Advisory Committee on Fishery Management

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HERRING ASSESSMENT WORKING GROUP FOR THE AREA SOUTH OF 62°N

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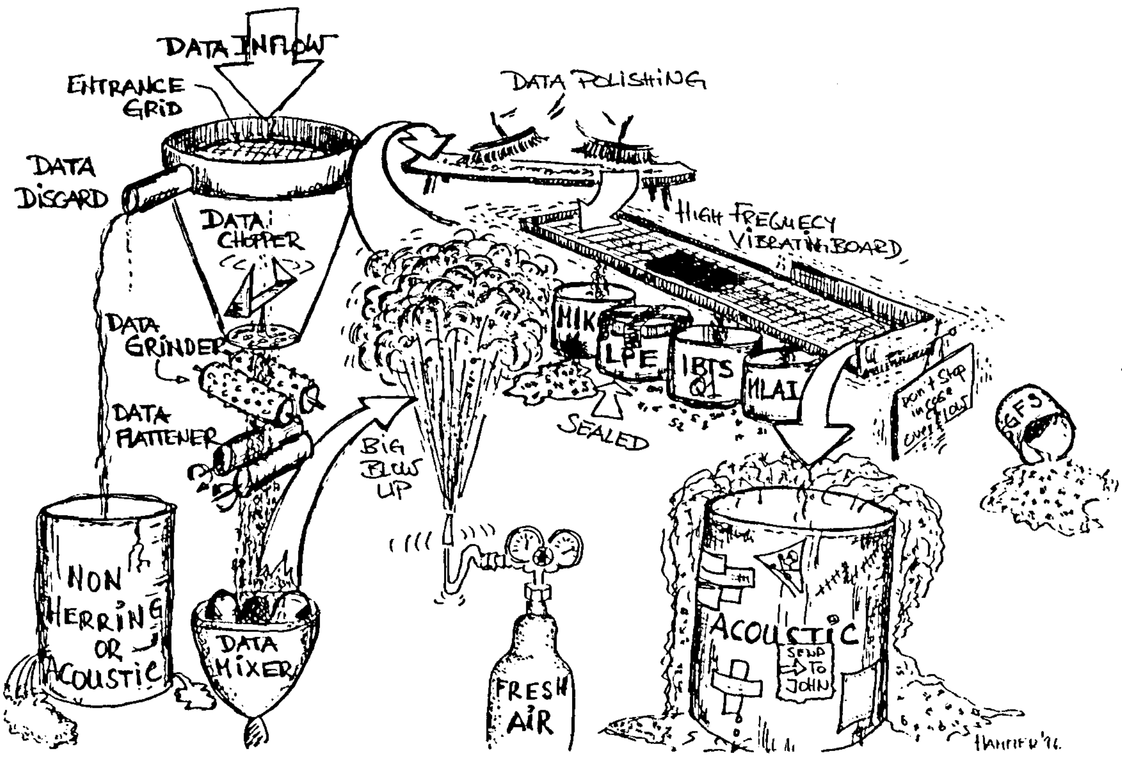
PART 2 OF 2



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International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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4 CELTIC SEA AND DIVISION VIIJ HERRING

4.1 Introduction

The herring fisheries to the south of Ireland in the Celtic Sea and in Division VIIj have been considered to exploit the same stock. For the purpose of stock assessment and management these areas have been combined since 1982. The areas for which the assessments are now made, together with the area for which the TAC is set by the EU is shown in Figure 4.1.1. It should be noted that, although the management unit covers all of Divisions VIIg,h,j and k and the southern part of Division VIIa, the total Irish catch which constitutes over 95% of the catch from this entire management unit is taken from the inshore waters along the Irish coast.

4.2 The Fishery in 1995–1996

4.2.1 Advice and management applicable to 1995 and 1996

In 1994 ACFM considered this stock to be within safe biological limits and suggested that a continuation of the current fishing mortality would lead to little change in spawning stock biomass in the immediate future. The EU subsequently set a TAC of 21,000 t for the fishery in 1995 which was at the same level since 1991. The total catch in 1995 was about 19,000 t.

In 1995 ACFM reacted to the apparent decrease in stock in the area and recommended that F should be reduced in 1996 by 60% of the 1994 value, corresponding to a catch of only 9,800 t. The EU subsequently introduced a TAC for 1996 of 16,500 t.

The spawning box closure system was again continued during 1995 - the box closed being that in Division VIIg. The Irish fishery was again closed from mid-February through to early October.

The total Irish quota was subdivided into boat quotas on a week by week basis. All vessels were again regulated by licences which restrict landings to specific ports and to specific times.

4.2.2 The fishery in 1995/1996

As has been the case for a number of years the major portion of the catches in this area was taken by the Irish fishery during the spawning season which normally lasts from October to February. This fishery is directed to the Japanese roe market.

The pattern of fishing during 1995/1996 was very similar to that of the previous seasons. Shoals appeared to be very scarce during October and November throughout all areas particularly on the inshore spawning grounds. However, as in 1994/1995, unusually large shoals appeared in January and early February on the important spawning grounds in Division VIIa (South). Shoals were also abundant in Dingle Bay (Division VIIj) in January and early February. It was pointed out by the 1995 Working Group that there appears to have been a continued increase in the abundance of fish from this area at this time in recent years. The distribution of the total international herring catches (t) in Sub-areas VI and VII per quarter are shown in Figure 4.2.1a–d.

The maximum number of Irish vessels participating in the 1995/1996 fishery was 62 which was similar to the numbers participating in 1993 and 1994.

4.2.3 The catch data

The estimated national catches from 1986–1995 for the combined areas by year and by season (1 April–31 March) are given in Tables 4.2.1 and 4.2.2 respectively. The total catches for the fishery over the longer period from 1958 to 1995 are shown in Figure 4.2.2. The reported catch including the estimates of discards and unallocated landings, taken during 1995/1996 was over 23,000 t compared with 19,300 t during the previous season. The increase was mainly due to unusually high catches taken during the first quarter of 1996. Landings from this fishery have been stable for a number of years and have averaged about 19,000 t since 1985.

<u>Discards</u>

The level of discards in this fishery is believed to have decreased in recent years as fishermen have become more expert in identifying suitable shoals for the Japanese roe market and in controlling the amounts of fish in their nets.

Nevertheless, discards were reported at a high level for a very short period in late December 1995 when reports from fishermen suggested that over 3,000 t were discarded. Discarding during the early part of the season was negligible because of lack of shoals, and apart from the 3,000 t already mentioned, there appears to have been little discarding for the remainder of the season. The total amount of discards therefore taken during the season and included in the catch used in the assessment is 3,000 t, which is about 13% of the total catch.

The results of an EU funded project (EU Project BIOECO/93/17) indicate that the overall discard rate of 10%–20% used by the Working Group prior to 1995 was realistic.

4.2.4 Quality of catch and biological data

Management authorities are confident that the accuracy of the landing statistics has increased considerably in recent years. There have, however, been persistent but unconfirmed reports that the overall catch figure may be considerably underestimated (see Section 1.6 sampling). Misreporting of catches from Division VIIj to Division VIIb has decreased in recent years to very small amounts because of the poor fishing along the boundary between the two divisions. Biological sampling of the catches throughout the area continues to be satisfactory. Details of the sampling data per quarter are shown in Table 4.2.3, while the length distributions of the catches taken by the Irish fleet per quarter are shown in Table 4.2.4.

4.2.5 Catches in numbers at age

The total catches in numbers at age, including discards, per season from 1958 to 1995 are shown in Table 4.2.5. The catch during 1995/1996 was dominated by 2.w.ring fish (the 1992/1993 year class). The 1990/91 year class, which was a very strong one, constituted over 23% of the catches during 1995/1996.

4.3 Mean weights at age

As the major portion of the catch from this fishery continues to be taken during the spawning season the mean weights at age in the catches have traditionally been taken as the mean weights in the stock at spawning time (1 October). The mean weights for the last three seasons appear to be reasonably stable and are shown in Table 4.3.1 from 1958 to 1975.

4.4 Stock assessments

4.4.1 Acoustic surveys

Acoustic surveys have been carried out on this stock each season since 1989/1990. Two surveys were again carried out during 1995/1996 by the R.V. Lough Foyle and the results were presented by Molloy and Fernandes (W.D. 1996). The surveys were designed to estimate the size of the autumn and winter spawning components separately - the combined estimate being considered to be the size of the total spawning stock.

The survey transects during 1995/1996 were extended to 30 miles offshore because it had been suggested that the 1994/1995 surveys may have underestimated the total stock as they did not cover the offshore distributions. During the November 1995 survey stocks were virtually absent from Division VIIj and reports from commercial fishermen suggested a very low abundance in this area at that time. A number of shoals were located in Division VIIg and the overall abundance in this area was considerably higher than in 1994. A feature of these shoals was that they were composed of stage V fish and were distributed towards the offshore end of the transects. At the same time there appeared to be no spawning shoals on the inshore spawning grounds where commercial fishing was very poor. Water temperatures in November were approximately 2°C higher in 1995 than in 1994 and there were considerable quantities of warm water species (pilchards and anchovy) in the area.

The second survey, which took place in January 1996, was restricted by bad weather and did not cover any part of Division VIIj where considerable catches were taken later in the month. Nevertheless, the important spawning areas in Division VIIg and Division VIIa (South) were covered intensively. Very large shoals of fish were encountered during this survey particularly on the spawning grounds off Dunmore East. The shoals were the largest observed since these surveys were initiated. Commercial fishermen operating in this area also reported that the shoals were the largest observed for many years. Water temperatures in January 1996 were again approximately 2°C higher than in January 1995. The spawning stock biomass estimated from this survey was approximately 93,000 t.

It was decided that if the biomasses obtained from the two surveys were combined, as in previous years, to give an overall stock estimate, then the result might be an overestimate. This was considered likely because it appears that the offshore distributions located during November did not migrate inshore to spawn as usual because of the high water temperatures. The major spawning of both components appears to have taken place in January and this accounts for the unusually high concentrations observed. The biomass for the 1995/1996 season is therefore estimated by combining the biomass from the January survey, together with a small amount of fish observed from the November survey from Division VIIj and the catches taken prior to the survey.

The age disaggregated data for this stock, together with similar data for the stock estimated from previous surveys are shown in Table 4.4.1. The data show that the stock is dominated by the 1992/1993 year class while this year class also dominated the commercial catches. However, this year class which was abundant in the 1993/1994 surveys was very poorly represented in the 1994/1995 surveys. It appears that the 1994/1995 surveys seriously underestimated the size of the year class - either because a large portion of it was still in the Irish Sea, as suggested by the 1991 tagging experiments (Anon. 1993a) or because the 1994/1995 surveys did not cover the total distribution of the adult spawning stock.

The total spawning stock estimated by the 1995/1996 surveys is over twice that estimated during the previous season. Considerable confidence can, however, be attached to the results of the 1995/1996 surveys because of the extended coverage, the success rate of fishing - viz. all the shoals located and classified as definitely herring were verified with substantial catches, and because the results were consistent with observations from the commercial fishing. The possibility of double counting does not arise because only the results of the January survey and a small portion of the November survey have been used in estimating the final stock size. In addition no estimate has been included for that portion of the overall stock which spawned in Division VIIj (Dingle Bay) during January and which appeared to have been substantial. There still exists a possibility that even though the spawning stock estimate is the highest recorded in these surveys it may still be an underestimate, because the survey in January did not include Division VIIj.

4.4.2 Results of Assessments

The integrated catch analysis program has been used since 1994 to estimate the fishing mortality and the size of the stock. In these analyses the age-disaggregated data from the acoustic surveys from 1990 to 1995/1996 were used as the only tuning index available. The 0 and 1-ring fish are excluded from the analyses as they are not believed to be fully recruited to the Celtic Sea from Division VIIa (North). The analyses carried out at the 1994 Working Group meeting indicated that using the acoustic surveys as a proportional index of stock abundance provided the best fit to the ICA model. This approach has again been adopted and the results of this run are shown in Table 4.4.2 and the results from the ICA model are shown in Figures 4.4.1, 4.4.2 and 4.4.3.

As shown by Molloy and Fernandes (W.D. 1996) the spawning stock biomasses estimated by the ICA model are consistently lower than those estimated by the acoustic surveys. There is approximately a twofold difference which is similar to that estimated for the North Sea and Division VIa North acoustic surveys. Similarly the spawning stock estimated from the latest ICA model is 85,000 t compared with 114,000 t based on the acoustic survey. Despite the dramatic decrease in SSB indicated by the 1994/1995 acoustic survey, the diagnostics from the ICA model suggest that there is a good fit between the acoustic age-disaggregated data and the catch at age data. The results from the latest run, however, are considerably different from those estimated in 1995 and are more comparable with the estimates obtained in 1994. The spawning stock biomass, which averaged about 56,000 t in the period, increased in 1994 and 1995 due to the recruitment of strong 1990 and 1992 year classes. At the same time the level of fishing mortality has decreased from a very high level in 1992 (0.90) to about 0.50 in 1995. It must again be stressed that F values in this stock are consistently higher than in other herring stocks. The difference in the results from this years assessment and that carried out in 1995 is caused by the increased SSB estimated by the 1995/1996 acoustic surveys.

4.5 Recruitment estimates

There are no recruitment indices available for this stock which can be used for predictive purposes. The numbers of 1-ring fish derived from the ICA model are shown in Figure 4.4.2. There is no apparent trend in recent years and so the geometric mean value over the period 1983–1994 was taken for predictive purposes. The value for the 1992 year class was not included as it is based on limited data. The resultant value was 535 million, compared with values of 517 million and 317 million used in the prediction carried out in 1994 and 1995.

4.6 Short-term Projections

Short-term projections were carried out for the following two scenarios:

1. A catch in 1996 of 18,150 t, i.e. the agreed TAC plus 10% discards. A catch in 1997 of 22,000 t including 10% discards.

2. A level of F in 1997 and 1998 = F95 i.e. 0.548.

The input data are shown in Table 4.6.1. The SSB in 1995 is estimated to be 85,000 t. The results from the various predictions are shown in Tables 4.6.2-4.6.3. A catch in 1996 of 18,150 t will result in a spawning stock in 1997 of 93,000 t. Catches of about 22,000 t in 1997 and 1998 will result in a stable stock of about 91,000 t to 93,000 t. Levels of fishing mortality will decrease to about 0.3.

If fishing mortality in 1997 and 1998 continues at about the 1995 level (i.e. F = 0.548) then the resulting catches in 1997 and 1998 will be 36,400 t and 28,600 t but the SSB will fall sharply to 77,000 t.

The most likely level of catches in 1996 may be about 22,000 t and a management option is therefore presented in Table 4.6.4 for various levels of F in 1997. A catch in 1997 of 15,900 t will enable the spawning stock to increase slightly to 95,000 t in 1998. A catch of 22,600 t will result in a slight decrease in spawning stock to 87,000 t in 1998. It would appear that catches of around 20,000 t will result in a stabilisation of the SSB at around 90,000 t.

The detailed results of the management options are shown in Table 4.6.5 and the yield/recruit in Figure 4.6.1.

4.7 Consideration of MBAL and stock/recruit relationships

The MBAL for the Celtic Sea was considered by the 1976 Herring Assessment Working Group (ICES 1976) to be one third of the biomass in a period of relatively light exploitation. The level was calculated at about 40,000 t and was estimated at a time when the stock was not combined with that in Division VIIj.

For the present combined stock the MBAL was first considered by examining the stock recruitment estimates (Figure 4.7.1). Recruitment appears to be independent of stock size over the range of stock sizes observed. It was then decided to calculate the unexploited spawning biomass using the same procedure as outlined in Section 7.7. The long-term arithmetic mean recruitment of 446 x 10^9 one-ringers was used in the calculation which is shown in Table 4.7.1. Unexploited SSB was calculated over the age groups 1-9 (age range used in the current assessment) and also for age ranges 1-15 and 1-20. Estimates of MBAL equivalent to 20% of the unexploited SSB were in the range 31-49,000 t and at 33% of unexploited SSB were in the range 52-82,000 t.

Estimates of MBAL at 20% of unexploited SSB over ages 1-20 and at 33% of unexploited SSB over ages 1-9 were similar at around 50,000t and correspond with criteria adopted for Division VIa(N) and VIIa(N) herring. With reference to the stock/recruit data (Figure 4.7.1) approximately 25% of the historical SSB estimates have fallen below 50,000t. The stock fell below this level in the 1970s following a period of increasing fishing mortality and during a period of poor recruitment.

Medium-term projections were carried out using an MBAL of 50,000 t as a reference point. Stochastic projections were carried out over a 10 year time horizon using the ICA linked program ICPRO ver 2.0 (Patterson W.D. 1996). Projections were carried out for two scenarios:

1. *Status quo* F at the 1995 level (F=0.54)
2. Constant catch (landings plus discards) of 20,000t per year.

Graphical outputs are shown in Figs 4.7.2 and 4.7.3. At F *status quo* landings and stock size decline slightly over the 10 year time horizon and the risk of SSB falling below MBAL increases from 0.1 in 1996 to approximately 0.3 in 2005. For a constant catch of 20,000 t stock size remains relatively stable (on average) with a smaller increase in risk (0.2) of falling below MBAL by 2005. However, declines in SSB below MBAL under constant catch conditions are likely to be more severe than under a constant fishing mortality as indicated by the increasing values of F in the upper 95th percentile (Figure 4.7.3).

The probability of the SSB falling below MBAL by the end of the 10 year projection, for different levels of F(2-7) is shown in Figure 4.7.4a. The probability attains 50% at an F level of about 0.65. The relationship between average fishing mortality and median SSB level after 10 years is shown in Figure 4.7.4b.

4.8 Management Considerations

The present assessment indicates that the spawning stock is considerably higher than that estimated by the 1995 Working Group. The increase is largely as a result of the high estimate obtained by the 1995 acoustic surveys and the recruitment of a strong 1992/1993 year class. The history of the fishery in this area shows that the stock fluctuates very much and it is very sensitive to increased catches. Overall fishing mortality rates have always been high compared to those in other herring stocks. At present the stock appears to be in a healthy state and capable of maintaining catches of around 20,000 t. This catch rate is consistent with the estimates of m.s.y and y/b ratio for the fishery (Anon. 1996).

The fleet which exploits this stock is capable of generating a very high fishing mortality particularly as the major fishery takes place for spawning shoals on the spawning beds. It is important that the fishery should continue to be effectively monitored and that the effort should be reduced if possible. It is extremely important that the fishery should continue to be effectively monitored and that the effort should be reduced. It is also important that discarding of herring should be eliminated. Accurate estimates of the quantities discarded should be obtained.

Protection of Herring Spawning Grounds

The herring spawning grounds in the Celtic Sea and Division VIIj are situated in shallow, inshore waters along the Irish coast. Although the spawning grounds themselves are well known the precise location of the spawning beds within the spawning grounds are not known. In recent years a number of threats to the spawning grounds have arisen in the form of possible removal of sand and gravel aggregate, the dumping of mud and silt from harbour dredging operations and the siteing of fish farms. Any activity which would result in a decreased spawning potential must have adverse effects on the size of the spawning population.

The effects of gravel extraction and siltation on sensitive communities has been discussed by the ICES Working Group on the Effects of Extraction of Marine Sediments on Fisheries (Anon. 1992b). In a special section dealing with herring the Working Group states that "Harmful consequences for the herring and its fisheries from the impact of the dredging of its spawning ground were pointed out at the first and second meetings of the Working Group (ICES 1977b, 1975)". Changes in the structure of the spawning grounds, caused by dredging, will negatively influence the return of herring to the spawning sites and therefore their reproduction to a high degree. In addition, excessive siltation could smother eggs during the period of incubation (Hildebrand, 1963).

Because of the potential damage to sensitive communities, including herring, the Working Group drew up a suggested code of practice intended to promote sound management to ensure that the dredging industry operates in harmony with fisheries and other ocean space users.

The importance of the inshore herring spawning grounds and their vulnerability along the Irish coast, not only in the Celtic Sea and Division VIIj, but also in the adjoining Divisions VIIb, VIa (South) and VIIa cannot be overemphasised. The Working Group therefore recommends that sufficient measure be taken to ensure their maximum protection and that the code of practice drawn up by ICES in relation to gravel extraction should be implemented.

Table 4.2.1 Celtic Sea and Division VIIj HERRING landings by calendar year (t), 1986–1995. (Data provided by Working Group members.)

These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	France	Germany	Ireland	Netherlands	U.K.	Unallocated	Discards	Total
1986	-	-	13,300	+	-	6,100	3,900	23,300
1987	800	-	15,500	1,500	-	5,300	4,200	27,300
1988	-	-	16,800	-	-	-	2,400	19,200
1989	+	-	16,000	1,900	-	1,300	3,500	22,700
1990	+	-	15,800	1,000	200	700	2,500	20,200
1991	+	100	19,400	1,600	-	600	1,900	23,600
1992	500	-	18,000	100	+	2,300	2,100	23,000
1993	-	-	19,000	1,300	+	-1,100	1,900	21,100
1994[1]	+	200	17,400	1,300	+	-1,500	1,700	19,100
1995[1]	200	200	18,000	100	+	-200	700	19,000

[1]Preliminary

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Table 4.2.2 Celtic Sea and Division VIIj herring landings (t) by season (1 April–31 March). (Data provided by Working Group members).

These figures may not in all cases correspond to the offical statistics and cannot be used for management purposes.

Year	France	Germany	Ireland	Netherlands	U.K.	Unallocated	Discards	Total
1986/1987	-	-	14,700	+	-	6,100	4,200	25,000
1987/1988	800	-	15,500	1,500	-	4,400	4,000	26,200
1988/1989	-	-	17,000	-	-	-	3,400	20,400
1989/1990	+	-	15,000	1,900	-	2,600	3,600	23,100
1990/1991	+	-	15,000	1,000	200	700	1,700	18,600
1991/1992	500	100	21,400	1,600	-	-100	2,100	25,600
1992/1993	-	-	18,000	1,300	-	-100	2,000	21,200
1993/1994	-	-	16,600	1,300	+	-1,100	1,800	18,600
1994/1995	+	200	17,400	1,300	+	-1,500	1,900	19,300
1995/1996	200	200	20,000	100	+	-200	3,000	23,300

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Table 4.2.3 Celtic Sea, Division VIIj (1995–1996). Sampling intensity of commercial catches.

Country		Catch (t)	No. of samples	No. of age readings	No. of fish measured	Aged per 1000 t	Estimates of discards
Ireland	Q 4	11,600	42	1,365	5,142	118	Yes
	Q 1	11,300	35	878	6,267	78	Yes
Netherlands	Q 3	100	-	-	-	-	-
Germany	Q 4	200	-	-	-	-	-
France	Q3	200	-	-	-	-	-

Table 4.2.4 Celtic Sea and Division VIIj. Length distribution (including discards) of Irish catches/quarter (thousands).

Length	Division VIIa South		Division VIIg	Division VIIj		
	Q4 95	Q1 96	Q4 95	Q3 95	Q4 95	Q1 96
18						
19		17				
		-	50			
20	11	52	176		71	13
	16	87	328		24	26
21	39	87	403		119	190
	74	157	479		381	428
22	125	385	631		452	651
	203	472	706		238	342
23	363	2,150	1,186		452	322
	527	3,566	1,211		428	382
24	766	6,031	2,700		1,094	717
	738	7,657	3,230		1,832	1,218
25	899	10,471	3,962		2,879	2,145
	895	6,450	3,230	2	3,069	1,836
26	590	7,202	2,851	6	2,379	1,106
	625	4,947	2,801	16	1,761	777
27	797	5,384	3,533	42	1,832	1,060
	738	4,405	4,038	85	1,761	1,336
28	582	4,038	5,072	91	2,070	1,612
	274	1,311	2,725	59	1,475	1,145
29	148	821	1,867	71	999	592
	90	245	656	48	571	296
30	55	157	202	32	404	118
	12		202	10	95	33
31	-		100	12	48	7
	8		-	-		-
32			25	-		7
				4		
Total	8,575	66,092	42,364	478	24,434	16,359
Tonnes	1,200	9,000	6,400	100	3,927	2,350

Table 4.2.5 Catch in numbers. Celtic Sea and Division VIIj herring.

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HER-IRLS: Herring South and South West of Ireland (Celtic Sea + VIIj)

CANUM: Catch in Numbers (Thousands)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
1958	1642	3742	33094	25746	12551	23949	16093	9384	5584
1959	1203	25717	2274	19262	11015	5830	17821	3745	7352
1960	2840	72246	24658	3779	13698	4431	6096	4379	4151
1961	2129	16058	32044	5631	2034	5067	2825	1524	4947
1962	772	18567	19909	48061	8075	3584	8593	3805	5322
1963	297	51935	13033	4179	20694	2686	1392	2488	2787
1964	7529	15058	17250	6658	1719	8716	1304	577	2193
1965	57	70248	9365	15757	3399	4539	12127	1377	7493
1966	7093	19559	59893	9924	13211	5602	3586	8746	3842
1967	7599	39991	20062	49113	9218	9444	3939	6510	6757
1968	12197	54790	39604	11544	22599	4929	4170	1310	4936
1969	9472	93279	55039	33145	12217	17837	4762	2174	3469
1970	1319	37260	50087	26481	18763	7853	6351	2175	3367
1971	12658	23313	37563	41904	18759	10443	4276	4942	2239
1972	8422	137690	17855	15842	14531	4645	3012	2374	1020
1973	23547	38133	55805	7012	9651	5323	3352	2332	1209
1974	5507	42808	17184	22530	4225	3737	2978	903	827
1975	12768	15429	17783	7333	9006	3520	1644	1136	1194
1976	13317	11113	7286	7011	2872	4785	1980	1243	1769
1977	8159	12516	8610	5280	1585	1898	1043	383	470
1978	2800	13385	11948	5583	1580	1476	540	858	482
1979	11335	13913	12399	8636	2889	1316	1283	551	635
1980	7162	30093	11726	6585	2812	2204	1184	1262	565
1981	39361	21285	21861	5505	4438	3436	795	313	866
1982	15339	42725	8728	4817	1497	1891	1670	335	596
1983	13540	102871	26993	3225	1862	327	372	932	308
1984	19517	92892	41121	16043	2450	1085	376	231	180
1985	17916	57054	36258	16032	2306	228	85	173	132
1986	4159	56747	42881	32930	8790	1127	98	29	12
1987	5976	67000	43075	23014	14323	2716	1175	296	464
1988	2307	82027	30962	9398	5963	3047	869	297	86
1989	8260	42413	68399	19601	8205	3837	2589	767	682
1990	2702	41756	24634	35258	8116	3808	1671	695	462
1991	1912	63854	38342	16916	28405	4869	2588	954	593
1992	10410	26752	35019	27591	10139	18061	3021	6285	689
1993	1608	94061	9372	10221	4491	2790	5932	855	508
1994	12130	35768	61737	3289	3025	4773	1713	1705	474
1995	9450	79159	22591	36541	3686	3420	2651	1859	842

Table 4.3.1 Mean weights at age in catches and spawning stock. Celtic Sea and Division VIIj herring.

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HER-IRLS: Herring South and South West of Ireland (Celtic Sea + VIIj)

WEST: Mean Weight in Stock (Kilograms)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
1958	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1959	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1960	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1961	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1962	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1963	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1964	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1965	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1966	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1967	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1968	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1969	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1970	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1971	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1972	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1973	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1974	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1975	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1976	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1977	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1978	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1979	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1980	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1981	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1982	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1983	0.115	0.174	0.211	0.229	0.244	0.257	0.260	0.263	0.266
1984	0.093	0.142	0.185	0.213	0.213	0.245	0.246	0.263	0.262
1985	0.104	0.140	0.170	0.201	0.234	0.248	0.256	0.260	0.263
1986	0.112	0.155	0.172	0.187	0.215	0.248	0.276	0.284	0.332
1987	0.096	0.138	0.186	0.192	0.204	0.231	0.255	0.267	0.284
1988	0.097	0.132	0.168	0.203	0.209	0.215	0.237	0.257	0.283
1989	0.106	0.129	0.151	0.169	0.194	0.199	0.210	0.221	0.240
1990	0.099	0.137	0.153	0.167	0.188	0.208	0.209	0.229	0.251
1991	0.092	0.128	0.168	0.182	0.190	0.206	0.229	0.236	0.251
1992	0.096	0.123	0.150	0.177	0.191	0.194	0.212	0.228	0.248
1993	0.092	0.129	0.155	0.180	0.201	0.204	0.210	0.225	0.240
1994	0.097	0.135	0.168	0.179	0.190	0.210	0.218	0.217	0.227
1995	0.088	0.126	0.151	0.178	0.188	0.198	0.207	0.227	0.227

Table 4.4.1 Total stock at age estimated from acoustic surveys (10^6).

W.Rs	1990/1991	1991/1992	1992/1993	1993/1994	1994/1995	1995/1996
0	204.8	213.8	141.8	258.8	41.3	5.1
1	131.6	62.6	426.9	217.1	38.0	279.5
2	249.0	195.2	117.0	437.9	127.2	550.7
3	108.6	94.7	87.8	58.7	160.3	138.4
4	152.5	54.0	49.6	63.4	10.5	93.5
5	32.4	84.8	22.2	26.0	10.6	7.9
6	14.9	22.1	24.2	16.3	6.5	9.2
7	6.1	5.3	9.6	24.6	1.6	8.4
8	2.5	6.1	1.8	2.3	2.6	9.2
9+	1.5	-	1.1	1.7	0.5	4.7
Total	903.9	738.6	882.0	1,106.8	399.1	1106.5
TSB (000't)	103.0	84.4	88.5	104.0	51.8	134.6
SSB (000't)	91.0	77.0	71.0	90.0	50.6	114.0

Table 4.4.2 Celtic Sea and Division VIIj.

CATCH NUMBERS AT AGE (Millions)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	3.	11.	7.	39.	15.	14.	20.	18.	4.	6.	2.	8.	3.	2.	10.	2.	12.	9.
2	13.	14.	30.	21.	43.	103.	93.	57.	57.	67.	82.	42.	42.	64.	27.	94.	36.	79.
3	12.	12.	12.	22.	9.	27.	41.	36.	43.	43.	31.	68.	25.	38.	35.	9.	62.	23.
4	6.	9.	7.	6.	5.	3.	16.	16.	33.	23.	9.	20.	35.	17.	28.	10.	3.	37.
5	2.	3.	3.	4.	1.	2.	2.	2.	9.	14.	6.	8.	8.	28.	10.	4.	3.	4.
6	1.	1.	2.	3.	2.	0.	1.	0.	1.	3.	3.	4.	4.	5.	18.	3.	5.	3.
7	1.	1.	1.	1.	2.	0.	0.	0.	0.	1.	1.	3.	2.	3.	3.	6.	2.	3.
8	1.	1.	1.	0.	0.	1.	0.	0.	0.	0.	0.	1.	1.	1.	6.	1.	2.	2.
9	0.	1.	1.	1.	1.	0.	0.	0.	0.	0.	0.	1.	0.	1.	1.	1.	0.	1.

INDICES OF SPAWNING STOCK BIOMASS
0

AGE - STRUCTURED INDICES
INDEX : 1 from 1990 to 1995

	1990	1991	1992	1993	1994	1995
2	.249E+03	.195E+03	.117E+03	.438E+03	.127E+03	.551E+03
3	.109E+03	.947E+02	.878E+02	.587E+02	.160E+03	.138E+03
4	.153E+03	.540E+02	.496E+02	.634E+02	.105E+02	.935E+02
5	.324E+02	.848E+02	.222E+02	.260E+02	.106E+02	.790E+01
6	.149E+02	.221E+02	.242E+02	.163E+02	.650E+01	.920E+01
7	.610E+01	.530E+01	.960E+01	.246E+02	.160E+01	.840E+01
8	.250E+01	.610E+01	.180E+01	.230E+01	.260E+01	.920E+01
9	.150E+01	-.100E+01	.110E+01	.170E+01	.500E+00	.470E+01

FISHING MORTALITY

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	.0333	.0781	.0809	.1633	.0374	.0298	.0555	.0545	.0124	.0097	.0085	.0259	.0104	.0131	.0231	.0127	.0121	.0132
2	.3016	.4044	.5544	.6790	.4838	.6964	.5238	.4002	.4317	.5052	.3054	.3714	.3233	.4084	.7191	.3972	.3783	.4124
3	.4050	.5428	.7745	1.1679	.7242	.7053	.7347	.4274	.6455	.7475	.4984	.4830	.4575	.5779	1.0177	.5621	.5353	.5836
4	.5445	.5460	.5927	1.0257	.8548	.6163	1.2358	.6836	.8292	.8400	.3353	.6485	.4094	.5172	.9107	.5030	.4791	.5222
5	.3732	.5344	.3037	.9186	.7738	.8605	1.2440	.4944	.8999	.9680	.4750	.4843	.3758	.4747	.8360	.4617	.4398	.4794
6	.3194	.5376	.9009	.6497	1.2287	.3326	2.0471	.2956	.4241	.6915	.4867	.5657	.4435	.5602	.9865	.5448	.5189	.5657
7	.3623	.4481	1.2173	.8744	.6761	.7496	.6932	.8894	.1786	.9316	.4357	.8838	.4588	.5796	1.0207	.5637	.5369	.5853
8	.5171	.6754	.9469	1.1871	1.0496	.9035	1.4349	.7103	.7788	1.0444	.5640	.7575	.5490	.6935	1.2212	.6745	.6424	.7003
9	.5171	.6754	.9469	1.1871	1.0496	.9035	1.4349	.7103	.7788	1.0444	.5640	.7575	.5490	.6935	1.2212	.6745	.6424	.7003

NUMBERS AT AGE (Millions)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	135.	237.	145.	408.	658.	729.	570.	532.	531.	983.	430.	510.	442.	197.	870.	331.	876.	1136.	546.
2	59.	48.	81.	49.	127.	233.	260.	198.	185.	193.	358.	157.	183.	161.	72.	313.	120.	318.	412.
3	39.	32.	24.	34.	18.	58.	86.	114.	98.	89.	86.	195.	80.	98.	79.	26.	156.	61.	156.

Table 4.4.2 (Cont'd)

4	14.	21.	15.	9.	9.	7.	24.	34.	61.	42.	35.	43.	99.	42.	45.	23.	12.	75.	28.
5	5.	7.	11.	8.	3.	3.	4.	6.	15.	24.	17.	22.	20.	59.	22.	16.	13.	7.	40.
6	6.	3.	4.	8.	3.	1.	1.	1.	3.	6.	8.	9.	12.	13.	33.	9.	9.	7.	4.
7	2.	4.	2.	1.	4.	1.	1.	0.	1.	2.	3.	5.	5.	7.	7.	11.	5.	5.	4.
8	2.	1.	2.	0.	1.	2.	0.	0.	0.	0.	1.	2.	2.	3.	4.	2.	6.	2.	3.
9	1.	2.	1.	1.	0.	0.	1.	0.	0.	0.	0.	0.	1.	1.	2.	1.	2.	4.	3.

STOCK SUMMARY

Year	Recruits x10^6	Total B tonnes	Spawn B tonnes	Landings tonnes	Yld/SSB	Ref. F Fbar 2- 7
1978	135.	41304.	26207.	7559.	.2884	.3843
1979	237.	51724.	28221.	10321.	.3657	.5022
1980	145.	44344.	26954.	13130.	.4871	.7239
1981	408.	69367.	30701.	17103.	.5571	.8859
1982	658.	106399.	46848.	13000.	.2775	.7902
1983	729.	140217.	68228.	24981.	.3661	.6601
1984	570.	112429.	61829.	26779.	.4331	1.0798
1985	532.	111173.	62030.	20426.	.3293	.5318
1986	531.	121035.	66965.	25024.	.3737	.5682
1987	983.	152598.	74209.	26200.	.3531	.7806
1988	430.	116557.	74269.	20447.	.2753	.4227
1989	510.	118622.	69222.	23254.	.3359	.5728
1990	442.	105499.	65003.	18404.	.2831	.4114
1991	197.	79262.	55738.	25562.	.4586	.5197
1992	870.	125566.	57389.	21127.	.3681	.9151
1993	331.	87329.	55238.	18618.	.3371	.5054
1994	876.	136593.	67841.	19300.	.2845	.4814
1995	1136.	167733.	85203.	23305.	.2735	.5248

PARAMETER ESTIMATES +/- SD

Separable Model: Reference F by year

1	1990	.4575	.3791	.5522
2	1991	.5779	.4871	.6857
3	1992	1.0177	.8791	1.1782
4	1993	.5621	.4717	.6698
5	1994	.5353	.4425	.6477
6	1995	.5836	.4624	.7366

Separable Model: Selection (S) by age

7	1	.0227	.0131	.0394
8	2	.7066	.5755	.8676
	3	1.0000	Fixed : Reference age	
9	4	.8949	.7423	1.0788
10	5	.8215	.6861	.9835
11	6	.9693	.8176	1.1491
12	7	1.0029	.8419	1.1946
	8	1.2000	Fixed : last true age	

Table 4.4.2 (Cont'd)

Separable Model: Populations in year 1995

13	1	1135792.	304397.	4237967.
14	2	318432.	229612.	441611.
15	3	61102.	47702.	78266.
16	4	74620.	59787.	93131.
17	5	6766.	5500.	8324.
18	6	7470.	6116.	9124.
19	7	5028.	4091.	6181.
20	8	2437.	1936.	3067.

Separable Model: Populations at age 8

21	1990	1719.8309	1237.3146	2390.5143
22	1991	2729.1327	2111.8767	3526.7992
23	1992	3670.1264	2914.6069	4621.4905
24	1993	2125.5665	1672.7978	2700.8841
25	1994	5799.7474	4648.0745	7236.7751

Age-structured index catchabilities

Age-Structured Index 1

Linear model fitted. Slopes at age:

26	2 Q	.28921E-02	.22696E-02	.36853E-02
27	3 Q	.31975E-02	.25165E-02	.40627E-02
28	4 Q	.26372E-02	.20768E-02	.33489E-02
29	5 Q	.22668E-02	.17828E-02	.28822E-02
30	6 Q	.23396E-02	.18262E-02	.29974E-02
31	7 Q	.22631E-02	.17212E-02	.29756E-02
32	8 Q	.27870E-02	.20404E-02	.38068E-02
33	9 Q	.20432E-02	.14077E-02	.29656E-02

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals
(log(Observed Catch)-log(Expected Catch))
and weights (W) used in the analysis.

Age	1990	1991	1992	1993	1994	1995	
1	-.64938E-01	.16146E+00	-.18817E+00	-.50217E+00	.59504E+00	-.39746E-08	.10000E+00
2	.51282E-01	.30576E+00	-.18933E+00	.50838E-01	.78436E-01	-.17096E+00	.10000E+01
3	.86574E-01	.25873E-01	.28530E+00	-.82476E-01	.45220E-01	-.90109E-01	.10000E+01
4	.10727E+00	.54477E-01	.67497E-01	.14426E+00	-.28906E+00	.23068E+00	.10000E+01
5	.28976E+00	.28227E+00	-.18147E+00	-.25334E+00	-.36453E+00	.40343E+00	.10000E+01
6	-.11391E+00	-.60991E-01	-.10627E+00	-.23429E+00	.27833E+00	.10283E+00	.10000E+01
7	-.42899E-02	-.16317E+00	-.28148E+00	.24543E+00	-.66097E-01	.21845E+00	.10000E+01
8	-.19412E-04	-.31480E+00	.92671E+00	-.15501E+00	-.43355E+00	.45886E+00	.10000E+01
Wts	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	

Table 4.4.2 (Cont'd)

Aged Index Residuals: log(Observed Index) - log(Expected Index)

Aged Index 1

Age	1990	1991	1992	1993	1994	1995
2	-.12913E+00	-.15941E+00	.44693E+00	-.27753E-01	-.32878E+00	.19815E+00
3	-.20062E+00	-.41832E+00	.15895E+00	.41891E+00	-.39774E+00	.43881E+00
4	-.25474E-01	-.89479E-01	.13833E+00	.62900E+00	-.53044E+00	-.12193E+00
5	.12444E+00	.11376E+00	.10898E+00	.20552E+00	-.46849E+00	-.84208E-01
6	-.12874E+00	.37042E+00	-.85349E-01	.41326E+00	-.59350E+00	.23901E-01
7	-.12788E-01	-.44952E+00	.69053E+00	.62803E+00	-.12377E+01	.38148E+00
8	-.24632E-02	.57248E+00	-.41644E+00	-.17206E+00	-.10850E+01	.11035E+01
9	.51533E+00	-.10000E+01	.92437E-01	.20515E+00	-.11708E+01	.36639E+00

PARAMETERS OF THE DISTRIBUTION OF ln CATCHES AT AGE

Separable model fitted from 1990 to 1995

Variance	:	.1500
Skewness test statistic	:	2.7185
Kurtosis test statistic	:	2.2082
Partial chi-square	:	.4186
Probability of chi-square	:	1.0000
Degrees of freedom	:	23

PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES

DISTRIBUTION STATISTICS FOR ln AGED INDEX 1

Linear catchability relationship assumed.

Age	:	2	3	4	5	6	7	8	9
Variance	:	.0780	.1533	.1439	.0618	.1369	.5502	.5852	.4553
Skewness test stat.	:	.5561	.0650	.4001	-1.2834	-.3908	-.7272	.0865	-1.1706
Kurtosis test stat.	:	-.4337	-.8582	-.1310	.0873	-.3967	-.3933	-.4461	-.0142
Partial chi-square	:	.0814	.1691	.2204	.1063	.2734	1.5326	2.1358	8.5036
Prob. of chi-square	:	.9999	.9994	.9989	.9998	.9981	.9093	.8301	.0748
Number of data	:	6	6	6	6	6	6	6	5
Degrees of freedom	:	5	5	5	5	5	5	5	4
Weight in analysis	:	.5625	.5625	.5625	.5625	.5625	.5625	.5625	.5625

Table 4.6.1

Herring South and South West of Ireland (Celtic Sea + VIIj)

Prediction with management option table: Input data

Year: 1996								
Age	Stock size	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	512.000	1.0000	0.5000	0.2000	0.5000	0.092	0.0147	0.092
2	412.000	0.3000	1.0000	0.2000	0.5000	0.130	0.4306	0.130
3	156.000	0.2000	1.0000	0.2000	0.5000	0.158	0.6094	0.158
4	28.000	0.1000	1.0000	0.2000	0.5000	0.179	0.5454	0.179
5	40.000	0.1000	1.0000	0.2000	0.5000	0.193	0.5006	0.193
6	4.000	0.1000	1.0000	0.2000	0.5000	0.204	0.5907	0.204
7	4.000	0.1000	1.0000	0.2000	0.5000	0.212	0.6112	0.212
8	2.000	0.1000	1.0000	0.2000	0.5000	0.223	0.7313	0.223
9+	2.000	0.1000	1.0000	0.2000	0.5000	0.231	0.7313	0.231
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Year: 1997								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	535.000	1.0000	0.5000	0.2000	0.5000	0.092	0.0147	0.092
2	.	0.3000	1.0000	0.2000	0.5000	0.130	0.4306	0.130
3	.	0.2000	1.0000	0.2000	0.5000	0.158	0.6094	0.158
4	.	0.1000	1.0000	0.2000	0.5000	0.179	0.5454	0.179
5	.	0.1000	1.0000	0.2000	0.5000	0.193	0.5006	0.193
6	.	0.1000	1.0000	0.2000	0.5000	0.204	0.5907	0.204
7	.	0.1000	1.0000	0.2000	0.5000	0.212	0.6112	0.212
8	.	0.1000	1.0000	0.2000	0.5000	0.223	0.7313	0.223
9+	.	0.1000	1.0000	0.2000	0.5000	0.231	0.7313	0.231
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Year: 1998								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	535.000	1.0000	0.5000	0.2000	0.5000	0.092	0.0147	0.092
2	.	0.3000	1.0000	0.2000	0.5000	0.130	0.4306	0.130
3	.	0.2000	1.0000	0.2000	0.5000	0.158	0.6094	0.158
4	.	0.1000	1.0000	0.2000	0.5000	0.179	0.5454	0.179
5	.	0.1000	1.0000	0.2000	0.5000	0.193	0.5006	0.193
6	.	0.1000	1.0000	0.2000	0.5000	0.204	0.5907	0.204
7	.	0.1000	1.0000	0.2000	0.5000	0.212	0.6112	0.212
8	.	0.1000	1.0000	0.2000	0.5000	0.223	0.7313	0.223
9+	.	0.1000	1.0000	0.2000	0.5000	0.231	0.7313	0.231
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Notes: Run name : MANJM01
Date and time: 17APR96:12:49

Herring South and South West of Ireland (Celtic Sea + VIIj)

Single option prediction: Summary table

Table 4.6.2

							1 January		Spawning time	
Year	F Factor	Reference F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1996	0.4872	0.2670	124097	18150	1160000	141098	904000	117290	700320	93426
1997	0.5513	0.3021	139325	22000	1120094	141350	852594	116472	659606	93310
1998	0.5897	0.3232	135302	22000	1084635	138207	817135	113330	632362	91219
Unit	-	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : SPRJM03
Date and time : 17APR96:13:00
Computation of ref. F: Simple mean, age 2 - 7
Prediction basis : TAC constraints

10:58 Tuesday, April 16, 1996

Herring South and South West of Ireland (Celtic Sea + VIIj)

Single option prediction: Summary table

Table 4.6.3

							1 January		Spawning time	
Year	F Factor	Reference F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1996	0.4379	0.2400	112787	16501	1160000	141098	904000	117290	702976	93817
1997	1.0000	0.5480	230832	36418	1129932	143026	862432	118148	643977	90925
1998	1.0000	0.5480	179258	28610	1012121	125304	744621	100426	551807	77147
Unit	-	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : SPRJM03
Date and time : 16APR96:11:00
Computation of ref. F: Simple mean, age 2 - 7
Prediction basis : F factors

Table 4.6.4

12:18 Wednesday, April 17, 1996

Herring South and South West of Ireland (Celtic Sea + VIIj)

Prediction with management option table

(cont.)

Year: 1996					Year: 1997					Year: 1998	
F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	Stock biomass	Sp.stock biomass
0.6000	0.3288	140852	92481	21781	0.2000	0.1096	137435	93021	8365	148387	103938
.	.	.	.	.	0.4000	0.2192	.	91327	15886	140750	95194
.	.	.	.	.	0.6000	0.3288	.	89670	22652	133907	87494
.	.	.	.	.	0.8000	0.4384	.	88049	28742	127772	80706
.	.	.	.	.	1.0000	0.5480	.	86464	34227	122271	74718
.	.	.	.	.	1.2000	0.6576	.	84913	39170	117337	69430
-	-	Tonnes	Tonnes	Tonnes	-	-	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes

(cont.)

Table 4.6.5

10:58 Tuesday, April 16, 1996

Herring South and South West of Ireland (Celtic Sea + VIIj)

Single option prediction: Detailed tables

Year: 1996 F-factor: 0.4379 Reference F: 0.2400

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0064	2078	193	512000	47616	256000	23808	155072	14422
2	0.1886	61456	7989	412000	53560	412000	53560	341488	44393
3	0.2669	33263	5256	156000	24648	156000	24648	133819	21143
4	0.2388	5672	1010	28000	4984	28000	4984	25392	4520
5	0.2192	7507	1449	40000	7720	40000	7720	36417	7028
6	0.2587	869	177	4000	816	4000	816	3613	737
7	0.2676	896	190	4000	848	4000	848	3607	765
8	0.3202	523	117	2000	446	2000	446	1784	398
9+	0.3202	523	120	2000	460	2000	460	1784	410
Total		112787	16501	1160000	141098	904000	117290	702976	93817
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Year: 1997 F-factor: 1.0000 Reference F: 0.5480

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0147	4941	460	535000	49755	267500	24878	161771	15045
2	0.4306	57177	7433	187146	24329	187146	24329	147786	19212
3	0.6094	105597	16684	252766	39937	252766	39937	202468	31990
4	0.5454	39305	6996	97807	17410	97807	17410	83423	14849
5	0.5006	7509	1449	19953	3851	19953	3851	17172	3314
6	0.5907	12400	2530	29069	5930	29069	5930	24570	5012
7	0.6112	1222	259	2794	592	2794	592	2352	499
8	0.7313	1375	307	2769	618	2769	618	2276	508
9+	0.7313	1305	300	2628	604	2628	604	2159	497
Total		230832	36418	1129932	143026	862432	118148	643977	90925
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Year: 1998 F-factor: 1.0000 Reference F: 0.5480

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0147	4941	460	535000	49755	267500	24878	161771	15045
2	0.4306	59254	7703	193943	25213	193943	25213	153154	19910
3	0.6094	37655	5949	90133	14241	90133	14241	72198	11407
4	0.5454	45215	8048	112512	20027	112512	20027	95965	17082
5	0.5006	19304	3726	51295	9900	51295	9900	44145	8520
6	0.5907	4668	952	10944	2233	10944	2233	9250	1887
7	0.6112	6373	1351	14570	3089	14570	3089	12265	2600
8	0.7313	681	152	1372	306	1372	306	1128	251
9+	0.7313	1167	268	2350	541	2350	541	1931	444
Total		179258	28610	1012121	125304	744621	100426	551807	77147
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : SPRJM03
Date and time : 16APR96:11:00
Computation of ref. F: Simple mean, age 2 - 7
Prediction basis : F factors

Estimation of unexploited biomass: Celtic Sea herring						
	Total	Number	Biomass			
Age	Number	mature	(t)	Maturity	M	weight
1	445536	222768	20717	0.5	1	0.093
2	163904	163904	21307	1	0.3	0.130
3	121423	121423	19185	1	0.2	0.158
4	99413	99413	17695	1	0.1	0.178
5	89952	89952	17361	1	0.1	0.193
6	81392	81392	16604	1	0.1	0.204
7	73647	73647	15613	1	0.1	0.212
8	66638	66638	14860	1	0.1	0.223
9	60297	60297	13868	1	0.1	0.230
10	54559	54559	12549	1	0.1	0.230
11	49367	49367	11354	1	0.1	0.230
12	44669	44669	10274	1	0.1	0.230
13	40418	40418	9296	1	0.1	0.230
14	36572	36572	8412	1	0.1	0.230
15	33092	33092	7611	1	0.1	0.230
16	29942	29942	6887	1	0.1	0.230
17	27093	27093	6231	1	0.1	0.230
18	24515	24515	5638	1	0.1	0.230
19	22182	22182	5102	1	0.1	0.230
20	20071	20071	4616	1	0.1	0.230
Total (1-9)	1202201	979432.6	157212			
Total (1-15)	1460877	1238109	216707			
Total (1-20)	1584680	1361912	245182			
% of Virgin stock						
	age(1-9)	age(1-15)	age(1-20)			
20%	31442	43341	49036			
33%	52404	72236	81727			

Table 4.7.1 Estimation of unexploited biomass. Celtic Sea and Division VIIj herring.

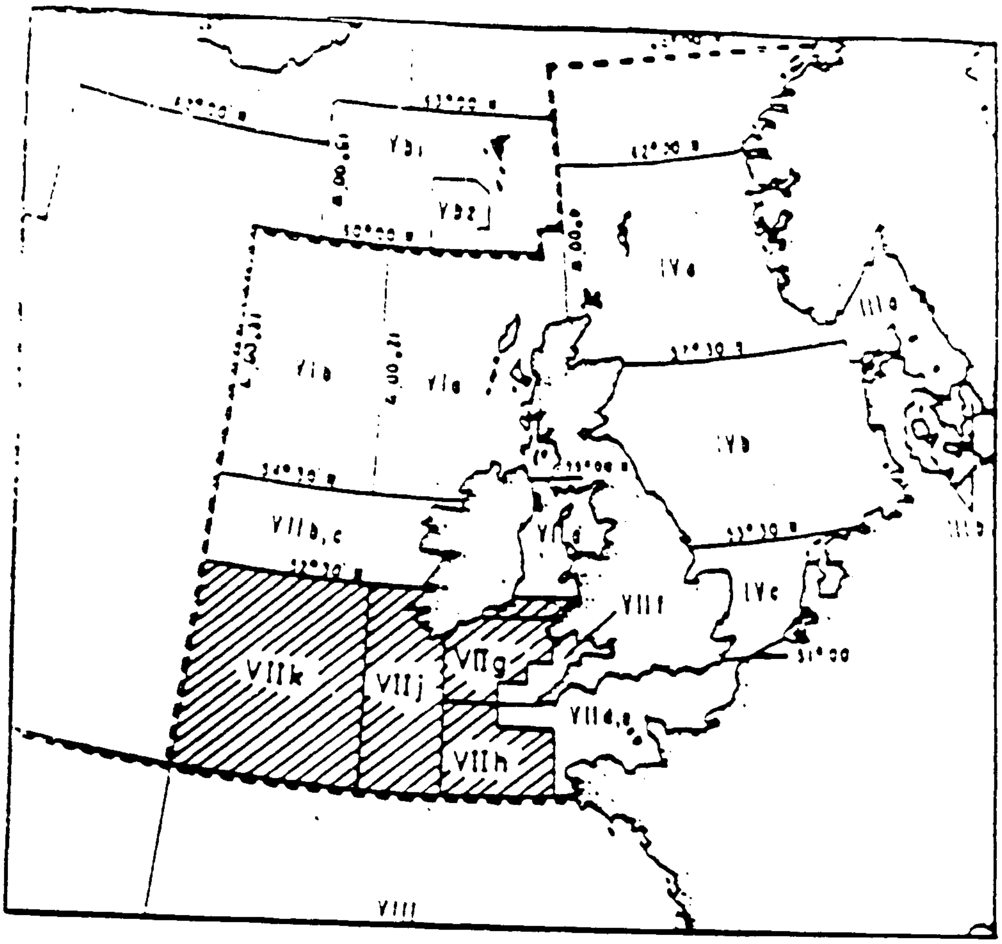


Figure 4.1.1 The assessment covers the area Divisions VIIj and VIIg and that part of Division VIIa below 52°30. TAC is set by EC for Divisions VIIg-k and that section of Division VIIa below 52°30.

Figure 4.2.1a : Distribution of herring catches. 1 quarter 1995. Total catch = 12 964 T (Based on Irish, Norwegian, Dutch, German and U.K data).

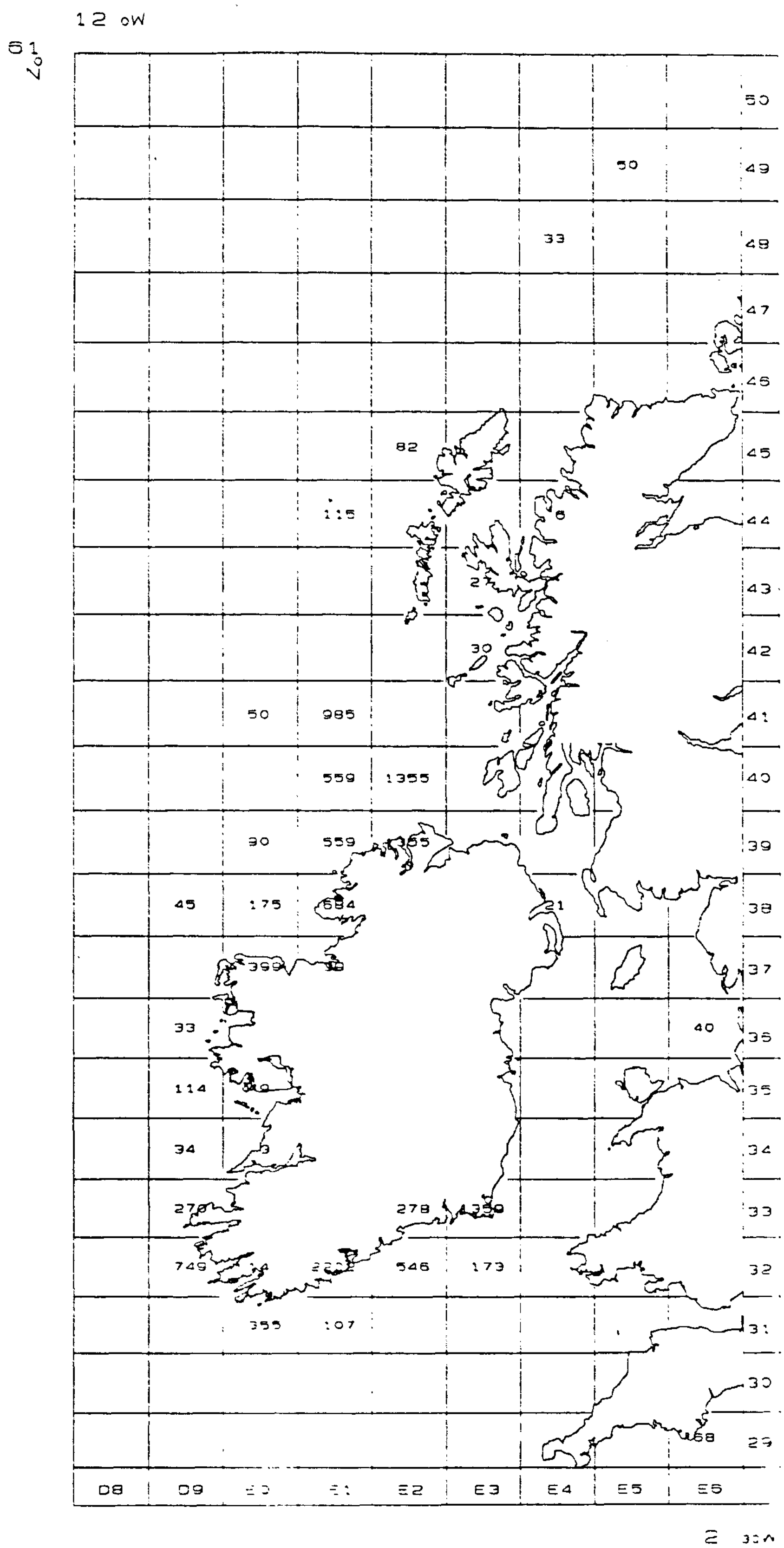


Figure 4.2.1b : Distribution of herring catches. 2 quarter 1995. Total catch = 13 143 T
(Based on Irish, Norwegian, Dutch, German and U.K data).

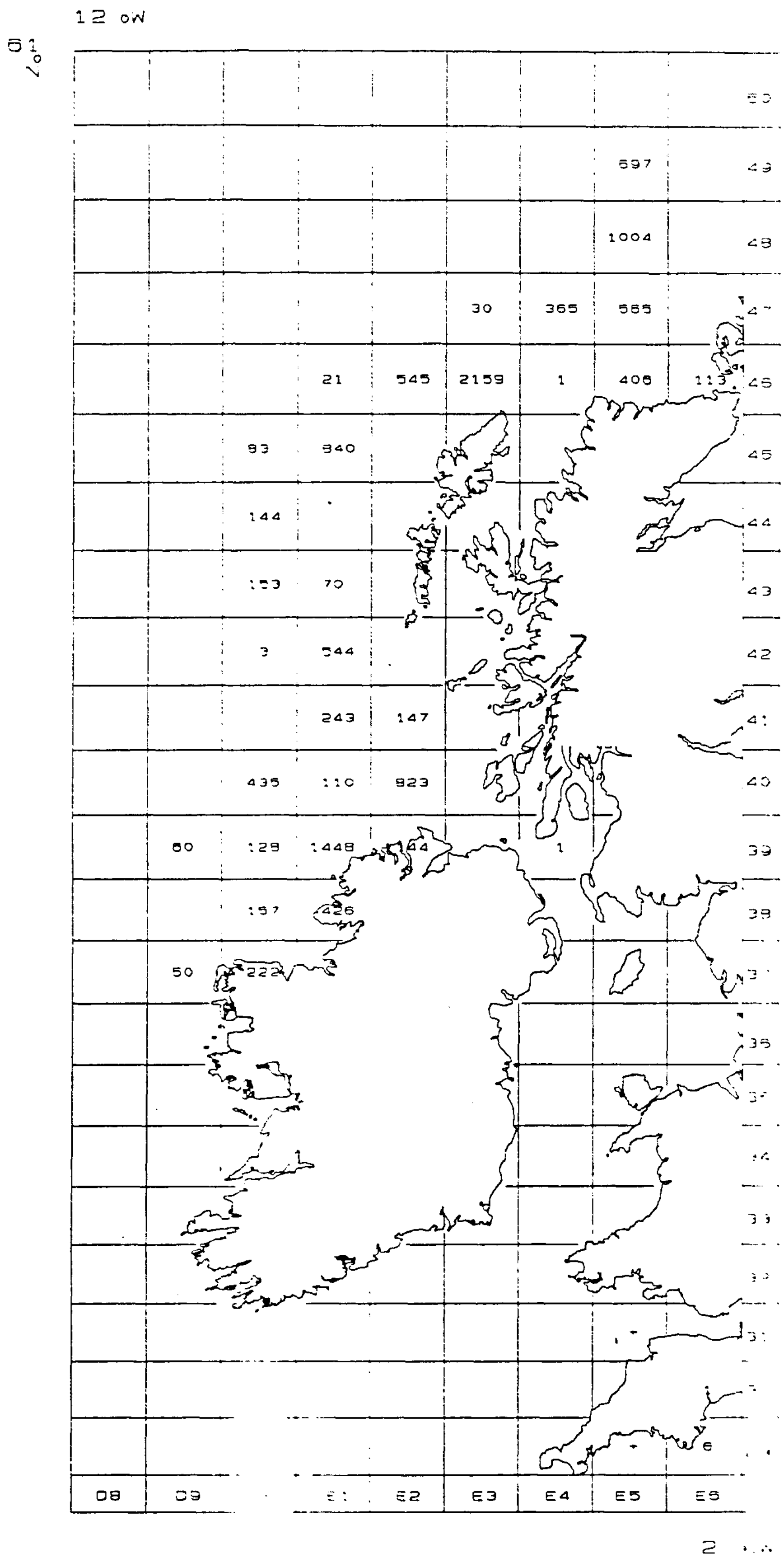


Figure 4.2.1c : Distribution of herring catches. 3 quarter 1995. Total catch = 50 640 T.
(Based on Irish, Norwegian, Dutch, German and U.K data).

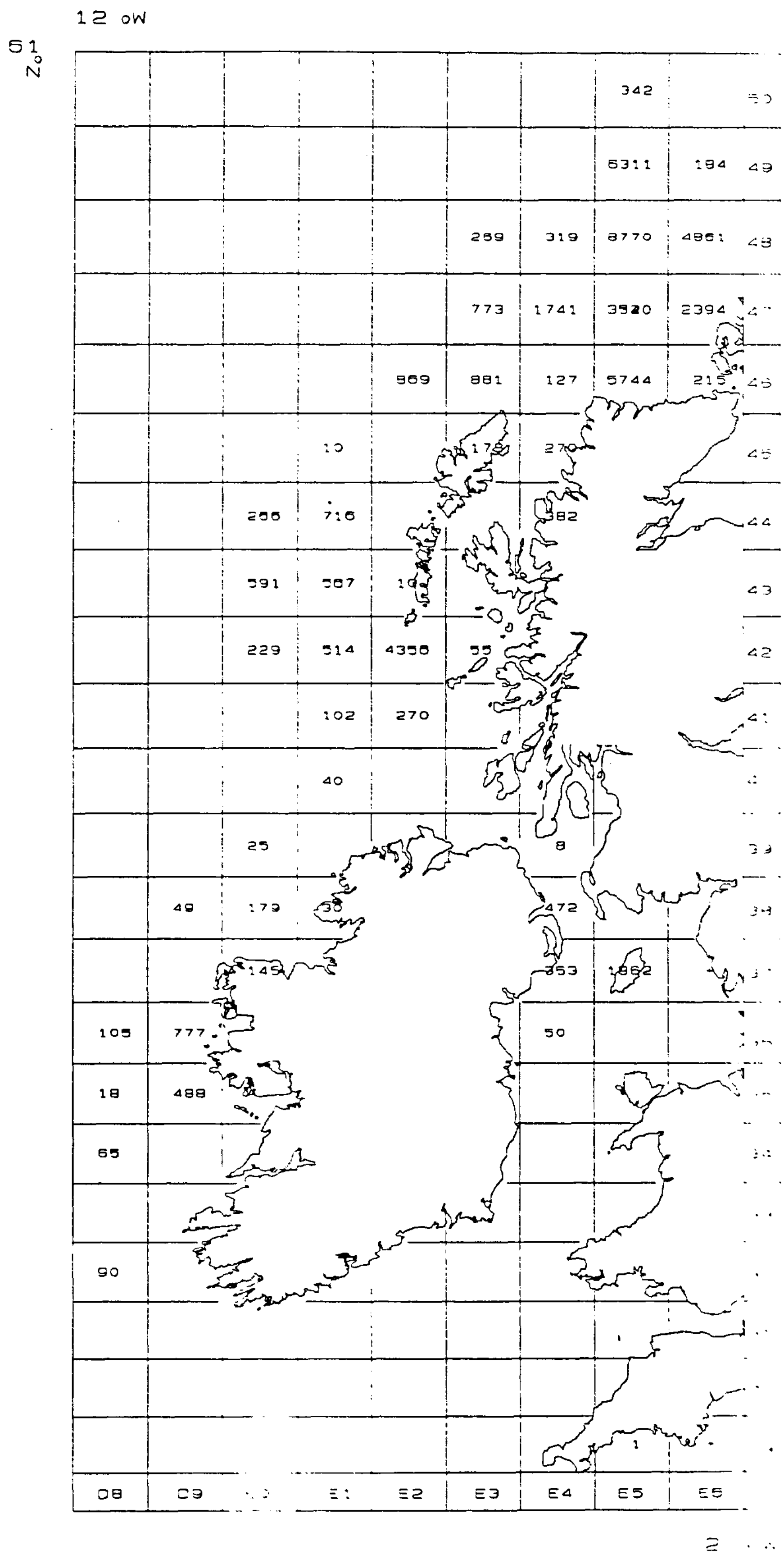


Figure 4.2.1d : Distribution of herring catches. 4 quarter 1995. Total catch = 39 226 T.
(Based on Irish, Norwegian, Dutch, German and U.K data).

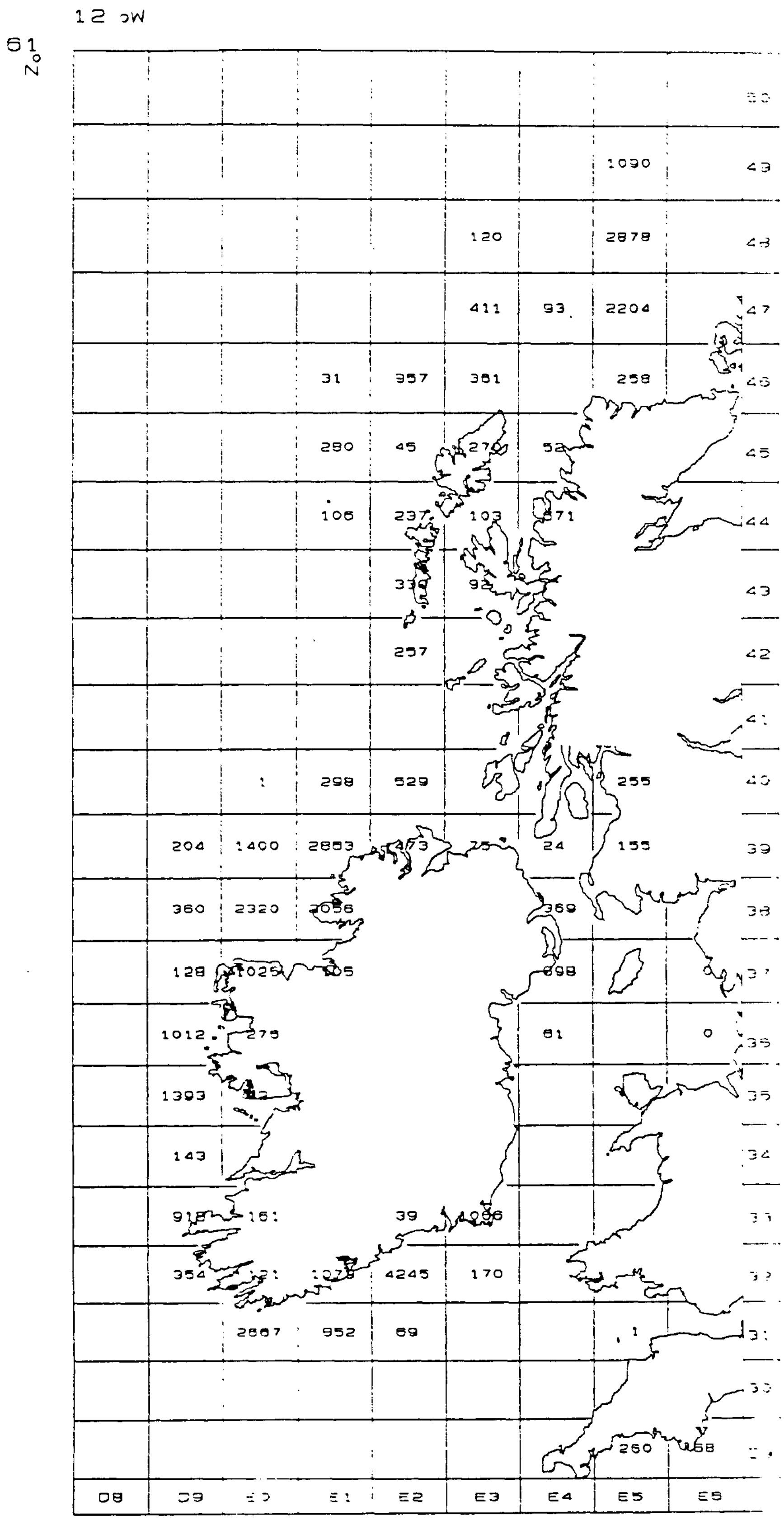


Figure 4.2.3.1 Herring: Landings from the Celtic Sea and Division VIIj for the period 1958-1995

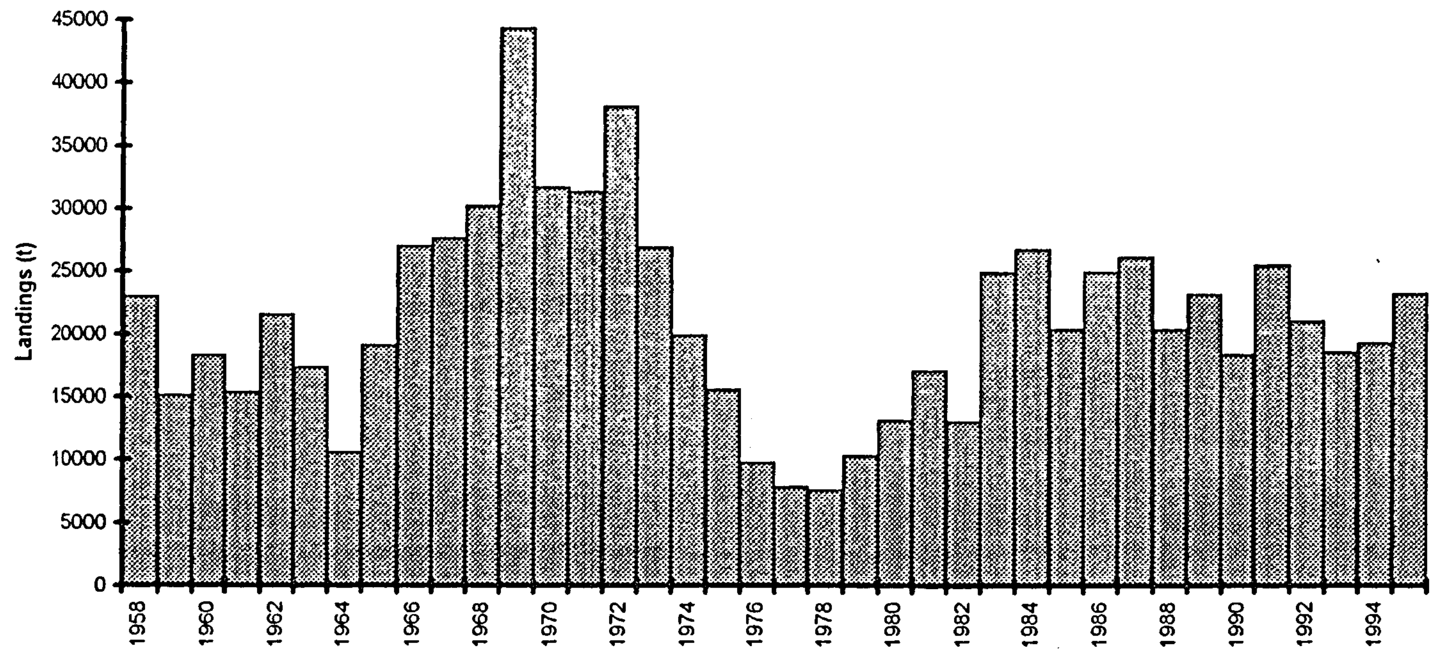


Figure 4.4.1

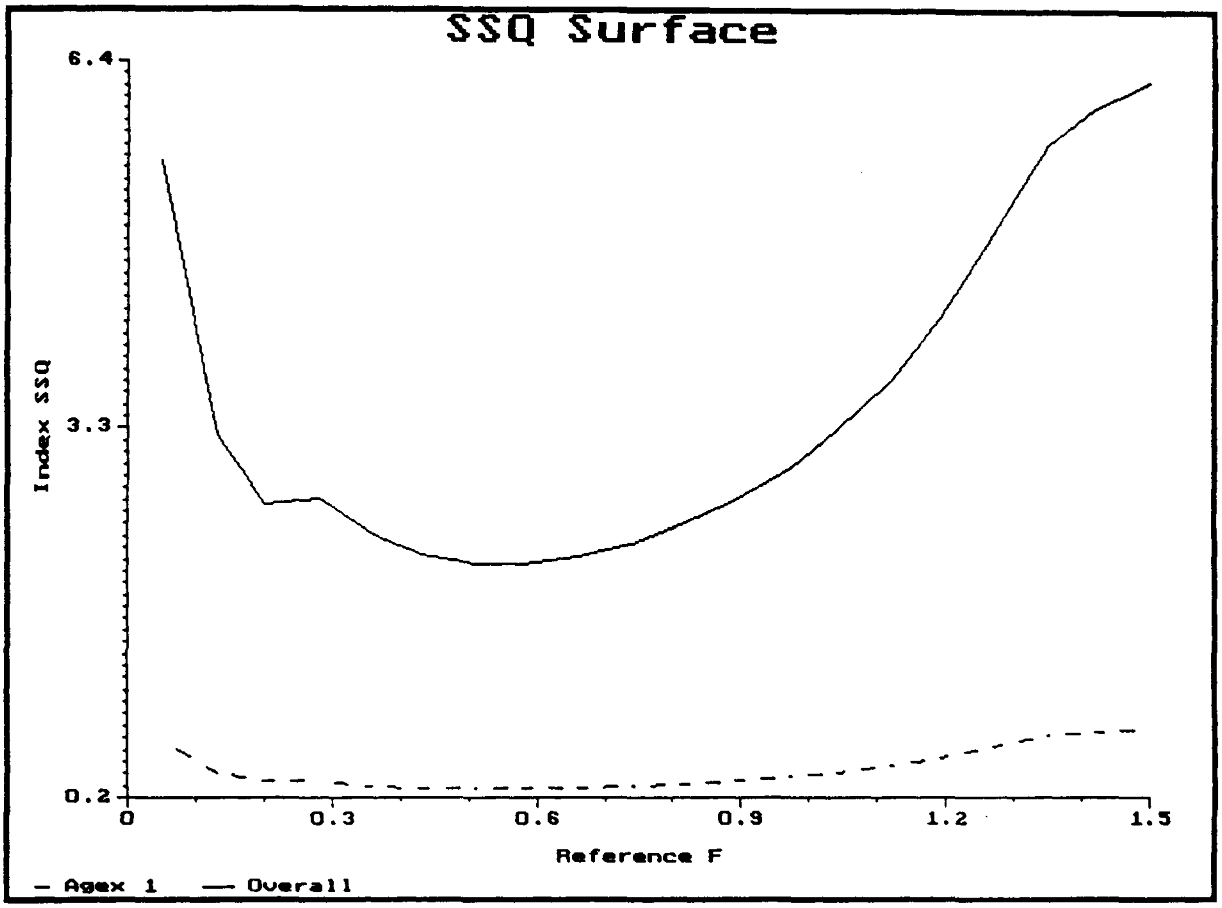

SSQ Surface
6.4
3.3
0.2
Index SSQ
0
0.3
0.6
0.9
1.2
1.5
Reference F
Agex 1
Overall

Figure 4.4.2

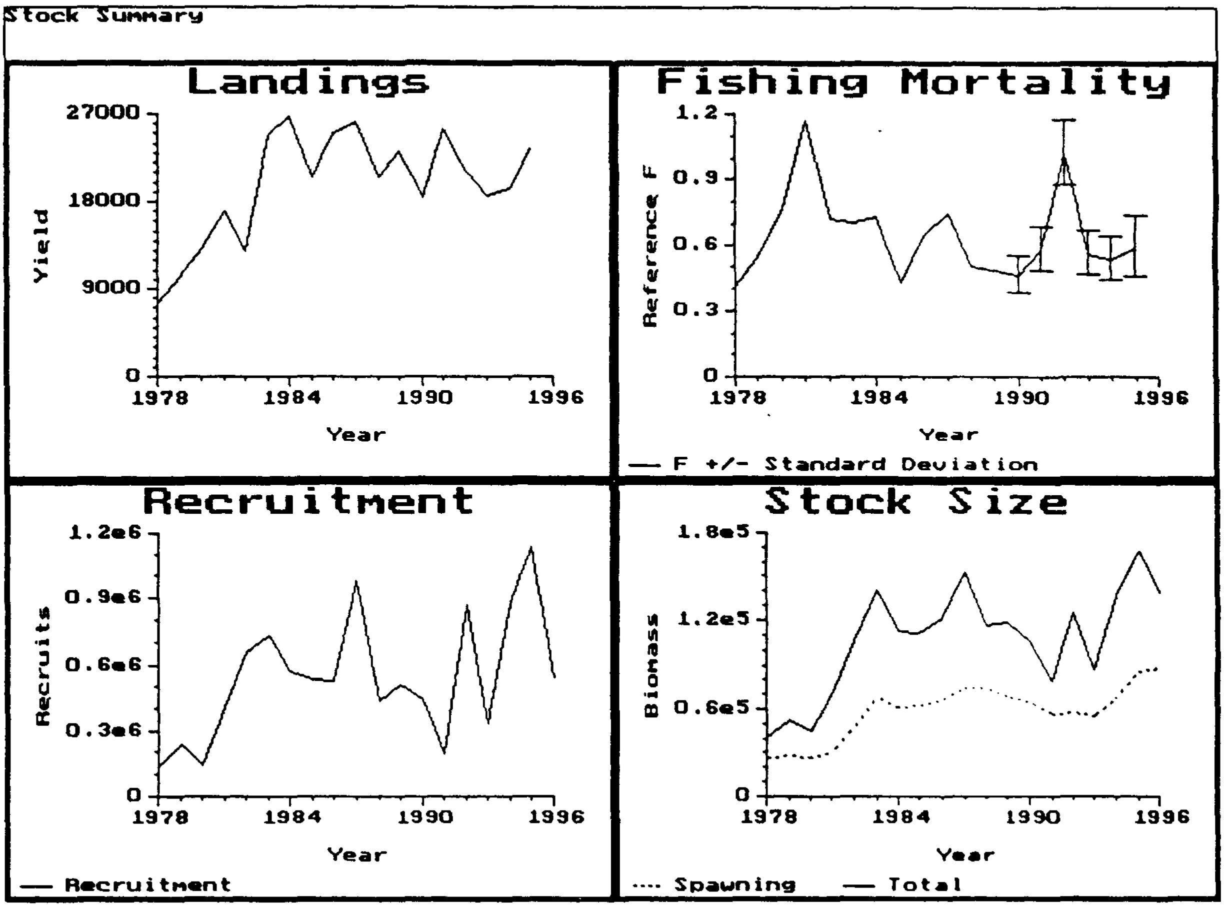
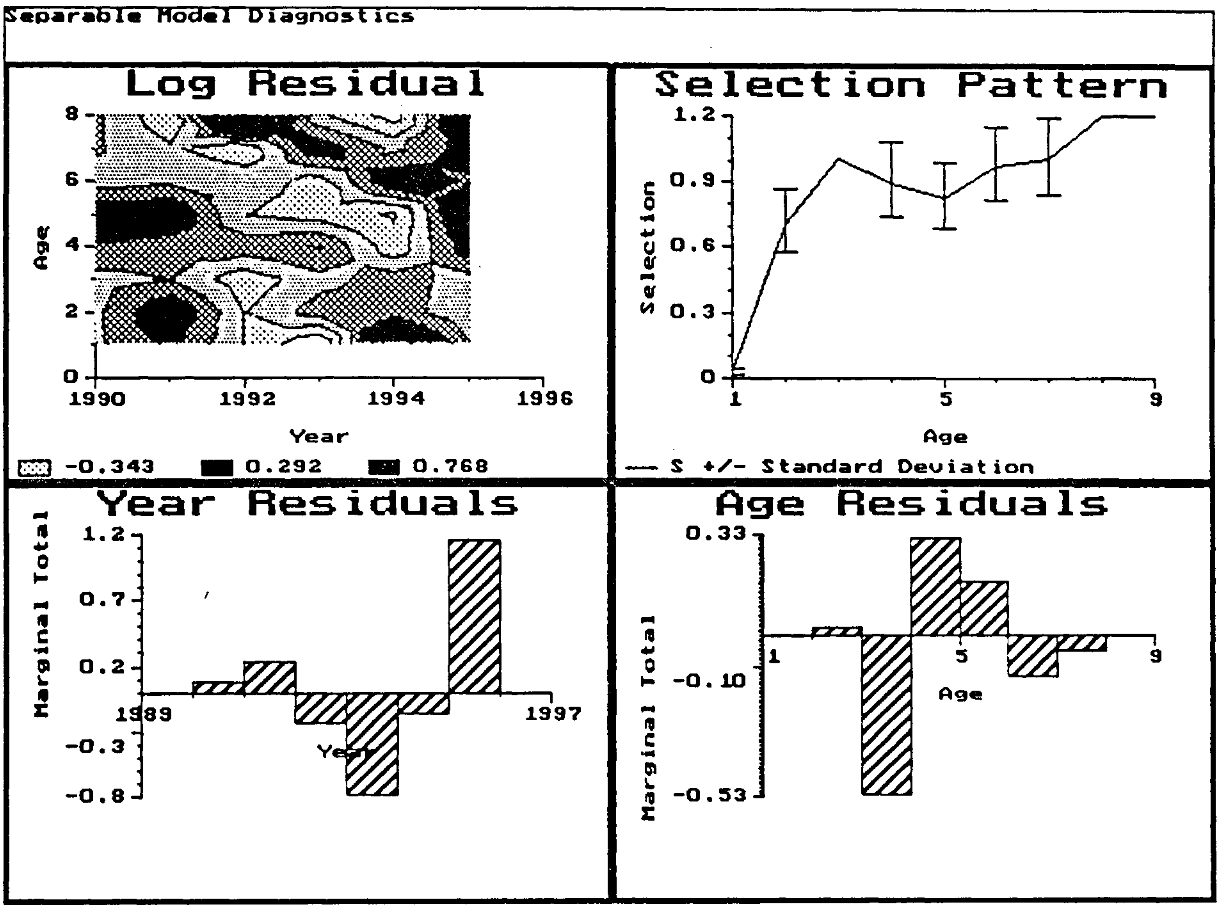

Stock Summary
Landings
27000
18000
9000
0
Yield
1978
1984
1990
1996
Year
Fishing Mortality
1.2
0.9
0.6
0.3
0
Reference F
1978
1984
1990
1996
Year
— F +/- Standard Deviation
Recruitment
1.2e6
0.9e6
0.6e6
0.3e6
0
Recruits
1978
1984
1990
1996
Year
— Recruitment
Stock Size
1.8e5
1.2e5
0.6e5
0
Biomass
1978
1984
1990
1996
Year
···· Spawning
— Total

Figure 4.4.3



Separable Model Diagnostics
Log Residual
Age
Year
1990
1992
1994
1996
-0.343
0.292
0.768
Selection Pattern
Selection
Age
S +/- Standard Deviation
Year Residuals
Marginal Total
1989
1997
Year
Age Residuals
Marginal Total
0.33
-0.10
-0.53
Age

Figure 4.4.3 (Cont'd)

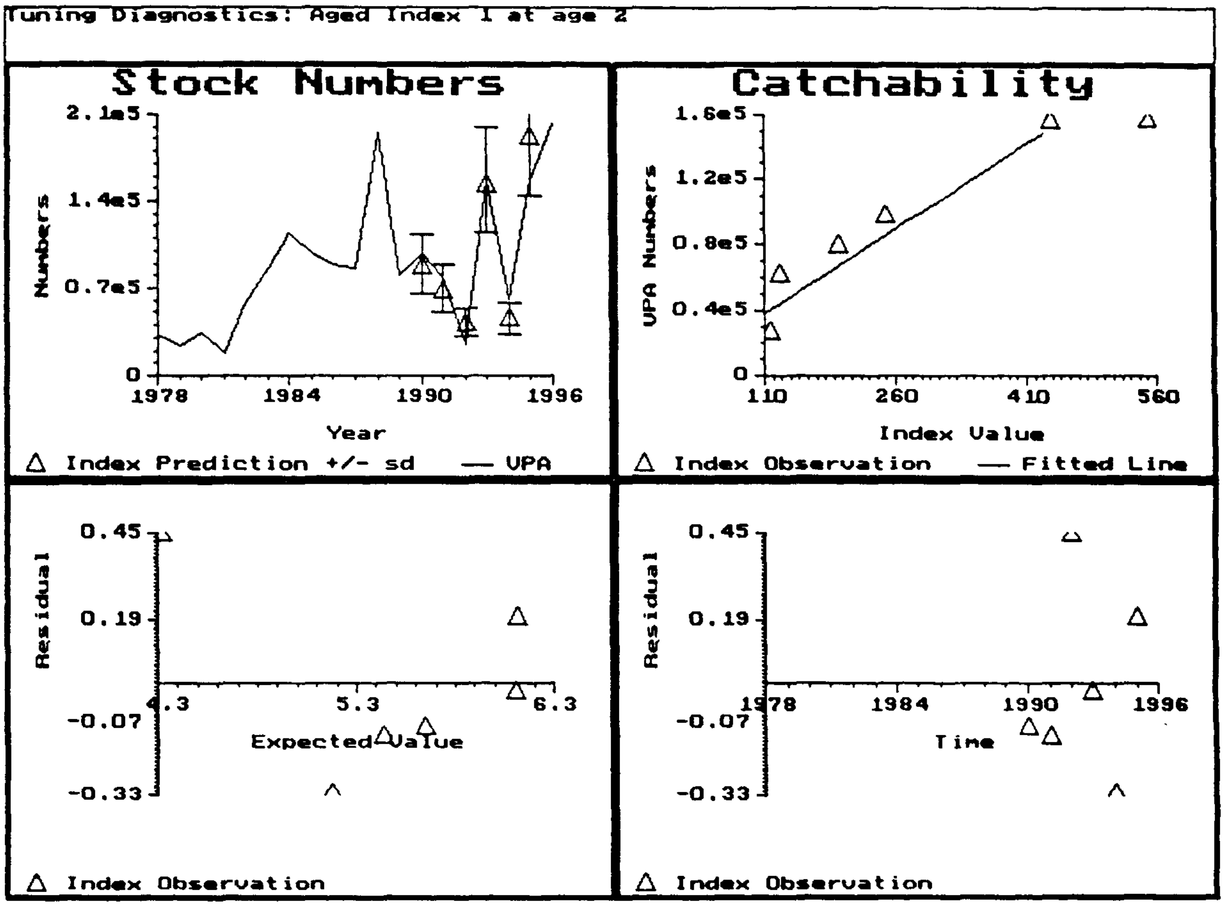


Figure 4.4.3 (Cont'd)

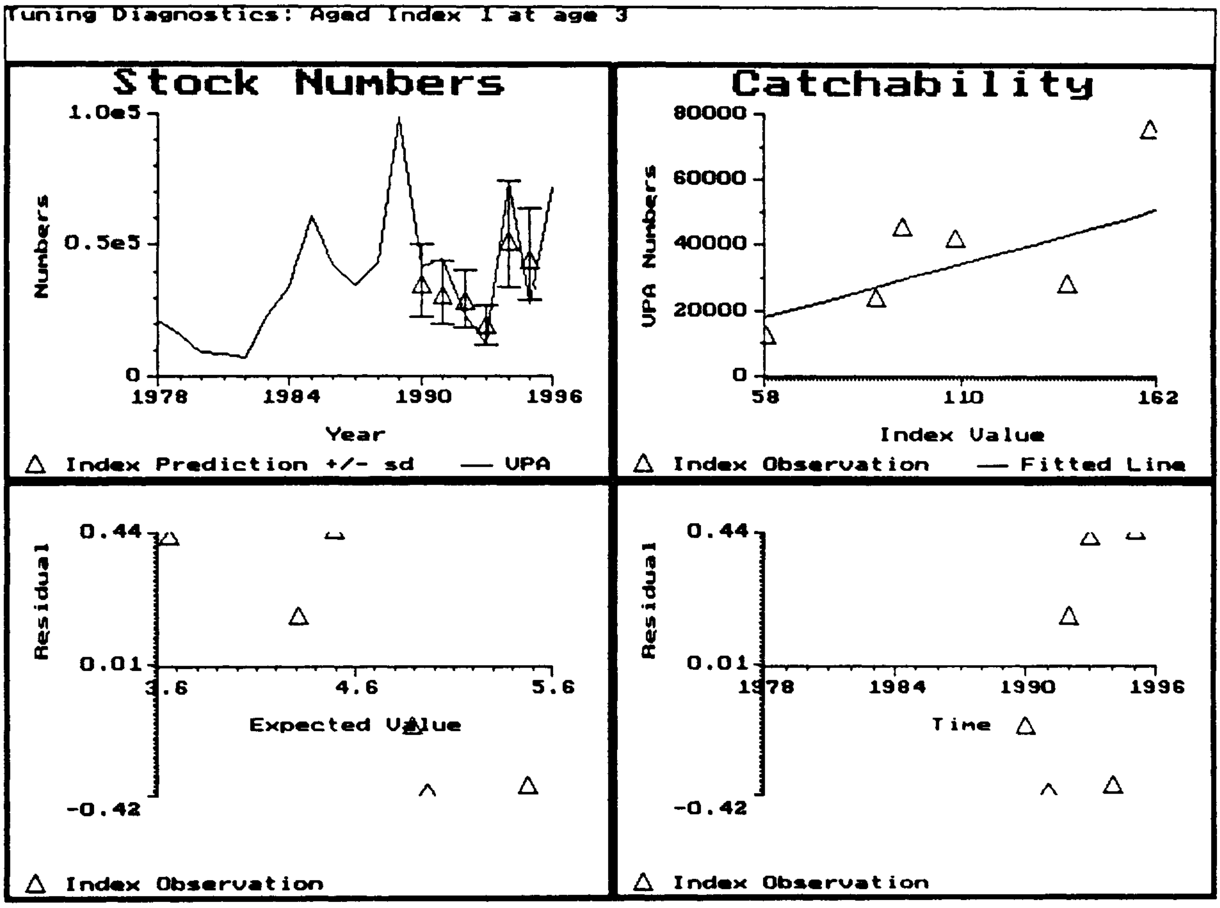


Figure 4.4.3 (Cont'd)

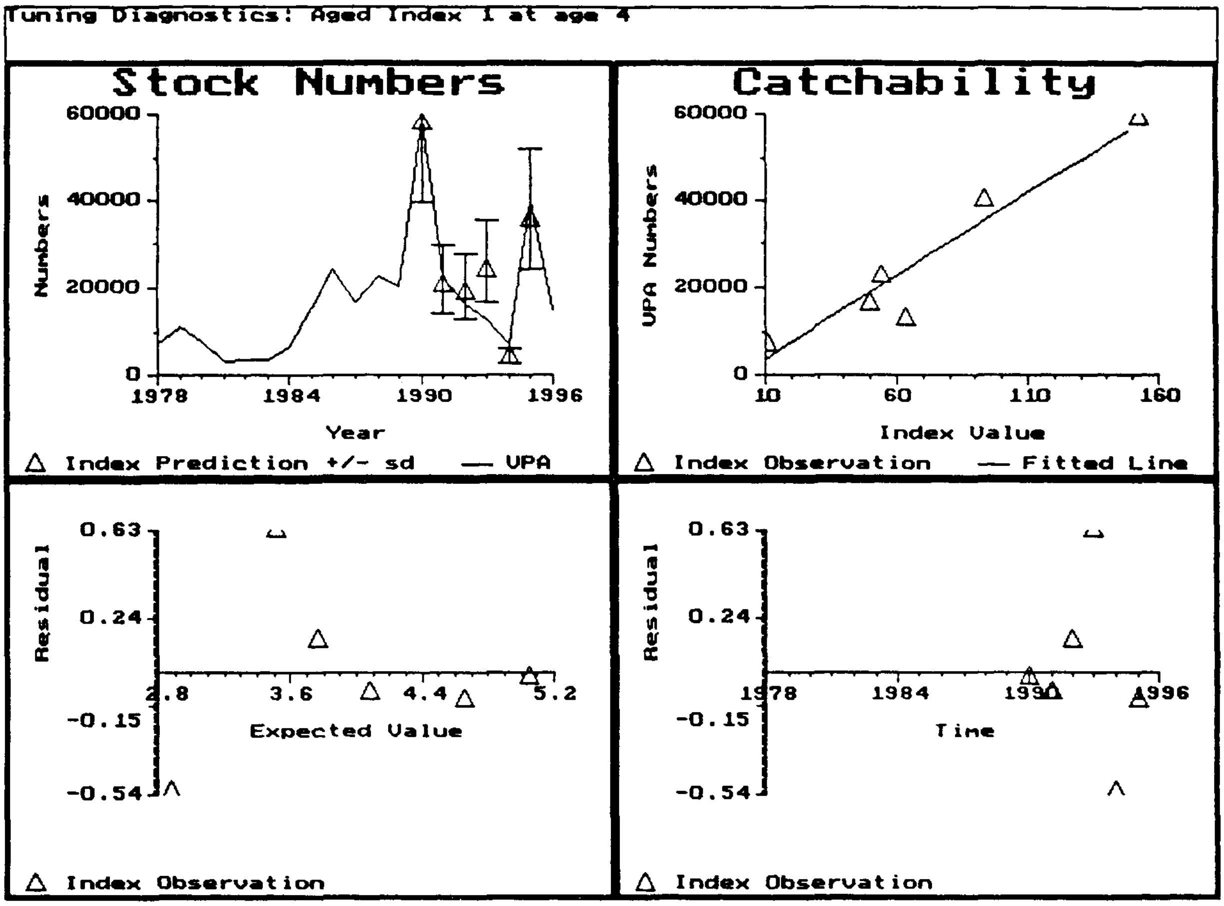


Figure 4.4.3 (Cont'd)

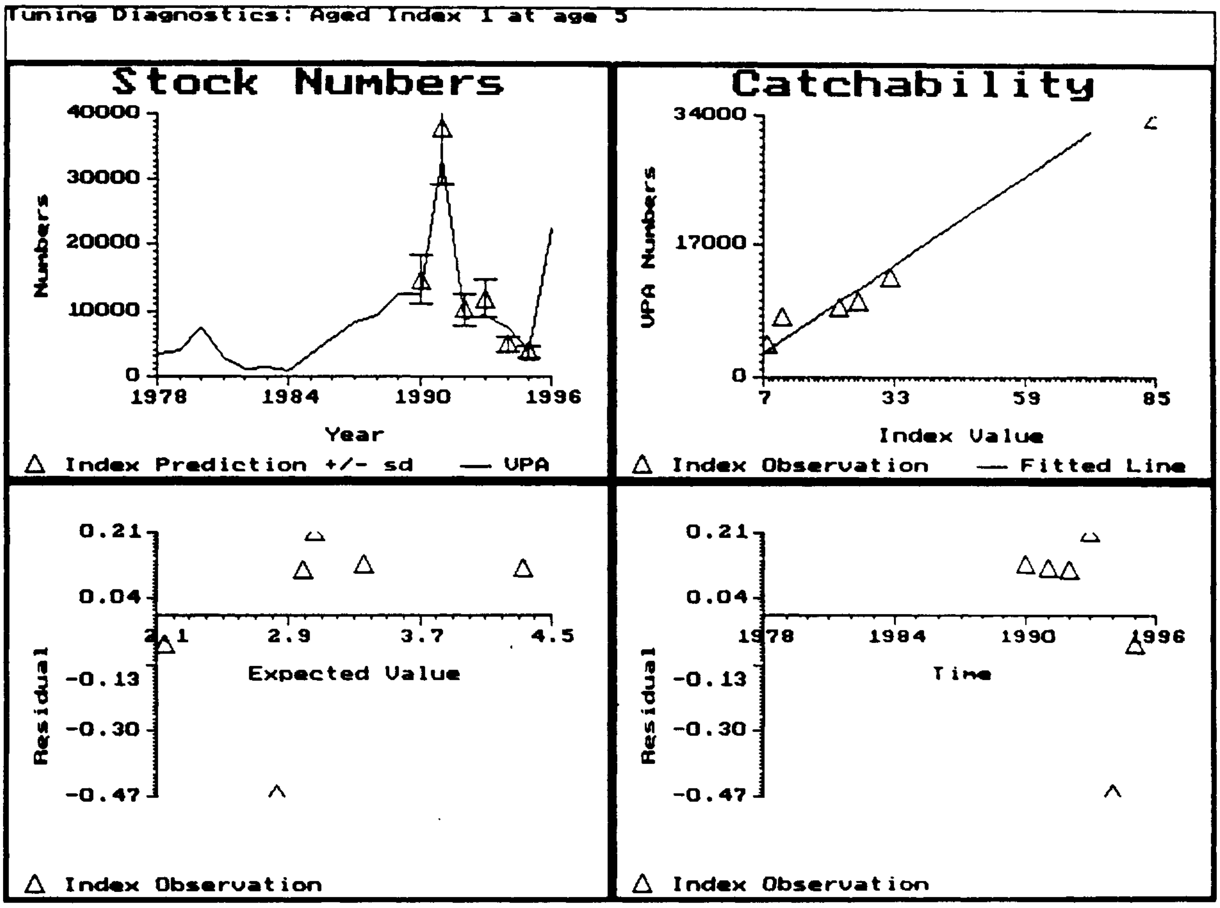


Figure 4.4.3 (Cont'd)

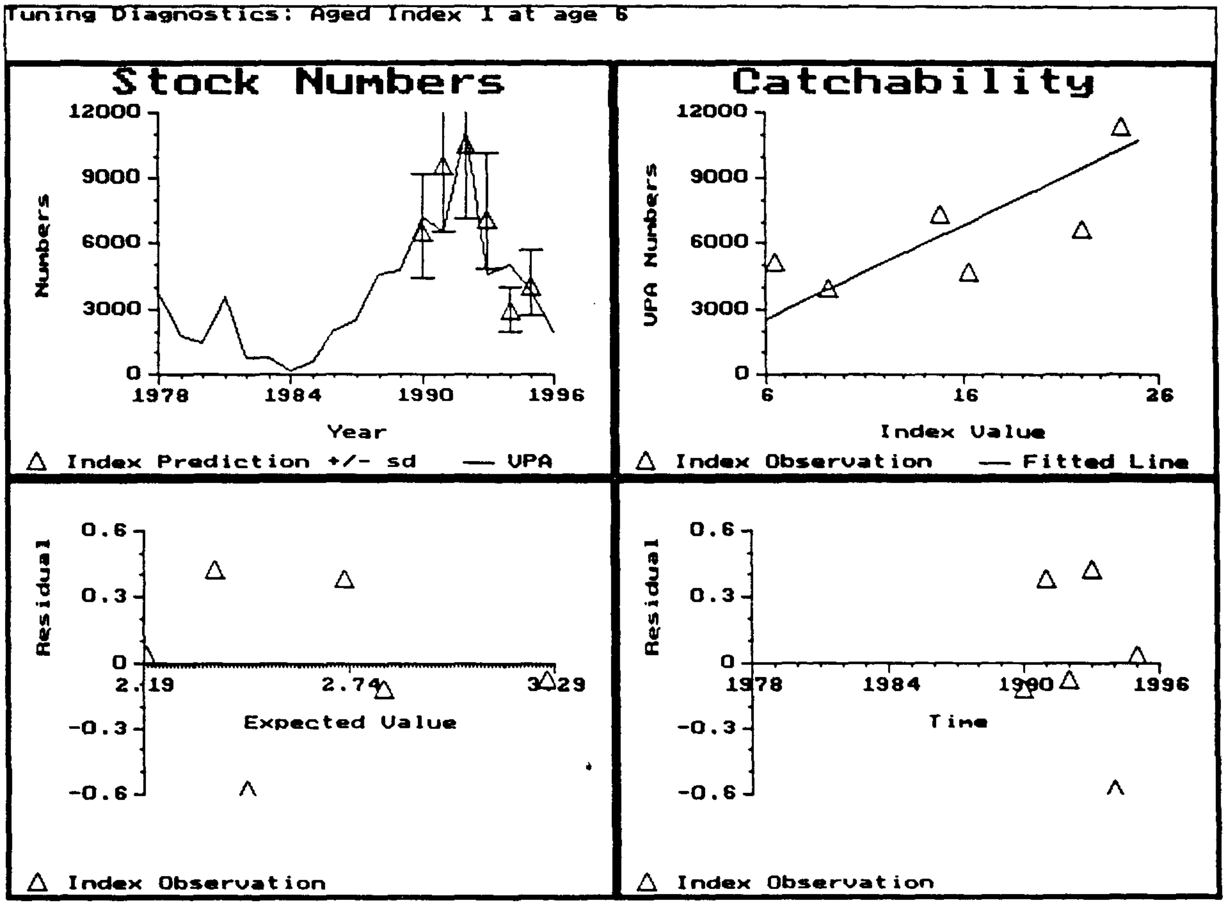


Figure 4.4.3 (Cont'd)

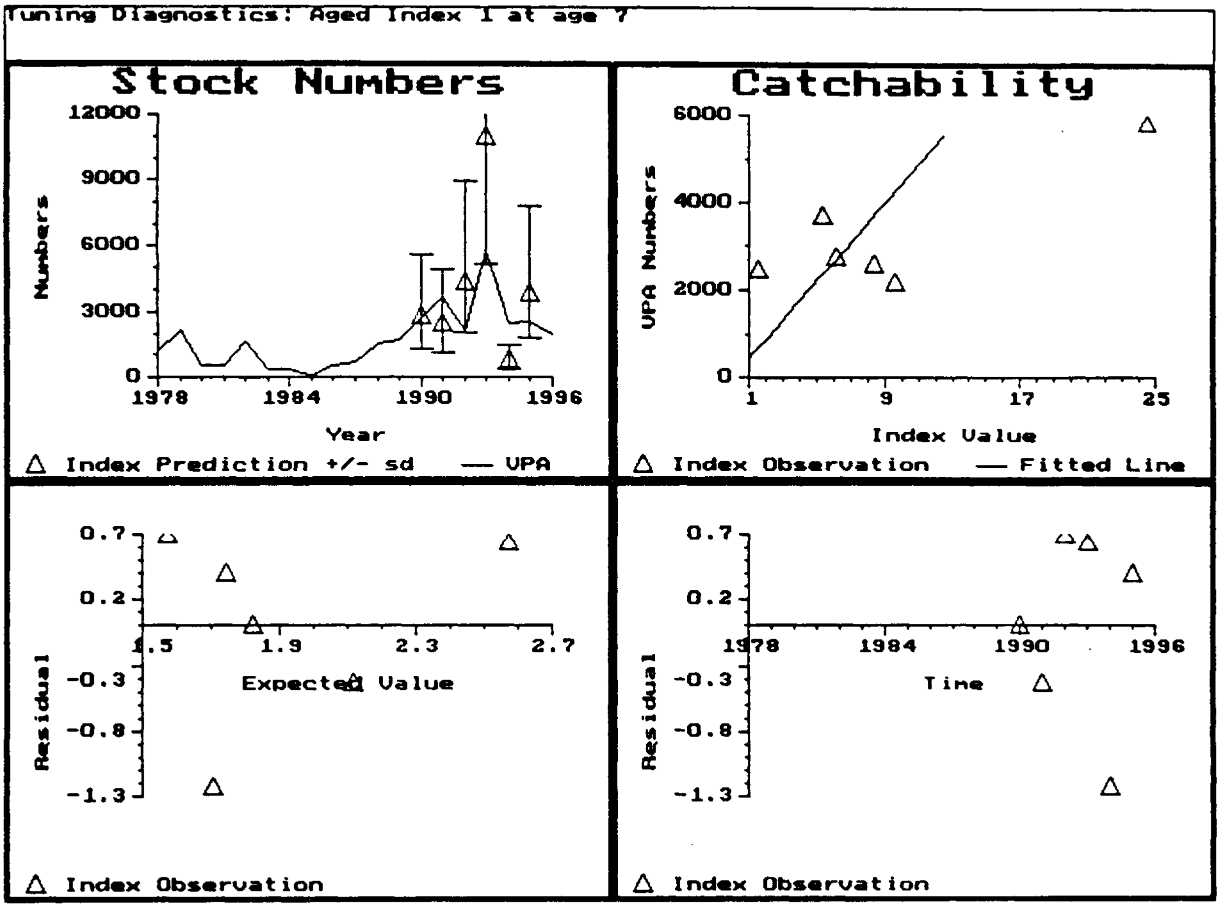
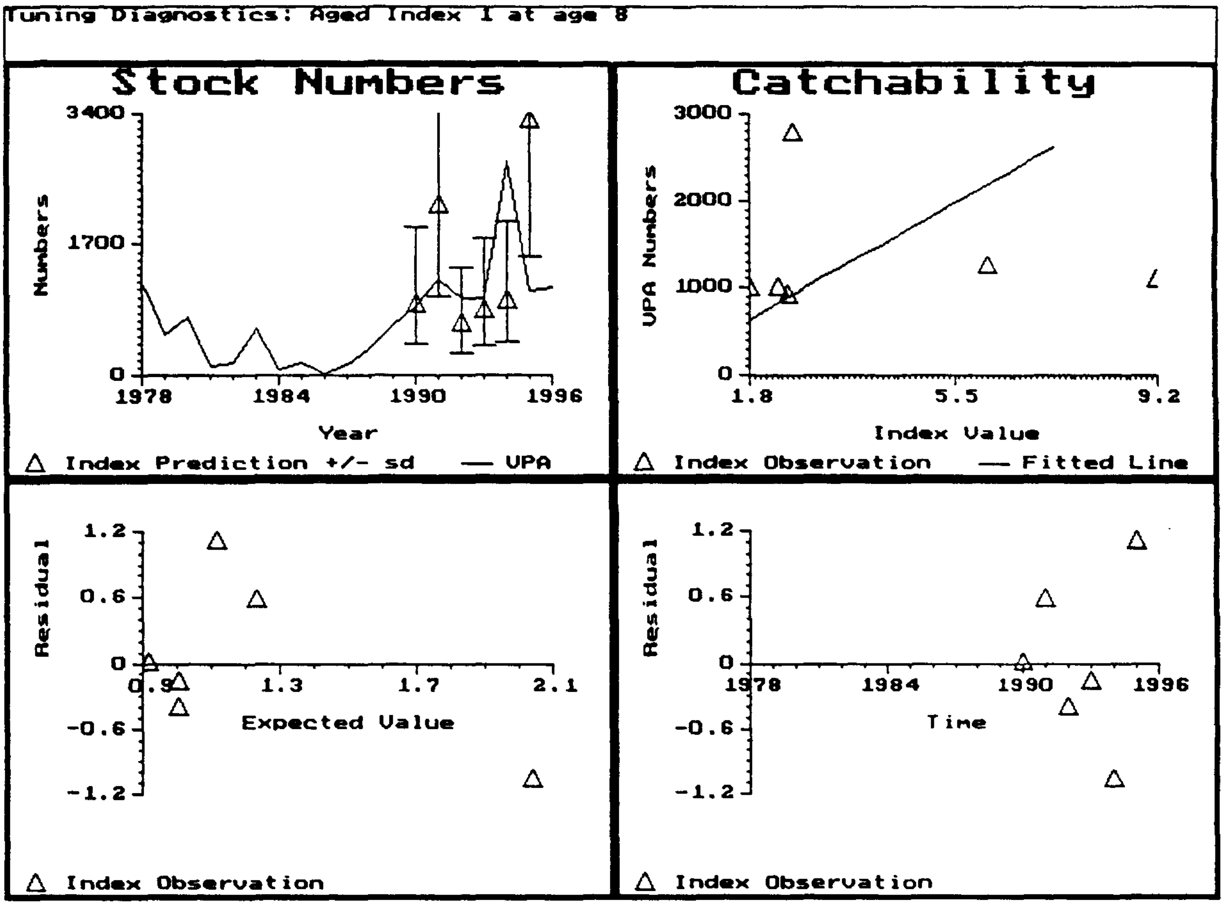


Figure 4.4.3 (Cont'd)



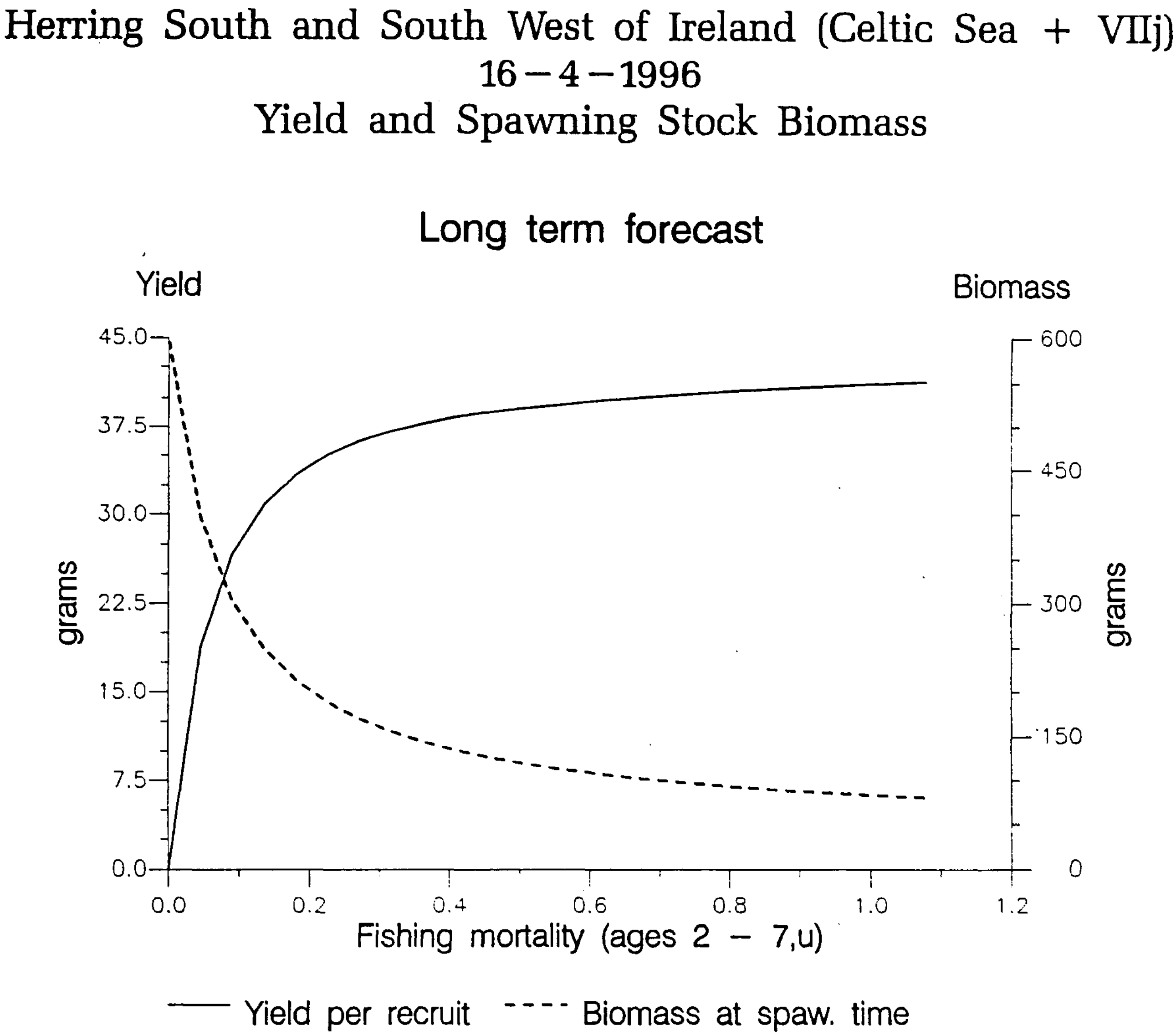


Figure 4.6.1 Yield/recruit. Celtic Sea and Division VIIj herring.

srr.xls

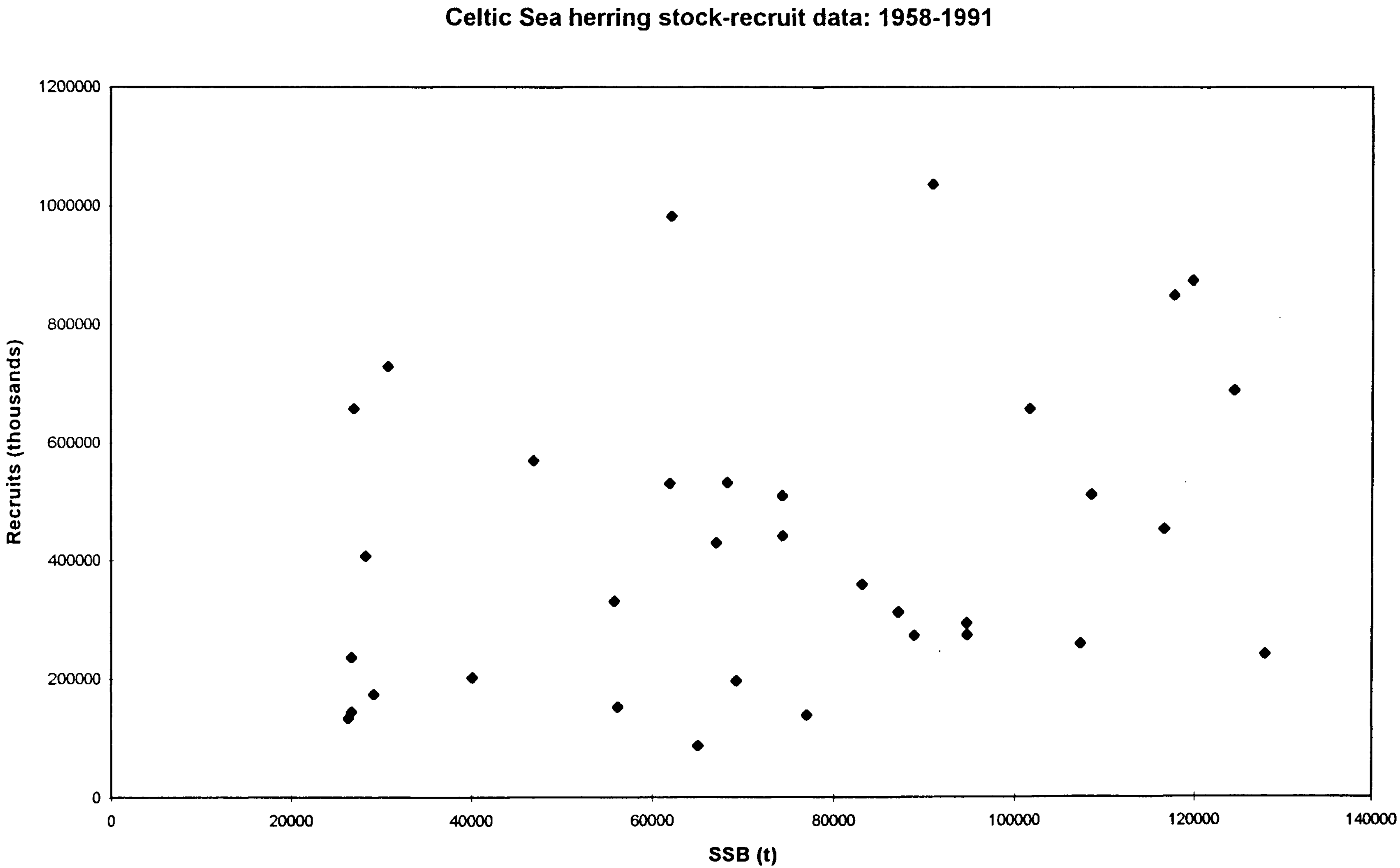


Figure 4.7.1 Stock and recruitment relationship. Celtic Sea and Division VIIj herring.

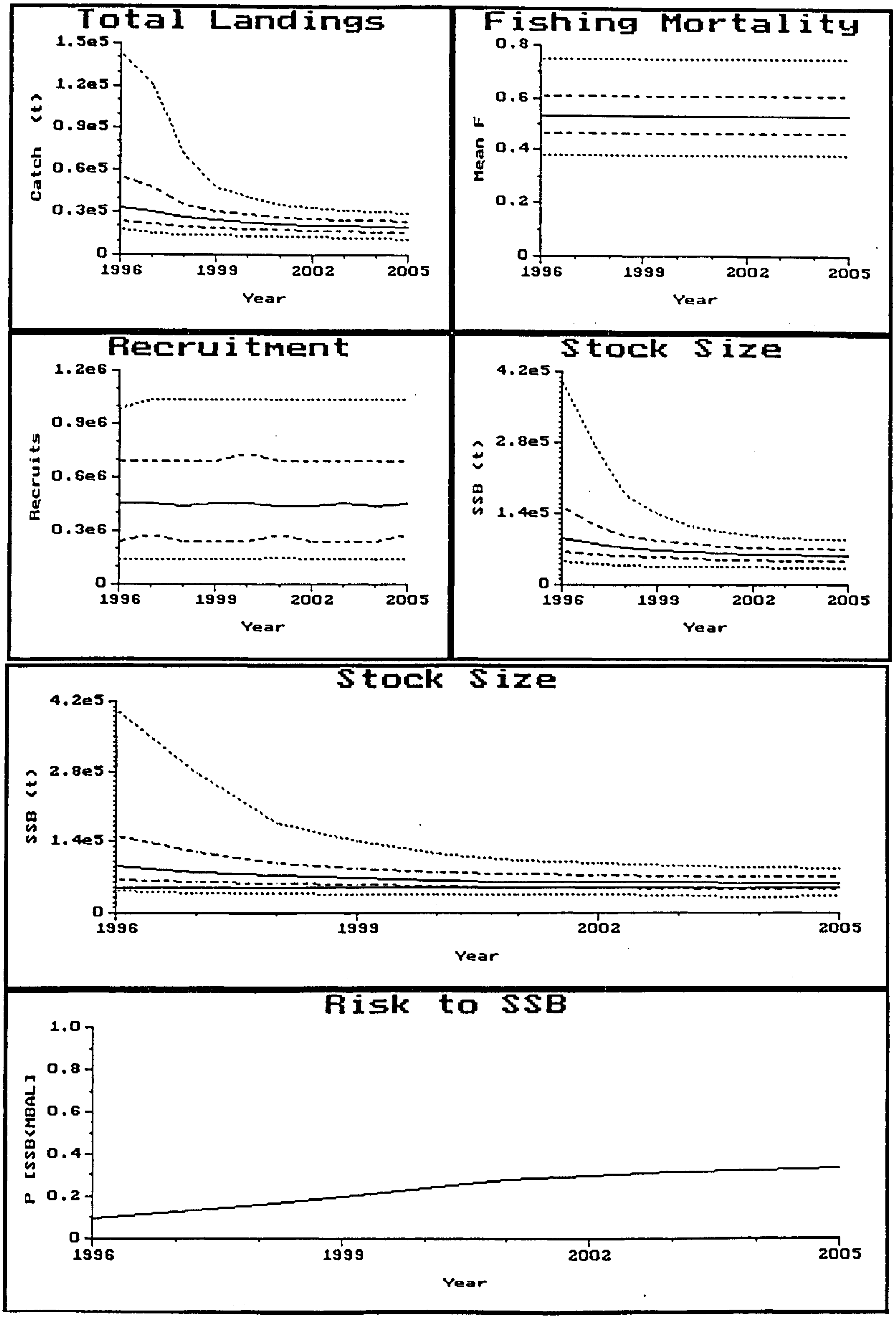


Figure 4.7.2 Herring in the Celtic Sea. Summary results of medium-term projections for fishing mortality from 1996 to 2005 constrained equal to the fishing mortality estimate for 1995. **Upper panel:** landings, fishing mortality (mean over ages 2 to 7), recruitment, and stock size. **Lower panel:** Stock size and the probability that the stock may fall below the MBAL level of 50 000t. Solid line, 50th percentile. dashed lines, 25th and 75th percentiles. Dotted line, 5th and 95th percentiles.

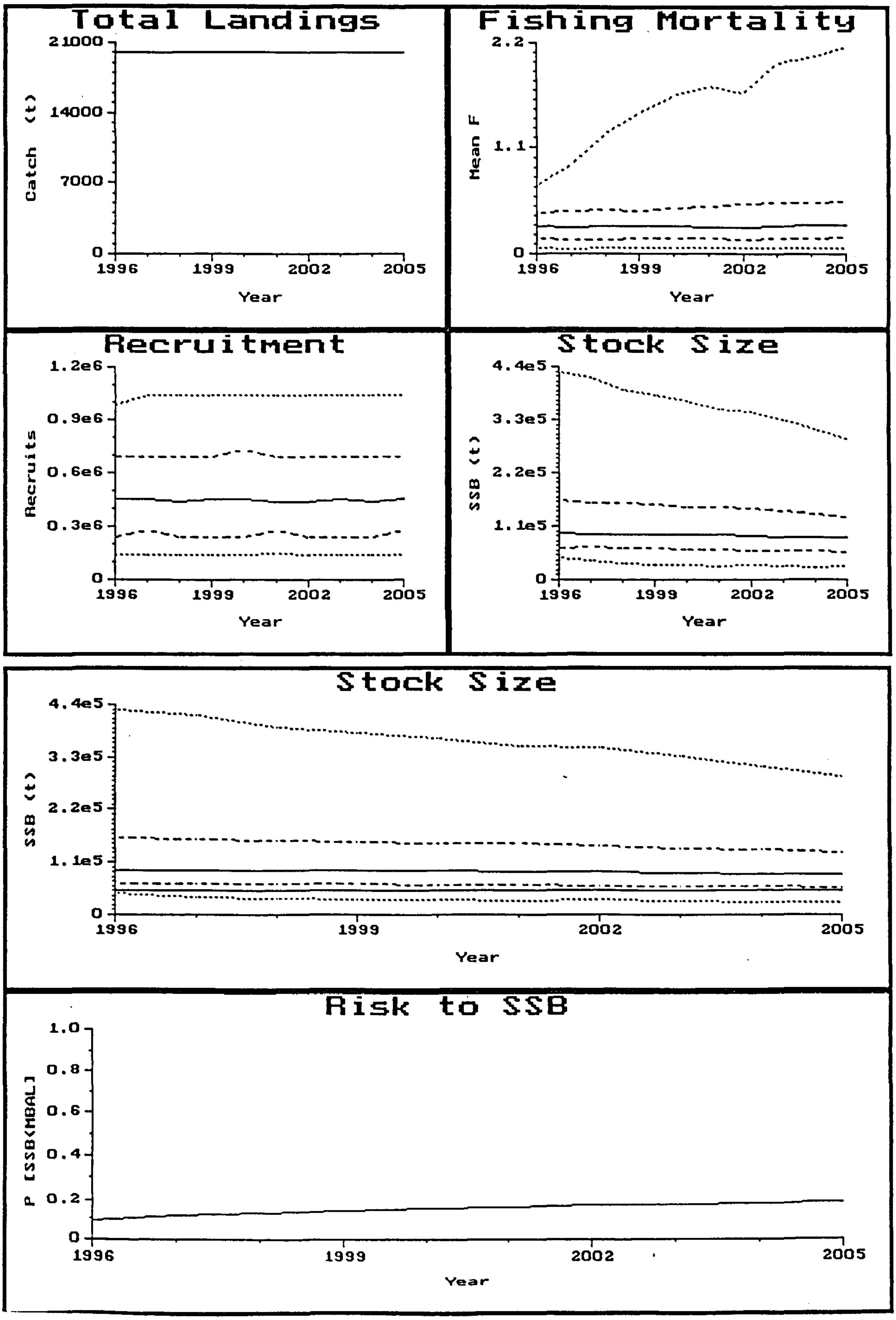


Figure 4.7.3. Herring in the Celtic Sea. Summary results of medium-term projections assuming a catch constraint of 20,000t in each year from 1996 to 2005. **Upper panel:** landings, fishing mortality (mean over ages 2 to 7), recruitment, and stock size. **Lower panel**, Stock size and the probability that the stock may fall below the MBAL level of 50 000t. Solid line, 50th percentile. dashed lines, 25th and 75th percentiles. Dotted line, 5th and 95th percentiles.

g:\acfm\hawg96\her_irls\riskplot.xls

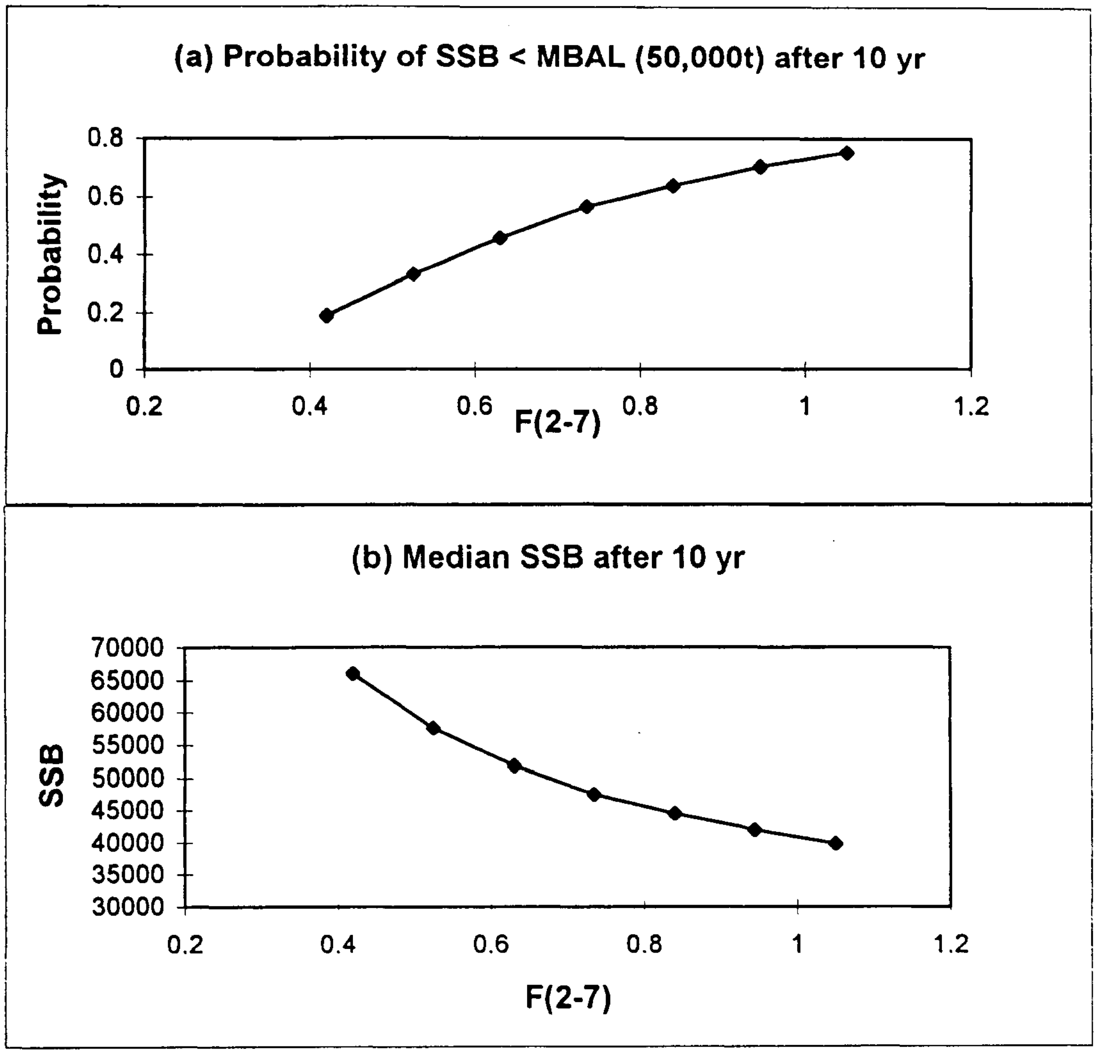


Fig. 4.7.4 Results of stochastic projection of Celtic Sea herring population at constant F, starting from ICA estimates of populations, F and variance/covariances.
(a) Probability of SSB falling below MBAL of 50,000t by 10th year;
(b) 50th percentile of SSB in 10th year of projection;

5 WEST OF SCOTLAND HERRING

5.1 Division VIa (North)

5.1.1 ACFM Advice applicable to 1995 and 1996

ACFM advice in 1995 was that the stock was lightly exploited and was considered to be within safe biological limits, but the absolute level of stock size could not be calculated. This was largely on account of problems with catch reporting. The agreed precautionary TACs were 77 000t in 1995 and 83 570t in 1996.

5.1.2 The fishery

Estimated catches by participating nations for 1995 are given in Table 5.1.1. Reported catches were 66,262 t after taking account of discards and reported unallocated catches, compared with the agreed TAC of 77 000 t. This is the seventh year in succession in which the TAC was not reached, but the TACs have been increased for the last two years. Negative unallocated landings arise because of misreporting of catches taken in adjacent areas.

Continued difficulties with catch reporting exist, with many examples of vessels operating and landing herring catches distant from Division VIa(N) but reporting catches from that area. The problem is particularly acute during the peak months of the herring fishery around Shetland (August to October).

The fishery has reported a marked decrease in the abundance of 1-ringed herring in coastal areas and in the Scottish sea lochs in recent years, which suggests that the local population may be more reliant than in recent years on recruitment of juveniles from the North Sea. Furthermore, there have been reports of populations of fish in spawning condition around December and January in the Barra - Stanton Banks area.

5.1.3 Catch in numbers at age

Age composition data for 1995 were available from Scotland (quarters 2, 3 and 4), the Netherlands (second and third quarters), Norway (in the second and third quarters) and Germany (in the third and fourth quarters). A summary of the age-distribution by fleet is shown in Figure 5.1.1, which shows that Scottish catches contain a larger proportion of 2-ringed fish (concomitant with the more coastal nature of that fishery). Norwegian and Dutch age-distributions were similar, but the German age-distribution was very different, with a predominance of ages older than 7 rings. Pending a verification of German age-readings, these were not used in the present analysis and German catches were treated as unsampled. Unsampled Scottish catches in quarter 2 were allocated to age by interpolation between quarter 1 and quarter 3. Catches by England and Wales were not sampled, but were assumed to have the same age-distribution as the Scottish fishery. Other unsampled catches were assumed to have the same age-distribution as the Dutch fishery.

The sampling effort used to derive the catch in numbers is summarised in Table 5.1.2., and the estimated catches in numbers at age are given in Table 5.1.3, including historical data to 1970.

5.1.4 Larvae surveys

Larvae surveys for this stock have been discontinued and no new information is available since 1994. As the larval survey indices of abundance will again be used in the assessment the available information has been reproduced in Table 5.1.4. for convenience. Details of the survey are given in the 1994 report of the Working Group (Anon. 1994).

5.1.5 Acoustic survey

Historical acoustic survey information documented in the 1994 Working Group report have been used. The time series has been updated to include information from the most recent survey (Table 5.1.5).

An acoustic survey of Division VIa (N) was completed from 8 to 28 July 1995 using a chartered fishing vessel. Prior to 1994, a single unstratified transect design was used for the surveys. In 1994, this was changed to a two-level stratified design, in order to reflect perceptions of fish aggregation observed in previous years. In 1995 three levels of stratification were introduced (Transect spacing = 4, 7.5 or 15 n.m.), and chosen to reflect perceptions of historical stock abundance in the area from 1992 to 1994. Prior analyses have shown that the stock size estimate is highly sensitive to a small number of observations of very dense shoals. Survey precision should therefore be improved substantially if more survey effort can be allocated to areas of high fish abundance.

Forty-three trawl hauls were shot on the echo traces, of which 16 captured more than 100 herring. As expected from previous surveys, 4 and 8-ring herring were abundant in the samples, but 3-ring herring were also numerous. The age-structure of the stock is consistent with that observed in the 1992 - 1994 surveys. Fewer problems in allocating echo-traces to species were encountered than in the 1994 survey, when Norway pout/herring species mixtures were frequently found. Echo-traces were allocated among the following categories, where the percentage in brackets indicates the contribution by number of each category to the biomass estimate.

1. Herring (79% of estimate)
2. Likely to be herring (21% of estimate)
3. Unlikely to be herring (would add 6% to stock estimate if included)
4. Known not be herring (Not calculated)

The spawning biomass of the stock was estimated to be 452,000t compared with 600,430 t in 1994 and 893,600 t in 1993. However, it is thought that the 1993 survey returned an exceptionally high stock estimate, possibly on account of a strongly contagious distribution. The spatial distribution of the herring stock found in the survey is shown in Figures 2.4.1. and 2.4.2.

In fitting the age-structured models to the survey data it was again assumed that 40% of annual mortality had been incurred before the surveys. This figure was calculated by assuming that natural mortality is constant throughout the year, and that fishing mortality can be apportioned in the ratio of seasonal catches in 1993.

5.1.6 Recruitment

New estimates of the arithmetic mean catch rate of 2-ring herring in West Scotland Groundfish surveys in statistical rectangles 47E4-E6, 46E4-E6, 45E3-E4 and 44E3-E4 for 1995 and 1996 are given in Table 5.1.6 together with historical data.

Use of the index in the assessment model was investigated by the Working Group in 1995. It was found that due to a very strongly non-linear relationship between recruitment and survey index, the index was a very poor estimator of population size, and its use in the assessment model was rejected. The index values will continue to be reported by the Working Group, however, as they may provide some qualitative indication of exceptionally weak or strong incoming year-classes. The 1995 and 1996 values do not indicate that the corresponding year classes are either exceptionally large or exceptionally small.

5.1.7 Mean weight at age

Weight at age data from the 1995 fishery were available from Scotland, Germany, Norway and the Netherlands. For reasons noted in Section 5.1.3 the German information was not used. Mean estimates weighted by the reported catches in number are given in Table 5.1.7 together with comparable historic information. Mean weights at age in the last three years of the catches and of the acoustic surveys are also given in the last columns of Table 5.1.7.

5.1.8 Data exploration and preliminary modelling

As in previous years, a range of different models have been fitted separately in order to examine the dependence of the fitted population parameters on prior assumptions about survey catchability models. Here we extend this analysis to include a short investigation of the sensitivity of the assessment to different assumptions about the use of catch information in the models.

The survey data and models tested were:

1. Acoustic surveys used as absolute estimates of stock size
2. Acoustic surveys used as proportionate indices of stock size
3. Larval abundance indices used as proportionate indices of stock size
4. Larval abundance indices used as power indices of stock size
5. The 'baseline' assessment used by the 1995 Working Group, based on model components (2) and (4) above included with equal weight.

In the 1995 Working Group report (Anon. 1995d) it was indicated that there were substantial reasons to believe that widespread and large scale misreporting of North Sea catches as West of Scotland catches occurs. Such catches were typically reported from the area immediately west of the administrative boundary between Division VIa and Division IVa which runs along the 4°W meridian. An assessment model was fitted for comparative purposes by excluding catches reported from the area between 4°W and 5°W. Catches reported from the area between 4° and 5°W were removed from the analysis, and catches in number were decremented by the appropriate proportions (Table 5.1.8.). Recent discussions with industry representatives and with pelagic fishery enforcement officers lend credence to the belief that by excluding these catch reports, a much better representation of the true catches is likely to be achieved. However, by the very nature of the problem it is not possible to define a reliable criterion for reallocating misreported catches. In consequence, it was decided to fit the assessment models to (1) the reported catches and (2) the catches adjusted by excluding catches reported between 4°W and 5°W, for comparative purposes.

Results are shown in summary form in Figure 5.1.2. This shows that:

- All model configurations indicate a low fishing mortality in 1995, with all estimates below 0.2 and the highest upper 95 percentile being lower than 0.3. The Working Group can report with some confidence that the stock is lightly exploited.

- Adjusting the catches for misreporting leads to even lower estimates of fishing mortality, being below 0.1. At such levels, fishing mortality is hardly detectable.

- The 'baseline' model formulation used by the working group in 1995, based on the LAI index used as a power index of stock size together with the acoustic survey used as a proportionate index of stock size, appears still to be appropriate. The model estimates of fishing mortality are consistent.

A new assessment model (referred to as a Missing Catch Model, MCM) was available to the Working Group that allowed an assessment calculation to be made for the case where no catch information is available (Section 1.5.1). This model was fitted with the assumption that the acoustic estimate of biomass is no more precise than the larval survey biomass estimate, and that the estimates of the proportions at age in the acoustic survey are no more precise than the proportions at age in the sampling of the catches (Eqns 1.5.2.4 and 1.5.2.5). This restriction is necessary as there are too few acoustic survey observations to permit reliable estimation of the corresponding variances. Fitting this model allows an independent evaluation to be made of likely misreported catches. In order to examine the consequences of assumptions made about the catches, summary results of three model fits are given in Figure 5.1.3. The models fitted are:

- The 'baseline' model formulation, using reported catches

- The 'baseline' model formulation, using adjusted catches

- The 'Missing Catch' model, using the same assumptions about the surveys as the 'baseline' model, but including no information about landings. Information on the proportions at age in the catches derived from biological sampling of the catch are included in this model.

Figure 5.1.3. shows rather clearly that similar population parameters are estimated either by using the 'MCM' fit or by assuming that catches reported between 4° and 5°W are misreported. The MCM fit indicates that catches may have been even somewhat lower than the catch estimates after area reallocation, suggesting that some misreporting from areas other than the 4° to 5° area. Overall, however, the MCM fit suggests that the practice of treating the catches reported from this area as misreported catches is consistent with the survey information and the biological catch sampling, and is therefore appropriate.

5.1.9 Stock Assessment

The 'baseline' assessment model fitted to the catch-at-age data adjusted for misreporting has been used as the reference model for the calculation of short- and medium-term projections. Discussions with industrial and administrative sectors have reinforced the belief that the catch adjustment procedure is appropriate, and the fit with the missing-catch model provides robust support that the catch adjustment procedure is in good agreement with other sources of information.

Defining the following variables,

a,y -	age and year subscripts
C	Catch in number at age and year
C'	Catch in number at age and year predicted by the structural model
SSB	Spawning stock size in the structural model
LAI	Larval abundance index
ACOUST	Acoustic survey estimates of abundance at age

N	Population abundance in the structural model
SSB	Spawning stock biomass in the structural model
Q_{LAI}	Coefficient of proportionality for larvae survey estimates of stock abundance
Q_{ACU}	Coefficient of proportionality for acoustic survey estimates of stock abundance
K	Power coefficient for the LAI estimate of stock abundance
λ	Weighting factor = 0.1 for age 1 and 1 for all other ages.
a,b	Parameters of the Beverton-Holt stock recruit relationship

The assessment model was fitted by a least-squares minimisation of:

$$\begin{gathered}\sum_{a,y}(\log(C_{a,y}) - \log(C'_{a,y}))^2 + \\ \sum_y(\log(Q_{LAI}SSB_y^K) - \log(LAI_y))^2 + \\ \lambda_a\sum_{a,y}(\log(Q_{ACU,a}N^*_{a,y}) - \log(ACOUST_{a,y}))^2 + \\ 0.01\sum_y(\log(N_{1,y+2}) - \log(\frac{a\,SSB_y}{b+SSB_y}))^2\end{gathered} \qquad (5.1.9.1)$$

This is the same assessment model as that used by the Working Group in 1994 and in 1995. Detailed results of this assessment are given in Table 5.1.9. and in Figures 5.1.3-5.1.15.

Salient points of the assessment are:

1. Fishing mortality in 1995 was very low, and in the range 0.08 to 0.14 (Parameter 95% C.I.s)
2. Catches of 2 ringers were unusually large in 1995.
3. 1-ringers are still highly variable in the acoustic index.
4. and 5-ringers are unusually abundant.
5. Assumptions of lognormality in the index observations are not demonstrably violated.
6. Fishing mortality is estimated to have followed a declining trend since 1986.

The assessment merits further comment. There has been a large catch of 2-ringers included in the catch at age matrix, and this has translated into a perception of increased selection at this age. This is not necessarily the case. Catches from the North Sea are presently dominated by 2-ringers, and it is possible that due to the misreporting problem there has been some confusion about the origin of samples. It is likely that in some cases a North Sea age-structure has been used to allocate catches to age for the Division VIa(N) stock. Therefore, the apparent change in selection may be due entirely to sampling problems.

In the present assessment, the estimated fishing mortality is below the assumed natural mortality at all ages. This means the assessment is very strongly dependent on the assumed value of M, and provides only limited information on the state of the stock. It is suggested that the assessment be treated as an indication that the stock is very lightly exploited. Quantitative estimates of fishing mortality provided here are likely to be of limited value.

5.1.10 Short-term projections

Conventional short term catch projections were calculated on the following basis:

- Fishing mortality in 1996 = Fishing mortality in 1995
- Starting populations on 1 January 1996 = Population model estimates, except for age 2 for which a geometric mean of population abundance from 1985 to 1994; also used for 1997 recruitment..
- Historic mean weights at age from 1993 to 1995 were used for both the stock weights and the catch weights.
- The exploitation pattern used for the projections was that estimated by the population model, and fishing mortality in 1995 was used as a reference value for the projections.

Input data for the projections are given in Table 5.1.10, and the consequences of fishing at different levels of fishing mortality (in terms of catch and spawning biomass) are given in Table 5.1.11.

At recent levels of fishing mortality, *status quo* catches are predicted to be of the order of 30,000 t.

5.1.11 MBAL and Stock-Recruit considerations

Considerations of an appropriate level for the minimum biologically acceptable level of spawning stock size are strongly dependent on perceptions of the dependence of recruitment on spawning stock. Although a Beverton-Holt relationship was included in the assessment model fit for precautionary purposes, alternative stock-recruit relationships have been considered further here. Treating fitted population estimates from 1970 to 1995 as observations, Ricker and Beverton-Holt stock-recruit relations were fitted by non-linear regression (assuming lognormal observation error). Inclusion of an autocorrelated error term was explored, but was not found to improve the fits (F test, P> 0.25) noticeably. A summary of results is given in Table 5.1.12, and diagnostic plots for the two models are given in Figure 5.1.16. Neither stock-recruit model fitted better to the observations than a simple geometric mean recruitment (F test, P=0.25) ; hence the dependence of recruitment on the spawning stock in Division VIa(N) cannot be quantified.

There could be some immigration of fish into Division VIa(N) from the North Sea. However, a scatterplot of Division VIa(N) recruitment on recruitment to the North Sea stock fails to provide convincing evidence for such dependence (Figure 5.1.17.). As a dependence of recruitment on either the spawning stock in Division VIa(N) or on North Sea recruitment could not be quantified, stock-recruit considerations cannot be used in order to define an MBAL. Instead, as a precautionary measure it is proposed to adopt the criterion used for the North Sea and for the Celtic Sea stock, which is to define the MBAL as one-third of the unexploited stock size.

Unexploited stock size cannot be calculated directly but was approximated by calculating the equilibrium stock size for zero fishing mortality under the following conditions:

- Expected recruitment is calculated as R.exp(σ^2 /2) where R represents the geometric mean recruitment from 1976 to 1994 and σ^2 represents the variance of ln(recruitment).
- Arithmetic mean weights at age in the stock, 1990 to 1995
- Assumed values of maturity and natural mortality as used by the Working Group.

This calculation is somewhat sensitive to the choice made about the treatment of fish older than 9 years. Excluding older fish leads to an estimate of unexploited stock size of some 485,000 t (Table 5.1.13). In contrast, including fish without making any assumption about senescence leads to an estimate of unexploited stock size of 952,000 t. Clearly, this calculation, and hence the MBAL estimate, is strongly dependent on arbitrary assumptions about senescence. Pending further analysis of this problem, an MBAL corresponding only to the age-range currently included in stock assessments has been used, as population parameters are only reasonably known for this range of ages.

This calculation leads to an estimate of unexploited equilibrium stock size of some 485,000 t. Taking one-third of this level (by analogy with the North Sea herring MBAL calculation, Section 2.9) and rounding appropriately leads to an indicative MBAL of 160 000t. For comparison, estimates of historical stock size range from 67,000 t to 310,000 t. The SSB in 1995 is estimated to be 367,000 t. Despite being below the MBAL for about five years in the 1970s, there was no apparent adverse effect on recruitment. Further work to address the problem of setting an appropriate MBAL for this stock is required.

5.1.12 Medium-term projections

Medium-term projections indicate a low risk for the stock if fishing continues at recent levels, but that if annual catches equal to the 1996 TAC were to be taken, the stock would decline steadily and would have a 50% chance of falling below the 160,000 t in 2003.

The method used to calculate medium-term projections is as described by Anon. (1996). A Monte-Carlo method was used, with a conventional stock projection being used for each iteration. Projections were either TAC-constrained or F-constrained. The generation of pseudo-data sets for the projections was performed separately for the population parameters derived from the stock assessment and for the generation of future recruitments.

Population parameters (vector of abundance at age in 1995, fishing mortality at reference age in 1995, selection at age) were drawn from a multivariate normal distribution with mean equal to the values estimated in the stock assessment model (Section 5.1.9), and with covariance as estimated in the same model fit. Pseudo-recruitments for subsequent years were generated by calculating a simple geometric mean recruitment because of the failure to identify a usable stock-recruit relationship and resampling randomly from the residuals according to a conventional non-parameteric bootstrap method.

The 'ICPROJ' version 2 program was used to implement the calculations.

Weights at age in the catch and in the stock, maturity ogives and natural mortality were as given in Section 5.1.10. Two scenarios were examined: (1) Exploitation at recent levels of fishing mortality, and (2) exploitation at the level of the 1996 TAC, put to 83,570 t. In both cases fishing mortality in 1996 was constrained at its estimated value for 1995. These two projections indicate a very slow increase in stock size for fishing at the 1995 fishing mortality, but a rather rapid stock decline if catches equal to the 1996 TAC were removed from the stock each year (Figures 5.1.18 and 5.1.19).

5.1.13 Risk Analysis

A calculation of the probability that the stock will fall below the 160,000 t level after ten years' exploitation at different levels of fishing mortality is given in Figure 5.1.20. This suggests that if the stock is to remain above the 160 000t level (with greater than 50% probability) by 2005, then fishing mortality should not exceed 0.3. This value is a similar value to that proposed as a target fishing mortality for the North Sea stock.

5.1.14 Long-term Yield

A calculation of yield per recruit and spawning biomass per recruit is given in Figure 5.1.21 for reference purposes.

5.1.15 Consistency of Assessments

It is not possible to calculate an informative retrospective analysis for this stock, as the assessments are heavily dependent on a short time-series of acoustic survey data. Thus, deleting recent data leaves a data set which is too small for a comparable analysis to be calculated. A summary of estimates of fishing mortality made in recent assessments shows that there has been a marked downwards revision in the fishing mortality estimate in this year's assessment (Figure 5.1.22). This is clearly due to the new perception that catches from this stock in recent years have probably been about half of the reported levels.

5.1.16 Uncertainty in the assessment

Parametric uncertainty in the stock assessment (i.e. uncertainty calculated assuming the assessment model is correctly specified) indicates a range in stock size for 1996 between 220,000 t and 520,000 t with 90% confidence. Estimates of the 90% interval for the fishing mortality at reference age in 1996 are from 0.05 to 0.14. The assessment is subject to additional uncertainty due to possible errors in the reallocation of catches that are assumed to be misreported, but the fit of the 'Missing Catch Model' suggests that such errors are unlikely to change the perception of the stock parameters very much. Errors in the allocation of samples to stock may introduce more uncertainty, but the extent of such errors cannot be quantified at present.

5.1.17 Management Considerations

The assessment calculation presented here indicates that this is a very lightly exploited stock. The modelling approaches used here indicate that continued fishing at recent levels is likely to result in catches around 30,000 t, and to present little risk of a stock decline. If, however, catches equal to the 1996 TAC were to be fished from this stock rather than misreported from adjacent areas, the stock is estimated to have a 5% chance of falling below the 160 000t level by 1998, 25% by 2000 and 50% by 2002. If the stock is to have a better than 50% probability of remaining above the 160,000 t level by 2005, fishing mortality should not exceed 0.3.

5.2 Clyde Herring

5.2.1 Advice and management applicable to 1995 and 1996.

Management of herring in the Clyde is complicated by the presence of two virtually indistinguishable stocks; a resident spring-spawning population and the immigrant autumn-spawning component. In recent years management strategies have been directed towards rebuilding the highly depleted spring-spawning component to historical levels.

The measures which remain in force in order to protect the indigenous spring-spawning stock are:

- A complete ban on herring fishing from 1 January to 30 April.
- A complete ban on all forms of active fishing from 1 February to 1 April on the Ballantrae Bank spawning grounds. to protect the demersal spawn and prevent disturbance of the spawning shoals.
- The TAC in 1995 was maintained at the same level as in recent years (1,000 t).

5.2.2 The fishery in 1995

Annual landings to 1995 are presented in Table 5.2.1. Landings in 1995 were 392 t which follows the general decline in recent years. Most of the landings were taken by pair trawlers in the directed fishery during October and November. A total of 40 t was taken as a by-catch in the demersal trawl fishery in the area throughout the year. The proportions of spring and autumn spawners in these landings could not be estimated.

Sampling levels in the fishery have remained high and are well above recommended levels (Table 5.2.2).

An index of effort (E) has been calculated for comparison with previous years as follows:

$$E = E_p \,.\, L \,/\, L_p$$

where E_p = days absent by pair trawlers.

L = total landings in t.
L_p = landings by pair trawlers in t.

Effort in 1995 continued the downward trend of recent years and was much less than half that recorded in 1993 (Table 5.2.3).

5.2.3 Weight at age and stock composition

The catch in numbers at age in 1995 is given in Table 5.2.4. The anomalous age distribution, with high numbers of 5 ringers, mentioned in previous reports (Anon., 1994, 1995d) was not a feature in 1995. The catch of 2 ringers was the highest since 1989 confirming the indication of an improved recruitment of the 1993 year class. However it is not possible to determine whether this reflects either improved spring spawner or autumn spawner recruitment. The abundance in the catch of the 3 ringers and older has declined since 1994.

Weights at age are given in Table 5.2.5. Mean weights in the stock have not been available from research vessel surveys since 1991; therefore the weights in the stock used are the weights at age in the catches. Weights at age in previous years are as used by the Working Group in 1994.

Once again no attempt has been made to apportion catches between spring and autumn-spawning stocks for 1995. The landings data show that the fishery has been directed at aggregations of autumn-spawning fish, with 89% of the catch taken in the last quarter and virtually all of the remainder taken throughout the year as by-catch in the demersal trawl fishery.

5.2.4 Surveys

No demersal egg surveys on the Ballantrae Bank and Brown Head spawning sites, no acoustic surveys in the Clyde and no spring trawl surveys were carried out in 1995. Historical estimates from these surveys are tabulated in Anon. (1995d).

5.2.5 Stock Assessment

The structure of the stock in the Clyde remains uncertain. No survey data are available from recent years; therefore no analytical assessment could be attempted.

5.2.6 Stock and catch projections

In the absence of an analytical assessment no stock projections can be provided.

5.2.7 Management considerations

The management of this fishery is made difficult by the presence of a mixture of a severely depleted spring-spawning component and autumn spawners from Division VIa south. The management objectives for these two components are necessarily distinct. The absence of fishery independent data from surveys further compounds the problem.

Historically the spring spawning stock supported a fishery with catches up to 15,000 t per year in the 1960's. Landings generally began to decline through the 1970's and 1980's with a rapid decline in effort during the late 1980's up to the present time. A TAC was first set in 1984 (3,000 t.) increasing to a maximum of 3,500 t in 1987 subsequently decreasing to 1,000 t by 1993. Estimated catches, including discards, exceeded the TAC for the first four years. This was followed by a decline in catches to 1990. In 1991 there was a dramatic drop in both landings and effort and since then landings have fluctuated at well below 1,000 t.

The spring spawning stock shows no signs of a recovery to its former high level prior to 1970. In the absence of surveys and no stock separation of the catches, nothing is currently known about the state of the spring spawning stock. All the management measures currently in force need to remain. Catches should be reduced to as low a level as possible and an attempt should be made to apportion those catches to spring and autumn spawning components.

5.2.8 Future research requirements

Provision of some fishery independent survey data for this area is necessary before an analytic assessment of the stock can be provided.

Further research is required to improve the understanding of the stock structure in the Clyde and in particular to attempt to apportion landings to spring and autumn spawners. If current management advice is required for the spring spawning stock, the otolith structure technique, described by Mosegaard and Madsen (W.D. 1996) for separating spring-spawners from autumn spawners in the Baltic, should be investigated.

Table 5.1.1. HERRING in Division VIa (North). Catch in tonnes by country, 1981-1995. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1982	1983	1984	1985	1986	1987
Denmark	-	-	96	-	-	-
Faroes	74	834	954	104	400	-
France	2 069	1 313	-	20	18	136
Germany	8 453	6 283	5 564	5 937	2 188	1 711
Ireland	-	-	-	-	6 000	6 800
Netherlands	11 317	20 200	7 729	5 500	5 160[2]	5 212[2]
Norway	10 018	7 336	6 669	4 690	4 799	4 300
UK England	90	-	-	-	-	-
UK Scotland	38 381	31 616	37 554	28 065	25 294	26 810
Unallocated	18 958	-4 059	16 588	502	37 840[2]	18 038[2]
Discards	-	-	-	-	-	-
Misreported(*)			11 270	4 819	8 987	18 902
Total	92 360	63 523	63 864	38 994	71 078	44 105

Country	1988	1989	1990	1991	1992	1993
Denmark	-	-	-	-	-	-
Faroes	-	-	326	482	-	-
France	44	1342	1287	1168	119	818
Germany	1 860	4 290	7 096	6 450	5 640	4 693
Ireland	6 740	8 000	10 000	8 000	7 985	8 236
Netherlands	6 131	5 680	7 693	7 979	8 000	6 132
Norway	456	-	1 607	3 318	2 389	7 447
UK Eng. & Wales	1 892	1 977	2 376	2 998	3 327	2 965
UK Scotland	25 002	27 897	35 877	29 630	29 403	29 637
Unallocated	5 229[2]	2 123[2]	2 397	-10 597	-5 485	-3 753
Discards	-	1 550	1 300	1 180	200	820
Misreported(*)	11 839	19 094	25 185	18 218	22 697	24 155
Total	35 516	33 945	44 774	32 388	28 888	32 020

Country	1994	1995
Denmark	0	0
Faroes	0	0
France	274	3 672
Germany	5 087	3 733
Ireland	7 938	3 548
Netherlands	6 093	7 808
Norway	8 183	4 840
UK Eng. & Wales	3 511	5 375
UK Scotland	27 165	37 286
Unallocated	-3 587	- 4 541
Discards	700	
Misreported(*)	30 089	32 468
Total	24 619	33 794

Discards are included in national catches.

(*) Catches assumed misreported are catches reported from the area between 4°W and 5°W. They are not included in the catch totals, but are included in the catches by country.

Table 5.1.2 HERRING in Division VIa (North), 1993. Sampling intensity of commercial catches.

Country	Catch in tonnes	No. of samples	No. of age readings	No. of fish measured	Estimate of discards
France	3672	0	0	0	NONE
Germany*	3733	6	537	22297	NONE
Ireland	3548	0	0	0	NONE
Netherlands	7808	8	200	890	YES
Norway	4840	2	447	447	NONE
UK (England and Wales	5375	0	0	0	NONE
UK (Scotland)	37286	9	808	1810	NONE

* Samples not used due to anomalous age-readings

Table 5.1.3. Estimated catches at age of herring in Area VIa(N).

Rings	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	238738	169947	801663	51170	309016	172879	69053	34836	22525	392
2	205454	372615	804097	235627	124944	202087	319604	47739	46284	225
3	359711	560348	219502	808267	151025	89066	101548	95834	20587	122
4	139718	357745	63069	131484	519178	63701	35502	22117	40692	31
5	53320	113391	85920	63071	82466	188202	25195	10083	6879	21
6	203462	54571	37341	54642	49683	30601	76289	12211	3833	12
7	29141	181592	13377	18242	34629	12297	10918	20992	2100	7
8	32860	18042	100938	6506	22470	13121	3914	2758	6278	2
9+	30651	36395	20465	32223	21042	13698	12014	1486	1544	0

Rings	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	12867	36740	13304	81923	2961	45663	38943	27645	2273	9690
2	1335	77961	250010	77810	253291	77063	178714	93679	158832	57305
3	452	105600	72179	92743	66857	166112	99264	64575	55529	170687
4	246	61341	93544	29262	46963	19269	137077	45488	37815	29497
5	62	21473	58452	42535	20057	17027	21723	71188	26292	28228
6	43	12623	23580	27318	15250	7422	20759	11973	37993	11830
7	40	11583	11516	14709	12478	7731	2973	10378	4327	23400
8	3	1309	13814	8437	5940	3720	16177	4982	2956	2529
9+	1	1326	4027	8484	2629	2450	2273	8498	3140	5463

Rings	1990	1991	1992	1993	1994	1995
1	22374	46826	9346	41169	3863	542
2	75241	40824	43538	147513	81712	167365
3	63832	44755	44344	30400	89846	61910
4	116270	50048	42228	18642	13428	43324
5	41512	66554	38818	24045	16616	10948
6	20826	24007	60262	27464	18109	8564
7	15463	13449	11301	36129	23505	17933
8	33585	12226	7681	8839	27178	16234
9+	8644	7904	9805	13825	22814	19933

Table 5.1.4. HERRING in Division VIa (North). Larvae abundance indices (Numbers in billions), larvae mortality rates (Z/K), fecundity estimate (10^5 eggs/g). LPE Biomass estimate in thousands of tonnes.

Year	LAI	10% Trim LAI	Z/K	LPE		
				Larvae	Fecundity	SSB
1973	2 442	46.49	0.74	318	(1.39)	229
1974	1 186	17.44	0.42	238	(1.39)	171
1975	878	22	0.46	157	1.46	108
1976	189	11.04	-	60	1.23	49
1977	787	25	-	223	1.49	150
1978	332	32.8	-	132	1.37	109
1979	1 071	26.94		118	1.49	79
1980	1 436	26.33	0.39	287	2.04	141
1981	2 154	35.61	0.34	448	2.12	211
1982	1 890	32.58	0.39	267	1.95	137
1983	668	24.55	-	112	1.88	60
1984	2 133	45.99	0.57	253	1.75	145
1985	2 710	50.03	0.37	418	(1.86)	225
1986	3 037	45.36	0.24	907	(1.86)	488
1987	4 119	45.47	0.53	423	(1.86)	227
1988	5 947	75.13	0.47	781	(1.86)	420
1989	4 320	82.68	0.40	752	(1.86)	404
1990	6 525	86.2	0.64	426	(1.86)	229
1991	4 430	63.06	0.60	632	(1.86)	340
1992	12 252	41.79	0.66	463	(1.86)	248
1993	2 941	65.01	0.56	538	(1.86)	289

Table 5.1.5. HERRING in Division VIa (North). Estimates of abundance from Scottish acoustic surveys. Thousands of fish at age, and spawning biomass (SSB, tonnes).

Age	1987	1991	1992	1993	1994	1995
1	249 100	338 312	74 310	2 760	494 150	441 240
2	578 400	294 484	503 430	750 270	542 080	1103 400
3	551 100	327 902	210 980	681 170	607 720	473 220
4	353 100	367 830	258 090	653 050	285 610	450 270
5	752 600	488 288	414 750	544 000	306 760	152 970
6	111 600	176 348	240 110	865 150	268 130	187 100
7	48 100	98 741	105 670	284 110	406 840	169 080
8	15 900	89 830	56 710	151 730	173 740	236 540
9	6 500	58 043	63 440	156 180	131 880	201 500
SSB:	273 000*	452 000	351 460	866 190	533 740	452 120

* - Biomass of 2+ ringers in November.

Table 5.1.6. HERRING in Division VIa(North). Scottish bottom trawl survey indices of 2-ringed herring catch rates. Mean catches per hour's trawling.

Trawl survey Year	Number of Trawls	2-ringer index
1981	9	1 237
1982	10	2 361
1983	12	11
1984	12	12 456
1985	17	98
1986	12	359
1987	15	40
1988	19	15 770
1989	15	1 435
1990	16	46
1991	18	1 242
1992	14	38
1993	13	836
1994	18	343
1995	16	3 127
1996	15	3 204

Table 5.1.7. HERRING in Division VIa (North). Mean weights at age (g).

Age	Weight in the catch												
(Age, Rings)	1982-1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Mean 93-95
1	90	69	113	73	80	82	79	84	91	89	83	105	92
2	140	103	145	143	112	142	129	118	122	128	142	142	137
3	175	134	173	183	157	145	173	160	172	158	167	180	168
4	205	161	196	211	177	191	182	203	194	197	190	191	193
5	231	182	215	220	203	190	209	211	216	206	195	198	200
6	253	199	230	238	194	213	224	229	224	228	201	213	214
7	270	213	242	241	240	216	228	236	236	223	244	207	225
8	284	223	251	253	213	204	237	261	251	262	234	227	241
9+	295	231	258	256	228	243	247	271	258	263	266	277	269

Weight in the stock from Acoustic surveys

	Historical	1992	1993	1994	1995	Mean 92-95
1	90	68	75	52	45	60
2	164	152	162	150	144	153
3	208	186	196	192	191	191
4	233	206	206	220	202	209
5	246	232	226	221	225	226
6	252	252	234	233	226	237
7	258	271	254	241	247	253
8	269	296	260	270	260	272
9	292	305	276	296	293	292

Table 5.1.8. HERRING in VIa(N). Catches that are assumed misreported in the part of Division VIa(N) between 4°W and 5°W, as a proportion of the total reported catches from Division VIa(N). Where available, the proportion of the stock found to be located in this area by the acoustic surveys is also given.

Year	Proportion of VIa(N) Catch reported East of 5°W (%)	Proportion of VIa(N) Stock reported East of 5°W (%)
1984	15	
1985	11	
1986	13	
1987	30	
1988	25	
1989	36	
1990	36	
1991	36	9.8
1992	44	11.8
1993	43	1.1
1994	55	2.9
1995	49	18.7

Table 5.1.9. HERRING in Division VIa(N). Results of baseline a ssment.

CATCH NUMBERS AT AGE (Millions)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	69.	35.	23.	0.	13.	37.	13.	82.	2.	41.	34.	19.	2.	6.	14.	26.	5.	18.	2.	0.
2	320.	48.	46.	0.	1.	78.	250.	78.	189.	69.	155.	66.	119.	37.	48.	23.	24.	95.	37.	82.
3	102.	96.	21.	0.	0.	106.	72.	93.	50.	148.	86.	45.	42.	110.	41.	25.	25.	19.	40.	30.
4	36.	22.	41.	0.	0.	61.	94.	29.	35.	17.	119.	32.	28.	19.	74.	28.	24.	11.	6.	21.
5	25.	10.	7.	0.	0.	21.	58.	43.	15.	15.	19.	50.	20.	18.	27.	38.	22.	13.	7.	5.
6	76.	12.	4.	0.	0.	13.	24.	27.	11.	7.	18.	8.	29.	8.	13.	14.	34.	15.	8.	4.
7	11.	21.	2.	0.	0.	12.	12.	15.	9.	7.	3.	7.	3.	15.	10.	8.	6.	19.	11.	9.
8	4.	3.	6.	0.	0.	1.	14.	8.	4.	3.	14.	4.	2.	2.	21.	7.	4.	5.	12.	8.
9	12.	1.	2.	0.	0.	1.	4.	8.	2.	2.	2.	6.	2.	4.	6.	4.	6.	7.	10.	10.

INDICES OF SPAWNING STOCK BIOMASS

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	.189E+03	.787E+03	.332E+03	.107E+04	.144E+04	.215E+04	.189E+04	.668E+03	.213E+04	.271E+04	.304E+04	.412E+04	.595E+04	.432E+04	.653E+04	.443E+04	MISSING	.294E+04

AGE - STRUCTURED INDICES

INDEX : 1 from 1987 to 1995

	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	.249E+06				.338E+06	.743E+05	.276E+04	.494E+06	.461E+06
2	.578E+06				.294E+06	.503E+06	.750E+06	.542E+06	.109E+07
3	.551E+06				.328E+06	.211E+06	.681E+06	.608E+06	.473E+06
4	.353E+06				.368E+06	.258E+06	.653E+06	.286E+06	.450E+06
5	.753E+06		MISSING		.488E+06	.415E+06	.544E+06	.307E+06	.153E+06
6	.112E+06				.176E+06	.240E+06	.865E+06	.268E+06	.187E+06
7	.481E+05				.987E+05	.106E+06	.284E+06	.407E+06	.169E+06
8	.159E+05				.898E+05	.567E+05	.152E+06	.174E+06	.237E+06
9	.650E+04				.580E+05	.634E+05	.156E+06	.132E+06	.202E+06

FISHING MORTALITY

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	.1809	.0864	.0373	.0004	.0219	.0347	.0262	.0381	.0027	.0471	.0474	.0108	.0018	.0088	.0202	.0173	.0127	.0134	.0079	.0103
2	.7376	.3210	.2724	.0008	.0027	.3079	.6382	.3659	.1956	.1839	.4493	.2088	.1415	.0821	.2237	.1913	.1402	.1481	.0876	.1143
3	1.1826	.5528	.2368	.0011	.0020	.3233	.5601	.5604	.4535	.2468	.3917	.2429	.2100	.1978	.1999	.1710	.1253	.1323	.0783	.1021
4	1.0977	.8682	.4566	.0005	.0025	.3690	.5006	.4402	.4032	.2637	.3027	.2338	.2236	.1319	.1647	.1409	.1032	.1090	.0645	.0841
5	.8779	.9873	.6465	.0003	.0010	.2774	.6331	.3956	.3745	.2728	.4531	.1802	.1981	.1942	.1720	.1471	.1078	.1138	.0674	.0878
6	1.0520	1.3864	1.2248	.0018	.0008	.2660	.4900	.6095	.1550	.2523	.5265	.3337	.1328	.0977	.1759	.1504	.1102	.1164	.0689	.0898
7	1.0691	.8384	.8501	.0049	.0065	.2523	.3667	.5720	.3804	.1195	.1317	.3729	.1853	.0862	.1740	.1488	.1090	.1152	.0682	.0889
8	.9090	.7663	.5706	.0014	.0023	.2693	.4741	.4438	.2975	.2022	.3347	.2377	.1651	.1191	.1647	.1409	.1032	.1090	.0645	.0841
9	.9090	.7663	.5706	.0014	.0023	.2693	.4741	.4438	.2975	.2022	.3347	.2377	.1651	.1191	.1647	.1409	.1032	.1090	.0645	.0841

NUMBERS AT AGE (Millions)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	650.	661.	971.	1544.	939.	1699.	813.	3457.	1287.	1397.	1149.	2867.	1466.	1119.	736.	783.	1474.	1522.	956.	44.	995.
2	696.	200.	223.	344.	568.	338.	604.	291.	1224.	472.	490.	403.	1043.	538.	408.	265.	283.	536.	553.	349.	16.
3	158.	247.	107.	126.	255.	420.	184.	236.	150.	746.	291.	232.	242.	671.	367.	242.	162.	182.	342.	375.	231.
4	55.	40.	116.	69.	103.	208.	249.	86.	110.	78.	477.	161.	149.	161.	451.	246.	167.	117.	131.	259.	277.
5	45.	17.	15.	67.	63.	93.	130.	136.	50.	67.	54.	319.	115.	108.	127.	346.	194.	136.	95.	111.	215.
6	122.	17.	6.	7.	60.	57.	64.	63.	83.	31.	46.	31.	241.	86.	80.	97.	270.	157.	110.	80.	92.
7	17.	39.	4.	2.	6.	54.	39.	35.	31.	64.	22.	25.	20.	191.	70.	61.	76.	219.	127.	93.	67.
8	7.	5.	15.	1.	1.	6.	38.	25.	18.	19.	52.	17.	15.	15.	158.	53.	47.	61.	177.	107.	77.
9	17.	9.	6.	11.	11.	11.	12.	28.	31.	33.	38.	58.	54.	53.	55.	164.	171.	178.	194.	315.	351.

Table 5.1.9. (Contd.)

STOCK SUMMARY

Year	Recruits x10^6	Total B tonnes	Spawn B tonnes	Landings tonnes	Yld/SSB	Ref. F Fbar 3- 6
1976	650.	271747.	101310.	93642.	.9243	1.0525
1977	661.	175168.	68536.	41341.	.6032	.9487
1978	971.	185322.	67296.	22176.	.3295	.6412
1979	1544.	259875.	104808.	60.	.0006	.0009
1980	939.	290475.	178230.	306.	.0017	.0016
1981	1699.	400166.	177561.	51420.	.2896	.3089
1982	813.	340349.	161738.	92361.	.5711	.5459
1983	3457.	501347.	124070.	63523.	.5120	.5014
1984	1287.	428487.	225448.	56012.	.2484	.3466
1985	1397.	431973.	230543.	39142.	.1698	.2589
1986	1149.	411089.	214648.	71345.	.3324	.4185
1987	2867.	524164.	205626.	44360.	.2157	.2477
1988	1466.	502337.	289633.	35591.	.1229	.1911
1989	1119.	482981.	308391.	34026.	.1103	.1554
1990	736.	442963.	300700.	44693.	.1486	.1781
1991	783.	409076.	278371.	28527.	.1025	.1523
1992	1474.	449549.	267794.	28992.	.1083	.1116
1993	1522.	449071.	277063.	31778.	.1147	.1179
1994	956.	409372.	307322.	24474.	.0796	.0698
1995	44.	362174.	307174.	29575.	.0963	.0910

PARAMETER ESTIMATES +/- SD

Separable Model: Reference F by year				
1	1990	.1647	.1345	.2018
2	1991	.1409	.1147	.1730
3	1992	.1032	.0841	.1268
4	1993	.1090	.0883	.1346
5	1994	.0645	.0515	.0809
6	1995	.0841	.0652	.1086
Separable Model: Selection (S) by age				
7	1	.1228	.0945	.1597
8	2	1.3580	1.0867	1.6970
9	3	1.2134	.9893	1.4884
	4	1.0000	Fixed : Reference age	
10	5	1.0440	.8732	1.2482
11	6	1.0677	.8971	1.2708
12	7	1.0562	.8837	1.2624
	8	1.0000	Fixed : last true age	
Separable Model: Populations in year 1995				
13	1	43833.	26160.	73446.
14	2	348919.	237964.	511611.
15	3	375018.	269265.	522307.
16	4	259019.	197136.	340327.
17	5	110875.	86043.	142874.
18	6	80441.	63821.	101388.
19	7	92847.	74590.	115573.
20	8	107063.	86405.	132660.
Separable Model: Populations at age 8				
21	1990	158493.3843	111241.1440	225817.1029
22	1991	53429.4353	39782.4970	71757.8024
23	1992	47464.1821	36560.8300	61619.1861
24	1993	61350.1542	48463.6608	77663.1676
25	1994	176569.1753	143017.3476	217992.2518

SSB Index catchabilities: Larval abundance Index

26	1	Power Model : Q	.59330E+01	.49104E+01	.71686E+01
27	1	Power Model : K	-.13973E+02	-.16241E+02	-.11705E+02

Age-structured index catchabilities
Age-Structured Index 1 : Acoutic Surveys in Division VIa(N)
Linear model fitted. Slopes at age:

28	1 Q	.24671E+00	.65250E-01	.93277E+00
29	2 Q	.18172E+01	.11554E+01	.28580E+01
30	3 Q	.20790E+01	.13315E+01	.32460E+01
31	4 Q	.23887E+01	.15393E+01	.37069E+01
32	5 Q	.24541E+01	.15876E+01	.37935E+01
33	6 Q	.26280E+01	.17012E+01	.40599E+01
34	7 Q	.19913E+01	.12861E+01	.30830E+01
35	8 Q	.16059E+01	.10323E+01	.24983E+01
36	9 Q	.46426E+00	.29502E+00	.73058E+00

Table 5.1.9. (contd.)

Parameters of the B.-H. stock-recruit relationship

37	a	.1129641E+07	.2992676E+06	.4264041E+07
38	b	.1964745E+04	.2728112E-41	.1414979E+49

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals: log(Observed Catch)-log(Expected Catch)) and weights (W) used in the analysis.

Age	1990	1991	1992	1993	1994	1995	
1	.42651E+00	.11331E+01	-.80540E+00	.32393E+00	-.10164E+01	-.69388E-01	.10000E+01
2	-.39119E+00	-.55503E+00	-.27115E+00	.39939E+00	-.93830E-01	.92334E+00	.10000E+01
3	-.39519E+00	-.31378E+00	.36218E+00	-.92001E-01	.54139E+00	-.83466E-01	.10000E+01
4	.12973E+00	-.89076E-01	.42068E+00	-.49257E-01	-.25845E+00	.66483E-01	.10000E+01
5	.32307E+00	-.18363E+00	.14680E+00	-.50226E-01	.23092E+00	-.50173E+00	.10000E+01
6	.76055E-01	.45946E-01	.23200E+00	-.10649E+00	.15029E+00	-.44803E+00	.10000E+01
7	-.79512E-01	-.56202E-01	-.15816E+00	-.16763E+00	.27987E+00	.15796E+00	.10000E+01
8	-.66894E-01	.29819E-01	-.26687E-01	-.24792E+00	.14585E+00	-.31615E-01	.10000E+01
Wts	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	

Biomass Index Residuals: log(Observed Index) - log(Expected Index): Larval Abundance Index

Idx	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	-.13077E+01	.81466E+00	-.15902E-01	.36647E+00	-.28563E+00	.12654E+00	.16197E+00	-.40599E+00	-.30841E+00	-.10878E+00	.13234E+00	.51354E+00	.27088E+00 -

1989	1990	1991	1992	1993
.16048E+00	.29687E+00	.47009E-01	-.10000E+01	-.35426E+00

Table 5.1.9. (Contd.)

Aged Index Residuals: log(Observed Index) - log(Expected Index): Acoustic Survey

Age	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	-.63930E+00				.96771E+00	-.11831E+01	-.45079E+01	.11428E+01	.41559E+01
2	-.32276E-01				-.29606E+00	.15479E+00	-.80918E-01	-.46144E+00	.70299E+00
3	.31183E+00				-.27867E+00	-.33922E+00	.71959E+00	-.46063E-01	-.37954E+00
4	.47563E-01		MISSING		-.37344E+00	-.35309E+00	.93056E+00	-.23267E-01	-.24421E+00
5	.72936E-01				-.45420E+00	-.52756E-01	.57301E+00	.34034E+00	-.50060E+00
6	.48398E+00				-.26968E+00	-.10002E+01	.82522E+00	-.70809E-02	-.46410E-01
7	.17134E+00				-.10556E+00	-.27049E+00	-.34223E+00	.54532E+00	-.13233E-01
8	-.42831E+00				.14220E+00	-.21445E+00	.51541E+00	-.42403E+00	.39283E+00
9	-.12903E+01				-.17343E+00	-.14110E+00	.71999E+00	.44601E+00	.39570E+00

PARAMETERS OF THE DISTRIBUTION OF ln CATCHES AT AGE

Separable model fitted from 1990 to 1995

Variance	:	.2957
Skewness test statistic	:	.6737
Kurtosis test statistic	:	2.1624
Partial chi-square	:	.7195
bability of chi-square	:	1.0000
..grees of freedom	:	23

PARAMETERS OF THE DISTRIBUTION OF THE SSB INDICES

DISTRIBUTION STATISTICS FOR ln SSB INDEX 1

Power catchability relationship assumed. Last age is a plus-group.

Variance	:	.2332
Skewness test statistic	:	-1.7229
Kurtosis test statistic	:	1.5933
Partial chi-square	:	.5220
Probability of chi-square	:	1.0000
Number of observations	:	17
Degrees of freedom	:	15
Weight in the analysis	:	1.0000

DISTRIBUTION STATISTICS FOR ln(ACOUSTIC SURVEY)

Linear catchability relationship assumed.

Age	:	1	2	3	4	5	6	7	8	9
Variance	:	8.3285	.1653	.1908	.2385	.1818	.3981	.1057	.1699	.5177
Skewness test stat.	:	-.1763	.7381	.7558	1.3077	.0245	-.3008	.6770	.1118	-.9600
tosis test stat.	:	-.2614	-.1913	-.4529	.1632	-.6775	-.3456	-.3340	-.8227	-.1096
..tial chi-square	:	3.9116	.0622	.0743	.0945	.0714	.1548	.0430	.0746	.2467
Prob. of chi-square	:	.5622	.9999	.9999	.9999	.9999	.9995	1.0000	.9999	.9985
Number of data	:	6	6	6	6	6	6	6	6	6
Degrees of freedom	:	5	5	5	5	5	5	5	5	5
Weight in analysis	:	.0111	.1111	.1111	.1111	.1111	.1111	.1111	.1111	.1111

Total weighted SSQ is : 12.044

Unweighted Residuals About the Model fit

	Start SSQ	End SSQ	df	Variance	IV Wt
Separable model:	7.7467	6.8019	23	.2957	3.38139
Biomass idx 1	4.6909772	3.5000769	15	.2333	1.26741
Aged index 1	78.1062631	51.4821742	45	1.1440	.25850

Partition of the weighted residuals

Catch at Age Matrix : .6802E+01 for 48 observations.

SSB Index 1 3.50008 17

Aged Index 1

Age:	1	2	3	4	5	6	7	8	9
Wted SSQ:	.4627E+00	.9181E-01	.1060E+00	.1325E+00	.1010E+00	.2212E+00	.5870E-01	.9438E-01	.2877E+00
No data:	6	6	6	6	6	6	6	6	6

Table 5.1.10. Herring in VIa(N). Input data for short-term deterministic predictions.

Year: 1996								
Age	Stock size	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
2	465167.00	0.3000	1.0000	0.6700	0.6700	153.000	0.1143	137.000
3	230578.00	0.2000	1.0000	0.6700	0.6700	191.000	0.1021	168.000
4	277241.00	0.1000	1.0000	0.6700	0.6700	209.000	0.0841	193.000
5	215459.00	0.1000	1.0000	0.6700	0.6700	226.000	0.0878	200.000
6	91889.000	0.1000	1.0000	0.6700	0.6700	237.000	0.0898	214.000
7	66533.000	0.1000	1.0000	0.6700	0.6700	253.000	0.0889	225.000
8	76869.000	0.1000	1.0000	0.6700	0.6700	272.000	0.0841	241.000
9+	350700.00	0.1000	1.0000	0.6700	0.6700	292.000	0.0841	269.000
Unit	Thousands	-	-	-	-	Grams	-	Grams

Year: 1997								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
2	465167.00	0.3000	1.0000	0.6700	0.6700	153.000	0.1143	137.000
3	.	0.2000	1.0000	0.6700	0.6700	191.000	0.1021	168.000
4	.	0.1000	1.0000	0.6700	0.6700	209.000	0.0841	193.000
5	.	0.1000	1.0000	0.6700	0.6700	226.000	0.0878	200.000
6	.	0.1000	1.0000	0.6700	0.6700	237.000	0.0898	214.000
7	.	0.1000	1.0000	0.6700	0.6700	253.000	0.0889	225.000
8	.	0.1000	1.0000	0.6700	0.6700	272.000	0.0841	241.000
9+	.	0.1000	1.0000	0.6700	0.6700	292.000	0.0841	269.000
Unit	Thousands	-	-	-	-	Grams	-	Grams

Year: 1998								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
2	465167.00	0.3000	1.0000	0.6700	0.6700	153.000	0.1143	137.000
3	.	0.2000	1.0000	0.6700	0.6700	191.000	0.1021	168.000
4	.	0.1000	1.0000	0.6700	0.6700	209.000	0.0841	193.000
5	.	0.1000	1.0000	0.6700	0.6700	226.000	0.0878	200.000
6	.	0.1000	1.0000	0.6700	0.6700	237.000	0.0898	214.000
7	.	0.1000	1.0000	0.6700	0.6700	253.000	0.0889	225.000
8	.	0.1000	1.0000	0.6700	0.6700	272.000	0.0841	241.000
9+	.	0.1000	1.0000	0.6700	0.6700	292.000	0.0841	269.000
Unit	Thousands	-	-	-	-	Grams	-	Grams

Notes: Run name : MANKRP01
Date and time: 16APR96:17:43

Table 5.1.11. Herring in VIa(N). Management option table. Estimated effect on stock biomass of different levels of catches and fishing mortality on the stock..

Year: 1996					Year: 1997					Year: 1998	
F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	Stock biomass	Sp.stock biomass
1.0000	0.0910	383771	327058	28427	0.6000	0.0546	398016	347111	18092	421815	368433
.	.	.	.	.	0.7000	0.0637	.	344958	21012	418559	363275
.	.	.	.	.	0.8000	0.0728	.	342819	23905	415334	358192
.	.	.	.	.	0.9000	0.0819	.	340693	26772	412139	353184
.	.	.	.	.	1.0000	0.0909	.	338581	29613	408974	348249
.	.	.	.	.	1.1000	0.1000	.	336482	32428	405839	343387
.	.	.	.	.	1.2000	0.1091	.	334396	35217	402733	338595
.	.	.	.	.	1.3000	0.1182	.	332323	37981	399657	333874
.	.	.	.	.	1.4000	0.1273	.	330263	40720	396609	329221
.	.	.	.	.	1.5000	0.1364	.	328216	43434	393590	324636
.	.	.	.	.	1.6000	0.1455	.	326182	46123	390600	320118
.	.	.	.	.	1.7000	0.1546	.	324161	48788	387638	315666
.	.	.	.	.	1.8000	0.1637	.	322152	51429	384703	311279
.	.	.	.	.	1.9000	0.1728	.	320156	54045	381797	306956
.	.	.	.	.	2.0000	0.1819	.	318173	56638	378917	302696
.	.	.	.	.	2.1000	0.1910	.	316202	59207	376065	298498
.	.	.	.	.	2.2000	0.2001	.	314243	61753	373239	294360
.	.	.	.	.	2.3000	0.2092	.	312297	64276	370440	290283
.	.	.	.	.	2.4000	0.2183	.	310363	66776	367668	286[illegible]
.	.	.	.	.	2.5000	0.2274	.	308441	69253	364921	2823[illegible]
.	.	.	.	.	2.6000	0.2365	.	306531	71708	362200	278404
.	.	.	.	.	2.7000	0.2456	.	304634	74140	359505	274559
.	.	.	.	.	2.8000	0.2547	.	302748	76551	356835	270769
.	.	.	.	.	2.9000	0.2638	.	300874	78940	354190	267035
.	.	.	.	.	3.0000	0.2729	.	299011	81307	351570	263354
.	.	.	.	.	3.1000	0.2819	.	297161	83652	348975	259727
.	.	.	.	.	3.2000	0.2910	.	295322	85976	346404	256152
.	.	.	.	.	3.3000	0.3001	.	293494	88280	343857	252629
.	.	.	.	.	3.4000	0.3092	.	291678	90562	341334	249157
.	.	.	.	.	3.5000	0.3183	.	289873	92824	338835	245735
.	.	.	.	.	3.6000	0.3274	.	288080	95065	336359	242363
-	-	Tonnes	Tonnes	Tonnes	-	-	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes

Notes: Run name : MANKRP01
Date and time : 12APR96:14:22
Computation of ref. F: Simple mean, age 3 - 6
Basis for 1996 : F factors

Table 5.1.12 Summary of parameter estimates obtained on fitting Ricker and Beverton-Holt stock-recruit relationships. Models fitted to recruitment in thousands of fish and to spawning stock biomass in tonnes.

Model	Parameter	Estimate	Variance	d.f.
Geometric Mean Recruitment			0.2122	23
	Mean	1297231		
Ricker: Recruits = a.SSB.exp(-b.SSB)			0.2705	22
	a	25.1126		
	b	2.903 . 10^-6		
Beverton-Holt: Recruits=a.SSB/(1+SSB/b)			0.2148	22
	a	50.964		
	b	29594.1		

Table 5.1.13. Herring in VIa(N). Calculation of equilibrium stock biomass for geometric mean recruitment and using Working Group assumptions about natural mortality and maturity ogives. Weights at age calculated from acoustic surveys.

Age	Population	Natural Mortality	Weights at age	Maturity Ogive	Biomass	Spawning Biomass
Winter Rings	(Millions)		(Kg)		(Tonnes)	(Tonnes)
1	1444	1	0.066	0	95292	0
2	531	0.3	0.154	1	82010	67077
3	393	0.2	0.195	1	76572	66969
4	322	0.1	0.213	1	68749	64294
5	292	0.1	0.230	1	67045	62701
6	264	0.1	0.239	1	63145	59052
7	239	0.1	0.254	1	60668	56736
8	216	0.1	0.271	1	58522	54730
9+	195	0.1	0.292	1	57135	53432
Sum					629138	484991

Proportion of Mortality before spawning: 0.67

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Table 5.2.1 Catches of HERRING from the Firth of Clyde. Spring and autumn-spawners combined. Catch in tonnes by country, 1955–1995.

Country	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
Scotland											
Other UK											
Unallocated[1]											
Discards											
Agreed TAC											
Total	4,050	4,848	5,915	4,926	10,530	15,680	10,848	3,989	7,073	14,509	15,096

Country	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Scotland											
Other UK											
Unallocated[1]											
Discards											
Agreed TAC											
Total	9,807	7,929	9,433	10,594	7,763	4,088	4,226	4,715	4,061	3,664	4,139

Country	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Scotland						2,506	2,530	2,991	3,001	3,395	2,895
Other UK						-	273	247	22	-	-
Unallocated[1]						262	293	224	433	576	278
Discards						1,253	1,265	2,308[3]	1,344[3]	679[3]	439[4]
Agreed TAC								3,000	3,000	3,100	3,500
Total	4,847	3,862	1,951	2,081	2,135	4,021	4,361	5,770	4,800	4,650	3,612

Country	1988	1989	1990	1991	1992	1993	1994	1995
Scotland	1,568	2,135	2,184	713	929	852	608	392
Other UK	-	-	-	-	-	-	-	-
Unallocated[1]	110	208	75	18	-	-	-	-
Discards	245[4]	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]
Agreed TAC	3,200	3,200	2,600	2,900	2,300	1,000	1,000	1,000
Total	1,923	2,343	2,259	731	929	852	608	392

[1]Calculated from estimates of weight per box and in some years estimated by-catch in the sprat fishery
[2]Reported to be at a low level, assumed to be zero.
[3]Based on sampling.
[4]Estimated assuming the same discarding rate as in 1986.

Table 5.2.2 Sampling levels of Clyde HERRING 1988-1995.

Year	Reported catch (tonnes)	No. of samples	No. of fish measured	No. of fish aged	Discards
1988	1,568	41	5,955	2,574	Based on local
1989	2,135	45	8,368	4,152	reports
1990	2,184	37	5,926	3,803	" "
1991	713	29	4,312	2,992	" "
1992	929	23	4,604	1,579	No information
1993	852	16	3,408	798	No information
1994	608	16	3,903	1,388	No information
1995	392	16	2,727	1,073	No information

Table 5.2.3 Effort on Clyde HERRING. Number of days' absence from port by pair trawlers in the Firth of Clyde, 1974 to 1995, and estimated total effort in pair trawl units.

Year	Days absent (pair trawl)	Raised to total landings
1974	3 376	3 376
1975	3 209	3 209
1976	3 016	3 016
1977	4 186	4 186
1978	4 379	4 379
1979	2 933	2 933
1980	1 982	1 982
1981	1 529	1 529
1982	1 755	1 755
1983	1 644	1 644
1984	1 401	1 401
1985	1 688	1 688
1986	1 375	1 375
1987	850	998
1988	540	626
1989	582	639
1990	388	429
1991	169	254
1992	137	165
1993	194	224
1994	104	111
1995	79	89

Table 5.2.4 Clyde HERRING catch in numbers at age. Spring- and autumn-spawners combined. Thousands of fish.

Age(Rings)	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	5008	2207	1351	9139	5308	12694	6194	1041	14123	507
2	7551	6503	8983	5258	8841	1876	10480	7524	1796	4859
3	10338	1976	3181	4548	2817	2483	913	6976	2259	807
4	8745	4355	1684	1811	2559	1024	1049	1062	2724	930
5	2306	3432	3007	918	1140	1072	526	1112	634	888
6	741	1090	1114	1525	494	451	638	574	606	341
7	760	501	656	659	700	175	261	409	330	289
8	753	352	282	307	253	356	138	251	298	156
9	227	225	177	132	87	130	178	146	174	119
9+	117	181	132	114	59	67	100	192	236	154

Age(Rings)	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	333	312	220	314	4156	1639	678	508	0	845
2	5633	2372	11311	10109	11829	2951	4574	1376	1062	1523
3	1592	2785	4079	5232	5774	4420	4431	3669	1724	9239
4	567	1622	2440	1747	3406	4592	4622	4379	2506	876
5	341	1158	1028	963	1509	2806	2679	3400	2014	452
6	204	433	663	555	587	2654	1847	1983	1319	252
7	125	486	145	415	489	917	644	1427	510	146
8	48	407	222	189	375	681	287	680	234	29
9	56	74	63	85	74	457	251	308	66	16
9+	68	18	53	38	80	240	79	175	16	5

Age(Rings)	1990	1991	1992	1993	1994	1995
1	716	42	145	3	399	118
2	1004	615	411	418	964	1425
3	839	472	493	261	964	186
4	7533	703	385	268	358	189
5	576	1908	1947	1305	534	149
6	359	169	333	327	319	130
7	329	92	91	78	76	66
8	119	113	69	111	57	35
9	49	22	32	38	16	15
9+	16	9	10	0	17	1

Table 5.2.5 HERRING in the Firth of Clyde. Mean weights at age in the catch and stock (g).

Age	Weight in		Weight in the catch											
(rings)	the stock (Spr spawn)		1970-81	1982-85	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	-	-	-	-	-	-	-	-	-	-	-	-	-	102
2	-	-	225	149	166	149	156	149	170	143	141	141	92	151
3	171	173	270	187	199	194	194	174	186	163	187	174	157	174
4	195	218	290	228	224	203	207	203	202	188	188	198	184	201
5	210	215	310	253	253	217	211	221	216	192	216	213	212	226
6	210	245	328	272	265	225	222	227	237	198	227	216	249	241
7	234	-	340	307	297	236	230	235	234	210	206	229	248	249
8	-	-	345	291	298	247	225	237	234	222	218	261	240	252
9	-	-	350	300	298	255	244	219	257	200	201	233	249	242
10+	-	-	350	300	321	258	230	254	272	203	221	254	294	270

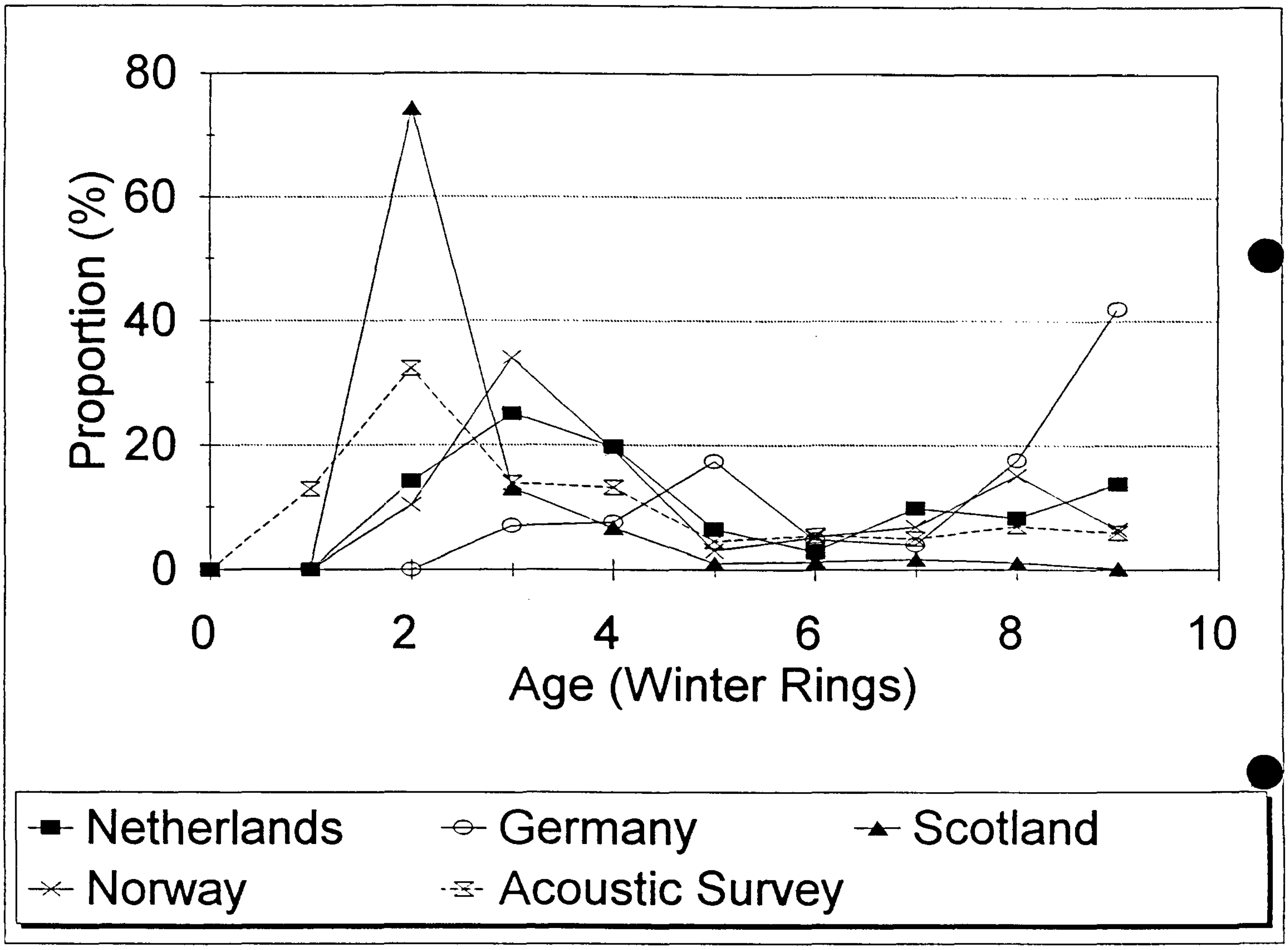
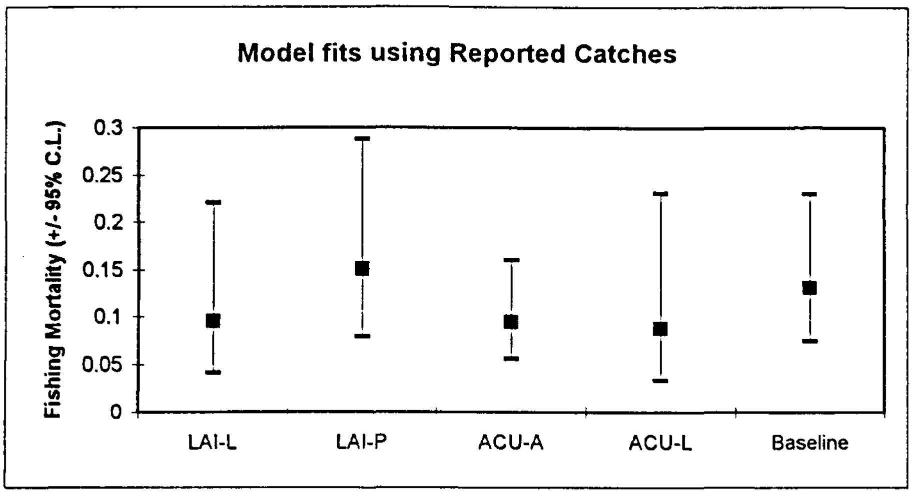


Figure 5.1.1. Herring in VIa(N). Age-composition of commercial catches by fleet, together with the age-composition recorded in the commercial surveys. Proportion of fish at each age.



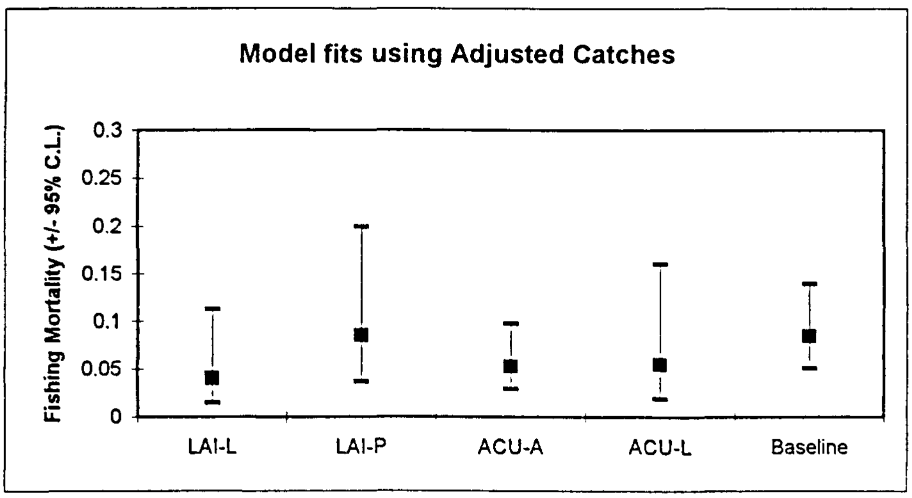


Figure 5.1.2. Herring in VIa(N). Estimates of fishing mortality (+/- 95% C.L.) in population models fitted to the larval abundance index (LAI-L, proportionate model); LAI-P, power model), the acoustic survey used as an absolute measure of biomass (ACU-A) or as a proportionate measure of abundance (ACU-L). Lastly, baseline model fits in which the LAI-P and the ACU-L are given equal weights. Upper panel, fitted using official catch reportes for the VIa(N) area. Lower panel, fitted excluding catches reported between 4 and 5 degrees West and assumed to be misreported North Sea catches.

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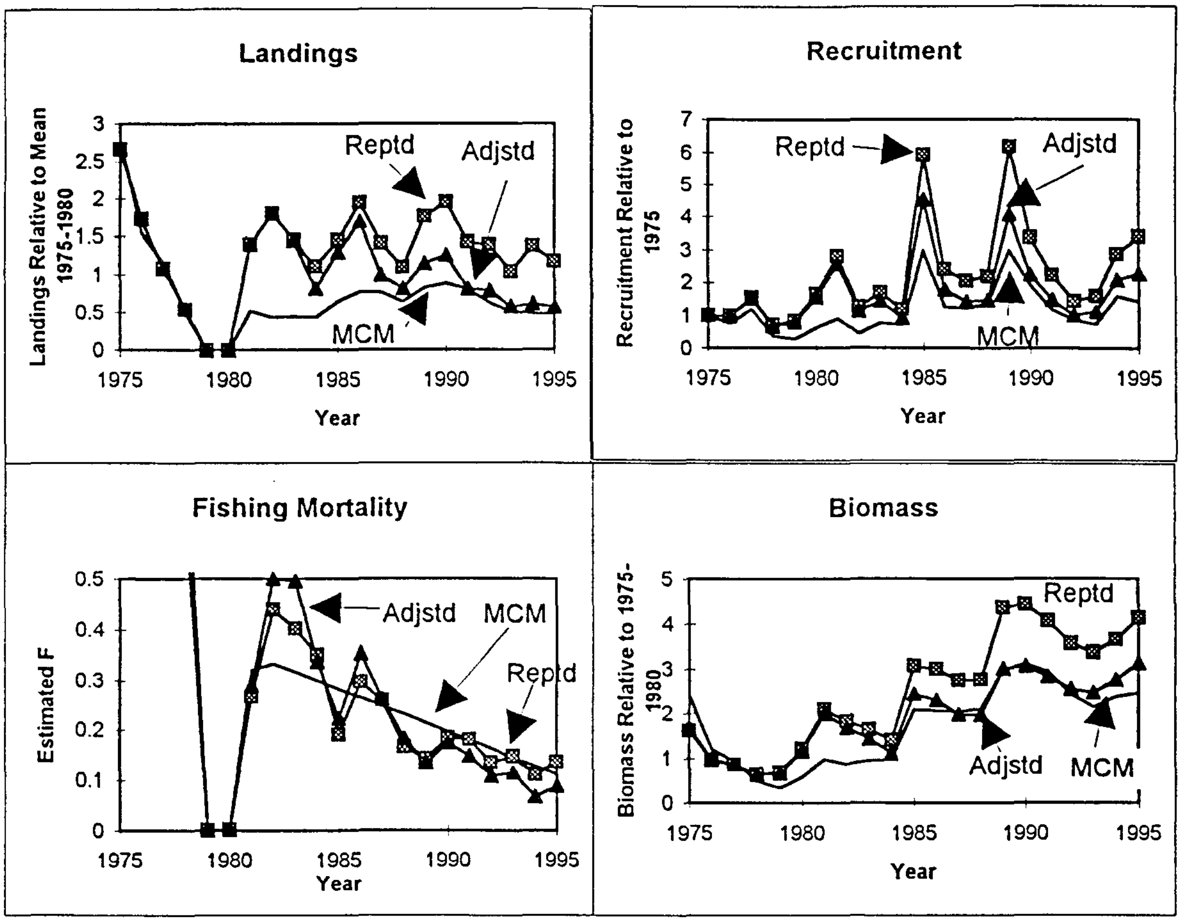

Figure 5.1.3. Comparison of assessment based on reported catches ('Reptd', line and square markers), assessment based on catches adjusted for supposed misreporting ('Adjstd', line and triangle markers) and estimates obtained by fitting a model that treats catches as missing data but constrains fishing mortality to a linear trend with time from 1981 onwards ('MCM',line with no markers).

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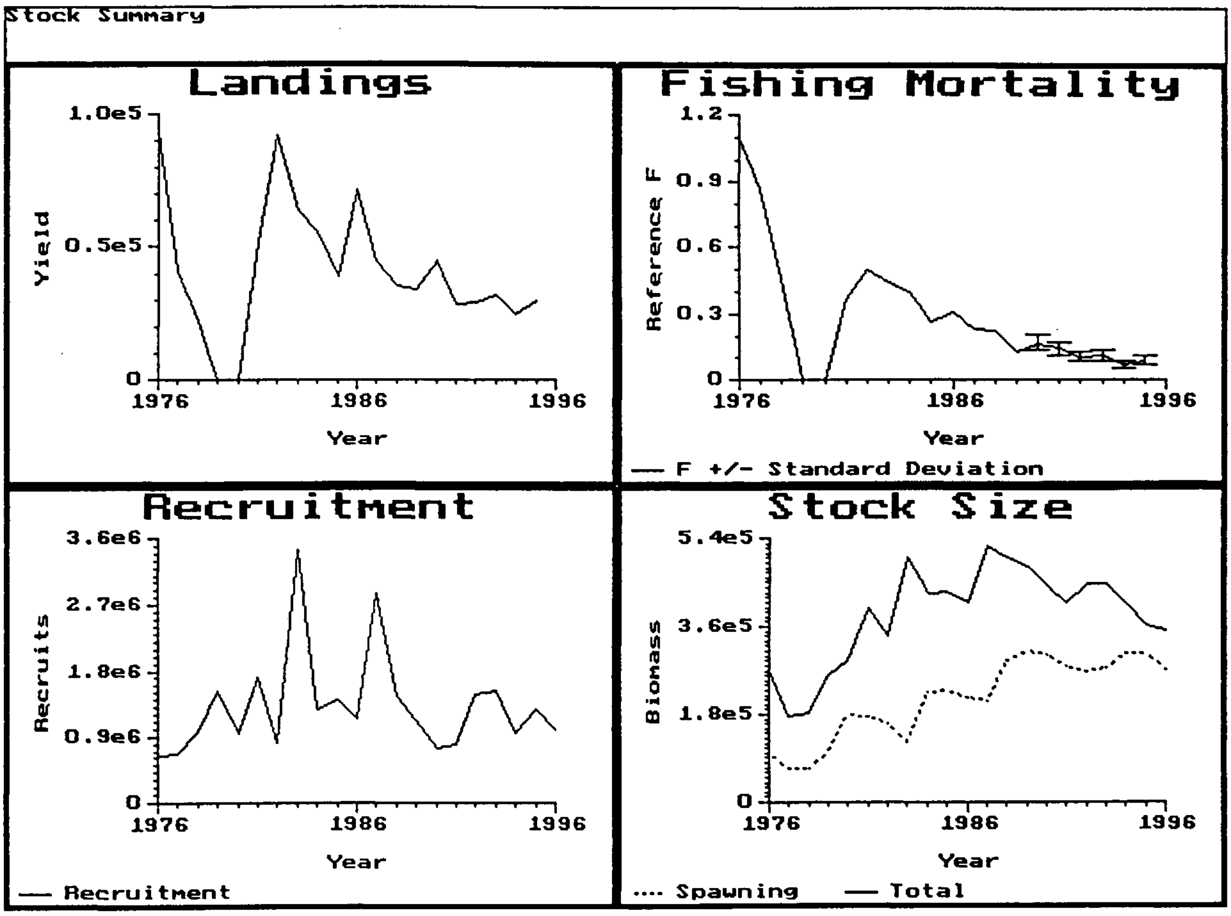

Figure 5.1.4. Herring in VIa(N). Results of baseline assessment. Summary of estimates of landings, fishing mortality at age 3, recruitment at age 1, stock size on 1 January and spawning stock size at spawning time.

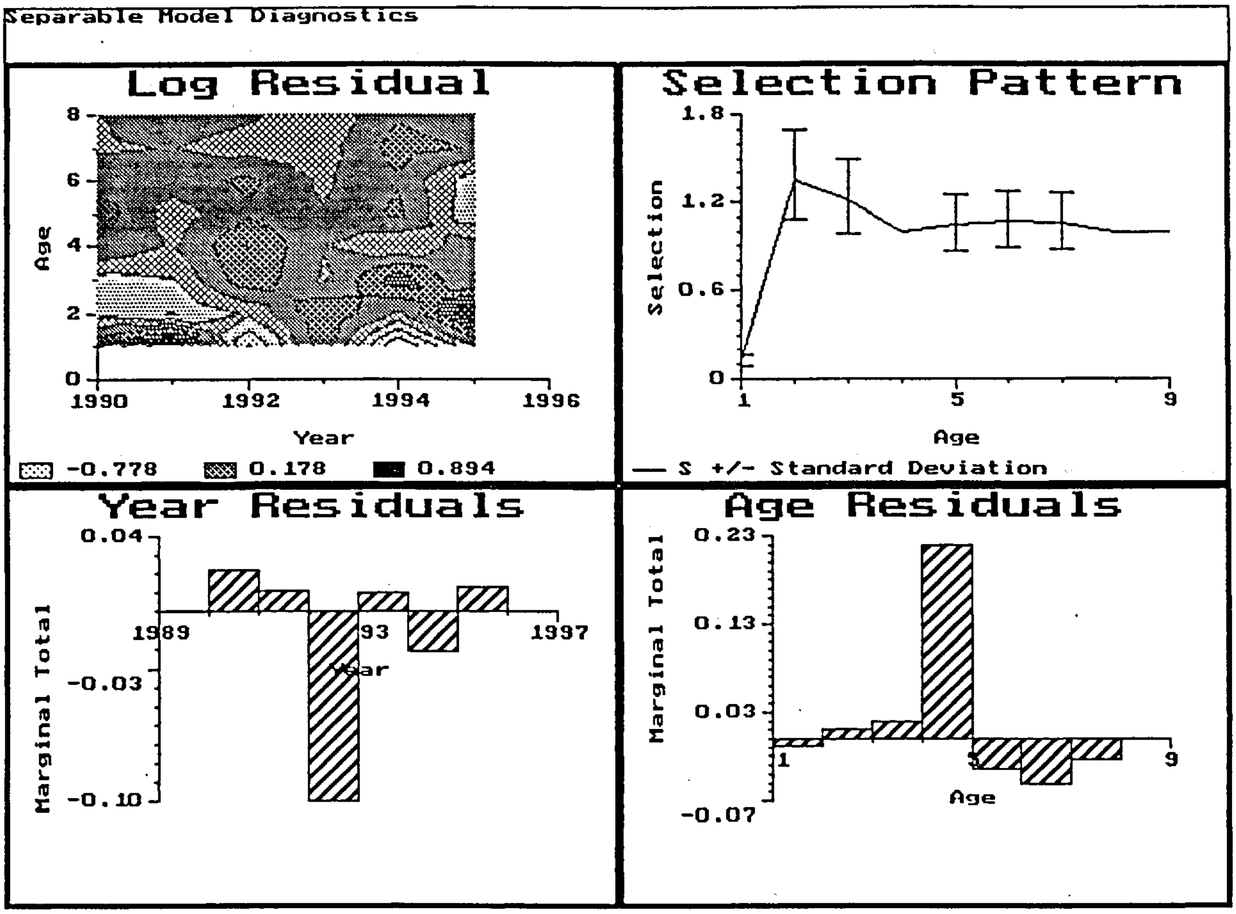

Figure 5.1.5. Herring in VIa(N). Results of baseline assessment. Selection pattern diagnostics. Top left, contour plot of selection pattern residuals. Top right, estimated selection (relative to age 3) +/- standard deviation. Bottom, marginal totals of residuals by year and age.

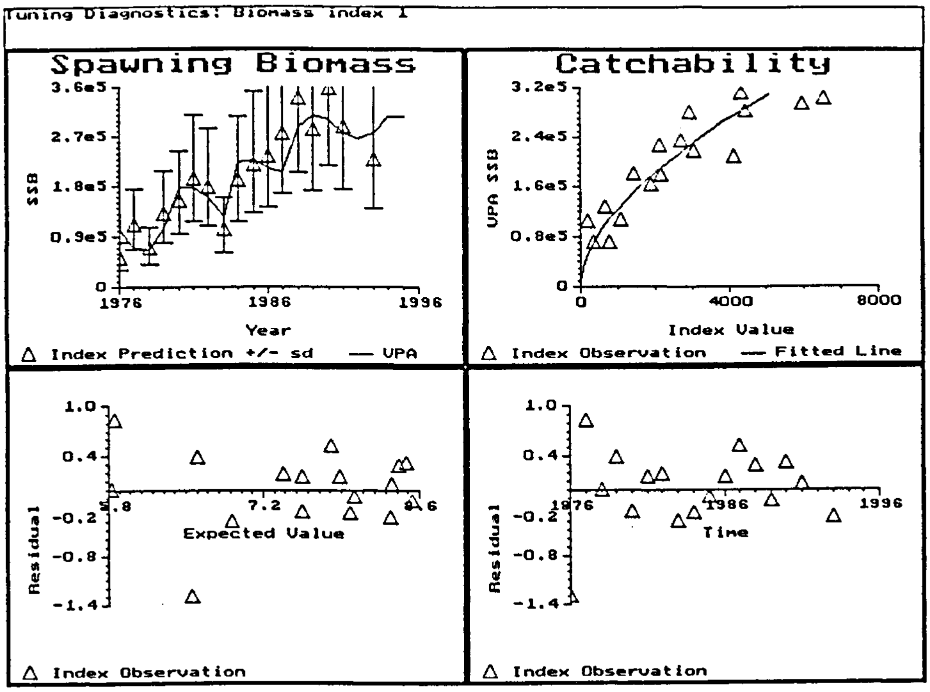

Figure 5.1.6. Herring in VIa(N). Results of the baseline assessment. Diagnostics of the fit of the larval abundance index against the estimated spawning biomass. Top left, spawning biomass from the fitted populations (line), and predictions of spawning biomass in each year made from the index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of spawning biomass from the fitted populations and larval survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

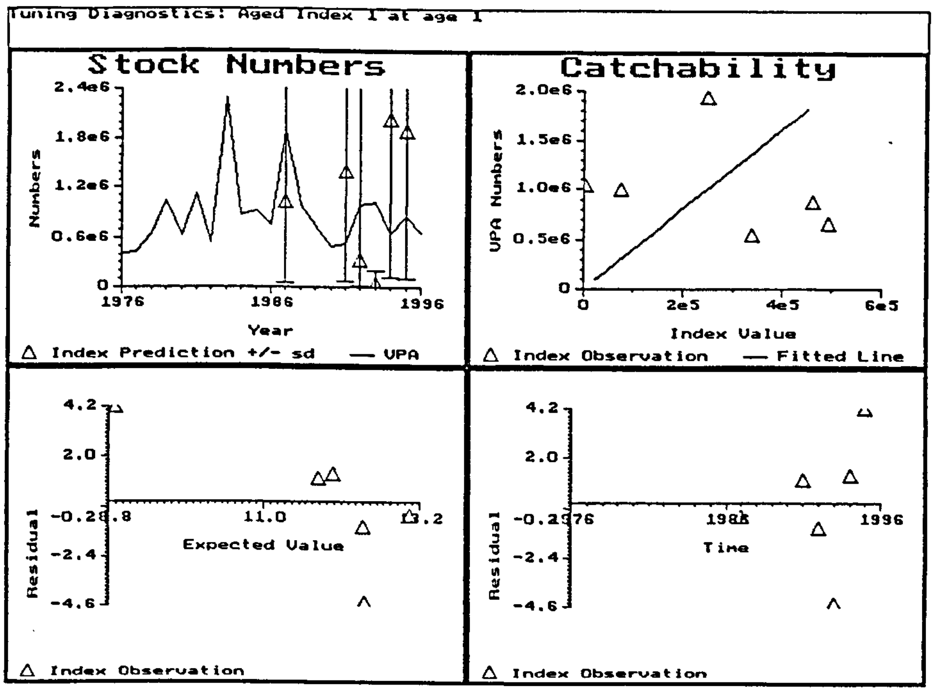

Figure 5.1.7. Herring in VIa(N). Results of the baseline assessment. Diagnostics of the fit of the acoustic index at age 1 against the estimated populations at age 1. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

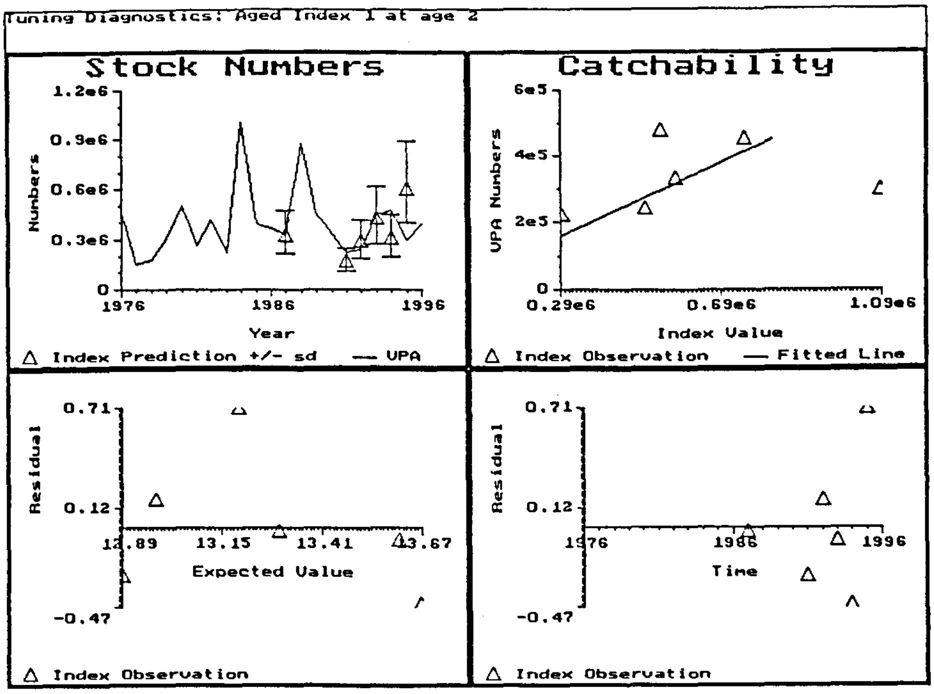

Figure 5.1.8. Herring in VIa(N). Results of the baseline assessment. Diagnostics of the fit of the acoustic index at age 2 against the estimated populations at age 2. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

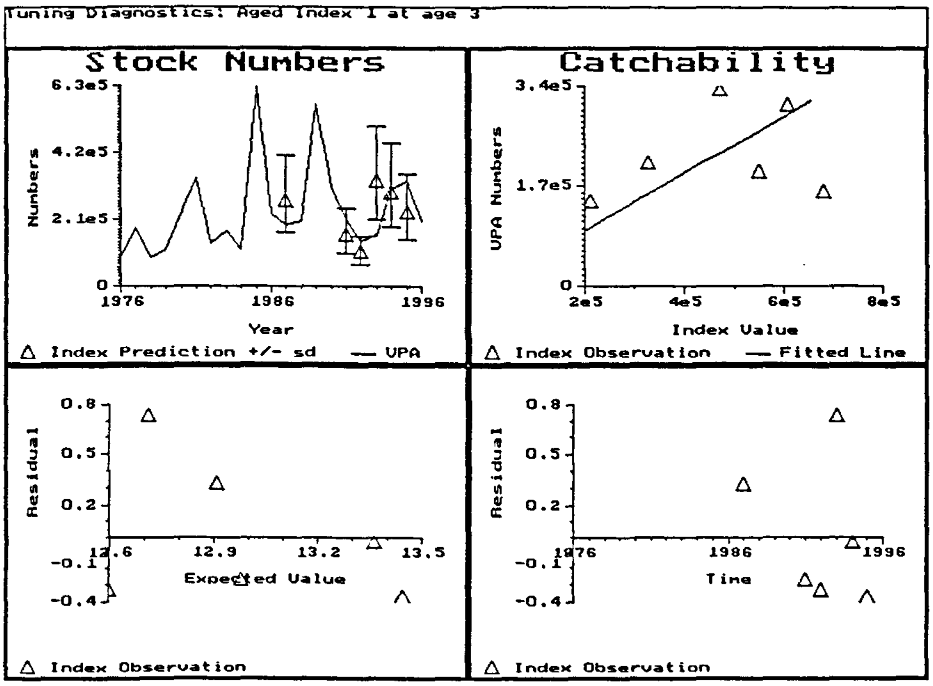

Figure 5.1.9. Herring in VIa(N). Results of the baseline assessment. Diagnostics of the fit of the acoustic index at age 3 against the estimated populations at age 3. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

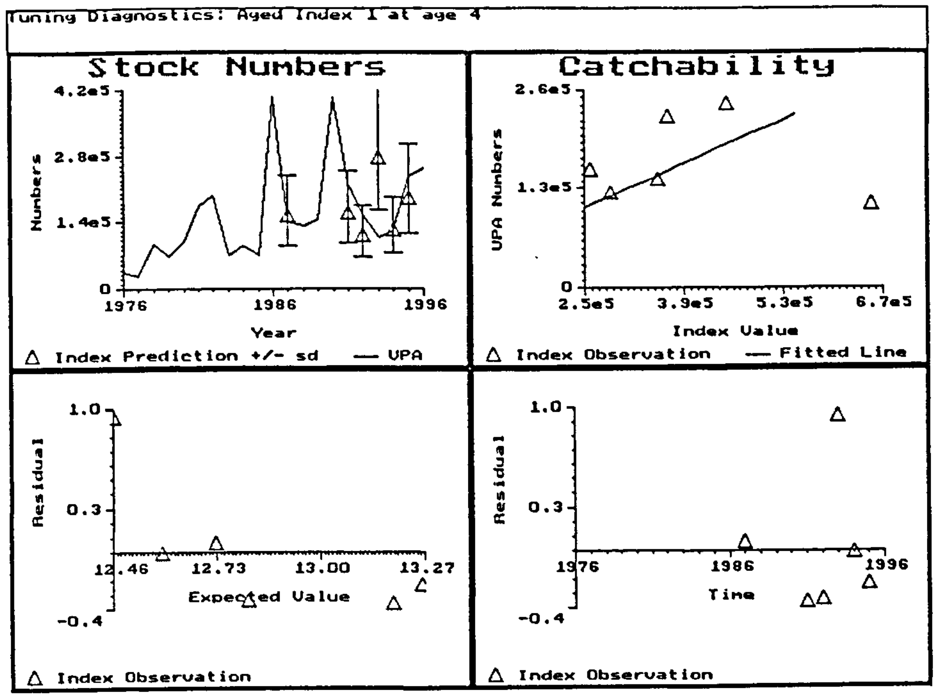

Figure 5.1.10. Herring in VIa(N). Results of the baseline assessment. Diagnostics of the fit of the acoustic index at age 4 against the estimated populations at age 4. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

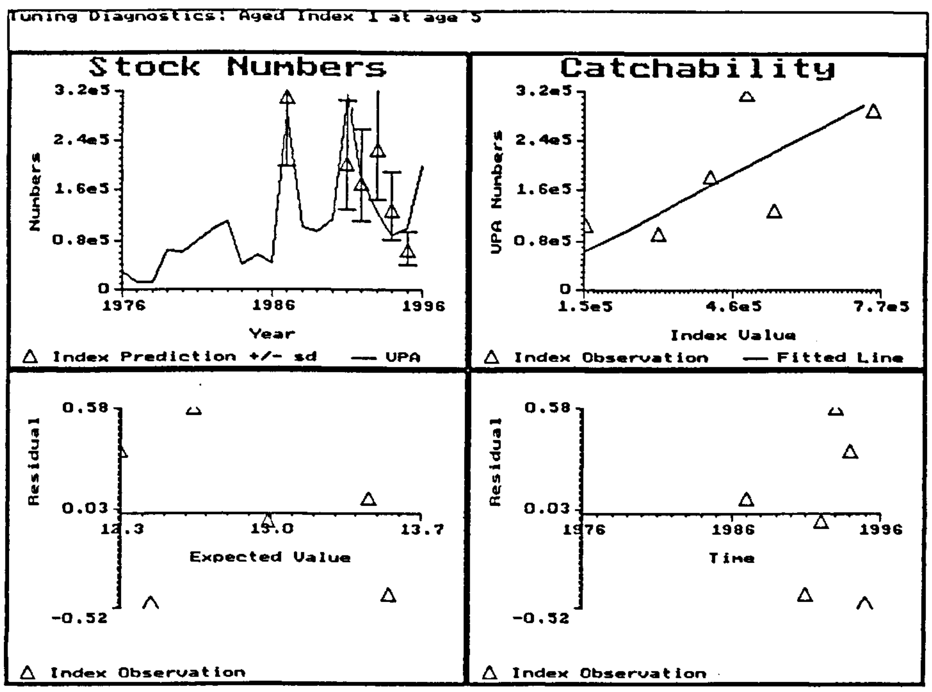

Figure 5.1.11. Herring in VIa(N). Results of the baseline assessment. Diagnostics of the fit of the acoustic index at age 5 against the estimated populations at age 5. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

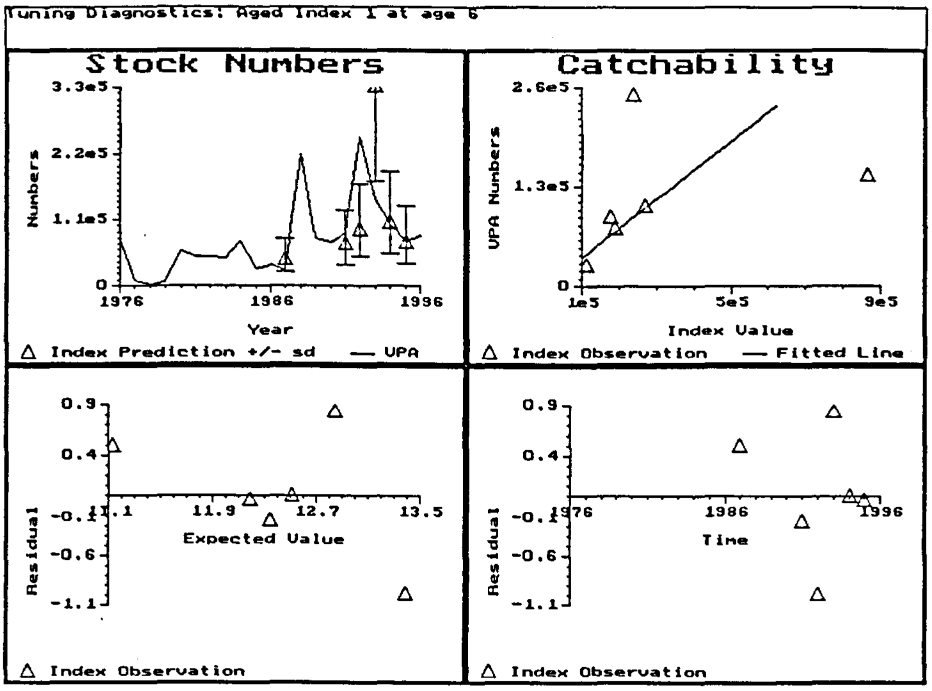

Figure 5.1.12. Herring in VIa(N). Results of the baseline assessment. Diagnostics of the fit of the acoustic index at age 6 against the estimated populations at age 6. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

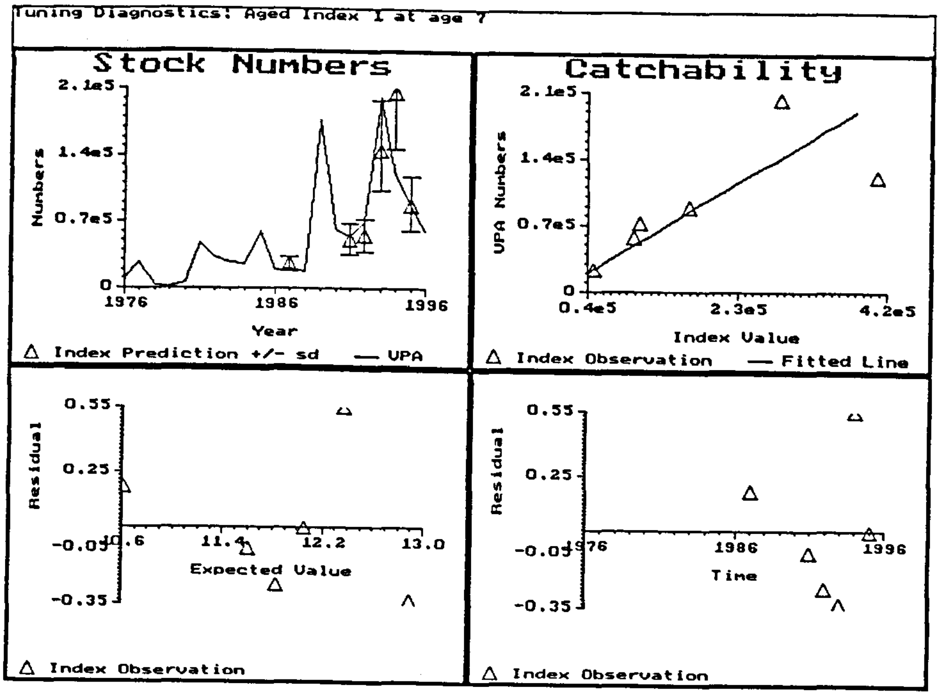

Figure 5.1.13. Herring in VIa(N). Results of the baseline assessment. Diagnostics of the fit of the acoustic index at age 7 against the estimated populations at age 7. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

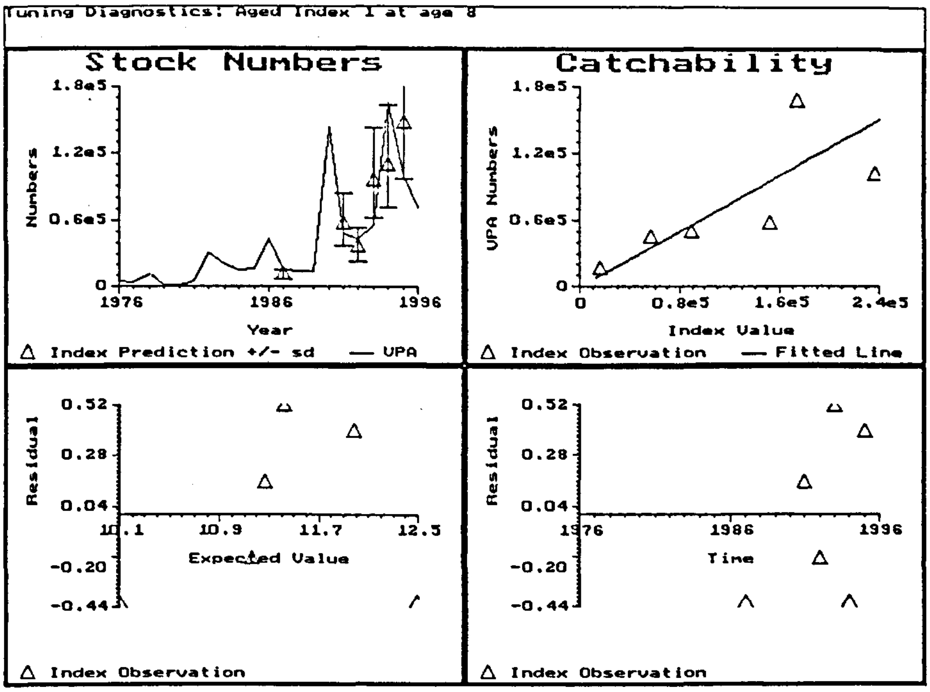

Figure 5.1.14. Herring in VIa(N). Results of the baseline assessment. Diagnostics of the fit of the acoustic index at age 8 against the estimated populations at age 8. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

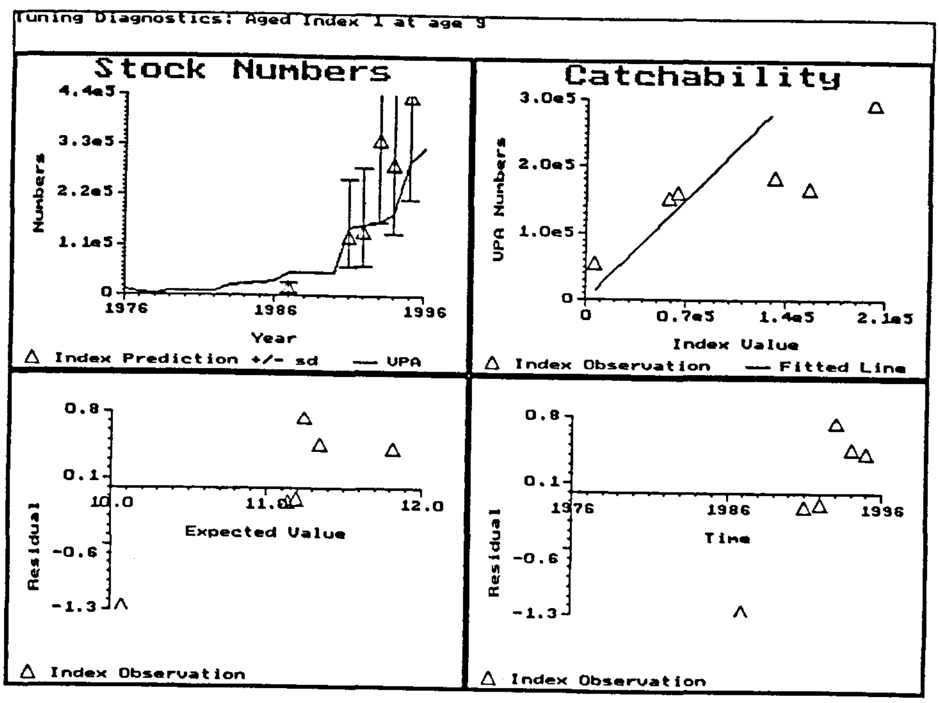

Figure 5.1.15. Herring in VIa(N). Results of the baseline assessment. Diagnostics of the fit of the acoustic index at age 9 against the estimated populations at age 9. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

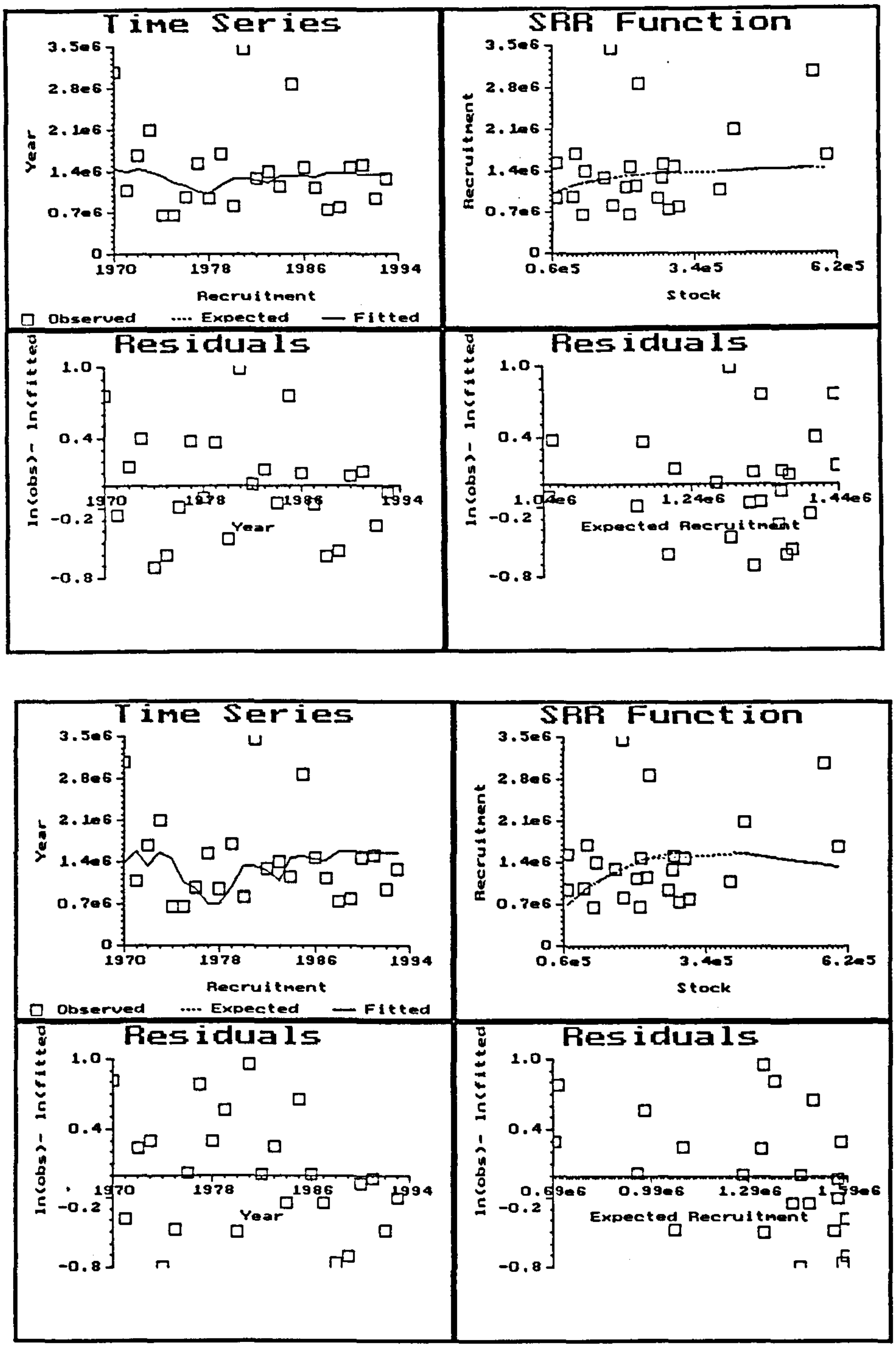

Figure 5.1.16. Herring in VIa(N). **Upper panel**: Summary of the fit of the Beverton-Holt Stock-recruit relationship. Top left, the time series of recruitments estimated in the population model (squares) and the recruitments fitted by the stock-recruitment model. Top right, spawning stock size and corresponding recruitments and the fitted function. Bottom left, residuals as ln(observed recruitment) -ln(expected recruitment) plotted against year, and lastly residuals plotted against ln(expected recruitment) **Lower panel**: Summary of the fit of the Ricker Stock-recruit relationship. Top left, the time series of recruitments estimated in the population model (squares) and the recruitments fitted by the stock-recruitment model. Top right, spawning stock size and corresponding recruitments and the fitted function. Bottom left, residuals as ln(observed recruitment) -ln(expected recruitment) plotted against year, and lastly residuals plotted against ln(expected recruitment)

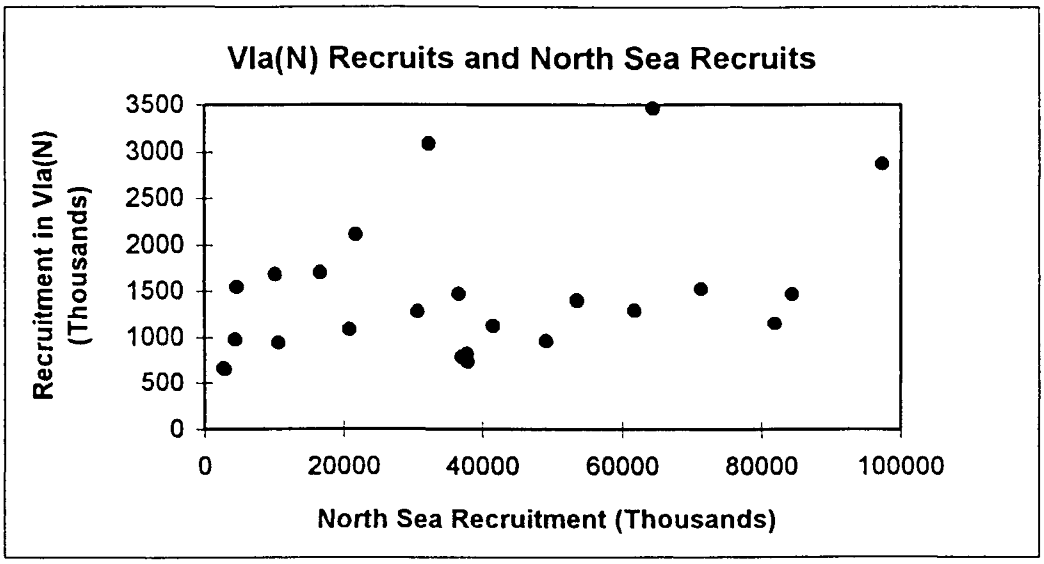

Figure 5.1.17. Herring in VIa(N). Scatterplot of recruitment in the VIa(N) stock and of recruitment in the North Sea populations.

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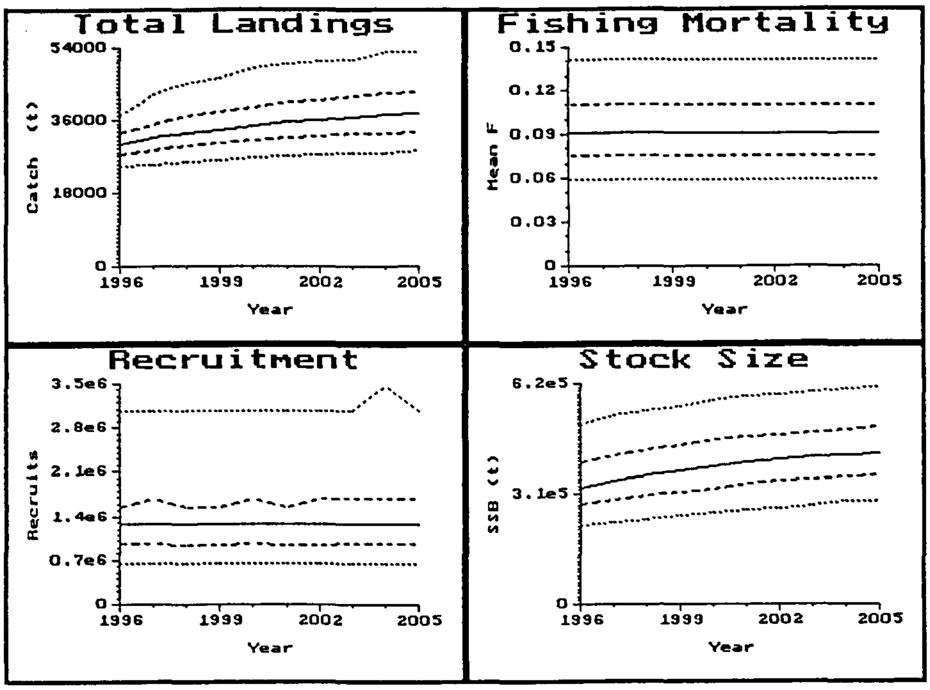

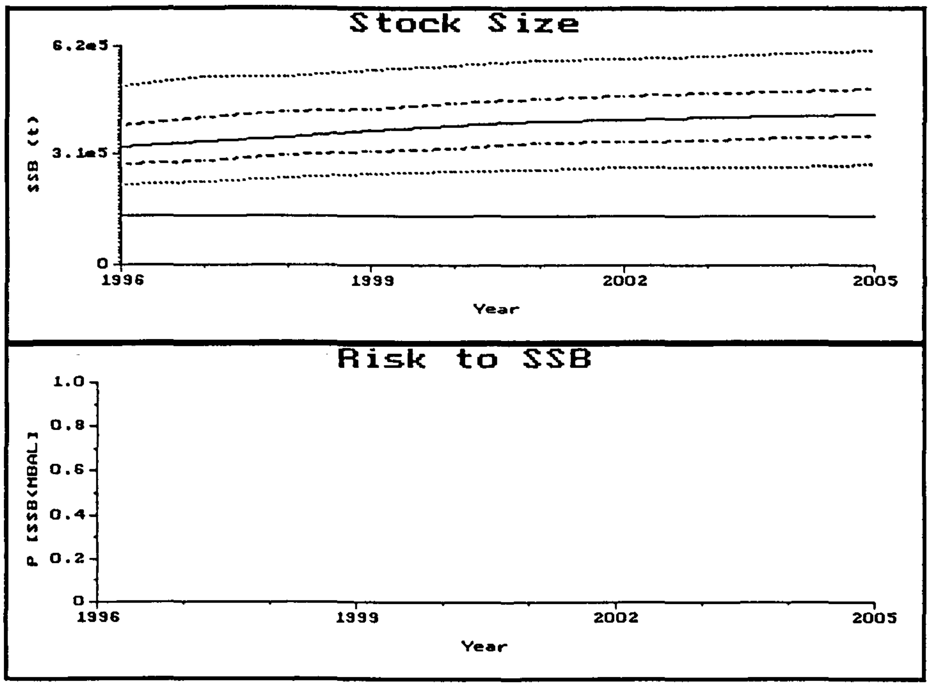

Figure 5.1.18 Herring in VIa(N). Summary results of medium-term projections for fishing mortality from 1996 to 2005 constrained equal to the fishing mortality estimate for 1995. **Upper panel:** landings, fishing mortality (mean over ages 3 to 6), recruitment, and stock size. **Lower panel:** Stock size and the probability that the stock may fall below the MBAL level of 135 000t. Solid line, 50th percentile. dashed lines, 25th and 75th percentiles. Dotted line, 5th and 95th percentiles.

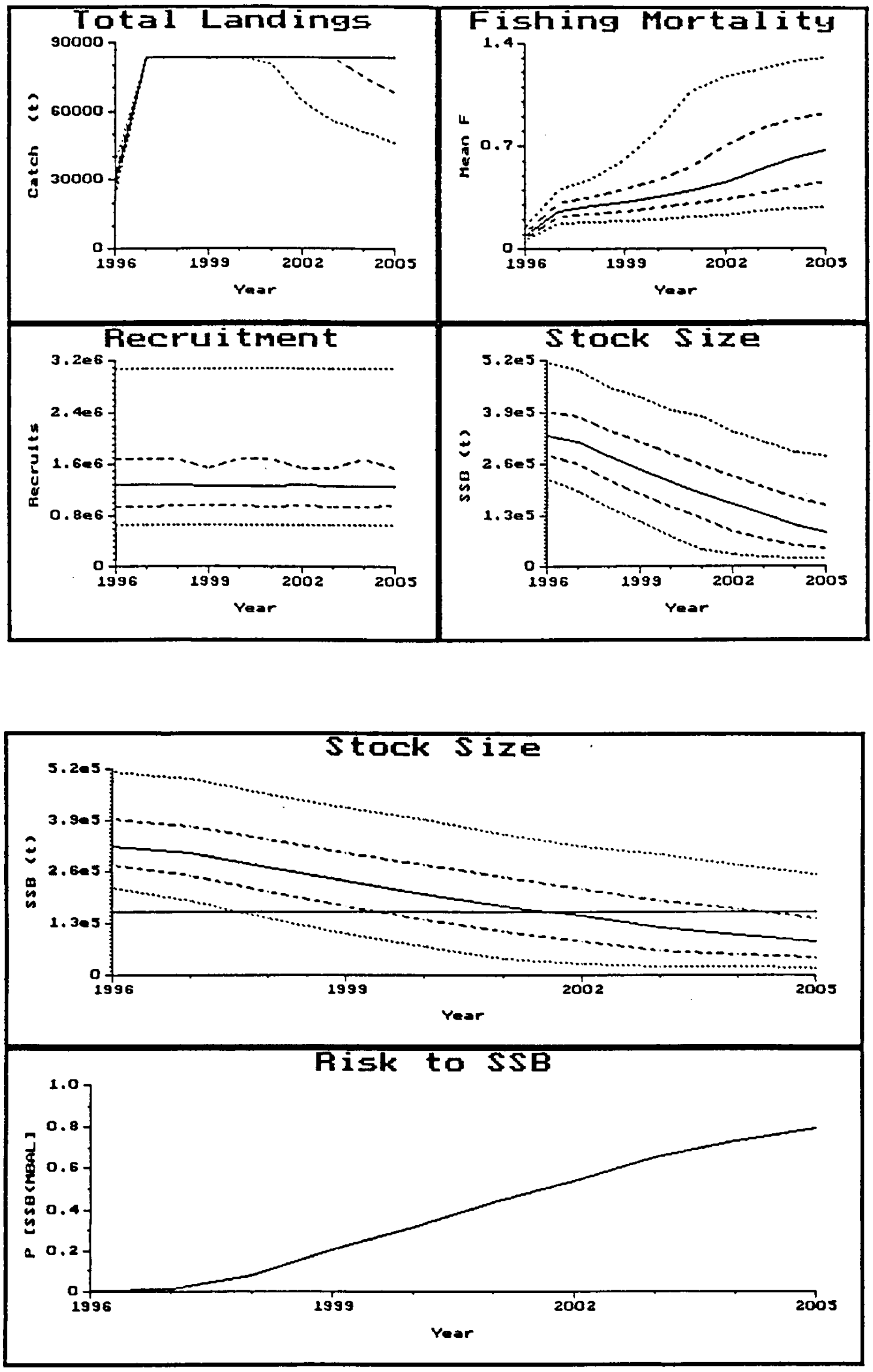

Figure 5.1.19. Herring in VIa(N). Summary results of medium-term projections for fishing mortality in 1996 constrained equal to the fishing mortality estimate for 1995, but assuming a catch of 83 570t in each year up to 2005 thereafter. **Upper panel:** landings, fishing mortality (mean over ages 3 to 6), recruitment, and stock size. **Lower panel**, Stock size and the probability that the stock may fall below the MBAL level of 150 000t. Solid line, 50th percentile. dashed lines, 25th and 75th percentiles. Dotted line, 5th and 95th percentiles.

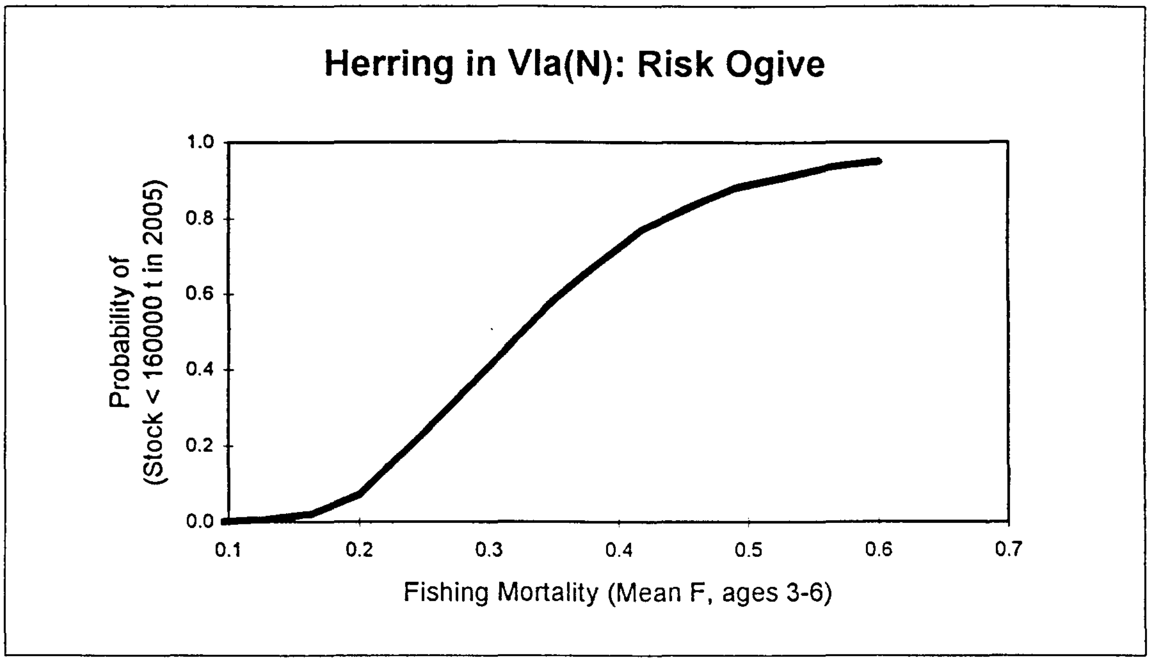

Figure 5.1.20. Herring in VIa(N). Risk, as estimated probability that the stock size will fall below the assumed MBAL of 160 000t in 2005, after ten years' exploitation at varying levels of fishing mortality from 1997 to 2005. Fishing mortality in 1996 was assumed equal to the value estimated for 1995.

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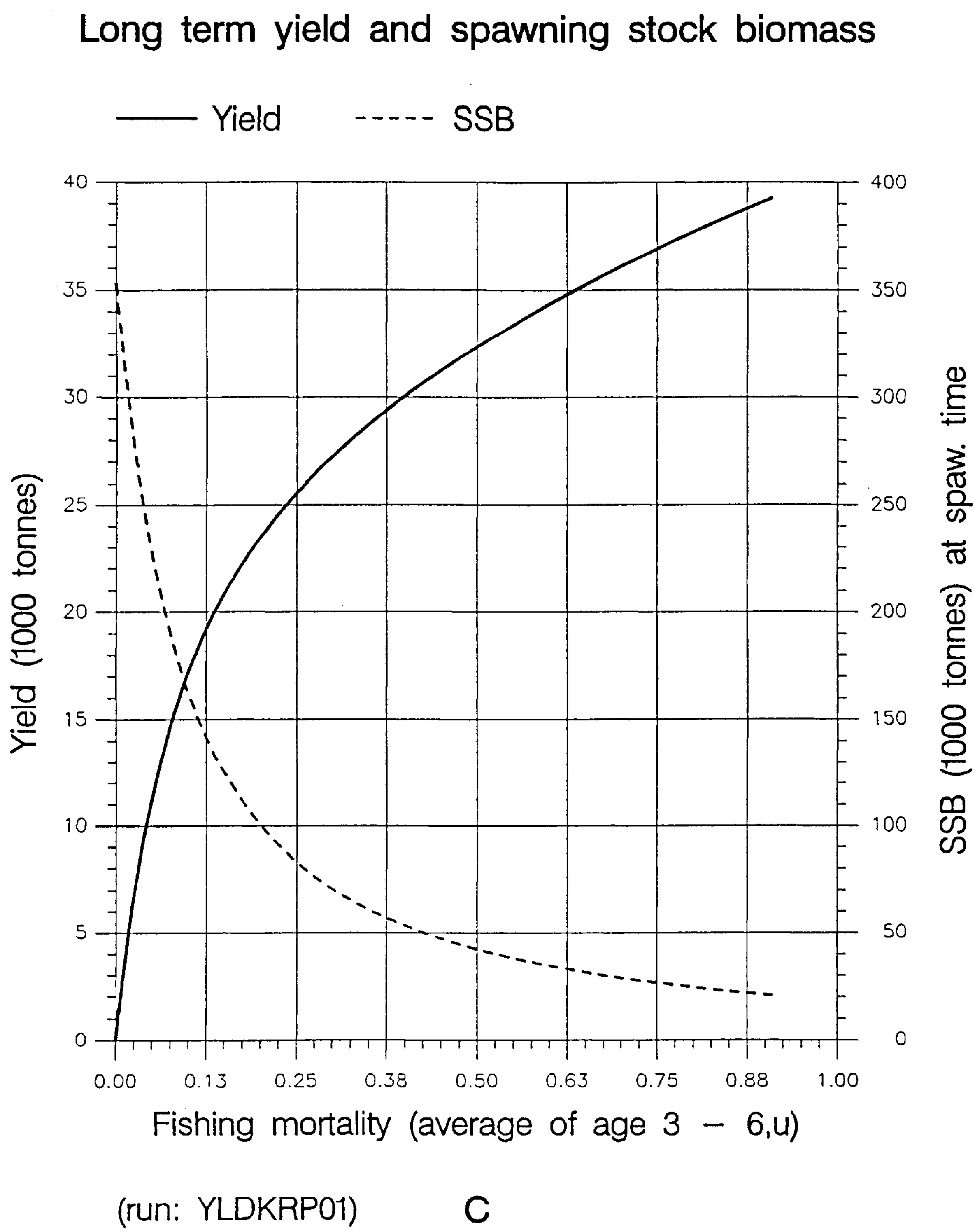

Figure 5.1.21. Herring in VIa(N). Yield per recruit analysis. Yield and spawning stock biomass calculated for a range of values of fishing mortality (mean for ages 3-6). Recruitment taken as geometric mean from 1976 to 1994.

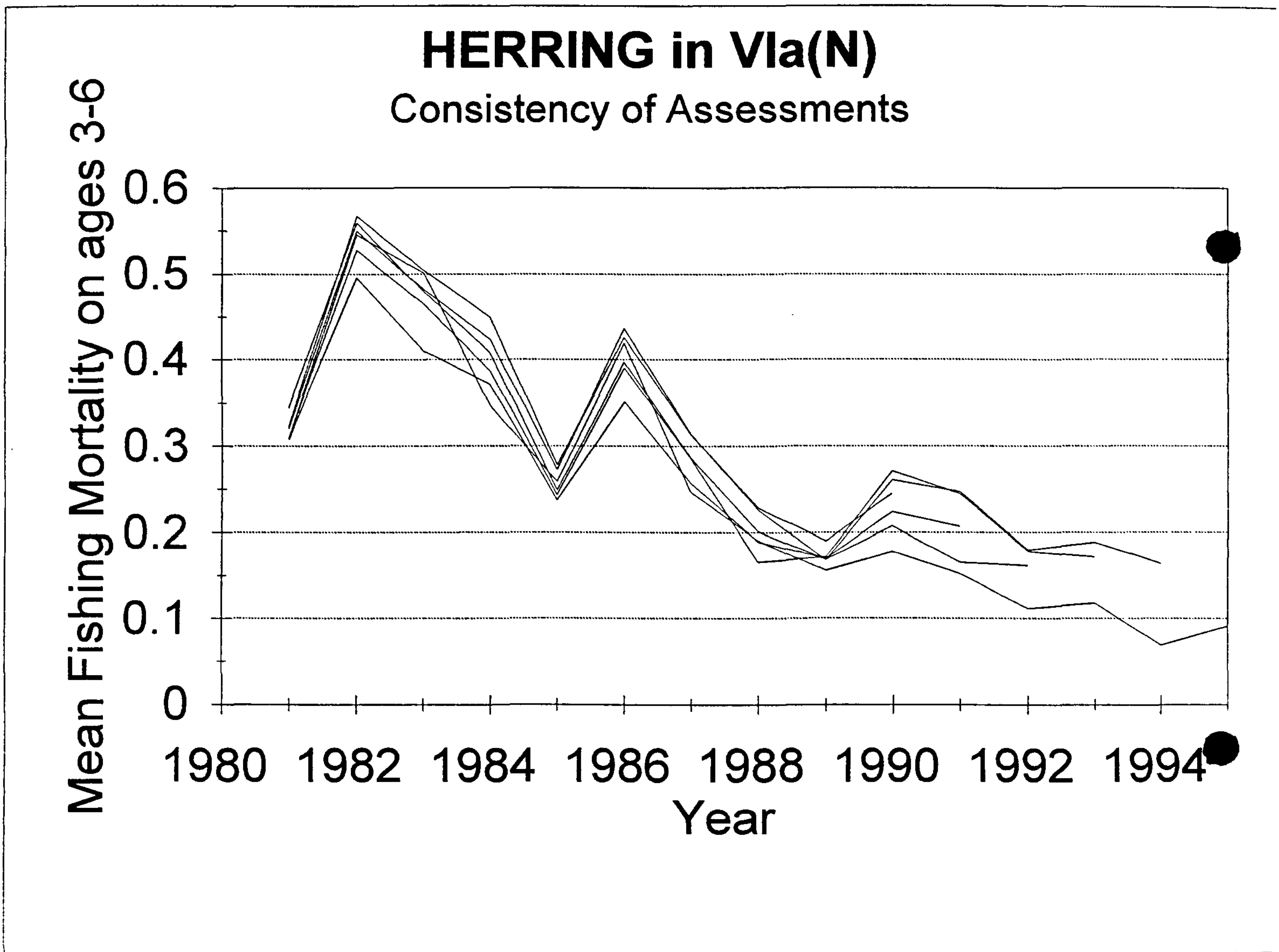

Figure 5.1.22. Herring in VIa(N). Estimates of fishing mortality (Arithmetic unweighted mean over ages 3 to 6) as made by the Herring Assessment Working Group in mettings from 1990 to date.

6 HERRING IN DIVISIONS VIA (SOUTH) AND VIIB,C

6.1 The fishery

6.1.1 Advice and management applicable to 1995 and 1996

The TAC set for this area for 1995 was 28,000 t. This was a precautionary TAC and was the same as that set each year since 1992. The total catch estimated by the Working Group to have been taken from the stock during 1995 was approximately 27,800 t. This was the lowest catch level recorded since 1985 and the first time that the catch has been below the agreed TAC.

The 1995 Herring Working Group did not carry out an analytical assessment for this stock but suggested that the stock had declined although the level (at that time) was not known. The Working Group stressed that it was extremely important to ensure that the 1995 catches are restricted to the advised level. ACFM, in 1995, in the absence of an assessment did not carry out a forecast for the stock but advised that a precautionary TAC, if required, should be set at a level so that the resulting catches did not exceed the average of recent years. The subsequent TAC agreed by the EU for 1996 was again set at 28,000 t.

6.1.2 Catch data

The main landings in 1995 from this fishery were again taken by Ireland who took over 95% of the total recorded.

The total amount of unallocated catches in 1995 was 1,100 t which was the lowest reported figure since before 1985. This total was composed of catches which were reported as having been taken in Division VIa (North) but which were in fact taken in Division VIa (South). The total international catches from Sub-areas VI and VII are shown in Figures 4.2.1 a-d.

The catches and landings taken by each country fishing in this area from 1986-1995 are shown in Table 6.1.1 and the total catch from 1970 is shown in Figure 6.1.1. There were no estimates of discards reported from 1995 and there are no indications that discarding is a major problem in this fishery.

The catches for 1995 are preliminary. It has not been found necessary to make any alterations to the 1994 data.

Reports from the Irish fishery throughout most of 1995 suggested that herring shoals were very scarce, particularly in Division VIIb. There were, however, good landings from Division VIa (South) off the north Donegal coast during Quarter 1. As has been the pattern in recent years these landings contained substantial amounts of full and spawning fish. These fish amounted to over 70% of the total catch in that quarter and had a typical winter/spring vertebral count of 56.86, compared with a vertebral count of 56.42 for full and spawning fish during Quarter 4. Recent Herring Working Groups have commented on the increasing numbers of winter/spring spawning fish which have appeared in the catches from this area in recent years. Herring shoals again appeared to be very scarce on the traditional autumn spawning grounds in Division VIIb. The main landings by the Irish fleet were taken during Quarter 4.

The composition of the Irish (R.S.W) "tank" fleet was similar to that of recent years. However, the re-introduction of one large factory ship into the fishery during the year, which exploited herring at various times, increased the overall catching capacity of the fleet considerably. Landings by the Irish fleet were again regulated by weekly quotas and a closed season was introduced during June and July. This closed season is designed to prevent landings of herrings at a time when marketing difficulties are usually experienced.

6.1.3 Catch in numbers at age

The catches at age for this fishery since 1970 are shown in Table 6.1.2. In recent years the catches in numbers at age are derived mainly from Irish sampling data. The catches during Quarter 1, 1995 were mainly composed of 3, 4 and 5 w. ring fish. Catches taken during Quarter 4 from Division VIa (South) were mainly composed of 2 w. ring fish while over 29% of the catch taken in this Quarter from Division VIIb were composed of fish over 8+ w. rings. The 1991 year class which constituted 28% of the catches in 1994, constituted 23% of the catches in 1995. Fish older than 8 w.rings and mainly consisting of the strong 1985 year class still constituted over 9% of the catches in 1995.

6.1.4 Quality of the catch and biological data

Although management authorities are confident about the accuracy of catch statistics from this area there may still be some under-reporting. However, the extent of this cannot be quantified. As in 1994 the scarcity of herring throughout the year did not put pressure on skippers to under-report to any great extent. Misreporting of catches to the adjoining Division VIa (North) did continue but on a lower scale than in previous years and it was possible to re-allocate these catches based on information from fishermen.

The numbers of samples and the biological data, together with the length distribution of the catches taken per quarter by the Irish fleet, are shown in Tables 6.1.3 and 6.1.4 respectively. Sampling of catches throughout the year was considerably lower than in 1994. In Quarter 2, nearly 6,000 t of herring were landed but were not covered by any samples whatsoever. Sampling levels were also unsatisfactory in Quarter 4.

6.2 Mean Weights at Age

The mean weights (g) at age in the catches in 1995 are based mainly on Irish samples, together witn one Dutch sample. The mean weights from 1970-1995 are shown in Table 6.2.1

The 1995 mean weights at age for the stock at spawning time (1 October) are based on Irish samples of full fish taken during the fourth Quarter. The mean weights from 1970-1995 are shown in Table 6.2.2.

Apart from some decrease in the mean weights of 2 and 3 w. ring fish the overall mean weights appear to be similar to those of recent years.

6.3 Ground fish Surveys

Ground fish surveys have been carried out during November along the west coast of Ireland from 1993 to 1995. Over 60 stations were sampled each year with a bottom trawl fitted with fine mesh liner. Although these surveys are designed to obtain an abundance index for demersal fish it is hoped that they will also provide recruitment indices for herring. The series, however, has not yet been long enough established to provide useful information.

6.4 Acoustic surveys

Acoustic surveys were initiated in this area in 1994, and are designed to provide an estimate of the total stock size. The second survey, again using the **R.V. Lough Foyle**, was carried out in July 1995 and covered the same areas as that in 1994. The results were presented in a working paper (Molloy and Fernandes, 1996, W.D.) and were also reported in the report of the 1996 Coordinated Acoustic Survey (Simmonds *et al.*, 1996 W.D.). The total stock size estimated from the 1995 survey was 137,670 t, compared with 350,000 t from the 1994 survey.

Thirty five hauls were made during the 1995 survey, nine of which contained herring although herring were the dominant species in only three hauls. Even though more herring were taken during the 1995 survey compared with that of 1994 - when no adult herring were taken - there are still difficulties in relocating herring shoals and actually catching herring. This is mainly because the shoals in the area at this time are small and very patchily distributed. Sufficient samples were obtained to enable the stock to be broken down in numbers and biomass of fish at each age group and these data are shown in Table 6.4.1. The age distributions are composed mainly of immature herring which comprise over 60% of the total stock numbers. The 1992 year class appears to be dominant among the adult fish and this year class is also very well represented in the commercial catches from the area.

Although the dramatic decrease in the stock in the area as indicated from the results of the 1994 and 1995 surveys may not be realistic because of the lack of confidence attached to the surveys at present it ıs important that these surveys should be continued and that a time series should be established. The low stock size indicated by the 1995 surveys is consistent with the reports and observations of the commercial fishermen from the area.

6.5 State of the Stock

Analytical assessments have not been carried out on this stock for a number of years because of the absence of survey data. Recent working groups have therefore only carried out VPA analyses to study the development of the stock and no stock projections have been made. The results of those analyses indicated that the stock had decreased in recent years from a high level in 1988. This high level was as a result of the recruitment of the exceptionally strong 1985 year class (which in 1995 still constituted nearly 10% of the catches).

The only additional data available to the present Working Group are the results of the 1995 acoustic surveys. This suggested that the spawning stock in the summer of 1995 was about 125,000 tonnes. It was therefore decided to run a series of VPAs with different input F values in order to recreate an equivalent SSB value. A separable VPA was carried out using the updated catch data and a terminal S value of 1.0 and down weighted prior to 1990 to 0.001. Age 4 was taken as reference age and the exploitation pattern was reasonably flat topped. The results of the separable VPA are shown in Table 6.5.1. The terminal populations from the separable VPA were used to carry out traditional VPAs for input F values = 0.3, 0.4 and 0.5. The spawning stock biomass for 1995 as a result of using input F in 1995 = 0.3 was calculated at about 125,000 t. This value coincides with the value used in the assessments carried out by recent working groups which was selected as 0.3 each year in order to reflect the apparent stability of effort in the area. The summary results of this VPA are shown in Table 6.5.2 and the spawning stock estimates are shown in Figure 6.5.1.

The results from the VPA (Table 6.5.2) indicate that over the period 1970–1995 the spawning stock was at its maximum in 1988 and has since declined steadily each year. The recruitment of the exceptionally strong 1985 year class had a dramatic effect on the spawning stock in 1988. Since 1985 there have been no other outstanding year classes although there are indications that the 1992 year class may be above average size. The overall age distribution of the stock shows considerable numbers of fish in the upper age groups - in fact 20% are over 6 years of age. This would suggest that the stock has not been heavily exploited in recent years.

6.6 Stock Forecasts and Catch Predictions

As there is no method of obtaining a recruitment index for this stock and because the assessment relies on only one independent stock estimate (i.e. the SSB derived from the 1995 acoustic survey), it was decided that it would not be advisable to carry out any predictions. These will not be possible until a time series of acoustic estimates is established.

6.7 Management Considerations

The results of the assessment indicate that the spawning stock has declined considerably in recent years and is now at a comparatively low level. This is consistent with observations from fishermen in the area who in recent years have expressed alarm at the scarcity of herring in this area. However, the age distribution of the stock does not suggest that it is in any danger of collapse. The scarcity of herring in the area may be due to a combination of the decline in stock and a more northerly distribution of the stock in recent years. It is also interesting to note the increasing importance of winter/spring spawning fish in this area. The old traditional fisheries in this area which were extremely important in the early part of the century were all based on winter/spring spawning herring

The fishery in this area appears to depend on the recruitment to the stock of occasional very strong year classes. The last such strong year class was that of 1985 which recruited in 1988. This boosted the spawning stock in that year to over 300,000 t but it has subsequently continuously declined each year as the strong year class progressed through the fishery. During the period 1988-1992 the average F was 0.26 and the average catches were about 34,000 t. The present stock size is uncertain and the most recent value of F is not known. There are some signs that the 1992 year class may be a strong one but it has only recruited in 1995 and its strength cannot yet be confirmed. Because of the uncertainty of the stock size and the high catching potential of the fleet in the area and its ability to quickly change its target species, a cautious management for the fishery is advocated. Catches should not be allowed to rise above the present level until more information about the stock is available. It is, therefore, extremely important that the present acoustic and ground fish surveys should be continued and that the 1995 sampling level should be improved.

6.8 Medium Projections and Consideration of MBAL

In the absence of information about recruitment and because of the uncertainty about the current stock size no projections were carried out. An examination of the spawning stock/recruitment relationship (Figure 6.8.1) suggests that there is little evidence of any relationship between spawning stock and recruitment over the range of SSB and recruitment encountered.

An examination of the historical data series (1970-1995) did not suggest any period when the stock was subjected to a low fishing effort. During the period 1984 to 1986 the lowest F values were recorded and the mean F for that period was 0.21 and the average SSB was 180,000 t. At the same time the average catches were about 26,500 t. The present assessment suggests that the spawning stock has declined in recent years and even though the exact size is not known it would appear to be well below 180,000 t. This in turn would suggest that the present catches are too high. It has not been possible with the present data to calculate the MBAL for this stock.

Table 6.1.1 Estimated Herring catches in tonnes in Divisions VIa (South) and VIIb,c, 1985–1994. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1985	1986	1987	1988	1989
France	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	-
Ireland	13,900	15,540	15,000	15,000	18,200
Netherlands	1,270	1,550	1,550	300	2,900
UK (N.Ireland)	-	-	5	-	-
UK (England + Wales)	-	-	51	-	-
UK Scotland	-	-	-	-	+
Unallocated	8,204	11,785	31,994	13,800	7,100
Total landings	23,374	28,785	48,600	29,100	28,200
Discards	-	-	-	-	1,000
Total catch	23,374	28,785	48,600	29,100	29,200

Country	1990	1991	1992	1993[1]	1994[1]	1995
France	+	-	-	-	-	-
Germany, Fed.Rep.	-	-	250	-	-	11
Ireland	25,000	22,500	26,000	27,600	24,400	25,450
Netherlands	2,533	600	900	2,500	2,500	1,207
UK (N.Ireland)	80	-	-	-	-	-
UK (England + Wales)	-	-	-	-	50	24
UK (Scotland)	-	+	-	200	-	-
Unallocated	13,826	11,200	4,600	6,250	6,250	1,100
Total landings	41,439	34,300	31,750	36,550	33,200	27,792
Discards	2,530	3,400	100	250	700	-
Total catch	43,969	37,700	31,850	36,800	33,900	27,792

[1]Provisional

Table 6.1.2 HER-IRLW: Herring West of Ireland & Porcupine Bank (Fishing Area VIa South)

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
1970	0	135	35114	26007	13243	3895	40181	2982	1667	1911
1971	0	883	6177	7038	10856	8826	3938	40553	2286	2160
1972	0	1001	28786	20534	6191	11145	10057	4243	47182	4305
1973	46	6423	40390	47389	16863	7432	12383	9191	1969	50980
1974	0	3374	29406	41116	44579	17857	8882	10901	10272	30549
1975	194	7360	41308	25117	29192	23718	10703	5909	9378	32029
1976	823	16613	29011	37512	26544	25317	15000	5208	3596	15703
1977	0	4485	44512	13396	17176	12209	9924	5534	1360	4150
1978	82	10170	40320	27079	13308	10685	5356	4270	3638	3324
1979	4	5919	50071	19161	19969	9349	8422	5443	4423	4090
1980	0	2856	40058	64946	25140	22126	7748	6946	4344	5334
1981	0	1620	22265	41794	31460	12812	12746	3461	2735	5220
1982	0	748	18136	17004	28220	18280	8121	4089	3249	2875
1983	0	1517	43688	49534	25316	31782	18320	6695	3329	4251
1984	0	2794	81481	28660	17854	7190	12836	5974	2008	4020
1985	0	9606	15143	67355	12756	11241	7638	9185	7587	2168
1986	0	918	27110	24818	66383	14644	7988	5696	5422	2127
1987	0	12149	44160	80213	41504	99222	15226	12639	6082	10187
1988	0	0	29135	46300	41008	23381	45692	6946	2482	1964
1989	0	2241	6919	78842	26149	21481	15008	24917	4213	3036
1990	0	878	24977	19500	151978	24362	20164	16314	8184	1130
1991	0	675	34437	27810	12420	100444	17921	14865	11311	7660
1992	0	2592	15519	42532	26839	12565	73307	8535	8203	6286
1993	0	191	20562	22666	41967	23379	13547	67265	7671	6013
1994	0	11709	56156	31225	16877	21772	13644	8597	31729	10093
1995	0	284	34471	35414	18617	19133	16081	5749	8585	14215

Table 6.1.3 Divisions VIa (South) and VIIb. Sampling intensity of catches in 1995.

Country	Q	Catch[1]	No. of samples	No. of age readings	No. of fish measured	Aged per 1000 t.	Estimate of discards
Ireland	1	4,800	11	548	2,817	110	No
	2	6,000	-	-	-	-	No
	3	1,100	6	198	761	176	No
	4	14,600	6	299	1,324	21	No
Netherlands	3	1,200	2	50	206	42	Yes
UK (England & Wales)	4	+	-	-	-	-	-
Germany	2	+	-	-	-	-	-

[1]including Division VIa (North).

Table 6.1.4 Divisions VIa(S) and VIIb. Length distributions of Irish catches (pelagic trawlers) per quarter (10^3) in 1995.

Length	1st quarter	2nd quarter*	3rd quarter	4th quarter
18.0				
18.5				
19.0				
19.5				
20.0				
20.5				
21.0				
21.5			7	
22.0	10	12	-	402
22.5	20	25	37	57
23.0	71	86	14	345
23.5	227	271	7	345
24.0	273	333	133	2,240
24.5	395	482	236	3,619
25.0	911	1,112	228	5170
25.5	1,103	1,347	324	5,055
26.0	1,771	2,162	523	6,204
26.5	2,327	2,841	346	3,734
27.0	2,317	2,829	383	5,227
27.5	2,003	2,446	346	5,343
28.0	3,410	4,163	361	6,377
28.5	4,108	5,016	678	5,285
29.0	4,361	5,324	803	10,111
29.5	2,529	3,089	545	7,583
30.0	1,305	1,594	346	5,455
30.5	556	680	125	2,183
31.0	273	309	96	747
31.5	182	222	37	287
32.0	131	161	15	287
32.5	121	148	15	
33.0	40	49		
33.5	51	62		
34.0	-	-		
34.5	20	25		
35.0	10	12		
Total	28,525	34,800	5,605	76,056
Tonnes	4,800	5,922	1,124	14,600

* Using samples from Q1

Table 6.2.1

HER-IRLW: Herring West of Ireland & Porcupine Bank (Fishing Area VIa South)

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
1970	0.010	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1971	0.010	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1972	0.010	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1973	0.010	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1974	0.010	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1975	0.010	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1976	0.010	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1977	0.010	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1978	0.010	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1979	0.010	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1980	0.010	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1981	0.010	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1982	0.010	0.110	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1983	-1.000	0.090	0.129	0.165	0.191	0.209	0.222	0.231	0.237	0.241
1984	-1.000	0.106	0.141	0.181	0.210	0.226	0.237	0.243	0.247	0.248
1985	-1.000	0.077	0.122	0.161	0.184	0.196	0.206	0.212	0.225	0.230
1986	-1.000	0.095	0.138	0.164	0.194	0.212	0.225	0.239	0.208	0.288
1987	-1.000	0.085	0.102	0.150	0.169	0.177	0.193	0.205	0.215	0.220
1988	-1.000	-1.000	0.098	0.133	0.153	0.166	0.171	0.183	0.191	0.201
1989	-1.000	0.080	0.130	0.141	0.164	0.174	0.183	0.192	0.193	0.203
1990	-1.000	0.094	0.138	0.148	0.160	0.176	0.189	0.194	0.208	0.216
1991	-1.000	0.089	0.134	0.145	0.157	0.167	0.185	0.199	0.207	0.230
1992	-1.000	0.095	0.141	0.147	0.157	0.165	0.171	0.180	0.194	0.219
1993	-1.000	0.112	0.138	0.153	0.170	0.181	0.184	0.196	0.229	0.236
1994	-1.000	0.081	0.141	0.164	0.177	0.189	0.187	0.191	0.204	0.220
1995	-1.000	0.080	0.140	0.161	0.173	0.182	0.198	0.194	0.206	0.217
1996	.	.	.	.	.	.	.	.	.	.

Table 6.2.2.

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HER-IRLW: Herring West of Ireland & Porcupine Bank (Fishing Area VIa South)

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
1970	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1971	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1972	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1973	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1974	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1975	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1976	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1977	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1978	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1979	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1980	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1981	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1982	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1983	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1984	0.010	0.120	0.169	0.210	0.236	0.260	0.273	0.283	0.290	0.296
1985	-1.000	0.100	0.150	0.196	0.227	0.238	0.251	0.252	0.269	0.284
1986	-1.000	0.098	0.169	0.209	0.238	0.256	0.276	0.280	0.287	0.312
1987	-1.000	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1988	-1.000	0.097	0.164	0.206	0.233	0.252	0.271	0.280	0.296	0.317
1989	-1.000	0.138	0.157	0.168	0.182	0.200	0.217	0.227	0.238	0.245
1990	-1.000	0.113	0.152	0.170	0.180	0.200	0.217	0.225	0.233	0.255
1991	-1.000	0.102	0.149	0.174	0.190	0.195	0.206	0.226	0.236	0.248
1992	-1.000	0.102	0.144	0.167	0.182	0.194	0.197	0.214	0.218	0.242
1993	-1.000	0.118	0.166	0.196	0.205	0.214	0.220	0.223	0.242	0.258
1994	-1.000	0.098	0.156	0.192	0.209	0.216	0.223	0.226	0.230	0.247
1995	-1.000	0.090	0.144	0.181	0.203	0.217	0.226	0.227	0.239	0.246

Table 6.4.1 Numbers (millions of fish) and biomass (thousands of tonnes) at age for the July/August '95 herring acoustic cruise.

Age	Mean Length (cm)	Mean Weight (g)	Number $\times 10^6$	%	Biomass $\times 10^3$ T	%
0+1	9.65	7.08	987.12	59.74	6.99	5.08
2I	25.91	170.95	19.31	1.17	3.30	2.40
2M	25.72	167.23	294.28	17.81	49.21	35.74
3I	27.50	207.85	7.61	0.46	1.58	1.15
3M	27.43	206.77	175.69	10.63	36.33	26.39
4A	27.74	214.48	71.54	4.33	15.34	11.14
5A	28.17	225.44	7.76	0.47	1.75	1.27
6A	29.99	277.43	19.79	1.20	5.49	3.99
7A	29.55	263.95	10.69	0.65	2.82	2.05
8A	29.78	270.70	6.50	0.39	1.76	1.28
9+	29.15	252.26	51.94	3.14	13.10	9.52
Total	**16.99**	**83.33**	**1652.23**	**100.00**	**137.67**	**100.00**
Immature			1014.04	61.37	11.87	8.62
Mature			**638.19**	**38.63**	**125.80**	**91.38**

Table 6.5.1

```
Title : Herring VIa South (run: SEPJM09/S09)

At 16-Apr-96  15:54:51

Separable analysis
from 1970 to 1995 on ages  1 to  8
with Terminal F of  .200 on age  4 and Terminal S of 1.200

Initial sum of squared residuals was   415.239 and
  final sum of squared residuals is     69.208 after 113 iterations

Matrix of Residuals


 Years,     1970/71,1971/72,1972/73,1973/74,1974/75,
  Ages

  1/ 2,     -.802,   .029,  -.286,  1.966,   .648,
  2/ 3,     1.659,  -.663,  -.093,   .420,   .218,
  3/ 4,      .546,   .287,   .206,   .080,  -.046,
  4/ 5,      .133,   .184,  -.131,  -.008,   .262,
  5/ 6,     -.339,   .023,  -.121,  -.211,   .048,
  6/ 7,     -.549,  -.128,  -.134,  -.112,  -.273,
  7/ 8,     -.151,  -.084,   .669,  -.223,  -.393,

  TOT ,      .001,   .001,   .001,   .001,   .001,
  WTS ,      .001,   .001,   .001,   .001,   .001,


 Years,     1975/76,1976/77,1977/78,1978/79,1979/80,1980/81,1981/82,1982/83,1983/84,1984/85,

  1/ 2,     1.863,  1.668,   .705,  1.579,  1.502,   .797,   .476,  -.499, -1.497,  1.384,
  2/ 3,      .218,   .324,   .362,   .899,   .115,  -.242,   .146,  -.456,  -.116,   .290,
  3/ 4,     -.394,  -.134,  -.548,   .053,  -.311,   .095,  -.138,  -.251,   .065,   .527,
  4/ 5,     -.183,  -.117,  -.043,   .142,  -.109,   .078,   .056,   .066,   .346,   .234,
  5/ 6,      .030,  -.056,   .230,  -.044,   .103,  -.126,  -.100,   .111,  -.079,  -.346,
  6/ 7,      .077,  -.228,   .031,  -.511,  -.100,  -.093,   .364,   .101,  -.089,  -.163,
  7/ 8,     -.008,   .264,  -.260,  -.402,   .060,   .169,  -.580,   .238,   .129,  -.613,

  TOT ,      .001,   .001,   .001,   .001,   .001,   .001,   .000,   .000,   .000,   .000,
  WTS ,      .001,   .001,   .001,   .001,   .001,   .001,   .001,   .001,   .001,   .001,


 Years,     1985/86,1986/87,1987/88,1988/89,1989/90,1990/91,1991/92,1992/93,1993/94,1994/95,        TOT,        WTS,

  1/ 2,     2.119,  -.113,  1.778, -3.196,   .985,  -.573,  -.020,  1.288, -2.634,  1.927,       .000,       .112,
  2/ 3,     -.309,  -.322,  -.410,  -.930,  -.621,  -.003,  -.084,  -.015,  -.373,   .475,       .000,       .296,
  3/ 4,     -.179,  -.139,  -.103,   .253,  -.624,   .163,  -.227,  -.014,  -.060,   .138,       .000,       .553,
  4/ 5,     -.277,   .017,  -.155,   .381,   .153,   .175,  -.224,   .158,   .347,  -.456,       .000,       .751,
  5/ 6,      .147,   .316,  -.023,   .120,   .087,   .006,   .041,  -.119,   .163,  -.090,       .000,      1.000,
  6/ 7,     -.112,  -.307,  -.235,   .070,  -.268,  -.209,   .256,  -.167,  -.135,   .258,       .000,       .735,
  7/ 8,      .245,   .207,   .740,   .088,  1.051,  -.022,   .234,  -.022,   .289,  -.479,       .000,       .394,

  TOT ,      .000,   .000,   .000,   .000,   .000,   .000,   .000,   .000,   .000,   .000,     10.113,
  WTS ,      .001,   .001,   .001,   .001,   .001,  1.000,  1.000,  1.000,  1.000,  1.000,


  Fishing Mortalities (F)

        ,    1970,   1971,   1972,   1973,   1974,   1975,
F-values,   .1754,  .1523,  .2199,  .2917,  .4316,  .4602,

        ,    1976,   1977,   1978,   1979,   1980,   1981,   1982,   1983,   1984,   1985,
F-values,   .5431,  .3424,  .2714,  .2833,  .3853,  .2921,  .2269,  .3575,  .1834,  .1687,

        ,    1986,   1987,   1988,   1989,   1990,   1991,   1992,   1993,   1994,   1995,
F-values,   .1683,  .3183,  .1932,  .1724,  .2215,  .2104,  .2032,  .2535,  .2308,  .2000,

 Selection-at-age (S)

        ,       1,      2,      3,      4,      5,      6,      7,      8,
S-values,   .0104,  .5087,  .8872, 1.0000, 1.1547, 1.2932, 1.1767, 1.2000,
```

Table 6.5.1 (cont'd)

Run title : Herring VIa South (run: SEPJM09/S09)

At 16-Apr-96 15:54:56

Traditional vpa Terminal populations from weighted Separable populations

Fishing mortality residuals

YEAR,	1970,	1971,	1972,	1973,	1974,	1975,
AGE						
1,	-.0013,	.0001,	-.0001,	.0164,	.0047,	.0247,
2,	.2983,	-.0281,	.0065,	.0431,	-.0235,	.0200,
3,	.0906,	-.0039,	.0483,	.0498,	-.0595,	-.1364,
4,	.0045,	-.0061,	-.0649,	.0144,	.0728,	-.0804,
5,	-.0355,	-.0190,	-.0573,	-.0854,	.0435,	-.0441,
6,	-.0721,	.0299,	-.0440,	-.0673,	-.0851,	.0510,
7,	-.0140,	.0273,	.1020,	-.0227,	-.0722,	.0459,
8,	-.0001,	.0153,	.0851,	-.0978,	.1087,	.1771,

Fishing mortality residuals

YEAR,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,	1984,	1985,
AGE										
1,	.0339,	.0090,	.0130,	.0069,	.0048,	.0008,	-.0006,	-.0025,	.0025,	.0107,
2,	-.0105,	.0673,	.1166,	.0256,	-.0533,	-.0015,	-.0254,	.0407,	.0417,	-.0374,
3,	-.0694,	-.1035,	.0003,	-.0554,	.0264,	-.0287,	-.0319,	.0825,	.0740,	.0175,
4,	-.0580,	-.0235,	.0249,	-.0163,	.0156,	-.0020,	.0012,	.0274,	.0486,	-.0194,
5,	-.0436,	-.0131,	-.0147,	-.0155,	.0237,	-.0117,	-.0184,	-.0294,	-.0520,	.0058,
6,	-.1250,	-.0216,	-.0949,	-.0052,	-.0909,	.1011,	.0208,	-.0982,	-.0029,	.0091,
7,	.0311,	-.0186,	-.0326,	.0634,	.0509,	-.0581,	-.0208,	-.0111,	-.0432,	.0357,
8,	.1180,	-.0875,	.0903,	.1374,	.0979,	-.0140,	.1472,	-.1401,	-.0360,	.1044,

Table 6.5.2

Run title : Herring VIa South (run: SEPJM10/S10)

At 16-Apr-96 16:01:28

Table 17 Summary (with SOP correction)

Traditional vpa Terminal populations from weighted Separable populations

	RECRUITS, Age 1	TOTALBIO,	TOTSPBIO,	LANDINGS,	YIELD/SSB,	SOPCOFAC,	FBAR 3- 7,
1970,	403449,	194005,	119977,	20306,	.1692,	.8968,	.1865,
1971,	811550,	218465,	109276,	15044,	.1377,	.8707,	.1720,
1972,	728391,	232739,	118014,	23474,	.1989,	.8975,	.2373,
1973,	528108,	277593,	160914,	36719,	.2282,	1.0162,	.2977,
1974,	581534,	213956,	99084,	36589,	.3693,	.9762,	.4534,
1975,	400670,	205951,	102586,	38764,	.3779,	1.1237,	.4718,
1976,	675522,	196635,	72779,	32767,	.4502,	1.0472,	.5420,
1977,	567740,	184794,	80770,	20567,	.2546,	1.0778,	.3391,
1978,	1020052,	232660,	79448,	19715,	.2482,	1.0161,	.2744,
1979,	950801,	268676,	109398,	22608,	.2067,	1.0664,	.3051,
1980,	511633,	214113,	109684,	30124,	.2746,	.9636,	.4286,
1981,	657890,	229947,	111086,	24922,	.2243,	1.0312,	.3218,
1982,	676741,	230507,	114685,	19209,	.1675,	1.0301,	.2408,
1983,	2005203,	397302,	110231,	32988,	.2993,	1.0042,	.3911,
1984,	974970,	335330,	170518,	27450,	.1610,	.9688,	.2099,
1985,	1186987,	328759,	168005,	23343,	.1389,	.9846,	.1990,
1986,	919679,	346829,	204538,	28785,	.1407,	1.0002,	.2051,
1987,	3315151,	550584,	173106,	48600,	.2808,	.9488,	.4091,
1988,	490350,	413647,	285398,	29100,	.1020,	.9992,	.3088,
1989,	675281,	360005,	214225,	29210,	.1364,	1.0010,	.2526,
1990,	891014,	338123,	182398,	43969,	.2411,	1.0006,	.2708,
1991,	498469,	273900,	171824,	37700,	.2194,	.9971,	.2644,
1992,	557192,	233104,	135335,	31856,	.2354,	.9951,	.2639,
1993,	703033,	253897,	124164,	36763,	.2961,	1.0060,	.3612,
1994,	1395327,	290376,	112003,	33908,	.3027,	.9980,	.3233,
1995,	133329,	179708,	124089,	27792,	.2240,	1.0525,	.3334,
Arith. Mean ,	856156,	276985,	137059,	29703,	.2340		.3101,
Units,	(Thousands),	(Tonnes),	(Tonnes),	(Tonnes),			

Run title : Herring VIa South (run: SEPJM10/S10)

At 16-Apr-96 16:01:28

Traditional vpa Terminal populations from weighted Separable populations

Table 8 Fishing mortality (F) at age

YEAR,	1970,	1971,	1972,	1973,	1974,	1975,
AGE						
1,	.0005,	.0017,	.0022,	.0194,	.0092,	.0294,
2,	.3867,	.0493,	.1182,	.1912,	.1957,	.2538,
3,	.2454,	.1309,	.2430,	.3081,	.3227,	.2714,
4,	.1788,	.1455,	.1546,	.3054,	.5029,	.3787,
5,	.1654,	.1557,	.1956,	.2505,	.5398,	.4851,
6,	.1530,	.2242,	.2383,	.3079,	.4704,	.6419,
7,	.1898,	.2038,	.3552,	.3169,	.4314,	.5820,
8,	.2072,	.1949,	.3430,	.2471,	.6153,	.7167,
+gp,	.2072,	.1949,	.3430,	.2471,	.6153,	.7167,
FBAR 3- 7,	.1865,	.1720,	.2373,	.2977,	.4534,	.4718,

Table 8 Fishing mortality (F) at age

YEAR,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,	1984,	1985,
AGE										
1,	.0396,	.0126,	.0159,	.0099,	.0089,	.0039,	.0017,	.0012,	.0045,	.0129,
2,	.2654,	.2413,	.2547,	.1699,	.1432,	.1481,	.0909,	.2261,	.1365,	.0503,
3,	.4116,	.1999,	.2409,	.1959,	.3689,	.2314,	.1707,	.4048,	.2414,	.1692,
4,	.4837,	.3179,	.2956,	.2666,	.4009,	.2908,	.2293,	.3891,	.2360,	.1528,
5,	.5807,	.3805,	.2976,	.3106,	.4677,	.3257,	.2444,	.3862,	.1620,	.2049,
6,	.5727,	.4178,	.2545,	.3592,	.4054,	.4774,	.3143,	.3657,	.2366,	.2312,
7,	.6615,	.3794,	.2835,	.3933,	.5000,	.2838,	.2451,	.4098,	.1736,	.2371,
8,	.7557,	.3166,	.4082,	.4695,	.5524,	.3322,	.4156,	.2874,	.1841,	.3090,
+gp,	.7557,	.3166,	.4082,	.4695,	.5524,	.3322,	.4156,	.2874,	.1841,	.3090,
FBAR 3- 7,	.5420,	.3391,	.2744,	.3051,	.4286,	.3218,	.2408,	.3911,	.2099,	.1990,

Table 6.5.2 (cont'd)

Run title : Herring VIa South (run: SEPJM10/S10)

At 16-Apr-96 16:01:28

Traditional vpa Terminal populations from weighted Separable populations

Table 8 Fishing mortality (F) at age

YEAR,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	1994,	1995,	FBAR 93-95
AGE											
1,	.0016,	.0058,	.0000,	.0053,	.0016,	.0021,	.0074,	.0004,	.0134,	.0034,	.0057,
2,	.0754,	.1633,	.0282,	.0454,	.1240,	.1294,	.1030,	.1240,	.2872,	.0819,	.1644,
3,	.1150,	.3525,	.2735,	.1047,	.1839,	.2096,	.2477,	.2278,	.2977,	.3154,	.2803,
4,	.2376,	.2706,	.2907,	.2322,	.2843,	.1623,	.3038,	.3899,	.2510,	.2759,	.3056,
5,	.2349,	.5830,	.2151,	.2174,	.3132,	.2747,	.2193,	.4177,	.3196,	.4415,	.3930,
6,	.1967,	.3624,	.5158,	.1867,	.2901,	.3551,	.2943,	.3451,	.4072,	.3671,	.3731,
7,	.2412,	.4769,	.2490,	.5222,	.2828,	.3203,	.2543,	.4256,	.3412,	.2670,	.3446,
8,	.1919,	.3879,	.1427,	.2102,	.2869,	.2883,	.2619,	.3389,	.3240,	.5940,	.4190,
+gp,	.1919,	.3879,	.1427,	.2102,	.2869,	.2883,	.2619,	.3389,	.3240,	.5940,	
FBAR 3- 7,	.2051,	.4091,	.3088,	.2526,	.2708,	.2644,	.2639,	.3612,	.3233,	.3334,	

Run title : Herring VIa South (run: SEPJM10/S10)

At 16-Apr-96 16:01:28

Traditional vpa Terminal populations from weighted Separable populations

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR,	1970,	1971,	1972,	1973,	1974,	1975,
AGE						
1,	403449,	811550,	728390,	528108,	581534,	400670,
2,	125520,	148342,	298040,	267379,	190547,	211972,
3,	131348,	63165,	104604,	196182,	163609,	116068,
4,	84885,	84142,	45372,	67169,	118031,	97009,
5,	26813,	64234,	65825,	35175,	44783,	64588,
6,	297155,	20563,	49740,	48981,	24776,	23618,
7,	18097,	230720,	14869,	35463,	32576,	14006,
8,	9346,	13544,	170270,	9431,	23372,	19148,
+gp,	10714,	12798,	15536,	244193,	69509,	65396,
TOTAL,	1107327,	1449057,	1492646,	1432080,	1248737,	1012474,

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR,	1976,	1977,	1978,	1979,	1980,	1981,	1982,	1983,	1984,	1985,
AGE										
1,	675522,	567740,	1020052,	950800,	511633,	657890,	676740,	2005204,	974970,	1186987,
2,	143125,	238872,	206252,	369345,	346338,	186558,	241082,	248525,	736792,	357046,
3,	121835,	81317,	139021,	118440,	230863,	222346,	119184,	163082,	146860,	476197,
4,	72442,	66094,	54515,	89457,	79718,	130705,	144433,	82263,	89073,	94453,
5,	60108,	40410,	43516,	36705,	61999,	48307,	88426,	103907,	50441,	63654,
6,	35980,	30431,	24993,	29240,	24346,	35142,	31561,	62665,	63896,	38814,
7,	11248,	18361,	18132,	17532,	18474,	14687,	19727,	20856,	39335,	45635,
8,	7081,	5252,	11368,	12356,	10705,	10139,	10006,	13969,	12527,	29920,
+gp,	30922,	16028,	10387,	11426,	13145,	19351,	8854,	17838,	25079,	8550,
TOTAL,	1158262,	1064506,	1528237,	1635302,	1297221,	1325125,	1340013,	2718308,	2138973,	2301257,

Table 6.5.2 (cont'd)

Run title : Herring VIa South (run: SEPJM10/S10)

At 16-Apr-96 16:01:28

Traditional vpa Terminal populations from weighted Separable populations

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR,	1986,	1987,	1988,	1989,	1990,	1991,	1992,	1993,	1994,	1995,	1996,	AMST
AGE												
1,	919679,	3315153,	490350,	675280,	891014,	498469,	557193,	703033,	1395326,	133329,	0,	8638
2,	431083,	337798,	1212508,	180390,	247118,	327276,	182984,	203472,	258521,	506504,	48884,	3099
3,	251537,	296151,	212534,	873283,	127710,	161718,	213018,	122285,	133159,	143706,	345730,	2021
4,	329204,	183565,	170432,	132373,	643887,	86999,	107369,	136141,	79721,	80953,	85833,	1329
5,	73351,	234882,	126722,	115315,	94961,	438449,	66926,	71697,	83411,	56121,	55589,	883
6,	46927,	52474,	118640,	92471,	83954,	62820,	301437,	48632,	42721,	54827,	32654,	687
7,	27871,	34878,	33046,	64090,	69424,	56838,	39852,	203219,	31160,	25726,	34366,	457
8,	32576,	19814,	19589,	23311,	34401,	47341,	37333,	27962,	120148,	20043,	17824,	254
+gp,	12779,	33187,	15501,	16798,	4750,	32060,	28608,	21918,	38219,	33188,	26593,	
TOTAL,	2125009,	4507902,	2399322,	2173312,	2197219,	1711970,	1534721,	1538360,	2182386,	1054399,	647473,	

Fig. 6.1.1 Herring: Landings from Division VIa(S) and VIIb for the period 1970 to 1995

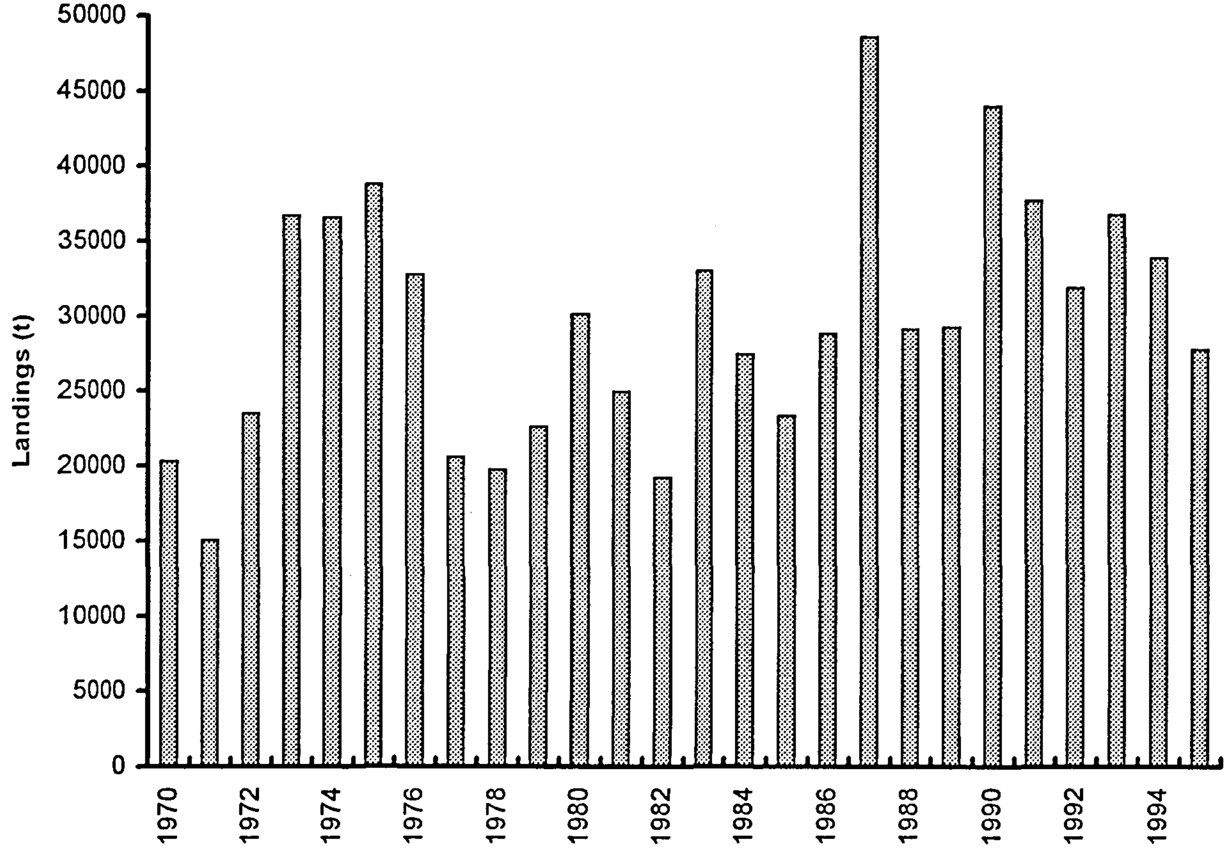


Fig. 6.5.1 Division VIa(S) and VIIb SSB levels arising from different input levels of F for 1995.

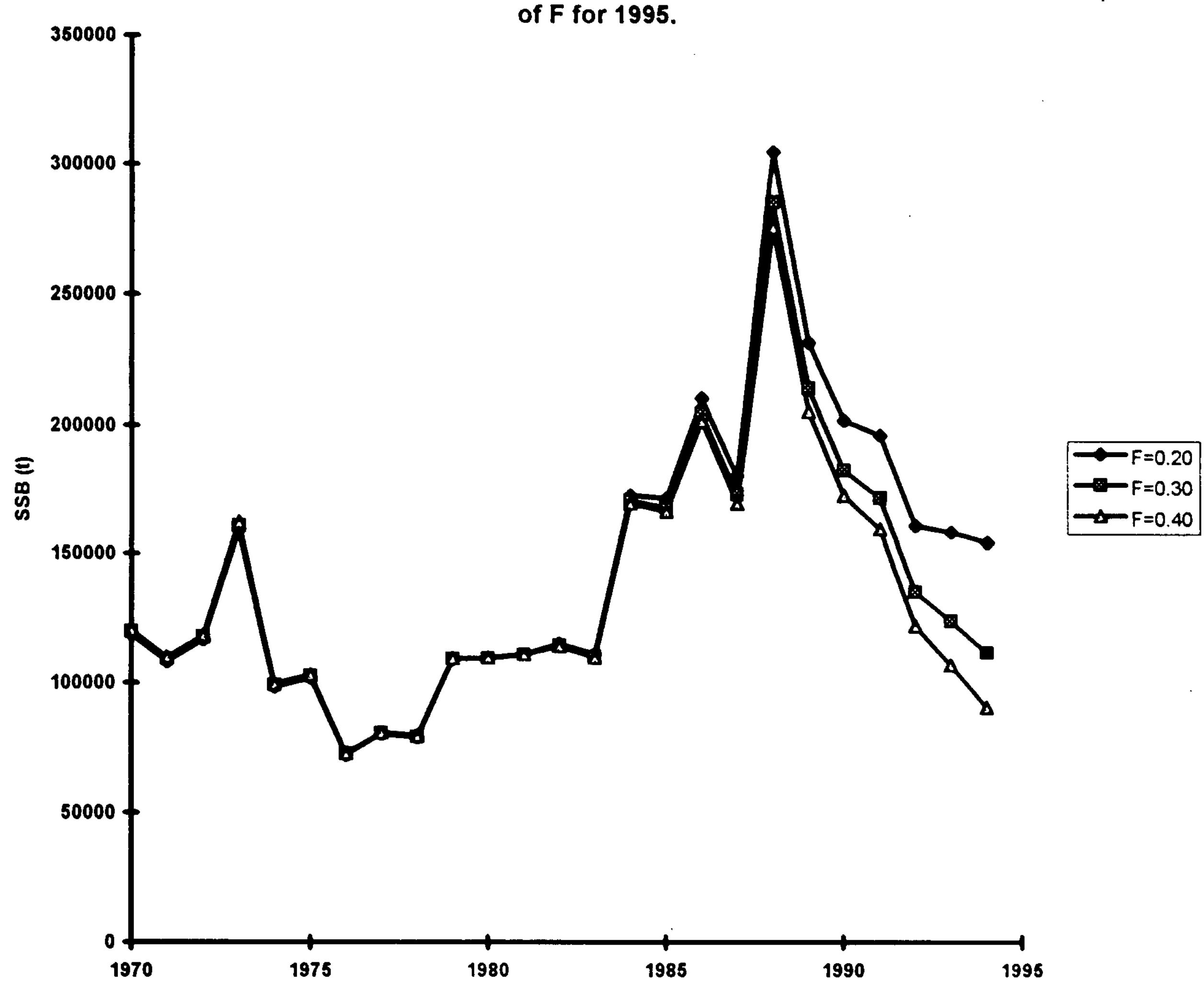
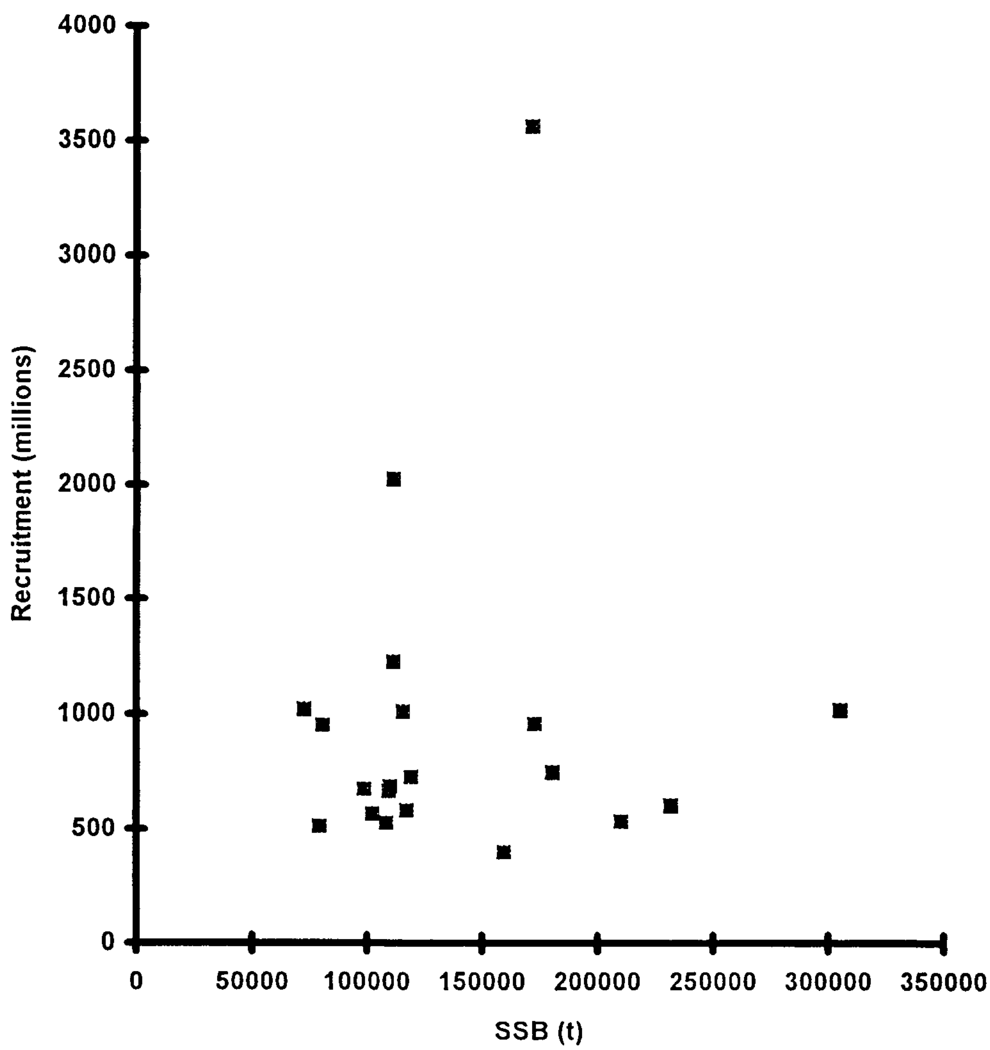


Fig. 6.8.1 Herring in VIa(S) + VIIb. Relationship between stock and recruitment for the years 1970 to 1989



7 . IRISH SEA HERRING (DIVISION VIIA, NORTH)

7.1 The Fishery

7.1.1 Advice and management applicable to 1995 and 1996

In 1994 no analytical assessment of this stock was undertaken due to continued uncertainty about the fishing mortality and level of SSB. ACFM concluded that the present state of the stock was not known. Consequently the ACFM advice was that if a precautionary TAC is required for 1995 it should not exceed the recent catch levels of 5,100 t (average over the period 1990-1993). A TAC of 7,000 t was subsequently adopted for 1995 and partitioned as 1,820 t to the Republic of Ireland and 5,180 t to the UK. ACFM also considered a request by the UK (Northern Ireland) for amendment of the spawning closure to the east of the Isle of Man. Due to not being able to assess the state of the Division VIIa(N) stock ACFM stated that it was not possible to evaluate, on scientific grounds, the effect of the current closure or of the proposed amendments.

In 1995 the UK fishery opened in the third week in June. The Republic of Ireland fishery opened in the second week of August but no boats participated. Closed areas for herring fishing in the Irish Sea along the east coast of Ireland and within 12 nautical miles of the west coast of Britain were maintained throughout the year. The Mourne gillnet fishery, which has a derogation to fish within the Irish closed box, opened in September and closed in November. The area to the east of the Isle of Man (encompassing the Douglas Bank spawning ground) was closed from 21 September to 31 December. Two sets of pair trawlers (four vessels in total) undertook a series of three surveys and fishing operations inside this closed area on 26-28 September, 9-10 October and 18-26 October 1995 (see Section 7.3.3).

In 1995, ACFM concluded that the state of the stock is still unknown. Further, they suggested that if a precautionary TAC is required it should be such that the catch does not exceed the catch of recent years (about 5,000t). A TAC of 7,000t was adopted for 1996 and partitioned as 1,820t to the Republic of Ireland and 5,180 to the UK.

7.1.2 The fishery in 1995

The catches reported from each country, for the period 1982 to 1995 are given in Table 7.1.1. Again there has been no estimate of discarding or slipping. The total catch of 5,076 t was again below the recommended TAC of 7,000t. As in 1993 and 1994, this was mainly due to the Republic of Ireland not taking any herring from Division VIIa(N). The catches reported here include 600 t from the survey/fishing experiment on the spawning closed area to the east of the Isle of Man, which was not put against quota. The Northern Ireland fleet took 58% of their catch in the 2nd and 3rd quarters and the remainder in the 4th quarter. Landings from the Mourne gillnet fishery were low in 1995 (109 t).

7.1.3 Quality of catch and biological data

There are still no estimates of discarding or slippage of herring in the Irish Sea fisheries.

Biological sampling in this fishery remains fairly high with approximately one sample per 60 t landed (Table 7.1.2). No samples were taken in the 1st and 2nd quarters; however, landings in these quarters were only 62 t. Coverage in the 4th quarter was higher than normal due to the survey/fishing experiment on Douglas Bank.

7.1.4 Catch in number at age

Catches in numbers at age are given in Table 7.1.3 for the years 1972 to 1994. The predominant year class in 1995 was the 2-ringers (1992 year class). The 1990 year class, which was numerically the most abundant year class in the 1993-1994 catches was still abundant in the 1995 catches. The catch in numbers at length is given in Table 7.1.4 for 1988 to 1995. The distribution of lengths in 1995 was similar to that in the preceding year with a low abundance of fish over 30cm compared with 1988 and 1989, during which the strong 1979 and 1980 year classes were abundant in the catches (see Table 7.1.3).

7.2 Mean length, weight, maturity and natural mortality at age

Mean lengths at age were calculated for the 3rd quarter using the Northern Ireland data and are given for the years 1985 to 1995 in Table 7.2.1. In general, mean lengths at age have remained fairly stable since 1988.

Mean weights at age in the stock are given in Table 7.2.2. Mean weights at age in 1995 were, in general, comparable to the mean weights in 1994. Mean weights at age in the third-quarter catches have been used as estimates of stock weights at spawning time.

The maturity ogive used in 1994 (Anon. 1995d) was used again since there was no evidence to suggest a change: 0.08 for 1-ringers, 0.85 for 2-ringers and 1.00 for 3+-ringers.

As in previous years, natural mortality was assumed to be 1.0 yr^{-1} on 1-ringers, 0.3 on 2-ringers, 0.2 on 3-ringers and 0.1 on all older age classes.

7.3 Research surveys

7.3.1 Acoustic surveys

An acoustic survey was undertaken on Douglas Bank on 22 to 26 September 1994 using the shoal-mapping techniques described by Nash & Hughes (1996 WD). This survey located the main spawning shoal, the biomass of which was estimated to be 28,200 t The time series of information from these surveys is given in Table 7.3.1.

An acoustic survey was undertaken over the whole northern Irish Sea (Division VIIa(N)) between 11 and 22 September 1995 by Northern Ireland as part of a time series that commenced in 1994. The survey is described in detail by Armstrong *et al.* (1996 WD). The 1994 and 1995 surveys were both carried out using a Simrad EK500 echosounder with a towed 38 kHz split-beam transducer. The surveys were stratified to allow variable sampling intensity according to the expected distribution of herring. Targets were identified where possible by midwater trawling. However, due to difficulties in sampling some midwater herring schools which contributed significantly to the overall biomass estimate in both years, the surveys are treated as providing age-aggregated estimates of biomass of 1-ring and older herring. The spatial distribution of pelagic fish targets in 1995 was similar to that observed in 1994. Herring targets were located mainly around the Isle of Man (Figure 7.3.1). The herring off the west coast of the Isle of Man comprised a mixture of immature and mature fish. Herring on or near the spawning grounds off the east coast of the Isle of Man were predominantly adult fish (23-30 cm). Along the Mull of Galloway (North Channel) there was a scattering layer of mixed sprats and adult herring close inshore. Comparatively few 1+ herring were detected off the Irish coast. There were very high concentrations of mixed sprat and juvenile (0-ring) herring off the coasts of Ireland, NE Isle of Man and England particularly off the Solway Firth and Cumbria. The occurrence of herring inshore in Liverpool Bay could not be assessed as this area was not surveyed.

The estimated biomass of 1+ herring in the Irish Sea (Division VIIa(N)) in 1995 was 53,000t with an overall approximate CV of 0.32 (Table 7.3.1). The estimate for 1994 was lower at 31,400t with an approximate CV of 0.36. Earlier acoustic surveys of Division VIIa(N) in 1991 and 1992 (Table 7.3.1) did not cover the entire northern Irish Sea and took place in summer when part of the stock of mature fish may occur outside the Irish Sea. Hence the results of these surveys were not included in the assessment of the stock carried out this year.

7.3.2 Larvae surveys

Larvae surveys were undertaken by Northern Ireland (whole of Division VIIa(N)) and the Isle of Man (Douglas Bank). The Isle of Man was not able to undertake a survey of the northeastern Irish Sea due to poor weather conditions in November, December and January. The Douglas Bank survey (the 7th in the series) was undertaken between 18 and 20 October 1995 over the usual 5 nautical mile grid centred on Douglas Bank (see Nash & Hughes 1996 WD). The numbers of larvae at 6mm length and the estimated larval production were the second lowest on record (Table 7.3.2). The distribution of spawning dates, back-calculated from the length at capture, suggested that the majority of the larvae were spawned around 3 October 1995. However, water temperatures in the area were up to 2°C higher than normal and the duration of the egg and larval time may have been shorter than estimated. Hence, the estimate of spawning date may be too early. The results are, however, consistent with the time periods when spawning herring were detected during a series of acoustic surveys of the Douglas Bank (see Section 7.3.3).

The larvae survey of Division VIIa(N) was undertaken by Northern Ireland from 26 to 29 November 1995 (Armstrong *et al.* 1996 W.D.). Herring larvae were caught at only four out of 50 stations, to the north and north-east of the Isle of Man. Although sea surface temperatures were at least 1°C warmer than in previous years, no corrections could be made for variations in growth or mortality rate of larvae. The distribution of spawning dates estimated from the size composition of larvae indicated a spawning period from late September to the end of October. This, again, was consistent with the results of acoustic surveys discussed in Section 7.3.3. The estimate of total larval production in 1995

(1.54×10^{12}) was lower than in previous years (Table 7.3.2). Both the Douglas Bank larval survey and the Division VIIa(N) survey show similar interannual variations in estimated larval production (Table 7.3.2).

7.3.3 Study of spawning patterns on Douglas Bank

7.3.3.1 Methods employed

An experiment to examine the spawning patterns on Douglas Bank was undertaken in September and October 1995 by the Department for Agriculture for Northern Ireland, the Port Erin Marine Laboratory, the Isle of Man Department of Fisheries and Agriculture and the Northern Ireland fishing industry. The experiment took place in four phases. Phase 1 included the acoustic survey of Division VIIa(N) from 11-22 September (see Section 7.3.1). Phases 2 to 4 consisted of observer surveys by commercial fishing vessels and concurrent acoustic surveys by research vessels inside the spawning closed area to the east of the Isle of Man (Armstrong *et al.* 1996 WD), covering the period 26 September to 26 October.

Phases 2 and 3 (26-28 September, 9-10 October) were undertaken by a pair of herring trawlers and the *RV Roagan*. The trawlers covered the area to the east of the Isle of Man, with scientific observers noting the positions and types of herring targets. Work was carried out mainly during the hours of darkness. The pair of trawlers was permitted to capture up to 200t in the area during each phase. Samples were taken from these catches to estimate length frequency, age composition and stage of maturity of the fish. The research vessel started an acoustic survey on the second night, targeting only the areas where significant aggregations were reported. The research vessel also obtained samples from the spawning aggregations surveyed.

Phase 4 (23-26 October) involved four commercial trawlers and the *RV Lough Foyle*. A larger area surrounding the spawning grounds was surveyed by the commercial vessels. Methods were as employed in Phases 2 and 3.

7.3.3.2 Survey results

During Phase 1, herring were scattered widely in the vicinity of the Douglas Bank spawning grounds to the east of the Isle of Man (Figure 7.3.1). Highest densities were in the vicinity of the main spawning aggregations located in Phases 2 and 4. The estimate of biomass for the survey stratum covering the spawning grounds (indicated by the box in Figure. 7.3.1) was 4,700 t (CV=0.22).

In Phase 2, herring spawning aggregations were detected in three groups approximately 3-5 nautical miles off the east side of the Isle of Man. A line of midwater schools was observed extending northwards from the aggregations along the coast. The *RV Roagan* surveyed one large aggregation of approximately 1.6 x 0.6 nautical miles in extent, and one smaller aggregation, using a Simrad EY500 (single beam 38 kHz) echosounder. The majority of the fish were within 5m of the bottom. Although the area covered by the shoal was much larger than previously recorded in similar surveys, the overall density of fish appeared much lower. Unfortunately, the acoustic data have become irretrievable so an acoustic estimate of this phase could not be delivered prior to the Working Group.

In Phase 3, the survey using commercial vessels detected a single cluster of herring spawning aggregations approximately 3-5 nautical miles east of the Isle of Man. As in Phase 2 there was a line of midwater schools extending northward from the aggregations along the coast. The aggregations (three main shoals) were mapped by the *RV Roagan*. Each aggregation was mapped twice, the second after the commercial vessels had taken a total catch of 200 t. The mean of the two mappings (allowing for the catch) was 9,800 t.

The Phase 4 surveys took place at the end of the expected spawning season. The observer survey indicated herring spawning aggregations in a single cluster approximately 3-5 nautical miles off the east coast of the Isle of Man with very little evidence of herring over the rest of the Manx closed box. The *RV Lough Foyle* undertook an intensive acoustic survey of the area reported to contain herring aggregations. Small patches of dispersed herring targets were recorded in a band 3 nautical miles offshore, with several large aggregations in the vicinity of the spawning herring noted previously. The estimate of biomass of spawning fish at this time was 1,750 t (CV=0.51).

Over the period 20 September to 26 October the herring found on Douglas Bank progressed from a mixture of stage 3-4 and stage 5s to predominantly stage 6 and spent fish. The acoustic estimates indicate that the spawning occurred mainly between mid September and the end of October. These dates are similar to estimates produced from the Division VIIa(N) surveys on herring larvae. Adult herring were initially widely scattered on and around the spawning grounds but coalesced rapidly into spawning aggregations which were concentrated within only a small part of the Manx closed box. By the end of October, only comparatively small aggregations were present on the spawning grounds with little evidence of post-spawning fish in other areas of the closed box. Unfortunately the date of peak spawning could not be accurately determined due to missing echo-integration data from the Phase 2 survey. The general pattern of spawning appeared similar to that observed in 1994, although the densities of fish in the spawning aggregations appeared lower. Spawning behaviour in 1995 may not have been typical because of unusually high sea temperatures in this year, as observed also in the Celtic Sea (see Section 4.4.1).

7.4 Data exploration and preliminary modelling

It has previously not been possible to carry out an analytical assessment of this stock due to the paucity of catch-independent estimates or indices of stock size. This year, the availability of new survey indices allowed an analytical assessment to be carried out using an integrated catch-at-age analysis including a separable constraint (Deriso *et al.* 1985). The ICA version 1.2 implementation was used (Patterson and Melvin W.D. 1996). The following short survey series were available for inclusion in an assessment using the ICA package:

1. Larval production estimates from Douglas Bank surveys: 1989 - 1995 (**DBL**)
2. Age-aggregated acoustic estimates of Manx herring spawning aggregations in 1989, 1990 and 1994 (**AC_DB**)
3. Age-aggregated acoustic estimates of 1+ ring herring in Division VIIa(N) in September 1994 and 1995 (**AC_VIIa(N)**)
4. Western Irish Sea groundfish survey indices of 0-ring herring in September 1991 - 1995 (**GFS0S**)
5. Western Irish Sea groundfish survey indices of 1-ring herring in March 1992 - 1996 (**GFS1M**)
6. Western Irish Sea groundfish survey indices of 1-ring herring in June 1991 - 1994 (**GFS1J**)
7. Western Irish Sea groundfish survey indices of 1-ring herring in September 1991 - 1995 (**GFS1S**)

As it was not possible to include both age-aggregated indices of SSB and of total biomass in the present version of ICA, it was necessary to adjust the Division VIIa(N) acoustic survey estimates to reflect SSB rather than total biomass. This was achieved by carrying out a range of tuned and untuned VPAs and calculating the ratio of SSB to total biomass at spawning time. The ratio was comparatively robust to choice of input parameters, and averaged approximately 60%. The Division VIIa(N) acoustic estimates of total biomass were reduced accordingly and included in a tuning file as age-aggregated indices of SSB. The different indices are given in Table 7.4.1 and are also plotted in Figure 7.4.1. Although individual CVs of the GFS series were comparatively high, similar overall trends were apparent in the four series, with the 1992 year class being strongest in each series. Larval production on the Douglas Bank was also high in 1992. Although the larval production indices may also provide information on recruitment, it was decided to treat the series as SSB indices in accordance with practices for other herring stocks.

The ICA model was fitted using each series in turn (the acoustic survey data were analysed together because of the shortness of the AC_VIIa(N) series). The following input values were used:

- Separable constraint over last 6 years (weighting = 1.0 for each year)
- Reference age = 4
- Selectivity on oldest age = selectivity on reference age
- Weighting on 1-ringers = 0.1; all other age classes = 1.0
- No S/R relationship fitted
- All indices treated as proportionate

It was decided not to treat the Division VIIa(N) acoustic survey estimates as absolute because of large discrepancies between acoustic estimates and tuned SSB estimates in other stocks assessed during the meeting. No solution could be found using series GFS0S and GFS1M. Estimates of F(95) for the reference age class 4 from the other tuning series are shown in Figure 7.4.2 together with $\pm$ 1 SD intervals. Estimates ranged from <0.1 to 0.4. Precision was poor except for the acoustic surveys. However, the estimated precision of the model fit for the latter series will not reflect the true level of precision because of over-parameterization associated with the small number of data. In view of the limited data available for analysis, it was decided to carry out the final assessment using all tuning series for which a solution could be found, and to weight each index equally.

7.5 Stock assessment

The following objective function was chosen for the baseline assessment, based on the results given in Section 7.4:

$$\Sigma_{a,y}(\log(C_{a,y}) - \log(C'_{a,y}))^2 +$$
$$\Sigma_{y}(\log(Q_{DBL}SSB_y) - \log(DBL_y))^2 +$$
$$\Sigma_{y}(\log(Q_{AC\_VIIaN}SSB_y) - \log(AC\_VIIaN_y))^2 +$$
$$\Sigma_{y}(\log(Q_{AC\_DB}SSB_y) - \log(AC\_DB_y))^2 +$$
$$\Sigma_{1,y}(\log(Q_{GFS1J}N_{1,y}) - \log(GFS1J_{1,y}))^2 +$$
$$\Sigma_{1,y}(\log(Q_{GFS1S}N_{1,y}) - \log(GFS1S_{1,y}))^2$$

where,

a,y -	age and year subscripts
C	Catch in number at age and year
C'	Catch in number at age and year predicted by the structural model
SSB	Spawning stock biomass in the structural model
DBL	Larval abundance index, Douglas Bank
AC_DB	Acoustic survey estimates of SSB on Douglas Bank
AC_VIIaN	Acoustic survey estimates of 1+ ringer biomass, adjusted to SSB
GFS1J	GFS index of 1-ringers in June
GFS1S	GFS index of 1-ringers in September
N	Population numbers at survey time in the structural model
$Q_{...}$	Coefficient of proportionality for survey indices

Results of the baseline model fit are shown in Figuress 7.5.1 - 7.5.8 and Table 7.5.1. The SSQ surfaces for each index show shallow minima at low levels of fishing mortality. The estimate of F(2-6) for 1995 was 0.11 (stock summary, Table 7.5.1), with a corresponding SSB estimate of 37.8 thousand t. The log SE of the estimate of reference F was 0.55, whilst the log SEs for the population estimates ranged from 0.49 at age 2 to 0.68 at age 1. Hence the overall precision is poor, not unexpected given the limited tuning data available. The effect of the poor precision on stock projections is explored more fully in Section 7.8.

Although the catch-at-age matrix (Table 7.1.3) indicates a relatively strong 1990 year class, this is not apparent in the GFS indices. Because the SSB indices are not age-disaggregated, the model interprets the apparent (although weakly defined) increase in SSB as being caused primarily by a strong 1992 year class which is strongly represented in the 1995 catch at age. The comparatively large catches of 1990 year class herring in successive years are interpreted as positive catchability residuals (Figure. 7.5.3). The possibility of a strong 1992 year class is supported by comparison with other herring stocks to the west of the British Isles, as there is a tendency for all the stocks to show similar occurrences of strong and weak year classes.

In view of the low precision of the assessment, the apparent reduction in F(2-6) to 0.11 in 1995 from values of 0.15-0.21 over the period 1991 to 1994 should be treated with caution. The reduction in F(2-6) in the early 1990s compared with previous years is a reasonable assertion in view of the withdrawal of the Irish fleet from the fishery during this period. A very small fleet of vessels has subsequently fished the stock, supporting the likelihood of a low level of F. However, it was decided that it would be appropriate to shrink the model estimate of 1995 F to the mean of the 1991 - 1995 estimates in order to improve the robustness of the assessment. Three runs were carried out following an initial fit of the ICA model. In the first, the shrunk value of F in 1995 was obtained according to the CV of the 1991-95 F estimates and the CV of the estimated F in 1995. In the second and third runs, the CV of the 1991-95 F estimates was constrained to minimum values of 0.2 and 0.5 respectively. The effect on estimates of F(2-6) was as follows:

Minimum shrinkage CV	F(2-6) in 1995
0	0.152
0.2	0.148
0.5	0.131
no shrinkage	0.107

A minimum CV of 0.5 was chosen to fix equal weighting to the estimated F in 1995 and the mean of the 1991-95 estimates of F. The shrunk estimates of F and population sizes were used for making short-term predictions. Medium-term projections were carried out using the unshrunk population estimates as starting values, although the shrunk estimate of F was included as one option for *status quo* F. The population estimates, fishing mortalities and stock summary table for the shrunk assessment are given in Table 7.5.2.

7.6 Stock and Catch Projection

A short-term prediction was carried out using the shrunk ICA estimates of population numbers and fishing mortalities. Numbers of 1-ringers in 1995 and subsequent years were assumed equal to the long-term geometric mean as there are no indications of trends in recruitment over time. The ICA estimates of selectivity at age were rescaled to the shrunk estimate of F(2-6) in 1995 to provide the exploitation pattern. Predictions of stocks and yields in 1996 were made assuming a TAC constraint of 7000 t in 1996. Predictions for 1997 and 1998 were made for a range of F-multipliers. Weights at age in the stock and catch were averages for the years 1993-95. A TAC constraint of 7000 t for 1996 was chosen as there were some indications that the Irish fleet may fish again in Division VIIa(N) in 1996.

Input data for the predictions are given in Table 7.6.1. Management options are given in Table 7.6.2, with detailed output for status quo F given in Table 7.6.3. These predictions are based on an ICA model fit with CVs of around 0.5 on 1995 population estimates, and must be regarded as very approximate only. The TAC constraint of 7,000 t in 1996 implies an F of 0.16. SSB in 1996 is expected to increase slightly and to remain at about 40,000 t in 1997 and 1998 at *status quo* F. The SSB in 1997 and 1998 is expected to remain above 20,000 t even if F is increased by a factor of 3. The *status quo* catch in 1997 is 5,755 t.

7.7 MBAL and stock-recruit considerations

The possible level of MBAL for this stock was investigated through consideration of the average SSB in the absence of fishing and through examination of historical estimates of stock and recruitment.

The unexploited stock size was calculated using the following:

- arithmetic mean recruitment (calculated as GM recruitment * $\exp(\sigma^2/2)$) for the years 1972-1994
- arithmetic mean weights-at-age in the stock (1993-1995)
- values of maturity and natural mortality used by this Working Group for Division VIIa(N) herring
- different assumptions regarding range of ages in the unexploited stock.

Four different age ranges were examined:

- 1 to virtual extinction of the cohort (no assumption about senescent mortality)
- 1 to 20 rings (a reasonable maximum age for herring in Division VIIa when unexploited)
- 1 to 15 rings (maximum age currently found in the stock)
- 1 to 8 rings (plus-group in the current age matrix)

The first three make the assumption that fish of 9-rings and older have the same weight at age as in the plus group (8+).

The unexploited stock (referred to as 'virgin stock' by the Methods Working Group (Anon. 1993b)) was estimated as being between 61,000 and 134,000 t depending on whether one uses age 8 as the maximum age (as used in the catch-at-age matrix) or a range of ages where the cohort becomes virtually extinct (see Table 7.7.1).

In considering MBAL levels for Division VIa(N), where a stock-recruit curve did not appear appropriate (see Section 5.1.11), one third of the unexploited equilibrium stock was considered an indicative MBAL. In that case the age range used was that currently used in the catch-at-age matrix. In Division VIIa(N) a comparable calculation indicates an MBAL of 20,000 t. However, making alternative choices about the age range for calculating unexploited stock size can lead to a range of values from 20,000 to 45,000 t. Furthermore, the 33% figure is arbitrary. Arguably, a 20% figure could be used, leading to a possible range of MBAL of 12,000 to 27,000 t.

A Beverton-Holt stock-recruit curve was fitted to the historical (1972-93) stock and 1-ring recruit data for Division VIIa(N) herring (Figure 7.7.1). This is not a good fit to the data but serves in further considerations of MBAL. As suggested by Anon. (1993b) the intersection between the F=0 replacement line and the stock-recruit curve was determined. A value of 20% of the stock size at this intersection point was calculated as 12-27,000 t (Table 7.7.1). Anon. (1993b) suggest that this could be considered as MBAL.

Another suggestion by Anon. (1993b) was 50% of the long-term average of recruitment and the appropriate SSB from the stock-recruit curve. This suggests an MBAL of 2,300 t (Table 7.7.1). This is clearly rather low and approximately 38% of the smallest SSB suggested for this stock (Table 7.7.1) and between 2 and 4% of the unexploited stock. The calculation of MBAL from this part of the stock-recruit relationship is suspect since there is no information about the dependence of recruitment on SSB at low biomasses.

Given the uncertainties in trying to assess MBAL for this stock the Working Group feel that MBAL cannot be adequately described for this stock at present. However, the stock-recruit scatter plot suggests that at SSBs below 20,000 t there are very few good recruitment events. With an SSB above 20,000 t large recruitments do occur. Also, the most appropriate method of calculating unexploited stock is to utilise either ages 1 to 20-rings or 1 to 15-rings. These calculations point toward an MBAL of around 20,000 t. Considering the development of the stock between 1972 and the present (Figure 7.7.2) a figure of 20,000 t appears well above the precipitous decline seen through the late 1970s. Therefore, maintaining the SSB above 20,000 t for the present, until further analysis can be undertaken on determining MBAL, appears sensible.

7.8 Medium-term predictions of stock size

Stochastic projections over a 10-year time horizon were carried out using the ICA-linked program ICPRO ver 2.0 (Patterson W.D. 1996). The program reads ICA estimates of populations and Fs and the variance-covariance matrix for parameter estimates. Although there is only weak evidence for a stock-recruit relationship in this stock, a Beverton-Holt fit to the full historic series of stock and recruitment (see Figure 7.7.1) was used in the projection to allow the possibility of recruitment overfishing at low stock sizes. Projections were carried out for a range of F multipliers including the multiplier giving an F equivalent to the shrunk estimate of F from the baseline ICA assessment. Recruitment residuals in each of 1500 Monte Carlo simulations at each F multiplier were selected randomly and independently from the stock-recruit model residuals. Probability distributions of SSB were evaluated relative to a preliminary estimate of MBAL of 20,000 t.

Graphical output of the projection at the baseline assessment estimate of 1995 F (2-6) = 0.11 is shown in Figure 7.8.1. Median values of total landings increase slowly to just over 6000 t, whilst median SSB increases slowly to just over 50,000 t. The risk of SSB falling below MBAL remains small over the 10 years despite the large variance of population estimates resulting from the poor precision of the underlying stock assessment. A projection carried out for a TAC constraint of 7,000 t in each year (the present precautionary TAC) also resulted in probability of SSB<MBAL of less than 10% (Figure 7.8.2).

Figure 7.8.3(a) shows the probability of SSB falling below MBAL at the end of the 10 year projection, for different levels of F(2-6). The probability attains 50% at Fs of around 0.35 and approaches 100% at F=1.0. Figure 7.8.3(b) shows the median SSB at the end of the 10 year projection for different levels of F. The SSB approaches MBAL at approx F=0.35 and collapses to below 10,000 t at F > 0.5. The total yield over the 10-year period increases progressively with increasing F, but this must be balanced against the depression of SSB and the increasing risk of stock collapse (Figure 7.8.3c).

It is noteworthy that the simulations at F values similar to the actual values of 0.8 - 1.0 recorded during the 1970s when a large fleet of vessels fished Irish Sea herring, show a similar decline in SSB to that recorded in the historical VPA estimates. This emphasises the high risk to the stock caused by this level of F.

The long-term yield and spawning biomass per recruit are shown in Figure 7.8.4. Note that these are computed by assuming an age range of 1 to virtual extinction at each level of mortality (see discussion in Section 7.7).

Outputs of all simulation runs not shown in the report are held in the ICES stock files.

7.9 Management considerations

7.9.1 Precision of the assessment

Although the precision of the assessment presented here is low because of the short time-series of survey data, there is a strong indication that the overall herring stock in Division VIIa(N) is presently only lightly exploited. The stock appears to be dominated by the Manx herring component, and there appears to be only a small risk of the stock falling below the preliminary estimate of MBAL of 20,000 t SSB unless fishing mortalities are increased by a factor of three or more. The precision of the assessment should improve with the acquisition of further indices of abundance from the acoustic, larvae and groundfish surveys which are now established in the area. The present assessment indicates that the precautionary TAC of 7,000 t imposed in recent years could be taken safely as a constant catch, at least in the short term.

7.9.2 Spawning and Juvenile Fishing Area Closures

The present arrangement of closed boxes in Division VIIa(N) along the east coast of Ireland and the west coast of England, Scotland and Wales was established to protect juvenile herring at a time when an industrial fishery had been operating in the area, and when a large fleet of herring vessels operated in the Irish Sea. The Irish closed box was reduced in size following advice by the 1985 ICES Herring Assessment WORKING GROUP based on the results of a trawling survey. As there is no longer an industrial fishery, and the present herring fleet is small, the necessity for the juvenile closures is questionable. The series of acoustic and trawling surveys of Division VIIa(N) discussed in the present report have shown that juvenile herring are widespread throughout the year in areas beyond the closed boxes. Highest concentrations of 1-ring herring are often found off the west coast of the Isle of Man, where there is no closed box. Commercial fishermen claim that there are concentrations of adult herring within the eastern Irish Sea juvenile closure area during winter and spring, and that the present regulations restrict fishing opportunities. In view of the apparently low level of fishing mortality and the absence of an industrial fishery, the Working Group considers that the present juvenile closures could be relaxed. A system allowing temporary closures if catches of juvenile herring become excessive may be more appropriate than the present system.

The results of surveys have indicated a comparatively low spawning stock size of Mourne herring in the western Irish Sea. Continued protection of this spawning stock through a seasonal spawning closure would seem appropriate. It is not possible to evaluate the effect of the seasonal gillnet catch of spawning fish in this area. Catches are constrained by a quota that is usually set at around 600 t, although this is often not attained.

The SSB of Manx herring appears to have recovered substantially from the low levels recorded in the 1970s, and levels of F appear to be low at present. The 1994 and 1995 studies of the Douglas Bank spawning grounds indicated that spawning fish are concentrated within a much smaller area than covered by the closure. Spawning is mostly completed by the end of October, whereas the closure remains in force until 31 December. The closure is clearly an important management tool because of the concentration of the stock in such a small area, and the starting date of 21 September is appropriate in view of the pattern of spawning in most years. However, the Working Group considers that, provided the size of this stock is monitored through continuation of the present series of acoustic surveys, and provided an effective procedure for control of fishing activities is in place, some modification of the present Manx spawning closure could be acceptable to relax the restrictions on fishing opportunities.

7.10 Research and Data Requirements

The Working Group recommends that the present series of acoustic and larvae surveys be maintained to provide indices of spawning biomass of herring in the Irish Sea. Efforts should be made to provide age-disaggregated indices. In view of the known and surmised migrations of herring between the Irish Sea and surrounding regions, the Working Group also recommends the implementation of studies to quantify the extent of these migrations and their potential effect on the accuracy of stock assessments and the appropriateness of present management units.

Table 7.1.1. Irish Sea HERRING (Division VIIa(N)). Catch in tonnes by country, 1982-1995. These figures do not in all cases correspond to the official statistics and cannot be used for mangement purposes.

Country	1982	1983	1984	1985	1986	1987	1988
France	-	48	-	-	-	-	-
Ireland	300	860	1,084	1,000	1,640	1,200	2,579
UK	3,375	3,025	2,982	4,077	4,376	3,290	7,593
Unallocated	1,180	-	-	4,110	1,424	1,333	-
Total	4,855	3,933	4,066	9,187	7,440	5,823	10,172

Country	1989	1990	1991	1992	1993	1994	1995
France	-	-	-	-	-	-	-
Ireland	1,430	1,699	80	406	0	0	0
UK	3,532	4,613	4,318	4,864	4,408	4,828	5,076
Unallocated	-	-	-	-	-	-	-
Total	4,962	6,312	4,398	5,270	4,408	4,828	5,076

Table 7.1.2 Irish Sea HERRING. Sampling intensity of commercial landings for Division VIIa (N) in 1995.

Quarter	Country	Landings (t)	No. samples	No. fish measured	No. fish aged	Estimation of discards
	Ireland	0	-	-	-	-
1	UK (N.Ireland)	40	0	0	0	No
	UK (Isle of Man)	0	-	-	-	-
2	Ireland	0	-	-	-	-
	UK (N.Ireland)	22	0	0	0	No
	UK (Isle of Man)	0	-	-	--	--
3	Ireland	0	2*	569	100	No
	UK (N.Ireland)	2,734	64	6,520	1,996	No
	UK (Isle of Man)	615	8	2,182	400	No
4	Ireland	0	-	-	-	-
	UK (N.Ireland)	1,064	11	1,762	549	No
	UK (Isle of Man)	0	-	-	-	-

* Samples from NI landings

Table 7.1.3 Herring in the North Irish Sea (Manx plus Mourne VIIa(N)). Catch in numbers (thousands) by year.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1972	40640	46660	26950	13180	13750	6760	2660	1670
1973	42150	32740	38240	11490	6920	5070	2590	2600
1974	43250	109550	39750	24510	10650	4990	5150	1630
1975	33330	48240	39410	10840	7870	4210	2090	1640
1976	34740	56160	20780	15220	4580	2810	2420	1270
1977	30280	39040	22690	6750	4520	1460	910	1120
1978	15540	36950	13410	6780	1740	1340	670	350
1979	11770	38270	23490	4250	2200	1050	400	290
1980	5840	25760	19510	8520	1980	910	360	230
1981	5050	15790	3200	2790	2300	330	290	240
1982	5100	16030	5670	2150	330	1110	140	380
1983	1305	12162	5598	2820	445	484	255	59
1984	1168	8424	7237	3841	2221	380	229	479
1985	2429	10050	17336	13287	7206	2651	667	724
1986	4491	15266	7462	8550	4528	3198	1464	877
1987	2225	12981	6146	2998	4180	2777	2328	1671
1988	2607	21250	13343	7159	4610	5084	3232	4213
1989	1156	6385	12039	4708	1876	1255	1559	1956
1990	2313	12835	5726	9697	3598	1661	1042	1615
1991	1999	9754	6743	2833	5068	1493	719	815
1992	12145	6885	6744	6690	3256	5122	1036	392
1993	646	14636	3008	3017	2903	1606	2181	848
1994	1970	7002	12165	1826	2566	2104	1278	1991
1995	3204	21330	3391	5269	1199	1154	926	1452

Table 7.1.4 HERRING in Division VIIa (North). Catch at length for 1988-1995. Numbers of fish in thousands.

Length	1988	1989	1990	1991	1992	1993	1994	1995
14	1							
	1							
15	1				95			
	10				169			
16	13		6		343			21
	16		6	2	275			55
17	29		50	1	779		84	139
	44	24	7	4	1,106		59	148
18	46	44	224	31	1,263		69	300
	85	43	165	56	1,662		89	280
19	247	116	656	168	1,767	39	226	310
	306	214	318	174	1,189	75	241	305
20	385	226	791	454	1,268	75	253	326
	265	244	472	341	705	57	270	404
21	482	320	735	469	705	130	400	468
	530	401	447	296	597	263	308	78[illegible]
22	763	453	935	438	664	610	700	1,509
	1,205	497	581	782	927	1,224	785	2,541
23	2,101	612	2,400	1,790	1,653	2,016	1,035	4,198
	3,573	814	1,908	1,974	1,156	2,368	1,473	4,547
24	5,046	1,183	3,474	2,842	1,575	2,895	2,126	4,416
	5,447	1,656	2,818	2,311	2,412	2,616	2,564	3,391
25	5,276	2,206	4,803	2,734	2,792	2,207	3,315	3,100
	4,634	2,720	3,688	2,596	3,268	2,198	3,382	2,358
26	4,082	3,555	4,845	3,278	3,865	2,216	3,480	2,334
	4,570	3,293	3,015	2,862	3,908	2,176	2,617	1,807
27	4,689	2,847	3,014	2,412	3,389	2,299	2,391	1,622
	4,124	2,018	1,134	1,449	2,203	2,047	1,777	990
28	3,406	1,947	993	922	1,440	1,538	1,294	834
	2,916	1,586	582	423	569	944	900	123
29	2,659	1,268	302	293	278	473	417	248
	1,740	997	144	129	96	160	165	56
30	1,335	801	146	82	70	83	9	40
	685	557	57	36	36	15	27	5
31	563	238	54	12	2	4		
	144	128	31	3				
32	80	57	29					
	7	7						
33	2	5						
	1	6						
34		0						
		5						

Table 7.2.1 HERRING in Division VIIa (North). Mean length at age.

Year	Lengths at age (cm)							
	Age (rings)							
	1	2	3	4	5	6	7	8
1985	22.1	24.3	26.1	27.6	28.3	28.6	29.5	30.1
1986	19.7	24.3	25.8	26.9	28.0	28.8	28.8	29.8
1987	20.0	24.1	26.3	27.3	28.0	29.2	29.4	30.1
1988	20.2	23.5	25.7	26.3	27.2	27.7	28.7	29.6
1989	20.9	23.8	25.8	26.8	27.8	28.2	28.0	29.5
1990	20.1	24.2	25.6	26.2	27.7	28.3	28.3	29.0
1991	20.5	23.8	25.4	26.1	26.8	27.3	27.7	28.7
1992	19.0	23.7	25.3	26.2	26.7	27.2	27.9	29.4
1993	21.6	24.1	25.9	26.7	27.2	27.6	28.0	28.7
1994	20.1	23.9	25.5	26.5	27.0	27.4	27.9	28.4
1995	20.4	23.6	25.2	26.3	26.8	27.0	27.6	28.3

Table 7.2.2 HERRING in Division VIIa (North). Mean weights at age.

Year	Weights at age (g)							
	Age (rings)							
	1	2	3	4	5	6	7	8
1985	87	125	157	186	202	209	222	258
1986	68	143	167	188	215	229	239	254
1987	58	130	160	175	194	210	218	229
1988	70	124	160	170	180	198	212	232
1989	81	128	155	174	184	195	205	218
1990	77	135	163	175	188	196	207	217
1991	70	121	153	167	180	189	195	214
1992	61	111	136	151	159	171	179	191
1993	88	126	157	171	183	191	198	214
1994	73	126	154	174	181	190	203	214
1995	72	120	147	168	180	185	197	212

Table 7.3.1 Herring: Summary of acoustic survey information for Division VIIa(N) for the period 1989-1995. Small clupeoids include sprat and 0-ring herring unless otherwise stated. CVs are approximate. Biomass in t.

Year	Area	Dates	herring biomass	CV	composition	small clupeoids biomass	CV
1989	Douglas Bank	25-26 Sept	18000	-	SSB	-	-
1990	Douglas Bank	26-27 Sept	26600	-	SSB	-	-
1991	Western Irish Sea	26 July - 8 Aug	12760	0.23	1+ ringers	66000[1]	0.20
1992	Western Irish Sea + IOM east coast	20 - 31 July	17490	0.19	1+ ringers	43200	0.25
1993	Douglas Bank	22-25 Sept	*	-	SSB	-	-
1994	Area VIIa(N)	28 Aug - 8 Sep	31400	0.36	1+ ringers	68600	0.10
	Douglas Bank	22-26 Sept	28200	-	SSB	-	-
1995	Area VIIa(N)	11-22 Sept	53200	0.32	1+ ringers	344700	0.13
	Douglas Bank	26-28 Sept	*	-	SSB	-	-
	Douglas Bank	10-11 Oct	9840	-	SSB	-	-
	Douglas Bank	23-24 Oct	1750	0.51	SSB	-	-

* data not supplied to WG

[1] sprat only

Table 7.3.2 Irish Sea HERRING larval production (10^{11}) indices for the Manx component of Division VIIa(N)

Year	Douglas Bank	North east of the Isle of Man	
		Northern Ireland	Isle of Man
1989	3.39		
1990	1.92		
1991	1.56		
1992	15.64		128.86
1993	4.81	34.7	1.10
1994	7.30	52.5	12.50
1995	1.58	15.4	-[1]

[1]No assessment

Table 7.4.1 Tuning indices used for the Irish Sea (VIIa(N)) herring assessment. Values and approximate CVs are given. na = not available. GFS0S = Groundfish survey, 0-ring herring, September; GFS1J = Groundfish survey, 1-ring herring, June; GFS1M = Groundfish survey, 1-ring herring, March; GFS1S = Groundfish survey, 1-ring herring, September; SSBA = Spawning stock biomass by acoustic techniques (AC_DB = Douglas Bank acoustic surveys covering only the spawning stock, AC_VIIa(N) = Irish Sea acoustic surveys covering 1+ringers); DBL = larvae production on Douglas Bank.

Year	GFS0S[1]	GFS1J[1]	GFS1M[1]	GFS1S[1]	SSBA		DBL[4]
					AC_DB[2]	AC_VIIa(N)[3]	
1989					18000 (na)	-	3.39 (0.49)
1990					26000 (na)	-	1.92 (0.24)
1991		409 (0.50)		102 (0.33)	-	-	1.56 (0.22)
1992	54 (0.41)	358 (0.39)	392 (0.51)	36 (0.50)	-	-	15.64 (0.55)
1993	210 (0.47)	434 (0.42)	36 (0.50)	122 (0.54)	-	-	4.81 (0.18)
1994	633 (0.52)	953 (0.47)	2472 (0.75)	490 (0.28)	28200 (na)	18840 (0.36)	7.30 (0.58)
1995	548 (0.29)		1299 (0.52)	153 (0.40)	-	31920 (0.32)	1.58 (0.42)
1996	67 (0.34)		1055 (0.60)				

1. Numbers per 3 nautical miles, western Irish Sea only
2. Biomass of spawning aggregation, t
3. Biomass of 1+ herring, t.
4. Numbers of larvae at 6mm x 10^{-11}

Table 7.5.1 Herring in VIIa(N): results of baseline assessment.

CATCH NUMBERS AT AGE (Millions)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	35.	30.	16.	12.	6.	5.	5.	1.	1.	2.	4.	2.	3.	1.	2.	2.	12.	1.	2.	3.
2	56.	39.	37.	38.	26.	16.	16.	12.	8.	10.	15.	13.	21.	6.	13.	10.	7.	15.	7.	21.
3	21.	23.	13.	23.	20.	3.	6.	6.	7.	17.	7.	6.	13.	12.	6.	7.	7.	3.	12.	3.
4	15.	7.	7.	4.	9.	3.	2.	3.	4.	13.	9.	3.	7.	5.	10.	3.	7.	3.	2.	5.
5	5.	5.	2.	2.	2.	2.	0.	0.	2.	7.	5.	4.	5.	2.	4.	5.	3.	3.	3.	1.
6	3.	1.	1.	1.	1.	0.	1.	0.	0.	3.	3.	3.	5.	1.	2.	1.	5.	2.	2.	1.
7	2.	1.	1.	0.	0.	0.	0.	0.	0.	1.	1.	2.	3.	2.	1.	1.	1.	2.	1.	1.
8	1.	1.	0.	0.	0.	0.	0.	0.	0.	1.	1.	2.	4.	2.	2.	1.	0.	1.	2.	1.

INDICES OF SPAWNING STOCK BIOMASS

	1989	1990	1991	1992	1993	1994	1995
1	.339E+04	.192E+04	.156E+04	.156E+05	.481E+04	.730E+04	.158E+04
2	.180E+05	.266E+05	-.100E+01	-.100E+01	-.100E+01	.282E+05	-.100E+01
3	-.100E+01	-.100E+01	-.100E+01	-.100E+01	-.100E+01	.188E+05	.319E+05

AGE - STRUCTURED INDICES

INDEX : 1 from 1991 to 1994

	1991	1992	1993	1994
1	.409E+03	.358E+03	.434E+03	.953E+03

INDEX : 2 from 1991 to 1995

	1991	1992	1993	1994	1995
1	.102E+03	.360E+02	.122E+03	.490E+03	.153E+03

FISHING MORTALITY

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	.2291	.1570	.1029	.1406	.0586	.0346	.0337	.0084	.0130	.0238	.0371	.0104	.0282	.0090	.0245	.0173	.0220	.0151	.0158	.0110
2	.7897	.8536	.5318	.7453	1.0443	.3899	.2500	.1768	.1139	.2527	.3549	.2439	.2209	.1498	.2592	.1829	.2318	.1590	.1666	.1158
3	.9716	.9869	.9148	.8528	1.2888	.3568	.2505	.1371	.1606	.3833	.3214	.2506	.4538	.1992	.2507	.1770	.2243	.1538	.1611	.1120
4	1.0935	.9820	.8920	.8124	.8487	.5875	.4095	.1805	.1249	.4646	.3134	.1958	.4878	.2705	.2159	.1524	.1931	.1324	.1388	.0965
5	.8866	1.0543	.6482	.7279	1.0333	.5106	.1108	.1233	.1889	.3222	.2525	.2219	.4570	.2015	.2390	.1687	.2138	.1466	.1536	.1068
6	.9464	.7000	.9498	.9336	.6727	.4082	.4394	.2105	.1322	.3202	.2066	.2166	.4056	.1920	.2279	.1608	.2039	.1398	.1465	.1018
7	.8571	.8317	.7216	.7419	.8799	.4135	.2700	.1513	.1308	.3199	.2619	.2041	.3719	.1861	.2159	.1524	.1931	.1324	.1388	.0965
8	.8571	.8317	.7216	.7419	.8799	.4135	.2700	.1513	.1308	.3199	.2619	.2041	.3719	.1861	.2159	.1524	.1931	.1324	.1388	.0965

NUMBERS AT AGE (Millions)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	263.	325.	249.	140.	162.	235.	243.	248.	143.	163.	195.	339.	148.	205.	171.	135.	232.	175.	539.	299.	185.
2	117.	77.	102.	83.	45.	56.	83.	86.	90.	52.	59.	69.	123.	53.	75.	61.	49.	84.	63.	195.	109.
3	36.	39.	24.	45.	29.	12.	28.	48.	54.	60.	30.	30.	40.	73.	34.	43.	38.	29.	53.	40.	129.
4	24.	11.	12.	8.	16.	7.	7.	18.	34.	37.	33.	18.	19.	21.	49.	22.	29.	25.	20.	37.	29.
5	8.	7.	4.	4.	3.	6.	3.	4.	14.	27.	21.	22.	13.	11.	14.	36.	17.	22.	20.	16.	30.
6	5.	3.	2.	2.	2.	1.	3.	3.	3.	10.	18.	15.	16.	8.	8.	10.	27.	12.	17.	15.	13.
7	4.	2.	1.	1.	1.	1.	1.	2.	2.	3.	7.	13.	11.	10.	6.	6.	8.	20.	10.	13.	12.
8	2.	2.	2.	1.	1.	1.	1.	1.	2.	3.	4.	7.	15.	16.	19.	18.	19.	20.	32.	33.	38.

Table 7.5.1 contd.

STOCK SUMMARY

Year	Recruits x10^6	Total B tonnes	Spawn B tonnes	Landings tonnes	Yld/SSB	Ref. F Fbar 2- 6
1976	263.	54629.	12956.	21250.	1.6402	.9375
1977	325.	49690.	9668.	15410.	1.5939	.9154
1978	249.	43938.	11259.	11080.	.9841	.7873
1979	140.	35700.	9997.	12338.	1.2341	.8144
1980	162.	29636.	5969.	10613.	1.7780	.9776
1981	235.	31814.	8233.	4377.	.5316	.4506
1982	243.	39854.	13822.	4855.	.3512	.2920
1983	248.	47409.	20599.	3933.	.1909	.1656
1984	143.	45879.	25690.	4066.	.1583	.1441
1985	163.	46100.	20307.	9187.	.4524	.3486
1986	195.	44131.	20652.	7440.	.3603	.2897
1987	339.	48582.	20552.	5823.	.2833	.2258
1988	148.	46731.	21900.	10172.	.4645	.4050
1989	205.	47337.	22465.	4949.	.2203	.2026
1990	171.	47039.	23582.	6312.	.2677	.2385
1991	135.	40444.	23108.	4398.	.1903	.1684
1992	232.	41489.	20124.	5270.	.2619	.2134
1993	175.	49218.	25586.	4409.	.1723	.1463
1994	539.	74535.	27722.	4828.	.1742	.1533
1995	299.	72176.	37843.	5076.	.1341	.1066

PARAMETER ESTIMATES +/- SD

Separable Model: Reference F by year				
1	1990	.2159	.1376	.3387
2	1991	.1524	.0959	.2422
3	1992	.1931	.1200	.3109
4	1993	.1324	.0802	.2186
5	1994	.1388	.0824	.2338
6	1995	.0965	.0557	.1671
Separable Model: Selection (S) by age				
7	1	.1137	.0535	.2415
8	2	1.2004	.8431	1.7092
9	3	1.1612	.8395	1.6062
	4	1.0000	Fixed : Reference age	
10	5	1.1070	.8404	1.4581
11	6	1.0555	.8025	1.3882
	7	1.0000	Fixed : last true age	
Separable Model: Populations in year 1995				
12	1	298718.	152070.	586787.
13	2	195340.	119464.	319407.
14	3	39681.	23553.	66851.
15	4	36798.	21877.	61894.
16	5	15857.	9267.	27133.
17	6	15265.	8865.	26286.
18	7	13350.	7653.	23286.

Table 7.5.1 contd.

Separable Model: Populations at age 7

19	1990	5628.2272	2906.0061	10900.5077
20	1991	5745.7223	3216.2301	10264.6028
21	1992	7893.4084	4597.9371	13550.8373
22	1993	20223.9557	11652.1519	35101.5323
23	1994	9603.4359	5541.8013	16641.8781

SSB Index catchabilities

24	1	Linear Model : Q	.14764E+00	.10086E+00	.21610E+00
25	2	Linear Model : Q	.10088E+01	.68411E+00	.14875E+01
26	3	Linear Model : Q	.75966E+00	.41810E+00	.13802E+01

Age-structured index catchabilities

Age-Structured Index 1

Linear model fitted. Slopes at age:

27	1 Q	.35941E-02	.22859E-02	.56508E-02

Age-Structured Index 2

Linear model fitted. Slopes at age:

28	1 Q	.11318E-02	.71907E-03	.17814E-02

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals
(log(Observed Catch)-log(Expected Catch))
and weights (W) used in the analysis.

Age	1990	1991	1992	1993	1994	1995	
1	-.12884E+00	.30860E+00	.13357E+01	-.93858E+00	-.99811E+00	.44061E+00	.10000E+00
2	-.14479E+00	.89212E-01	-.24284E+00	.31782E+00	-.18469E+00	.14177E+00	.10000E+01
3	-.17344E+00	.68159E-01	-.27752E-01	-.21087E+00	.53265E+00	-.11892E+00	.10000E+01
4	.63249E-01	-.22010E-01	.31019E+00	.28419E-01	-.30826E+00	.49138E+00	.10000E+01
5	.21044E+00	-.45550E-01	.60197E-01	.22060E-01	-.39392E-01	-.24384E+00	.10000E+01
6	.69383E-01	.28665E-01	.61197E-01	.57082E-01	-.52484E-01	-.19880E+00	.10000E+01
7	-.37796E-04	-.73687E-01	-.24345E+00	-.91340E-01	.75096E-01	-.23347E+00	.10000E+01
Wts	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	

Biomass Index Residuals: log(Observed Index) - log(Expected Index)

Idx	1989	1990	1991	1992	1993	1994	1995
1	.21871E-01	-.59518E+00	-.78251E+00	.16609E+01	.24162E+00	.57863E+00	-.12630E+01
2	-.23031E+00	.11168E+00	-.10000E+01	-.10000E+01	-.10000E+01	.83525E-02	-.10000E+01
3	-.10000E+01	-.10000E+01	-.10000E+01	-.10000E+01	-.10000E+01	-.11136E+00	.10469E+00

Table 7.5.1 contd.

Aged Index Residuals: log(Observed Index) - log(Expected Index)

Aged Index 1

Age	1991	1992	1993	1994
1	.35301E+00	-.31994E+00	.15400E+00	-.18707E+00

Aged Index 2

Age	1991	1992	1993	1994	1995
1	.37408E+00	-.12060E+01	.29422E+00	.55715E+00	-.19473E-01

PARAMETERS OF THE DISTRIBUTION OF ln CATCHES AT AGE

Separable model fitted from 1990 to 1995

Variance	:	.2803
Skewness test statistic	:	1.2570
Kurtosis test statistic	:	6.1945
Partial chi-square	:	.6607
Probability of chi-square	:	1.0000
Degrees of freedom	:	19

PARAMETERS OF THE DISTRIBUTION OF THE SSB INDICES

DISTRIBUTION STATISTICS FOR ln SSB INDEX 1

Linear catchability relationship assumed.

Variance	:	.9519
Skewness test statistic	:	.4362
Kurtosis test statistic	:	-.3731
Partial chi-square	:	.6960
Probability of chi-square	:	.9946
Number of observations	:	7
Degrees of freedom	:	6
Weight in the analysis	:	1.0000

Table 7.5.1 contd.

DISTRIBUTION STATISTICS FOR ln SSB INDEX 2

Linear catchability relationship assumed.

Variance	:	.0308
Skewness test statistic	:	-.7892
Kurtosis test statistic	:	-.3285
Partial chi-square	:	.0065
Probability of chi-square	:	1.0000
Number of observations	:	3
Degrees of freedom	:	2
Weight in the analysis	:	1.0000

DISTRIBUTION STATISTICS FOR ln SSB INDEX 3

Linear catchability relationship assumed.

Variance	:	.0233
Skewness test statistic	:	-.0535
Kurtosis test statistic	:	-.5763
Partial chi-square	:	.0023
Probability of chi-square	:	1.0000
Number of observations	:	2
Degrees of freedom	:	1
Weight in the analysis	:	1.0000

PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES

DISTRIBUTION STATISTICS FOR ln AGED INDEX 1

Linear catchability relationship assumed.

Age	:	1
Variance	:	.0952
Skewness test stat.	:	.0893
Kurtosis test stat.	:	-.6686
Partial chi-square	:	.0475
Prob. of chi-square	:	.9973
Number of data	:	4
Degrees of freedom	:	3
Weight in analysis	:	1.0000

Table 7.5.1 contd.

DISTRIBUTION STATISTICS FOR ln AGED INDEX 2

Linear catchability relationship assumed.

Age	:	1
Variance	:	.4979
Skewness test stat.	:	-1.0916
Kurtosis test stat.	:	-.0814
Partial chi-square	:	.4109
Prob. of chi-square	:	.9816
Number of data	:	5
Degrees of freedom	:	4
Weight in analysis	:	1.0000

Table 7.5.2 Herring in VIIa(N). Population estimates after shrinkage of 1995 F to 1991-95 mean.

Conventional VPA with Fishing Mortality Shrinkage

Fs shrunk over 5 years
Minimum CV of the mean taken as .500

Shrinkage Diagnostics

F from Model fit Estimate	Variance	Historic Mean F Estimate	Variance	Wt for F from Model	Shrunk Estimate
.011	.766	.016	.250	.246	.014
.116	.328	.167	.250	.432	.143
.112	.333	.162	.250	.428	.138
.096	.302	.139	.250	.453	.118
.107	.327	.154	.250	.433	.131
.102	.336	.147	.250	.427	.126
.096	.302	.139	.250	.453	.120
*****	.420	.139	.250	.373	.120

Fishing Mortality Estimates

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	.2290	.1563	.1026	.1393	.0587	.0332	.0330	.0082	.0130	.0237
2	.7883	.8530	.5284	.7425	1.0271	.3909	.2387	.1733	.1111	.2527
3	.9688	.9829	.9131	.8418	1.2756	.3455	.2513	.1296	.1568	.3714
4	1.0988	.9744	.8829	.8090	.8234	.5730	.3907	.1812	.1172	.4496
5	.8952	1.0693	.6372	.7116	1.0224	.4820	.1070	.1161	.1898	.2977
6	.9877	.7150	.9870	.8991	.6433	.3997	.4012	.2021	.1234	.3222
7	1.0580	.9249	.7537	.8121	.8044	.3837	.2622	.1342	.1246	.2937
8	1.0580	.9249	.7537	.8121	.8044	.3837	.2622	.1342	.1246	.2937

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	.0363	.0103	.0288	.0102	.0214	.0258	.0709	.0061	.0058	.0145
2	.3532	.2385	.2185	.1534	.2556	.1995	.1965	.1941	.1404	.1426
3	.3214	.2490	.4395	.1965	.2125	.2199	.2190	.1305	.2603	.1381
4	.2997	.1958	.4832	.2584	.2278	.1468	.3343	.1367	.1038	.1179
5	.2410	.2094	.4569	.1989	.2864	.1600	.2241	.2114	.1481	.1314
6	.1866	.2043	.3750	.1920	.2423	.1651	.2154	.1474	.2090	.1256
7	.2641	.1804	.3442	.1678	.2167	.1717	.2861	.1325	.1380	.1201
8	.2641	.1804	.3442	.1678	.2167	.1717	.2861	.1325	.1380	.1201

Table 7.5.2 continued

Numbers at Age (Thousands)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	264.	327.	250.	142.	161.	244.	248.	253.	143.	164.	198.	342.	145.	180.	173.	124.	279.	169.	534.	299.	185.
2	117.	77.	103.	83.	45.	56.	87.	88.	92.	52.	59.	70.	125.	52.	65.	62.	44.	96.	62.	195.	108.
3	36.	39.	24.	45.	29.	12.	28.	51.	55.	61.	30.	31.	41.	74.	33.	38.	38.	27.	58.	40.	126.
4	24.	11.	12.	8.	16.	7.	7.	18.	36.	38.	35.	18.	20.	22.	50.	22.	25.	25.	19.	37.	28.
5	8.	7.	4.	5.	3.	6.	3.	4.	13.	29.	22.	23.	13.	11.	15.	36.	17.	16.	20.	16.	30.
6	5.	3.	2.	2.	2.	1.	4.	3.	3.	10.	20.	16.	17.	8.	8.	10.	28.	12.	12.	15.	13.
7	4.	2.	1.	1.	1.	1.	1.	2.	2.	3.	7.	15.	12.	11.	6.	6.	8.	20.	10.	9.	12.
8	2.	2.	1.	1.	0.	1.	2.	0.	4.	3.	4.	11.	15.	13.	9.	5.	2.	7.	16.	13.	18.

Stock Summary

Year	Recruits	Total B	Spawn B	Landings	Yld/SSB
1976	264.	54528.	12781.	21250.	1.6627
1977	327.	49650.	9578.	15410.	1.6088
1978	250.	43816.	11199.	11080.	.9894
1979	142.	35705.	10001.	12338.	1.2336
1980	161.	29679.	6083.	10613.	1.7447
1981	244.	32732.	8446.	4377.	.5182
1982	248.	41093.	14503.	4855.	.3348
1983	253.	48570.	21216.	3933.	.1854
1984	143.	47468.	27022.	4066.	.1505
1985	164.	46907.	21029.	9187.	.4369
1986	198.	45263.	21460.	7440.	.3467
1987	342.	50474.	22013.	5823.	.2645
1988	145.	47213.	22557.	10172.	.4510
1989	180.	45002.	22278.	4949.	.2221
1990	173.	43701.	21225.	6312.	.2974
1991	124.	36278.	20165.	4398.	.2181
1992	279.	39977.	16506.	5270.	.3193
1993	169.	46185.	22867.	4409.	.1928
1994	534.	70315.	24114.	4828.	.2002
1995	299.	67203.	32876.	5076.	.1544

Table 7.6.1

14:24 Wednesday, April 17, 1996

Herring in the North Irish Sea (Manx plus Mourne VIIa North)

Prediction with management option table: Input data

Year: 1996								
Age	Stock size	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	222.000	1.0000	0.0800	0.9000	0.7500	0.078	0.0135	0.078
2	108.000	0.3000	0.8500	0.9000	0.7500	0.124	0.1423	0.124
3	126.000	0.2000	1.0000	0.9000	0.7500	0.153	0.1377	0.152
4	28.000	0.1000	1.0000	0.9000	0.7500	0.171	0.1186	0.168
5	30.000	0.1000	1.0000	0.9000	0.7500	0.181	0.1313	0.179
6	13.000	0.1000	1.0000	0.9000	0.7500	0.189	0.1252	0.187
7	12.000	0.1000	1.0000	0.9000	0.7500	0.199	0.1186	0.198
8+	18.000	0.1000	1.0000	0.9000	0.7500	0.213	0.1186	0.210
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Year: 1997								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	222.000	1.0000	0.0800	0.9000	0.7500	0.078	0.0135	0.078
2	.	0.3000	0.8500	0.9000	0.7500	0.124	0.1423	0.124
3	.	0.2000	1.0000	0.9000	0.7500	0.153	0.1377	0.152
4	.	0.1000	1.0000	0.9000	0.7500	0.171	0.1186	0.168
5	.	0.1000	1.0000	0.9000	0.7500	0.181	0.1313	0.179
6	.	0.1000	1.0000	0.9000	0.7500	0.189	0.1252	0.187
7	.	0.1000	1.0000	0.9000	0.7500	0.199	0.1186	0.198
8+	.	0.1000	1.0000	0.9000	0.7500	0.213	0.1186	0.210
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Year: 1998								
Age	Recruit-ment	Natural mortality	Maturity ogive	Prop.of F bef.spaw.	Prop.of M bef.spaw.	Weight in stock	Exploit. pattern	Weight in catch
1	.	1.0000	0.0800	0.9000	0.7500	0.078	0.0135	0.078
2	.	0.3000	0.8500	0.9000	0.7500	0.124	0.1423	0.124
3	.	0.2000	1.0000	0.9000	0.7500	0.153	0.1377	0.152
4	.	0.1000	1.0000	0.9000	0.7500	0.171	0.1186	0.168
5	.	0.1000	1.0000	0.9000	0.7500	0.181	0.1313	0.179
6	.	0.1000	1.0000	0.9000	0.7500	0.189	0.1252	0.187
7	.	0.1000	1.0000	0.9000	0.7500	0.199	0.1186	0.198
8+	.	0.1000	1.0000	0.9000	0.7500	0.213	0.1186	0.210
Unit	Millions	-	-	-	-	Kilograms	-	Kilograms

Notes: Run name : MANRDN02
Date and time: 17APR96:14:42

Table 7.6.2

Herring in the North Irish Sea (Manx plus Mourne VIIa North)

14:24 Wednesday, April 17, 1996

Prediction with management option table

Year: 1996					Year: 1997					Year: 1998	
F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	F Factor	Reference F	Stock biomass	Sp.stock biomass	Catch in weight	Stock biomass	Sp.stock biomass
1.1834	0.1551	68783	38142	7000	0.0000	0.0000	67949	44521	0	57525	50238
.	.	.	.	.	0.2000	0.0262	.	43522	1208	56295	47995
.	.	.	.	.	0.4000	0.0524	.	42545	2387	55095	45856
.	.	.	.	.	0.6000	0.0786	.	41591	3537	53926	43814
.	.	.	.	.	0.8000	0.1048	.	40659	4660	52786	41865
.	.	.	.	.	1.0000	0.1310	.	39748	5755	51674	40006
.	.	.	.	.	1.2000	0.1572	.	38858	6824	50590	38231
.	.	.	.	.	1.4000	0.1834	.	37988	7867	49533	36537
.	.	.	.	.	1.6000	0.2096	.	37138	8885	48502	34920
.	.	.	.	.	1.8000	0.2358	.	36307	9878	47497	33376
.	.	.	.	.	2.0000	0.2620	.	35495	10848	46517	31903
.	.	.	.	.	2.2000	0.2882	.	34702	11794	45561	30496
.	.	.	.	.	2.4000	0.3144	.	33927	12718	44630	29154
.	.	.	.	.	2.6000	0.3407	.	33169	13619	43721	27872
.	.	.	.	.	2.8000	0.3669	.	32429	14499	42835	26648
.	.	.	.	.	3.0000	0.3931	.	31706	15358	41970	25479
-	-	Tonnes	Tonnes	Tonnes	-	-	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes

Notes: Run name : MANRDN02
Date and time : 17APR96:14:42
Computation of ref. F: Simple mean, age 2 - 6
Basis for 1996 : TAC constraints

Table 7.6.3

Herring in the North Irish Sea (Manx plus Mourne VIIa North)

Single option prediction: Detailed tables

Year: 1996 F-factor: 1.1834 Reference F: 0.1550

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0160	2227	174	222000	17242	17760	1379	8269	642
2	0.1684	14522	1796	108000	13392	91800	11383	62995	7811
3	0.1630	17219	2617	126000	19236	126000	19236	93655	14298
4	0.1404	3493	588	28000	4788	28000	4788	22894	3915
5	0.1554	4114	738	30000	5440	30000	5440	24200	4388
6	0.1482	1706	319	13000	2453	13000	2453	10555	1991
7	0.1404	1497	296	12000	2392	12000	2392	9812	1956
8+	0.1404	2246	472	18000	3840	18000	3840	14718	3140
Total		47023	7000	557000	68783	336560	50911	247099	38142
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Year: 1997 F-factor: 1.0000 Reference F: 0.1310

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0135	1884	147	222000	17242	17760	1379	8288	644
2	0.1423	9243	1143	80375	9966	68319	8472	47996	5951
3	0.1377	7901	1201	67608	10322	67608	10322	51408	7848
4	0.1186	9337	1572	87648	14988	87648	14988	73082	12497
5	0.1313	2581	463	22018	3993	22018	3993	18150	3291
6	0.1252	2605	487	23239	4384	23239	4384	19262	3634
7	0.1186	1081	214	10143	2022	10143	2022	8457	1686
8+	0.1186	2513	529	23591	5033	23591	5033	19670	4196
Total		37145	5755	536621	67949	320325	50592	246315	39748
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Year: 1998 F-factor: 1.0000 Reference F: 0.1310

						1 January		Spawning time	
Age	Absolute F	Catch in numbers	Catch in weight	Stock size	Stock biomass	Sp.stock size	Sp.stock biomass	Sp.stock size	Sp.stock biomass
1	0.0135	.	.	.	.	.	.	.	.
2	0.1423	9266	1146	80574	9991	68488	8493	48115	5966
3	0.1377	6035	917	51645	7885	51645	7885	39270	5995
4	0.1186	5138	865	48233	8248	48233	8248	40217	6877
5	0.1313	8257	1481	70438	12773	70438	12773	58065	10529
6	0.1252	1959	366	17471	3296	17471	3296	14482	2732
7	0.1186	1976	391	18553	3698	18553	3698	15470	3084
8+	0.1186	2888	607	27110	5783	27110	5783	22605	4822
Total		35519	5773	314023	51674	301937	50175	238223	40006
Unit	-	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes	Thousands	Tonnes

Notes: Run name : SPRRDN02
Date and time : 17APR96:14:55
Computation of ref. F: Simple mean, age 2 - 6
Prediction basis : F factors

Table 7.7.1. Estimation of MBAL and minimum observed stock size for the Irish Sea (VIIa(N)). Recruitment taken as 256 million.

Method		**SSB (t) (MBAL?)**	
Minimum size of SSB		6,082	
Equilibrium unexploited stock calculations			
Age range	Equilibrium unexploited stock (SSB)	33% of Equilibrium unexploited stock (SSB)	20% of Equilibrium unexploited stock (SSB)
1-virtual extiction	134,000	44,700	26,800
1- 20 rings	111,900	37,300	22,400
1- 15 rings	97,000	32,500	19,500
1- 8 rings	60,500	20,167	12,100

50% of recruitment on stock-recruit curve (Beverton-Holt)	2,300

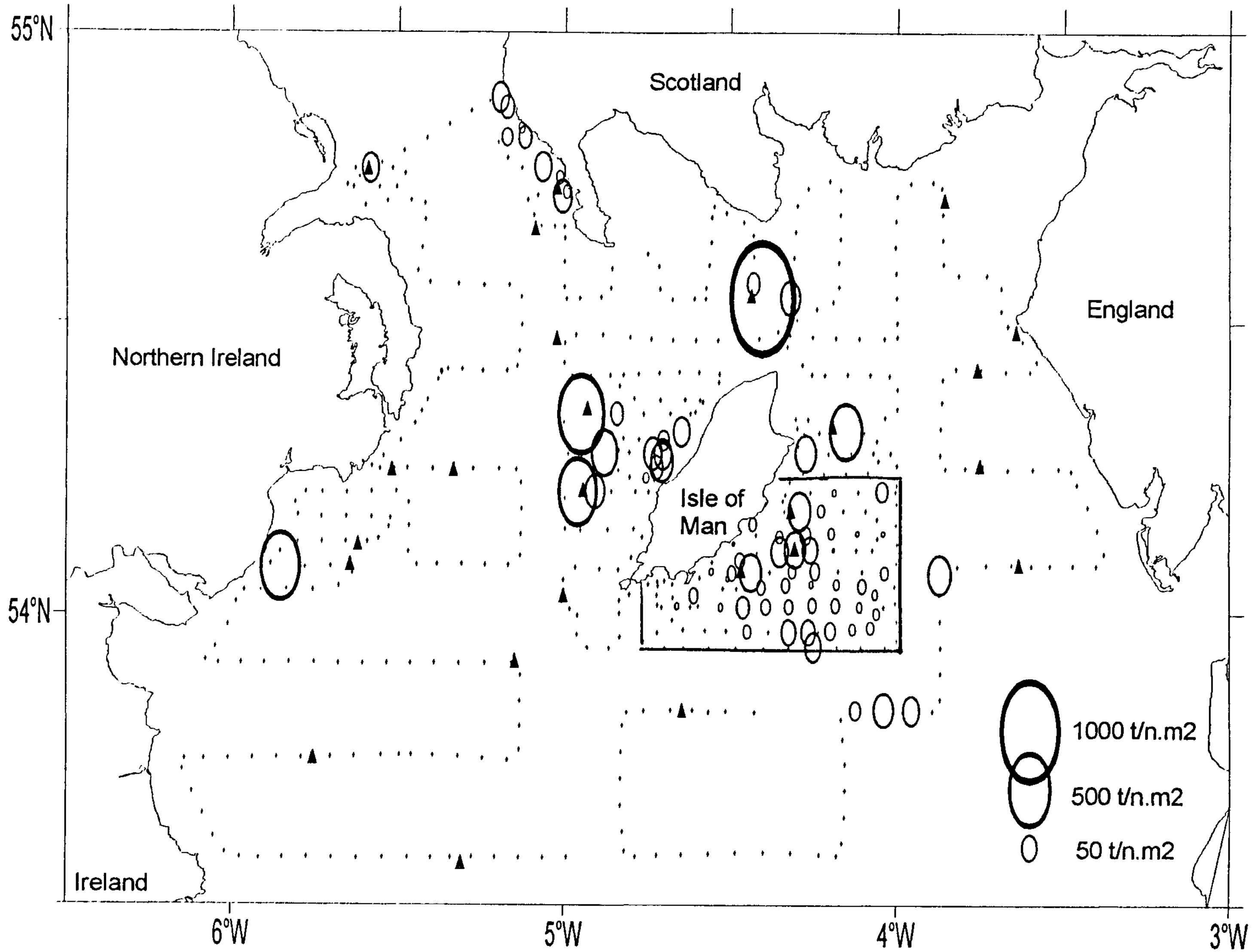
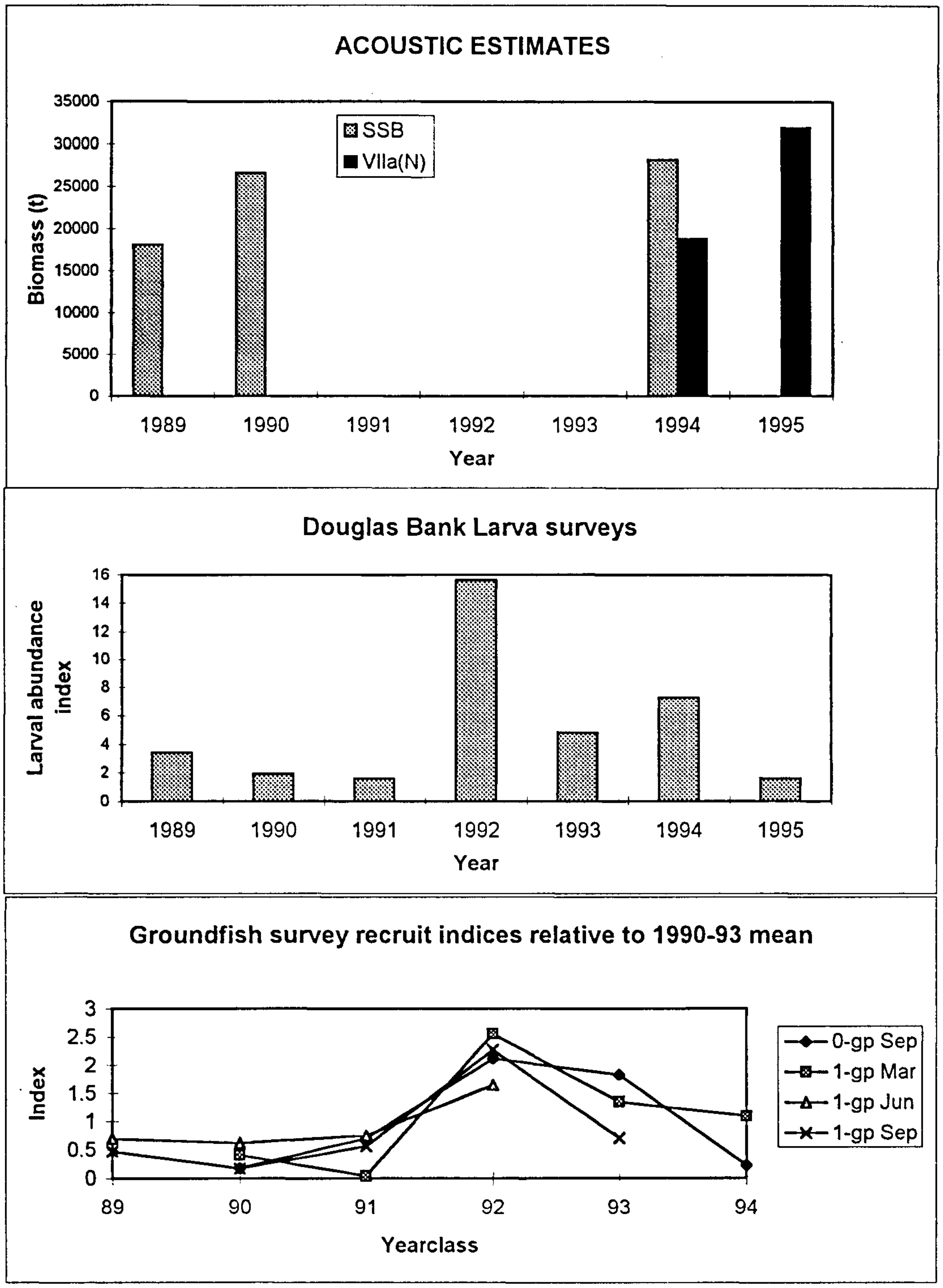


Figure 7.3.1 Density distribution of herring considered to be 1+ ringers during the hydroacoustic survey of the Irish Sea from 11-22 September 1995. Areas of ellipses are proportional to density of herring. Triangles are trawl positions.

Fig. 7.4.1 Survey indices used for tuning the ICA runs for herring in the Irish Sea (VIIa(N)). The acoustic estimates for VIIa(N) are for 1+ ringers and have been reduced to 60% to reflect SSB estimates.



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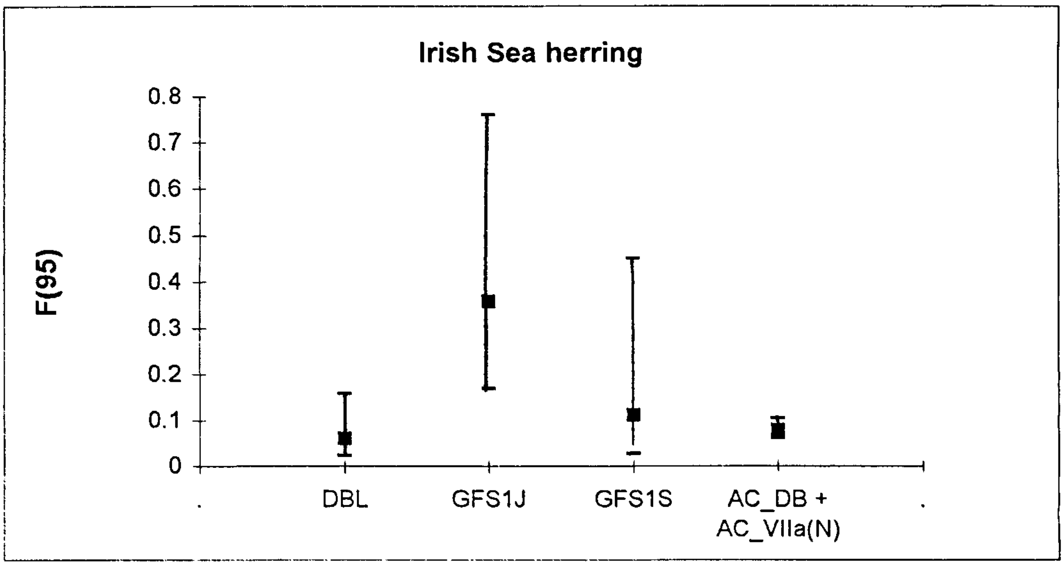

Fig. 7.4.2 Estimates of reference F in 1995 with 1 SD error bars from separate fits of ICA model to four tuning data sets for Irish Sea herring

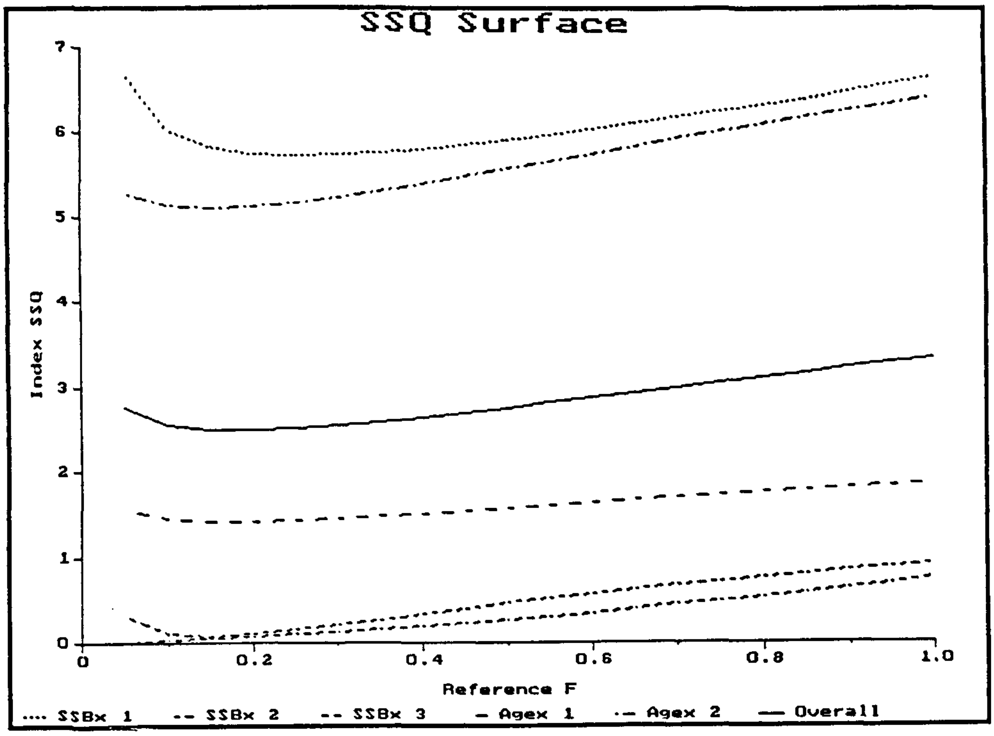

Figure 7.5.1 Herring in VIIa(N). SSQ surface for the baseline assessment. SSBx 1 = Douglas Bank larvae survey; SSBx 2 = Douglas Bank acoustic survey index; SSBx 3 = VIIa(N) acoustic survey adjusted to give SSB; Agex 1 = GFS index of 1-ringers in June; Agex 2 = GFS index of 1-ringers in September.

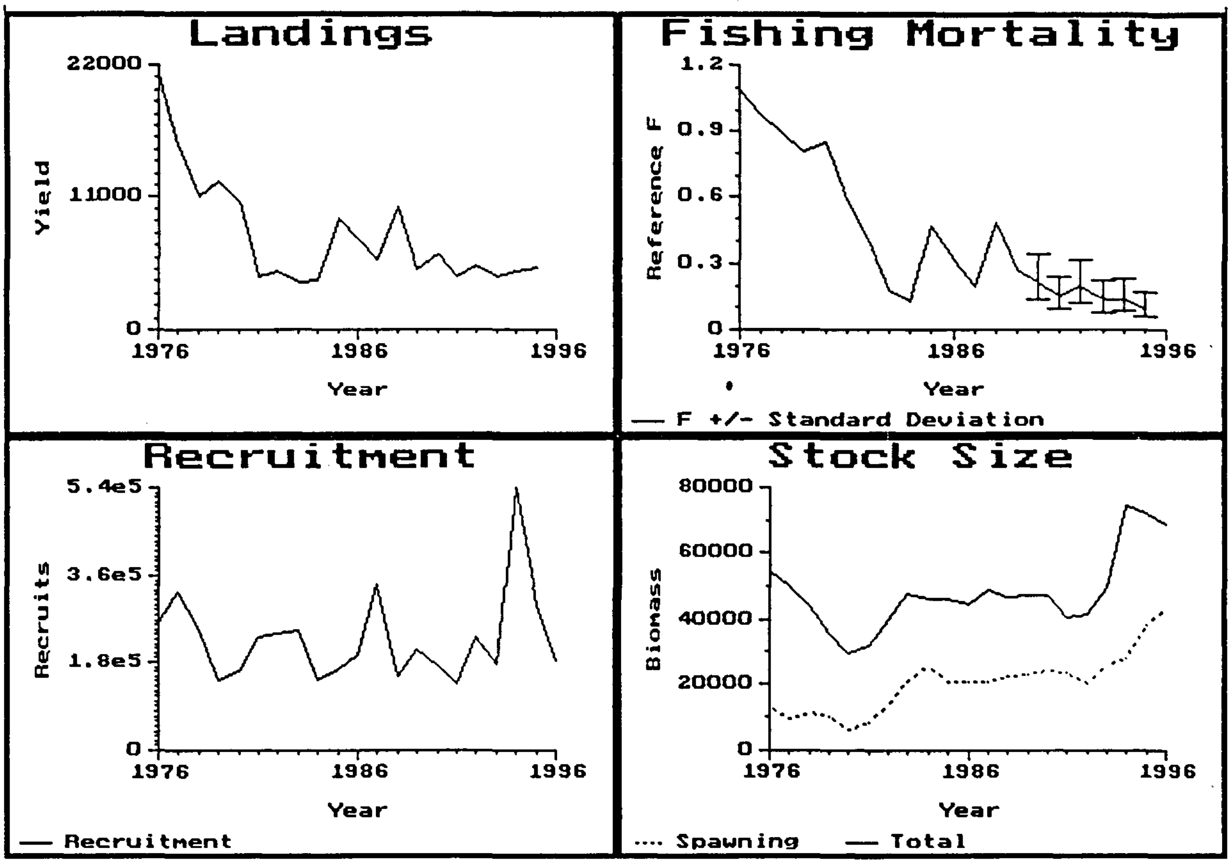

Figure 7.5.2. Herring in VIIa(N). Results of baseline assessment. Summary of estimates of landings, fishing mortality at age 4, recruitment at age 1, stock size on 1 January and spawning stock size at spawning time.

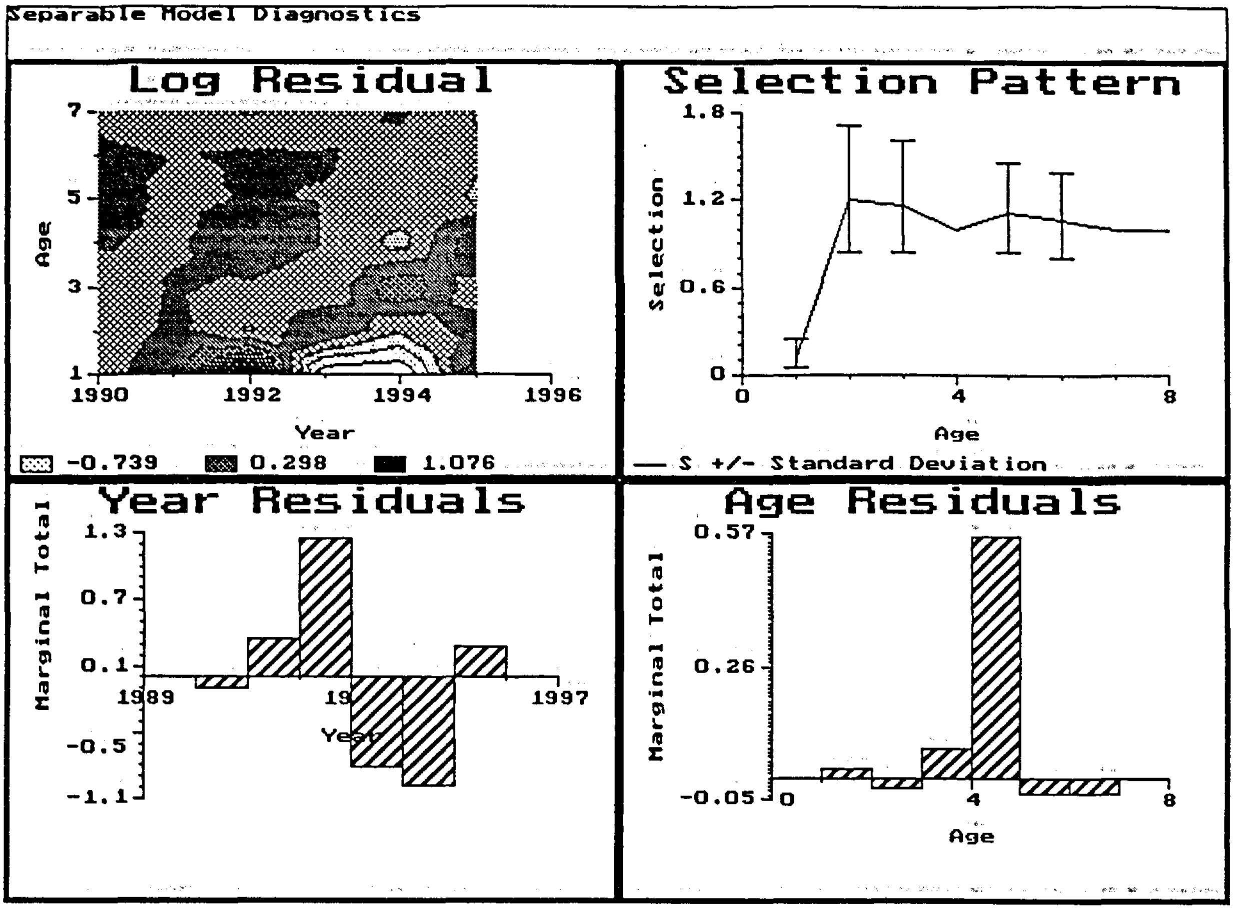

Figure 7.5.3. Herring in VIIa(N). Results of baseline assessment. Selection pattern diagnostics. Top left, contour plot of selection pattern residuals. Top right, estimated selection (relative to age 4) +/- standard deviation. Bottom, marginal totals of residuals by year and age.

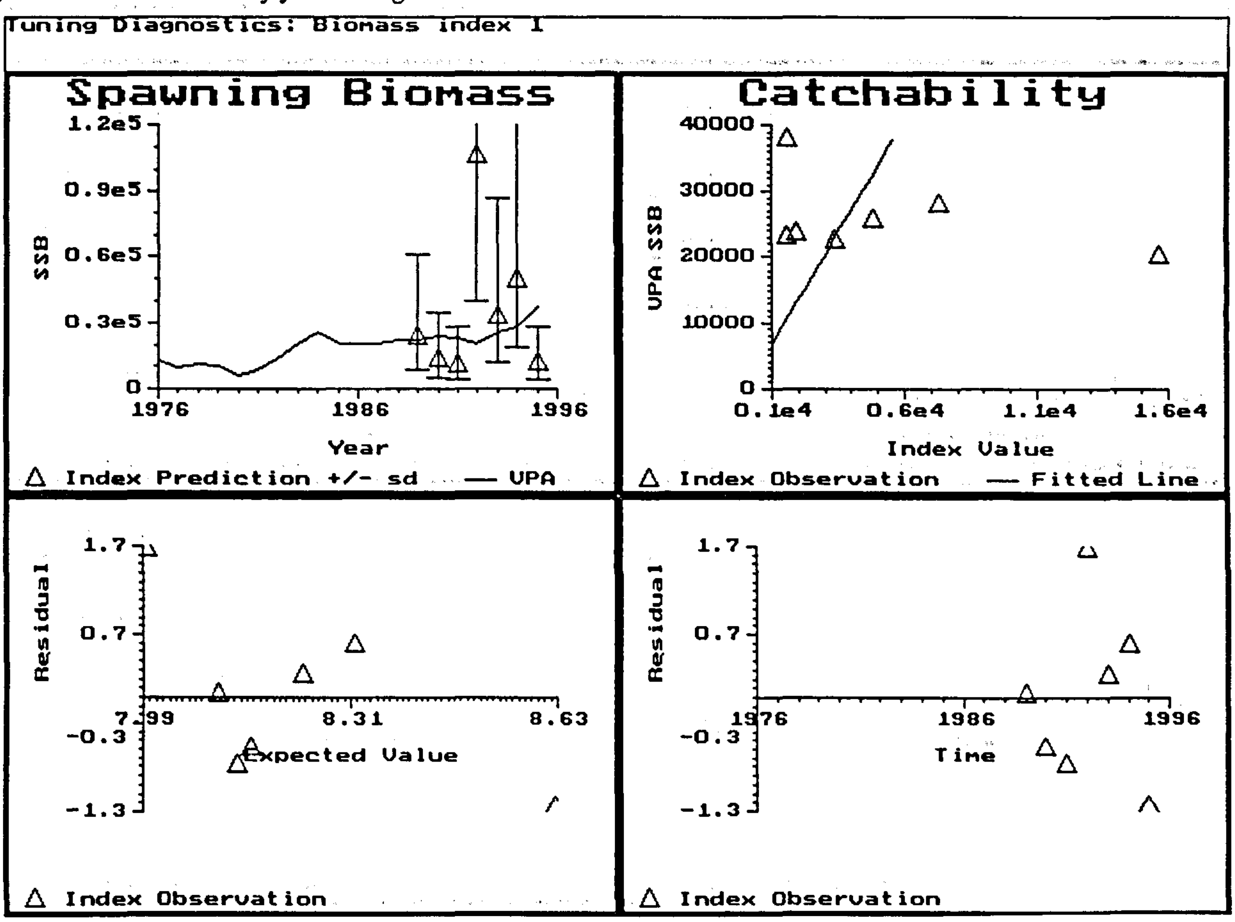

Figure 7.5.4. Herring in VIIa(N). Results of the baseline assessment. Diagnostics of the fit of the larval abundance index DBL against the estimated spawning biomass. Top left, spawning biomass from the fitted populations (line), and predictions of spawning biomass in each year made from the index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of spawning biomass from the fitted populations and larval survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

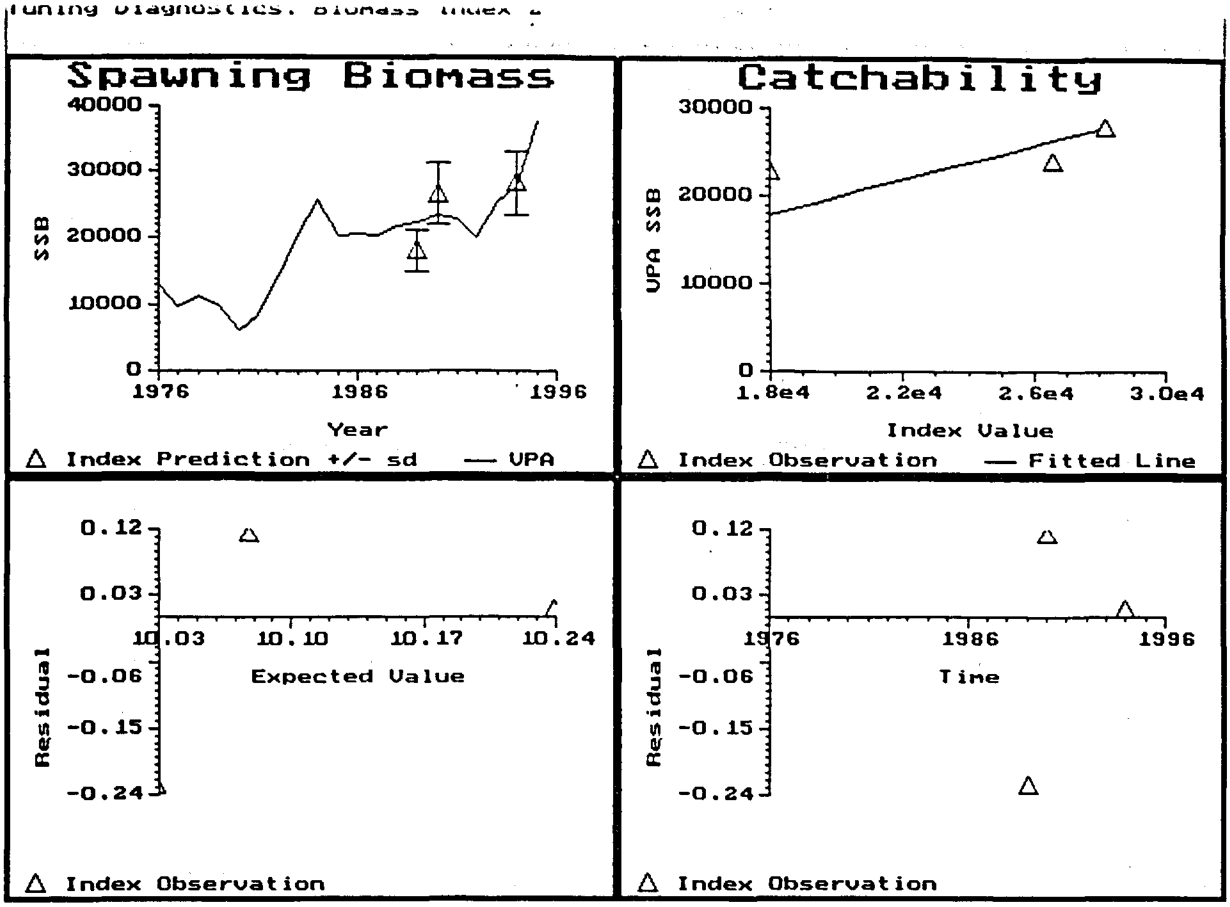

Figure 7.5.5. Herring in VIIa(N). Results of the baseline assessment. Diagnostics of the fit of the Douglas Bank acoustic index of SSB (AC_DB) against the model estimated SSB. Top left, fitted SSB (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

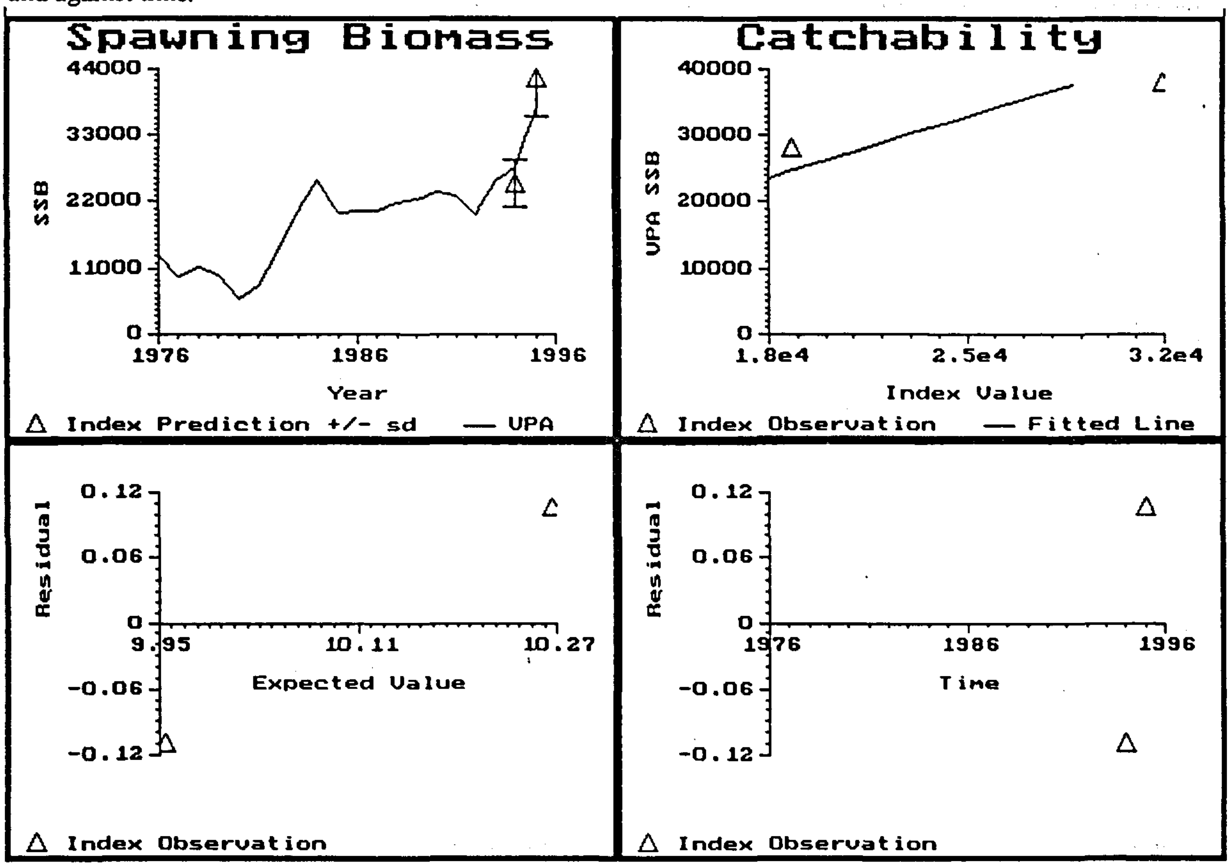

Figure 7.5.6. Herring in VIIa(N). Results of the baseline assessment. Diagnostics of the fit of the VIIa(N) acoustic index of SSB (AC_VIIa(N)) against the model estimated SSB. Top left, fitted SSB (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

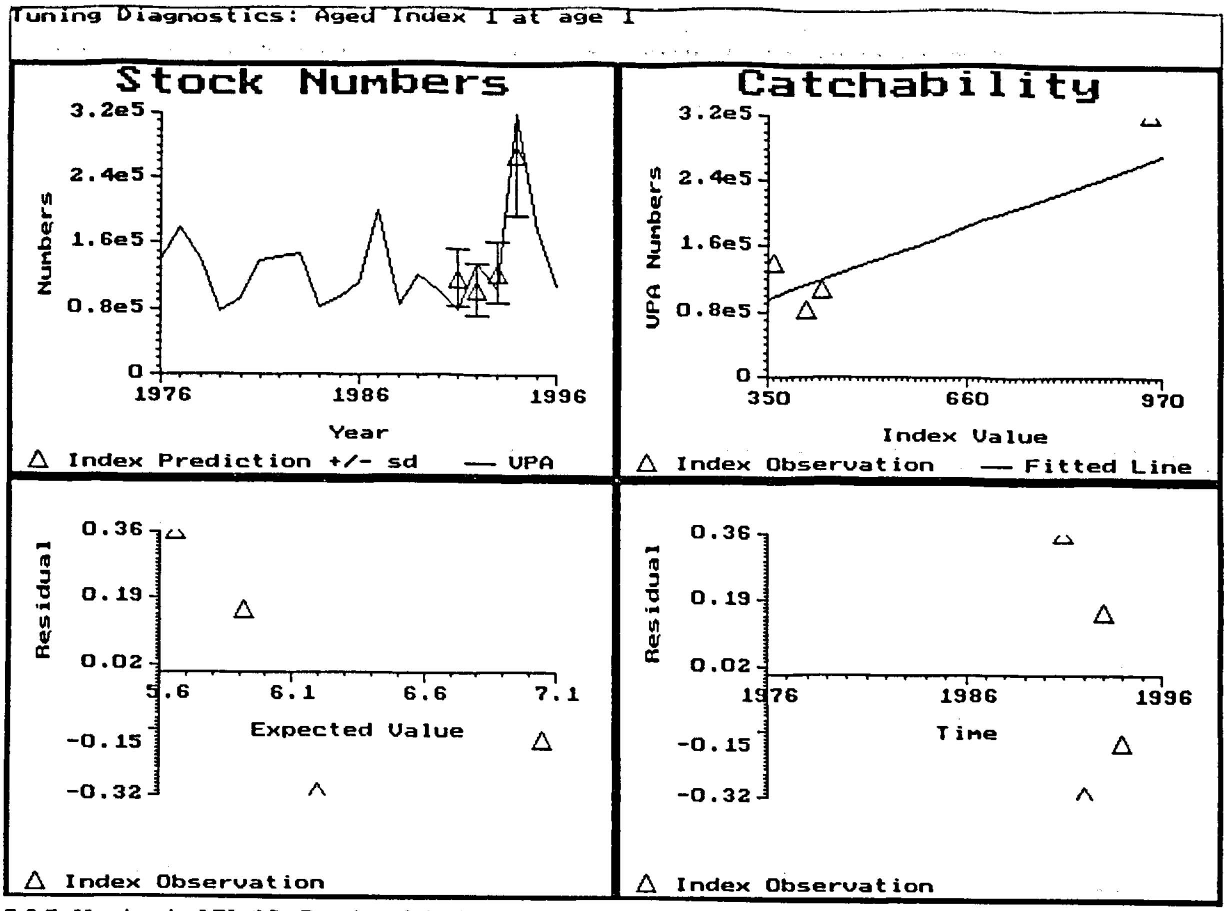

Figure 7.5.7. Herring in VIIa(N). Results of the baseline assessment. Diagnostics of the fit of the groundfish survey index at age 1 in June (GFS1J) against the estimated populations at age 1. Top left, fitted populations (line), and predictions of abundance in each year made from the survey index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

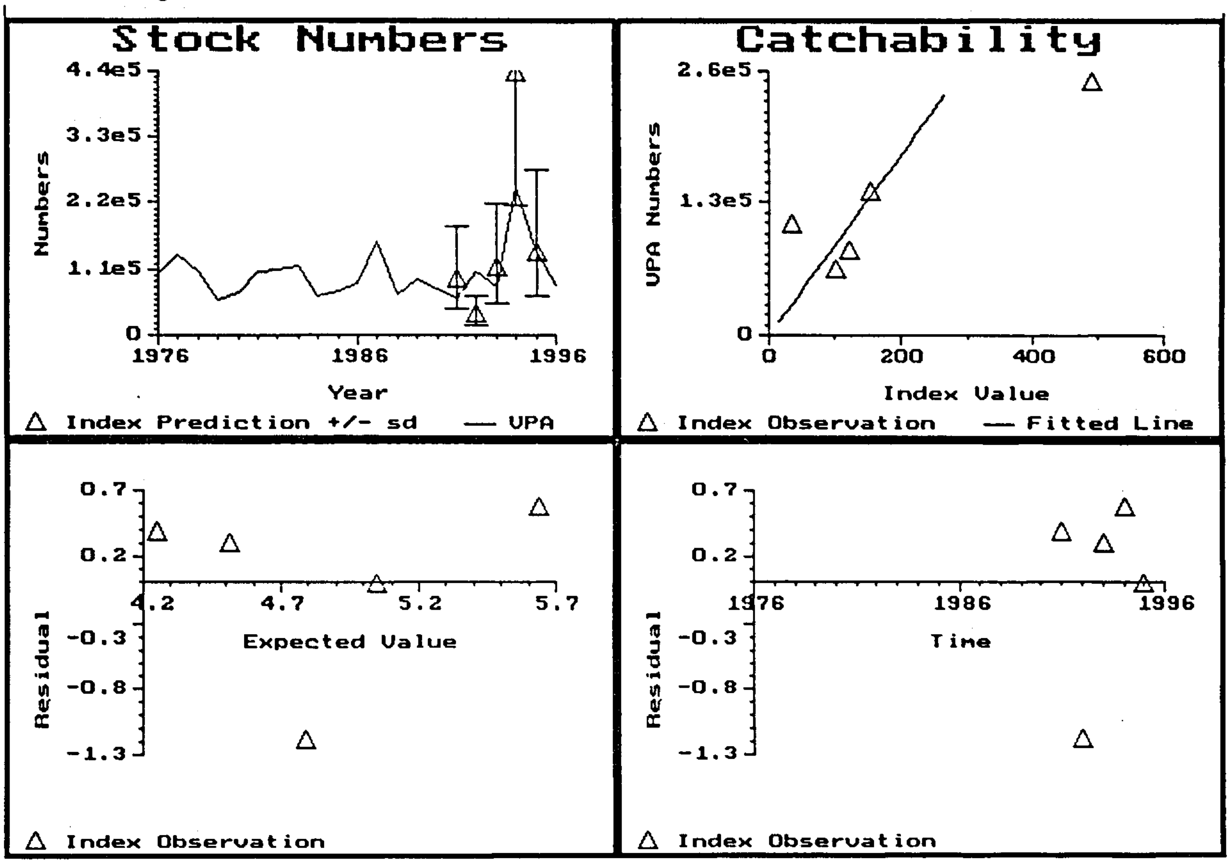

Figure 7.5.8. Herring in VIIa(N). Results of the baseline assessment. Diagnostics of the fit of the groundfish survey index at age 1 in September (GFS1S) against the estimated populations at age 1. Top left, fitted populations (line), and predictions of abundance in each year made from the survey index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

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Fig. 7.7.1 Irish Sea (VIIa(N)) herring Beverton-Holt S/R fit

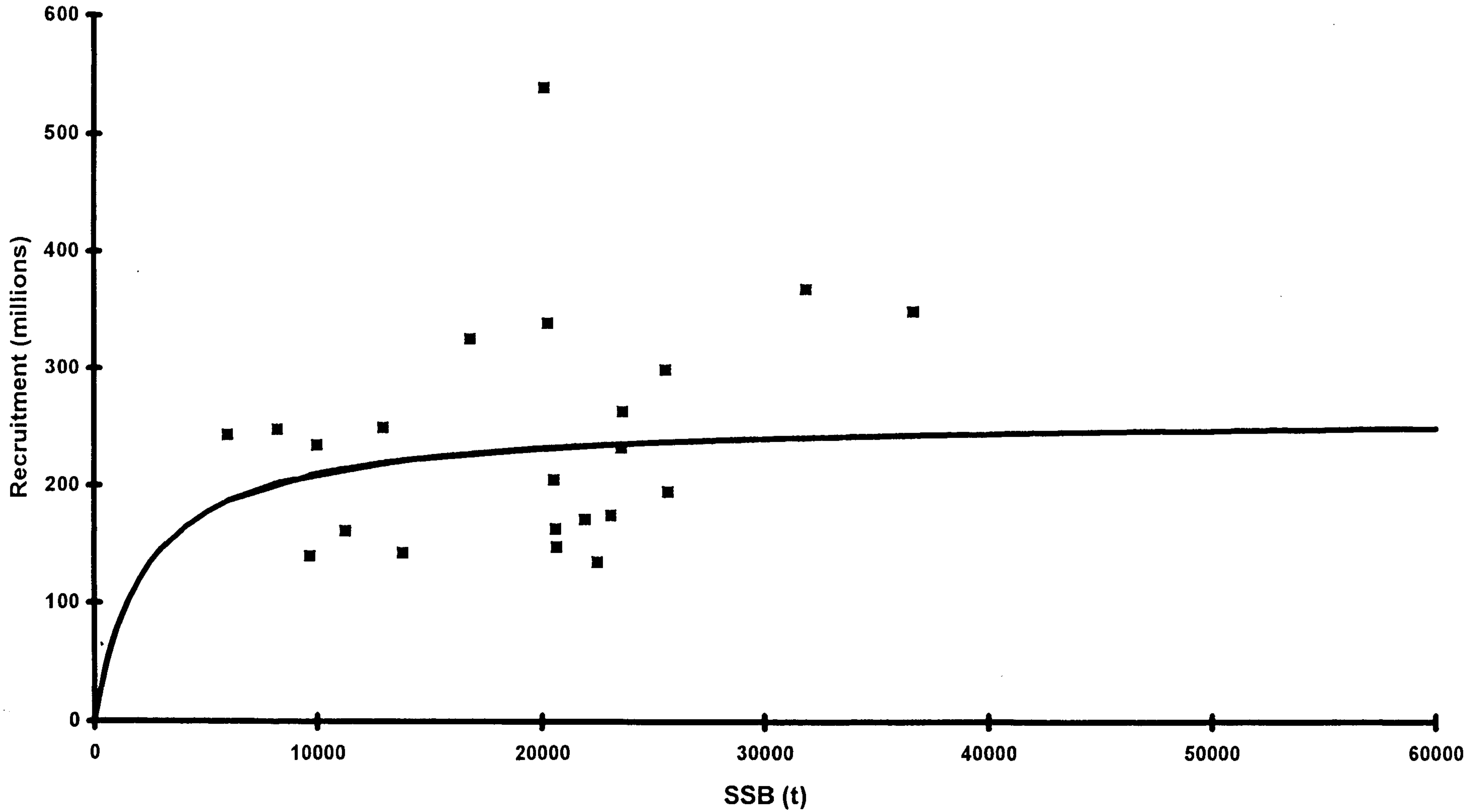
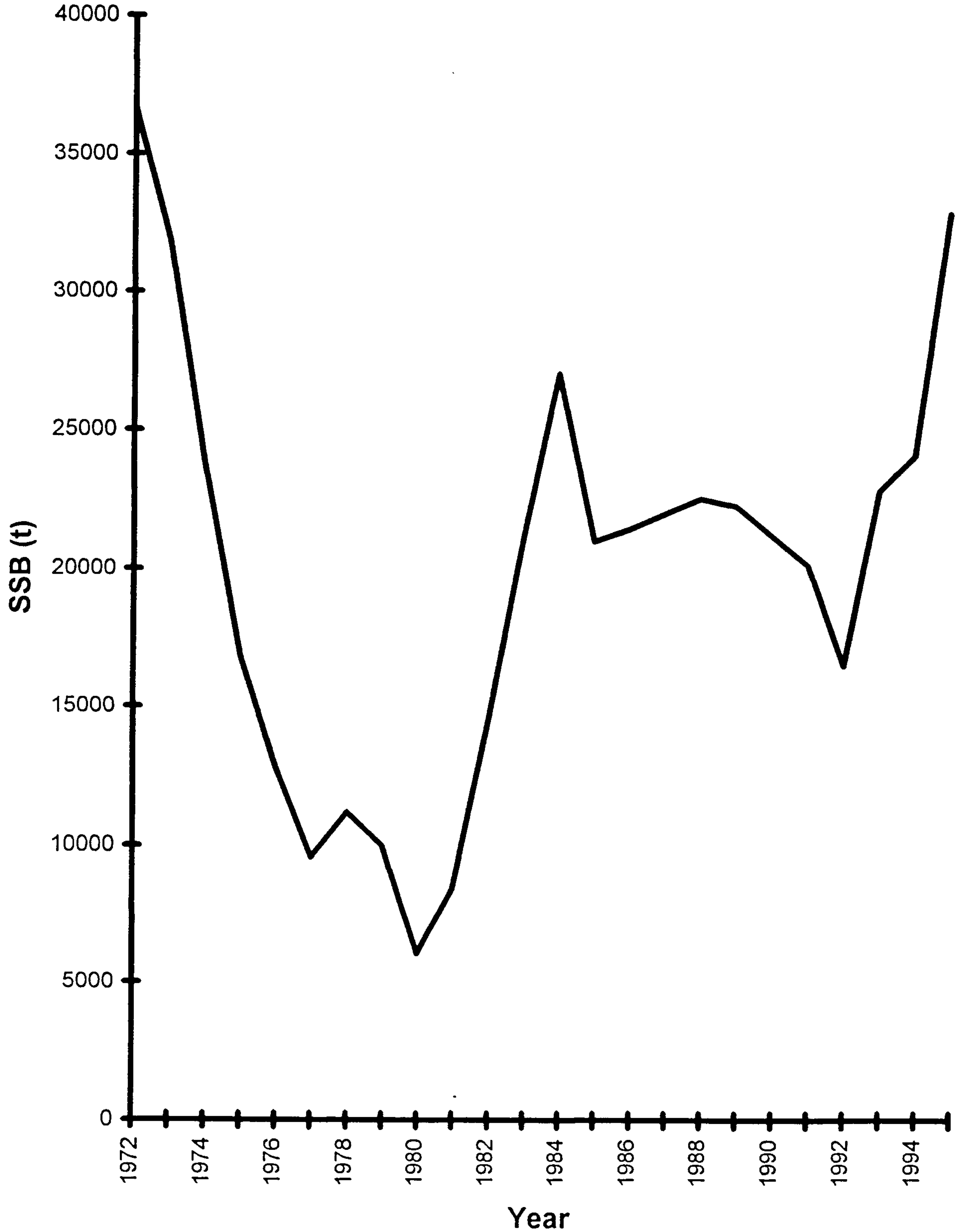


Fig. 7.7.2. Development of the Irish Sea (VIIa(N)) stock from 1972 to 1995. Data from 1972 to 1975 were obtained from traditional VPA outputs. Remaining data from ICA output.



SSBDEV.XLS

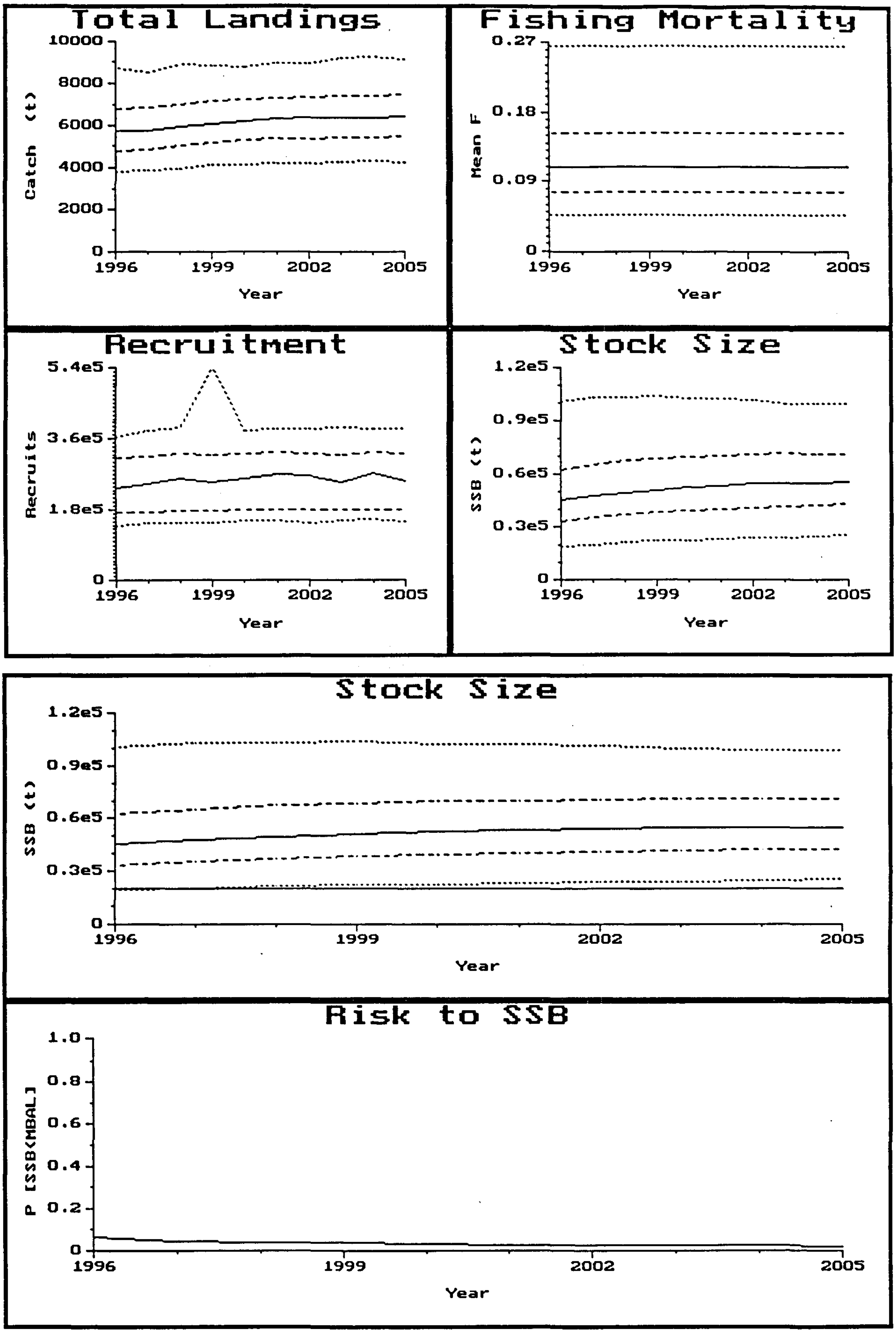


Figure 7.8.1 Herring in VIIa(N). Summary results of medium-term projections for fishing mortality from 1996 to 2005 constrained equal to the fishing mortality estimate for 1995. **Upper panel:** landings, fishing mortality (mean over ages 2 to 6), recruitment, and stock size. **Lower panel:** Stock size and the probability that the stock may fall below the MBAL level of 20 000t. Solid line, 50th percentile, dashed lines, 25th and 75th percentiles. Dotted line, 5th and 95th percentiles.

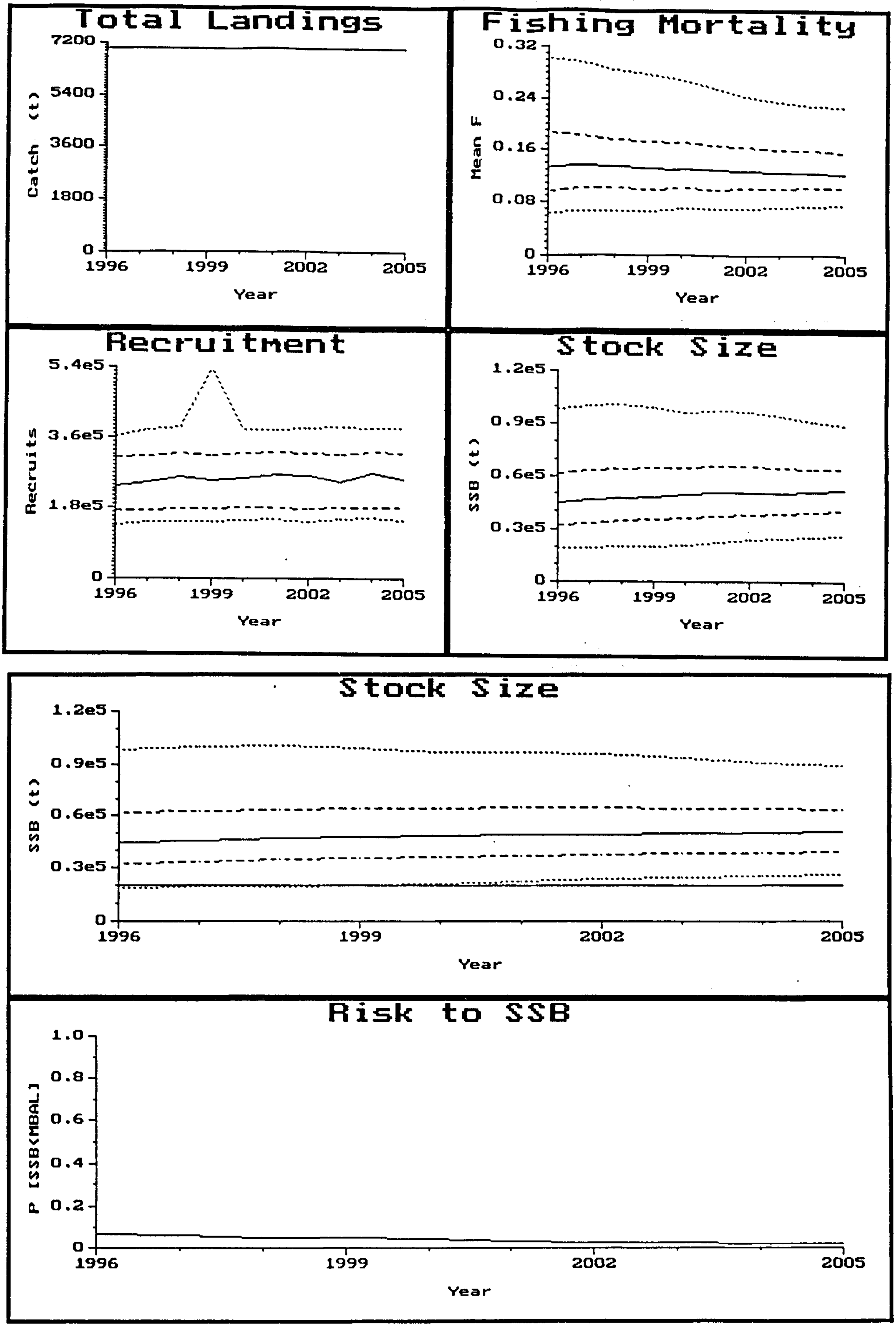


Figure 7.8.2. Herring in VIIa(N). Summary results of medium-term projections assuming a catch constraint of 7000t in each year up to 2005. **Upper panel:** landings, fishing mortality (mean over ages 2 to 6), recruitment, and stock size. **Lower panel**, Stock size and the probability that the stock may fall below the MBAL level of 20 000t. Solid line, 50th percentile. dashed lines, 25th and 75th percentiles. Dotted line, 5th and 95th percentiles.

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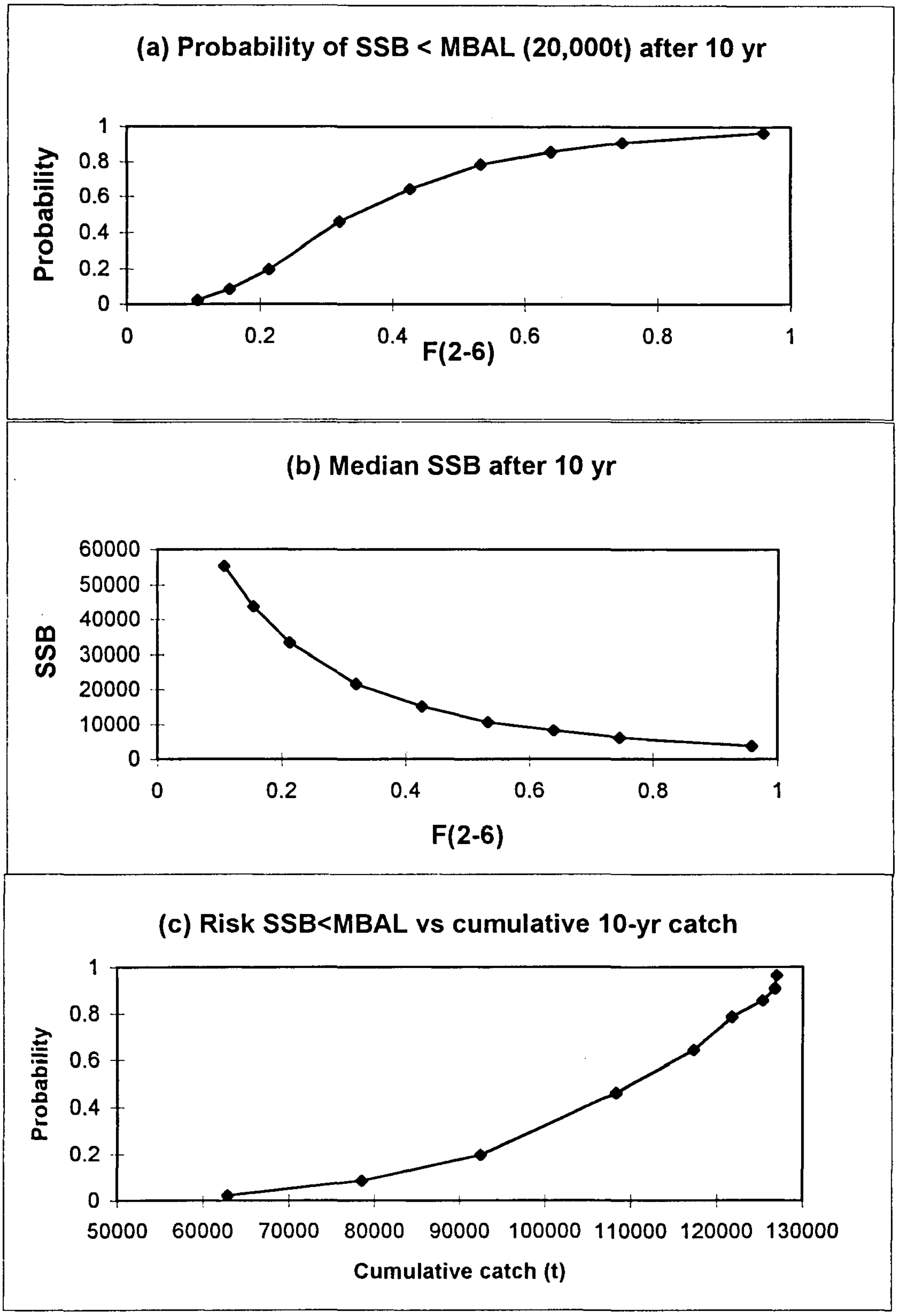
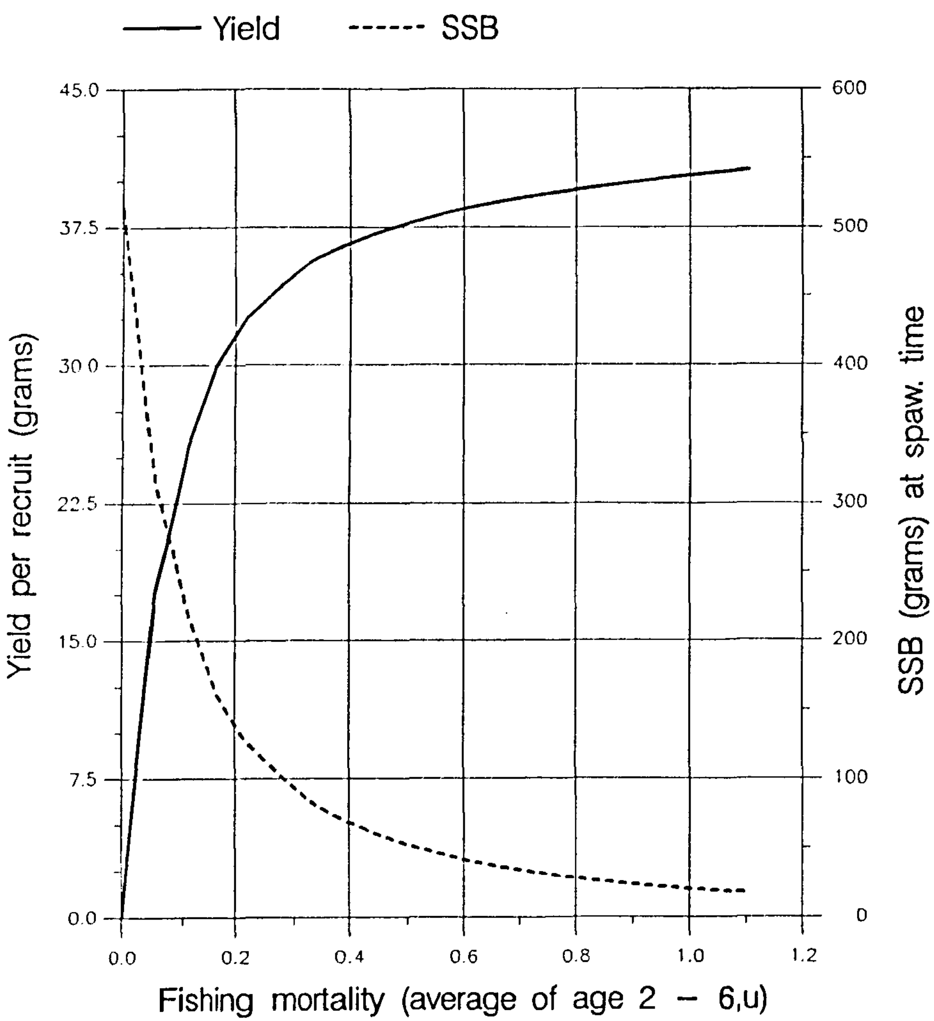


Fig. 7.8.3 Results of stochastic projection of VIIa(N) herring population at constant F, starting from ICA estimates of populations, F and variance/covariances.
(a) Probability of SSB falling below MBAL of 20,000t by 10th year;
(b) 50th percentile of SSB in 10th year of projection;
(c) probability of SSB < MBAL by 10th year, plotted against total of the average annual yields over the 10-year projection period, for different levels of F(2-6).

Figure 7.8.4. Fish Stock Summary
Herring in the North Irish Sea (Manx plus Mourne VIIa North)
16 – 4 – 1996

Long term yield and spawning stock biomass



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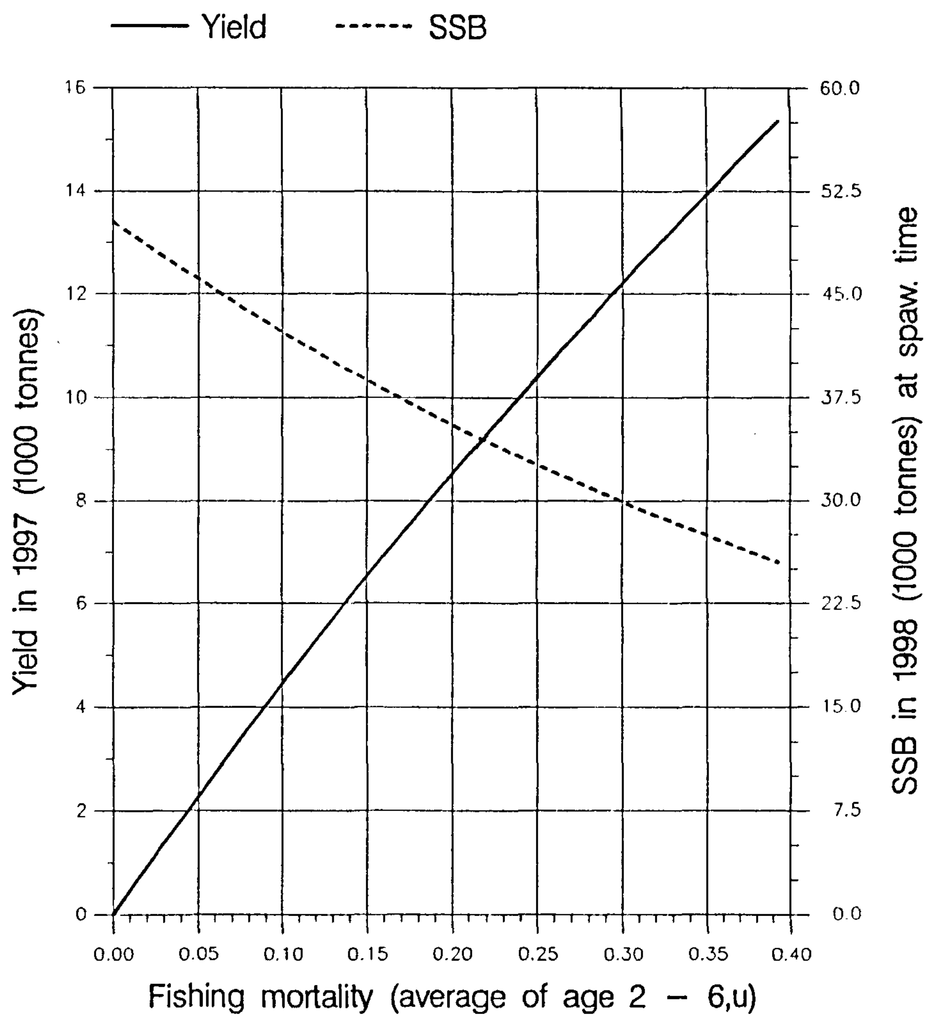
Short term yield and spawning stock biomass



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8 SPRAT IN THE NORTH SEA

8.1 The Fishery

8.1.1 ACFM advice applicable for 1995 and 1996

No ACFM advice on a sprat TAC has been given in recent years. The TAC set by the management bodies was 114,000 t for 1994 [Subarea IV(EU zone) + Division IIa (EU zone)] and 175,000 t for 1995. The agreed TAC for 1996 is 200,000 t.

8.1.2 Catches in 1995

Landing statistics for sprat for the North Sea by area and country are presented in Table 8.1.1 for 1983-1995. The monthly and annual distribution of catches by rectangle for Sub-area IV are shown in Figures 8.1.1-8.1.13. There is probably some misreporting within Division IVb, as evident from catches of sprat outside the area of normal distribution. As in previous years, sprat from the fjords of western Norway were not included in the landings for the North Sea. Landings from the fjords are considered separately because uncertainty remains concerning the sprat stock identity. Norwegian catches in the western fjords for 1983-1995 are presented in Table 8.1.2.

Preliminary sprat landing figures for Denmark, Sweden, Norway and UK indicate that 357,000 t were harvested from the North Sea in 1995. This represents about a 10 % increase in landings from 1994. Catches by Denmark, which represent nearly 90 % of the North Sea sprat landings, continued their upward trend started in 1990 and were the largest reported since the mid 1970's. The Norwegian landings were at the same level as in 1994. UK catches continued to be at a very low level. Catches by Norway in the western fjords decreased compared to 1994, mainly due to lower quotas set by the canning industry.

Landings by area and quarter are shown in Table 8.1.3. Again, the largest component of the catch was reported from Division IVb, predominantly Division IVbe, in the third quarter. Significant catches from this division were also made during the fourth quarter.

8.1.3 Fleets

Fleet descriptions were provided by the Industrial Fisheries Working Group (IFWG) in 1992 (Anon., 1992c).

8.2 Catch Composition

8.2.1 Catches in number

Uncertainties in the reliability and/or absence of quarterly aged samples have prevented the IFWG, and later the HAWG, from running a VPA since 1984. A historical perspective of the problems associated with estimates of catch in numbers at age by previous groups up to 1992 was described in the report of the Herring Working Group for 1993 (Anon. 1993a).

The estimated quarterly catch-at-age in numbers is presented in Table 8.2.1. Age composition data for commercial landings for 1995 were provided by Denmark and Norway. The difference in age composition of 1-and 2-groups in the Danish and the Norwegian landings may be a result of the different gears used in the two fisheries. The Danish fishery harvests sprat with bottom trawl gear and the Norwegian fishery uses purse seiners. The differences may also be explained by problems in ageing sprat (Torstensen, 1994, W.D. 1996).

The sampling intensity is given in Table 8.2.2. Although the number of samples has improved in recent years, the level of sampling is still far below the recommended 1 sample per 1 000 t. The Working Group still considers the data to be poor and unsuitable for catch-at-age estimation.

8.2.2 Mean weight at age

The mean weight (g) at age in catches taken in 1994 and in 1995 are presented by quarter in Table 8.2.3. Weights were estimated from Danish and Norwegian commercial data as provided by Working Group members.

8.2.3 Quality of catch and biological data

In 1995 the sampling of Danish landings for industrial purposes continued with the intensity and coverage largely unchanged compared to the previous years. A total of 804 landings was examined for species composition of which 63 were used to estimate age composition and weight at age of sprat. Only 9 samples were available from the Norwegian purse seine landings. No sprat were reported in the Norwegian small meshed fishery targeted at sandeel and Norway pout. Details of the biological sampling data are presented in Table 8.2.2.

8.3 Recruitment

8.3.1 Abundance

Division IVb is considered as the IBTS standard area for North Sea sprat (Anon. 1993a). The IBTS (February) sprat indices, used as an index of abundance, were revised by the Working Group as described in the 1995 Herring Assessment Working Group report (Anon. 1995d) for Division IIIa. The revised IBTS-indices, no./hr, are presented in Table 8.3.1 for age groups 1-4 and 5+, along with the number of rectangles sampled and the number of hauls considered.

The 1996 indices indicate a decrease for age groups 1 and 2, following 3 years of being higher than average. The 3-group index representing the 1993 year class, the strongest year class observed in recent years, was the highest since 1990. The total 1996-abundance index decreased to below the average for 1981-1994, and was at the same level as in 1990-1991.

The IBTS data are provided by rectangle in Figure 8.3.1 for age groups 1, 2 and 3+. Age 1-group were found to be concentrated in the central-eastern areas of Division IVb and IVc. The mean lengths in mm of age-group 1 by rectangle are presented in Figure. 8.3.2.

8.4 Acoustic Survey

No acoustic estimates were available to the Working Group for 1996.

8.5 State of the Stock

8.5.1 Catch-Survey Data Analysis

The IBTS surveys have had difficulties following strong and weak cohorts for sprat. This is illustrated by the text table below which is extracted from Table 8.3.1. The 1-group:2-group ratio varies between 0.32 (1981 year class) and 7.57 (1988 year class).

Year class	1-group	2-group	1-gr/2-gr
1980	957.28	501.87	1.91
1981	245..91	764.08	0.32
1982	201.21	393.57	0.51
1983	383.63	305.00	1.26
1984	675.49	104.77	6.45
1985	68.22	74.68	0.91
1986	758.28	1410..52	0.54
1987	152.29	445.72	0.34
1988	4293.66	567.46	7.57
1989	115.16	104.89	1.10
1990	834.45	344.08	2.43
1991	1562.20	602.01	2.60
1992	1732.54	1397.77	1.24
1993	4084.89	2643.93	1.55

This, combined with the catch data and ageing problems, implies that the available indices do not adequately reflect the dynamics of the stock.

8.6 Projections of Catch and Stock

Prior to 1996 the data have not permitted projections of either catches or stock sizes. As discussed in the 1995 Herring Working Group report (Anon 1995d), the 1989 IBTS index continues to be an outlier in a regression of total landings and IBTS-indices. The regression was also highly affected by the 1994 observation.

Regression of the total catches and the IBTS index for 1981-1995 (Figure 8.6.1) shows the 1989 index to be an outlier and the effects of the high 1994 and 1995 values. Applying the 1996 (February) index to a regression excluding the 1989-index (r^2=0.84) estimates a total landing of 84,000 t for 1996. The assumption behind the above regression is that the exploitation level is fairly constant over the years, i.e. that the variability in abundance is greater than that of the exploitation.

It was attempted to improve the analysis by including a model for stock development. The Biomass dynamic model:

$$B_{(t+1)} = B_{(t)} + r \cdot [1- B_{(t)}/K] - C_{(t)}$$

$$I_{(t)} = q \cdot B_{(t)}$$

where $B_{(t)}$ is the biomass at time t, $C_{(t)}$ is the catch and $I_{(t)}$ the total abundance IBTS index. r, K and q are parameters of the model. This model was fitted using the CEDA program (see Anon, 1993a). The data were total catch and IBTS (February) abundance data for 1978 to 1995. The initial state of the stock in 1978 was assumed to be that the biomass was 0.8 of the carrying capacity K. The 1989 observation was again considered as an outlier. A new run was made using an adjusted 1989-index estimated by the linear regression of total catches and IBTS-indices excluding the 1989-index, given an adjusted 1989-index of 667. The model suggests that the biomass is at a very low level, (Figure. 8.6.2).

SHOT estimates (Shepherd, 1991) were provided by the WG, but as demonstrated in their report of 1992 (Anon., 1992c), little confidence was put in the estimates. At that time the analysis was driven by the very strong 1989-index. With more data available, the Herring Assessment Working Group decided to undertake a new SHOT-estimate for the North Sea sprat. Three runs were made using the total IBTS-indices, the 1-group indices and the total with the adjusted 1989-index as inputs data together with the total catches. The estimated landings for 1996 appeared to be consistent between runs and in the range of 120-140,000 t.

8.7 Management Considerations

The stock shows signs of heavy exploitation as both catch and biomass appear to be decreasing with no signs of a good year class to follow. Therefore, catches should be reduced to the lowest possible level until there are signs of increased recruitment.

8.8 Research Recommendations

The Working Group considered the research required to improve the quality of the sprat assessment and recommends the following to be addressed before the next meeting of the Working Group:

- The acoustic surveys detect sprat and should be examined for the possibility of estimating sprat abundance. If feasible, the survey data should be revisited to obtain these estimates for as many years as possible.

- Sampling intensity still needs to be improved, as it is far below the recommended level.

Table 8.1.1 Sprat catches in the North Sea ('000 t) 1983-1995. Catch in tonnes by country. Catches in fjords of western Norway excluded. (Data provided by Working Group members except where indicated). These figures do not in all cases correspond to the offical statistics and cannot be used for management purposes.

Country	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994[1]	1995
						Division IVa West							
Denmark	-	-	0.9	0.6	0.2	0.1	+	-		0.26	0.6	-	-
Germany	-	-	-	-	-	-	-	-		-	-	-	-
Netherlands	-	-	6.7	-	-	-	-	-	-	-	-	-	-
Norway	-	-	-	-	-	-	-	-	0.1	-	-	-	-
UK (Scotland)	-	+	6.1	+	+	-	-	+	-	-	-	0.1	+
Total	-	+	13.7	0.6	0.2	0.1	+	+	0.1	0.26	0.6	0.1	+
						Division IVa East (North Sea) stock							
Denmark	-	-	+	0.2	+	+	+	-	-	-	+	+	+
Norway	-	-	-	-	-	-	-	-	-	0.54	2.5	+	+
Sweden	-	-	-	-	-	-	-	+	2.5	-	-	-	-
Total	-	-	+	0.2	+	+	+	+	2.5	0.64	2.5	+	+
						Division IVb West							
Denmark	32.6	5.6	1.8	0.4	3.4	1.4	2.0	10.0	9.4	19.9	13.0	19.0	26[illegible]
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-	-	-
Norway	0.9	0.5	-	-	-	3.5	0.1	1.2	4.4	18.4	16.8	12.6	21.0
UK (England)	-	+	-	-	-	-	-	-	-	0.48	0.5	-	+
UK (Scotland)	+	+	-	-	0.1	-	-	-	-	-	0.5	-	-
Total	33.5	6.1	1.8	0.4	3.5	4.9	2.1	11.2	13.8	38.26	30.5	31.6	47.0
						Division IVb East							
Denmark	39.2	62.1	36.6	10.3	28.0	80.7	59.2	59.2	67.0	66.56	136.2	251.7	283.2
Germany	-	0.6	0.6	0.6[3]	-	-	-	-	-	-	-	-	-
Norway	10.8	3.1	-	-	-	0.6	-	0.6	25.1	9.5	24.1	19.1	14.7
Sweden	-	-	-	-	-	-	-	+[2]	+[2]	-	-	-	0.2
Total	50.0	65.8	37.2	10.9	28.0	81.3	59.2	59.8	92.1	76.49	160.3	270.8	298.1
						Division IVc							
Belgium	-	-	+	+	+	-	+[2]	+[2]	+[2]	-	-	-	-
Denmark	1.0	0.5	+	0.1	+	0.1	0.5	1.5	1.7	2.49	3.5	-	11.4
France	-	-	-	+	-	-	+[2]	-	+[2]	-	+	+	+
Netherlands	-	0.1	-	-	-	0.4	0.4[2,3]	-	+[2,3]	-	-	-	
Norway	0.5	3.4	-	-	-	-	-	-	-	-	0.4	4.6	0.[illegible]
UK (England)	3.6	0.9	3.4	4.1	0.7	0.6	0.9	0.2	1.8	6.12[1]	2.0	2.9	0.2
Total	5.1	4.9	3.4	4.3	0.7	1.1	1.8	1.7	3.5	8.61	5.9	21.2	12.0
						Total North Sea							
Belgium	-	-	+	+	+	-	+	+[2]	+[2]	-	-	-	-
Denmark	72.6	68.1	39.5	11.7	31.7	82.3	61.9	69.2	78.1	89.1	153.3	284.4	320.6
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-	-	-
France	-	-	-	+	-	-	+	-	+[2,3]	-	+	-	+
Germany	-	0.6	-	0.6	-	-	-	-	-	-	-	-	-
Netherlands	-	0.1	0.6	-	0.5	0.4	0.4	-	+[2,3]	-	-	-	-
Norway	12.0	7.0	6.1	-	-	4.1	0.1	1.8	29.6	28.5	43.8	36.3	36.2
Sweden	-	-	-	-	-	-	-	+[2]	+[2]	-	0.1	-	0.2
UK (England)	3.6	0.9	3.4	4.1	0.7	0.6	0.9	0.2	1.8	6.6	2.6	2.9	0.2
UK (Scotland)	+	+	-	+	0.2	-	-	+	-	-	0.5	0.1	+
Total	88.4	76.7	49.6	16.4	33.1	87.4	63.3	71.2	109.5	124.2	200.3	323.7	357.2

[1]Preliminary.
[2]Official statistics.
[3]Includes Division IV a-c.

Table 8.1.2 Sprat catches ('000 t) in the fjords of western Norway, 1983–1995.

1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995[1]
3.2	4.4	7.1	2.2	8.3	5.3	2.4	2.7	3.2	3.8	1.9	5.3	3.7

[1]Preliminary.

Table 8.1.3. Sprat catches (tonnes) in the North Sea by quarter in 1994 (Denmark and Norway) and 1995 (Denmark, Sweden, Norway and the UK). Catches in fjords of Western Norway excluded.

Year	Quarter	Area					Total
		IVaW	IVaE	IVbW	IVbE	IVc	
1994	1		42	2616	17227	16091	35976
	2			242	10857	2	11101
	3			10479	184747	3572	198798
	4	97		18224	57959	1325	77605
Total		97	42	31561	270790	20990	323480
1995	1			17752	16900	7324	41976
	2			1138	5752	1	6891
	3		86	25305	183500	6	208897
	4		5	2826	92054	4693	99578
	Total	0	91	47021	298206	12024	357342

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Table 8.2.1 North Sea Sprat. Catch in numbers (millions) taken by quarter in 1994 and 1995 by Denmark and Norway.

Country	Fishing area	Quarter	Age					
			0	1	2	3	4	5+
1994								
Denmark	IVa	4	0.54	2.13	0.61	0.06		0
Denmark	IVb	1		485.02	670.18	268.1		
		2		2983.51	15	0		
		3		24541.41	272.95	0		
		4	887.11	4528.93	1289.6	144.85	2.97	5.38
Norway	IVb	1			794.57	172.58	12.82	
Denmark	IVc	1		22.74	673.41	150.43	27.99	
		2		0.27	0			
		4	1.26	85.25	23.6	4.12	0.23	
1995								
Denmark	IVa	4		0.23	0.17	0.02		
Denmark	IVb	1		5.78	1133.81	360.51		
		2		2.17	552.92	169.57		
		3	513.23	11686.05	7402.48	138.18		
		4		4327.87	3179.02	361.97		
Norway	IVb	1			1278.16	518.37	43.56	
		3			315.84	115.49	3.22	
Denmark	IVc	1			537.11	98.77	9.68	
		2			0.08	0.01		
		3		0.26	0.16	0.02		
		4		206.66	125.95	15.31		

Table 8.2.2. North Sea Sprat. Sampling of commercial landings in 1993-1995.

Country	Quarter	Total catch ('000 t)	No. samples	No. aged	No. meas.
1993					
Denmark		153.3	81	1209	6832
Norway		43.8	3	100	315
Sweden		0.1			
UK(England)		2.6			
UK(Scotland)		0.5			
Total		200.3	84	1309	7147
1994					
Denmark	1	18.7	13	839	1565
	2	11.1	4	191	194
	3	174.8	23	1479	2639
	4	76.3	33	1776	3619
Total		280.9	73	4285	8017
Norway	1	14.5	17	707	1870
	3	20.4	0	0	0
	4	1.5	0	0	0
Total		36.4	17	0 707	0 1870
UK(England)		6	0	0	0
UK(Scotland)		0.1	0	0	0
Grand		323.4	90	4992	9887
1995					
Denmark					
IVa	1				
	2				
	3				
	4	+		0	0
Total		0	0	0	0
IVbE	1	9.4	5	617	308
	2	5.7	3	6	0
	3	176.3	12	1288	456
	4	91.9	25	2635	433
Total		283.3	45	4546	1197
IVbW	1	3.8	3	365	156
	2	0.7	10	80	0
	3	18.6	2	7	0
	4	2.8	0	0	0
Total		25.9	15	452	156
IVbc	1	6.7	2	242	137
	2	+	0	0	0
	3	+	0	0	0
	4	4.7	1	106	0
Total		11.4	3	348	137
Denmark	Total	320.6	63	5346	1490
Norway					
IVaE	1				
	2				
	3	+	0	0	0
	4				
Total		0	0	0	0
IVbW	1	13.9	4	165	378
	2	0.4	0		
	3	6.7	2	200	182
	4		0		
Total		21.0	6	365	560
IVbE	1	7.5	3	250	300
	2				
	3	7.1	0	0	0
	4	0.2	0	0	0
Total		14.8	3	250	300
IVbc	1	0.4	0	0	0
	2				
	3				
	4				
Total		0.4	0	0	0
Norway	Total	36.2	9	615	860
UK(England)		0.2	0	0	0
UK(Scotland)		+			
UK	Total	0.2	0	0	0
GRAND	**Total**	357	72	5961	2350

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Table 8.2.3. North Sea Sprat. Quarterly mean weight (g) at age in the landings in 1994-1995 . Weight were estimated from data provided by Working Group members.

Quarter			Age			
1994	0	1	2	3	4	5+
1		1.8	9.6	12.8	17.4	
2		3.7	8.0			
3		7.0	10.8			
4	8.4	10.4	13.7	18.5	24.7	
Total	8.4	7.1	11.0	13.9	18.1	
1995						
1		3.0	9.4	12.9	19.4	
2		3.0	8.4	10.3		
3	2.4	7.6	13.9	16.4	20.7	
4		10.5	13.9	16.2		
Total	2.4	8.4	12.8	14.0	19.5	

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Table 8.3.1. North Sea Sprat. Abundance indices by age group from IBTS(February) for the standard area for sprat (Div. IVb)

Year	No rect.	No hauls	Age					
			1	2	3	4	5+	Total
1981	70	146	957.28	1414.02	341.79	4.11	0.31	2717.51
1982	67	155	245.91	510.86	125.42	5.64	0.19	888.02
1983	79	211	201.21	764.08	192.43	8.26	0.85	1166.83
1984	80	251	383.63	393.57	47.43	6.66	0.41	831.70
1985	79	289	675.49	305.00	38.22	4.32	0.90	1023.93
1986	78	285	68.22	104.77	29.38	1.31	0.26	203.94
1987	78	299	758.28	74.68	24.80	3.61	0.21	861.58
1988	78	208	152.29	1410.52	109.66	8.78	0.00	1681.25
1989	79	236	4293.66	445.72	318.65	4.10	13.44	5075.57
1990	78	192	115.16	567.46	149.83	30.79	0.59	863.83
1991	78	179	834.45	104.89	27.84	2.63	1.17	970.98
1992	79	185	1562.20	344.08	38.25	5.51	0.45	1950.49
1993	79	181	1732.54	602.01	84.12	4.35	0.06	2423.08
1994	78	173	4084.89	1397.77	129.96	2.79	0.67	5616.08
1995	79	166	1059.30	2643.93	134.01	3.23	1.12	3841.59
1996	78	146	346.37	483.45	141.96	23.64	0.56	995.98

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Figure 8.1.1 : North Sea and Divisions VIId,e sprat catches in tonnes for January 1996.

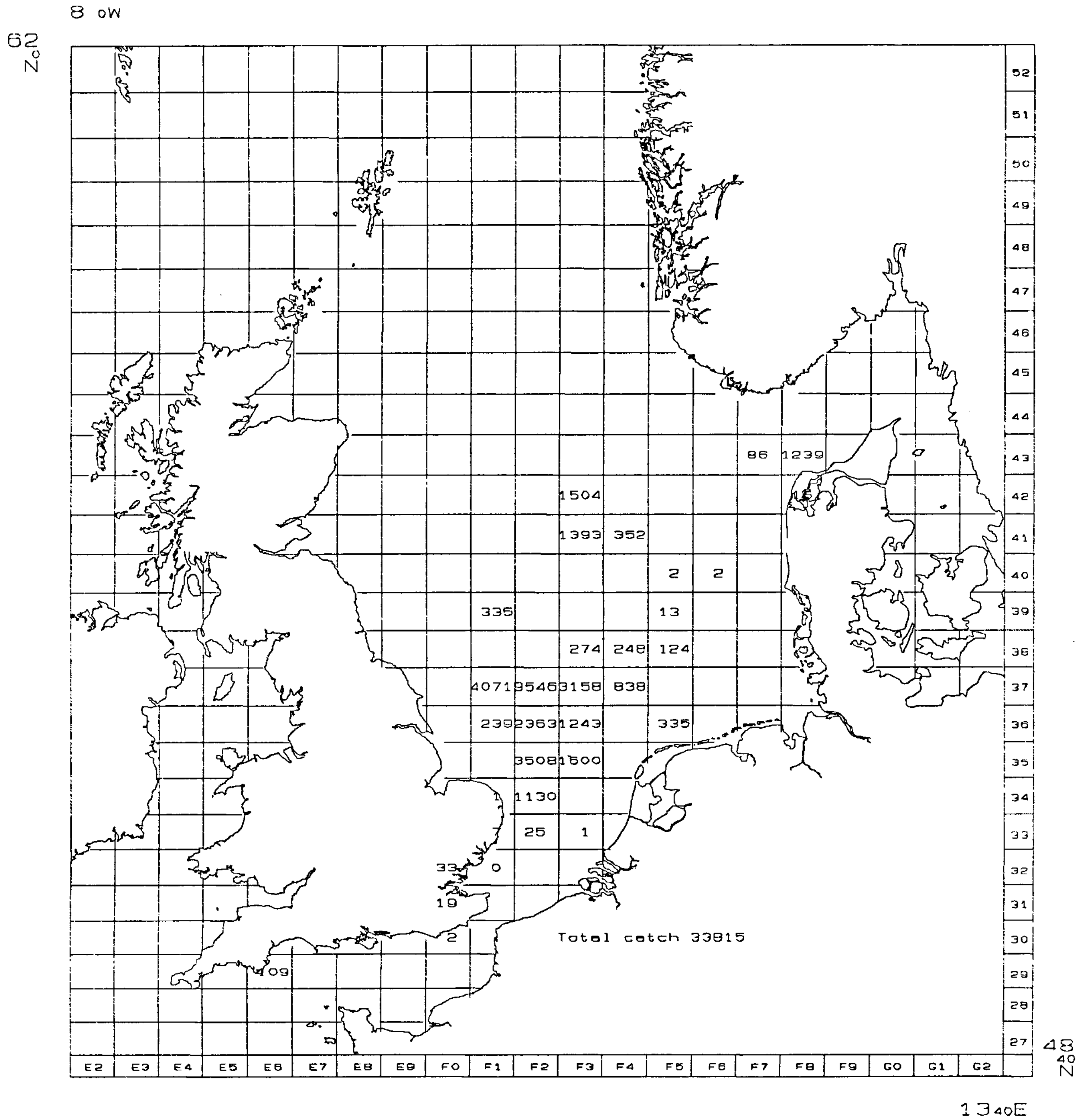


Figure 8.1.2 : North Sea and Divisions VIId,e sprat catches in tonnes for February 1996.

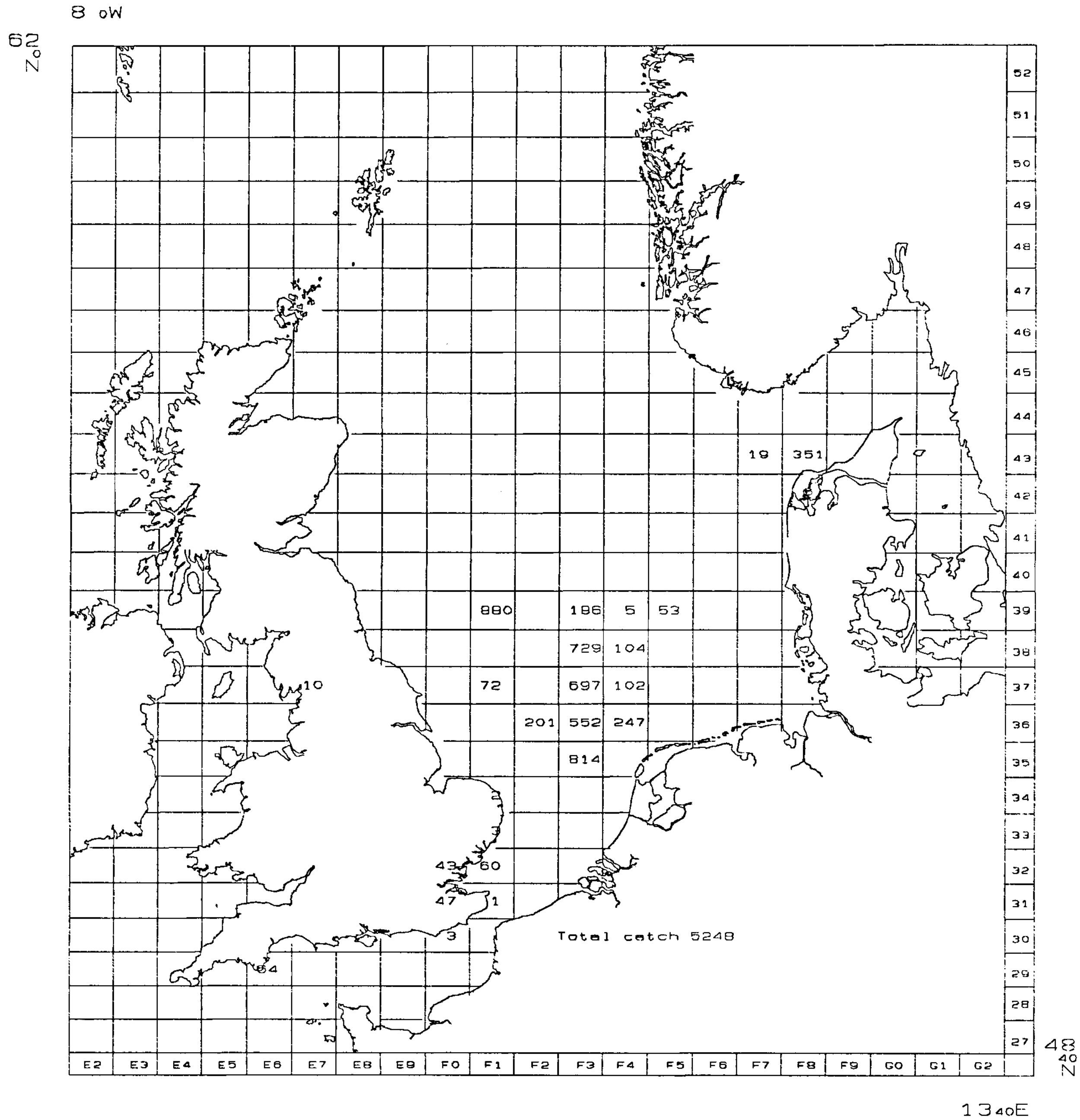


Figure 8.1.3 : North Sea and Divisions VIId,e sprat catches in tonnes for March 1996.

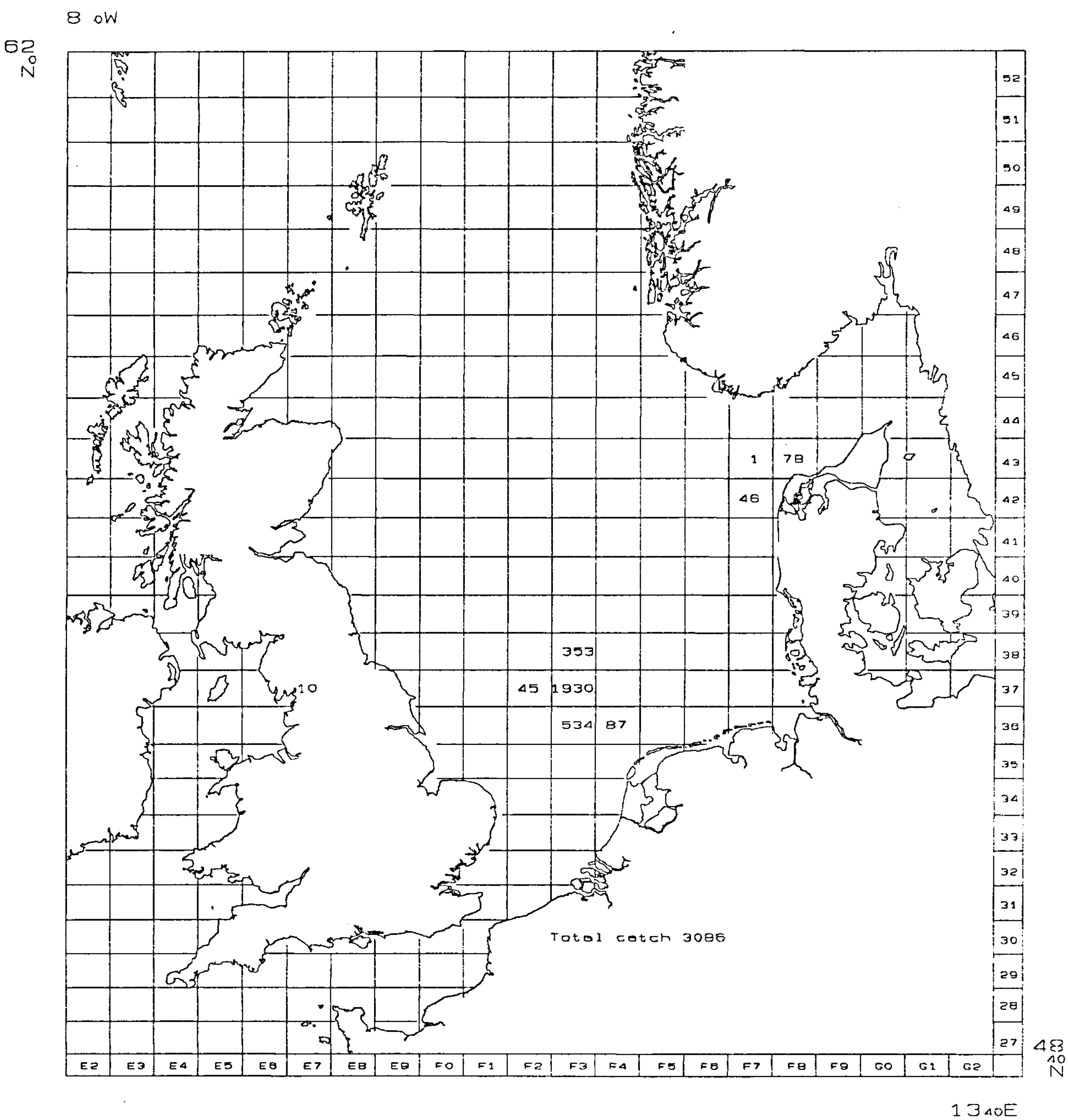


Figure 8.1.4 : North Sea and Divisions VIId,e sprat catches in tonnes for April 1996.

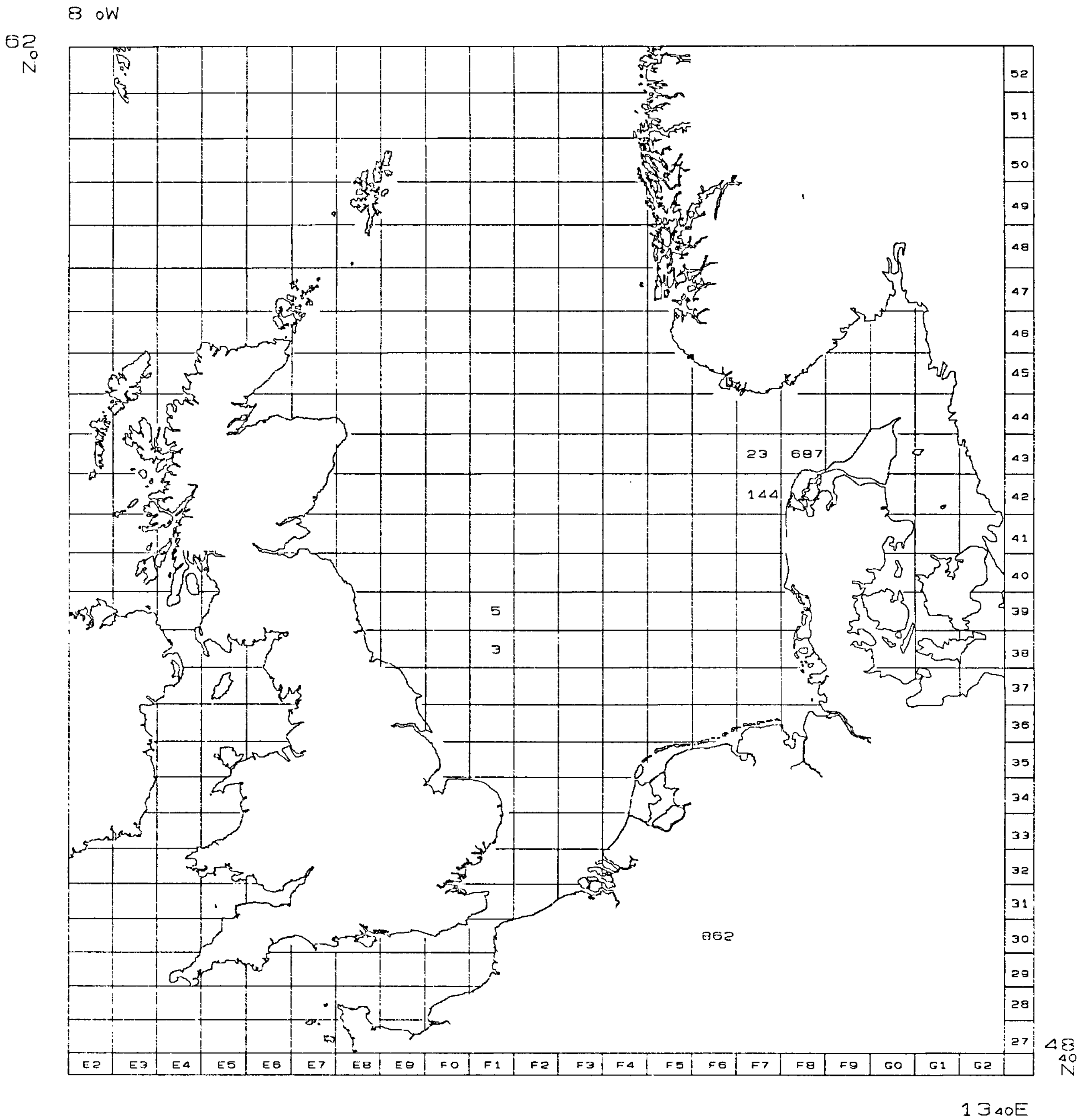


Figure 8.1.5 : North Sea and Divisions VIId,e sprat catches in tonnes for May 1996.

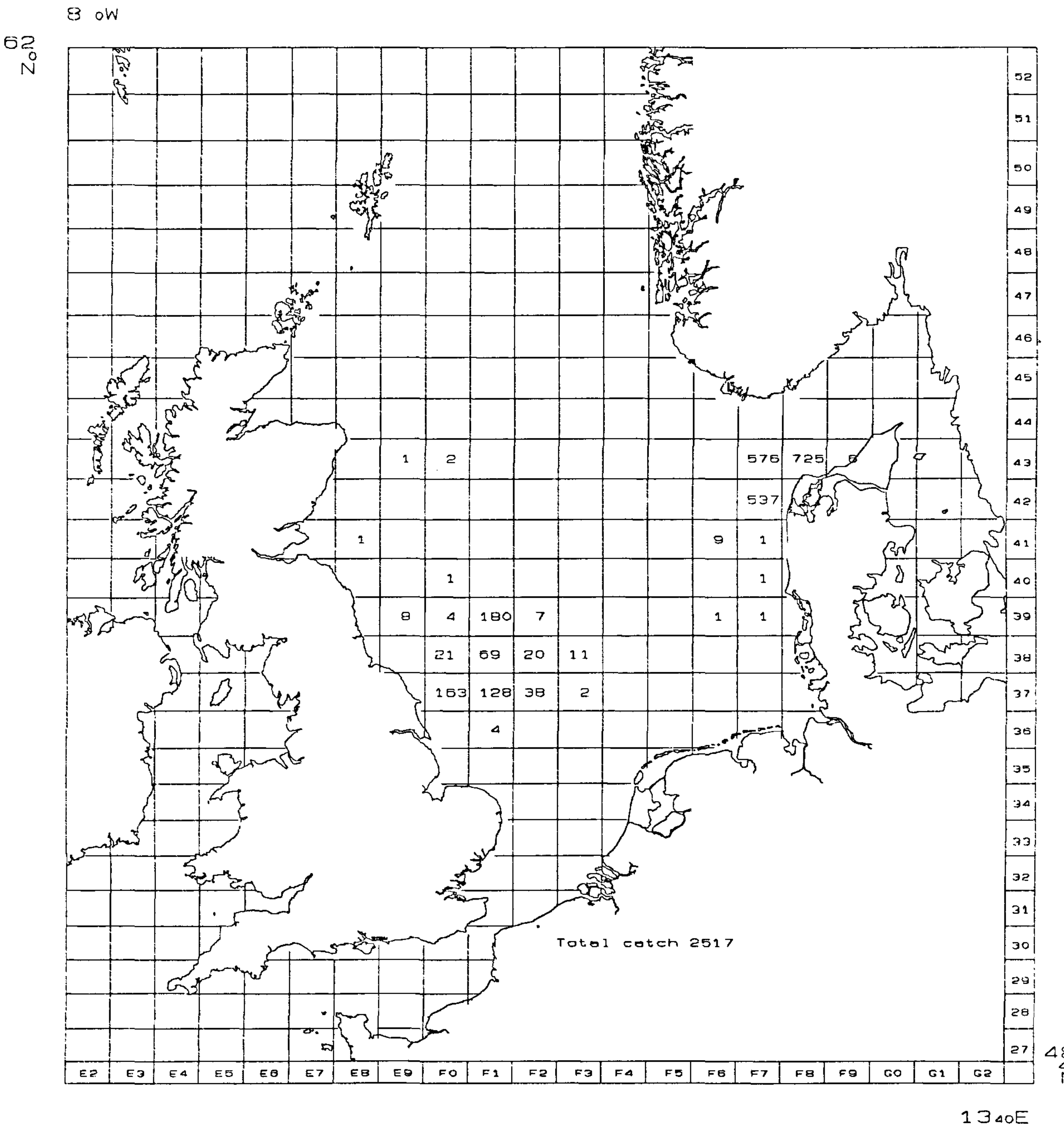


Figure 8.1.6 : North Sea and Divisions VIId,e sprat catches in tonnes for June 1996.

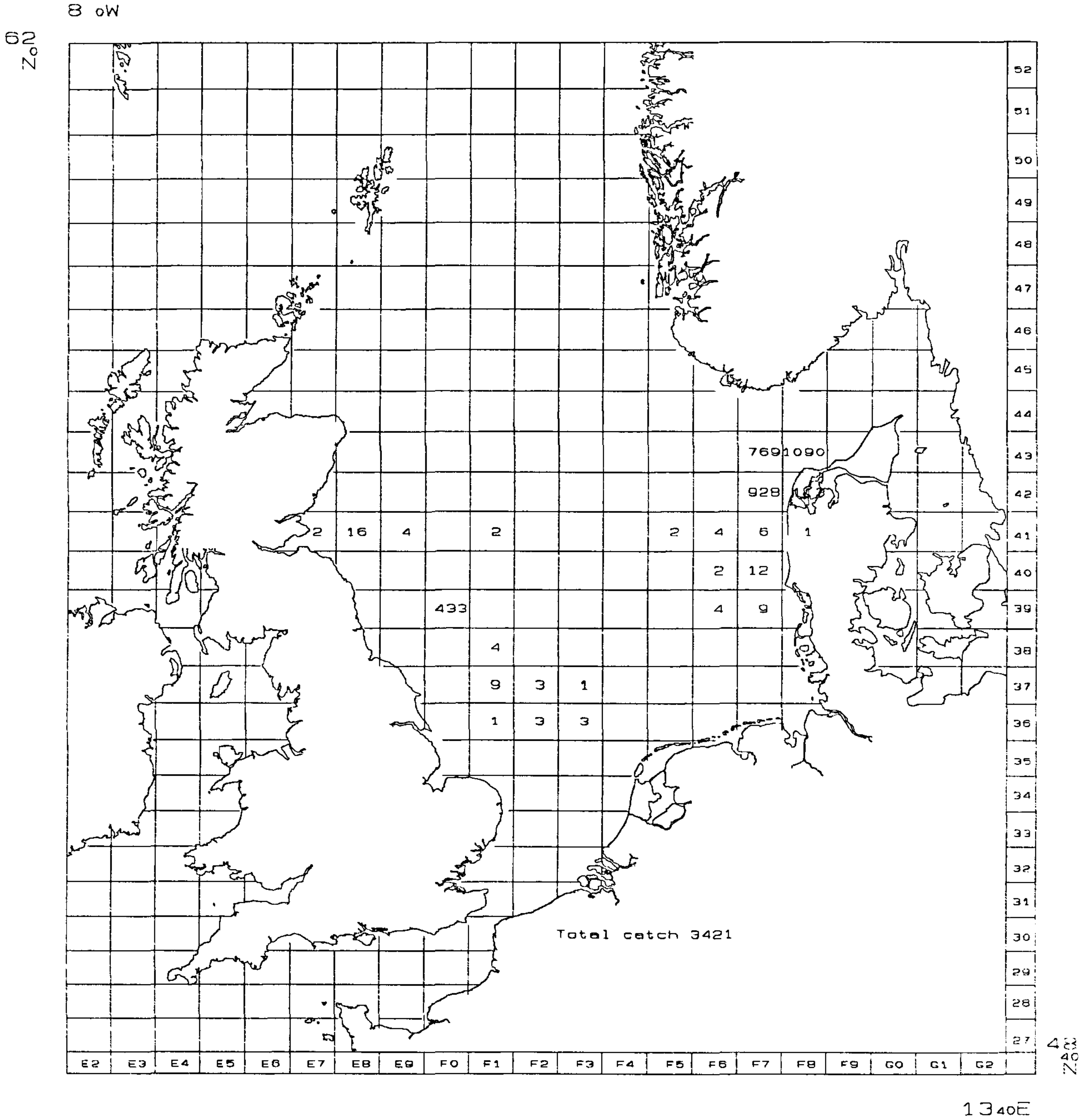


Figure 8.1.7 : North Sea and Divisions VIId,e sprat catches in tonnes for July 1996.

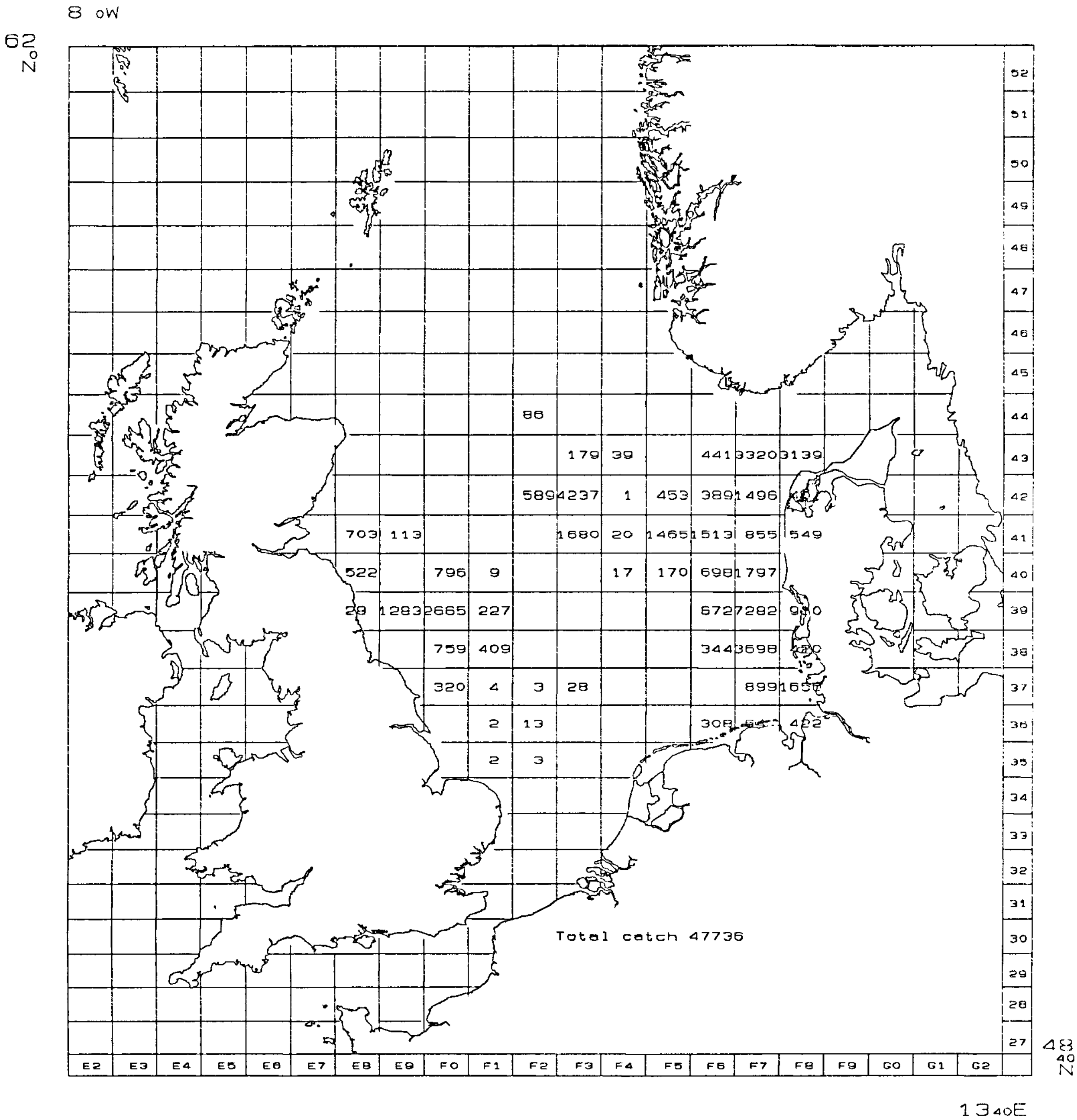


Figure 8.1.8 : North Sea and Divisions VIId,e sprat catches in tonnes for August 1996.

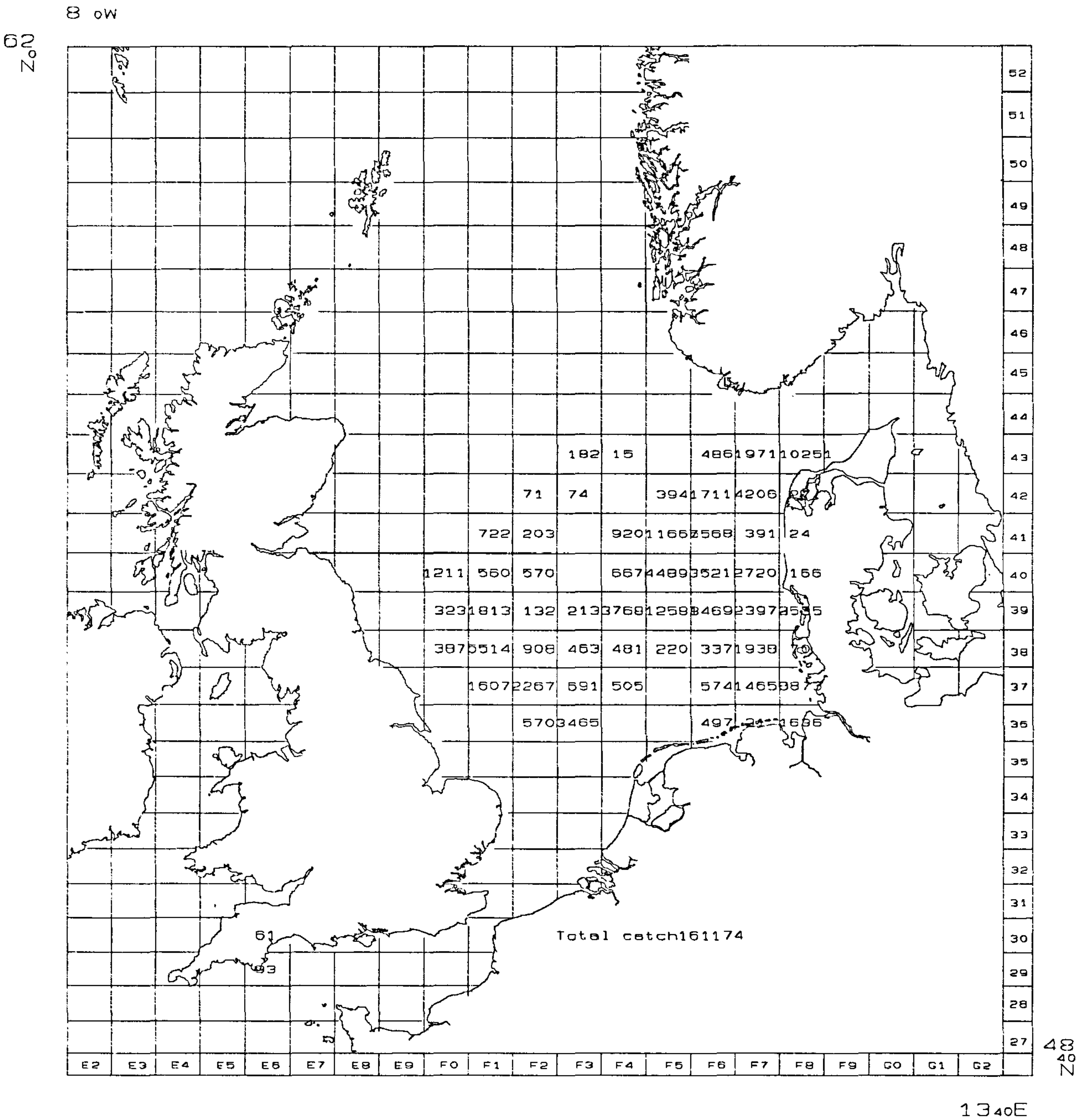


Figure 8.1.9 : North Sea and Divisions VIId,e sprat catches in tonnes for September 1996.

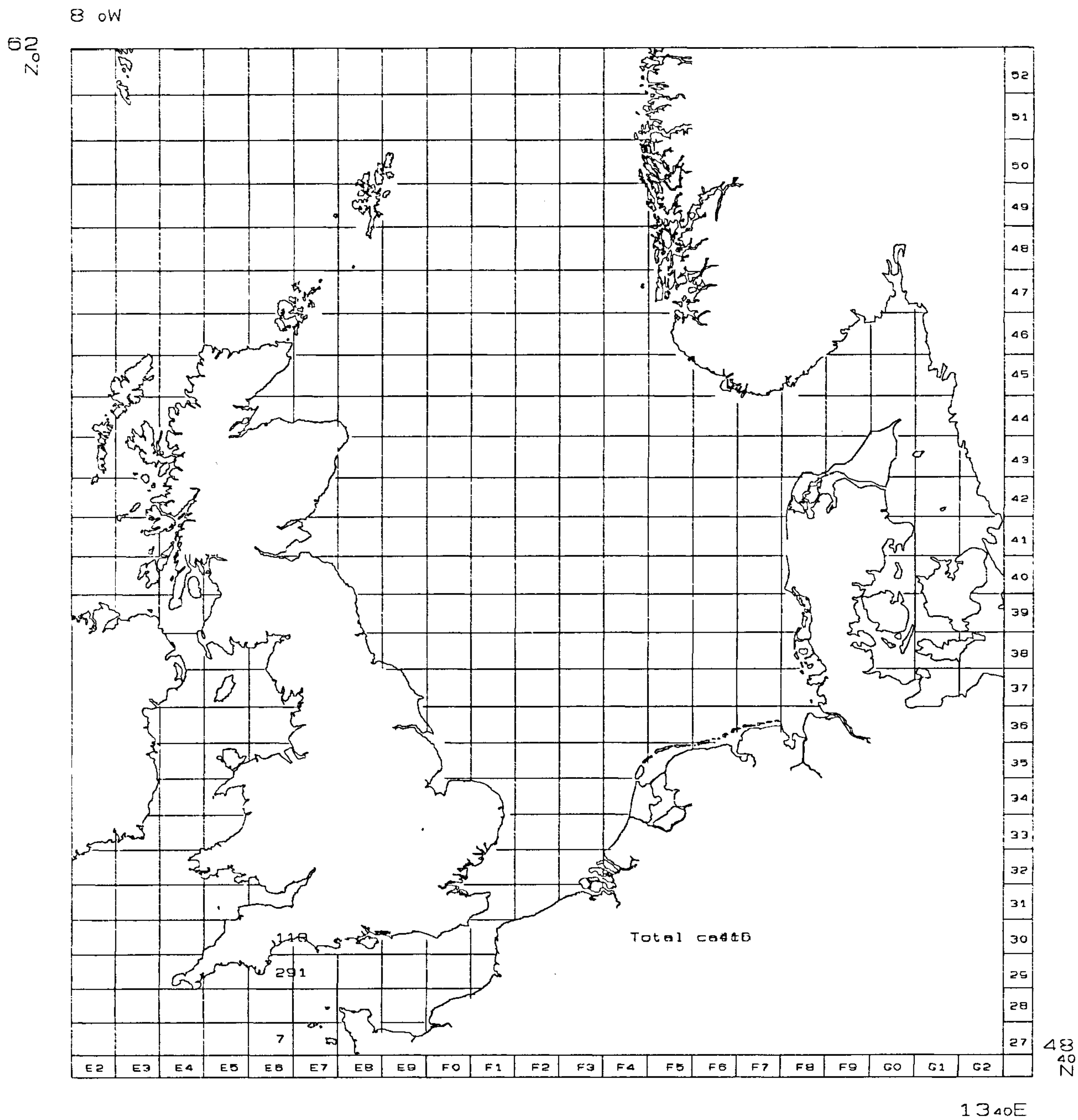


Figure 8.1.10 : North Sea and Divisions VIId,e sprat catches in tonnes for October 1996.

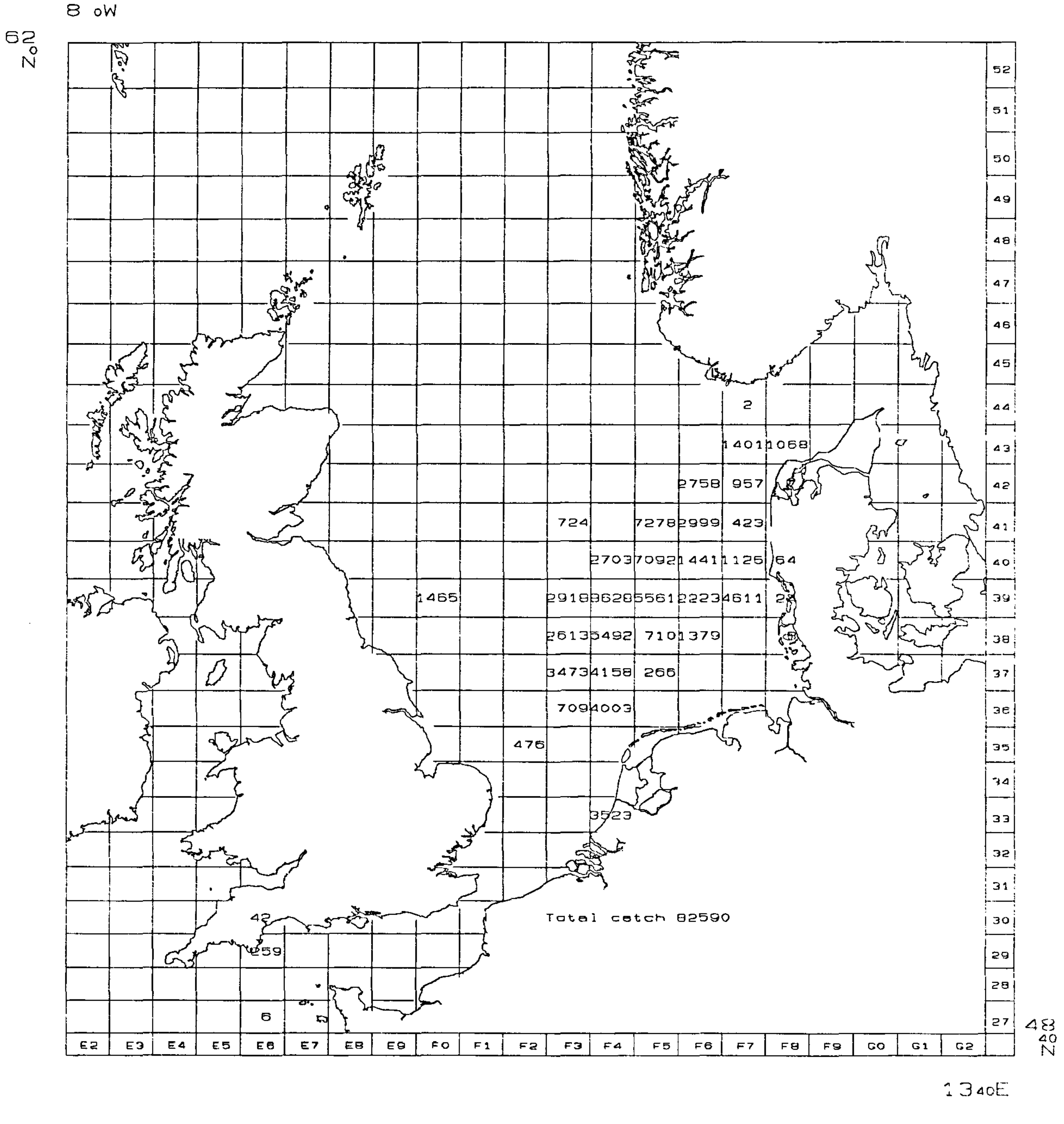


Figure 8.1.11 North Sea and Divisions VIId,e sprat catches in tonnes for November 1996.

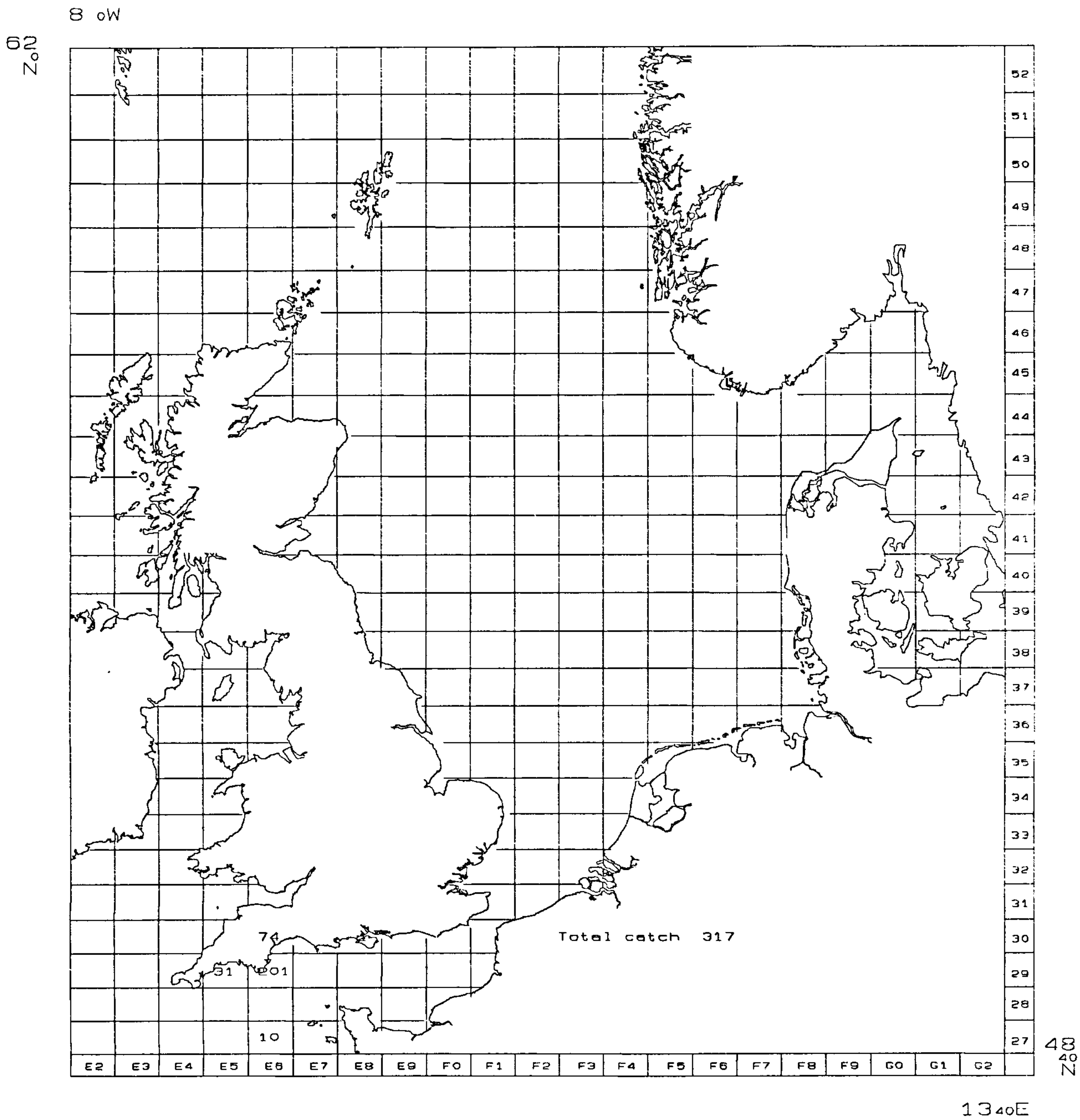


Figure 8.1.12 : North Sea and Divisions VIId,e sprat catches in tonnes for December 1996.

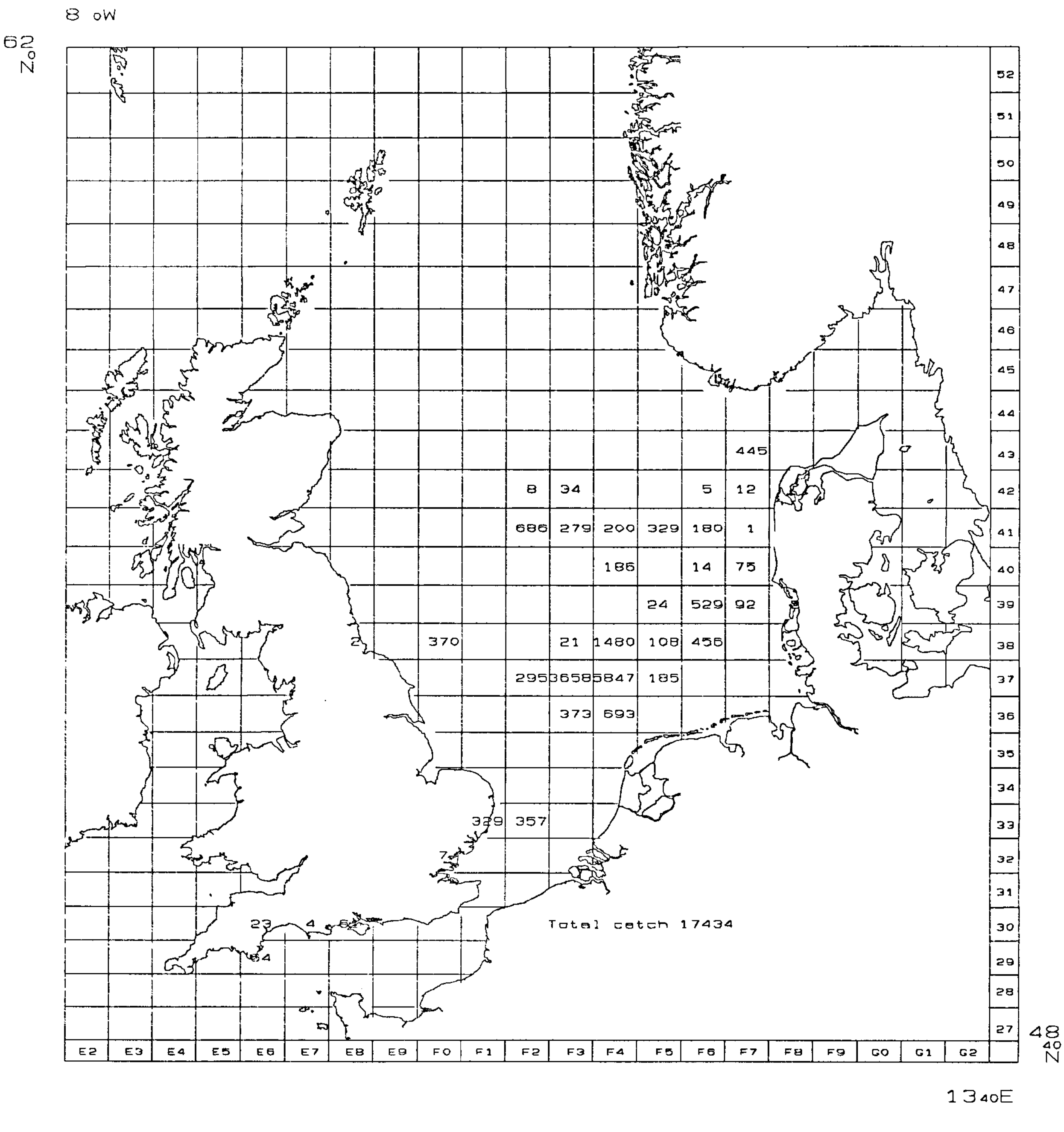
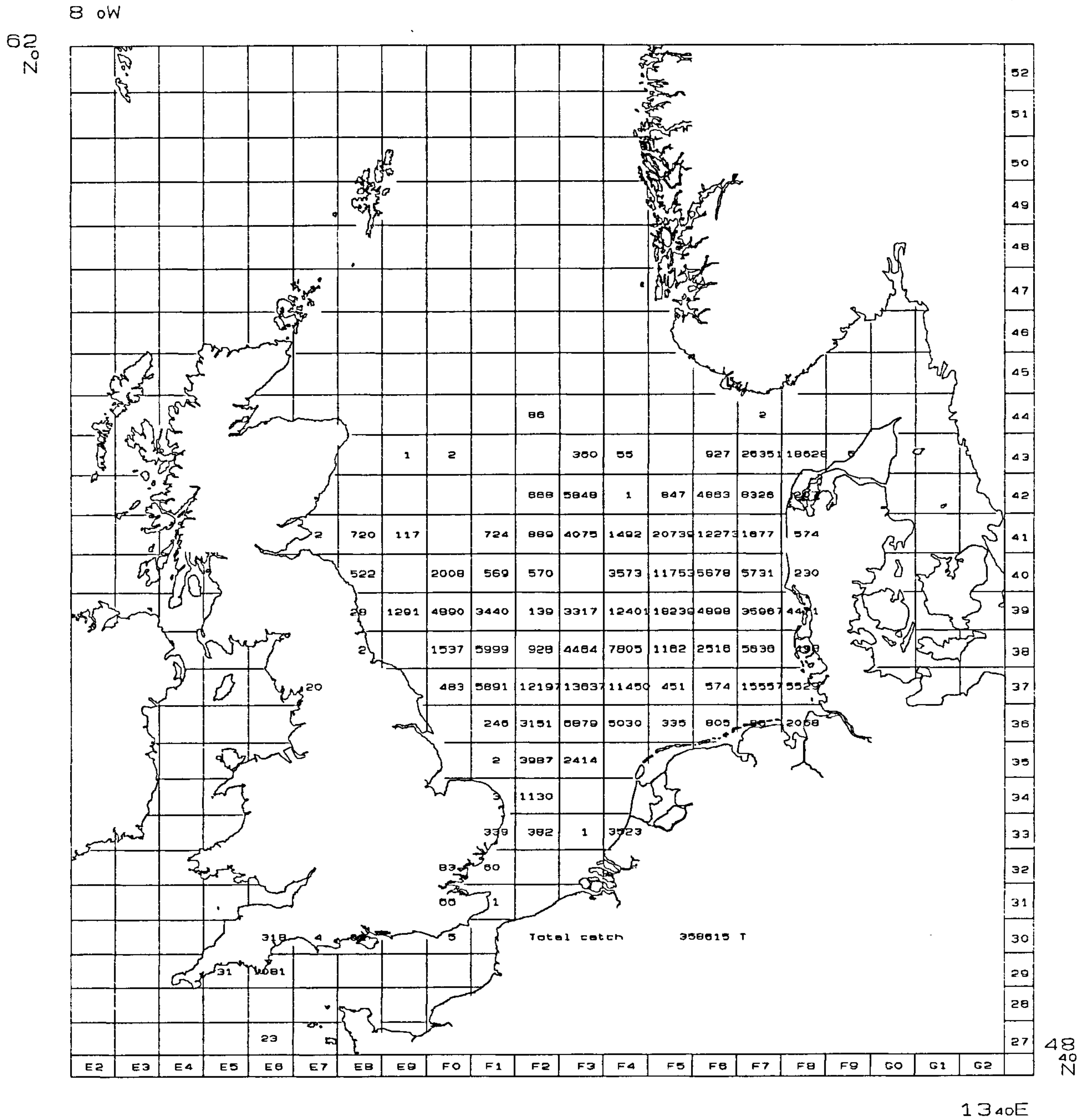
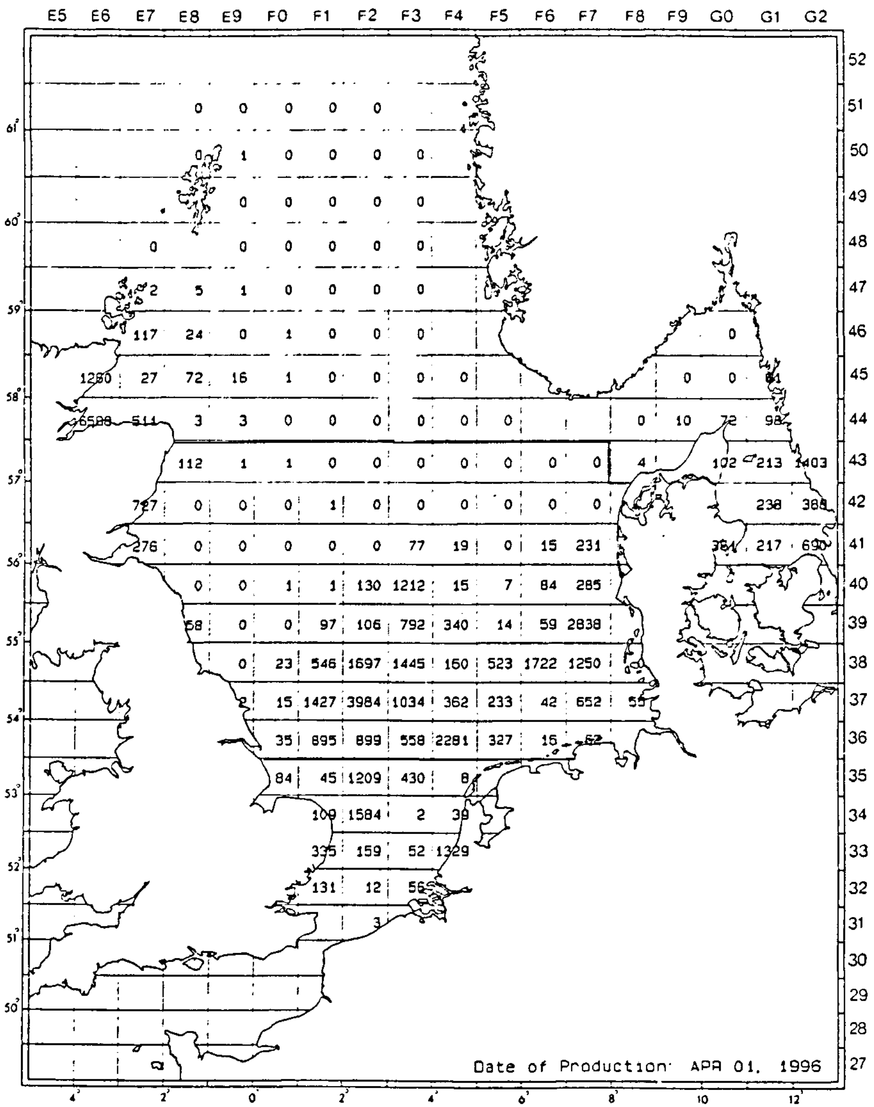


Figure 8.1.13 : North Sea and Divisions VIId,e sprat catches in tonnes for 1996.

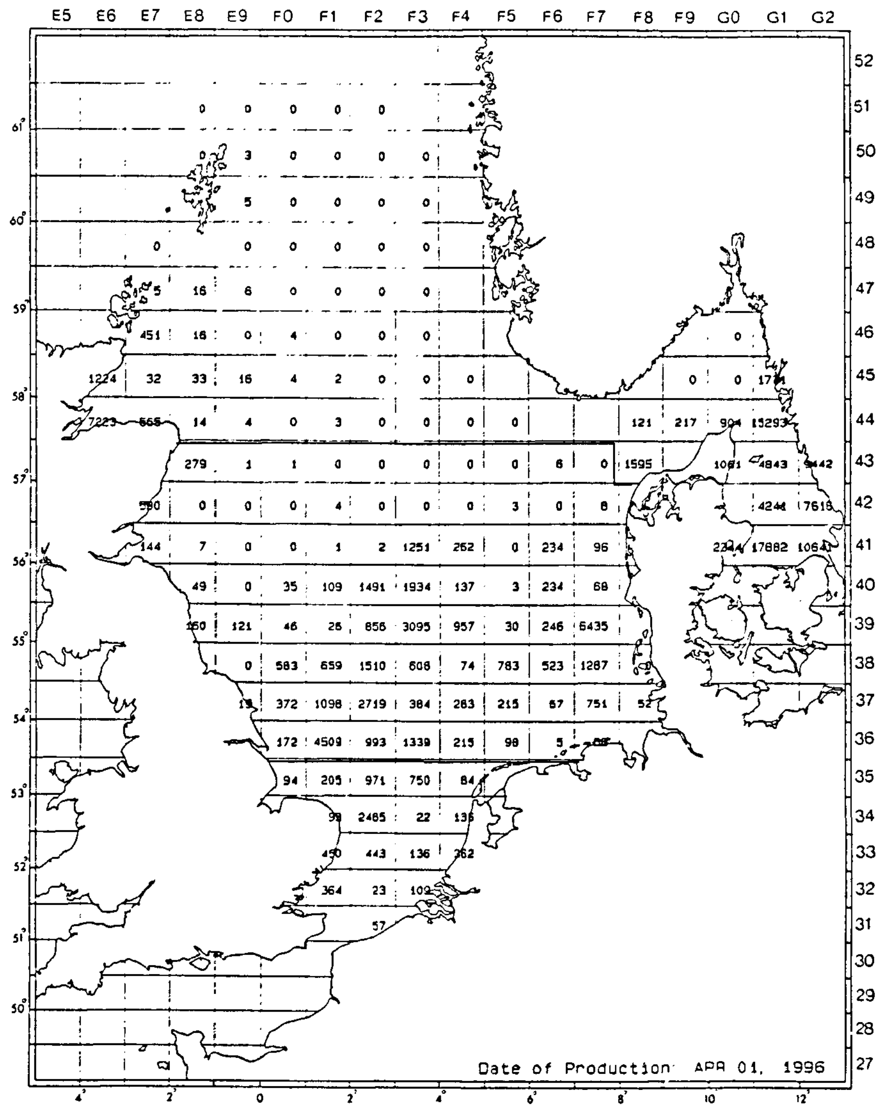


International Bottom Trawl Survey 1996Q1



Sprat, SPRA SPR
Number per Hour , Age Group 1.

International Bottom Trawl Survey 1996Q1



Sprat, SPRA SPR
Number per Hour , Age Group 2.

Figure 8.3.1. SPRAT. Distribution by age groups in the IBTS(February) 1996, in the North Sea and Division IIIa.

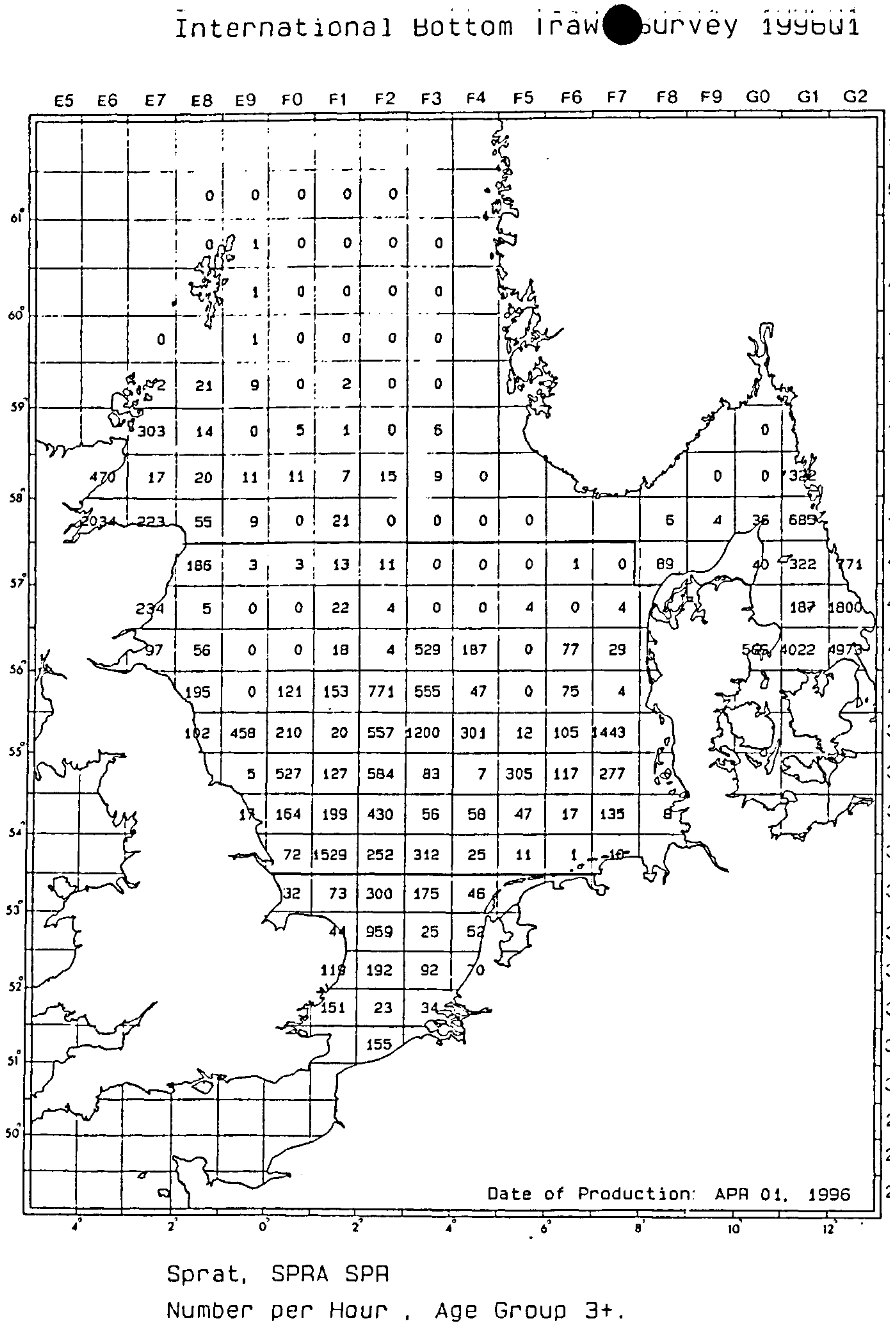


Figure 8.3.1. (continued).

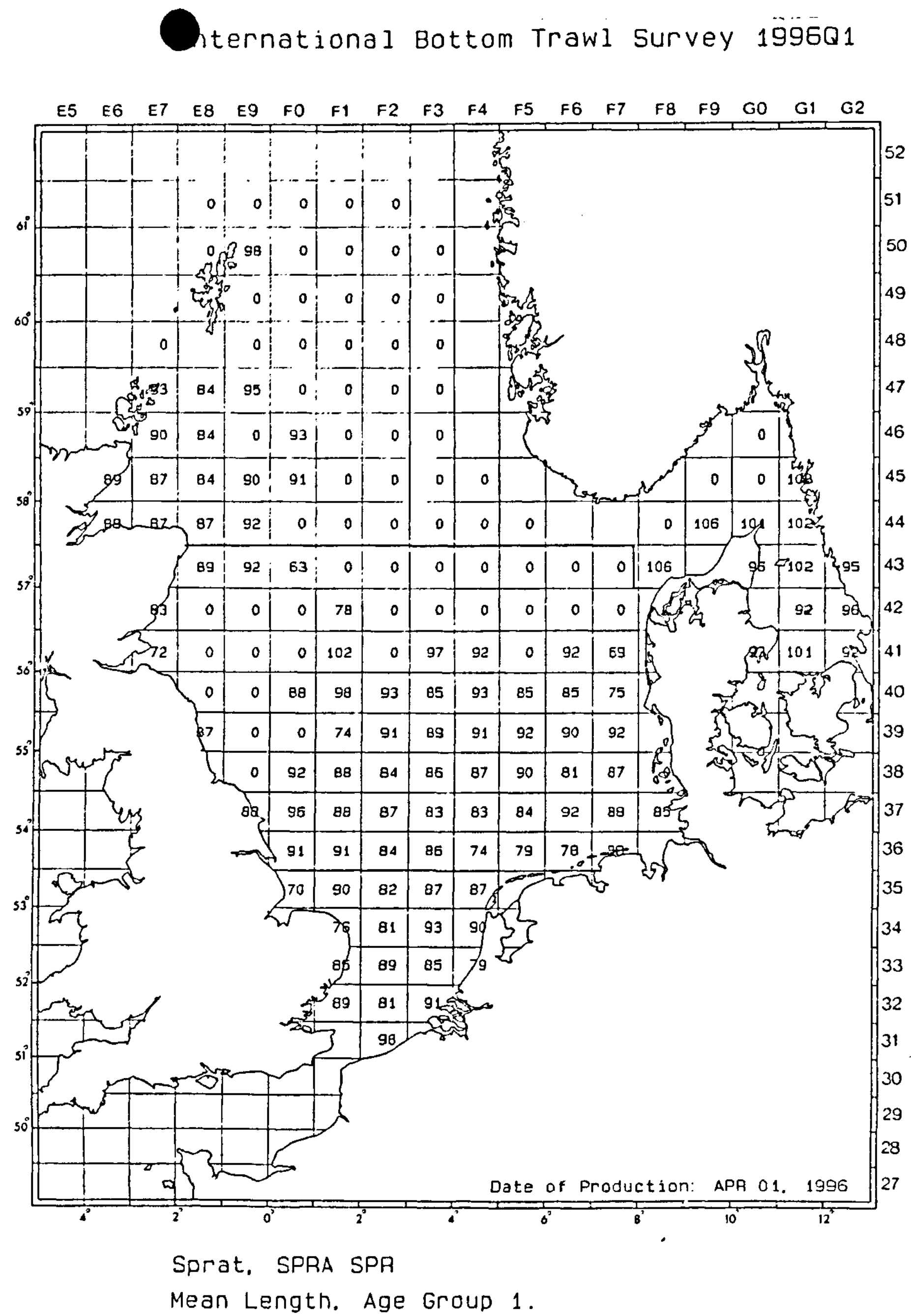


Figure 8.3.2. SPRAT. Mean length (mm) of age group 1 in the IBTS(February) 1996, in the North Sea and Division IIIa.

Figure 8.6.1. North Sea Sprat. IBTS indices vs total catches in 1981-1995.

(R^2 = 0,45)

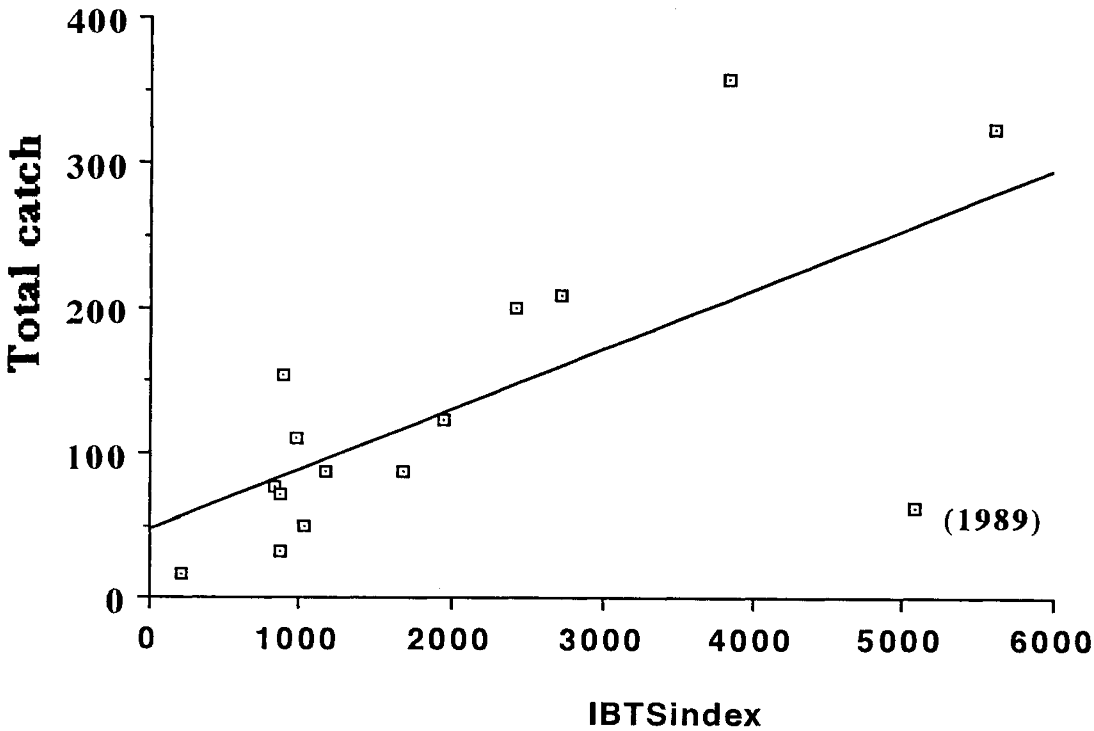
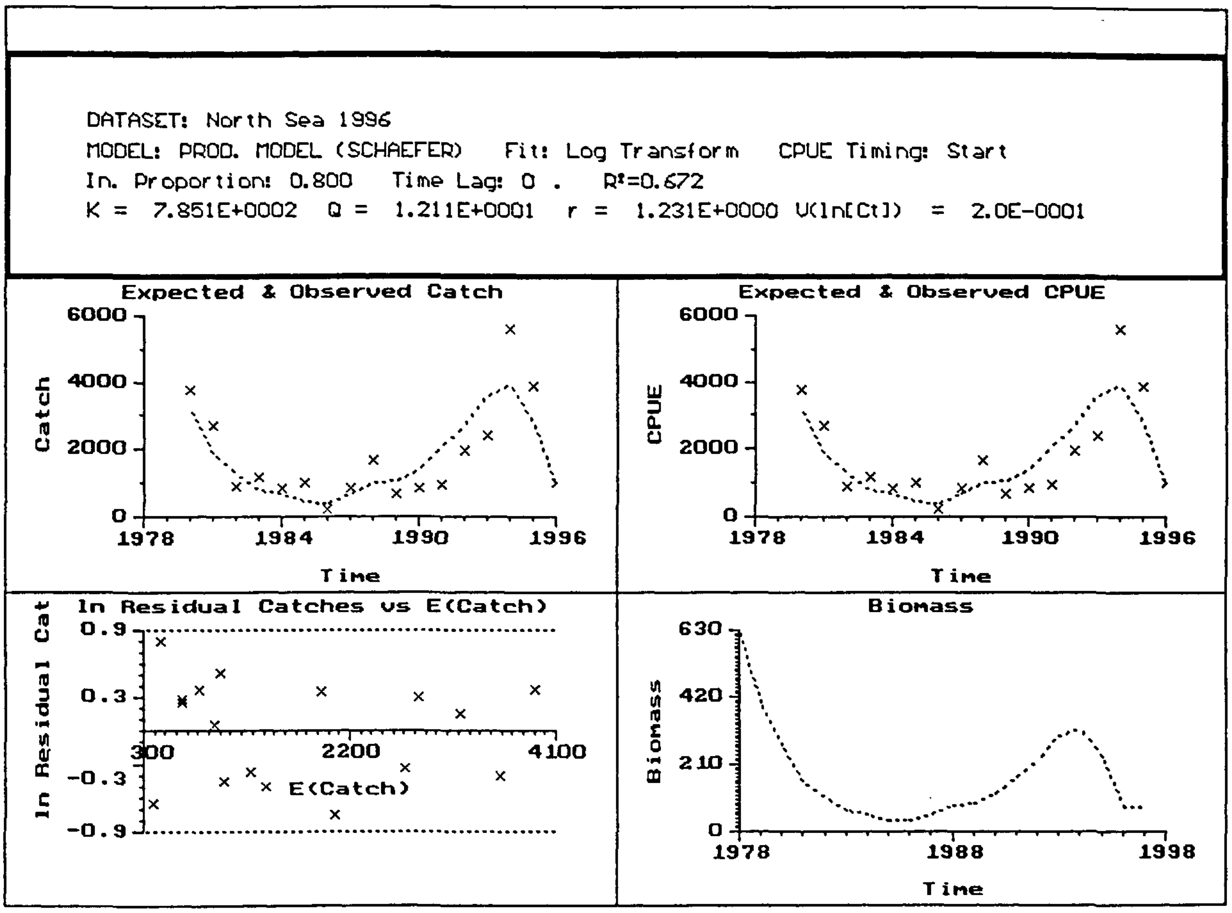


Figure 8.6.2. Biomass *vs*. year for the North Sea sprat, 1978-1994, using the adjusted total 1989-IBTS index of 667.



9 SPRAT IN DIVISIONS VIID,E

9.1 The fishery

The nominal landings for 1983-1995 are shown in Table 9.1.1. In Table 9.1.2 monthly catches for the Lyme Bay sprat fishery are shown. Monthly and annual distributions of catches by rectangle are shown in Figures 8.1.1-8.1.13.

9.2 Catch Composition

Data on catch composition and mean weights were available for the Working Group for September (one sample). Table 9.2.1 and Table 9.2.2 show catch compositions and the mean weights for 1991-1995.

Table 9.1.1 Nominal catch of sprat (t) in Divisions VIId,e, 1983-1995.

Country	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Belgium	3	-	-	-	-	-	-	-	-	-	-	-	-
Denmark	638	1,417	-	15	250	2,529	2,092	608	-	-	-	-	-
France	60	47	14	-	23	2	10	-	-	35	2	1	+
Germany	-	-	-	-	-	-	-	-	-	-	-	-	-
Netherlands	1,454	589	-	-	-	-	-	-	-	-	-	-	-
Norway	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (Engl.& Wales	4,756	2,402	3,771	1,163	2,441	2,944	1,319	1,508	2,567	1,790	1,798	3,132	1,535
Total	6,911	4,455	3,785	1,178	2,714	5,475	3,421	2,116	2,567	1,825	1,800	3,133	1,535

Preliminary

Table 9.1.2 Lyme Bay sprat fishery. Monthly catches (t). (UK vessels only).

Season	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
1991/92	0	0	205	450	952	60	358	258	109	51	2443
1992/93	0	0	302	472	189	294	248	284	158	78	2025
1993/94	8	0	156	82	302	529	208	417	134	53	1889
1994/95	0	0	299	834	545	608	232	112	68	0	2698
1995/96	0	0	154	409	301	307	151				1322

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Table 9.2.1. Lyme Bay sprat fishery. Number caught by age group (millions).

Season	0/1	1/2	2/3	3/4	4/5	5/6
1991/92	1.7	56.03	44.69	16.24	0.57	0.03
1992/93[1]	0.22	28.23	48.61	12.94	1.56	0
1993/94[2]	0	0.83	44.81	15.7	1.95	0.58
1994/95			No data			
	1	2	3	4	5	6
1995[3]	0.33	5.2	2.31	0.23	0.03	

1 August to December only (samples in August and December only, so these are best estimates

2 August to December only (samples in August, September and November only, so these are best estimates

3 Only September (one sample)

Table 9.2.2 Lyme Bay area SPRAT. 1991–1995 mean weight (g) at age.

Season	Quarter	0/1	1/2	2/3	3/4	4/5	5/6	Overall mean
1991/91	3	4.7	16.6	22.6	25.4	29.2	34.6	20.7
	4	6.6	17.1	23	26.3	30.9		21.0
	1	5.7	13.3	17.5	20.2	24.1		14.4
1992/93	3	4.2	12.1	22.8	24.6	32.4		21.8
	4		15.8	20.0	23.8	24.8		21.0
	1		13.2	17.1	21.2			14.2
1993/94	3			19.1	22.2	20.8		19.8
	4[1]		14.2	18.9	24.5	28.1	25.5	20.6

Season	Quarter	1	2	3	4	5	6	Overall mean
1995	3[2]		12.0	17.0	19.0	21.0	29.0	-

[1]Based on November samples only.
[2]Based on September sample only.

10 SPRAT IN DIVISION IIIA

10.1 Fishery

10.1.1 ACFM advice applicable for 1995 and 1996

ACFM advice on a sprat TAC has not been provided in recent years. Sprat is landed under the TAC for the mixed clupeoid fishery, including all catches of species taken in this fishery. The proportion of sprat in the mixed clupeoid fishery increased substantially between 1993 and 1994, but in 1995 it was again dominated by herring. In 1994 there was, for the first time in several years, a directed sprat fishery for industrial purposes in the Skagerrak and the northern part of the Kattegat. The TACs for this fishery as adopted by the management bodies, were 45,000 t in 1993 and 43,000 t in 1994 and 1995. The TAC set for 1996 was 43,000 t.

10.1.2 Catches in 1995

The total annual landings for Division IIIa by area and country in 1974-1995 are given in Table 10.1.1. The Norwegian and Swedish catches include the coastal and the fjord fisheries. The total landings in 1995, as estimated by the Working Group were 55,600 t, which is a reduction of about 42% from 1994. It was still higher than reported for 1982-1993. Decreases were reported in both the Danish and Swedish landings for 1995. Of the total landings only 3% were taken for consumption, 480 t by Norway and 1,160 t by Sweden, all in the Skagerrak.

Landings by quarter for all three countries in 1995 are shown in Table 10.1.2. About 40 % of the total landings were taken in the third quarter, with the same level of landings distributed among quarter 1,2 and 4.

10.1.3 Fleet

The sprat fishery in Division IIIa is conducted by fleets from Denmark, Norway and Sweden. The Danish landings are taken by two fleet categories: 1) a directed sprat (mixed clupeoid) trawl fishery using a minimum mesh size of 32 mm and 2) by-catches from the small mesh (16 mm) fisheries for Norway pout, blue whiting and sandeel (Dahlskov W.D. 1996). The landings are for reduction purposes.

The Swedish sprat fishery can be divided into three categories: 1) directed herring trawl fishery with minimum mesh size of 32 mm and by purse seiners, mainly for human consumption, 2) directed sprat fishery for human consumption carried out by purse seiners and 3) a directed sprat (mixed clupeoid) trawl fishery with mainly 16, 18 or 22 mm mesh size, for human consumption and for reduction purposes. Due to low market prices for herring for consumption, the Swedish landings of sprat in 1995 were mainly for reduction purposes.

The Norwegian sprat fishery in Division .IIIa is an inshore purse seine fishery for human consumption.

10.2 Catch composition

10.2.1 Catches in number and weight at age

No weight-at-age data in the catches were available for 1983-1991. For 1992-1993 data were supplied by Denmark, and in 1994 and 1995 also by Sweden.

The numbers and the mean weights at age in the Danish and Swedish industrial landings in 1992-1995 are presented in Tables 10.2.1 and Table 10.2.2, respectively, representing 96% of the total sprat landings in Division IIIa.

10.2.2 Quality of catch and biological data

In 1994 the sampling was extended to cover the Swedish landings for industrial purposes. In 1995 about 26 landings were sampled for species composition of which 8 were used for estimation of sprat age and mean weight at age. The Danish sampling intensity and coverage of the landings in the "mixed clupeoid" fishery were largely unchanged compared with last year. A total of 305 landings were analysed for species composition of which 69 samples of sprat were analysed for age and weight at age. As in previous years, no samples of sprat were taken from the fisheries for human consumption. The sampling intensity by Sweden and Denmark was increased in 1995 for total sprat landings from Division IIIa to meet the recommended level. Further details on the sampling for biological data are shown in Table 10.2.3.

10.3 Recruitment

10.3.1 Abundance of 1-group and older sprat from IBTS

The IBTS(February) indices for 1993-1995, were revised by the 1995 Herring Working Group (Anon. 1995d). The 1984-1992 indices were revised by the 1996 Herring Working Group, as described in the 1995 report. The indices, calculated as mean cpue (no./hr) weighted by the area of the rectangle with water depths between 10 and 150 m, are presented in Table 10.3.1. The IBTS data are provided by rectangle in Figure 8.3.1 for age groups 1,2 and 3+, and the mean length (mm) of 1-gr sprat in Figure 8.3.2.

The 1996 IBTS index indicates a dramatic reduction in the 1-group index. The very high index of 2-group, however, suggests that there may be problems in the age separation. The total 1996 sprat index for Division IIIa was one of the highest recorded in the period 1984-1996.

The age structure of sprat in the survey is rather variable, with difficulties in following strong and weak cohorts from year to year, as demonstrated below.

Year class	1-group	2-group	1-gr/2-gr
1983	5780	2395	2.41
1984	2397	1919	1.25
1985	665	2501	0.27
1986	2244	5461	0.41
1987	940	994	0.95
1988	438	238	1.84
1989	503	457	1.10
1990	636	606	1.05
1991	6016	4624	1.30
1992	1790	614	2.91
1993	1547	1829	0.85
1994	2283	5800	0.39

10.4 State of the Stock

No assessments of the sprat stock in Division IIIa have been presented since 1985 and this year is no exception. The Working Group concluded that the data available do not allow any assessment which could be helpful for management.

10.5 Projection of Catch and Stock

Figure 10.5.1 shows the IBTS (February) index plotted against the catch in the same year (r^2=0.05). The 1994 and 1995 observations are anomalously high.

SHOT estimates (Shepherd, 1991) were provided by the IFWG in 1992, with little confidences in the estimates. With more data available, new SHOT estimates using total IBTS index, 1-group index and a combined 1-and 2-age index as input data, were made. The estimated landings for 1996 were in the range of 15,000 to 43,000 t. The SHOT forecast using the total index as an input is presented in Table 10.5.1. The Working Group concludes that no projection of either catch or stock size can be provided with any confidence due to problems in the total catch and the IBTS-index by age data.

10.6 Management Considerations

The recruitment variation between years does not appear to be driven directly by fishing. The sprat stock has in recent years been mainly fished together with herring, except from 1994 when a directed sprat fishery was implemented. The human consumption fishery is only a minor part of the total catch. There are no indications of overexploitation but the data available are quite variable.

10.7 Research Recommendations

The Working Group considered the research required to improve the quality of the sprat assessment and recommends the following to be addressed before the next meeting of the Working Group:

- The acoustic surveys detect sprat and should be re-examined for the possibility of estimating sprat abundance. If feasible, the survey data should be revisited to obtain these estimates for as many years as possible.

The improvement of the biological sampling intensity of 1994 and 1995 should be continued.

Table 10.1.1 Landings of SPRAT in Division IIIa Catch (in tonnes 10^3). (Data provided by Working Group members). These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1974	1975	1976	1977	1978	1979	1980	1981
					Skagerrak			
Denmark	17.9	15.0	12.8	7.1	26.6	33.5	31.7	26.4
Sweden	2.0	2.1	2.6	2.2	2.2	8.1	4.0	6.3
Norway	1.2	1.9	2.0	1.2	2.7	1.8	3.4	4.6
Total	21.1	19.0	17.4	10.5	31.5	43.4	39.1	37.3

Country	1974	1975	1976	1977	1978	1979	1980	1981
					Kattegat			
Denmark	31.6	60.7	27.9	47.1	37.0	45.8	35.8	23.0
Sweden	18.6	20.9	13.5	9.8	9.4	6.4	9.0	16.0
Total	50.2	81.6	41.4	56.9	46.4	52.2	44.8	39.0
Div. IIIa Total	**71.3**	**100.6**	**58.8**	**67.4**	**77.9**	**95.6**	**83.9**	**76.3**

Country	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994[1]	1995[1]
						Skagerrak								
Denmark	10.5	3.4	13.2	1.3	0.4	1.4	1.7	0.9	1.3	4.2	1.1	0.6	47.7	29.1
Sweden	-	-	-	-	-	-	-	-	-	-	-	4.7	32.2	9.7
Norway	1.9	1.9	1.8	2.5	1.1	0.4	0.3	1.1	1.3	1.0	0.6	1.3	1.8	0.5

Country	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994[1]	1995[1]
						Kattegat								
Denmark	21.4	9.1	10.9	4.6	0.9	1.4	1.3	3.0	1.1	2.2	2.2	0.8	11.7	11.7
Sweden	-	-	-	-	-	-	-	-	-	-	-	1.7	2.6	4.6

Country	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994[1]	1995[1]
						Division IIIa								
Sweden	5.9	13.0	10.2	11.3	8.4	11.2	5.4	4.8	6.0	6.6	6.6	-	-	-
Div. IIIa Total	**39.7**	**26.4**	**36.1**	**19.7**	**10.8**	**14.4**	**8.7**	**9.8**	**9.7**	**14.0**	**10.5**	**9.1**	**96.0**	**55.6**

[1]Preliminary.

Table 10.1.2. Sprat Div. IIIa. Landings of sprat (' 000 tonnes) by quarter by the three countries. (Data provided by the Working Group members).

Quarter		Denmark	Norway	Sweden	Total
1994	1	0.3	0.0	0.5	0.8
	2	6.0	0.0	0.3	6.3
	3	37.0	0.1	23.0	60.1
	4	16.1	1.7	11.0	28.8
Total		59.4	1.8	34.8	96.0
1995	1	4.8	0.1	4.8	9.7
	2	10.4	0.0	0.9	11.3
	3	19.3	0.0	2.3	21.6
	4	6.3	0.4	6.3	13.0
Total		40.8	0.5	14.3	55.6

Table 10.2.1 Division IIIA Sprat. Landed numbers (millions) of sprat by age groups in 1994-1995.

Country	Fishing area	Quarter	Age					
1994			0	1	2	3	4	5+
Denmark	Skagerrak	1		16.28				
		2		1191.33				
		3		4221.72	21.21			
		4	16.47	874.75	23.79			
Denmark	Kattegat	1		5.02	7.39	3.48	0.31	
		2		0.92	36.53	6.30		
		3	3.69	632.38	5024.00	42.11		
		4	5.73	287.74	42.28	21.50		
Sweden	Skagerrak	1						
		2						
		3	18.49	2135.32	37.64	8.21	2.08	6.53
		4	1.51	911.44	7.30	7.10	0.32	
Total Div.IIIa		1	0.00	21.30	7.39	3.48	0.31	0.00
		2	0.00	1192.25	36.53	6.30	0.00	0.00
		3	22.18	6989.42	5082.85	50.32	2.08	6.53
		4	23.71	2073.93	73.37	28.60	0.32	0.00
1995								
Denmark	Skagerrak	1		66.07	199.32	8.77		
		2		1026.38	758.87	34.58		
		3		1304.54	108.83			
		4		255.41	2.32			
Denmark	Kattegat	1		205.54	194.92	32.79	21.25	7.38
		2		124.37	117.94	19.84	12.86	4.48
		3		315.11	16.64	13.31		
		4		277.62	19.66		0.60	
Sweden	Div.IIIa	1		21.54	342.64	8.70	4.39	1.08
		2		22.37	56.35	2.94	1.46	
		3						
		4		315.08	109.50	28.14	9.34	
TOTAL	Div. IIIa	1		293.15	736.88	50.26	25.64	8.46
		2		1173.12	933.16	57.36	14.32	4.48
		3		1619.65	125.47	13.31	0.00	0.00
		4		848.11	131.48	28.14	9.94	0.00

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Table 10.2.2. Div. IIIa Sprat. Quarterly mean weight (g) at age in the landings in 1994-1995 . (Danish and Swedish data)

Quarter	Age					
1994	0	1	2	3	4	5+
1		4.5	18.3	20.3	24.7	
2		4.3	20.0	22.8		
3	7.8	8.1	17.4	21.6	22.1	17.6
4	4.2	11.2	17.1	22.3	31.0	
Total	6.0	8.4	17.8	21.9	27.2	17.6
1995						
1		2.3	8.9	18.8	22.9	26.1
2		2.9	7.3	12.4	23.7	27.0
3		10.5	18.4	15.5		
4		11.5	15.6		18.2	
Total		7.8	9.2	15.3	22.2	26.4

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Table 10.2.3 Division IIIa Sprat. Sampling of industrial landings in 1993-1995

Country	Total catch ('000 t)	No. samples	No. aged	No. meas.
1993				
Denmark	0.6	30	98	654
Norway	1.3			
Sweden	4.7			
Total	6.6	30	98	654
1994				
Denmark	59.4	80	3420	6564
Norway	1.8	1		96
Sweden	34.8	45	687	3719
Total	96.0	126	4107	10379
1995				
Denmark	40.8	69	2234	6834
Norway	0.5	0	0	0
Sweden	14.3	23	1385	15643
Total	55.6	92	3619	22477

Table 10.3.1. Div. IIIa Sprat. Revised indices of sprat per age group from IBTS(February) 1984-1996. (Mean number per hour per rectangle weighted by area. Only hauls taken in depths of 10-150 m are included).

Year	No Rect	No hauls	Age Group					
			1	2	3	4	5+	Total
1984	15	38	5779.73	854.30	207.60	80.09	61.47	6983.19
1985	14	38	2397.24	2395.15	368.76	128.50	49.11	5338.76
1986	15	38	664.99	1918.53	1786.59	116.20	31.91	4518.22
1987	16	38	2244.33	2501.38	2224.94	1655.66	78.69	8705.00
1988	13	38	939.91	5461.23	1519.15	2130.02	459.41	10509.72
1989	14	38	437.60	994.37	1077.13	603.41	147.86	3260.37
1990	15	38	502.83	237.76	69.90	65.65	49.04	925.18
1991	14	38	636.17	456.74	493.57	86.03	215.58	1888.09
1992	16	38	6016.26	605.99	272.13	215.45	79.26	7189.09
1993	16	38	1789.73	4623.70	996.75	218.97	260.08	7889.23
1994	16	38	1546.88	614.35	961.44	299.48	67.58	3489.73
1995	17	38	2282.92	1828.84	37.24	47.86	4.53	4201.39
1996	15	38	176.15	5800.45	794.23	135.95	228.51	7135.29

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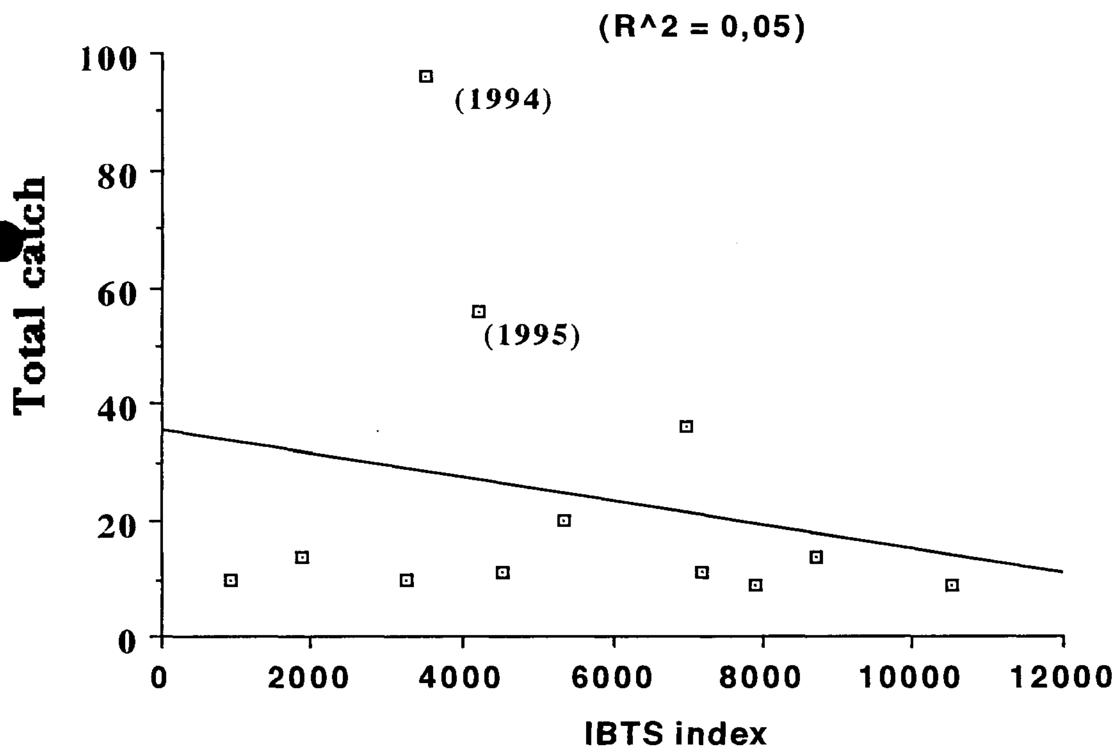
Table 10.5.1. SPRAT Div. IIIa. SHOT forecast of landings in 1996 using total landings and the total IBTS(February) indices as input data.

```
Div.IIIa Sprat                      SHOT forecast spreadsheet version 4
Total Index                                             April 1996

running recruitment weights
      older    0.00                           G-M =  0.00
      central  1.00                          exp(d)  1.00
      younger  0.00                        ex p(d/2) 1.00
```

Year	Land -ings	Recrt Index	W'td Index	Y/B Ratio	Hang -over	Act'l Prodn	Est'd Prodn	Est'd SQC.	Act'l Expl Biom	Est'd Expl Biom	Est'd Land -ings
1984	36	6983		0.77	0.23				47		
1985	20	5339	5339	0.77	0.23	15			26		
1986	11	4518	4518	0.77	0.23	8	26	24	14		
1987	14	8705	8705	0.77	0.23	15	31	27	18		
1988	9	10509	10509	0.77	0.23	8	22	20	12	26	20
1989	10	3260	3260	0.77	0.23	10	5	6	13	8	6
1990	10	925	925	0.77	0.23	10	2	4	13	5	4
1991	14	1888	1888	0.77	0.23	15	4	5	18	7	5
1992	11	7189	7189	0.77	0.23	10	17	16	14	21	16
1993	9	7889	7889	0.77	0.23	8	17	16	12	20	16
1994	96	3490	3490	0.77	0.23	122	7	7	125	10	7
1995	56	4201	4201	0.77	0.23	44	17	35	73	46	35
1996		7135	7135	0.77	0.23	0	33	38	0	49	38

Figure 10.5.1. Div.IIIa Sprat. IBTS total indices vs total catches in 1984-1996.



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