions)	Mean length (cm)	Mean weight (kg) in catch	in stock
0	0.000			
1	4.036	19.5	0.059	
2	615.759	21.1	0.078	0.087
3	841.304	22.5	0.090	0.095
4	157.053	25.1	0.125	0.118
5	67.924	25.9	0.141	0.129
6	45.939	26.7	0.155	0.148
7	48.597	27.6	0.166	0.172
8	49.091	28.3	0.177	0.183
9	44.193	29.2	0.191	0.185
10	48.439	29.9	0.206	0.202
11	89.046	30.6	0.224	0.206
12	65.209	31.2	0.233	0.217
13	54.915	31.0	0.229	0.221
14	343.831	32.7	0.280	0.237
15+	165.073	35.0	0.332	0.273

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Table 6.7.1. Western Horse Mackerel. Estimated catch in number (Thousands of fish).

The SAS System 09:57 Friday, September 12, 1997

HOM-WEST: Western horse mackerel (IIa,IVa,VIa,VIIa-c,e-k,VIIIa-b,d-e)

CANUM: Catch in Numbers (Thousands)

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15
1982	0	2523	14320	91566	7825	8968	7979	6013	1122	281	1122	4473	12560	19489	13205	5579
1983	0	5668	1627	23595	38374	11005	31942	37775	12854	2360	3948	2428	12204	17142	27505	33335
1984	0	0	183682	3378	27621	114001	17009	29105	25890	11230	3121	0	486	1337	3866	38732
1985	0	1267	3802	467741	3462	32441	77862	9808	12545	4809	7155	263	659	2888	970	27005
1986	0	0	0	1120	489397	6316	47149	79428	18609	15328	11052	2255	746	619	211	37295
1987	0	83	414	0	2476	748405	1730	34886	76224	9854	8015	16252	7484	1173	168	27613
1988	767	23975	5354	1839	3856	16616	824940	10613	34963	59452	8531	14301	15158	4537	4285	28378
1989	0	0	0	18860	16604	4821	13169	1159554	10940	53909	75496	12629	21975	12471	8162	16468
1990	0	19117	42191	130153	57561	31195	9883	19305	1297370	34673	66058	95505	14040	32496	16935	53023
1991	3230	19570	47240	13980	187410	126310	68330	19000	21090	1173940	21140	13060	51200	9710	9000	49400
1992	12420	83830	24040	66180	50210	243720	110620	42840	14202	17930	1063910	12000	22750	69970	12110	32200
1993	0	94250	49520	7700	52870	83770	307370	124050	65790	25250	3250	1177060	6420	16110	52610	33490
1994	2315	15324	796606	104631	49463	40466	26961	205842	87767	37045	40453	21847	909325	9861	14411	37138
1995	0	50843	411412	382838	198181	52812	85565	26425	230028	107838	95799	58051	62531	1044929	38647	149957
1996	0	4036	615759	841304	157053	67924	45939	48597	49091	44193	48439	89046	65209	54915	343831	165073

Table 6.7.2. Western Horse Mackerel. Estimated mean weight in the catches (Kg).

The SAS System 09:57 Friday, September 12, 1997

HOM-WEST: Western horse mackerel (IIa,IVa,VIa,VIIa-c,e-k,VIIIa-b,d-e)

WECA: Mean Weight in Catch (Kilograms)

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15
1982	0.015	0.054	0.090	0.142	0.178	0.227	0.273	0.276	0.292	0.305	0.369	0.348	0.348	0.348	0.356	0.366
1983	0.015	0.039	0.113	0.124	0.168	0.229	0.247	0.282	0.281	0.254	0.260	0.300	0.310	0.315	0.311	0.332
1984	0.015	0.034	0.073	0.089	0.130	0.176	0.216	0.245	0.278	0.262	0.259	0.255	0.344	0.232	0.306	0.308
1985	0.015	0.029	0.045	0.087	0.150	0.156	0.199	0.243	0.256	0.294	0.257	0.241	0.251	0.314	0.346	0.321
1986	0.015	0.029	0.045	0.110	0.107	0.171	0.196	0.223	0.251	0.296	0.280	0.319	0.287	0.345	0.260	0.360
1987	0.015	0.068	0.067	0.110	0.155	0.143	0.174	0.198	0.249	0.264	0.321	0.336	0.244	0.328	0.245	0.373
1988	0.015	0.031	0.075	0.114	0.132	0.147	0.157	0.240	0.304	0.335	0.386	0.434	0.404	0.331	0.392	0.424
1989	0.012	0.050	0.075	0.149	0.142	0.142	0.220	0.166	0.258	0.327	0.330	0.381	0.400	0.421	0.448	0.516
1990	0.015	0.032	0.031	0.090	0.124	0.126	0.129	0.202	0.183	0.227	0.320	0.328	0.355	0.399	0.388	0.379
1991	0.012	0.031	0.046	0.113	0.125	0.148	0.141	0.144	0.187	0.185	0.215	0.303	0.323	0.354	0.365	0.330
1992	0.008	0.014	0.092	0.117	0.139	0.143	0.157	0.163	0.172	0.235	0.222	0.288	0.306	0.359	0.393	0.401
1993	0.010	0.033	0.083	0.120	0.126	0.142	0.154	0.163	0.183	0.199	0.177	0.238	0.308	0.327	0.376	0.421
1994	0.021	0.037	0.052	0.106	0.124	0.158	0.153	0.167	0.194	0.199	0.280	0.275	0.240	0.326	0.342	0.383
1995	0.015	0.038	0.052	0.073	0.089	0.126	0.130	0.170	0.176	0.200	0.204	0.222	0.215	0.246	0.237	0.298
1996	0.015	0.059	0.078	0.090	0.125	0.141	0.155	0.166	0.177	0.191	0.206	0.224	0.233	0.229	0.280	0.332
1997	0.017	0.045	0.061	0.090	0.112	0.142	0.146	0.168	0.182	0.197	0.208	0.241	0.229	0.268	0.286	0.266
1998	0.017	0.045	0.061	0.090	0.112	0.142	0.146	0.168	0.182	0.197	0.230	0.220	0.229	0.268	0.286	0.271
1999	0.017	0.045	0.061	0.090	0.112	0.142	0.146	0.168	0.182	0.197	0.230	0.241	0.233	0.268	0.286	0.274
2000	0.017	0.045	0.061	0.090	0.112	0.142	0.146	0.168	0.182	0.197	0.230	0.241	0.229	0.243	0.286	0.278
2001	0.017	0.045	0.061	0.090	0.112	0.142	0.146	0.168	0.182	0.197	0.230	0.241	0.229	0.268	0.252	0.280
2002	0.017	0.045	0.061	0.090	0.112	0.142	0.146	0.168	0.182	0.197	0.230	0.241	0.229	0.268	0.286	0.282

Table 6.7.3. Western Horse Mackerel. Estimated mean weight in the stock (Kg).

The SAS System — 09:57 Friday, September 12, 1997

HOM-WEST: Western horse mackerel (IIa,IVa,VIa,VIIa-c,e-k,VIIIa-b,d-e)

WEST: Mean Weight in Stock (Kilograms)

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15
1982	0.000	0.000	0.050	0.080	0.207	0.232	0.269	0.280	0.292	0.305	0.369	0.344	0.348	0.348	0.361	0.364
1983	0.000	0.000	0.050	0.080	0.171	0.227	0.257	0.276	0.270	0.243	0.390	0.305	0.309	0.311	0.312	0.310
1984	0.000	0.000	0.050	0.077	0.122	0.155	0.201	0.223	0.253	0.246	0.338	0.300	0.300	0.300	0.305	0.285
1985	0.000	0.000	0.050	0.081	0.148	0.140	0.193	0.236	0.242	0.289	0.247	0.300	0.300	0.325	0.325	0.303
1986	0.000	0.000	0.050	0.080	0.105	0.134	0.169	0.195	0.242	0.292	0.262	0.300	0.300	0.300	0.300	0.346
1987	0.000	0.000	0.050	0.080	0.105	0.126	0.150	0.171	0.218	0.254	0.281	0.291	0.297	0.303	0.303	0.339
1988	0.000	0.000	0.050	0.080	0.105	0.126	0.141	0.143	0.217	0.274	0.305	0.337	0.352	0.361	0.352	0.390
1989	0.000	0.000	0.050	0.080	0.105	0.103	0.131	0.159	0.127	0.210	0.252	0.263	0.302	0.411	0.383	0.358
1990	0.000	0.000	0.050	0.080	0.105	0.127	0.135	0.124	0.154	0.174	0.282	0.272	0.404	0.404	0.404	0.404
1991	0.000	0.000	0.050	0.080	0.121	0.137	0.143	0.144	0.150	0.182	0.189	0.266	0.295	0.349	0.361	0.381
1992	0.000	0.000	0.050	0.080	0.105	0.133	0.151	0.150	0.158	0.160	0.182	0.292	0.211	0.245	0.361	0.403
1993	0.000	0.000	0.050	0.080	0.105	0.153	0.166	0.173	0.172	0.170	0.206	0.211	0.258	0.288	0.338	0.405
1994	0.000	0.000	0.050	0.080	0.105	0.147	0.185	0.169	0.191	0.191	0.190	0.197	0.231	0.270	0.270	0.338
1995	0.000	0.000	0.050	0.066	0.119	0.096	0.152	0.166	0.178	0.187	0.197	0.187	0.229	0.218	0.272	0.348
1996	0.000	0.000	0.050	0.095	0.118	0.129	0.148	0.172	0.183	0.185	0.202	0.206	0.217	0.221	0.237	0.273
1997	0.000	0.000	0.050	0.080	0.112	0.124	0.162	0.169	0.184	0.188	0.208	0.197	0.226	0.236	0.260	0.256
1998	0.000	0.000	0.050	0.080	0.112	0.124	0.162	0.169	0.184	0.188	0.196	0.220	0.226	0.236	0.260	0.261
1999	0.000	0.000	0.050	0.080	0.112	0.124	0.162	0.169	0.184	0.188	0.196	0.197	0.233	0.236	0.260	0.264
2000	0.000	0.000	0.050	0.080	0.112	0.124	0.162	0.169	0.184	0.188	0.196	0.197	0.226	0.243	0.260	0.268
2001	0.000	0.000	0.050	0.080	0.112	0.124	0.162	0.169	0.184	0.188	0.196	0.197	0.226	0.236	0.252	0.270
2002	0.000	0.000	0.050	0.080	0.112	0.124	0.162	0.169	0.184	0.188	0.196	0.197	0.226	0.236	0.260	0.272

Table 6.7.4. Western Horse Mackerel. Estimated proportion of fish mature.

The SAS System 09:57 Friday, September 12, 1997

HOM-WEST: Western horse mackerel (IIa,IVa,VIa,VIIa-c,e-k,VIIIa-b,d-e)

MATPROP: Proportion Mature at Year Start

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15
1982	0.00	0.00	0.40	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1983	0.00	0.00	0.30	0.70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1984	0.00	0.00	0.10	0.60	0.85	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1985	0.00	0.00	0.10	0.40	0.80	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1986	0.00	0.00	0.10	0.40	0.60	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1987	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1988	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1989	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1990	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1991	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1992	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1993	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1994	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1995	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1996	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1997	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1998	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1999	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2000	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2001	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2002	0.00	0.00	0.10	0.40	0.60	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 6.7.5. Western Horse Mackerel . Summary results of Bayesian stock assessment. Percentiles of the distribution of fishing mortality relative to natural mortality (Population mean fishing mortality over ages 4 to 14 divided by natural mortality), spawning stock size, and recruitment by year from 1982-1996. Percentiles calculated from 750 drawn parameter vectors from the Markov Chain.

a. Fishing Mortality relative to Natural Mortality (F 4-14w/M)

Percentile	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
5	0.20	0.29	0.37	0.24	0.20	0.29	0.36	0.54	0.71	0.80	0.93	1.32	1.24	2.02	1.09
25	0.34	0.49	0.61	0.39	0.32	0.46	0.54	0.81	1.08	1.18	1.35	1.88	1.76	2.95	1.67
50	0.50	0.70	0.86	0.55	0.44	0.63	0.74	1.08	1.43	1.55	1.76	2.46	2.31	4.00	2.26
75	0.65	0.92	1.12	0.72	0.57	0.81	0.93	1.39	1.81	1.95	2.23	3.12	2.95	5.31	3.30
95	0.79	1.12	1.35	0.89	0.68	0.97	1.16	1.74	2.33	2.53	2.92	4.29	4.35	8.79	6.43
Expectation	0.50	0.70	0.86	0.56	0.44	0.63	0.74	1.10	1.46	1.59	1.82	2.58	2.47	4.49	2.82

b. Spawning Stock Size (Thousand t at spawning time)

Percentile	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
5	625	695	717	1184	839	2046	2482	1460	2127	2066	1602	1532	1161	787	539
25	705	786	816	1353	1014	2341	2862	1922	2505	2436	1935	1916	1534	1176	936
50	789	880	904	1507	1269	2591	3153	2282	2833	2799	2258	2302	1925	1587	1381
75	907	1008	1023	1706	1588	2900	3555	2665	3183	3164	2613	2706	2333	1979	1795
95	1173	1294	1272	2099	2180	3432	4191	3222	3865	3867	3230	3441	3042	2713	2559
Expectation	828	916	936	1554	1352	2640	3220	2305	2889	2853	2320	2372	1982	1624	1415

c. Recruitment (Millions of fish aged 0)

Percentile	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
5	20695	739	768	1174	1285	2182	590	652	412	841	2167	571	627	586	588
25	23567	1088	1155	1667	1549	2428	791	838	564	1057	2620	973	980	965	1008
50	26920	1368	1458	2056	1782	2680	974	1006	712	1260	3060	1397	1384	1386	1403
75	32119	1775	1891	2612	2079	3020	1181	1195	869	1473	3506	2015	1898	1958	1915
95	43134	2479	2622	3502	2629	3683	1562	1541	1150	1857	4361	3470	3035	3144	3147
Expectation	28819	1465	1552	2167	1844	2769	1011	1039	736	1292	3125	1610	1551	1563	1552

d. Natural Mortality (all ages) (approx.)

Percentile	M
5	0.052
25	0.056
50	0.068
75	0.084
95	0.115
Expectation	0.074

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Table 6.8.1. Western Horse Mackerel. Catch option table, calculated as expectation and percentiles of Bayes posterior distributions. (a) SSB, catch and F/M in 1997, (b) SSB in 1998, for F=M or catch = 50 to 400Kt in 1998; (c) SSB in 1999, for F=M or catch = 50 to 400Kt in 1998 and 1999; (d) Catch corresponding to F=M; (e) F/M in 1998; (f) F/M in 1999

(a)	1997				Estimated Risk in 1997	
	Expected	Percentiles				
		25%	50%	75%	P(SSB<500,000t)	P(SSB<SSB(1983)
SSB (Thousand t)	1088	699	1179	1650		
Catch (Thousand t)	400	*no uncertainty admitted*			0.15	0.43
F(4-14,w)/M	8.09	4.96	6.72	10.08		

(b)	SSB in 1998 (Kt)				Estimated Risk in 1998	
Catch (Thousand t)	Expected	Percentiles				
		25%	50%	75%	P(SSB<500,000t)	P(SSB<SSB(1983)
Catch for F=M	1090	554	1020	1490	0.21	0.44
50	1070	541	1010	1480	0.22	0.41
100	1050	521	989	1460	0.23	0.46
200	1010	477	947	1420	0.26	0.54
300	968	429	901	1370	0.29	0.62
400	933	414	851	1320	0.32	0.7

(c)	SSB in 1999 (Kt)				Estimated Risk in 1999	
Catch (Thousand t)	Expected	Percentiles				
		25%	50%	75%	P(SSB<500,000t)	P(SSB<SSB(1983)
Catch for F=M	1130	554	1020	1490	0.2	0.39
50 Kt in 1998 and 1999	1100	557	1040	1530	0.21	0.39
100 Kt in 1998 and 1999	1040	495	973	1460	0.26	0.46
200 Kt in 1998 and 1999	840	365	840	1330	0.33	0.59
300 Kt in 1998 and 1999	816	280	704	1190	0.4	0.71
400 Kt in 1998 and 1999	731	265	596	1050	0.45	0.8

(d)	Catch for F=M			
Catch (Thousand t)	Expected	Percentiles		
		25%	50%	75%
1998	41	24	39	53
1999	44	26	41	55

(e)
Fishing Mortality Relative to Natural Mortality in 1998, for catch options in 1998 = 50 to 400 000t and catch in 1997=400 000t

Catch in 1998 (Thous. t)	Expected	Percentiles		
		25%	50%	75%
50	1.35	0.66	0.96	1.57
100	2.84	1.37	1.97	3.29
200	5.85	2.91	4.24	7.40
300	8.31	4.61	6.95	11.05
400	10.36	6.57	9.58	13.43

(f)
Fishing Mortality Relative to Natural Mortality in 1999, for catch options in 1998 -1999 = 50 to 400 000t and catch in 1997=400 000t

Catch in 1998 and 1999	Expected	Percentiles		
(Thousand t)		25%	50%	75%
50	1.31	0.65	0.91	1.43
100	3.04	1.38	2.00	3.29
200	6.55	3.19	4.88	8.82
300	9.45	5.64	8.64	12.54
400	11.65	8.14	11.23	14.88

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TABLE 6.10.1 Results from ADAPT analysis

HOM-WEST: Western horse mackerel (IIa, IVa, VIa, VIIa-c,e-k,VIIIa-b,d-e)

M = 0.15
Proportion of F and M before spawning is 0.45

FISHING MORTALITY

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.002	0.004	0.000	0.001	0.000	0.003
1	0.002	0.000	0.000	0.001	0.000	0.000	0.007	0.000	0.017	0.026	0.069	0.034	0.002	0.013	0.061
2	0.008	0.001	0.004	0.002	0.000	0.000	0.003	0.000	0.043	0.050	0.039	0.050	0.406	0.055	0.201
3	0.021	0.016	0.003	0.013	0.001	0.000	0.001	0.010	0.051	0.017	0.087	0.015	0.135	0.329	0.144
4	0.008	0.010	0.022	0.003	0.016	0.002	0.003	0.008	0.037	0.092	0.074	0.088	0.118	0.382	0.205
5	0.009	0.013	0.036	0.031	0.007	0.030	0.013	0.004	0.018	0.102	0.158	0.160	0.086	0.169	0.205
6	0.009	0.038	0.024	0.030	0.055	0.002	0.039	0.012	0.009	0.048	0.115	0.288	0.067	0.248	0.205
7	0.012	0.051	0.041	0.016	0.036	0.049	0.017	0.067	0.020	0.020	0.037	0.173	0.300	0.083	0.205
8	0.004	0.031	0.043	0.021	0.036	0.042	0.061	0.020	0.095	0.026	0.017	0.069	0.169	0.603	0.205
9	0.014	0.009	0.032	0.010	0.031	0.023	0.040	0.119	0.079	0.110	0.027	0.037	0.048	0.304	0.205
10	0.057	0.267	0.014	0.024	0.026	0.019	0.024	0.062	0.198	0.060	0.131	0.006	0.072	0.159	0.205
11	0.105	0.160	0.000	0.001	0.009	0.046	0.041	0.042	0.098	0.052	0.042	0.198	0.045	0.133	0.205
12	0.068	0.431	0.041	0.072	0.005	0.036	0.052	0.078	0.057	0.066	0.114	0.027	0.219	0.167	0.205
13	0.076	0.118	0.071	0.342	0.085	0.009	0.026	0.052	0.151	0.048	0.115	0.104	0.049	0.395	0.205
14	0.043	0.138	0.033	0.064	0.035	0.028	0.037	0.057	0.088	0.054	0.075	0.113	0.121	0.262	0.205
15	0.043	0.138	0.033	0.064	0.035	0.028	0.037	0.057	0.088	0.054	0.075	0.113	0.121	0.262	0.205
F(2-4)U	0.012	0.009	0.010	0.006	0.006	0.001	0.002	0.006	0.044	0.053	0.067	0.051	0.220	0.255	0.183
F(5-14)U	0.040	0.126	0.034	0.061	0.033	0.028	0.035	0.051	0.081	0.059	0.083	0.117	0.118	0.252	0.205
F(5-14)W	0.022	0.046	0.035	0.025	0.032	0.030	0.038	0.060	0.082	0.090	0.112	0.167	0.170	0.313	0.205

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TABLE 6.10.2 **Results from ADAPT analysis**

HOM-WEST: Western horse mackerel (IIa, IVa, VIa, VIIa-c,e-k,VIIIa-b,d-e)

M = 0.15
Proportion of F and M before spawning is 0.45

POPULATION ABUNDANCE

Unit: thousands

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	60,712	3,072	3,062	3,952	3,129	4,416	1,470	1,429	943	1,575	3,583	11,186	4,971	86	2,196	2,196
1	1,730	52,256	2,644	2,636	3,402	2,693	3,801	1,265	1,230	812	1,353	3,072	9,628	4,277	74	1,884
2	1,880	1,487	44,972	2,276	2,268	2,928	2,318	3,249	1,089	1,041	681	1,087	2,557	8,273	3,634	60
3	4,818	1,605	1,278	38,537	1,955	1,952	2,520	1,990	2,797	898	852	563	890	1,466	6,739	2,558
4	1,087	4,062	1,360	1,097	32,736	1,682	1,680	2,167	1,695	2,287	760	672	478	669	909	5,022
5	1,096	928	3,461	1,145	941	27,722	1,445	1,442	1,850	1,406	1,795	607	530	366	393	637
6	955	935	788	2,873	955	804	23,167	1,228	1,237	1,563	1,093	1,319	445	418	266	275
7	541	814	775	663	2,401	778	691	19,176	1,045	1,055	1,282	838	852	358	281	186
8	322	460	666	640	561	1,993	638	585	15,431	882	891	1,064	607	543	284	197
9	21	276	384	549	539	466	1,645	517	493	12,081	739	754	855	441	256	199
10	22	18	236	320	468	450	392	1,360	395	392	9,311	620	625	701	280	179
11	48	18	12	200	269	393	380	329	1,101	279	318	7,030	530	501	515	196
12	206	37	13	10	172	229	323	314	272	859	228	263	4,962	436	377	361
13	287	166	21	11	8	147	190	264	250	221	692	175	220	3,431	318	264
14	337	229	127	17	7	6	126	160	216	185	181	531	136	180	1,989	223
15	142	278	1,273	466	1,158	1,067	832	322	675	1,015	482	338	350	700	955	2,788

Unit: tonnes

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Egg Surv. SSB											2,210,000			1,710,000		
Fitted SSB:	1577035	1753222	1891705	2648009	3545459	4152512	4686182	4128613	3715105	3590282	2806692	2489073	1925140	1491251	1380700	1368000

Table 6.10.3 Stock summary table for WESTERN HORSE MACKEREL
Results are taken from the ADAPT analysis.

	SSB ('000t)	F(2-4)U	F(5-14)U	F(5-14)W	Yield ('000t)	Recruitment at age 1 (millions)	Egg Survey SSB ('000t)
1977	-	-	-	-	-	-	740
1978	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	890
1981	-	-	-	-	-	-	-
1982	1,577	0.012	0.040	0.022	42	1,730	-
1983	1,753	0.009	0.126	0.046	65	52,256	530
1984	1,892	0.010	0.034	0.035	74	2,644	-
1985	2,648	0.006	0.061	0.025	81	2,636	-
1986	3,545	0.006	0.033	0.032	106	3,402	710
1987	4,153	0.001	0.028	0.030	156	2,693	-
1988	4,686	0.002	0.035	0.038	188	3,801	-
1989	4,129	0.006	0.051	0.060	269	1,265	2,280
1990	3,715	0.044	0.081	0.082	373	1,230	-
1991	3,590	0.053	0.059	0.090	334	812	-
1992	2,807	0.067	0.083	0.112	368	1,353	2,210
1993	2,489	0.051	0.117	0.167	432	3,072	-
1994	1,925	0.220	0.118	0.170	348	9,628	-
1995	1,491	0.255	0.252	0.313	513	4,277	1,710
1996	1,381	0.183	0.205	0.205	396	74	-
AR mean	2,785	0.062	0.088	0.095	250	6,058	1,488
GM mean	2,576	0.019	0.070	0.068	193	2,343	1,265
GM mean of year classes 1981,1983 - 1986,1988 - 1992 (prediction)						1,860	

Egg survey biomass estimtes are taken from ICES (1997/Assess:3 Table 2.1)
Only 1992 and 1995 egg survey SSB estimates have been used for tuning the assessment

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Table 6.10.4 Predicted spawning stock biomass (SSB) and catches (medians) for the period 1997 - 2002 for a fishing mortality constraint of F = M = 0.15 and for 5 different annual catch contraints over the period 1998 - 2002. Catch constrained to 400,000 t in 1997.

Results from ADAPT analysis

WESTERN HORSE MACKEREL

F and Catch constraints >		F=M	50	100	200	300	400
	year	('000t)	('000t)	('000t)	('000t)	('000t)	('000t)
SSB	1997	1,334	1,333	1,362	1,383	1,308	1,368
	1998	1,143	1,205	1,217	1,200	1,085	1,106
	1999	1,065	1,265	1,234	1,130	922	857
	2000	927	1,232	1,157	968	684	531
	2001	793	1,169	1,056	796	451	246
	2002	708	1,144	993	662	260	102

F and Catch constraints >		F=M	50	100	200	300	400
	year	('000t)	('000t)	('000t)	('000t)	('000t)	('000t)
Catch	1997	400 *	400 *	400 *	400 *	400 *	400 *
	1998	221	50	100	200	300	400
	1999	187	50	100	200	300	400
	2000	166	50	100	200	300	400
	2001	150	50	100	200	300	400
	2002	138	50	100	200	300	400

* = catch assumed to be taken

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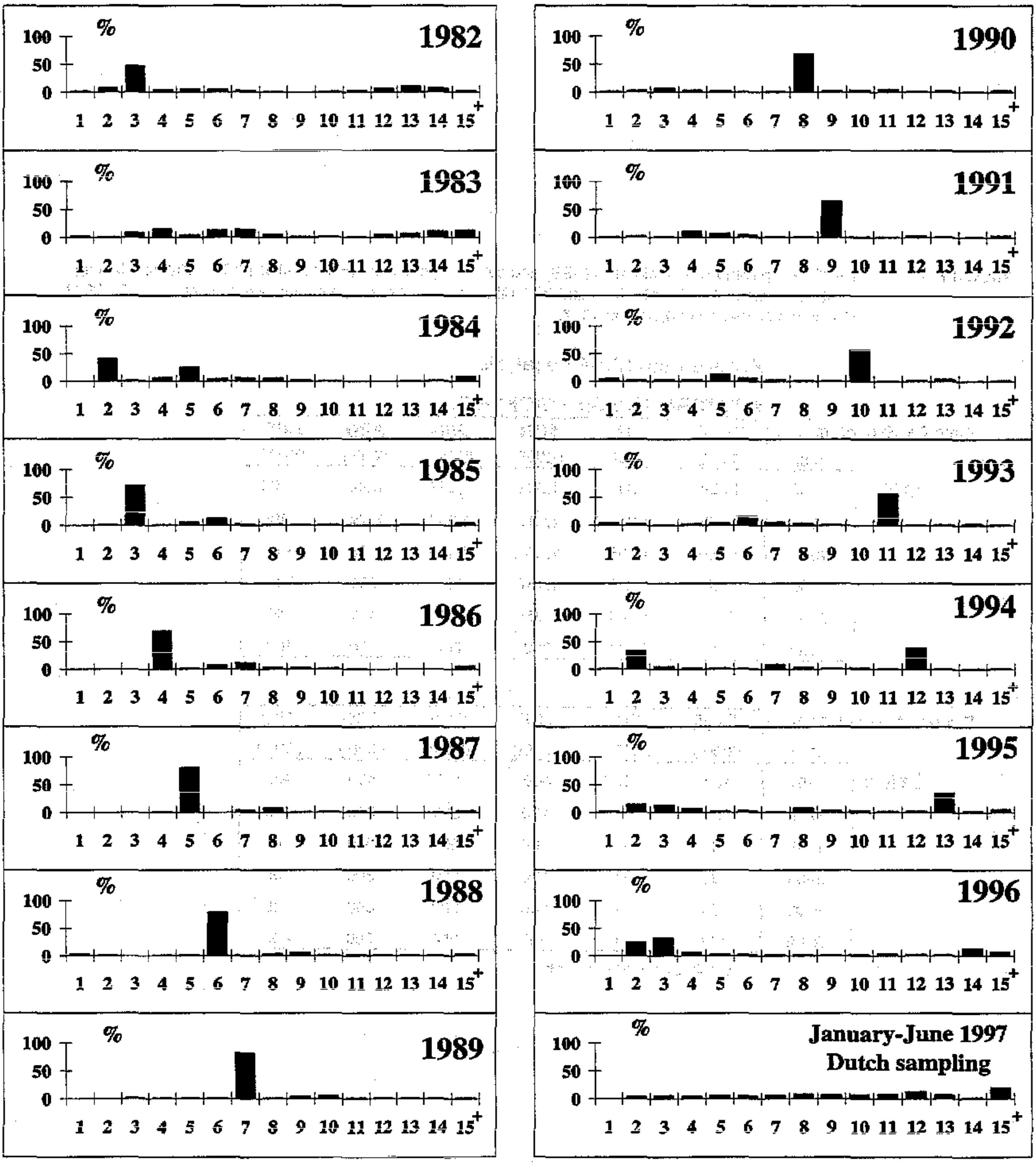


Figure 6.3.1 The age composition of the WESTERN HORSE MACKEREL in the internationa catches from 1982-1996. The age composition of Dutch catches for the first half 1997 is shown (a fishery in the adult area).

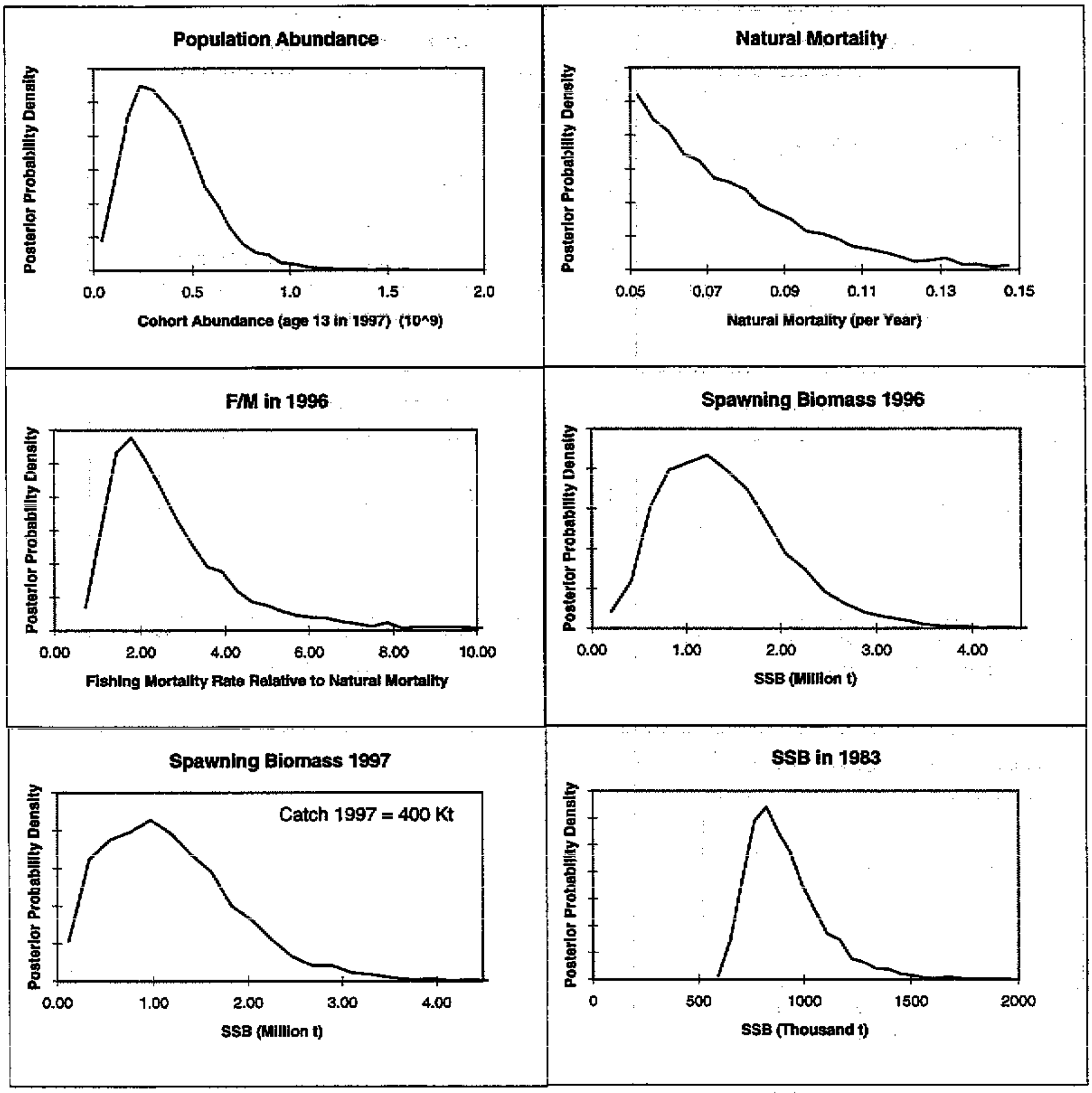


Figure 6.7.1. Western Horse Mackerel.Estimates of posterior probability density for some key parameters in the stock assessment.'F' here is taken as the population-weighted arithmetic mean F from ages 4 to 14, and is referenced to M because M is a stochastic variable. Distributions calculated from 4000 samples from Markov Chain thinned at intervals of 100 iterations.

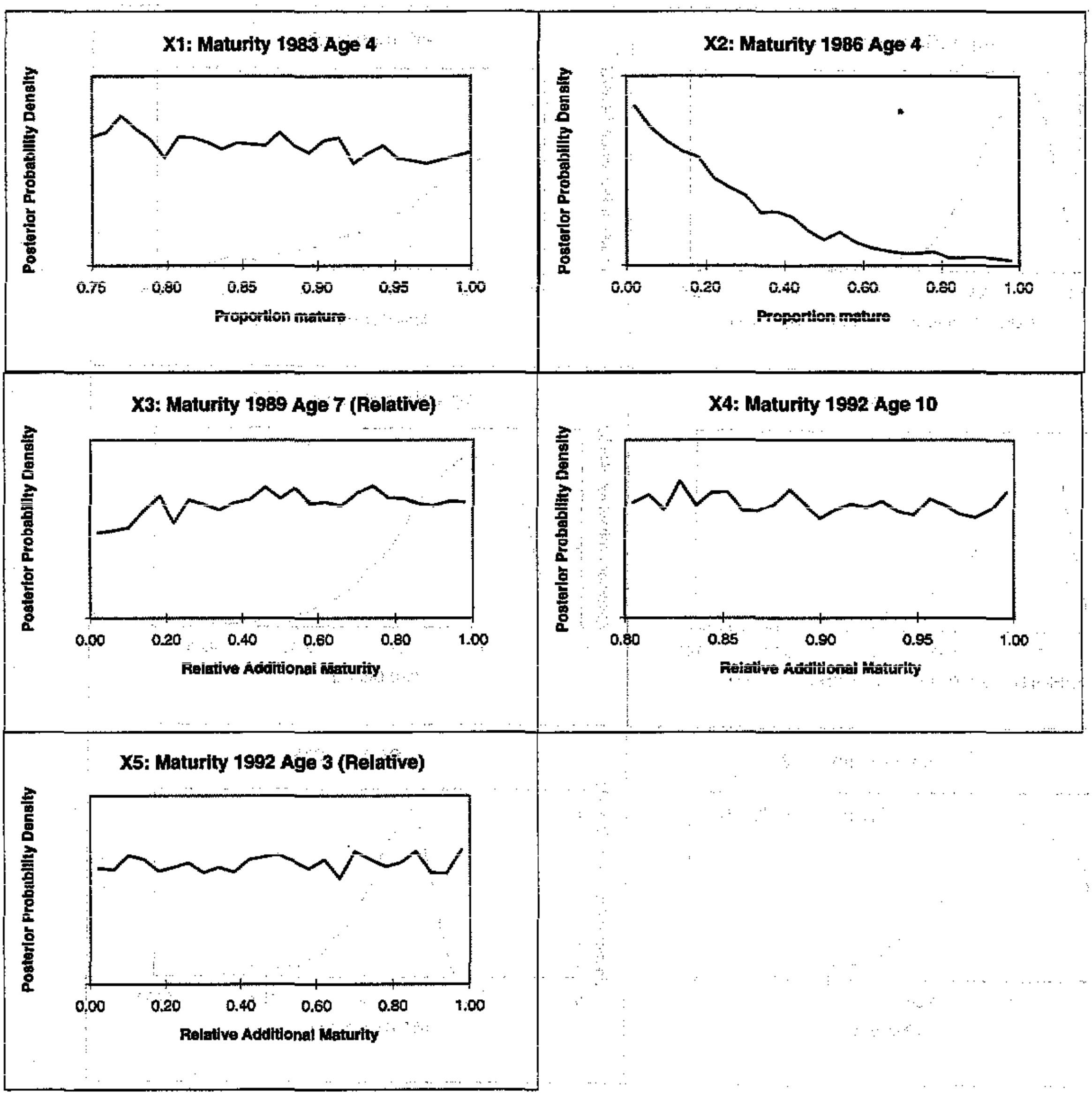


Figure 6.7.2. Western Horse Mackerel.Estimates of posterior probability density for some parameters of maturity proportions in the stock assessment.See section 6.7.2.2. for description of the expression of maturity in terms of parameters X1-X5

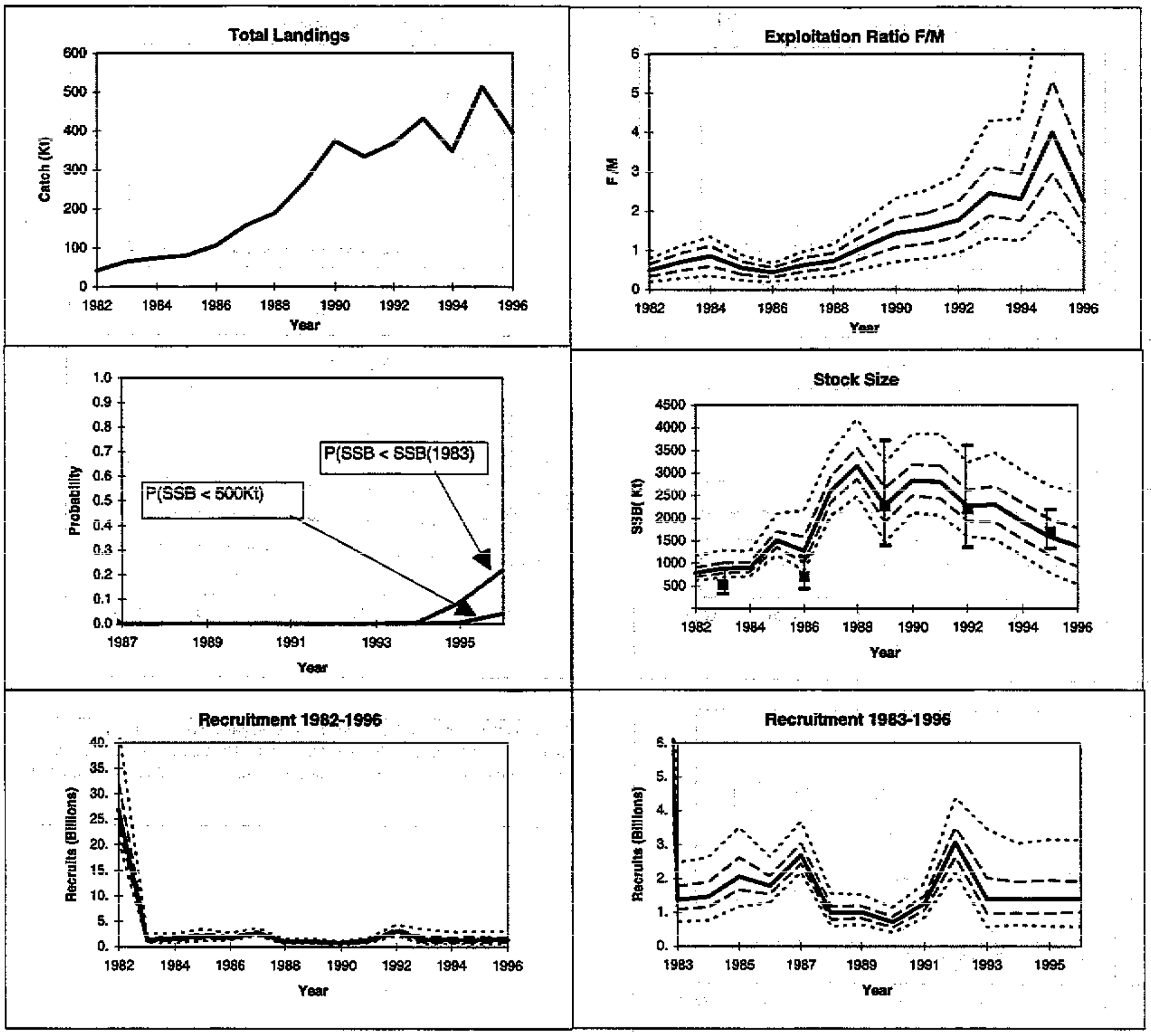
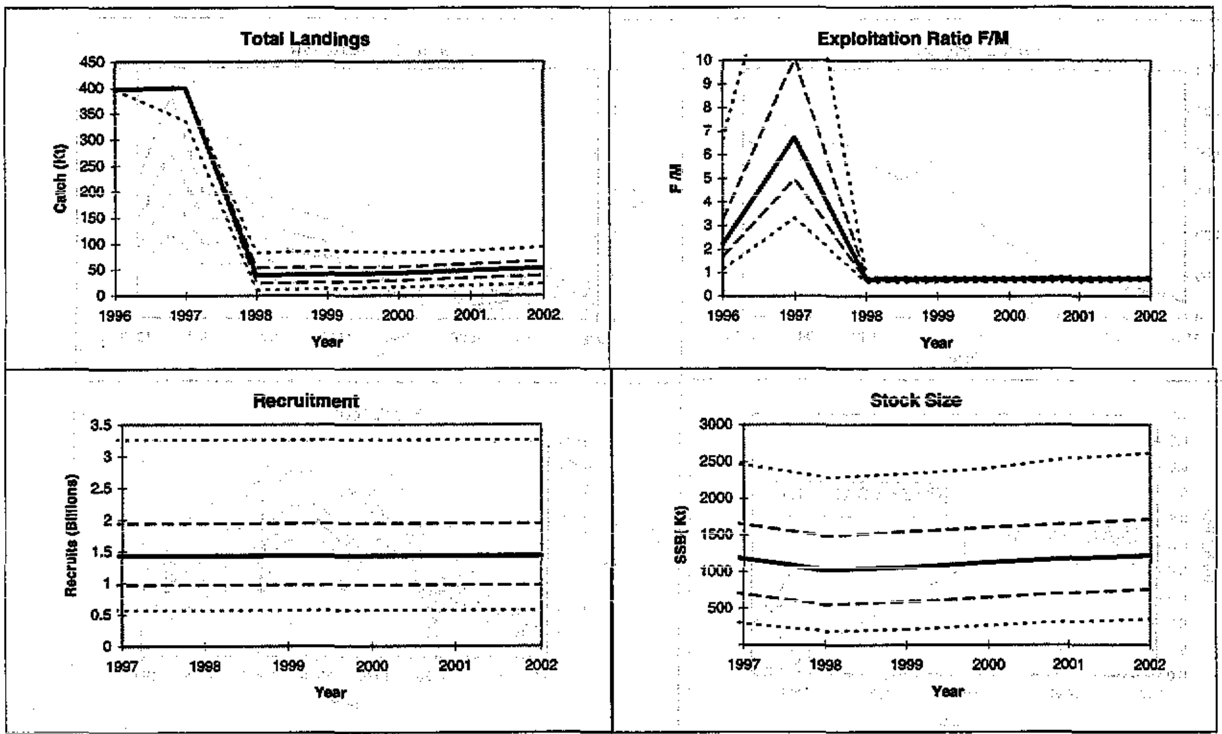


Figure 6.7.3. Western Horse Mackerel. Estimated historic stock trajectories for some population dynamics parameters. Fishing mortality calculated as population-weighted mean over ages 5 to 14 and referenced to natural mortality. Square markers indicate egg survey biomass estimates, +/- 95% confidence intervals based on 25% CV. Bold lines, medians. Dashed lines, 25th and 25th percentiles. Dotted lines, 5th and 95th percentiles.



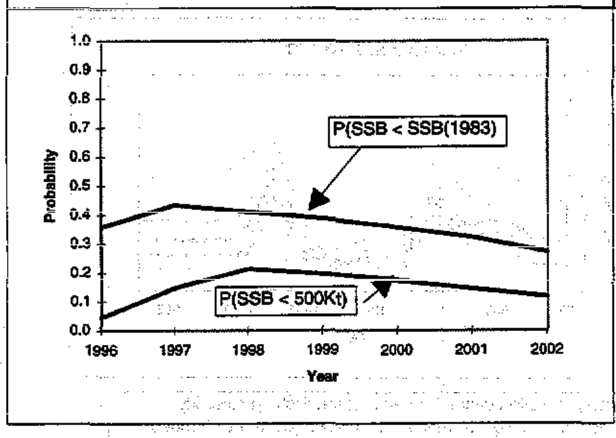
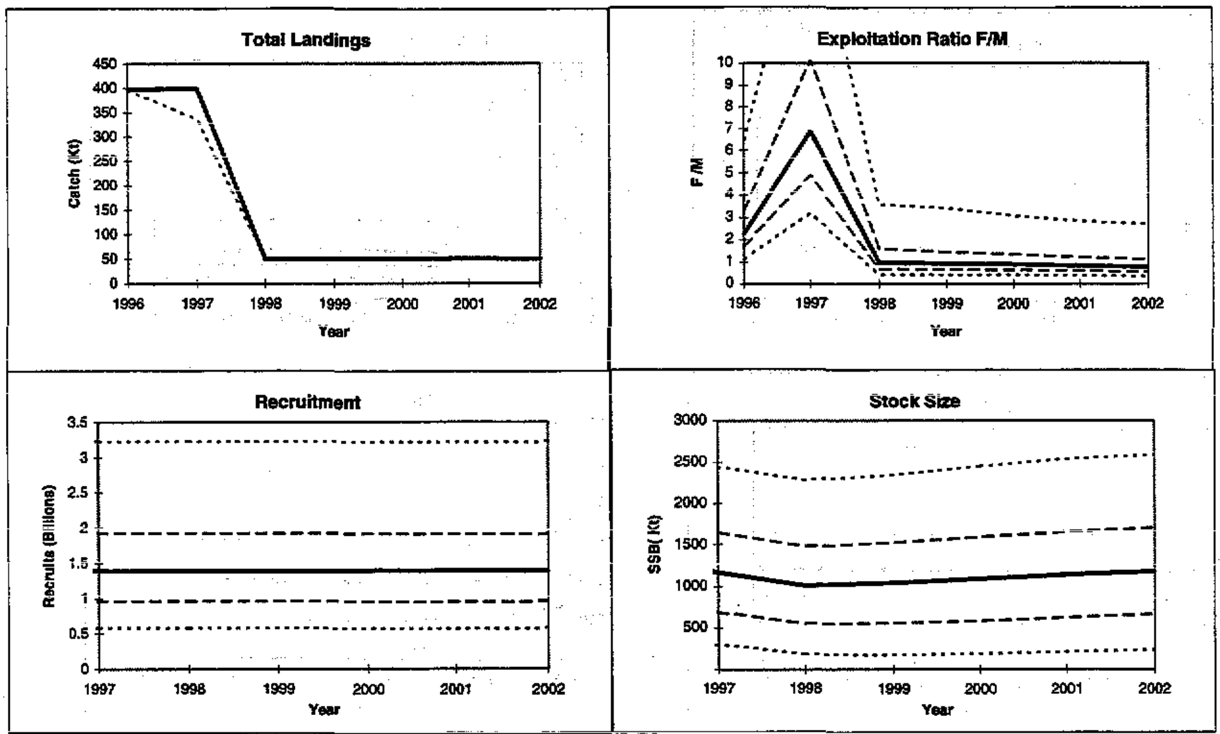


Figure 6.9.1. Western Horse Mackerel. Bayesian medium-term projections assuming F1997-F2002 = M. Full lines, medians. Dashed lines, 75th and 25th percentiles. Dotted lines, 5th and 95th percentiles.



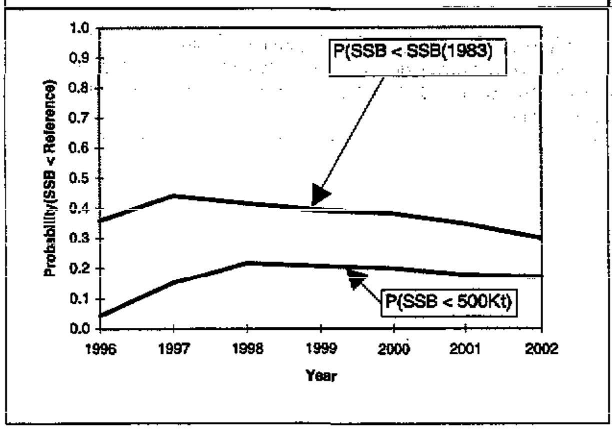


Figure 6.9.2. Western Horse Mackerel. Bayesian medium-term projections assuming C1997=400Kt and catch 1998-2002 = 50Kt. Full lines, medians. Dashed lines, 75th and 25th percentiles. Dotted lines, 5th and 95th percentiles.

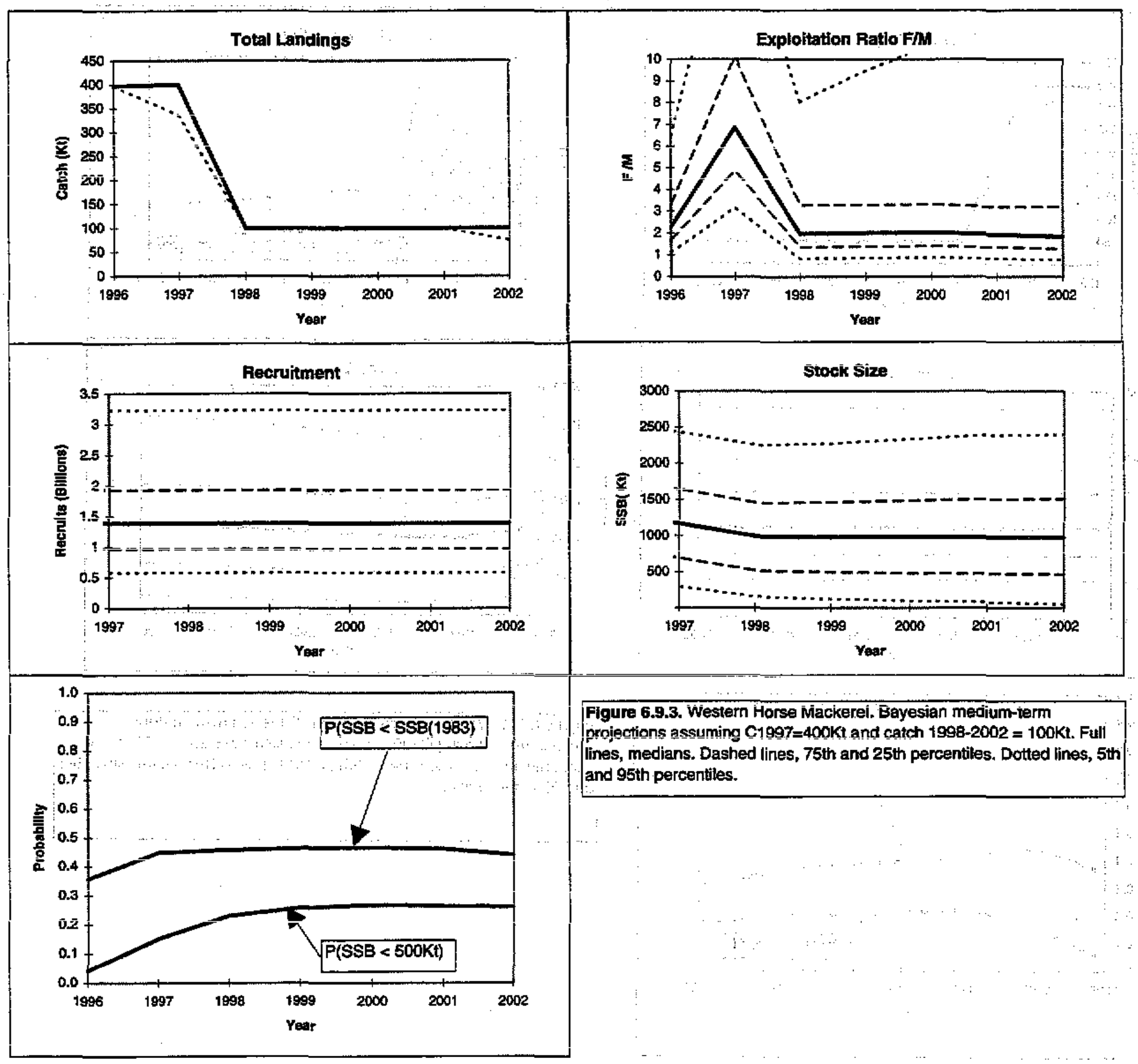


Figure 6.9.3. Western Horse Mackerel. Bayesian medium-term projections assuming C1997=400Kt and catch 1998-2002 = 100Kt. Full lines, medians. Dashed lines, 75th and 25th percentiles. Dotted lines, 5th and 95th percentiles.

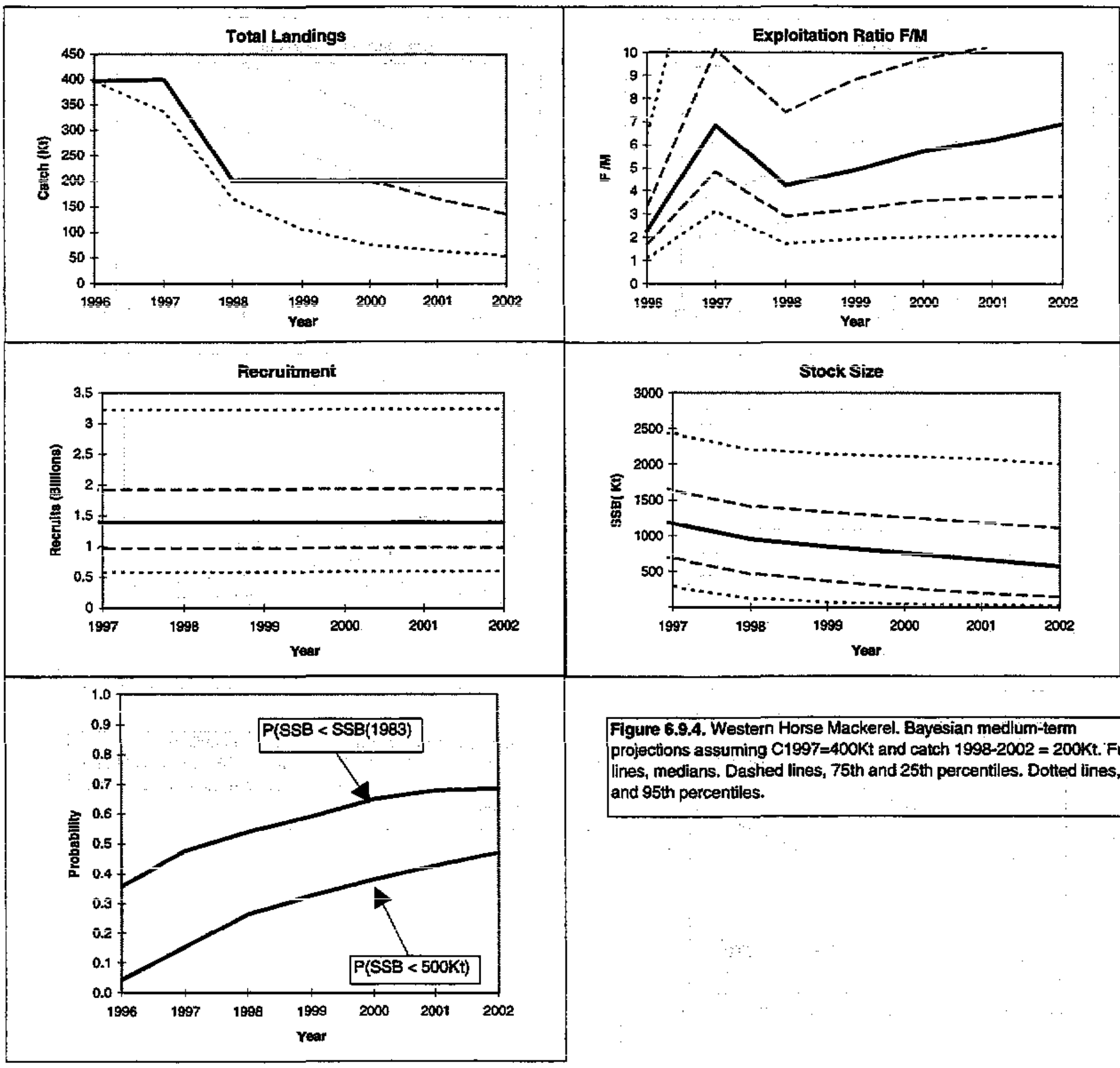
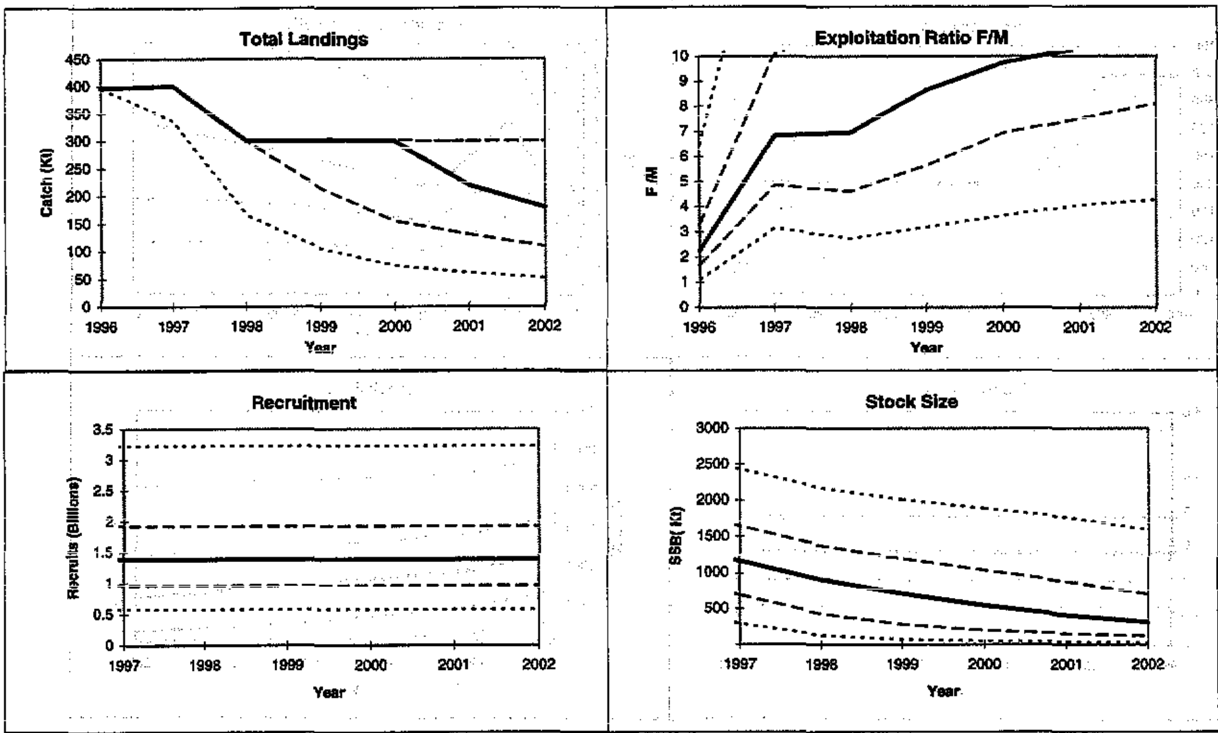


Figure 6.9.4. Western Horse Mackerel. Bayesian medium-term projections assuming C1997=400Kt and catch 1998-2002 = 200Kt. Full lines, medians. Dashed lines, 75th and 25th percentiles. Dotted lines, 5th and 95th percentiles.



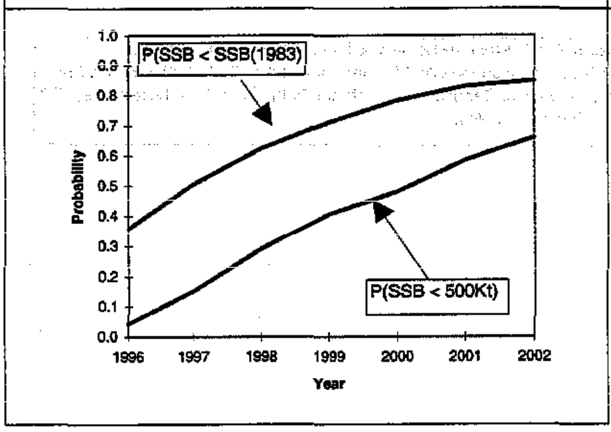
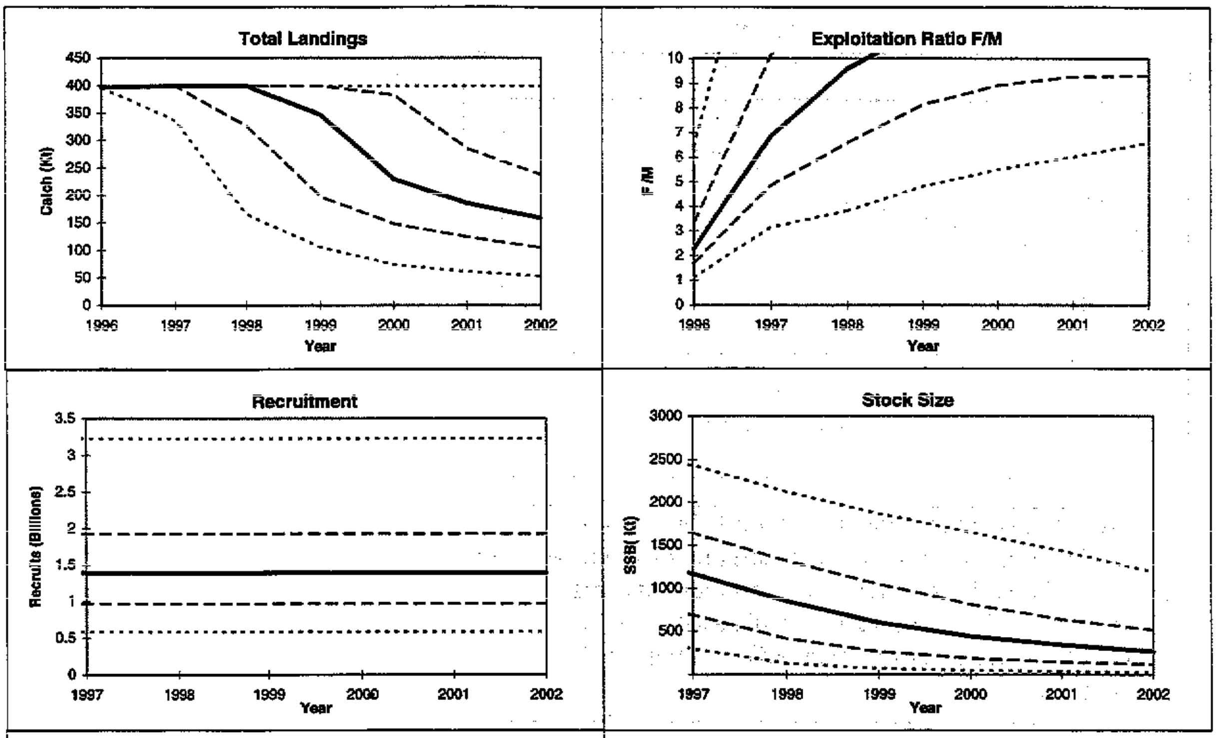


Figure 6.9.5. Western Horse Mackerel. Bayesian medium-term projections assuming C1997=400Kt and catch 1998-2002 = 300Kt. Full lines, medians. Dashed lines, 75th and 25th percentiles. Dotted lines, 5th and 95th percentiles.



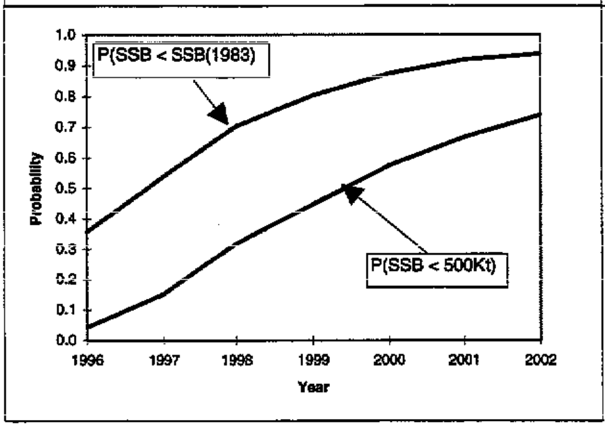


Figure 6.9.6. Western Horse Mackerel. Bayesian medium-term projections assuming C1997=400Kt and catch 1998-2002 = 400Kt. Full lines, medians. Dashed lines, 75th and 25th percentiles. Dotted lines, 5th and 95th percentiles.

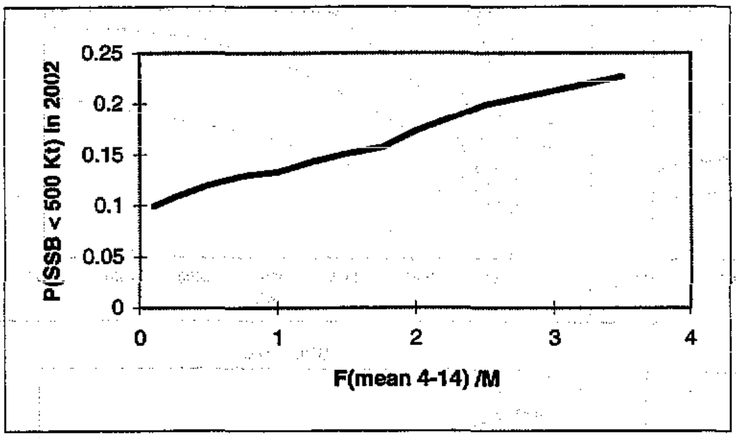


Figure 6.9.7. Western Horse Mackerel. Estimated probability of the spawning stock biomass falling under 500 Kt in 2002 for various levels of fishing mortality referenced to natural mortality. Probabilities estimated from 750 samples from the posterior distribution of the stock assessment.

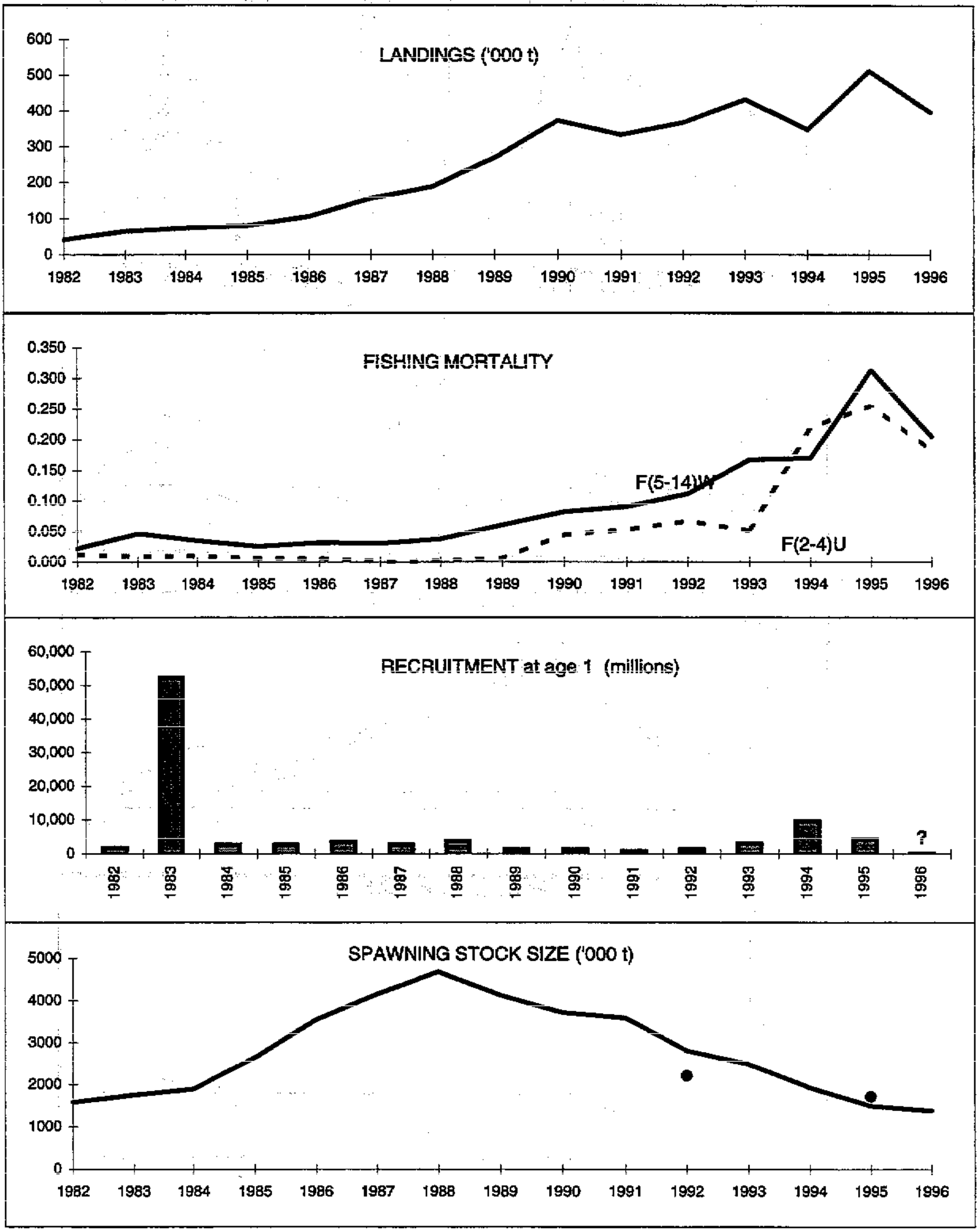


Figure 6.10.1 WESTERN HORSE MACKEREL. Summary of landings, fishing mortality, recruitment and spawning stock biomass. Spawing stock biomas estimates from the egg surveys in 1992 and 1995 are also indicated. Results are taken from the ADAPT analysis.

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F = M = 0.15 from 1998 - 2002 ADAPT ANALYSIS

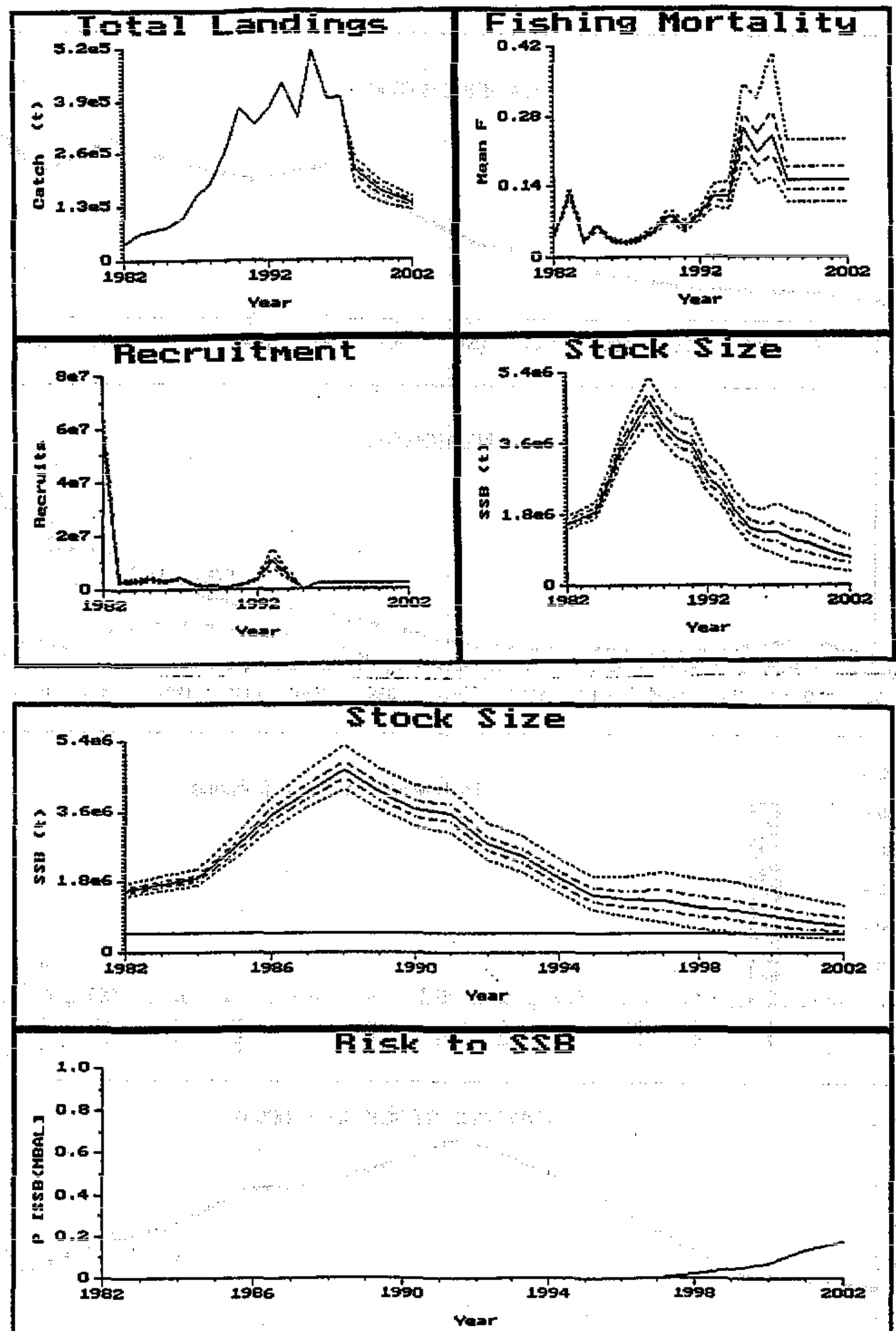

Figure 6.10.2 **WESTERN HORSE MACKEREL.** Uncertainty in assessment and in medium-term projections. **Upper pannels:** Landings, fishing mortality, recruitment and spawning stock size estimates for a fishing mortality constraint equivalent to fishing at **F = M = 0.15** over the period 1998-2002. Catch contrained to 400,000 t in 1997. Fishing mortality in the projections constrained to be less than 5 times fishing mortality in 1996. **Lower pannels:** Trajectories of stock size estimates, and the estimated probability of the stock size being below the 500,000 t by year. Full lines, medians. Dashed lines, 25th and 75th percentiles. Dotted lines, 5th and 95th percentiles.

50,000 t/y from 1998 - 2002 ADAPT ANALYSIS

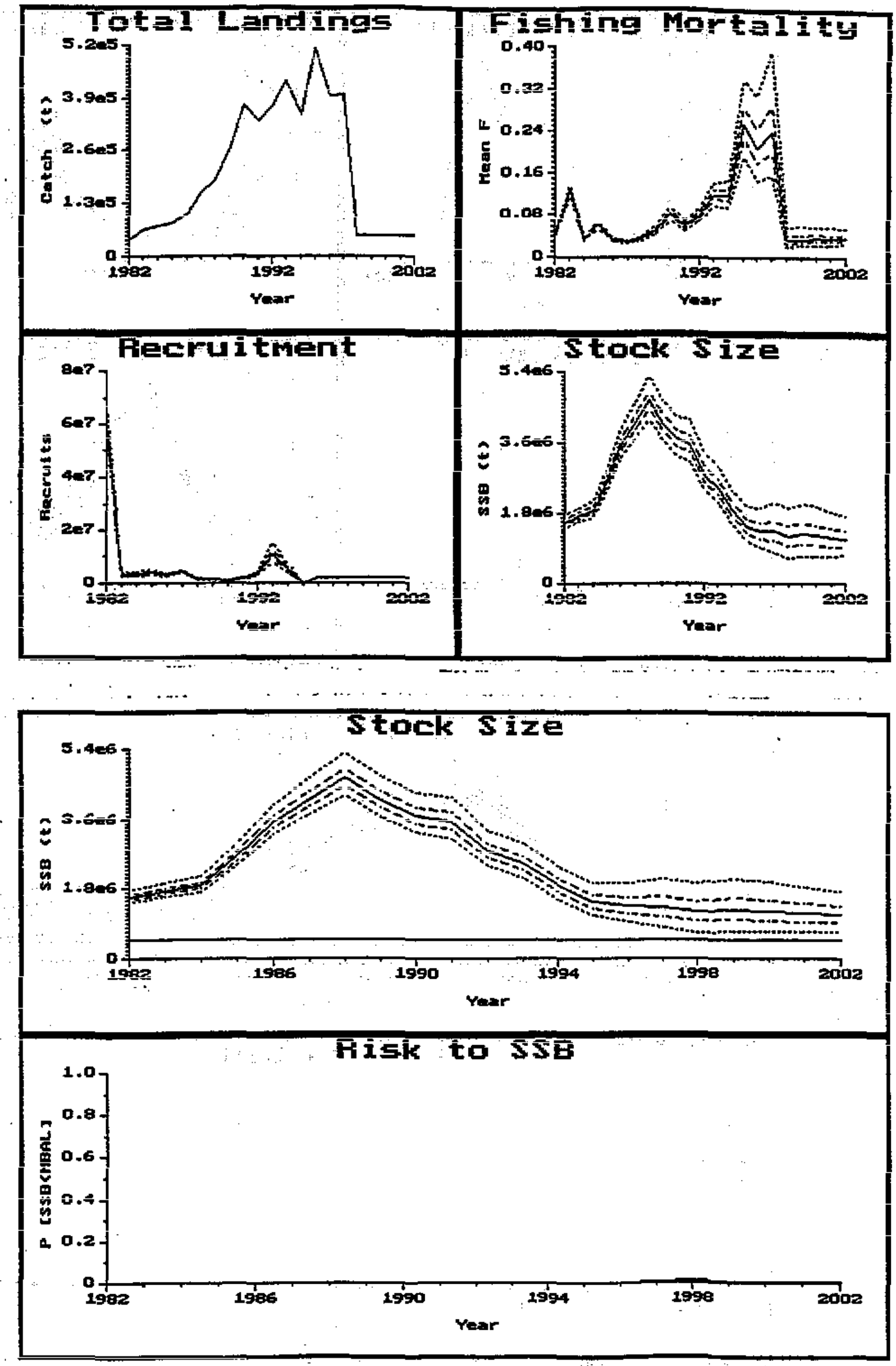

Figure 6.10.3 **WESTERN HORSE MACKEREL.** Uncertainty in assessment and in medium-term projections. **Upper pannels:** Landings, fishing mortality, recruitment and spawning stock size estimates for an annual catch contraint of **50,000t** over the period 1998-2002. Catch contrained to 400,000 t in 1997. Fishing mortality in the projections constrained to be less than 5 times fishing mortality in 1996. **Lower pannels:** Trajectories of stock size estimates, and the estimated probability of the stock size being below the 500,000 t by year. Full lines, medians. Dashed lines, 25th and 75th percentiles. Dotted lines, 5th and 95th percentiles.

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100,000 t/y from 1998 - 2002 ADAPT ANALYSIS

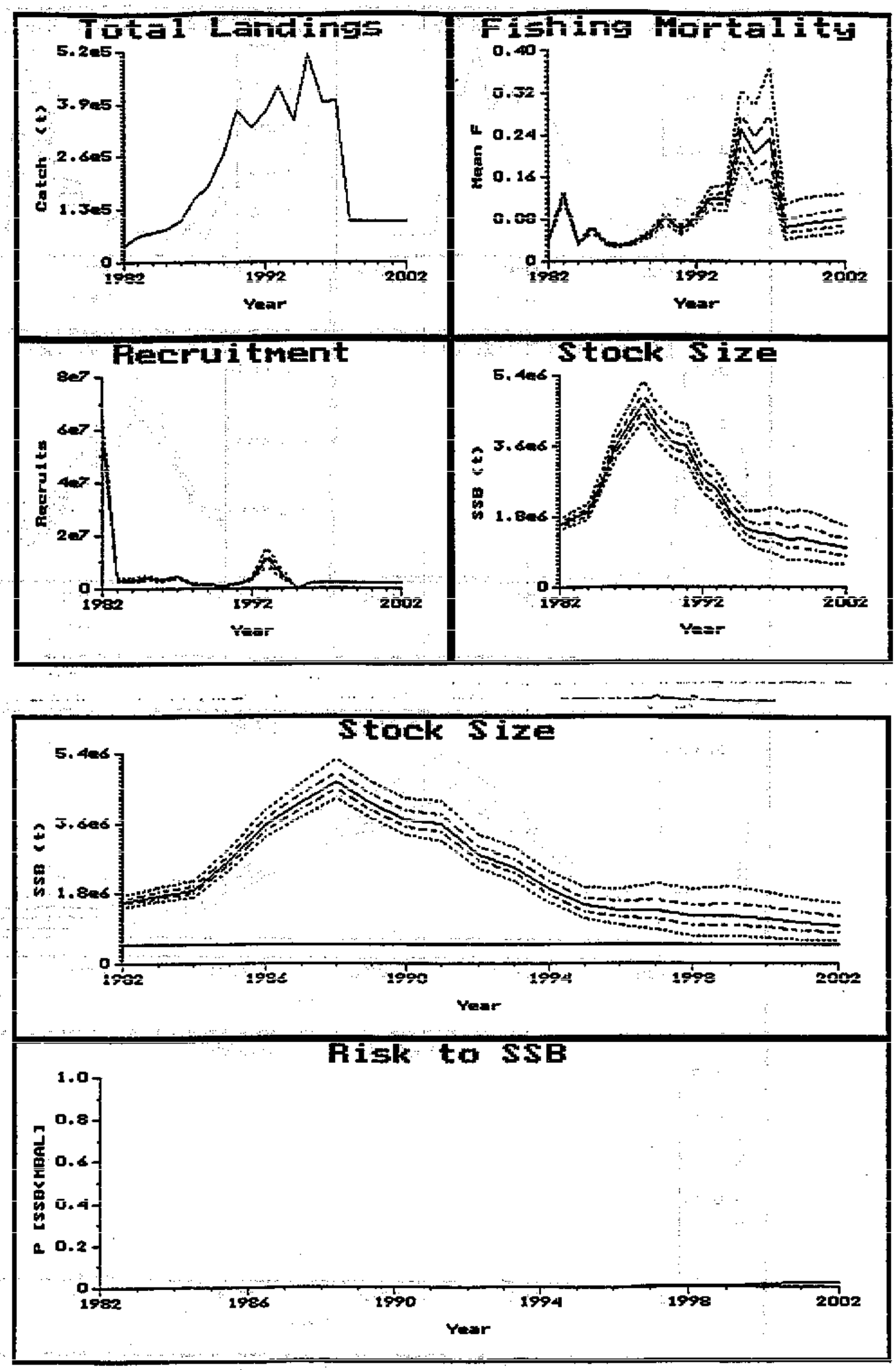


Figure 6.10.4 **WESTERN HORSE MACKEREL.** Uncertainty in assessment and in medium-term projections. **Upper pannels:** Landings, fishing mortality, recruitment and spawning stock size estimates for an annual catch contraint of **100,000t** over the period 1998-2002. Catch contrained to 400,000 t in 1997. Fishing mortality in the projections constrained to be less than 5 times fishing mortality in 1996. **Lower pannels:** Trajectories of stock size estimates, and the estimated probability of the stock being below the 500,000 t by year. Full lines, medians. Dashed lines, 25th and 75th percentiles. Dotted lines, 5th and 95th percentiles.

200,000 t/y from 1998 - 2002 ADAPT ANALYSIS

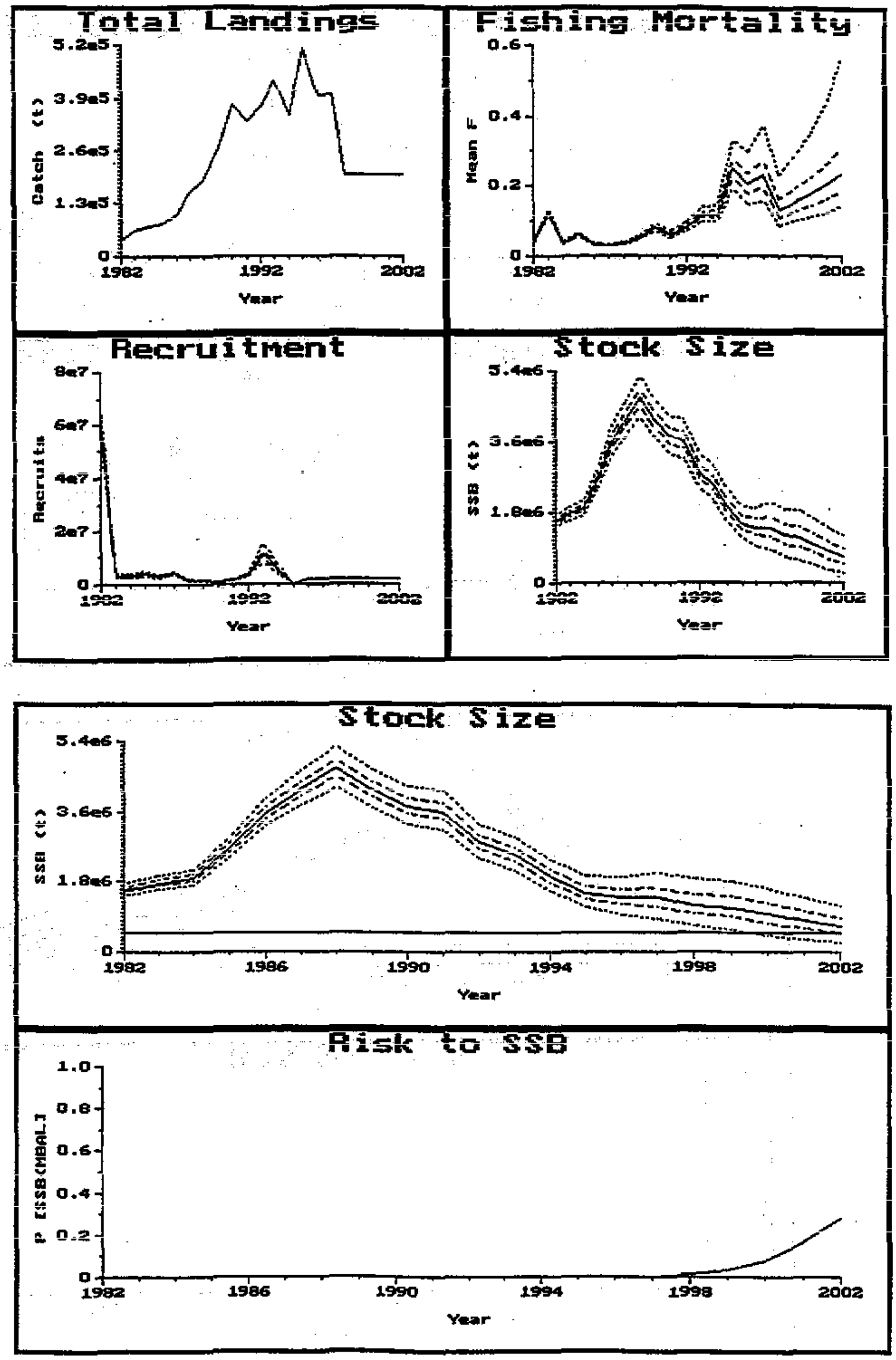


Figure 6.10.5 **WESTERN HORSE MACKEREL.** Uncertainty in assessment and in medium-term projections. **Upper pannels:** Landings, fishing mortality, recruitment and spawning stock size estimates for an annual catch contraint of **200,000t** over the period 1998-2002. Catch contrained to 400,000 t in 1997. Fishing mortality in the projections constrained to be less than 5 times fishing mortality in 1996. **Lower pannels:** Trajectories of stock size estimates, and the estimated probability of the stock being below the 500,000 t by year. Full lines, medians. Dashed lines, 25th and 75th percentiles. Dotted lines, 5th and 95th percentiles.

300,000 t/y from 1998 - 2002 ADAPT ANALYSIS

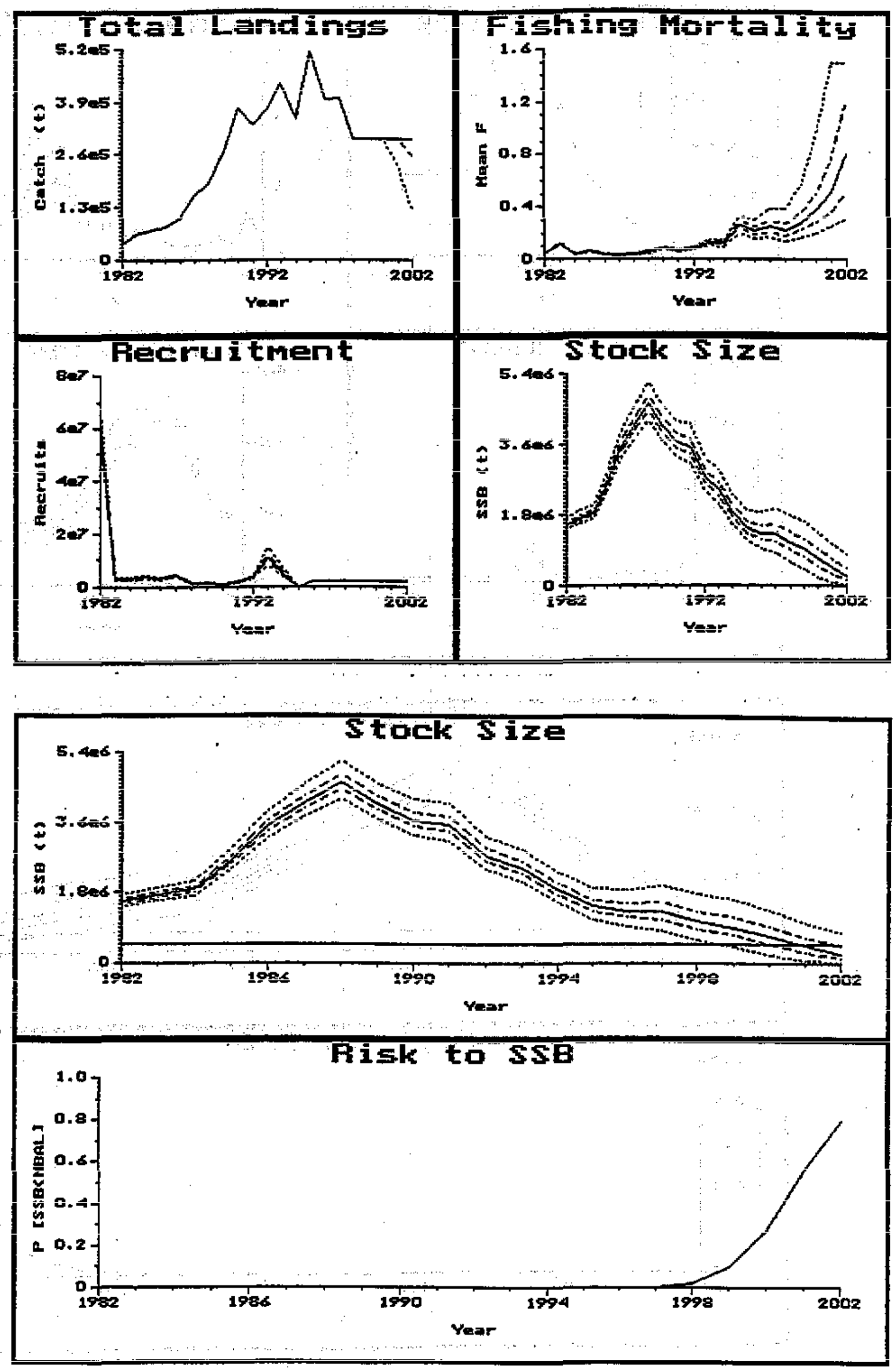
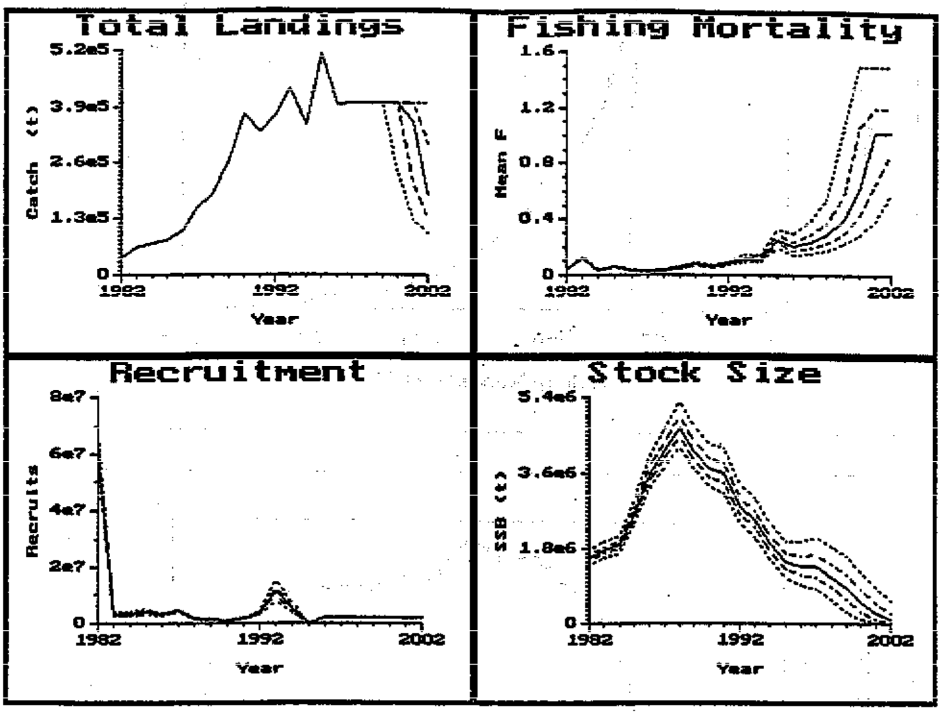


Figure 6.10.6 **WESTERN HORSE MACKEREL.** Uncertainty in assessment and in medium-term projections. **Upper pannels:** Landings, fishing mortality, recruitment and spawning stock size estimates for an annual catch contraint of **300,000t** over the period 1998-2002. Catch contrained to 400,000 t in 1997. Fishing mortality in the projections constrained to be less than 5 times fishing mortality in 1996. **Lower pannels:** Trajectories of stock size estimates, and the estimated probability of the stock size being below the 500,000 t by year. Full lines, medians. Dashed lines, 25th and 75th percentiles. Dotted lines, 5th and 95th percentiles.

400,000 t/y from 1998 - 2002 ADAPT ANALYSIS



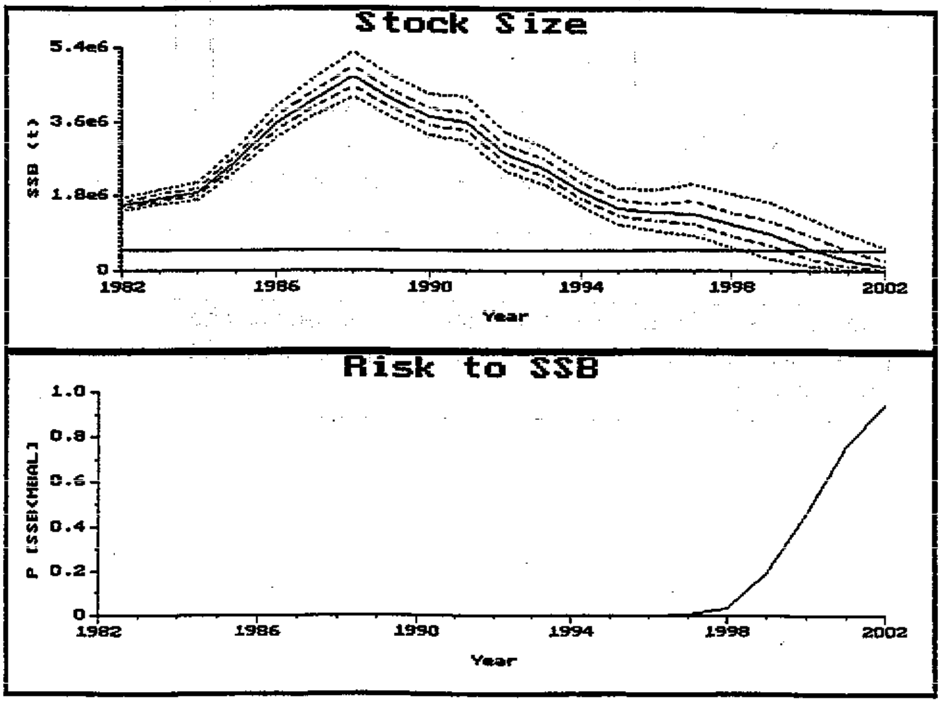


Figure 6.10.7 **WESTERN HORSE MACKEREL.** Uncertainty in assessment and in medium-term projections. **Upper pannels:** Landings, fishing mortality, recruitment and spawning stock size estimates for an annual catch contraint of **400,000t** over the period 1998-2002. Catch contrained to 400,000 t in 1997. Fishing mortality in the projections constrained to be less than 5 times fishing mortality in 1996. **Lower pannels:** Trajectories of stock size estimates, and the estimated probability of the stock size being below the 500,000 t by year. Full lines, medians. Dashed lines, 25th and 75th percentiles. Dotted lines, 5th and 95th percentiles.

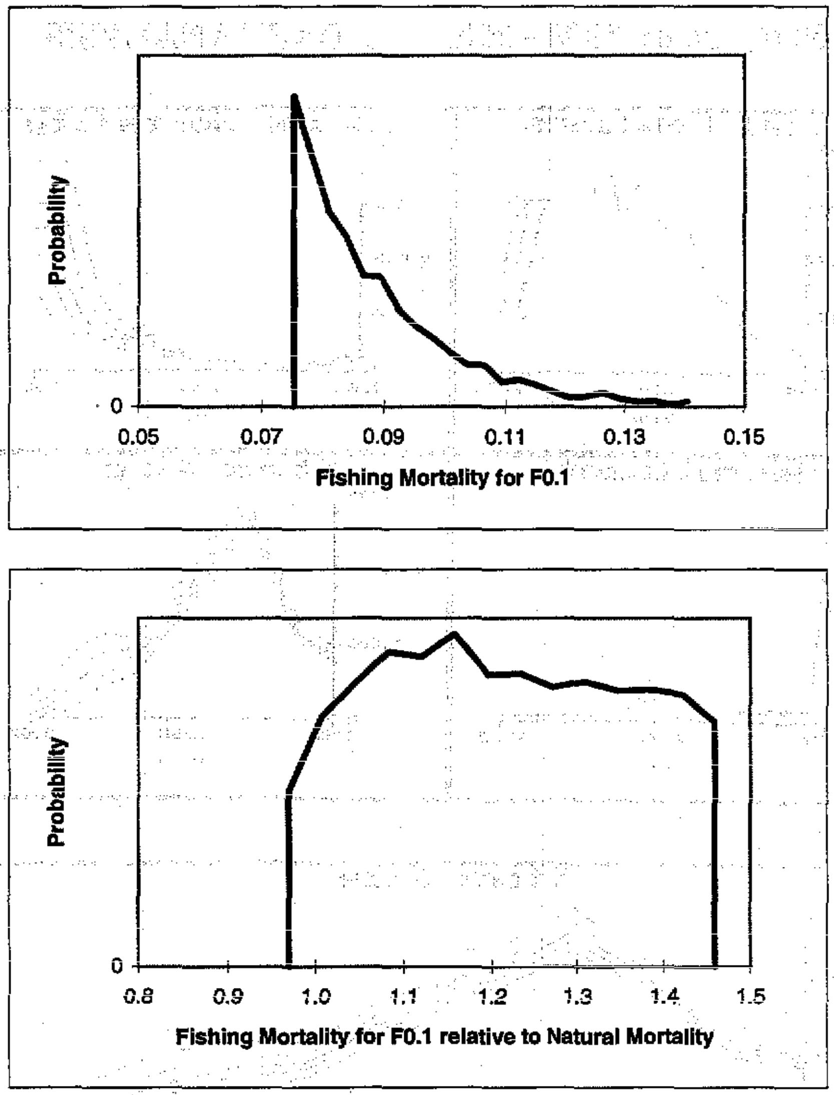


Figure 6.13.1 Western Horse Mackerel. Estimated posterior probability distribution for F0.1 (upper panel) and for F0.1/M (lower panel).

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