This Report not to be cited without prior reference to the Council[x)]

International Council for
the Exploration of the Sea

C.M. 1979/G:9
Demersal Fish Committee
Ref. Pelagic Fish Committee

REPORT OF THE WORKING GROUP ON DIVISION IIIa STOCKS

Charlottenlund, 2.-9. April 1979

This Report has not yet been approved by the International Council for the Exploration of the Sea; it has therefore at present the status of an internal document and does not represent advice given on behalf of the Council. The proviso that it shall not be cited without the consent of the Council should be strictly observed.

---

x) General Secretary,
ICES,
Charlottenlund Slot,
DK-2920 Charlottenlund,
Denmark.

CONTENTS

REPORT OF THE WORKING GROUP ON DIVISION IIIa STOCKS

1. Introduction

1.1. Terms of reference

The Working Group on Division IIIa stocks was established at the ICES Statutory Meeting in 1978. According to C.Res.1978/2:12, the Working Group's terms of reference are:

(i) make available and evaluate all relevant information and data on stock components in Division IIIa herring with special reference to the occurrence of North Sea autumn spawners;

(ii) consider and recommend feasible methods for a continous census of stock composition in the area;

(iii) assess TACs for 1980 for cod, whiting, plaice and sprat.

In a letter dated 13 March 1979, the Commission of the European Communites asked ICES to consider a number of questions which arise from the Agreed Record between Norway, Sweden and the Community of 2 February 1979 concerning the fisheries in the Skagerrak and Kattegat.

In agreement with the Chairman of the ICES Advisory Committee on Fishery Management, the following questions from the EEC were included in the present Working Group's terms of reference:

1. review the extent to which, on the basis of available scientific data, agreed mesh size for fishing in the Skagerrak and Kattegat should be changed taking into account, inter alia, current recommendations by ACFM for the North Sea area;

2. consider whether, on the basis of available scientific data, there is any biological justification for management purposes to extend the prohibition of fishing with beam trawls or similar types of trawls designed for catching flatfish outside 12-miles coastal limits and with special regard to the Skagerrak;

4. Review the extent to which, on the basis of available scientific data, minimum fish sizes should be changed in Skagerrak and Kattegat taking into account, inter alia, recommendations by ACFM for the North Sea area.

   These minimum fish sizes in Kattegat and Skagerrak being those indicated in Chapter 5 of the "Agreed Record".

5. Consider the effect of a mesh size smaller than 16 mm which may be used in Kattegat during the period 1 March to 31 July and in Skagerrak during the period 1 March to 31 October when fishing for sandeels (Ammodytes).

7. Consider the appropriate mesh size for Nephrops.

Questions No. 3 and 6 which are omitted from the list above concerned technical aspects which were thought more appropriately handled by other expert groups within ICES.

1.2. Venue and Participation

The Working Group on IIIa Stocks met at ICES Headquarters in Charlottenlund, Denmark, in the period of 2 - 6 April 1979.

The following experts participated in the meeting:

Dr. R.S. Bailey (United Kingdom)
Mr. E. Bakken (Norway)
Mr. A. Corten (Netherlands)
Mr. H. Gislason (Denmark)
Mr. T. Jakobsen (Norway)
Dr. F. Lamp (F.R.G.)
Mr. P. Lewy (Denmark)
Ms. E. Nielsen (Denmark)
Mr. K. Popp Madsen - Chairman (Denmark)
Mr. R. Rosenberg (Sweden)
Mr. B. Sjöstrand (Sweden)
Mr. R.J. Wood (United Kingdom)
Mr. O.J. Østvedt (Norway)
Mr. V. Nikolaev - ICES Statistician

2. Division IIIa.

2.1. Definition.

In sensu ICES the IIIa Division is essentially a statistical unit for reporting catch, effort and other data pertinent to the fisheries. It comprises largely the geographical concepts of the Skagerrak and the Kattegat, which are sometimes denoted as IIIa north and IIIa south respectively.

The geographical boundary between the Skagerrak and the North Sea (ICES Subarea IV) is a line from the lighthouse of Hanstholm on the Danish coast to the lighthouse of Cape Lindesnes on the Norwegian coast. As the development of fisheries created the need for reporting catch-statistics by much smaller units of areas i.e. by statistical rectangles ICES introduced in 1964 the boundary shown in Figure 2.1 as being that partition on a rectangle-basis which most closely agreed with the original borderline. Fisheries statistics and biological advice since 1964 thus refer to the ICES boundary, while legal enforcement and technical measures still adhere to the straight line: Hanstholm-Lindesnes.

The southern border of III a is also shown in the figure below. It stretches from Hasenøre on the east coast of Jutland to Gniben on Sealand. It then cuts off the Isefjord-complex from the Kattegat and finally follows a line from Gilbjerg Head on Sealand to Kullen on the Swedish coast. This borderline does not allow reporting of statistics by ICES's statistical rectangles. The latter are, however, far too coarse for these enclosed waters where fisheries statistics should be reported by sub-rectangles, i.e. quarters or even smaller units.

Defining the borderline between the Skagerrak and the Kattegat is somewhat complex:

i) There is no geographically defined line of separation.

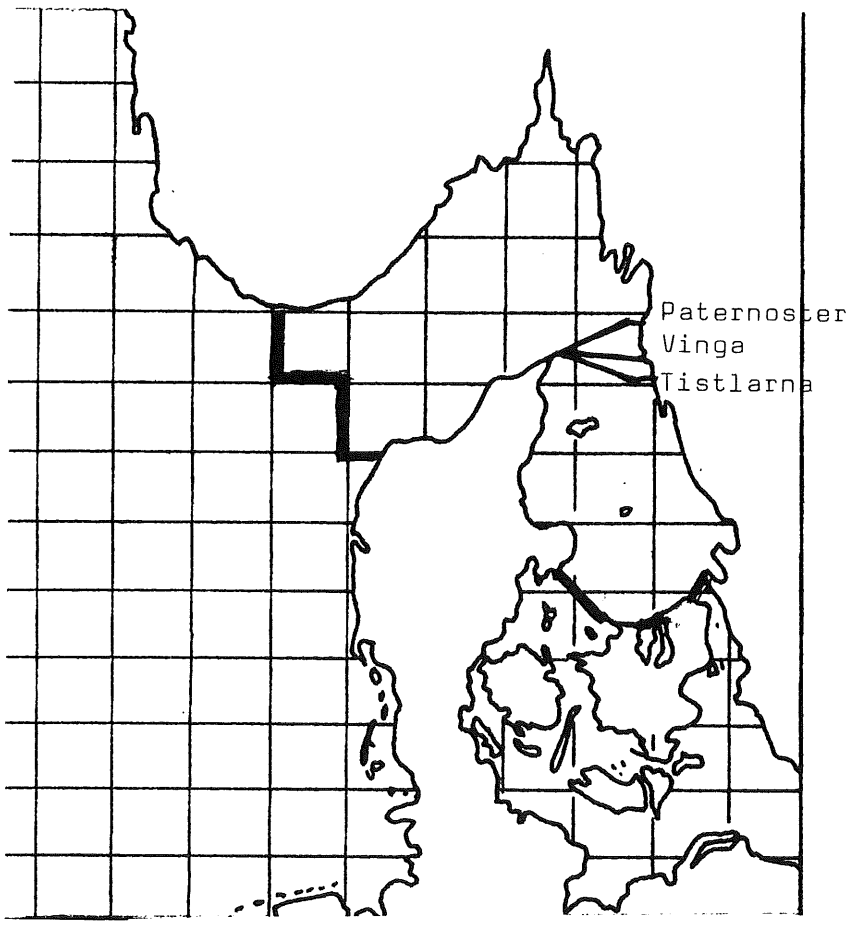
ii) NEAFC defined the border as the line between Skagen and the lighthouse of Paternoster.

iii) According to the agreement of 1966 between Norway, Sweden and Denmark concerning the rights to fish in each others waters in the Skagerrak, the border between the Skagerrak and the Kattegat is defined as: the line between Skagen and Tistlarna.

iv) According to the agreement of 1932 between Denmark and Sweden concerning mutual fishing rights in their respective national waters in the Kattegat the borderline is defined as the line between Skagen and the lighthouse of Vinga.

v) ICES defined the division between the Kattegat and the Skagerrak in 1964 as being a line drawn from Skagen to the lighthouse of Paternoster.

The three dividing lines stated above are shown in the figure below. It should be noted, that the fisheries agreement for 1979 between EEC, Norway and Sweden of 2. February 1979 refers to the line Skagen-Tistlarna. There is an obvious disagreement between the area statistics upon which the biological advice is founded and the areas of fisheries legislation eventually taking this advice into account.



3. Herring

3.1. Herring stocks

The fisheries in ICES Division IIIa exploit herring which belong to a number of different stocks. Some of these are native stocks (mostly spring spawners) which spawn within the Skagerrak and Kattegat, but in addition members of both the North Sea stock (autumn spawners) and western Baltic stocks (spring and autumn spawners) are known to be present.

The movements and mixing of herring within Division IIIa are therefore likely to be complex.

The Working Group investigated this problem by comparing the meristic characters of herring caught in the IIIa fisheries with pure stock characters of the relevant spawning populations. Since the herring caught in the IIIa fisheries, however, are predominantly juveniles, a comparison was also made of meristic characters and mean lengths of 1- and 2-group herring between the North Sea and IIIa.

3.1.1. Meristic characters

The meristic characters of some relevant spawning groups are given in Table 3.1.1. As pointed out in the last report of the Danish-Swedish Study Group (C.M.1978/H:56), the two spring-spawning stocks indigenous to IIIa differ markedly in mean VS and as mean VS of North Sea autumn spawners are intermidiate it would be difficult to separate a mixture of indigenous stocks from North Sea autumn spawners on this criterion alone. The mean values of keeled scales (K_2) in the indigenous stocks are lower than in the North Sea autumn spawners, but approximately the same as Minch (VIa) autumn spawners.

The meristic characters of adult herring caught in the mainly summer fishery in IIIa lie within the range of those of the indigenous spring-spawning stocks and there is no likelihood that any migrant components at present form a significant part of the catches.

The mean VS and K_2 in Swedish samples of 1- and 2-ring herring taken in Division IIIa are shown in Figures 3.1.1 and 3.1.2. Danish data on meristic characters are shown in Table 3.1.2.

These can be compared with the meristic characters of the same age groups in the North Sea derived from the International Young Herring Surveys (see Figs. 3.1.3 and 3.1.4). These data which are derived from a mixture of stocks, but predominantly North Sea stocks with a percentage of VIa and possibly Danish west coast herring, indicate a similar range of VS in the Skagerrak, but a much greater range of the K_2 than in the pure North Sea spawning stocks. The reason for this is not clear. Whatever the reason, the range of K_2 values of 1- and 2-ringers caught in Division IIIa therefore shows a greater overlap with those of juvenile herring caught in the North Sea than with those of North Sea spawning stocks. It is therefore difficult to rule out the possibility that juvenile herring caught in Division IIIa contain some recruits to the North Sea autumn-spawning stocks.

3.1.2. Mean length

The mean length of 1-ring herring caught in Division IIIa on the International Young Herring Surveys from 1976-1978 is shown in Figure 3.1.5. In the southern part of the Kattegat, the mean length is from 13 - 14.2 cm whereas in the northern part of the Kattegat and eastern Skagerrak it is between 14.3 and 17.1 cm. This indicates a possible difference in stock composition between the northern and southern parts of IIIa but could also be the result of separation by depth. For comparison the mean length and length range (cm) of 1-ring herring in the International Young Herring Survey in a block of 16 rectangles in the North Sea approaches to the Skagerrak is shown below:

Year	Mean	Range in individual rectangles with more than 10 fish measured
1972	17.68	16.89 - 19.35
1973	16.50	15.84 - 18.24
1974	17.19	13.85 - 18.33
1975	16.36	14.0 - 18.7
1976	15.09	14.28 - 17.87
1977	16.70	12.36 - 17.80
1978	14.74	13.41 - 19.70

3.1.3. Continuous Census of the Herring Stock Composition in Division IIIa

The Working Group recommends that otolith samples should be collected from both spawning and juvenile herring and a workshop set up at an early date in order to determine the range of types present in the otoliths of the indigenous stocks, and to compare these with otoliths of North Sea autumn spawners.

Although the meristic characters available to the W.G. did not provide conclusive evidence as regards the racial composition of herring in IIIa, the Working Group considered it useful to initiate or continue the taking of VS and K_2 counts. These characteristics could be particularly useful in substantiating any split in races made on the basis of otolith type or length distribution.

Genetic studies, allready commenced in Sweden, may provide a possible further method of differentiating the various herring stocks.

In order to shed further lights on the migration through IIIa it is recommended that tagging experiments be considered.

3.2. The Landings

Catch data for the Kattegat and the Skagerrak for the more recent years are given in Tables 3.2.1 and 3.2.2.

According to an agreement between Sweden, Norway, and EEC a TAC of 50 000 tons was set for Kattegat and 14 500 tons for Skagerrak in 1978.

As a result the directed fishery for herring in Skagerrak was stopped by Denmark in August and by Sweden in the middle of September when it was thought that the TAC had been taken. The preliminary catch figures for 1978 given in Tables 3.2.1 and 3.2.2 show that in the Kattegat the TAC was overfished by 14 400 tons and in Skagerrak by 6 400 tons. These totals do not include Norwegian Fjords herring.

To reduce the catch of juvenile herring the following additional restrictions were in force from 1 January 1978:

a) Directed fishing for herring for industrial purposes prohibited.

b) Directed trawl fishing for herring, minimum mesh size 32 mm.

c) Fishing not allowed on Saturday and Sunday with trawls and purse seine.

d) By-catch of herring in sprat landings maximum 15 % in Kattegat, 10 % in Skagerrak, in other fisheries 5 %.

It should be noted that the total industrial catch of 12 626 tons in the Kattegat in 1978 (Table 3.2.1) consisted mainly of herring taken in the fisheries for human consumption but later rejected, or as by-catch in the sprat fisheries. The best estimate of the proportion between these two categories is 1:1.

In the previous reports by the Danish-Swedish Study Group the catch figures given for the Skagerrak did not include the catch of "Fjord herring" taken by Norway within 2 n. miles off the baseline on the Skagerrak coast.

3.3. Age composition

Numbers of herring at age in landings from Skagerrak and Kattegat are given in Table 3.3.1. National sampling for age composition covered 90 % of the total catches. The amount not covered was dealt with in the following way:

The Faroese catch was distributed according to Norwegian age distributions in the purse seine catches.

The Danish landings from the Kattegat in the first half of the year used for human consumption were apartioned to Swedish age distribution for the same area and period.

The age distribution of the Swedish by-catches in the Kattegat was applied to the Swedish by-catches in the Skagerrak.

As a result of a ban on directed fisheries on herring for industrial purposes in Kattegat in 1978 the numbers of 0 and I group caught decreased. Nevertheless, as the human consumption fisheries continued the exploitation of young agegroups, 95 % of the catch in number consisted of immatures (1- and 2- groups). That is approximately the same as in the year before.

3.4. Recruitment

During the International Young Herring Survey carried out for three weeks in March 1979 12 hauls were made in the Skagerrak and 18 hauls in the Kattegat with the GOV trawl. No herring were caught in 7 and 5 of these hauls, respectively. The preliminary abundance index of the I ringers in Division IIIa was

12.0. This figure represents all herring < 20 cm, i.e., an overestimation of the abundance of I-group fish. The abundance indices over the previous 5 years varied between 204 and 1 339 (Anon. 1978). Thus, the exceptionally low catches in 1979 could indicate a poor recruitment to the spring spawning stocks. However, the Working Group feels uncertain how reliable the results from the International Young Herring Survey are as an indication of the year class strength in area IIIa.

3.5. Management

3.5.1. The management of IIIa herring presents some special problems because of the mixed stock composition and migration in and out of the area. As described in paragraph 3.1 not all the juvenile herring in the area can be considered as local recruits; some will recruit to herring stocks outside IIIa. Management should be directed both at protecting, and if necessary rebuilding the local spawning stocks, and at protecting the exogenous juvenile herring which occur temporarily in the area.

As regards the local spawning stocks, there is not much information available concerning their present size and recent development. Judging from the age composition of the catches, it seems that the spawning stocks are quite small at present. In a previous assessment report on these stocks, the combined total of all spawning stocks in the area was estimated at approx. 20 000 tons (see Table 3.5.1).

It seems very unlikely that a spawning stock of this size has been able to produce the high numbers of juvenile herring which have been caught in IIIa in recent years, particularly when one considers the relationship between spawning stock size and recruitment in other areas such as the North Sea, VI a, and the Celtic Sea (Anon 1978b).

It is not possible to indicate what the minimum size of spawning stocks in this area should be. Considering the high numbers of juvenile herring which are still caught in the area, it may seem premature to worry about a possible stock-recruitment relationship, but then again, the juveniles present may to some extent have been foreign fish. The age composition of the catches shows that the adult fish in the area are sustaining a high mortality (hardly any fish older than 6 years are encountered)

and the local spawning stocks may indeed be below their minimum level for normal recruitment. It seems advisable therefore to reduce the high mortality on the local spawning stocks, and to monitor more precisely the development in each of the major subpopulations. This might be achieved by measuring the catch per unit of effort in some selected inshore fisheries based on spawning herring. Also the age composition of the various spawning stocks should be adequately sampled.

The juvenile herring in IIIa should be protected as much as possible, no matter whether they will recruit to the local spawning populations or to stocks outside the area. It is appreciated that the consumption fishery in IIIa cannot avoid taking some quantities of I-group herring because of the mixed occurrence of juvenile and adult herring in the area (as opposed to the North Sea for instance), but these by-catches of juvenile herring should be reduced as much as possible.

For this reason the Working Group strongly supports the newly introduced minimum landing size of 18 cm in the Kattegat, which should result in an about total cessation of exploitation on the 0-group and on the I-group in the first few months of the year. The present mesh size of 32 mm should be increased to correspond more closely to the minimum landing size. In view of the need to avoid the problem of meshing, however, it would be unrealistic to use the formula suggested by ACFM. The appropriate mesh size appears to be that at present in use by part of the fleet in the Kattegat i.e. 36-37 mm.

3.5.2. The Working Group considered the possibility of calculating a new prognosis, but finally decided against this on the basis of the following arguments. There is no adequate method of estimating F during 1978, nor is it possible to calculate the exploitation pattern on the basis of historical catch/age data.

The previous stock prognosis carried out by the Study Group in 1978 is compared in Table 3.5.1, with the actual catch in number in 1978. It is quite clear that the high number of 2-ringers caught could not have originated from the estimated stock. For this reason little confidence can be placed in this prognosis.

Moreover, the exploitation pattern is likely to change in 1979 because of the introduction of new minimum mesh and minimum landing sizes. Another problem is the occurence in the catch of fish that do not stay in Division IIIa throughout their lifetime. Part of the adult catch may consist of Baltic herring that have grown up elsewhere. On the other hand, an unknown proportion of the juveniles present in Division IIIa will emigrate from the area in subsequent years. If one would assume that all juvenile herring in IIIa are going to recruit to the adult stock in the area, a serious overestimate of future stock size might result.

Because of the problems mentioned above, the Working Group was not able to calculate a range of TACs which would generate certain predetermined levels of F in future years. The only possible management strategy to protect the spawning stock in Division IIIa is to set a precautionary TAC well below the level of recent catches, and to monitor the effects of this regulation upon the local populations. The Working Group considered a catch of 45 000 tons in 1980 as a reasonable level for a precautionary TAC, provided that any exces of the quota in 1979 is deducted from the quota in 1980.

The Working Group must stress the fact, that all landings of herring from Division IIIa are recorded and taken into consideration as basis for advice. It is therefore absolutely vital that all landings whether caught inside or off the national base-lines are counted against the TAC's and against the national quotas.

Table 3.1.1. Meristic characters.

	VS	K_2	Reference
Kattegat spring spawners)	55.5 - 56.5	13.7 - 14.3	(1)
Kattegat coastal spring spawners)			
Skagerrak spring spawners	56.6 - 57.3	13.7 - 14.3	(2)
Rügen spring spawners	55.5 - 55.8		(3)
North Sea autumn spawners (1970 stock)			(4)
Central North Sea	56.2 - 56.4	14.4 - 14.55	
Southern North Sea	56.3 - 56.6	14.5 - 14.8	
West of Scotland	56.5	14.0	

References:

(1) Ackefors, 1977 (Meld. No. 225)
(2) " " (Meld. No.227)
(3) Anwand 1963
(4) Anon. 1974 (ICES Coop.Res.Rep.52:Table 7).

Table 3.1.2. Meristic characters in Danish herring samples in 1978.

The Skagerrak.

Age (W.r.)		0	1	2	3	4
27/6	K_2		-	13.85	13.85	14.40
	VS		-	55.87	56.00	55.58
	N		6	46	28	12
26/7	K_2		13.66	13.93	-	
	VS		56.13	55.75	-	
	N		136	119	3	
31/8	K_2		14.01	-		
	VS		56.28	-		
	N		97	3		
4/12	K_2	13.90	-			
	VS	56.63	-			
	N	104	1			

The Kattegat

Age (W.r.)		0	1	2	3	4
29/8	K_2		-	14.07	13.97	-
	VS		-	55.83	55.90	-
	N		4	64	33	2
29/8	K_2		14.07	13.70	-	-
	VS		56.06	55.73	-	-
	N		56	42	1	1
10/10	K_2		13.92	-	-	
	VS		55.97	-	-	
	N		143	6	1	
31/10	K_2		13.93			
	VS		55.82			
	N		50			
9/11	K_2	-	÷	-		
	VS	-	55.70	-		
	N	4	81	4		
5/12	K_2	14.11				
	VS	56.04				
	N	54				

Table 3.2.1 Herring landings. Kattegat 1968-78 (in tons)
C = landed for human consumption. I = industrial landings.

Year	Sweden		Denmark		Total		Grand Total
	C	I	C	I	C	I	
1968	27 400	14 400	9 030	58 422	36 430	72 822	109 252
1969	21 400	10 300	7 912	31 137	29 312	41 437	70 749
1970	31 400	9 053	10 562	28 872	41 962	37 925	79 887
1971	36 586	13 174	10 588	39 589	47 174	52 763	99 937
1972	26 214	13 758	12 740	40 015	38 954	53 773	92 727
1973	27 969	12 449	8 713	69 412	36 682	81 861	118 543
1974	22 356	17 423	7 705	46 835	30 061	64 258	94 319
1975	20 074	3 695	8 619	40 355	28 693	44 050	72 743
1976	27 652	2 611	7 820	33 929	35 472	36 540	72 012
1977	31 502	5 658	5 190	33 015	36 692	38 673	75 365
1978x)	31 766	3 427	20 042	9 199	51 808	12 626	64 434

x) Preliminary.

Table 3.2.2 Herring landings. Skagerrak 1970-78 (in tons).

Year	Denmark	Faroe Isl.	Germany Fed.Rep.	Iceland	Norway	Sweden	Total	Norwegian fjords	Grand total
1970	30 107	-	-	6 453	7 581	26 930	71 071	1 830	72 901
1971	26 985	5 636	-	3 066	6 120	19 763	61 570	3 166	64 736
1972	34 900	4 115	-	7 317	1 045	19 644	67 021	4 222	71 241
1973	42 098	5 265	-	15 938	836	20 429	84 566	1 680	66 246
1974	35 732	7 132	36	231	698	11 683	55 512	1 720	57 214
1975	29 997	8 053	108	1 209	196	12 348	51 911	1 459	53 370
1976	7 363	1 553	6	123	-	6 505	15 550	2 304	17 854
1977	19 382	10 064	32	-	-	8 109	37 587	1 837	39 424
1978x)	6 425	1 041	28	-	1 860	11 551	20 905	2 271	23 176

x) Preliminary.

Table 3.3.1. Age Composition. Herring landed from the Skagerrak and the Kattegat. Numbers caught at age (x 10^{-6}).

	Age w.r.	0	1	2	3	4	5	6	7	8+
Skagerrak	Consumption	0.2	110.8	98.3	19.0	3.46	0.81	0.42	0.26	0.13
	By-catch	41.3	27.0	3.4	0.01			0.09		
	Skagerrak total	41.5	137.8	91.7	19.0	3.46	0.81	0.51	0.26	0.13
Kattegat	Consumption	1.8	358.0	335.1	45.3	5.95	0.51	0.11	0.08	0.10
	By-catch	103.9	380.5	27.7	0.4	0.45				
	Kattegat total	105.7	738.5	362.8	45.7	6.40	0.51	0.11	0.08	0.10
	Grand total	147.2	876.3	454.5	64.7	9.86	1.32	0.62	0.34	0.23

Table 3.5.1 Herring. Kattegat and Skagerrak

Comparison between predicted and actual catch in 1978 (Numbers x 10^{-6}).

Age W.R.	M	Mean weight (g)	Catch 1977 in nos.	F 1977	Stock 1.1.77 in nos.	Stock 1.1.78 in nos.	F 1978	Predicted catch 1978 in nos.x)	Actual catch catch 1978 in nos.
0	0.3	14.9	933.65	0.40	3245.6	(3 250)	0.11	303	147.14
1	0.25	26.3	1436.48	1.30	2174	1612	0.50	564	876.21
2	0.2	116.3	328.55	1.30	488	461	0.75	223	454.42
3	0.1	138.2	61.37	1.30	87.7	109	0.83	59.0	64.66
4	0.1	190.4	12.05	1.30	17.2	21.6	0.83	11.7	9.86
5	0.1	213.9	5.85	1.30	8.36	4.24	0.83	2.29	1.32
6	0.1	241.1	4.23	1.30	6.04	2.06	0.83	1.11	0.62
7	0.1	277.5	1.51	1.30	2.16	1.49	0.83	0.80	0.34
8	0.1	295.3	0.04	1.30	0.06	0.53	0.83	0.28	0.23
Yield (tonnes x 10^{-3})								61.2	actual 85.3
Spawning stock (tonnes x 10^{-3})					20.7	22.8			

x) corrected by applying 1.08.

Legends.

Fig. 3.1.1. Mean vertebral numbers (VS) and mean numbers of keeled scales (K_2) of 1-ringed herring ($n = \geq 10$) from the Swedish Young Herring Surveys and Swedish commercial samples i 1976-1978. The arrow shows the border between the Skagerrak and the Kattegat.

Fig. 3.1.2. Mean vertebral numbers (VS) and numbers of keeled scales (K_2) of 2-ringed herring. For further explanation see Fig. 3.1.1.

Fig. 3.1.3. Mean VS of 1-ringed autumn spawners during the IYHS in February 1974. Figures for Skagerrak and Kattegat contain nearly all 1-ringed herring caught in the area. Numbers in small print indicate mean catches per square.

Fig. 3.1.4. Mean K_2 of 1-ringed autumn spawners during the IYHS in February 1974. Figures for Skagerrak og Kattegat contain nearly all 1-ringed herring caught in the area. Numbers in small print indicate mean catches per square.

Fig. 3.1.5. Mean length of 1-ring herring caught in the eastern part of Division IIIa on the International Young Herring Survey, 1976 - 1978, by latitude.

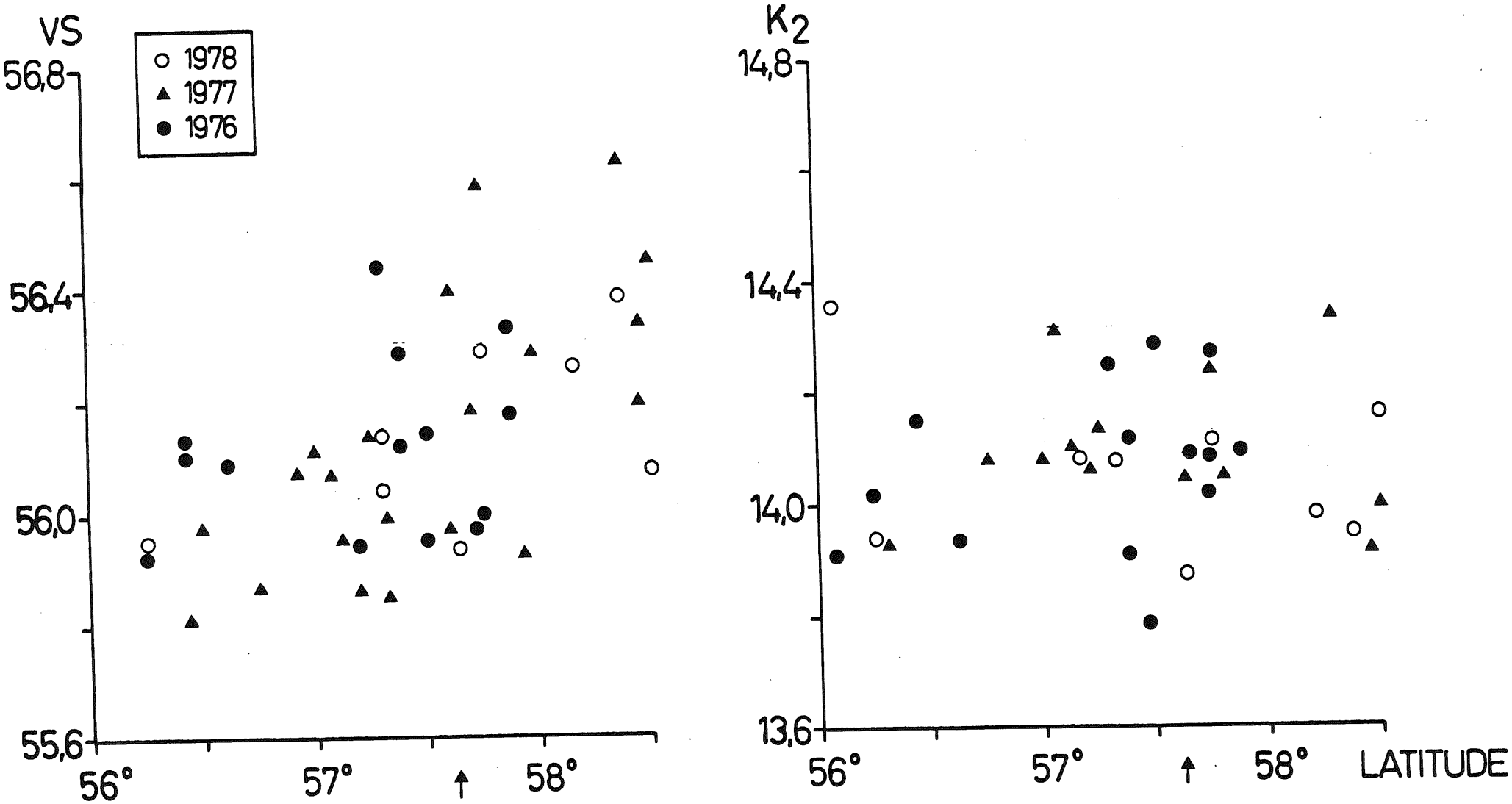

VS
1978
1977
1976
56,8
56,4
56,0
55,6
56°
57°
58°
K2
14,8
14,4
14,0
13,6
56°
57°
58°
LATITUDE

Fig. 3.1.1.

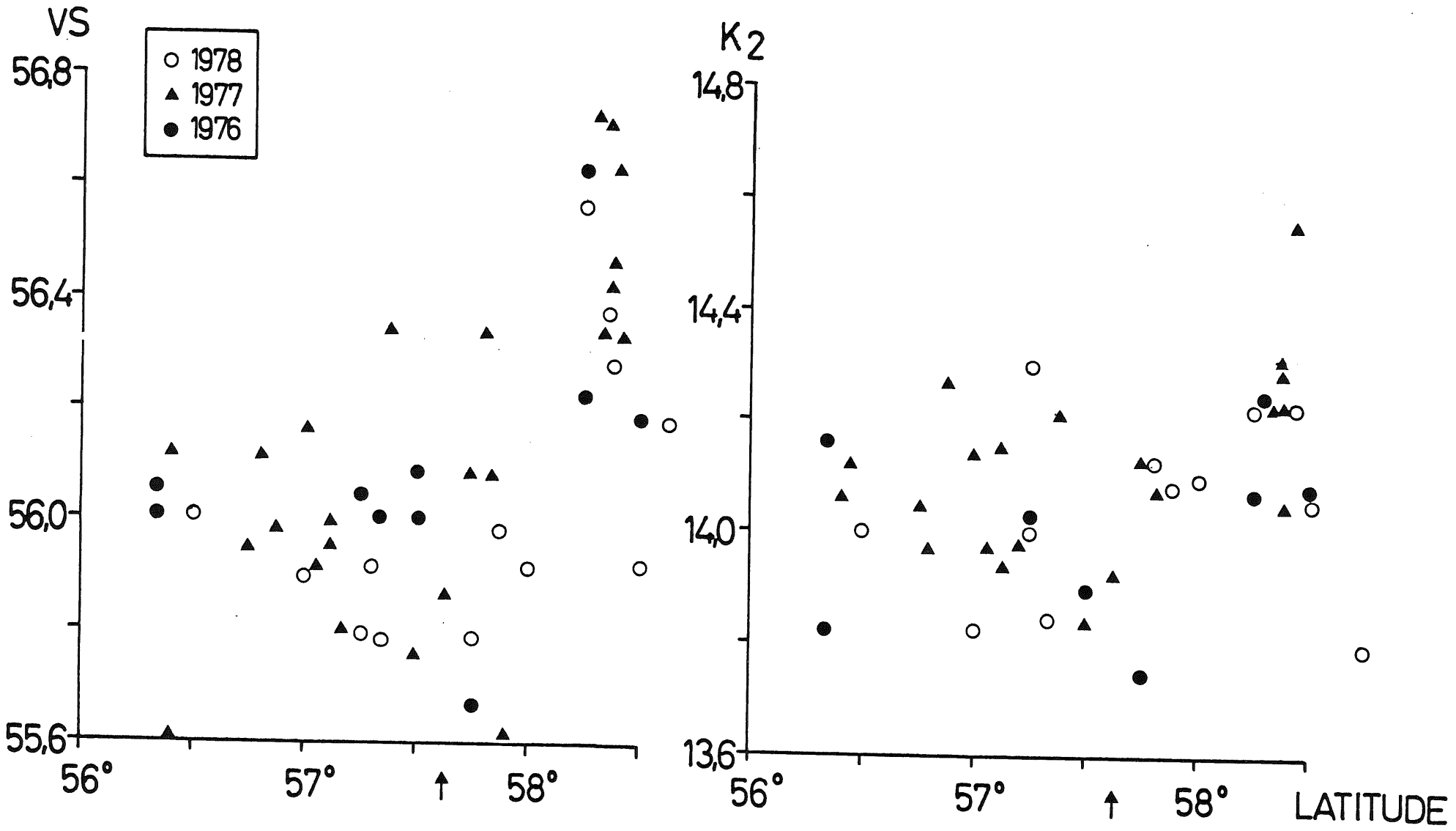

VS
1978
1977
1976
56,8
56,4
56,0
55,6
56°
57°
58°
K2
14,8
14,4
14,0
13,6
56°
57°
58°
LATITUDE

Fig. 3.1.2.

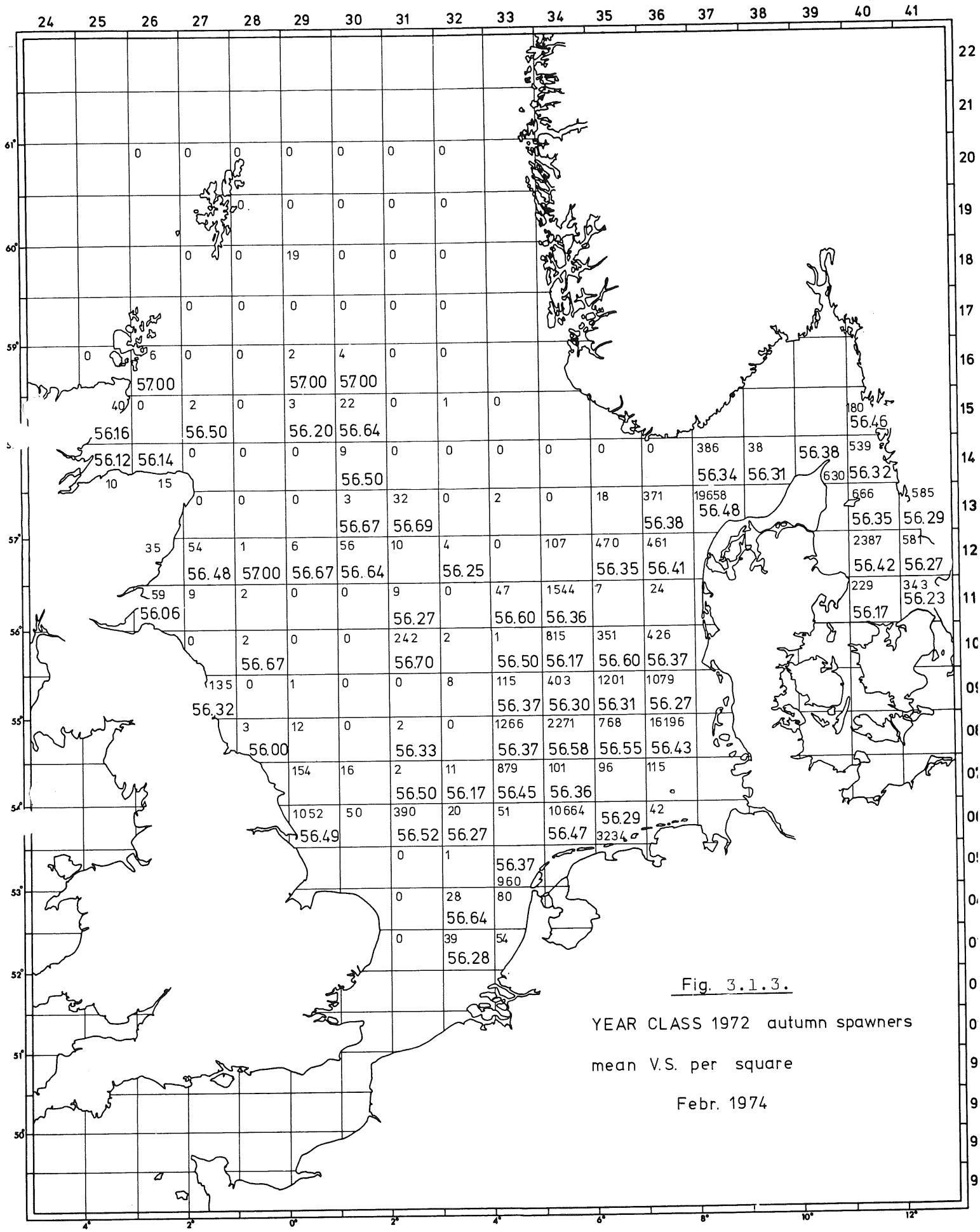


Fig. 3.1.3.

YEAR CLASS 1972 autumn spawners

mean V.S. per square

Febr. 1974

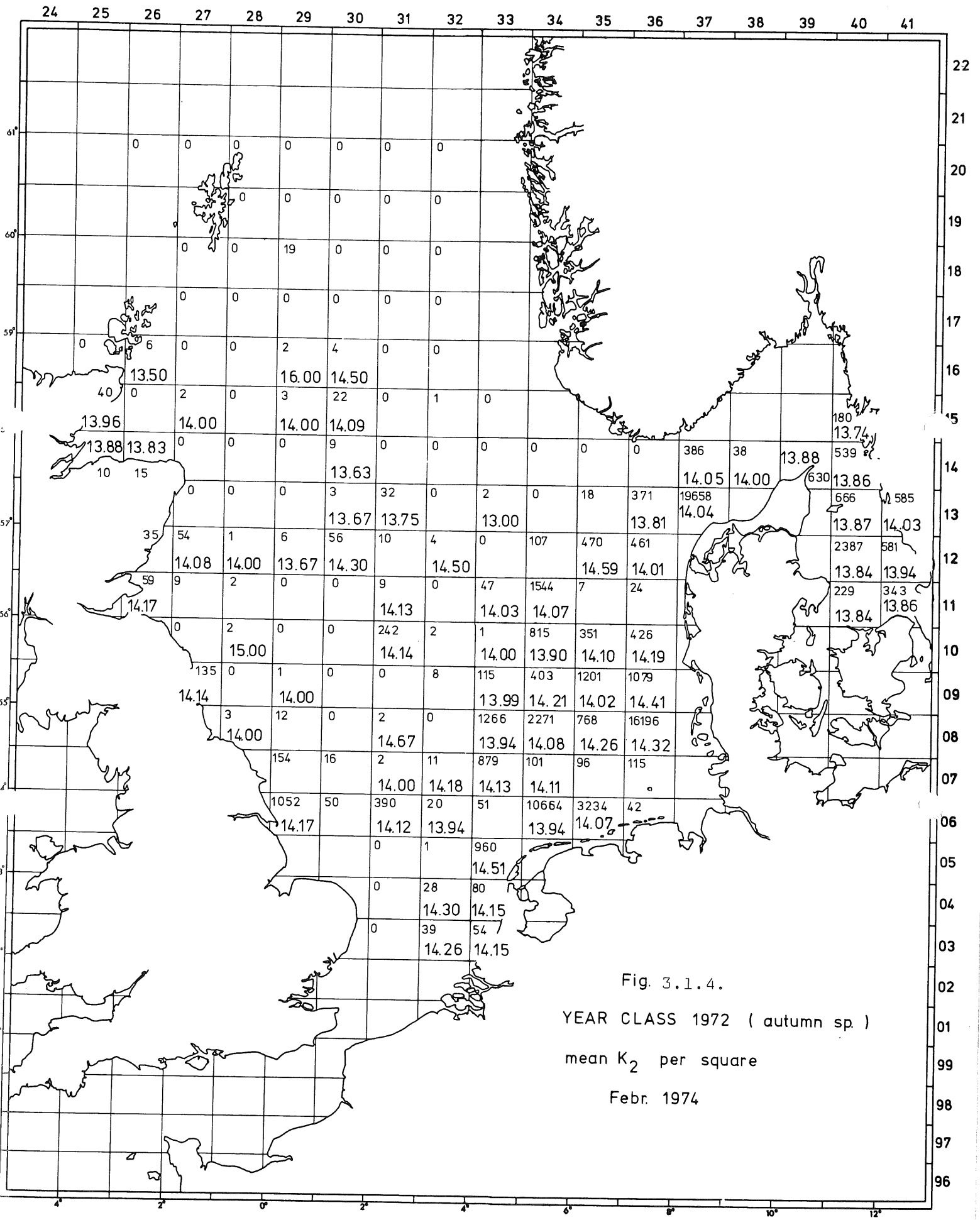


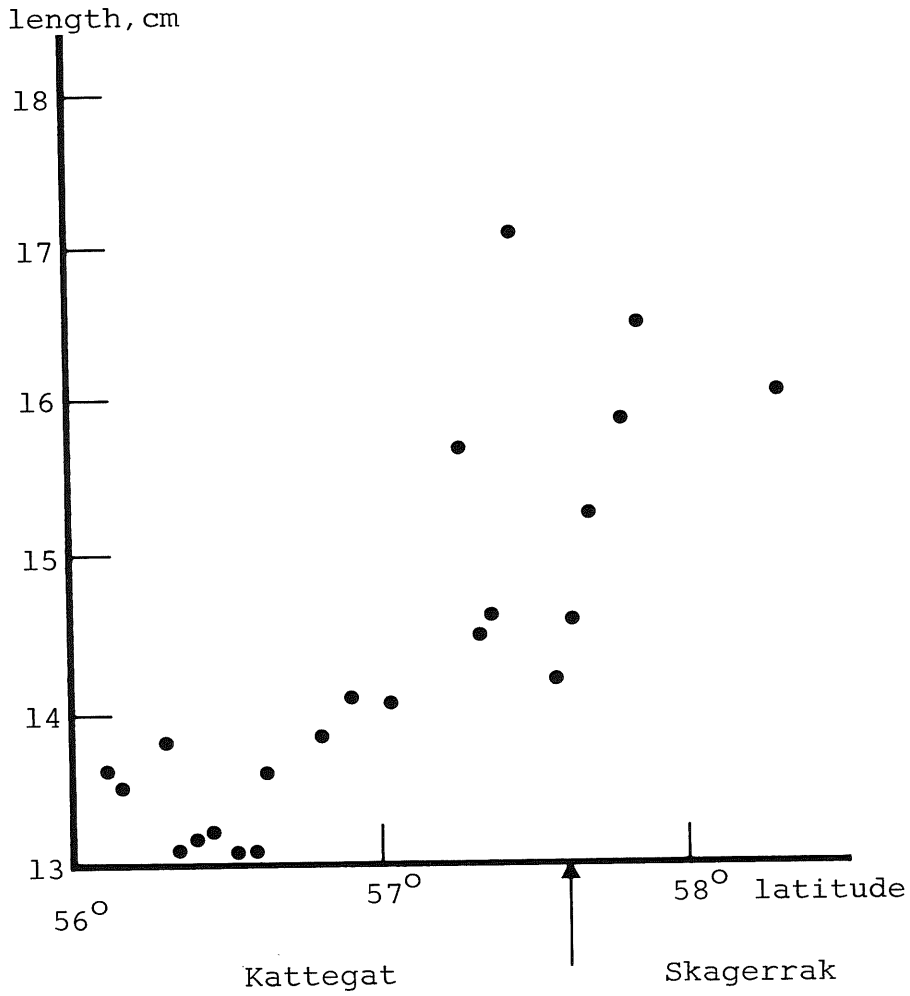
Fig. 3.1.4.

YEAR CLASS 1972 (autumn sp.)

mean K_2 per square

Febr. 1974

Fig. 3.1.5. Mean length of 1-ring herring caught in the eastern part of Division IIIa on the International Young Herring Survey, 1976-1978, by latitude.



4. Sprat.

Previous Assessments

The sprat stocks in the ICES Subarea IV and Division III a have been assessed as two different management units: a) the North Sea, and b) the Skagerrak, the Kattegat and the Norwegian fiords south of 62° N lat. Assessments of the latter stock were previously made by the Herring Assessment Working Group for the Area South of 62°N (Anon., 1978a). The Danish-Swedish Study Group on the Fish Stocks in the Kattegat and adjacent waters also included a sprat assessment (Anon., 1978b).

4.1. The landings

The landings of sprat in Division IIIa and Division IVa east (Norwegian fjords) are shown in Table 4.1.1. The total catch in 1978 was about 79 000 tons which is nearly the same as in 1977. The 1978 fishery was, however, restricted by the TAC of 70 000 tons excluding the Norwegian fiord catches. As in earlier years, a major part of the catch was taken in the Kattegat, but compared to 1977 the Skagerrak catches increased markedly. Danish landings accounted for 75 % of the total, as they did in 1977. The Danish sprat fishery was, however, closed on 31 August, when the allocated national quotum was exhausted.

Table 4.1.2. shows the quarterly catches in the Kattegat and the Skagerrak. The highest catches in 1978 were taken i July-September. The low catch figures in the later part of that year are due to the closure of the Danish fishery.

4.2. Biological Data

Catches taken for industrial purposes by Danish vessels have been sampled throughout the year. Based on these samples, catch in numbers per age group has been calculated for each quarter of the years 1975-78 (Table 4.2.1). No biological data are available for the Swedish and Norwegian catches in 1978. The observed age compositions in the Danish catches cannot be applied to the Swedish and Norwegian catches as these are likely to contain higher percentages of older age groups.

Data from the International Young Herring Survey (IYHS) provide an estimate of recruitment, measured as the mean catch of I-group sprat per hour trawling in a standard area composed of 7 statisti-

cal squares in the Skagerrak and the Kattegat. The following numbers have been found:

Year class	No/hour
1971	1 004
1972	1 322
1973	1 324
1974	5 074
1975	464
1976	1 403
1977	4 223
1978	886

Some correlation was indicated between this index of recruitment and the catch of the same year class as 0-group in the Danish fishery in the last quarter of the year.

It seems clear that the 1977 year class was strong. As shown in Table 4.2.1. this year class recruited quite strongly to the fishery as 0-group in the last quarter of the year and also accounted for a very high proportion of the catches during 1978.

The 1977 year class was also reported being distributed over wide areas in the open part of Skagerrak as 0-group in December 1977 (Føyn et al., 1978) and as I-group in January.

4.3. Acoustic Surveys

Attempts have been made to estimate the stock size of sprat in Kattegat and Skagerrak by echo-integrator technique (Unpubl. report by Inst. of Mar. Res., Lysekil, Sweden). In April 1978, the spawning stock biomass in an area of 5 100 n. miles^2 was estimated to 20 000 tons corresponding to a total biomass of about 34 000 tons.

It is pointed out that this quantity is an underestimate due to the limited horizontal and vertical coverage and to the conversion factor used. It has not been possible to work out reliable estimates of stock size to be used for assessments and catch prognosis.

4.4. Virtual Population Analysis (VPA)

Owing to the small number of age groups represented in the catch, the lack of information on the age distribution in the Swedish catch and the lack of data prior to 1975, the Working Group did not consider it worth while to carry out a VPA.

4.5. Management

As no fishing effort or catch per unit effort data are available, a prognosis of the stock size in 1978 was not possible. Furthermore, as the catches are dominated by the 1-group, the usefulness of such an analysis for making catch predictions is very limited. The following table, which shows the mean percentage contribution of each age group to the total Danish catch, was constructed on the basis of the mean weight at age in 1977 and 1978 and the mean age composition in the period 1975 to 1978:

Age groups	0	I	II	III	IV	V
Percentage of total catch	6.17	76.51	14.15	2.98	0.17	0.02

As can be seen from this table, the I-group constitutes 77 % of the total catch. A catch prediction for 1980 would therefore be heavily dependent on the strength of the 0-group in 1979, which was not yet born when the Working Group met.

For the above reasons, the Working Group concluded that available data do not permit an analytical assessment. In accordance with the guidelines from ACFM, however, the Group decided to advise on a precautionary TAC for 1980.

A precationary TAC aims at preventing over-exploitation and depletion of the stock until more data become available. This seems particularly important in the present case as the indications are that the 1978 year class may be rather weak. It may also prevent a transfer of fishing effort from the North Sea and the Baltic for which areas restrictions on the sprat fisheries are likely to be imposed again in 1980. The lack of a TAC for Division IIIa could also lead to misreporting of sprat catches, resulting in distorted data for future assessments. Finally, a restriction on the sprat fishery may also limit the quantity of young herring taken as by-catch.

On the basis of these considerations the Group suggests a TAC of 70 000 tons for 1980. A catch of this size corresponds to the average catch taken in 1976-78, and it is similar to the TAC advocated by ACFM for 1979.

A precationary TAC based on recent average catches is designed purely to prevent an escalation of the exploitation rate. The Group realised, however, that this may equally result in large-scale wastage in the event of a larger year class. A more realistic TAC can only be calculated if a measure of 0-group abundance is available. Preliminary investigations by Norwegian and Swedish research vessels have indicated that acoustic surveys in winter combined with sampling by trawl, may provide the necessary data. To utilise any information to the full, however, assessment would have to be carried out shortly after data have been collected and the resulting TAC put into operation very soon afterwards.

4.6. Mesh size

A number of studies have shown that a minimum mesh size of 16 mm is appropriate for sprat trawls in the North Sea. As the growth of sprats in Division IIIa is very similar, it seems reasonable to adopt the same mesh size regulation there also.

Table 4.1.1 Landings of sprat in Division IIIa and in Norwegian fjords south of 62°N lat. (10-3 tons)x)

Year	SKAGERRAK				KATTEGAT			IIIa total	Norwegian fjords south of 62°N	Grand total
	Denmark	Sweden	Norway	Total	Denmark	Sweden	Total			
1969	0.8	1.9	1.7	4.4	0.8	1.6	2.4	6.8	11.8	18.6
1970	1.1	2.4	2.4	5.9	3.1	6.0	9.1	15.0	6.4	21.4
1971	0.7	2.4	2.9	6.0	1.5	9.6	11.1	17.1	4.4	21.5
1972	0.8	3.3	2.4	6.5	1.4	17.9	19.3	25.8	6.9	32.7
1973	19.4	2.5	3.2	25.1	19.3	16.2	35.5	60.6	8.8	69.4
1974	17.3	2.0	1.2	20.5	31.6	18.6	50.2	70.7	3.3	74.0
1975	14.9	2.1	1.9	18.9	69.7	20.9	90.6	109.5	2.9	112.4
1976	12.8	2.6	2.0	17.4	30.4	13.5	43.9	61.3	0.6	61.9
1977	7.2	2.2	1.2	10.6	53.3	9.8	63.1	73.7	5.4	79.1
1978	23.1	2.2	2.7	28.0	36.1	9.4	45.5	73.5	5.2	78.7

x) Data provided by Working Group members.

Table 4.1.2 Landings of sprat in Division IIIa, by quarters (tons) x)

Year	Months	Kattegat	Skagerrak	Total
1975	Jan-Mar	6 569	2 316	8 885
	Apr-Jun	11 610	450	12 060
	Jul-Sep	53 347	7 976	61 323
	Oct-Dec	19 541	8 248	27 789
	Total	91 067	18 990	110 057
1976	Jan-Mar	9 462	913	10 375
	Apr-Jun	4 867	997	5 864
	Jul-Sep	18 070	5 493	23 563
	Oct-Dec	10 253	10 001	20 254
	Total	42 652	17 404	60 056
1977	Jan-Mar	9 340	1 507	10 847
	Apr-Jun	10 499	189	10 688
	Jul-Sep	24 217	2 808	27 025
	Oct-Dec	18 938	6 067	25 005
	Total	62 994	10 571	73 565
1978	Jan-Mar	13 139	2 899	16 038
	Apr-Jun	7 949	6 313	14 262
	Jul-Sep	18 511	15 175	33 686
	Oct-Dec	6 757	4 398	11 155
	Total	46 356	28 785	75 141

x) Data provided by Working Group members.

Table 4.2.1 Danish landings of sprat in Division IIIa in numbers at age (x 10^{-6}).

Year	Months	0	1	2	3	4	5
1975	Jan-Mar		435.86	200.44	56.28	2.46	
	Apr-Jun		230.75	398.91	146.51	0.16	
	Jul-Sep	32.81	5 979.74	527.61	50.92	0.34	
	Oct-Dec	139.22	985.73	54.32	0.68		
	Total	172.03	7 632.08	1 181.28	254.39	2.96	
1976	Jan-Mar		336.00	164.95	9.11	1.23	0.65
	Apr-Jun		556.41	57.07	27.38	0.91	
	Jul-Sep	509.96	2 334.72	171.39	16.80	2.21	
	Oct-Dec	918.64	1 084.09	23.24	0.55		0.11
	Total	1 428.60	4 311.22	416.65	53.84	4.35	0.76
1977	Jan-Mar		2 515.11	408.99	11.29		
	Apr-Jun		2 177.51	483.23	20.70	3.37	
	Jul-Sep	725.13	2 185.47	208.70	30.26	7.42	1.21
	Oct-Dec	1 948.34	813.86	142.90	0.79		
	Total	2 673.47	7 691.95	1 243.82	63.04	10.79	1.21
1978	Jan-Mar		4 376.51	203.89	12.52		
	Apr-Jun		5 004.51	33.18	3.57		
	Jul-Sep	23.99	3 987.97	61.57	14.70	0.70	
	Oct-Dec	261.12	262.21	16.70	0.84		
	Total	285.11	13 631.20	315.34	31.63	0.70	

5. Cod

5.1. The landings

A full separation of the landings from Division IIIa into Kattegat and Skagerrak landings is only done by Denmark and Sweden. Landings of the Federal Republic of Germany from Division IIIa are only separated in the case of vessels larger than 35 GRT. As these landings merely vary between 11 and 120 tonnes p.a., they are not included in Table 5.1.1, showing the "total" landings. From 1960 to 1965 the landings increased from 10 000 tons to about 14 000 tons and remained at that level until 1971. The landings then increased to a maximum of 21 800 tons in 1974. After a decrease in the following two years, the 20 000 tons were exceeded again in 1977.

The Danish and the Federal Republic of Germany landings by months are shown in the Tables 5.1.2 and 5.1.3. While the Danish fishery on cod in the Kattegat covers the whole year with maximum landings in February, the F.R.G. cutters only fish during the autumn and winter also with a maximum in February.

The landings in the Skagerrak are shown in table 5.1.4. The landings has been at a constant level of 8 000 tons in 1965-1974. Since 1975 the landings increased to about 23 000 tons in 1978.

5.2. Age Distribution

The Danish sampling was intensified in 1978. In previous years sampling was only carried out in the harbour of Grenå, while in 1978 Skagen, Strandby and Gilleleje were also included as regards the fisheries in the Kattegat. Sampling in Hanstholm and Hirtshals provided data on the Skagerrak cod for the first time.

As in 1977 only Danish age distributions were available and these were consequently raised to the total international landings from Skagerrak and Kattegat separately. The results are shown as numbers caught at age in Table 5.2.1 while the Danish age distribution by quarters is shown in Table 5.2.2.

5.3. Weight at Age

Weight at age data from 1977 (anon. 1978, Table 4.10) were used, since no weight measurements of single fish were obtained for the first half of 1978. The 1977 data are the mean weights of gutted fish. These weights therefore had to be raised by a factor of 1.18. Mean weights at age are shown below:

Age	1	2	3	4	5	6	7	8+
Mean weight (kg)	0.192	0.445	1.17	1.69	2.86	4.12	5.18	6.9

5.4. Virtual Population Analysis

Catch data for a VPA were available since 1971 for the Kattegat. As regards eventual migrations the tagging experiments mentioned in Doc. C.M.1978/H:56 are still the only information available. Although these gave no clear evidence of cod migration into of out of the Kattegat, the Working Group made three assumptions in the VPA and in the catch predictions about migration by varying the values of M.

I No migration, M = 0,2 for all age groups

I a Emigration of older fish:

M_a = 0.2 for a = 1, 2 and 3 years old

M_a = 0.4 for a = 4-8 years old.

I b Immigration of older fish:

M_a = 0.2 for a = 1, 2 and 3 years old

M_a = 0.1 for a = 4-8 years old

The alternatives I a and I b with emigration and immigration give an estimate of the upper and lower bound of a migration effect.

In all three alternatives the same exploitation pattern was used. The assumed fishing mortalities for 1978 are close to the average of the last three years as no effort information were available.

The input to the VPA in Alternative I is shown in Table 5.4.1.

From Alternative I the calculated fishing mortalities are shown in Table 5.4.2 while the calculated stock in numbers is given in Table 5.4.3.

Because the migration coefficients are small compared to the fishing mortalities, the calculated stock in numbers for alterna-

tives I a and I b differ little from alternative I (about 6 % for age-groups 4-8).

5.5. Yield per Recruit

In the yield per recruit calculations the exploitation pattern corresponding to the input Fs for 1978 and the weight-at-age data given in Section 5.3 were used. Three sets of calculations were made using the same assumptions about migration as in the V.P.A.

The yield per recruit curves are shown in Figure 5.5.1. In the case of no migration F_{max}= 0.34 as compared to the present level of F = 1.0. The estimated potential long-term gain in reducing effort to F_{max} level is 5 400 tons (29 %).

Whereas the effect of migration at the present level of fishing mortality is small, it may be very important for the choice of management options, and more information is clearly needed. In this connection tagging of older age groups is desirable.

5.6. Spawning Stock and Recruitment

The spawning stock biomass of the Kattegat cod was reduced by about 50 percent from 1973 to 1978 (Table 5.6.1). A further reduction to 9 300 tons in 1979 has been estimated, but the spawning stock is, unless the 1979 TAC is overfished, expected to be back to about the 1978 level of 13 000 tons in 1980.

Inspection of the recruitment figures from the V.P.A.(Table 5.6.1) indicates that recruitment is largely independent of spawning stock size within the range 15-30 000 tons. Nothing can be inferred about the form of the relationship below this level.

Indices of recruitment of cod from Young Herring Surveys(Table 5.6.1) show poor correlation with the V.P.A. figures, but it is possible that the surveys may give indications of outstanding year classes like the 1973 year class. In that case the 1977 year class would be a good one.

5.7. Management

5.7.1. Principles of management for Cod in the Kattegat

Conventional management principles for most species of fish aim at maximising the long-term yield of that species. How-

ever, the effect that increases in stock-size might have on the prey of the species in question are not considered. The management of the larger, predatory fish therefore depends on a choice between two conflicting principles: to maximize the long-term yield of the predator or of that of its prey.

Taking the specific example of cod in the North Sea, Sparre (1978) has prepared a model to calculate the consequences on yieldcurves under certain assumptions on the stock of cod and its main species of prey.

As data on the food of cod in the Kattegat were available (Bagge, personal communication) a trial of this model was carried out prior to the W.G. meeting using as input a preliminary assessment of the cod stock in this area. Although the detailed data on which this trial was made, were not available to the Working Group, the results are included here as an example of the consequences which might follow from such an approach, on the assumption that growth, natural mortality and food consumption parameters would not vary with stock size.

As input to the model, growth data and stomach content analysis from research vessels in the period 1950-1978 were used. The samples indicate that the diet of cod in the southern part of the Kattegat contains a much higher percentage of herring than in the northern part (30-50 % by weight compared with <10 %). In the north the cod eat more plaice, whiting and small cod, while in the deeper part of the Skagerrak-Kattegat area, Kühlman (1968) showed that Norway pout was the main item of diet. In addition, the evidence indicates that fish are mainly eaten by larger cod.

On the basis of the Danish samples from both the northern and the southern Kattegat, it was calculated that approximately 9 % of the total food was herring and sprat (in the ratio 3:1), 21 % other fish species (whiting, smaller cod, plaice and dabs) and 70 % invertebrates. An overall growth pattern for the prey is given by the parameters in Table 5.7.1. Total food consumption was taken from Daan (1975).

The results of the runs of the model are given in Table 5.7.1 and 5.7.2. In absolute terms, Table 5.7.2. shows that a decrease in F on cod from 0.8 to 0.2 would result in an increase in the food

consumed by cod from 89 000 tons to 331 000 tons. This is equivalent to an increase in comsumption of 15-20 000 tons of herring.

5.7.2. Prognoses

The working group appreciated that these figures can only be used to put on order of magnitude on the size of the effect on prey species. Nevertheless, the reduction in yield of valuable prey species cannot be ignored, and the Working Group therefore carried out prognoses of the cod stock on three options of fishing mortality:

i) that fishing mortality will be maintained at the 1978 level up to 1981.

ii) that the level of fishing mortality in 1978 will be reduced by 20 % each year in 1980 and 1981. In this way the MSY level would be reached by 1982.

iii) that the catch will remain constant from 1979-1981 (and the F be reduced accordingly).

The input data for each of the three options are given in the text table below:

Age	Mean weight (kg)	Assumed F in 1978	Stock in numbers 1978 ($\times 10^{-3}$)
1	0.192	-	26.000 x)
2	0.445	0.3	25.478
3	1.170	0.8	5.045
4	1.690	1.1	3.412
5	2.860	0.8	1.805
6	4.120	0.8	164
7	5.180	0.8	196
8	6.900	0.8	89

x) Recruitment in 1979-1981, assumed to be at the same level as in 1978, is the average of 1971-1975.

In all options the 1978 exploitation pattern was used.

Fishing mortality as proportion of 1978 value above:

Option	i)	ii)	iii)
1978	1	1	1
1979	1	1	1
1980	1	0.80	0.87
1981	1	0.60	0.78

In all three options, it is assumed that the fishing mortality in 1979 will be maintained at the 1978 level. This results in a catch in 1979 very close to the agreed TAC of 16 000 tons.

The results of the three options are given below:

	Catch in tons Option		
	i) Constant F	ii) F reduced by 20 % in 1980 and 1981	iii) Constant catch
1978	13 200	13 200	13 200
1979	16 400	16 400	16 400
1980	17 900	15 400	16 400
1981	18 100	13 900	16 400

In paragraph 5.4 the consequences of assuming different levels of emigration and immigration were considered. If such assumptions are made in the prognoses, the results given above are not greatly altered and this is due to the fact that F is considerably higher than the migration factors incorporated in the value of natural mortality.

5.7.3. Cod in the Skagerrak

Owing to the lack of biological data from the Skagerrak before 1978, the only apparent basis for a recommendation of TAC is past landings. In the 1978 report (Anon. 1978) the Danish-Swedish Study group on this basis suggested a TAC of 10 000 tons

for 1979. This may also be an option for TAC in 1980. However, in subsequent negotiations a TAC of 14 000 tons was agreed. Another option is therefore to recommend a TAC of 14 000 tons for 1980 in order to stabilize the fishery until further information is available.

Table 5.1.1 Cod landings from the Kattegat, 1960-78 (in tons)

Year	Denmark	Sweden	Total
1960	5566	4366	9932
1961	5619	4474	10093
1962	8432	5385	13817
1963	7801	4408	12209
1964	9061	4017	13078
1965	9573	4831	14404
1966	10173	5726	15899
1967	9488	5289	14777
1968	9825	5339	15166
1969	9775	4067	13842
1970	9841	4015	13856
1971	11748	3962	15710
1972	13451	3957	17408
1973	14913	3850	18763
1974	17043	4717	21760
1975	11749	3642	15391
1976	12986	3242	16228
1977	16668	3400	20068
1978	10293	2893	13186

Table 5.1.2.

Danish landings of cod by months (tons). Kattegat 1973-78.

	1973	1974	1975	1976	1977	1978
Jan.	2366	4208	2073	2525	3947	1590
Febr.	2967	3713	2486	2609	3988	2501
Mar.	2896	2117	1265	1876	2964	1858
Apr.	647	965	994	1097	727	874
May	1147	798	1016	687	684	431
June	597	568	640	309	549	517
July	543	535	533	424	731	295
Aug.	637	735	508	594	472	317
Sept.	439	436	385	415	426	274
Oct.	635	855	599	469	797	368
Nov.	849	1007	415	833	415	492
Dec.	1179	1105	834	1148	968	776
Total	14902	17042	11748	12986	16668	10293

Table 5.1.3. German Federal Republic landings of cod by months in kg from cutters larger than 35 GRT, Kattegat 1968-78.

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Σ
1968	17594	45657	7114							1704	2817	2306	77192
1969	4072	11183	8520								942	4482	29119
1970	8069									1277	1344	567	11257
1971	2977	3995									6017	5355	18344
1972	7815	6692									13813	5801	34121
1973	12494	23885	20033							4252	7342	6406	74412
1974	26750	62723	17193	7675							15	6060	120420
1975	5087	44524	10838	6653					10839	1109	1000	13651	93701
1976	18180	10461	6376	623							8430	2353	46423
1977	13966	18060										571	32597
1978										969196*	260109*	7455*	1236760*

x Preliminary figures.

Table 5.1.4 Danish and Swedish cod landings from the Skagerrak 1965-78. (From national sources.)

Year	Denmark	Sweden
1965	4 093	2 316
1966	4 445	2 460
1967	6 026	2 592
1968	5 241	2 953
1969	2 505	1 734
1970	3 459	1 964
1971	5 914	2 040
1972	6 959	1 925
1973	6 673	1 690
1974	6 694	1 380
1975	14 171	917
1976	18 847	873
1977	18 618	560
1978	23 614	592

Table 5.1.5 Federal Republic of Germany. Landings of cod by months in kg from cutters larger than 35 GRT, Skagerrak 1968-78.

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Σ
1968								2547	5416				7963
1969								4592	6765		501		11858
1970				5461			3150	5001	9014				22626
1971							5204					8111	13315
1972								15340	6225				21565
1973								412					412
1974										779			779
1975					5854								5854
1976													----
1977													----
1978					2511 x					73862 x		11395 x	87768 x

x Preliminary

Table 5.1.6.

Danish landings of cod by months (tons). Skagerrak 1973-78.

	1973	1974	1975	1976	1977	1978
Jan.	593	642	849	1289	1684	1301
Febr.	429	575	1587	1468	1197	1276
Mar.	815	612	1316	1695	2060	1271
Apr.	441	699	1250	1511	1082	1502
May	889	566	1523	1501	1522	1636
June	640	333	1159	1112	1467	2533
July	621	349	936	1323	1030	1277
Aug.	489	521	1217	1891	1815	2405
Sept.	377	376	1182	1642	1627	2191
Oct.	437	638	1514	870	1789	2590
Nov.	650	779	702	2469	1428	3317
Dec.	295	604	935	2076	1917	2315
Total	6676	6694	14170	18847	18618	23614

Table 5.1.7. Cod landings from Division IIIa - Kattegat and Skagerrak.
(Danish and Swedish landings from national sources, other countries from Bulletin Statistique).

Year	Denmark	Norway	Sweden	Others	Total
1966	14 618	1 016	8 186	72	23 892
1967	15 514	1 347	7 881	149	24 891
1968	15 066	1 390	9 292	186	25 934
1969	12 280	903	5 801	59	19 043
1970	13 300	882	5 979	56	20 217
1971	17 662	1 355	6 002	35	25 054
1972	20 410	1 201	5 862	56	27 549
1973	21 586	1 253	5 540	101	28 480
1974	23 737	1 197	6 097	213	31 244
1975	25 920	1 190	4 559	146	31 815
1976	31 833	1 241	4 537	513	38 124
1977	33 475	979	5 137	726	40 317
1978	31 833	1 442	3 485	67[x]	36 827[xx]

x) Only for Jan.-June
xx) Preliminary

Table 5.2.1 Landings in number of cod in the Skagerrak and Kattegat 1978 ($\times 10^{-3}$)

Age	Kattegat	Skagerrak
1	88	4 291
2	6 015	11 056
3	2 551	2 858
4	2 100	767
5	913	180
6	83	164
7	99	44
8+	71	51
Total	11 920	19 412
Catch in tonnes	13 186	24 206

Table 5.2.2 The quarterly Danish catch in number of cod in the Skagerrak 1978 ($\times 10^{-3}$)

Quarter	1	2	3	4
Age				
1		37	847	3 302
2	2 754	3 063	2 932	2 037
3	731	967	599	491
4	184	221	186	157
5	16	44	34	81
6	28	83	26	24
7	2	22	7	13
8+	4	24	12	9

Table 5.4.1. Input data for the VPA of cod in the Kattegat. Catch in numbers ($\times 10^{-3}$).

age	1971	1972	1973	1974	1975	1976	1977	1978
1	15049	38	5	591	188	166	1	88
2	7937	3811	623	4250	3610	4431	2218	6015
3	6936	6422	2167	6943	2906	6983	7078	2551
4	1918	2427	3954	4543	3251	1835	4942	2100
5	887	809	2280	1538	661	1039	492	913
6	207	433	780	349	429	287	376	83
7	30	94	212	68	47	189	137	99
8+	30	38	160	31	19	52	102	71

Table 5.4.2. Fishing mortalities calculated by VPA. Cod in the Kattegat.

age	1971	1972	1973	1974	1975	1976	1977	1978
1	0.58	0.00	0.00	0.02	0.01	0.02	0.00	0.00
2	0.36	0.28	0.04	0.45	0.18	0.29	0.33	0.30
3	0.67	0.56	0.25	0.72	0.64	0.60	1.04	0.80
4	0.61	0.53	0.82	1.31	0.92	1.17	1.23	1.10
5	0.69	0.56	1.56	0.92	0.66	0.89	1.30	0.80
6	0.45	0.88	2.04	1.21	0.72	0.69	1.00	0.80
7	0.45	0.38	1.79	1.26	0.50	0.84	0.86	0.80
8	0.60	0.80	1.50	1.00	0.80	0.80	0.80	0.80
Mean age ≥ 3	0.65	0.56	0.73	0.91	0.76	0.71	1.11	0.90

Table 5.4.3. Stock in numbers ($\times 10^{-3}$) calculated by VPA. Cod in the Kattegat.

age	1971	1972	1973	1974	1975	1976	1977	1978
1	37363	22886	15671	30640	23820	10681	31106	-
2	28771	17126	18704	12827	24553	19332	8595	25478
3	15451	16428	10595	14751	6691	16850	11845	5045
4	4606	6454	7702	6725	5879	2881	7550	3412
5	1950	2056	3110	2782	1488	1920	732	1805
6	623	804	959	537	909	627	647	164
7	91	325	273	103	131	361	257	196
8	40	48	181	37	24	65	128	89

Table 5.6.1 Cod in the Kattegat. Spawning stock and recruitment.

Year/year class	Spawning stock (≥ 4 years) (tons)	Recruitment	
		R_1 from VPA (1 000 fish)	Abundance indices for 1-group cod from IYHS
1971	16 675	22 886	8.15
1972	22 115	15 671	17.87
1973	28 525	30 640	29.05
1974	22 383	23 820	4.59
1975	18 780	10 681	3.22
1976	15 262	31 106	8.11
1977	19 733	-	35.07
1978	(13 000)	-	12.82

Table 5.7.1. Long-term yield per recruit (kg) for Cod in Kattegat and its prey at different levels of fishing mortality.

F	Yield per cod recruit	Biomass per cod recruit	Total food consumption per cod recruit	Consumption of fish per cod recruit	Fish as percentage
0	0.0	16.85	40.25	11.08	27.5
.1	0.76	7.72	21.04	5.43	25.8
.2	0.85	4.34	13.24	3.18	24.1
.3	0.80	2.77	9.33	2.08	22.3
.4	0.74	1.94	7.09	1.46	20.7
.5	0.67	1.44	5.68	1.09	19.2
.6	0.62	1.13	4.74	0.84	17.8
.7	0.58	0.92	4.06	0.67	16.6
.8	0.54	0.77	3.57	0.55	15.6
.9	0.51	0.66	3.19	0.46	14.6
1.0	0.49	0.58	2.90	0.40	13.8

Population parameters used in the model.

	Cod	Average prey species
W	15.63 kg	2.0 kg
K	0.15	0.2
t_o	0.02	0.0
t_c	2.0	1.0
t_r	1.0	-
M	0.2	0.2
l_{5o} x)	40 cm	-

x) l_{5o} is the length at which 50 % of the cod eat fish.

Table 5.7.2. Yield, biomass and food consumption (tons x 10^{-3}) of cod in the Kattegat at different levels of fishing mortality.

F	Yield of cod	Biomass of cod	Total food consumption	Consumption of fish
0	0	421	100	277
.1	19	193	526	136
.2	21	109	331	80
.3	20	69	233	52
.4	19	49	177	37
.5	17	36	142	27
.6	16	28	119	21
.7	15	23	102	17
.8	14	19	89	14
.9	13	17	80	12
1.0	12	15	73	10

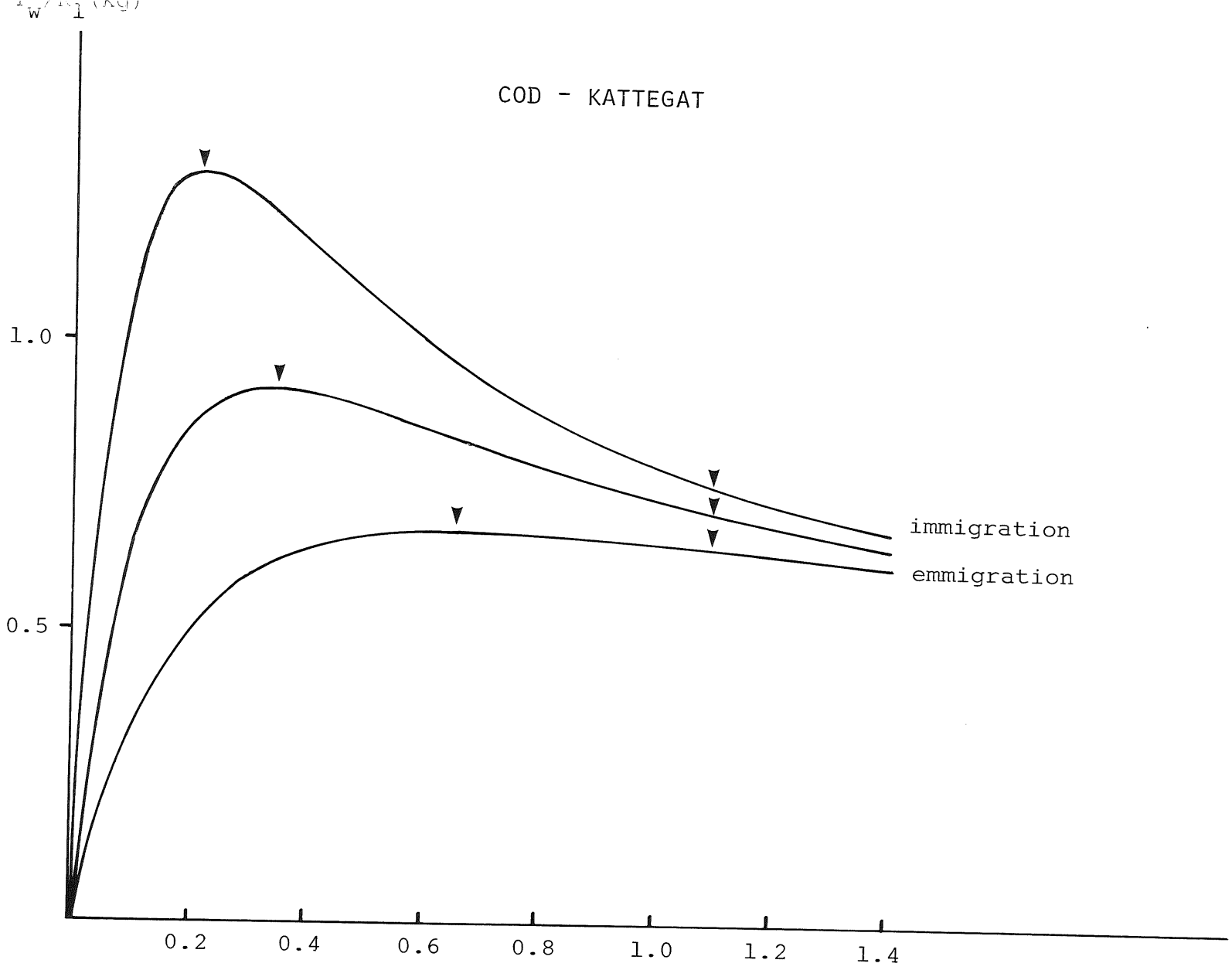


Fig. 5.5.1 Y/R curve for no migration, immigration of fish 4 years and older and emmigration of fish 4 years and older (see text).

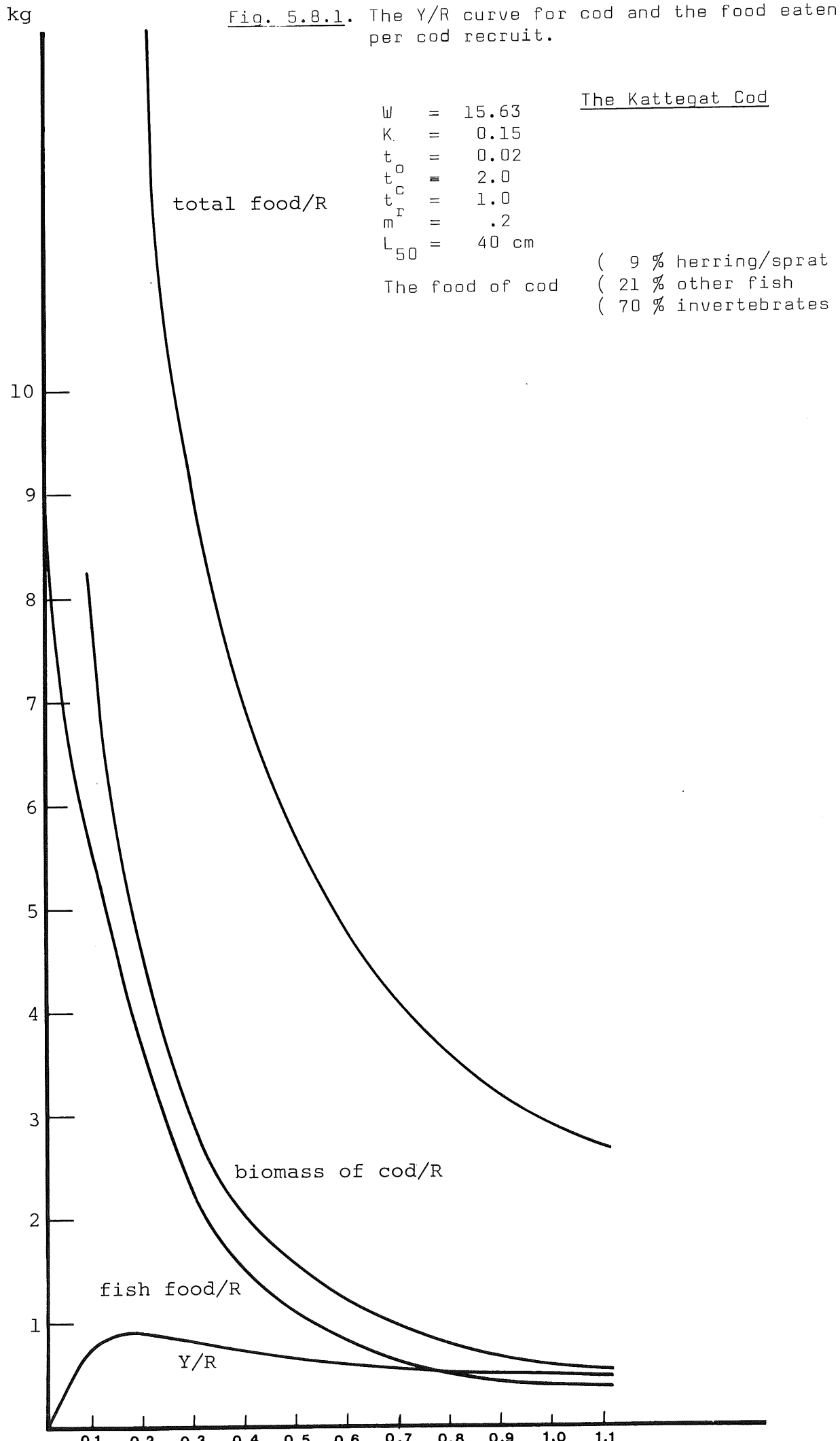


Fig. 5.8.1. The Y/R curve for cod and the food eaten per cod recruit.

The Kattegat Cod

W_∞ = 15.63
K = 0.15
t_o = 0.02
t_c = 2.0
t_r = 1.0
m = .2
L_{50} = 40 cm

The food of cod
(9 % herring/sprat
(21 % other fish
(70 % invertebrates

6. Whiting.

The only statistical data available for whiting are landing statistics from Division IIIa as reported in Bulletin Statistique. Swedish landings from Division IIIa have been separated from landings from Division IVa only since 1975,(Table 6.1).

Based on information from tagging experiments (Knudsen,1965, Hannertz and Hagström, in press) the group considered the whiting from the Kattegat and the Skagerrak to be a local stock.

There is no evidence that the annual exploitation of about 22 000 tons in average since 1966 had an adverse effect on the stock. Therefore, the group considered a continuation at this level to be justified for 1980. The increased Danish landings in 1978 are probably based on the apparantly outstanding 1977 year class (see Table 6.2).

A split of the TAC between the Kattegat and the Skagerrak seems not to be indicated for biological reasons.

Table 6.1. Whiting landings from Division IIIa (from Bulletin Statistique).

Year	Denmark	Norway	Sweden	Others	Total
1966	20 263	43	↑	-	20 306
1967	30 131	23		3	30 157
1968	29 467	28		2	29 497
1969	16 525	19		-	16 544
1970	13 115	15	IIIa incl.	-	13 130
1971	13 971	17	in IV a	1	13 989
1972	14 538	24		-	14 562
1973	22 479	67		1	22 547
1974	28 749	89	↓	4	28 842
1975	19 018	57	611	4	19 690
1976	17 870	48	1 002	57	18 977
1977	18 116	46	973	41	19 176
1978 x)	48 216	60	318	+	48 594

x) preliminary

Table 6.2. Whiting from International Young Herring Surveys from Div. IIIa (Total number of fish per hour from all stat. squares investigated).

Survey year	Age group I	Age group II	Age group III+	No of squares investigated
1976	2 737	210	144	14
1977	1 511	89	22	15
1978	7 507	606	144	13

7. Plaice.

7.1. Landings

7.1.1. The Kattegat.

Only Denmark and Sweden provided catch data for the Kattegat and the Skagerrak separately. Of other countries only the Federal Republic of Germany has very small catches in the Kattegat - estimated at 10 - 50 tons per year. It was not possible to separate all the German landings, therefore Table 7.1.1 only shows the Danish and Swedish landings from the Kattegat. No evidence of a trend is seen.

Table 7.1.2 shows the Danish and part of the German catches in the Kattegat per month. It also shows that the German fisheries only take place in the autumn and winter months while the Danish fishery is distributed over the whole year.

7.1.2. The Skagerrak.

The landing statistics from the Skagerrak are given in Tables 7.1.3 and 7.1.4. Landings from Belgium, Norway and the Federal Republic of Germany are very small, and the high figures in the column "other countries" refer almost exclusively to the high Dutch landings. It is assumed that in 1976 and 1977 at least 50% of these belonged to the North Sea. Nothing definite could be stated for 1978.

Despite the doubt about the Dutch landings, there seems to be an upward trend in the figures.

The landings for each month are given for Denmark in Table 7.1.5 and for the Federal Republic of Germany in Table 7.1.6.

7.2. Age distribution

7.2.1. The Kattegat.

The age composition is given in Table 7.2.1. The data are based on sampling of Danish landings, and were subsequently raised to the total catch in the Kattegat.

The sampling before 1971 was from unsorted landings. From 1971 to 1977 a stratified sampling by size categories was made of landings from Grenå only.

In 1978, the sampling system was changed as described in Section 5.2.

Comparing the age composition in 1978 with those in earlier years indicated that landings of II-group fish were unusually low. It is, however, not clear whether this feature reflects a low abundance of yearclass 1976 or is due to the changes in the sampling system introduced in 1978. Another anomaly is the rate between 3-groups in one year and 4-groups in the following year. It appears that the number caught of 4-groups is less than the number caught of the same yearclass as 3-groups in all cases except in 1970/71 when the sampling system was changed and now again in 1977/78.

The Working Group had no opportunity to analyse the problem further but recommends that this should be done as soon as possible.

7.2.2. The Skagerrak.

A Danish sampling program in the Skagerrak was started in 1978 and represents the only data recorded. The catch in numbers at age by quarters is shown in Table 7.2.2.

7.3. Recruitment

0- and 1-group surveys of plaice carried out along the Danish Kattegat coasts for many years were discontinued in 1975.A comparison between the results obtained in 1968-73 and the catch in numbers at age figures shown in Table 7.2.1 indicates a correlation which the Working Group thought sufficient basis for recommending that the young plaice surveys in the Kattegat should be reestablished.

7.4. Management

7.4.1. The Kattegat.

For reasons set out in Section 7.2 the Working Group agreed not to do a VPA nor to make any prognosis based upon the recent age distributions. If, in fact, yearclass 1976 is as weak as indicated by the latter,some precaution is advisable concerning management proposals for 1980. The Working Group could agree upon a TAC in 1980 of 10 800 tons being the average yearly landing in 1973-77. This would be a decrease of 17 % from the level in 1978 and 12 % less than the long term mean in 1969-78.

7.4.2. The Skagerrak.

Because data were insufficient for a prognosis, the Working Group agreed to suggest a precautionary TAC of 14 000 tons for 1980 being the same as agreed upon for 1979. This would stabilize the catch at the same level until more data are available. In order to establish a firmer data base, catch figures and biological samples from other countries are required.

7.5. Scientific Data on Beam Trawling

The Working Group was informed about the conclusions of a report being prepared at Lowestoft summarising the results of a number of experimental cruises on commercial beam trawlers which were carried out during 1977/78. The most important were:

1) Beam trawling on grounds where a significant quantity of "rubbish" (shell, stones, starfish, weed, etc.) is retained in the cod end leads to a reduction in the selection of the net equivalent to a reduction in mesh size of about 10 mm.

2) Undersized fish retained in the cod end are usually damaged and in a very moribund condition.

3) Beam trawling in nursery areas could lead to the destruction of considerable quantities of undersized flatfish.

Table 7.1.1. Plaice landings from the Kattegat 1960-1978 (in tons).

Year	Denmark	Sweden	Total
1960	7 146	434	7 580
1961	11 956	477	12 433
1962	15 924	513	16 437
1963	14 197	525	14 722
1964	19 437	498	19 935
1965	9 458	565	10 023
1966	5 900	345	6 245
1967	11 567	424	11 991
1968	13 358	515	13 873
1969	10 316	525	10 841
1970	11 582	381	11 963
1971	15 819	331	16 150
1972	15 504	348	15 852
1973	10 021	231	10 252
1974	11 401	255	11 656
1975	10 158	369	10 527
1976	9 487	271	9 758
1977	11 611	300	11 911
1978	12 685	368	13 053

Table 7.1.2.

Danish landings of plaice by months (tons). Kattegat 1973-78.

	1973	1974	1975	1976	1977	1978
Jan.	1060	1356	866	1262	1076	956
Febr.	567	851	783	716	554	598
Mar.	703	743	478	659	896	856
Apr.	300	649	729	712	639	587
May	552	1042	794	707	884	739
June	450	1047	849	677	974	1161
July	405	651	942	557	686	870
Aug.	869	1194	946	758	922	1304
Sep.	991	1016	893	868	1316	1641
Oct.	1585	1299	1503	946	1458	1711
Nov.	1577	834	497	986	922	1348
Dec.	962	719	878	639	1283	914
Total	10021	11401	10158	9487	11610	12685

Table 7.1.2

Plaice Kattegat, German Fed. Rep., Cutter > 35 Gr.T., Weight in kg

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Σ
1968	16494	28354	6510							1122	1770	2099	56354
1969	4905	10840	7305								2281	5686	31017
1970	5819									3361	1830	683	11693
1971		140									3324	11250	14714
1972	4453	4556									5330	4203	18542
1973	10428	9210	6125							1899	2879	6440	36981
1974	12551	19827	6907	8133							688	2698	50804
1975	5181	13008	7159	5458					1508	2090	419	35§§	38422
1976	7457	13442	2804	911							3916	2419	30949
1977	5145	4053										1074	10272
1978										27167	6765	1456	35388

Table 7.1.3. Plaice catches from the Skagerrak.

Year	Denmark	Sweden	Other countries
1966	3 284	6	
1967	3 075	42	
1968	3 187	65	
1969	3 262	62	
1970	3 219	57	
1971	3 741	64	
1972	5 095	70	
1973	3 871	80	
1974	3 429	70	
1975	4 888	77	
1976	9 251	81	5 331*)
1977	12 855	142	12 295*)
1978	13 383	94	52**)

*) Including Dutch catches. A large part of these is assumed to have been taken in the North Sea (1976:4575 tons, 1977:11384 tons)

**) Dutch catches not included.

Table 7.1.4. Plaice-catches. Kattegat and Skagerrak combined (Division III a). Denmark and Sweden from national sources, other countries from Bulletin Statistique .

Year	Denmark	Sweden	Other Countries	Total
1966	8 747	351	59	9 157
1967	13 945	466	61	14 472
1968	15 757	580	694	17 031
1969	12 932	587	63	13 582
1970	14 096	438	40	14 574
1971	18 629	395	19	19 043
1972	19 618	418	80	20 116
1973	13 346	311	54	13 711
1974	14 248	325	57	14 630
1975	14 508	446	199	15 153
1976	18 738	385	5 325 x)	23 040
1977	24 323	442	12 295 x)	37 031
1978	26 034	462	-	-

x) See also Table 7.1.3.

Table 7.1.5.

Danish landings of plaice by months (tons). Skagerrak 1973-78.

	1973	1974	1975	1976	1977	1978
Jan.	408	227	171	724	349	382
Febr.	188	315	265	430	429	306
Mar.	450	298	232	578	1341	601
Apr.	281	339	265	632	794	1198
May	408	438	381	948	1511	970
June	213	194	303	654	1312	1354
July	330	303	360	863	1276	1046
Aug.	430	483	645	1081	1784	1758
Sept.	268	312	509	1000	1554	1498
Oct.	356	205	1009	764	1191	2007
Nov.	425	195	410	1207	616	1700
Dec.	114	120	338	370	698	563
Total	3871	3429	4888	9251	12855	13383

Table 7.1.6.

Plaice Skagarrak, German Fed. Rep., Cutter > 35 Gr.T. Weight in kg

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Σ
1968								6740	669				7409
1969								2265	3869		515		6649
1970							6275	6715	3639				16629
1971												1880	1880
1972								33105	25138				58243
1973								10559					10559
1974										25			25
1975													---
1976													---
1977													---
1978					11737					9320		20	21077

Continued

Table 7.1.6 (Continued)

Plaice Kattegat/Skagarrak German Fed. Rep., Cutter < 35 Gr.T., Weight in 1000 Kg

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Σ
1968	1.7	4.8		0.2		1.4	0.2	0.1	0.3	0.5		0.2	9.4
1969				3.3		0.3	0.3	0.6	1.2	9.5		2.3	17.5
1970	5.3					0.1		0.1	3.5	0.1		0.1	9.2
1971	0.3												0.3
1972													---
1973													---
1974													---
1975								0.5		0.1			0.6
1976				0.1		0.6					0.1		0.8
1977	0.1				4.3	5.7			2.7		5.5	8.9	27.1++ 0.1
1978	8.2	13.3	0.2	9.0									30.7++

++ = Landings in Danmark

Table 7.2.1. Plaice - Kattegat.CATCH IN NUMBERS BY YEAR AND BY AGE.

AGE	1968	1969	1970	1971
1	0	0	0	0
2	3790	1180	3660	680
3	20320	14070	11830	8190
4	10570	10510	9760	23570
5	2280	2840	3140	14170
6	790	760	710	1870
7	500	300	650	350
8	260	300	370	190
9	180	270	370	330
10	70	240	240	260
11	0	50	80	80
12	50	100	140	40

AGE	1972	1973	1974	1975
1	0	1470	50	140
2	1120	8590	3100	7880
3	21790	5830	21630	7330
4	17720	6260	3470	8140
5	7910	3130	2620	1040
6	1110	1770	1020	730
7	200	510	740	420
8	120	180	330	350
9	80	20	120	150
10	80	10	80	110
11	30	30	50	50
12	60	30	140	10

AGE	1976	1977	1978
1	10	10	1
2	8657	3330	146.5
3	11026	20150	9686.1
4	2100	9230	27861.5
5	3060	2680	8685.1
6	431	900	1143.6
7	280	230	226.7
8	207	270	49.4
9	87	210	48
10	74	130	32.6
11	10	100	16.7
12	13	190	39.9

Table 7.2.2. Plaice in the Skagerrak. Danish catch in numbers ($\times 10^{-3}$) 1978.

Age / Quarter	I	II	III	IV	Total
1					
2			232.3	120	352.3
3	253.9	312.7	2 628.9	3 202.3	6 397.8
4	1 119.0	3 009.9	5 210.4	3 342.9	12 682.2
5	2 155.3	6 018.0	4 785.4	3 851.6	16 810.3
6	889.9	1 255.0	1 734.3	3 161.3	7 040.6
7	51.5	113.3	125.0	116.8	406.6
8	3.6	0.0	10.1	2.5	16.2
9	0.0		13.5	3.8	17.3
10			13.5	2.5	16.0
11			3.4	1.2	4.6
12			0.0	0.0	0.0

8. Mesh size and minimum landing size for cod, whiting and plaice in Div. III a.

In division IIIa legal minimum mesh size range from 70 to 80 mm depending on the material in the net. In the Skagerrak and the Kattegat 70 mm is commonly used in Swedish gears and 100-120 mm in Danish gears. The smaller legal mesh size in Division IIIa than in Sub-area IV will probably be of concern only to Denmark and Sweden because fishermen from other countries will find it unpractical to operate with different gears in the Skagerrak or the Kattegat than in the North Sea.

In the text table below, selection factors, minimum landing sizes and the mesh size for which the 25 % retention length equals the minimum landing size are given for cod, whiting and plaice. An increase in the mesh size to 80 or 90 mm will improve the consistency between minimum landing size and mesh size for cod and plaice, although for plaice the discrepancy will still be large.

Cod, whiting and plaice in Div. IIIa. Relations between mesh size and minimum landing size

Species		Selection factor	Minimum landing size	Min.landing size corresp. to 80 mm (25 % r.l.)	Min.landing size corresp. to 90 mm (25% r.l.)	Mesh size where 25% ret.length = min. landing size
Cod	High s.f.	3.77[a)]	30	28	31	87
Cod	Low s.f.	2.82[a)]		21	23	117
Whiting		3.83[b)]	23	28	31	66
Plaice		2.2[c)]	27	17	19	126

a) The North Sea Roundfish Working Group 1978.
b) Coop.Res.Rep., Ser. A, No. 25 (1971).
c) The North Sea Flatfish Working Group 1978.

9. Sandeel in Division IIIa

9.1. The Skagerrak

The sandeel fishery in the Skagerrak is partly taking place close to the border of the North Sea and partly in the Jammer Bay. The size of the fishery is indicated by the landing figures for 1974-78 as shown below:

Year	Tons
1974	5 993
1975	16 148
1976	20 997
1977	11 256
1978	17 479

Though small as compared with the North Sea landings they are still of major local importance.

Species composition by weight in 24 samples from 1978 is shown in Table 9.1.1. It appears that the major part of the by-catch consists of whiting and "other species" (mainly horse mackerel and dab). Applying the percentages of by-catch herring to the total catches the effect of this fishery on the herring stock may amount to approximately 100 tons. This amount is included in the Danish herring landing figures for the Skagerrak.

9.2. The Kattegat

The sandeel fisheries in this area are partly carried out for industrial purposes and partly in order to obtain bait for the long-line fishery for cod in the Kattegat. The size of the landings is indicated below:

Year	Tons
1974	1 919
1975	558
1976	421
1977	4 830

These fisheries are mainly taking place close to the shore and are in such cases subjects to special national restrictions. Data from sampling in 1977 are shown in Table 9.2.1, which indicates that the bycatch is negligible. In this case "other species" consisted of dab and invertebrates.

The Working Group agreed, that as long as the use of trawls with meshes less than 16 mm is kept under strict national control, these

fisheries have no measurable effect on the economically important fish species in Division IIIa.

Table 9.1.1 Species composition. Percentage by weight. Sandeel fisheries, Skagerrak, 1978.

Species	May	Jun	Jul	Aug	Sep
Sandeel	95.13	94.57	97.22	96.69	90.20
Herring	0.81	1.03	0	0	0
Sprat	2.08	0.71	0	0	0
Cod	0	0.27	0.02	0	0.83
Haddock	0	0	0	0.18	0
Whiting	0.99	0.82	1.16	1.83	8.97
Mackerel	0.20	0	0	0	0
Plaice	0	0.22	0	0.24	0
Others	0.79	2.38	1.60	1.06	0
Nos. of samples	4	4	5	10	1
Catch (in tons)	2 503	6 445	3 141	4 221	688

Table 9.2.1 Species composition. Percentage by weight. Sandeel fisheries, Kattegat, 1977.

Species	Mar	May	Jun
Sandeel	99.92	99.21	97.58
Herring	0	0	0
Sprat	0.02	0.07	0
Cod	0	0	0
Haddock	0	0	0
Whiting	0	0	0
Mackerel	0	0	0
Plaice	0	0	0
Others	0.06	0.72	2.42
Nos. of samples	2	4	2
Catch (in tons)	65	3 180	794