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REPORT OF THE NORTH SEA FLATFISH WORKING GROUP

Charlottenlund, 17-28 February 1975

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

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Report of the North Sea Flatfish Working Group

1. Introduction

1.1 The ICES North Sea Flatfish Working Group met in Charlottenlund from 17 to 28 February 1975 with the following members participating:

D W Armstrong	U.K. (Scotland)
R C A Bannister	U.K. (England)
K Brander	U.K. (England)
R De Clerck	Belgium
C Duggan	Ireland
H Knudsen	Denmark
H Lassen	Denmark
E Nielsen	Denmark
G Rauck	Germany (F.R.)
J F de Veen (Chairman)	Netherlands

Mr D de G Griffith (ICES Statistician) also participated in the meeting.

1.2 The Group was convened with the following terms of reference (C.Res. 1974/2:23):

"It was decided, that:

the North Sea Flatfish Working Group should meet at Charlottenlund 17-28 February 1975 in order to:

a) assess TAC's for 1976 for plaice and sole in the North Sea, Irish Sea, Bristol Channel and English Channel;

b) define the spawning and nursery grounds of plaice and sole in the areas mentioned under a);

c) assess further the effect of restricting fishing on nursery grounds; and

d) in order to be able to identify stock structure of North Sea plaice, to discuss and organise an international tagging experiment on the spawning, feeding and nursery grounds in 1976".

1.3 The Group felt that in order to deal properly with the terms of reference it would also have to discuss the reliability of statistics. In addition the Group considered the recommendation made by the ADP Working Group (Doc. C.M.1975/D:2) that the North Sea Flatfish Working Group should study the results of the trial run of the ICES FISHDAT System which had been carried out on North Sea herring, and if possible define specifications for a trial run on North Sea plaice.

2. Management Objectives

2.1 A previous Report of the North Sea Flatfish Working Group (Doc. C.M. 1973/F:18) recommended Total Allowable Catches (TAC's) for sole and plaice in the North Sea, and for sole in the Irish Sea and Bristol Channel.

2.2 The North Sea sole stock, hitherto heavily overfished, has declined to a low level of abundance. The TAC's of 6 000 tons recommended for

1974 (Doc. C.M.1973/F:18) provided for a reduction in fishing mortality to the level giving the maximum sustainable yield (MSY) and for the additional reduction in mortality necessary to promote some degree of recovery of the stock. The TAC eventually adopted by NEAFC for 1975 (12 500 tons) is sufficient to achieve only the first objective, and rather than bring about an increase in stock it will actually only reduce the rate of decline. An increase in the biomass of the stock is still a desirable objective because of the dependence of the fishery on the incoming year classes. The concept of stabilising stock level, discussed on occasions recently, is only a provisional step to management, since although it prevents stock decline it does not help to rebuild the stock. The Working Group is still of the opinion that the long-term objective of management is to rebuild the sole stock, and the present reassessment was conducted with this end in view. It should be pointed out that the long-term sustainable yield from North Sea sole is by no means as high as the yield levels enjoyed in the middle sixties, when the abundance of the stock was influenced by very good year classes.

2.3 For North Sea plaice, which was previously assessed as being at about the MSY level the objective of the TAC previously recommended was to prevent expansion of the fishery. Fishing mortality on plaice has increased recently but it is still possible to maintain the fishing close to the MSY position because of the rather flat-topped nature of the yield curve. On the other hand, abundance is now declining because of changes in the year class composition of the stock and the 1975 TAC finally adopted by NEAFC could now actually permit mortality to increase. The objective of the present reassessment was therefore to maintain a MSY position but to reduce the TAC to a level whereby this could be achieved, having regard to the most likely level of recruitment. As with sole the high yields of recent years have been partly the product of good year classes and are an unrealistic index of the long-term potential of the stock.

2.4 In the remaining areas the objective of TAC regulations was to ward off the effects which would arise if the stock were subject to extra mortality following increases in fishing effort, say by diversion from other regulated areas. The rather limited assessment material available for these stocks has been used to adjust the TAC to maintain this objective in the light of the observed levels of fishing mortality and the little that is known about recruitment in these areas.

3. North Sea Plaice

3.1 Introduction

3.1.1 The current NEAFC regulations provide for the enforcement of a Total Allowable Catch for the North Sea plaice of 126 000 metric tons. This is an increase on the TAC of 115 000 tons recommended by this Working Group following previous assessments made between 1968 and 1973. These assessments included preliminary conventional Beverton and Holt yield equation calculations for national data (Docs. C.M.1968/F:4 and C.M.1971/F:14) and, later, numerical predictions based on the use of a fishing mortality at age array, mean weight at age data, and minimum estimates of recruitment at two years of age (C.M.1973/F:18 and C.M.1973/F:27), for which data were derived using the Virtual Population Method of analysing a series of estimated international age compositions. The international age composition data were those produced by Bannister (1973) and updated by the Working Group. The baseline mortality array was the average for the period 1968-1971.

3.1.2 In calculating a new TAC for 1976 it was considered necessary to reassess the state of the stock to take account of:

a) those changes in abundance and in the level of fishing mortality likely to have occurred since the formulation of the original recommendations;

b) the availability of new age composition data.

The reassessment incorporated the 1973 age composition and preliminary estimates of that for 1974. A major feature was the availability of Danish age compositions for these two years. A new raising procedure was also adopted to take account of the Danish catch for previous years in the series.

3.1.3 The outcome of the reassessment is:

a) a new F at age array and a series of updated recruitment estimates;

b) a catch and stock prognosis for 1975 and 1976 for the current level and pattern of fishing;

c) a reference calculation of the steady-state relationships between catch, stock and fishing mortality for the current pattern of fishing.

As before, it has been assumed that the total international catch is supported by a single unit stock.

3.1.4 It is intended that the procedures discussed and adopted at this meeting shall form the basis of a year to year routine.

3.2 Trends in catch

The trend in total North Sea plaice catch ("Bulletin Statistique" figures) is brought up to date in Table 1. This shows that after a slight fall in 1971 and 1972, the 1973 catch was very close to the peak catch recorded previously in 1970. However, the preliminary 1974 figures indicate that catch has since fallen to 109 000 tons. The most obvious feature of recent years has been the higher Netherlands catch.

3.3 Age composition data

3.3.1 Summary descriptions of the sampling system of the member nations are given in Appendix I.

3.3.2 In the past, the international age composition has been based on the following series of annual national data:

United Kingdom:	1947-1972	Lowestoft and Grimsby otter trawl age composition raised to total U.K. catch.
Netherlands:	1957-1972	Beam trawl age composition raised to total Netherlands catch.
Germany, Federal Republic of:	1966-1972	Samples for the Schlickbank and Deutsche Bucht raised to total Fed.Rep. of Germany catch.
Belgium:	1969-1972	Beam trawl age composition raised to total Belgian catch.

The catches of Denmark and the remaining nations were accounted for by raising a sum of these age compositions directly to the total catch.

3.3.3 Danish samples for one year, 1960/61, suggest that the above raising procedure underestimates the Danish catch of young plaice, particularly 2 year olds, and may overestimate the abundance of older plaice, especially as Danish vessels do not engage in the fishery for spawning plaice on the exposed southerly grounds in winter.

3.3.4 A report by Dr E Ursin was presented comparing the VPA results for the previous data-raising procedure (Bannister, 1973) with a new analysis. In the latter, Danish catches were accounted for using a ratio of the Danish to Lowestoft age compositions per 1 000 kg in 1960-61, but on an unsexed basis and with an amended array of natural mortality (M) at age and different terminal fishing mortalities (F_t). This report is included as Appendix II.

3.3.5 Bearing in mind the differences in M and F_t the new results are quite similar to those obtained previously, though they do indicate a slightly higher overall level of recruitment, particularly for the newer year classes. The Group agreed that the traditional values of M = 0.1 (Beverton and Holt, 1957) or 0.1 (♀) and 0.15 (♂) (Beverton, 1964) might underestimate "natural" mortality arising in the I- and II-group plaice due to shrimp fishing and discarding at sea, but it could not comment on Ursin's view that these values could overestimate the natural mortality of older age groups. The Group accepted the point being made about the raising procedure. However, Ursin's analysis was based on unsexed data and did not include recent Belgian and Federal Republic of Germany age composition data. For 1958 to 1972 it was decided to adopt an intermediate series of data in which Danish landings had been estimated by raising from the Netherlands age composition. Though still present, the underestimation of 2-year old plaice is much less pronounced.

3.3.6 For 1973 and 1974 it has been possible to include a Danish age composition based on sampling at Esbjerg, so that 98% of the total catch is accounted for directly. The estimate for 1974 is only preliminary, since for some countries data were available only for the first three quarters of the year.

3.3.7 The complete series of 1958-1974 age composition data is given in Table 2. From this series the mean values of recruitment are as follows (in millions of fish):

	♂	♀
Including 1963 year class	217 ± 228	207 ± 196
Excluding 1963 year class	197 ± 105	185 ± 109

3.4 The Virtual Population Analysis

3.4.1 The new age composition data were processed by the Virtual Population Analysis (VPA). Following Ursin, the two year old M was increased to 0.25 (♂) and 0.2 (♀), but for the remaining age groups Beverton's (1964) values of 0.15 (♂) and 0.1 (♀) were retained. To avoid problems arising from the uneven sampling of the older fish the analyses were started at age 15 (♂) and 20 (♀) for a terminal F value of 0.2 (♂) and 0.1 (♀) for fully sampled cohorts, and for the arrays showns in Table 3 for the partially sampled cohorts. The latter values were estimated by trial and error, using the previous VPA to predict the 1972/73 catches.

3.4.2 The results of the VPA calculations are presented in Tables 4-6. Table 6 shows the following:

a) 1971-73 mean fishing mortality at age; and fishing mortality relative to F_{max};

b) 1967-70 mean fishing mortality at age for comparisons;

c) natural mortality at age;

d) 1974 catch;

e) 1974 stock, estimated from 1974 catch and mean 1971-73 fishing mortality.

Comparison of the 1967-70 and 1971-73 mortality rates shows more or less no change for male plaice. For females, however, mortality is now higher than that in the previous period involving increases of some 30% - 50% up to age 6, and much larger increases for the old fish. In the case of males the rather high F value for age 14 suggests that the terminal F value at age 15 is rather low, but this assumption has not apparently affected the rest of the array.

3.4.3 The VPA estimates of stock number at two years of age (Table 7) have been taken as minimum estimates of recruitment to the exploited population.

3.5 Growth

3.5.1 The prognosis programme requires estimates of mean weight at age for the catch and, if possible, the stock. Previously, catch weight at age was determined from the 1960-71 average annual mean length at age for landings of Lowestoft otter trawlers (Bannister, 1973 b) and converted to weight using the Lowestoft length/weight relaticnship:

Males	$l_nW = 2.897$	$l_nL = 4.309$
Females	$l_nW = 2.932$	$l_nL = 4.409$

The resulting figures were very similar to the mean weights derived from the Netherlands beam trawl fleet. It was decided to continue with the use of these weight data for estimating yield.

3.5.2 For this stock the use of catch weight at age to estimate stock biomass is suspect, because the mean lengths of recruiting plaice are rather high, leading to large negative values of the parameter t_o of the von Bertalanffy growth equation, as already discussed previously (C.M.1971/F:14). Separate weight data are not normally available for the stock, but for the younger ages it was decided to refer in this assessment to the original weights calculated from the growth curve of Beverton and Holt (1957), who incorporated observations from research work on young plaice by Wallace (1907), and to use the catch weights at age from the point where the Beverton and Holt curve intersected with the catch growth curve. The catch and stock weights at age are shown in Table 8. These weights are gutted weight. In the description of the prognosis results all weights have been raised to fresh weight using a factor of 1.125.

3.6 Prognosis

3.6.1 The method adopted here is to calculate the expected stock and catch in 1975 and 1976, using the mean 1971-73 relative F at age array and the 1974 catch and stock. The relative fishing mortality at age is assumed to remain unchanged. The calculation is carried cut for the most likely recruitments in the two years, for a suitable value of F_{max} in 1975, and for an array of F_{max} from 0.1 to 1.0 for 1976. The catch

weight, i.e. yield, is calculated on the basis of number and weight data referred to 1 June each year. Nominally stock is referred to as being that at 1 January. The Beverton and Holt stock weights used actually refer to mean weight for July and the stock biomass is therefore over-estimated here, but the adjustment for seasonal growth is unlikely to be greater than the initial error on the estimates.

3.6.2 For this stock, recruitment fluctuates with a coefficient of variation of about 50%, but so far there is no evidence of a formal relationship between recruitment and stock. In fact for catch the influence of age groups II and III is rather small, such that widely differing assumptions about R do not affect the calculation of a 1976 TAC to any high degree. This is shown below by the expected yield and stock biomass figures for the following range of recruitments, assuming that F_{max} and F at age are unchanged at the 1974 level:

	Number of recruits (millions)	
	♂	♀
(i) Two poor recruitments	130	130
(ii) Two low average recruitments	170	150
(iii) Two average recruitments	197	185
(iv) One good and one low average recruitment	(265 170)	(255 170)

North Sea Plaice. Catch and stock 1974-76 for a range of recruitment and for F_{max} unchanged.

		Recruitment			
		(i)	(ii)	(iii)	(iv)
Catch (metric tons)	1974	-	-	104 350	-
	1975	98 260	99 135	100 204	102 443
	1976	85 587	86 907	90 776	96 405
Stock (metric tons)	1974	-	-	276 742	-
	1975	255 206	259 769	264 128	274 219
	1976	232 281	242 822	253 527	264 422

3.6.3 In 1976 the range of predicted catch is about 10 000 tons in the different assumptions about recruitment. The influence of these assumptions on the years beyond 1976 will naturally be greater, but the plaice age composition obviously allows such assumptions to be modified on a year to year basis. In the predictions which follow, a conservative estimate of recruitment of 170×10^6 per sex was adopted.

3.6.4 The 1974 age composition and the catch weight at age data provide a reasonable diagnosis of the present stock situation, since the sum of products of number and weight estimates the 1974 catch to be about 104 350 tons, which compares with the observed catch of 109 000 tons.

3.6.5 Using the mean 1971-73 relative F at age array, the 1974 F_{max} of 0.54 (♂) and 0.42 (♀), and recruitments of R = 170 x 10^6 per sex, the results of the catch prognosis for various assumptions about the 1975 F_{max} are shown in Table 9.

3.6.6 If F_{max} 1975 is the same as F_{max} 1974, the most likely 1975 plaice catch will be 99 513 tons. The 1975 TAC of 126 000 tons will not therefore achieve any reduction in fishing mortality. (Carrying the prognosis through to 1976 suggests an expected catch of 91 465 tons at the 1974 F_{max} level). However, if each country attempts to take its 1975 plaice quota, say by diversion of spare catching capacity from other species or areas, mortality in 1975 must obviously increase, and it was agreed that the Working Group should take account of this possibility in making a prognosis.

3.6.7 On a proportional basis the increase in mortality would probably need to be about 30% in order to realise the full TAC, but a more conservative guess as to the increase likely to be achieved by various countries would be 15%. On these assumptions, F_{max} for 1975 would be increased to, respectively, 0.62 and 0.70 (♂) and 0.48 and 0.55 (♀), which would lead to the expected 1975 catches and stocks shown at the top of parts 2 and 3 of Table 9. For 1975 an increase in mortality to slightly more than 1.3 times the 1974 F_{max} could therefore result in the 1975 TAC being reached, whilst 1.5 times the 1974 F_{max} would generate a catch of 111 344 tons. The ensuing catch and stock prognosis for 1976 for the array of F_{max} of 0.1 to 1.0 is also shown in Table 9, together with the percentage long-term increase in biomass at each F level.

3.6.8 The relation between steady-state biomass per recruit, yield per recruit and F_{max} (Table 10) shows that while an increase in fishing mortality over the present level will not reduce the potential sustainable yield very much, there would be a distinct fall in stock and catch rate. For these reasons it is undesirable to permit any permanent increase in mortality which might arise out of attempts to take the 1975 TAC. It was therefore agreed that the 1976 TAC should be such that the mortality rate achieved in 1976 is no greater than the 1974 level, which is already greater than that of three or four years ago.

3.6.9 The catch required to return the 1976 F_{max} to the 1974 level is obtained by entering parts 2 and 3 of Table 9 at F = 0.54 (♂) and 0.42 (♀), leading to rounded figures of 88 000 tons and 84 000 tons for, respectively, F_{max} 1975 = 1.15 x F_{max} 1974 and F_{max} 1975 = 1.30 x F_{max} 1974. A reasonable compromise figure for the two situations is 85 000 tons, which is therefore the TAC for 1976 recommended by the Working Group.

3.6.10 This TAC will remain a valid recommendation even if no increase in F_{max} actually occurs during 1975. For R = 170 x 10^6 per sex, Table 10 shows the absolute steady-state catch and stock for the array of possible 1976 F_{max} values. Entering the table at the 1974 F_{max} values (0.54, male, 0.42, female) shows that a long-term sustainable yield of 86 665 tons could be expected. The proposed TAC is very close to this value and, compared to the catch of 91 465 tons expected if F_{max} does not change, would provide a small reduction in F from the 1974 level and a corresponding increase in stock.

3.6.11 The Working Group therefore recommends a TAC of 85 000 tons for 1976 to cover all the most likely circumstances in the fishery.

3.6.12 The difference between this figure and the 115 000 tons figure previously recommended in 1973 is accounted for by the intervening fall in stock associated with changing year class representation and the 1970-73 increase in mortality rate.

3.7 Recruitment prediction

During the last six years, in which pre-recruit surveys of plaice have been conducted by the Netherlands, Belgium and the Federal Republic of Germany, the changes in year class abundance have not been sufficiently marked to provide a good test of whether it will be possible to predict major changes in plaice recruitment using this type of survey.

4. North Sea Sole

4.1 Introduction

4.1.1 A new assessment of the situation in the sole fishery was made in order to calculate a total allowable catch for 1976. Since the previous TAC calculations, given in the 1973 Reports of the Flatfish Working Group and meant for 1974, two years have passed and the up to date information on weight at age and recruitment from virtual population analysis and pre-recruit surveys is now available.

4.1.2 The procedure used in the assessment is the same as for North Sea plaice and accepted by the Group as a standard routine in the coming years.

4.2 Catch trends

The annual catches of sole in the North Sea for the years 1960-74 are given in Table 11. The total catch rose from 19 000 tons in 1960 to 27 000 tons in 1962, and following a sharp decline to 11 000 tons in 1964 it increased again rapidly to 34 000 tons in 1967. Since then, the total catch has been decreasing to the 1973 level of 19 000 tons. Preliminary figures for 1974 indicate a somewhat lower figure of 18 000 tons. These trends may also be seen in the national sole fisheries in the North Sea.

4.3 Age composition data

4.3.1 For 1973 age compositions per sex were available for the Netherlands, Belgian and Danish total landings, accounting for 95% of the total landings.

Raising the total international catch was based on "Bulletin Statistique" catch figures (nominal weight in metric tons).

4.3.2 The 1974 age composition was calculated in the same manner but is preliminary, except for Belgium. Although data were provided for all 12 months by the Netherlands and Denmark, national catches were given for 10 months and those for November and December estimated on the basis of trends.

4.3.3 For the years prior to 1973 age compositions were taken from earlier assessments. Table 12 gives the age compositions per sex for the years 1957-74.

As has been accepted for the pre-1973 data no account was made for discarding.

4.4 The virtual population analysis

4.4.1 For male and female sole separately a new virtual population analysis was run. A constant natural mortality over the ages 2-14 was assumed, of M = 0.10 for both sexes.

4.4.2 Terminal F values of 0.15 for males and 0.25 for females were taken for cohorts fully sampled to the age of 14. For partially sampled cohorts, terminal F values were taken from average F at age arrays of an earlier VPA over 1969-72. These values are given in Table 13.

4.4.3 The resulting fishing mortality at age, and the stock in numbers from the VPA, are shown in Tables 14 and 15. The VPA shows that the level of F on the maximally exploited age groups 3-8 has not increased much since 1969, for although fishing effort has risen, the increase has been oriented mainly towards plaice fishing as is evident from the increased plaice fishing mortality.

4.4.4 The abundance of the recruiting year classes (2-year old fish) is shown in Table 16.

4.5 Prognosis of catch and stock in 1975 and 1976

4.5.1 In order to assess the effect of the present catch quota of 12 500 tons in 1975 in terms of reduction in F it is necessary to forecast catch and stock biomass for 1975, assuming the same F as in 1974, thus giving the situation if no catch limitation had been enforced.

4.5.2 For this forecast the relative fishing mortality at age per sex was taken to be the VPA average of 1969-73 which is given in Table 13. The distribution is normalised so that F_{max} x relative F at age gives the actual F.

4.5.3 For the weight at age per sex the average gutted weight at age array of 1969-73 determined from the Dutch market sampling system (described in Appendix I), covering more than 80% of the total international landings of North Sea sole, was taken and raised to nominal weight at age, using a conversion factor of 1.125. This array for the 1 June was used for the catch, whereas for the biomass the corresponding nominal weight at age for the 1 January was calculated. Both arrays are given in Table 17.

4.5.4 The next step was to determine a value for the recruitment in 1975. Fortunately two types of pre-recruit surveys had been started in 1969, namely a 0- and I-group study by Belgium, Federal Republic of Germany and the Netherlands in the nurseries covering the area from the Belgian-French to the Federal Republic of Germany-Danish borders, and in addition a II-group survey by the Netherlands in the coastal areas of the Netherlands, Federal Republic of Germany and the North Sea coast of Denmark.

4.5.5 Although estimates of only six year classes (1967-1972) could be compared, the regression of the II-group survey estimates (X) over the present VPA recruit estimates (Y) was good. The regression equation:

$$Y = 15.5 + 0.652\ X$$

has a correlation coefficient of r = 0.88.

4.5.6 The 0- and I-group survey estimates in their turn were related to the VPA recruit estimates giving

$$Y = 55.1 + 0.96\ X$$

with a correlation coefficient of r = 0.65.

4.5.7 The estimates of year class strength made by the 0- and I-Group surveys, the II-Group survey and the VPA recruitment estimates on which both regressions are based are as follows:

Year class	0- and I-Group survey Average relative abundance in 1968-72 %	II-Group survey Average relative abundance in 1967-72 %	VPA Recruit estimate in millions
1967		136.7	92.8
1968	138.6	60.2	44.7
1969	204.3	143.3	132.6
1970	98.3	44.0	39.0
1971	56.3	60.0	72.4
1972	150.0[1)]	139.0	91.4
1973	110.6		
1974	30.0		

1) Year class 1972 appeared to be of lower than average abundance per 0-group fish in most of the nurseries covered by the sampling, but showed a significant increase as I-group.

4.5.8 The significant correlations demonstrate that the estimates of the 1973 and 1974 year classes as estimated in 0- and I-group surveys could be used in the forecast. For 1975 this meant that for each sex a recruitment of 45 000 000 soles should be taken. In the case of the 1974 year class, abundance as 0-group can be assessed only from one cruise and in the absence of any other reliable figure this information had to be used. Since this year class will be only two years of age in 1976 its effect on the 1976 catch will be rather small. However, its influence as three- and four-year old fish will be greater.

4.5.9 From the observed 1974 catch and corresponding stock-age composition at the beginning of 1975 and the 1973 year class estimate of 90 000 000 soles, the 1975 fishing mortality required to give the TAC of 12 500 tons set by NEAFC was calculated. The estimated reduction in fishing mortality is 34%. This reduction was adopted in making the 1975 and 1976 prognoses.

4.5.10 For 1976 the recruitment was taken from the 0- and I-group surveys and was estimated as 15 000 000 soles of each sex. The 1976 catch and stock were forecast for several fishing mortalities and are given in the table on page 11:

	F_{max} ♀	F_{max} ♂	Catch (tons)	Biomass (tons)	Expected biomass Long-term increase (%)
1974	0.80	0.85	17 800	39 050	-
1975	0.53	0.57	12 940	37 760	-
1976	0.0		0	39 037	437
	0.1		3 075		268
	0.2		5 907		162
	0.3		8 505		93
	0.4		10 891		48
Level of 1975	→ 0.5		13 094		17
	0.6		15 124		-4
	0.7		16 991		-19
	0.8		18 706		-30
	0.9		20 300		-39
	1.0		21 762		-45

The implications of each entry in the table are given in terms of long-term gain in biomass, relative to the expected situation at the beginning of 1976. Details of the calculations are given in Appendix III.

4.5.11 It appears from the table that the expected level of fishing mortality in 1975 leaves little room for recovery of the stock. The stock is stabilized at its present low level, and therefore no increase in the present TAC can be recommended.

4.5.12 The sole fishery is very dependent on a few young year classes. Any succession of poor recruiting year classes will lead to a breakdown of the fishery. This situation can be avoided by rebuilding the stock and increasing the biomass. It is therefore recommended that the stock should be allowed to recover, i.e. the TAC for 1976 should be 8 000 tons which will, in the long term, double the biomass. A doubling in five years would be achieved by a TAC of 5 400 tons.

4.5.13 Rebuilding the stock in this way should ultimately make it possible to achieve a sustainable yield of 15 000 tons, corresponding to the present average recruitment level of 74 000 000 fish.

4.5.14 The present age distribution of the stock is far from stable. The average level of recruitment over the last nine years of 74 000 000 may be compared with the average of the period 1955-73 of 113 000 000, which is largely affected by the outstanding year classes of 1958 and 1963. Whether this low recruitment is introduced by a stock/recruitment relationship or by other natural agencies is not known. Experience with other stocks, e.g. herring, calls for care in such a situation.

4.5.15 Despite recent good year classes (1972 and 1973) which will influence catches for only two or three years, the 1977 catch prospects look rather poor at the moment due to the small 1974 year class coming into the fishery.

4.5.16 A comparison was made between the observed catches for 1972-74 and those predicted previously in the Report of the Flatfish Working Group 1973 (C.M.1973/F:18), as follows:

Comparison of predicted and observed catches (tons)

Year	Prediction Jan.1973 ($F_{72, 73, 74} = F_{71}$)	Observed Catches	Ratio observed catch / predicted catch
1971		23 654	
1972	20 342	21 093	1.04
1973	18 214	19 312	1 06
1974	14 902	17 801	1.20

4.5.17 Apart from the different management objectives involved, the difference between the TAC of 6 000 tons recommended earlier (C.M.1973/F:18) and that calculated here (8 000 tons) is accounted for by the recruitment of the good 1972 year class and that expected for the good 1973 year class and by the anticipated reduction in F due to the 1975 TAC.

4.5.18 The present situation with regard to the North Sea sole is that the incoming recruit year class has a significant effect on catch and stock biomass, and thus on the reliability of predicted values of catch and stock. Although a rather good correlation seems to exist between the estimates of year class strength as assessed in pre-recruit surveys and the VPA estimates, this is based on only 6 years of observations. Moreover, the present pre-recruit surveys carried out by Belgium, Federal Republic of Germany and the Netherlands cover only 50% of the nursery areas. The Working Group recommends that the coverage be improved by incorporating all nurseries in the North Sea, as has been outlined in the 1973 Report of the Working Group.

5. Irish Sea and Bristol Channel Plaice

5.1 Introduction

The assessment of Irish Sea and Bristol Channel plaice has been carried out using all the available information on stock parameters from Belgium, U.K. (England and Wales) and Ireland. This is at present barely adequate to reach firm conclusions about the stocks, but the quality of the data has improved greatly in recent years and it will be possible to carry out an improved assessment in future when English data have been fully brought up to date. The improvement expected in Irish and French biological sampling will be particularly welcome.

5.2 Catch trends

5.2.1 Nominal catches of plaice in the Irish Sea and Bristol Channel are given separately in Table 18 for the period 1962-74. Catch figures for 1960 and 1961 are also provided in the Table, but it is not possible to show the split between VIIa and VIIf for these two years.

5.2.2 All catches for 1974 (based on preliminary reports) are lower than in 1973. In Division VIIa the catches in the early 1960's were about 2 000 tons annually, rising to about 5 000 tons in 1967 and 1968. They then fell steadily to 3 500 tons in 1970 and increased again to 5 000 tons in 1972 and 1973. In Division VIIf, catches rose steadily from 200-300 tons in the early 1960's to about 1 500 tons in 1968. Since then they have been falling steadily to their present level of about 500 tons.

5.2.3 English catches in VIIa and VIIf, being the largest single component, largely determine the general trend in both areas. Catch figures reported by France are of uncertain reliability; they show erratic fluctuations throughout the period and have been recorded as zero in some years.

5.3 Growth parameters

5.3.1 Values of mean length at age for males and females from the Irish Sea and Bristol Channel are given separately in Table 19, along with the parameters of the von Bertalanffy growth equation calculated from them. For Division VIIa it is evident that the growth as measured from Irish commercial and research vessel samples is greater than that found in the English and Welsh samples, with the Belgian values intermediate. These differences are probably due to different areas being fished and are also reflected in the values of of t_c, the mean age of entry to the catch, which is estimated at 4 years for the English and at not more than 2.5 years for the Irish fishery. While it may be necessary in the future to consider separate assessments within Division VIIa to account for these differences, they were not taken into account in the present assessment.

5.3.2 The conversion of length to weight was carried out using a relationship calculated from Belgian length/weight data for the Irish Sea (Table 20) as follows:

Males: $\log_e$ weight (gm) = $\log_e$ length (cm) x 2.80 - 3.95

Females: $\log_e$ weight (gm) = $\log_e$ length (cm) x 2.84 - 3.93

The quality of English data for the Bristol Channel does not allow a similar comparison of growth rates to be made for this area.

5.4 Yield

Yield curves from males and females for two different levels of natural mortality for the two areas are given in Figure 2. The mean values used in making yield assessments are given in Table 21.

5.5 Assessment

5.5.1 Irish Sea - Values of total instantaneous mortality on male and female plaice calculated from English and Belgian catch and effort statistics are given in Table 22. These were calculated from age group 5 onwards (weighted inversely by the variance) for English and Welsh figures, and from age group 4 for the Belgian figures. The average total mortality over the period 1964-74 has been 0.67 on females and 0.80 on males, with no marked trend. For a natural mortality of 0.1 this means that fishing mortality is too high by a factor of about 2.7 for females while for males the yield curve is almost flat-topped, i.e. a decrease in effort could not be expected to improve the yield. A reduction in fishing mortality by this factor would be expected to result, in the long term, in an increase in total yield (males plus females) of 10%, and with an increase in catch per effort of about threefold.

5.5.2 Bristol Channel - Values of total instantaneous mortality for males and females, calculated from Belgian catch and effort data are given in Table 22. These were calculated from age group 5 onwards (weighted inversely by the variance) for English and Welsh figures, and from age group 3 onwards for the Belgian figures. The average total mortality over the period 1971-74 has been 0.53 on females and 0.90 on males. For a natural mortality of 0.1 this means that fishing mortality is too high by a factor of 2.4 on females. The male yield curve is flat-topped. A reduction in fishing mortality by a factor of 2.4 on both sexes would lead in the long term to an 8% increase in yield, with an increase in catch per effort of two and a half times.

5.6 Conclusions

Some reduction in the present level of catch is required to improve the long-term prospects of the plaice fisheries in the Irish Sea and Bristol Channel. At least in the Irish Sea it appears that the level of fishing mortality has been too high for a number of years.

5.7 Total allowable catches

5.7.1 The previous catch limitation proposals for these areas were intended as a holding operation to prevent further expansion of the plaice fisheries. The 1975 TAC was based on the average of the total catches in 1968-72, amended by NEAFC. The implication of the present assessment is that fishing mortality is too high and the 1974 total catch is unlikely to reach the level of TAC set for 1975. Consequently, the TAC levels for 1976 should not be allowed to exceed 4 000 tons for the Irish Sea and 500 tons for the Bristol Channel. The downward trend in catches in the Bristol Channel is particularly marked, but in this case the absence of information on the French catch makes further analysis difficult.

5.7.2 Apart from improved reporting of statistics and the availability of the up to date information from all countries it is essential to have some means of forecasting recruitment when trying to predict trends in stock and thus setting TACs. This could be provided by some form of pre-recruit survey.

6. Irish Sea and Bristol Channel Sole

6.1 Introduction

Previous assessments of the Irish Sea and Bristol Channel have been carried out by Holden (1971, 1972), and De Clerck (1973). The present assessment is based largely on Belgian data collected between 1970 and 1974. English and Welsh data have not been included because they were not available separately for the two sexes and a separate assessment of each was felt to be preferable. The results of the Belgian separate assessments have, however, been compared with the English and Welsh combined assessment and were found to be very similar. Dutch data were considered to be too seasonal to provide reliable estimates, but could be included in future if a quarterly breakdown of all the information available is made.

6.2 Catch trends

The total international catches of sole in Divisions VIIa and VIIf for the period 1960-74 are given in Table 23. Levels of catch have not fluctuated greatly since 1964 although prior to that time the average catches were rather lower. Catches in both areas were at their highest levels in 1970-71 due partly to increased fishing effort and partly to good recruitment.

6.3 Growth parameters

Values of mean length and weight at age for males and females from both areas are given separately in Table 24. The growth parameters calculated from them and used in the yield equations are given in Table 25. The values of L_∞ and W_∞ are higher than those used by Holden (1972), but compare closely with the growth estimates for both sexes combined from recent English and Welsh samples.

6.4 Yield curves and assessment

The yield curve for male and female sole for Divisions VII and VIIf are given in Figures 3 and 4 and present levels of mortality in Table 26.

6.4.1 Irish Sea: present levels of fishing mortality on both sexes are close to the level needed for MSY.

6.4.2 Bristol Channel: the present level of fishing mortality on females is slightly below that required to take the MSY but the level for males is slightly too high. The catch weight consists to a greater extent of females and this stock can therefore also be considered as optimally exploited.

6.5 Total allowable catch

6.5.1 The level of catch expected if the present optimal level of fishing is maintained will fluctuate due to changes in recruitment which might be predicted by pre-recruit surveys or from the catches of partially recruited year classes. However, the effects of these fluctuations will be small in the present situation as a large number of year classes are being fished.

6.5.2 The recommended TAC levels for 1976 are therefore 1 600 tons in the Irish Sea (VIIa) and 720 tons in the Bristol Channel (VIIf). These are the averages for the years 1969-73.

7. English Channel Plaice

7.1 The Working Group had before it an assessment on the English Channel plaice (Houghton, in preparation) and Belgian age composition data for 1971-73. Table 27 shows that the total international catch for Divisions VIId,e has been fairly steady over the period 1964-73. However, the provisional English catch for 1974 shows a marked decline. Table 28 shows the decline in English catch per effort over the period 1969-73. The average total mortality for the same period, calculated from English statistics, is 0.98 for males and 0.75 for females (Houghton). The Belgian catch per effort, also given in Table 28, shows an increase over the period 1972-74 and the total mortality calculated from Belgian data, for the period 1971-73, is 0.91 for males and 0.64 for females.

7.2 The English statistics are derived from sampling throughout the year at Brixham for the population in the western end of the English Channel. Belgian effort is mainly in the eastern English Channel during the spawning season.

7.3 From Houghton's yield curves for the western English Channel, or indeed any of the yield curves calculated for adjacent areas such as the Bristol Channel, these levels of fishing mortality are too high. Houghton presents evidence from age composition data that recruitment, at least in the western English Channel, was low in 1972 and 1973. A reduction in the TAC set by NEAFC (3 260 tons) is therefore recommended, but in the absence of any biological and statistical information on the 1974 French catch, the Working Group was unable ti give a figure for TAC. Furthermore, no biological data for the French fishery in previous years was made available to the Working Group.

7.4 There is evidence (Houghton & Harding, in press and Houghton, in preparation) for the presence of different local populations in the English Channel as

well as a component of spawning fish which migrate to the southern North Sea, derived from English tagging experiments. The difficulty in assessing the contributions of the different local populations to the total international catch derives largely from the lack of information about the distribution of French catches. Houghton suggests that sub-area TAC's should be considered for the English Channel because of the existence of separate local populations, and the Working Group felt that this problem should be investigated in more detail.

7.5. The Working Group recommends that catch statistics for the English Channel should in future be reported and published for Divisions VIId and VIIe separately.

8. English Channel - Sole

8.1. Estimates of the growth parameters from Belgian catches taken mainly in the eastern Channel were very different from those obtained from English (Brixham) samples in the western Channel and insufficient details of the sampling were available to explain and resolve these differences. Therefore no complete assessment of sole in the area has been carried out.

8.2. The average total mortality for males and females combined obtained from Belgian catch and effort data for the period 1971-74 was 0.49, compared with an estimate of 0.56 for the period 1969-73 for English catch and effort. Assuming a natural mortality of 0.1 and applying either of these values to the Bristol Channel yield curves (this area being closest in character to the English Channel) indicates that fishing mortality is slightly too high for MSY, but that little improvement in yield would be expected from a reduction in effort. In the absence of information on recruitment the Working Group could only recommend that, in order to protect the stock from diverted effort, the TAC for 1976 should be 1 300 tons, the average catch for the period 1969-73.

9. Spawning and Nursery Areas

9.1. Plaice

9.1.1 The positions of the major plaice spawning grounds in the North Sea, Irish Sea, Bristol Channel and English Channel based on Simpson (1959), Oray (1963), Griffith (unpubl., 1969), Armstrong (unpubl., 1972-74) and Bannister, Harding and Lockwood (1974) are shown in Figure 5. The most important spawning areas are those in the eastern English Channel, the Southern Bight and the Borkum area.

9.1.2 After a planktonic stage of 80-90 days, metamorphosis occurs and the young plaice settle in shallow nursery areas in coastal waters. The extent of the major nursery areas is shown in Figure 6.

9.1.3 For the first 1-2 years of their life the plaice tend to remain in the nursery areas, after which they start recruiting to the more offshore adult stocks.

9.2 Sole

9.2.1 The distribution of known sole spawning areas based on Boeke (1906), Ehrenbaum (1906-08), Tesch (1909), de Veen (unpubl., 1962), Riley (1974) and Brander (unpubl., 1975) is shown in Figure 7. Spawning areas of the sole are not as well known as those of the plaice, but the most important is the region along the coast between Belgium and Denmark. There are also small spawning areas in the English Channel which are not shown in Figure 7 because of a lack of precise information.

9.2.2 Spawning takes place between April and June and the subsequent development of the sole resembles that of the plaice. In the North Sea, however, the sole nursery areas coincide with the spawning areas. In the other regions, nursery areas for sole are not very well known but are probably similar to those indicated for the plaice nursery areas.

10. Closed Areas

10.1 In the previous Report of the Flatfish Working Group (C.M.1974/F:6), an assessment was made of the possible increase in recruitment to the adult stocks of plaice and sole which might result from closure of areas within 15 and 30 miles of the coast. Because no new data are available it has not been possible to improve on this assessment. However, papers giving data on discarding and survival rates of discarded fish in both the Dutch beam trawl fishery and the Federal Republic of Germany shrimp fishery are in preparation.

10.2 On the basis of the previous assessment it would be necessary to close a coastal zone much wider than 15 nautical miles to protect all the pre-recruit flatfish. As noted in the previous Report, such a closure would have adverse effects on various inshore fishing fleets.

11. Plaice Tagging Experiment 1976

11.1 The Working Group discussed the possibility of carrying out an international plaice tagging programme in 1976. It was decided that any such programme should be designed with the intention of improving biological knowledge of the stocks as the primary objective.

11.2 Such a programme could be divided into three major sections:

1) Tagging mature plaice at spawning time;
2) Tagging adult plaice on the feeding grounds;
3) Tagging juvenile plaice in the nursery areas.

11.3 Spawning and feeding ground tagging

11.3.1 A considerable amount of information which has not yet been worked up has been collected from plaice tagged at the spawning time by scientists of the Netherlands and the Federal Republic of Germany. In addition, spawning plaice have been tagged in 1974 by English scientists and by Scottish, Belgian and Dutch scientists in 1975. Feeding ground experiments were also conducted by the Netherlands from 1964-67 and by England in 1974. The Working Group realised that the design of experiments on fish on the feeding grounds could be greatly influenced by the results of experiments carried out on spawning plaice.

11.3.2 For these reasons it was decided to postpone the feeding and spawning ground tagging programmes until existing data have been worked up. The Group stressed the urgency of analysing and presenting the original data and recommends that the national laboratories involved should give priority to this work.

11.4 Nursery ground tagging

11.4.1 Preliminary results from nursery ground tagging by the Netherlands and the Federal Republic of Germany indicate that juvenile (I-group) plaice tagged in the nursery areas along the Dutch coast tend to move in a

westerly direction, whereas juveniles tagged between the mouths of the Ems and the Elbe tend to move to the north.

11.4.2 In order to define more closely the areas of the North Sea to which juvenile plaice from various nursery areas recruit, it was recommended that further studies should be carried out. These should involve tagging juveniles on all the nursery areas of the North Sea. Details of the proposed programme will be discussed by correspondence between the participating nations, and at a future meeting of the Working Group.

11.4.3 The countries which have agreed to participate in this programme are: Belgium, Federal Republic of Germany, Netherlands, U.K. (England) and U.K. (Scotland). It is hoped that tagging of juvenile plaice along the Danish coast can be carried out by Dutch and/or Federal Republic of Germany scientists.

12. Statistics Coverage and Reliability

12.1 Catch data

12.1.1 The Working Group considered a general review of the coverage and reliability of catch statistics.

12.1.2 The main difficulty for national statistical systems, at least in the fishing areas north of 48°N latitude, appears to be the allocation of catch to fishing area, usually at the level of statistical division (IVa, IVb, VIIa etc.). As a result the catches of some countries are given for groups of two or more fishing areas, thus:

France	Vb_1 includes Vb_2
Denmark	IVb includes IVa
Norway	IVa includes IVb
Sweden	IIId includes IIIb,c IVa includes IIIa and IVb VIa includes VIb

These are regular features of the "Bulletin Statistique", and more detailed breakdowns are frequently made by participants in ICES Working Groups on the basis of information available in their respective laboratories.

12.1.3 Other inaccuracies sometimes arise from poor reporting by the national office concerned, rather than from inherent deficiencies in the collecting system. One example has been the catch reported by Ireland for Divisions VIIa, VIIg-k, VIIb,c and VIa, which fishing areas were regarded for some years up to 1971 as being identical with the coastal breakdown (east, south, west and north-west respectively) used for the domestic handling of Irish fisheries statistics. Since 1972, however, Irish catches have been reported by the correct ICES statistical divisions, and corrected plaice catches for VIIa have been provided for the years from 1960 onwards. Another inaccuracy in the statistics of some countries, and which can be ascribed to poor reporting, is the submission of landed weights rather than nominal catches. The French data for North Sea plaice for 1963-66 were an example of this.

12.1.4 Irish catches are allocated to fishing area on the basis of port of landing, but in view of the predominantly inshore nature of Irish fisheries any inaccuracies resulting from this practice will generally not be large, at least for the flatfish fisheries.

12.1.5 The area allocation of French catches could probably be improved greatly. Over the next two years, however, a log book system is to be introduced for the larger vessels and a more effective sampling system implemented in the smaller coastal fisheries (Doc. C.M.1974/D:2).

12.1.6 Apart from inaccurate allocation to area, some countries have difficulties in identifying the species present in the catches. France, for example, groups brill and turbot together when reporting catches to "Bulletin Statistique".

12.1.7 Other difficulties in the matter of species identification are more serious. In 1972, a total of over 283 000 tons was reported in the category "unsorted, unidentified fishes". Six countries accounted for 88% of this quantity, as follows:

Spain	67 000
Portugal	65 000
Denmark	47 000
France	30 000
Sweden	25 000
Poland	16 000

12.1.8 More precise details on the species composition of catches, and also on the area breakdown as mentioned earlier, are frequently provided by participants in ICES Working Groups. Considerable discrepancies regularly appear, however, between some catch figures supplied by statistics-reporting agencies and those provided by fisheries laboratories for the same species, area, or period. In some countries the degree of communication and cooperation between statistics office and fisheries laboratory is very high, but in other countries it appears to be very poor.

12.1.9 Where the source of any discrepancy can be identified with reasonable certainty, it usually falls into one of the three groups - incorrect area allocation, incorrect species identification (both discussed above), or the grouping of the catch by biological units rather than by statistical areas. Most of the discrepancies between the catch figures reported to "Bulletin Statistique", and those used by ICES Working Groups, are ascribed to the last cause. Two other aspects should also be mentioned, however. It sometimes happens that for some countries the catch statistics compiled by biological laboratories simply do not agree with those submitted for publication in "Bulletin Statistique" by the national reporting agency, and that these differences cannot be reconciled by any of the three reasons mentioned above. It should also be borne in mind that apparent changes in catch from one year to the next may not always represent real changes in the quantity of distribution of the catches themselves, but may be partly or entirely the result of changes - usually improvements - in the national reporting system.

12.1.10 The Working Group noted that the ADP Working Group had drawn the attention of member countries to these problems (C.M.1974/D:2), and endorsed the need for close cooperation between national statistics-reporting agencies and national fisheries laboratories

12.2 Catch and fishing effort

12.2.1 The coverage of data on catch and fishing effort was also discussed with regard to the principal plaice and sole fisheries. Material for 1972 was taken as an example.

12.2.2 In 1972 the STATLANT 27 B forms submitted by most of the member countries ("Statistical News Letter" No.62) gave information on monthly fishing effort, by gears, for a total catch of 3.5 million tons of fish, including Nephrops, Pandalid shrimps and Crangonid shrimps. This quantity represented only 35% of the total catch in the ICES area.

12.2.3 The plaice and sole catches for 1972 for which effort data are available by statistical rectangles in "Statistical News Letter", No.61 are summarised in Table 29 for the areas under TAC regulation, together with the percentage relationship to the total catches given in "Bulletin Statistique".

12.2.4 Table 30 shows a similar summary for the catches given in the stock record section of "Statistical News Letter", No.61.

12.2.5 Table 31 expresses the percentage coverage for the fisheries in question, taking what appears to be the most comprehensive data (i.e. the largest catch) from both parts of "Statistical News Letter", No.62. The coverage of the plaice and sole fisheries in VIId,e is low (12% and 22% respectively), and the amount of information on the fishing effort on plaice in VIIa (54%) and VIIf (50%) could possibly be improved.

12.2.6 It would be more valuable, however, if a greater number of countries reported catch and fishing effort information by rectangles (and also stock record data) than are doing so at present, at least for the demersal species. The absence of such plaice and sole data from France and Ireland is particularly serious.

13. ICES FISHDAT System

13.1 The Working Group had been invited by the ADP Working Group (C.M.1975/D:2, Section 4.2):

(i) to consider the outcome of the trial run of the ICES FISHDAT System based on North Sea herring data,

(ii) to discuss the benefit of the present system in assessment of demersal stocks such as the North Sea plaice, and

(iii) to provide a specification for a similar trial run based on relevant demersal data.

13.2 The North Sea Flatfish Working Group agreed that the results of the herring trial run were very encouraging with regard to the use of the system for stock assessment purposes, and discussed the possible objectives of a trial run based on North Sea plaice data. The objective proposed was the derivation of the catch in numbers per age group of males and females, for the Netherlands sampling areas (Figure 8), for each quarter of the years 1972 and 1973.

13.3 The Working Group agreed to draw up specifications by correspondence, for presentation at the 1975 Statutory Meeting of ICES. The subsequent trial run could then be evaluated by the ADP Working Group. The North Sea Flatfish Working Group recommended that in addition to the Chairman, further members should participate in such a meeting of the ADP Working Group.

14. References

Bannister, R. C. A., 1973a. The assessment of the state of the North Sea plaice stock, using English data. ICES, Doc. C.M.1973/F:30 (mimeo).

Bannister, R. C. A., 1973 b. The results of a virtual population analysis of North Sea plaice data. ICES, Doc. C.M.1973/F:31 (mimeo).

Bannister, R. C. A., D. Harding and S. J. Lockwood, 1974. Larval mortality and subsequent year-class strength in the plaice (Pleuronectes platessa L.). In: The Early Life History of Fish, (Ed.) J.H.S.Blaxter, Springer Verlag.

Beverton, R. J. H., 1964. Differential catchability of male and female plaice in the North Sea and its effect on estimates of stock abundance. Rapp.p.-v.Réun.Cons.int.Explor.Mer, 155:103-112.

Beverton, R. J. H. and S. J. Holt, 1957. On the dynamics of exploited fish populations. Fish.Invest., Ser.II, XIX.

Boeke, J., 1906. Eier und Jugendformen von Fischen der südlichen Nordsee mit besonderer Berücksichtigung des holländischen Untersuchungsgebiet. Verhandl. Rijksinst. voor het Onderzoek der Zee, 1:3-35.

Ehrenbaum, E., 1907. Eier und Jugendformen der Seezunge und anderer im Frühjahr laichender Fische in der Nordsee. Wiss.Meeresunters., N.F., Bnd.VIII abt.Helgoland.

Ehrenbaum, E., 1909. Eier und Larven der im Winter laichenden Fische der Nordsee. - II. Die Laichverhältnisse von Scholle und Flunder. Wiss.Meeresunters. N.F., Bnd. IX abt. Helgoland.

Oray, I. K., 1967. Untersuchungen über das Laichen der Scholle in der südostlichen Nordsee. Ber.Deutsch.Wiss.Komm.Meeresforsch., N.F., Bnd XIX, 194-258.

Riley, J. D., 1974. The distribution and mortality of sole eggs (Solea solea (L.)) in inshore areas. In: The Early Life History of Fish, (Ed.) J.H.S.Blaxter, pp.39-52, Springer Verlag.

Simpson, A. C., 1959. The spawning of the plaice in the North Sea. Fish. Invest., Ser.II, XXII(7):1-57.

Simpson, A. C., 1959. The spawning of the plaice in the Irish Sea. Ibid., Ser.II, XXII(8):1-24.

Tesch, J. J., 1909. Eier und Larven einiger im Frühjahr laichender Fische besonders der südlichen Nordsee. Verhandl. Rijksinst. voor het Onderzoek der Zee, 2:3-44.

Tesch, J. J., 1913. Weitere Untersuchungen über das Laichen einiger Nutzfische besonders der südlichen Nordsee. Rapp. en Verhandl. Rijksinst. voor Visserijonderzoek, (1):58-99.

Wallace, W., 1907. Report on the age and growth rate of plaice in the southern North Sea, as determined by the investigation of otoliths. Mar.biol. Assoc. U.K., Int.Fish.Invest., 2nd Rep. (Southern Area), Part I:1-47.

Table 1. Nominal catch (metric tons) of plaice in the North Sea (statistical sub-area IV), 1960-1974

Year	Belgium	Denmark	France	Germany, Fed. Rep. of	Nether-lands	Norway	Sweden[a]	U.K. (England & Wales)	U.K. (Scotland)	Others	Total
1960	4 919	33 238	699	4 117	15 213	73	475	23 392	5 366	1	87 493
1961	3 950	32 086	1 341	3 830	15 951	60	497	22 732	5 326	161	85 934
1962	4 535	31 227	464	3 768	19 094	86	472	22 975	5 322	-	87 943
1963	5 662	39 926	501	4 526	23 143	36	438	28 143	5 181	-	107 556
1964	4 339	38 380	1 584	4 390	24 594	30	372	30 773	5 525	-	109 987
1965	3 931	30 560	1 933	4 333	23 271	38	286	26 826	5 534	-	96 712
1966	6 490	29 055	1 986	4 401	25 682	33	148	26 978	5 356	-	100 129
1967	6 778	28 287	1 730	5 290	29 905	35	237	30 974	5 709	-	108 945
1968	5 576	30 369	1 310	5 250	33 236	38	310	29 569	5 810	-	111 468
1969	4 476	35 227	1 330	5 071	39 420	26	309	30 349	4 981	-	121 189
1970	4 360	32 807	1 406	5 519	46 080	22	243	34 839	4 703	-	129 979
1971	5 073	22 278	1 380	3 296	44 502	18	235	32 576	4 210	-	113 568
1972	5 531	24 494	1 062	4 318	52 048	19	250	31 642	3 410	-	122 774
1973	6 133	23 266	1 355	4 976	57 948	15	173	30 400	4 815	399	129 480
1974[b]	3 862	19 030	(1 000)	2 825	53 369	(15)	168	24 019	4 531	-	108 819

a) Sweden - From 1962 onwards, the figures reported to Bulletin Statistique include catches made in IIIa. A note presented to the 12th (1974) meeting of NEAFC by the Swedish Delegation (Agenda item 7/paper 1) stated that "at present about 40% of the Swedish catch of plaice are caught in the North Sea". This correction has been applied to the Swedish figures for IIIa and IVa in Bulletin Statistique for the years 1962 onwards, prior to their inclusion in this table.

b) Preliminary figures as reported. No reports were received from France or Norway and estimates for these catches were made as shown by the bracketed figures.

Table 2a. North Sea Plaice. Age composition of total catch 1958-1974 (in thousands).

MALE

Age \ Year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	0	0	0	0	0	0	0	0	0	0	0	280	1 401	428	1 084	437	552
2	3 837	10 954	3 241	1 675	2 266	5 390	5 551	7 427	3 994	4 141	7 247	8 941	13 245	18 886	14 557	13 037	8 656
3	10 521	18 612	38 948	18 091	26 154	17 209	24 448	26 468	44 528	17 704	29 209	25 842	27 962	27 438	22 094	35 623	30 867
4	30 184	17 198	25 707	39 245	49 281	72 995	43 948	34 481	35 085	116 442	26 674	18 546	31 668	16 385	23 947	46 290	35 577
5	16 225	20 879	10 361	16 586	32 518	47 327	41 645	30 706	21 180	29 884	71 530	19 726	23 087	11 357	10 059	21 150	22 075
6	7 716	10 287	11 185	7 646	12 598	17 947	22 433	17 681	13 880	16 688	8 597	50 365	18 237	10 351	7 461	5 635	9 659
7	2 705	5 286	4 976	6 104	5 252	7 027	5 968	7 522	6 938	12 446	3 530	3 967	37 089	6 189	5 968	2 789	3 472
8	2 245	2 175	2 186	3 208	3 138	2 766	2 189	3 337	3 728	3 440	4 620	1 913	2 346	10 683	3 204	3 331	2 080
9	1 649	1 816	906	1 788	790	1 604	1 227	1 119	2 256	2 912	1 007	4 041	1 155	1 408	5 720	1 764	2 123
10	742	1 495	661	1 057	587	879	697	1 127	831	551	1 621	1 084	1 396	1 180	1 213	4 290	1 182
11	682	714	406	496	419	453	448	1 186	363	159	560	939	528	781	856	155	2 512
12	105	540	129	447	900	45	302	243	552	81	335	686	663	374	736	379	318
13	68	94	215	219	114	201	194	186	327	231	199	209	307	487	300	276	271
14	0	25	10	19	119	75	120	615	96	180	149	217	120	183	345	261	203
15	37	86	20	2	14	33	175	28	122	168	29	89	13	198	23	424	41

Table 2b. North Sea Plaice. Age composition of total catch 1958-1974 (in thousands).

FEMALES

Year / Age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	0	0	0	0	0	0	0	0	0	0	0	8	770	481	765	723	555
2	4 181	15 772	4 720	1 581	1 232	5 731	16 302	9 839	5 700	3 121	7 033	9 241	9 311	19 676	12 888	12 608	9 962
3	13 204	19 626	41 141	28 411	32 428	18 337	23 265	24 619	51 936	21 883	22 698	25 934	27 086	25 283	25 198	33 928	29 707
4	27 944	11 286	19 921	34 133	31 766	48 921	26 576	23 253	24 445	63 691	20 257	18 834	28 301	15 825	21 076	41 452	23 988
5	13 735	17 637	7 132	12 008	29 275	29 930	21 419	17 064	13 172	18 404	51 274	13 499	16 990	11 499	12 836	19 949	19 263
6	8 616	8 477	11 428	4 869	11 936	17 473	13 736	14 871	9 705	11 301	7 473	39 605	13 838	10 296	10 898	7 816	8 822
7	3 495	6 470	6 398	6 754	6 142	6 799	7 014	9 693	8 531	8 896	5 122	5 050	34 679	7 023	11 437	6 171	3 538
8	4 046	2 738	4 299	4 992	6 816	4 299	2 803	5 207	6 371	4 279	5 833	3 091	4 509	13 864	11 773	6 375	3 372
9	3 266	3 319	2 344	3 528	3 857	4 059	1 993	2 864	3 677	5 692	2 494	4 672	2 747	3 210	18 503	5 694	2 902
10	2 607	2 976	3 054	2 157	3 055	3 173	2 474	2 095	2 056	2 289	3 178	1 868	3 772	2 471	4 892	12 955	1 870
11	3 049	2 198	2 094	2 231	1 659	2 860	2 095	2 057	1 608	1 808	1 309	3 174	1 522	2 303	4 635	2 665	6 641
12	1 434	2 312	1 673	1 765	1 382	1 984	1 263	1 802	1 904	903	1 336	933	2 102	1 536	5 654	2 099	1 132
13	904	1 270	1 095	1 438	1 463	1 505	1 084	1 483	1 168	1 342	630	990	752	1 424	2 687	1 945	1 130
14	513	657	621	1 128	1 161	1 146	866	889	1 073	769	840	362	721	627	2 733	2 836	915
15	329	384	508	607	545	673	527	872	589	671	489	687	320	742	1 188	1 150	843
16	220	306	195	255	324	456	505	633	663	322	576	348	373	346	1 475	705	479
17	180	218	143	157	85	274	546	437	374	504	478	481	291	826	2 459	901	630
18	59	87	94	109	45	209	410	564	305	163	140	179	173	307	618	413	246
19	42	76	46	58	41	96	297	382	316	139	134	202	95	176	368	289	97
20	37	13	79	1	6	55	141	236	193	165	113	173	99	88	202	328	52

Table 3. North Sea Plaice. Table of terminal F values for partially sampled cohorts

Age	♂	♀
1	0.01	0.01
2	0.10	0.11
3	0.29	0.22
4	0.34	0.39
5	0.43	0.40
6	0.47	0.36
7	0.44	0.36
8	0.40	0.36
9	0.29	0.35
10	0.24	0.35
11	0.20	0.35
12	0.20	0.35
13	0.20	0.35
14	0.20	0.29
15	0.20	0.27
16		0.27
17		0.25
18		0.21
19		0.12
20		0.10

Table 4a. North Sea Plaice. Fishing mortalities.

MALE

Year / Age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974 = F_I
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
2	0.02	0.04	0.01	0.01	0.01	0.03	0.03	0.01	0.02	0.02	0.05	0.07	0.08	0.08	0.06	0.08	0.10
3	0.13	0.16	0.22	0.08	0.12	0.09	0.17	0.19	0.09	0.13	0.23	0.26	0.37	0.24	0.14	0.21	0.29
4	0.36	0.33	0.34	0.36	0.31	0.55	0.35	0.40	0.41	0.34	0.29	0.22	0.59	0.39	0.34	0.49	0.34
5	0.42	0.43	0.32	0.36	0.54	0.52	0.66	0.41	0.43	0.70	0.34	0.34	0.45	0.41	0.41	0.53	0.43
6	0.34	0.48	0.41	0.38	0.47	0.62	0.48	0.61	0.31	0.66	0.41	0.40	0.56	0.35	0.49	0.40	0.47
7	0.22	0.39	0.43	0.39	0.47	0.50	0.40	0.27	0.49	0.49	0.26	0.32	0.54	0.35	0.33	0.32	0.44
8	0.29	0.27	0.26	0.51	0.33	0.45	0.27	0.39	0.20	0.45	0.31	0.21	0.30	0.27	0.29	0.29	0.40
9	0.25	0.39	0.16	0.33	0.21	0.27	0.35	0.20	0.47	0.22	0.21	0.47	0.18	0.28	0.22	0.24	0.29
10	0.32	0.36	0.22	0.27	0.16	0.36	0.17	0.59	0.21	0.19	0.18	0.36	0.28	0.27	0.39	0.24	0.24
11	0.49	0.55	0.15	0.25	0.15	0.17	0.30	0.45	0.36	0.05	0.28	0.14	0.28	0.23	0.30	0.07	0.20
12	0.56	0.86	0.17	0.23	0.88	0.02	0.16	0.25	0.37	0.12	0.15	0.62	0.13	0.30	0.34	0.20	0.20
13	0.32	1.50	0.99	0.45	0.08	0.46	0.11	0.13	0.57	0.24	0.45	0.12	0.59	0.13	0.40	0.19	0.20
14	0.00	0.18	0.57	0.19	0.45	0.06	0.51	0.58	0.09	0.67	0.23	1.27	0.09	0.80	0.12	0.69	0.20
15 = F_I	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Table 4b. North Sea Plaice. Fishing mortalities.

FEMALES

Year / Age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974 = F_I
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
2	0.03	0.07	0.02	0.01	0.01	0.04	0.10	0.02	0.04	0.02	0.05	0.09	0.07	0.11	0.09	0.07	0.11
3	0.15	0.17	0.24	0.16	0.18	0.13	0.20	0.21	0.13	0.18	0.20	0.26	0.37	0.26	0.20	0.35	0.22
4	0.27	0.17	0.23	0.28	0.24	0.40	0.24	0.28	0.30	0.21	0.23	0.23	0.44	0.34	0.31	0.50	0.39
5	0.18	0.24	0.14	0.19	0.36	0.32	0.27	0.21	0.22	0.34	0.23	0.21	0.30	0.29	0.44	0.48	0.40
6	0.16	0.15	0.22	0.12	0.26	0.34	0.22	0.28	0.16	0.27	0.20	0.25	0.30	0.27	0.43	0.47	0.36
7	0.13	0.16	0.14	0.17	0.20	0.21	0.20	0.21	0.23	0.20	0.17	0.18	0.33	0.22	0.47	0.41	0.36
8	0.15	0.12	0.14	0.14	0.24	0.19	0.11	0.20	0.18	0.15	0.17	0.13	0.21	0.19	0.61	0.46	0.36
9	0.14	0.16	0.13	0.14	0.14	0.19	0.11	0.14	0.19	0.22	0.11	0.18	0.15	0.21	0.37	0.59	0.35
10	0.16	0.17	0.19	0.16	0.16	0.15	0.16	0.15	0.13	0.16	0.17	0.10	0.20	0.18	0.50	0.42	0.35
11	0.20	0.17	0.15	0.18	0.16	0.19	0.12	0.17	0.14	0.15	0.11	0.22	0.10	0.16	0.51	0.49	0.35
12	0.13	0.20	0.17	0.16	0.15	0.25	0.11	0.13	0.21	0.10	0.14	0.10	0.20	0.13	0.62	0.40	0.35
13	0.11	0.15	0.12	0.20	0.18	0.21	0.19	0.16	0.11	0.20	0.08	0.13	0.10	0.18	0.31	0.39	0.35
14	0.13	0.10	0.09	0.16	0.22	0.18	0.16	0.21	0.15	0.08	0.16	0.06	0.12	0.10	0.55	0.54	0.29
15	0.18	0.12	0.09	0.11	0.10	0.17	0.11	0.22	0.19	0.12	0.06	0.18	0.06	0.15	0.25	0.41	0.27
16	0.35	0.23	0.07	0.06	0.07	0.10	0.16	0.17	0.23	0.13	0.13	0.05	0.12	0.08	0.45	0.20	0.27
17	0.79	0.61	0.14	0.07	0.02	0.07	0.15	0.19	0.13	0.25	0.27	0.14	0.05	0.38	0.96	0.49	0.25
18	0.05	1.02	0.51	0.14	0.02	0.06	0.13	0.21	0.17	0.07	0.09	0.14	0.06	0.06	0.49	0.36	0.21
19	0.25	0.08	8.25	0.60	0.06	0.06	0.10	0.16	0.15	0.10	0.06	0.16	0.09	0.07	0.09	0.39	0.12
20 = F_I	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Table 5a. North Sea Plaice. Stock in numbers.

MALES

Year / Age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	381 302	455 377	443 704	373 501	292 362	293 180	1 018 370	281 804	270 454	218 824	180 279	259 197	341 290	367 877	247 225	132 222	62 687
2	190 337	296 958	354 648	345 557	290 883	227 692	228 329	793 105	219 469	210 630	170 420	140 401	201 616	264 564	286 126	191 585	102 590
3	96 652	144 859	221 638	273 348	267 646	224 546	172 585	172 939	611 135	167 409	160 395	126 351	101 487	145 379	189 448	210 038	137 750
4	106 408	66 037	96 487	138 486	196 986	185 478	159 757	112 968	111 480	436 829	114 836	99 328	75 779	54 614	89 190	128 152	132 360
5	50 896	63 736	40 964	59 320	82 985	124 047	92 442	96 947	65 430	63 598	268 507	74 205	68 351	36 086	31 893	54 664	67 656
6	28 764	28 846	35 609	25 692	35 752	41 488	63 187	41 278	55 129	36 788	27 278	165 084	45 662	37 550	20 587	18 175	27 576
7	14 426	17 636	15 350	20 335	15 060	19 164	19 202	33 716	19 264	34 635	16 323	15 551	95 636	22 514	22 768	10 846	10 446
8	9 456	9 916	10 303	8 624	11 872	8 123	10 021	11 024	22 072	10 189	18 344	10 788	9 722	48 166	13 667	14 087	6 760
9	7 919	6 066	6 526	6 848	4 468	7 322	4 442	6 603	6 410	15 551	5 599	11 524	7 517	6 202	31 589	8 804	9 049
10	2 884	5 292	3 546	4 779	4 244	3 115	4 820	2 691	4 649	3 439	10 693	3 888	6 195	5 402	4 037	21 901	5 948
11	1 890	1 797	3 176	2 441	3 137	3 110	1 870	3 504	1 279	3 233	2 450	7 704	2 346	4 042	3 559	2 356	14 886
12	261	999	890	2 358	1 642	2 312	2 258	1 196	1 923	766	2 636	1 592	5 762	1 532	2 758	2 273	1 884
13	264	128	364	647	1 616	588	1 948	1 664	805	1 146	584	1 959	739	4 346	973	1 694	1 606
14	592	165	24	117	355	1 286	321	1 498	1 260	392	773	320	1 492	353	3 290	561	1 203
15	219	510	119	12	83	196	1 037	166	723	996	172	527	77	1 173	136	2 513	243

Table 5b. North Sea Plaice. Stock in numbers.

FEMALES

Year / Age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	327 464	312 586	308 089	245 543	209 353	225 591	674 690	214 759	197 530	186 961	150 358	188 124	249 782	199 182	253 206	129 442	61 531
2	166 122	268 105	256 145	252 242	201 034	171 404	184 699	552 389	175 830	161 724	153 071	123 103	154 015	203 809	162 642	206 616	105 325
3	96 552	132 234	205 274	205 452	205 090	163 480	135 160	136 517	443 373	138 812	129 590	118 976	92 452	117 696	149 124	121 536	157 787
4	124 477	74 825	101 016	146 699	158 921	154 786	130 505	100 213	100 158	351 852	104 826	95 713	83 048	57 978	82 507	111 013	77 803
5	86 059	86 120	56 989	72 498	100 359	113 653	93 696	92 867	68 618	67 441	257 916	75 626	68 731	48 334	37 456	54 667	61 196
6	60 054	64 829	61 189	44 792	54 199	63 057	74 455	64 460	67 834	49 587	43 573	184 714	55 616	46 076	32 827	21 732	30 572
7	30 911	46 158	50 610	44 520	35 905	37 717	40 490	54 333	44 218	52 163	34 147	32 332	129 558	37 199	31 923	19 377	12 261
8	30 945	24 650	35 622	39 717	33 870	26 657	27 674	29 979	39 962	31 914	38 754	26 034	24 461	84 345	26 993	18 053	11 686
9	26 094	24 157	19 704	28 149	31 197	24 179	20 039	22 378	22 183	30 110	24 813	29 528	20 621	17 854	63 157	13 287	10 296
10	18 796	20 509	18 707	15 602	22 120	24 565	18 025	16 239	17 529	16 532	21 843	20 083	22 282	16 050	13 108	39 607	6 635
11	17 976	14 532	15 731	14 027	12 069	17 114	19 214	13 960	12 704	13 908	12 830	16 746	16 397	16 581	12 177	7 228	23 563
12	11 948	13 371	11 062	12 246	10 574	9 345	12 770	15 395	10 679	9 968	10 867	10 366	12 140	13 391	12 816	6 629	4 016
13	9 031	9 449	9 904	8 421	9 405	8 256	6 573	10 355	12 219	7 855	8 162	8 564	8 493	8 990	10 658	6 248	4 009
14	4 528	7 313	7 343	7 921	6 254	7 121	6 042	4 919	7 961	9 946	5 834	6 786	6 809	6 970	6 782	7 095	3 810
15	2 102	3 610	5 993	6 055	6 096	4 557	5 355	4 644	3 607	6 185	8 269	4 481	5 796	5 476	5 711	3 550	3 735
16	783	1 590	2 902	4 940	4 902	4 998	3 485	4 345	3 375	2 704	4 959	7 018	3 402	4 941	4 250	4 040	2 122
17	345	500	1 148	2 440	4 228	4 127	4 089	2 673	3 330	2 424	2 141	3 940	6 019	2 724	4 142	2 449	2 987
18	1 215	142	246	903	2 059	3 745	3 474	3 182	2 004	2 658	1 715	1 484	3 108	5 170	1 682	1 428	1 362
19	203	1 043	47	134	714	1 820	3 190	2 754	2 344	1 524	2 250	1 419	1 173	2 648	4 386	937	901
20	408	143	872	0	66	607	1 556	2 604	2 129	1 820	1 247	1 909	1 092	971	2 229	3 619	574

Table 6. North Sea Plaice. Results of 1975 virtual population analysis.

MALE

Age Group	Fishing mean 1967-70	Mortality mean 1971-73	Relative fishing mortality 1971-73	Natural mortality	1974 catch $Nx10^{-3}$	1974 stock $Nx10^{-6}$
2	0.06	0.07	0.13	0.25	8 656	145
3	0.25	0.21	0.39	0.15	30 867	175
4	0.36	0.41	0.76	0.15	35 577	113
5	0.46	0.45	0.83	0.15	22 075	65
6	0.51	0.41	0.76	0.15	9 659	31
7	0.40	0.33	0.61	0.15	3 472	13
8	0.32	0.28	0.52	0.15	2 080	9
9	0.27	0.25	0.46	0.15	2 123	10
10	0.25	0.30	0.56	0.15	1 182	5
11	0.19	0.20	0.37	0.15	2 512	15
12	0.26	0.28	0.52	0.15	318	1
13	0.35	0.24	0.44	0.15	271	1
14	0.57	0.54	1.00	0.15	203	0.5
15	0.20	0.20	0.37	0.15	41	0.2
16						
17						
18						
19						
20						
Total					119 036	584

FEMALE

Fishing mean 1967-70	Mortality mean 1971-73	Relative fishing mortality 1971-73	Natural mortality	1974 catch $Nx10^{-3}$	1974 stock $Nx10^{-6}$
0.10	0.09	0.21	0.20	9 962	128
0.25	0.27	0.64	0.10	29 707	132
0.28	0.38	0.91	0.10	23 988	80
0.27	0.40	0.95	0.10	19 263	61
0.26	0.39	0.93	0.10	8 822	29
0.22	0.37	0.88	0.10	3 538	12
0.17	0.42	1.00	0.10	3 372	10
0.17	0.39	0.93	0.10	2 902	9
0.16	0.37	0.88	0.10	1 870	6
0.15	0.39	0.93	0.10	6 641	22
0.14	0.38	0.91	0.10	1 132	4
0.13	0.29	0.69	0.10	1 130	5
0.11	0.40	0.95	0.10	915	3
0.11	0.27	0.64	0.10	843	4
0.11	0.24	0.57	0.10	479	2
0.18	0.40	0.95	0.10	630	2
0.09	0.30	0.71	0.10	246	1
0.10	0.18	0.43	0.10	97	0.6
				115 537	511

Table 7. North Sea Plaice.
Estimates of recruitment at age 2 (millions).

Year Class	MALE	FEMALE
1945	205	212
1946	180	198
1947	202	211
1948	151	161
1949	168	177
1950	157	175
1951	127	137
1952	151	177
1953	155	186
1954	189	203
1955	118	124
1956	174	166
1957	273	268
1958	323	256
1959	315	252
1960	265	201
1961	208	171
1962	209	185
1963	722	552
1964	200	176
1965	193	162
1966	157	153
1967	130	123
1968	186	154
1969	243	204
1970	263	163
1971	184	207

Table 8. North Sea Plaice. Mean weight at age per catch and stock

Age	MALE		FEMALE	
	Gutted weight stock g	Gutted weight catch g	Gutted weight stock g	Gutted weight catch g
2	65	200	65	215
3	122	260	122	303
4	194	315	194	376
5	282	370	282	451
6	382	413	382	527
7	450	450	490	602
8	485	485	606	676
9	517	517	724	749
10	546	546	819	819
11	573	573	886	886
12	598	598	950	950
13	620	620	1 010	1 010
14	640	640	1 067	1 067
15	694	694	1 120	1 120
16			1 170	1 170
17			1 220	1 220
18			1 260	1 260
19			1 300	1 300

Table 9. North Sea Plaice. Prognosis for catch and stock (tons) for 1975 and 1976 for various values of F_{max} in 1975

1). F_{max} 1975 = F_{max} 1974

	Catch ♂	Catch ♀	Total	Stock ♂	Stock ♀	Total
1974	44 274	60 075	104 349	125 983	150 759	276 742
1975	43 607	55 906	99 513	122 561	138 495	261 056
1976	40 501	50 964	91 465	116 145	130 079	246 224

2). F_{max} 1975 = 1.15 F_{max} 1974

	Catch ♂	Catch ♀	Total	Stock ♂	Stock ♀	Total	
1975	48 893	62 451	111 344	122 561	138 495	261 056	
1976 F_{max}							Long-term % change in biomass
0.1	8 103	13 735	21 838	111 629	124 835	236 464	134
0.2	15 713	26 415	42 128				53
0.3	22 862	38 125	60 987				10
0.4	29 582	48 944	78 529				-15
0.5	35 901	58 947	94 848				-31
0.6	41 846	68 196	110 042				-42
0.7	47 442	76 757	124 199				-49
0.8	52 712	84 680	137 392				-55
0.9	57 679	92 021	149 700				-59
1.0	62 360	98 822	161 182				-62

3). F_{max} 1975 = 1.30 F_{max} 1974

	Catch ♂	Catch ♀	Total	Stock ♂	Stock ♀	Total	
1975	53 921	69 699	123 620	122 561	138 495	261 056	
1976 F_{max}							Long-term % change in biomass
0.1	7 776	13 101	20 877	107 348	119 043	226 391	124
0.2	15 081	25 201	40 282				46
0.3	21 945	36 379	58 324				5
0.4	28 401	46 712	75 113				-19
0.5	34 472	56 267	90 739				-34
0.6	40 186	65 106	105 292				-44
0.7	45 568	73 290	118 858				-51
0.8	50 637	80 870	131 507				-57
0.9	55 416	87 893	143 309				-61
1.0	59 923	94 404	154 327				-64

Table 10. North Sea Plaice. Steady state yield and biomass against F_{max}

a) per recruit b) for R = 170 x 10^6 per sex

F_{max}	Yield per recruit (Kg) (gutted)		Biomass per recruit (Kg) (gutted)		Absolute yield (tons) (fresh)			Absolute biomass (tons) (fresh)		
	♂	♀	♂	♀	♂	♀	Total	♂	♀	Total
0.1	0.086	0.215	1.359	2.263	16 409	41 042	57 451	259 985	432 837	692 822
0.2	0.132	0.265	1.028	1.337	25 245	50 758	76 003	196 586	255 663	452 249
0.3	0.157	0.274	0.808	0.893	30 007	52 307	82 314	154 549	170 786	325 335
0.4	0.171	0.271	0.658	0.656	32 723	51 905	84 638	125 823	125 498	251 321
0.5	0.179	0.267	0.552	0.517	34 273	50 968	85 240	105 627	98 838	204 465
0.6	0.184	0.262	0.477	0.428	35 247	50 031	85 278	91 150	81 874	173 024
0.7	0.187	0.257	0.420	0.368	35 821	49 209	85 030	80 382	70 304	150 686
0.8	0.189	0.254	0.377	0.324	36 108	48 482	84 590	72 140	62 022	134 162
0.9	0.190	0.250	0.344	0.292	36 414	47 870	84 284	65 733	55 826	121 559
1.0	0.191	0.247	0.317	0.267	36 510	47 239	83 749	60 684	51 064	111 748

Table 11. Nominal catch (metric tons) of sole in the North Sea (statistical sub-area IV), 1960-1973

Year	Belgium	Denmark	France	Germany, Fed. Rep. of	Nether-lands	Sweden[b]	U.K. (England & Wales)	U.K. (Scotland)	Total
1960	3 974	1 760	398	1 776	9 274	3	1 444	-	18 629
1961	3 666	2 237	827	2 116	13 488	3	1 617	-	23 954
1962	4 068	2 507	322	1 999	16 287	-	1 694	-	26 877
1963	7 835	350	280	670	13 596	-	3 431	-	26 162
1964	1 071	570	384	277	8 272	-	768	-	11 342
1965	1 621	653	689	371	12 980	-	729	-	17 043
1966	3 586	536	504	1 074	25 192[a]	-	933	-	31 825
1967	4 455	1 593	444	1 094	24 900[a]	-	1 023	-	33 509
1968	3 874	1 590	273	1 138	25 175[a]	...	1 129	-	33 179
1969	2 703	842	364	692	22 032	-	927	-	27 560
1970	1 880	525	265	318	16 024	13	660	1	19 686
1971	2 227	1 149	403	600	18 776	12	485	2	23 654
1972	1 834	671	206	258	17 662	13	449	+	21 093
1973	1 485	957	250	336	15 883	13	387	1	19 312
1974[c]	924	704	(200)	160	15 211	11	325	-	17 535

a) Netherlands - The 1967 and 1968 catches given here include respectively 11 862 tons and 3 779 tons reported originally as "area unknown". Footnote in Bulletin Statistique allocate these quantities to "mostly IVb, the rest in IVc". No such explanation is provided for 1 515 tons reported in 1966 as "area unknown", and this quantity has not been included in the 1966 catch given in this table.

b) Sweden - Figures from 1968 onwards include catches made in IIIa. The 1968 catch was included in 148 tons of Various pleuronectiforms.

c) Preliminary figures as reported. No report was received from France, and the bracketed figure represents an estimate made by the Working Group.

Table 12a. North Sea Sole. Age composition of total catch 1957-1974 (thousands).

MALE

Age \ Year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	0	0	0	0	0	0	0	7	0	0	0	0	0	557	331	0	113	267
2	86	259	278	4 338	1 640	0	84	98	23 195	3 929	2 247	4 778	12 637	3 015	17 671	3 411	5 840	9 328
3	2 940	2 184	3 814	5 535	18 720	2 163	1 828	1 163	168	60 251	13 983	18 121	10 291	13 170	6 692	23 672	6 500	15 834
4	3 376	5 582	3 552	7 301	7 752	25 792	2 919	2 535	892	241	49 210	14 424	2 918	3 936	6 709	3 739	7 643	3 404
5	1 272	3 113	4 928	5 108	4 116	6 133	22 873	1 907	2 656	643	883	28 952	5 631	769	2 462	2 544	1 419	3 447
6	863	1 728	2 455	5 614	3 117	5 241	2 473	7 656	1 220	1 653	216	3 021	8 780	1 290	438	1 116	1 160	1 232
7	2 584	1 837	819	3 431	1 901	2 087	2 443	1 303	5 729	319	854	836	0	5 523	694	162	344	821
8	624	2 463	1 802	1 249	1 945	1 902	592	2 145	557	3 917	635	2 145	66	44	2 647	464	285	421
9	440	850	1 279	696	738	1 197	1 533	303	631	114	2 769	153	278	32	64	2 269	610	194
10	2 180	498	594	2 181	567	416	705	254	210	189	0	666	3	240	45	51	1 268	211
11	75	1 941	435	888	1 003	937	396	169	218	44	213	30	862	65	162	13	33	808
12	0	0	1 992	298	480	526	531	92	241	151	218	169	3	1 022	48	288	194	18
13	26	190	15	2 569	177	469	732	259	186	153	104	77	236	98	660	22	161	16
14	0	0	73	119	1 087	400	195	199	201	41	110	13	32	220	160	420	27	167

Table 12b. North Sea Sole. Age composition of total catch 1957-1974 (thousands).

FEMALE

Age \ Year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	0	0	0	0	0	0	0	71	0	0	0	0	265	649	185	0	610	410
2	1 199	1 890	3 900	9 148	3 158	1 729	537	119	26 685	9 470	2 750	4 624	13 812	4 068	20 731	5 393	7 376	10 207
3	5 925	6 622	10 057	9 983	38 429	4 053	6 582	1 457	756	74 396	17 282	13 898	10 086	13 946	7 214	19 772	5 470	12 729
4	7 248	6 548	9 156	11 560	19 004	33 036	5 949	4 721	551	358	56 301	10 876	2 174	4 953	6 298	3 795	8 795	2 969
5	1 624	3 953	5 173	4 475	6 603	8 477	24 975	1 934	2 196	402	1 497	21 188	5 083	1 042	1 703	2 905	2 503	3 199
6	1 192	1 304	3 671	3 875	3 436	4 651	5 432	8 626	1 213	1 232	418	2 536	13 408	1 677	584	856	1 208	814
7	2 260	1 201	707	2 621	2 434	2 280	3 856	1 753	5 719	464	1 510	1 283	243	7 832	914	282	748	571
8	573	1 170	622	633	1 504	2 224	1 580	796	812	3 981	246	2 551	115	168	4 266	567	565	208
9	263	633	1 411	475	730	1 083	1 864	470	712	435	3 062	529	537	56	79	3 059	684	235
10	1 801	219	614	995	508	250	668	544	145	447	475	1 371	193	479	47	47	2 002	206
11	50	1 783	341	500	634	516	331	283	464	211	506	259	1 544	74	219	24	188	1 200
12	77	63	1 063	278	536	419	130	85	121	339	139	558	154	1 542	0	186	116	48
13	19	37	85	1 272	427	559	1 210	177	244	56	418	275	291	85	1 094	26	207	4
14	49	63	22	44	995	73	170	168	203	62	97	327	96	303	72	658	46	101

Table 13. Average fishing mortalities and relative fishing mortalities for 1969-1973, used as terminal F values in the VPA and the prognosis

Age	Males		Females	
	Average F	Relative F	Average F	Relative F
2	0.23	0.27	0.28	0.35
3	0.85	1.00	0.80	1.00
4	0.77	0.91	0.66	0.83
5	0.64	0.76	0.52	0.65
6	0.81	0.95	0.66	0.83
7	0.50	0.59	0.60	0.75
8	0.25	0.29	0.40	0.50
9	0.18	0.21	0.35	0.44
10	0.14	0.16	0.29	0.36
11	0.09	0.11	0.21	0.26
12	0.11	0.13	0.16	0.20
13	0.11	0.13	0.16	0.20
14	0.15	1.8	0.25	0.31

Table 14a. North Sea Sole. Fishing mortalities 1957-1974.

MALES

Year / Age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974 = F_I
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.05
2	0.00	0.01	0.01	0.03	0.12	0.00	0.01	0.01	0.10	0.08	0.08	0.17	0.34	0.16	0.33	0.21	0.18	0.23
3	0.09	0.10	0.10	0.19	0.17	0.20	0.09	0.23	0.03	0.35	0.38	1.21	0.60	0.62	0.56	0.86	0.66	0.85
4	0.15	0.23	0.21	0.26	0.39	0.33	0.39	0.16	0.25	0.05	0.48	0.73	0.55	0.43	0.67	0.63	0.67	0.77
5	0.14	0.18	0.28	0.46	0.21	0.55	0.49	0.43	0.22	0.25	0.22	0.52	0.62	0.24	0.46	0.51	0.46	0.65
6	0.06	0.26	0.19	0.54	0.49	0.39	0.40	0.27	0.47	0.19	0.11	3.22	0.26	0.25	0.19	0.35	0.41	0.81
7	0.16	0.16	0.17	0.39	0.31	0.64	0.28	0.33	0.30	0.19	0.12	0.72	0.00	0.23	0.18	0.09	0.15	0.50
8	0.07	0.20	0.21	0.36	0.36	0.51	0.33	0.37	0.21	0.14	0.63	0.46	0.10	0.10	0.15	0.16	0.20	0.25
9	0.05	0.12	0.13	0.10	0.34	0.35	0.89	0.25	0.16	0.05	0.26	0.27	0.09	0.06	0.18	0.16	0.29	0.18
10	0.08	0.07	0.11	0.32	0.10	0.29	0.32	0.31	0.24	0.06	0.00	0.08	0.01	0.09	0.09	0.19	0.12	0.14
11	0.04	0.09	0.07	0.21	0.21	0.22	0.43	0.11	0.42	0.07	0.08	0.02	0.13	0.17	0.07	0.03	0.16	0.09
12	0.00	0.00	0.11	0.05	0.15	0.15	0.17	0.15	0.19	0.51	0.47	0.07	0.00	0.21	0.17	0.16	0.76	0.11
13	5.50	0.20	0.01	0.19	0.04	0.19	0.27	0.11	0.45	0.16	0.70	0.26	0.13	0.07	0.18	0.10	0.11	0.11
14 = F_I	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Table 14b. North Sea Sole. Fishing mortalities 1957-1974.

FEMALES

Year / Age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974 = F_I
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.05
2	0.03	0.03	0.06	0.05	0.15	0.06	0.08	0.01	0.10	0.18	0.11	0.18	0.37	0.20	0.39	0.34	0.25	0.28
3	0.14	0.19	0.20	0.19	0.27	0.26	0.27	0.29	0.09	0.41	0.51	1.07	0.66	0.69	0.56	0.70	0.59	0.80
4	0.30	0.20	0.39	0.32	0.59	0.34	0.64	0.29	0.15	0.05	0.54	0.63	0.40	0.70	0.69	0.58	0.70	0.66
5	0.21	0.24	0.21	0.30	0.28	0.50	0.41	0.39	0.19	0.14	0.29	0.36	0.60	0.30	0.49	0.70	0.85	0.52
6	0.12	0.23	0.33	0.21	0.36	0.28	0.62	0.22	0.40	0.14	0.19	0.96	0.36	0.36	0.25	0.43	0.62	0.66
7	0.18	0.15	0.17	0.36	0.18	0.38	0.36	0.37	0.20	0.23	0.22	1.22	0.19	0.32	0.30	0.16	0.73	0.60
8	0.08	0.12	0.10	0.20	0.32	0.22	0.43	0.10	0.26	0.18	0.17	0.63	0.27	0.17	0.26	0.28	0.50	0.40
9	0.09	0.10	0.18	0.09	0.33	0.36	0.27	0.20	0.11	0.19	0.19	0.57	0.23	0.18	0.10	0.27	0.56	0.35
10	0.08	0.09	0.12	0.17	0.12	0.16	0.35	0.10	0.08	0.09	0.30	0.11	0.37	0.29	0.21	0.08	0.25	0.29
11	0.06	0.10	0.17	0.13	0.14	0.15	0.29	0.22	0.11	0.14	0.12	0.24	0.15	0.21	0.19	0.14	0.42	0.21
12	0.21	0.09	0.07	0.18	0.18	0.11	0.05	0.10	0.12	0.10	0.11	0.17	0.19	0.20	0.00	0.21	1.58	0.16
13	0.03	0.14	0.15	0.10	0.41	0.25	0.48	0.07	0.40	0.07	0.15	0.31	0.11	0.14	0.19	0.11	0.34	0.16
14 = F_I	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.25	0.25

Table 15a. North Sea Sole. Stock in numbers (thousands).

MALES

Year / Age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	50 218	41 009	157 226	17 357	26 925	7 333	34 554	285 442	61 701	35 382	34 697	50 869	23 358	73 246	21 535	42 018	52 742	5 750
2	26 895	45 439	37 106	146 135	15 705	24 362	6 635	31 265	258 272	55 829	32 015	31 395	46 028	21 135	65 746	19 171	38 020	47 616
3	35 042	24 254	40 869	33 311	128 062	12 653	22 044	5 924	27 870	211 658	46 783	26 833	23 871	29 666	16 261	42 734	14 109	28 857
4	25 172	28 914	19 871	33 356	24 886	98 064	9 395	18 209	4 256	24 499	134 395	29 077	7 218	11 863	14 385	8 380	16 318	6 619
5	10 170	19 570	20 865	14 608	23 255	15 171	64 253	5 735	14 069	3 005	21 135	75 003	12 677	3 769	7 005	6 672	4 046	7 538
6	15 339	7 994	14 753	14 205	8 379	17 135	7 923	36 493	3 382	10 210	2 109	15 348	40 454	6 144	2 681	4 006	3 628	2 317
7	18 592	13 059	5 593	11 018	7 501	4 630	10 537	4 825	25 780	1 905	7 669	1 703	556	28 274	4 336	2 010	2 567	2 184
8	9 144	14 369	10 072	4 284	6 718	4 984	2 216	7 217	3 130	17 887	1 421	6 128	751	503	20 342	3 264	1 665	1 996
9	9 574	7 681	10 664	7 403	2 692	4 235	2 709	1 444	4 497	2 304	12 471	685	3 513	617	413	15 892	2 513	1 236
10	28 626	8 245	6 142	8 434	6 038	1 736	2 697	1 004	1 019	3 470	1 976	8 661	475	2 914	527	313	12 226	1 695
11	1 870	23 831	6 987	4 994	5 563	4 924	1 176	1 772	668	722	2 960	1 788	7 223	427	2 409	435	235	9 858
12	1 204	1 621	19 719	5 909	3 675	4 082	3 566	689	1 443	398	612	2 476	1 589	5 716	324	2 026	381	181
13	0	1 089	1 467	15 950	5 063	2 870	3 194	2 723	536	1 077	217	347	2 080	1 435	4 196	248	1 560	161
14	0	0	805	1 313	11 993	4 413	2 151	2 196	2 218	309	829	98	241	1 658	1 206	3 165	203	1 258

Table 15b. North Sea Sole. Stock in numbers (thousands).

FEMALES

Year / Age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	74 258	77 553	221 800	26 602	37 118	8 074	11 000	316 318	65 886	30 173	32 114	51 694	26 368	74 629	22 096	38 022	49 067	8 830
2	44 846	67 191	70 173	200 693	24 070	33 586	7 305	9 953	286 149	59 616	27 301	29 058	46 774	23 607	66 910	19 817	34 404	43 817
3	48 847	39 439	59 001	59 789	172 900	18 780	28 747	6 100	8 893	233 567	44 952	22 091	21 902	29 231	17 499	40 895	12 818	24 131
4	29 094	38 571	29 399	43 839	44 622	119 987	13 148	19 767	4 137	7 328	140 840	24 312	6 888	10 280	13 264	9 006	18 312	6 422
5	9 121	19 451	28 685	17 924	28 705	22 394	77 246	6 270	13 408	3 220	6 291	74 144	11 711	4 173	4 619	6 047	4 558	8 255
6	11 412	6 712	13 849	21 045	11 974	19 710	12 236	46 229	3 840	10 047	2 532	4 272	47 001	5 787	2 787	2 567	2 725	1 761
7	14 705	9 193	4 836	9 050	15 365	7 577	13 422	5 934	33 643	2 325	7 921	1 894	1 473	29 817	3 647	1 968	1 512	1 323
8	8 055	11 160	7 178	3 704	5 704	11 592	4 695	8 489	3 707	25 012	1 664	5 734	506	1 102	19 553	2 433	1 513	661
9	3 356	6 744	8 986	5 904	2 751	3 735	8 378	2 751	6 925	2 584	18 853	1 272	2 775	349	838	13 645	1 663	834
10	23 504	2 787	5 501	6 792	4 891	1 797	2 353	5 812	2 043	5 590	1 925	14 152	650	2 001	262	683	9 444	858
11	890	19 556	2 314	4 394	5 201	3 943	1 388	1 496	4 742	1 711	4 633	1 291	11 503	405	1 357	193	573	6 646
12	420	758	16 001	1 770	3 501	4 104	3 078	942	1 085	3 850	1 348	3 712	923	8 942	297	1 020	152	341
13	788	307	626	13 468	1 337	2 659	3 315	2 661	772	867	3 162	1 088	2 829	689	6 627	268	746	28
14	541	695	243	485	10 978	805	1 876	1 854	2 240	467	731	2 464	723	2 283	542	4 958	218	479

Table 16. Number of North Sea sole recruits in millions

Year class	Males	Females	Sexes combined
1955	26.9	44.8	71.7
1956	45.4	67.2	112.6
1957	37.1	70.2	107.3
1958	146.1	200.7	346.8
1959	15.7	24.1	39.8
1960	24.4	33.6	58.0
1961	6.6	7.3	13.9
1962	31.3	10.1	41.4
1963	258.3	286.1	544.4
1964	55.8	59.6	115.4
1965	32.0	27.3	59.3
1966	31.4	29.1	60.5
1967	46.0	46.8	92.8
1968	21.1	23.6	44.7
1969	65.7	66.9	132.6
1970	19.2	19.8	39.0
1971	38.0	34.4	72.4
1972	47.6	43.8	91.4

Table 17. Nominal weight (g) at age, for catch and stock (average 1969-1973)

Age	Males		Females	
	Biomass	Catch	Biomass	Catch
2	39	90	62	124
3	146	203	199	257
4	231	259	316	377
5	283	302	425	473
6	316	326	507	540
7	339	351	566	585
8	361	371	605	622
9	377	383	639	654
10	387	392	671	684
11	395	395	694	703
12	401	403	713	723
13	404	406	729	735
14	406	407	739	745

Table 18. Nominal catches of plaice in the Irish Sea (VIIa) and Bristol Channel (VIIf), 1960-1974

	Belgium		France		Ireland		Nether-lands		England/ Wales		N. Ireland		Scotland		Total	
	VIIa	VIIf	VIIa	VIIf	VIIa	VIIf	VIIa	VIIf	VIIa	VIIf	VIIa	VIIf	VIIa	VIIf	VIIa	VIIf
1960	140		157		611	-	-	-	1 620		34	-	18	-	2 580	
1961	82		67		743	-	-	-	1 443		22	-	42	-	2 399	
1962	11	73	54	4	594	-	-	-	1 436	205	28	-	20	-	2 143	282
1963	23	55	60	1	545	-	-	-	1 141	173	68	-	29	-	1 866	229
1964	253	184	147	3	844	-	-	-	1 388	204	185	-	62	-	2 879	391
1965	150	224	168	10	574	-	1	-	2 484	272	225	-	62	-	3 664	506
1966	72	113	562	21	782	-	-	-	2 527	467	174	-	151	-	4 268	601
1967	69	137	1 082	-	819	-	-	-	2 866	655	138	-	85	-	5 059	792
1968	152	260	40	669	1 449	-	-	-	2 764	521	178	-	112	-	4 695	1 450
1969	208	202	33	668	1 309	-	-	-	2 540	506	216	-	88	-	4 394	1 376
1970	305	226	250	102	909	-	8	-	1 869	501	184	-	58	-	3 583	829
1971	175	202	-	-	1 028	-	61	-	2 744	545	132	-	92	-	4 232	747
1972	179	137	440	110	863	-	48	-	3 366	377	134	-	89	-	5 119	624
1973	221	158	500	-	1 079	-	42	-	3 002	381	143	-	73	-	5 060	539
1974*	254	162	(500)	(100)	848	-	48	-	2 219	229	(100)	-	32	-	4 001	491

*Preliminary figures as reported. No reports were recieved from France or Northern Ireland, and estimates for these catches were made as shown by the bracketed figures.

Table 19. Plaice growth data - mean lengths (cm) at age, and parameters of von Bertalanffy equation. Data on age group 0-2 from research vessel samples; data on age group 3 onwards from commercial catch samples.

	Irish Sea (VIIa)						Bristol Channel (VIIf)			
	Female			Male			Female		Male	
Age group	Belgian 1970-74	English + Welsh 1964-71	Irish 1962-66	Belgian 1970-74	English + Welsh 1964-71	Irish 1962-66	Belgian 1970-74	English + Welsh 1969	Belgian 1970-74	English + Welsh 1969
0		7.3	11.8		7.3	11.6		9.6		9.5
1		15.3	18.7		15.3	18.8		17.0		17.1
2		21.0	23.7		21.0	23.3	29.5	29.9	28.8	28.1
3	31.1	26.8	32.0	28.8	26.8	29.4	32.4	31.0	30.6	29.4
4	33.8	31.8	34.5	31.4	29.8	31.9	35.0	32.2	31.5	29.8
5	37.1	33.4	38.2	32.4	30.5	34.4	37.0	32.9	32.3	32.1
6	39.3	35.5	40.4	32.8	31.1	36.6	40.4	34.7	32.0	34.5
7	41.5	37.8	44.1	35.8	32.0		42.9	35.0	35.5	27.6
8	43.7	38.9	46.1	36.4	35.2		44.8	41.9	38.0	
9	45.3	41.1		38.0	32.4		47.3	-		
10	46.8	44.1			34.1		49.0	47.5		
11	50.5	45.0			32.6		49.6	50.2		
12	50.6	48.8			39.6		50.5	53.9		
13	52.3	46.6			40.7		58.0			
14	52.5	50.8			37.7					
15	51.0	48.7								
16		54.3								
17		54.7								
18		49.4								
19		56.8								
20		55.5								
21		56.4								
L_∞		55.80			37.23			60.69		38.21
K		0.16			0.35			0.14		0.27
t_o		-0.83			-0.31			-0.94		-1.63

Table 20. Irish Sea plaice (VIIa). Belgian length/weight data

Age group	Females		Males	
	Length	Weight	Length	Weight
2	26.9	247		
3	31.1	320	28.8	239
4	33.8	391	31.4	311
5	37.1	522	32.4	326
6	39.3	669	32.8	322
7	41.5	731	35.8	459
8	43.7	897	36.4	470
9	45.3	963	38.0	500
10	46.8	1 096		
11	50.5	1 371		
12	50.6	1 410		
13	52.3	1 336		
14	52.5	1 357		
15	51.0	1 642		

Table 21. Parameters used in calculating yield equations - Plaice.

	VIIa		VIIf	
	♂	♀	♂	♀
W_∞	482.0	1 757.0	518.4	2 229.7
K	0.35	0.16	0.27	0.14
t_o	-0.32	-0.831	-1.63	-0.94
$t_c = t_r$	3.5	3.5	3.5	3.5
t_{max}	20	30	20	30

Table 22. Irish Sea (VIIa) and Bristol Channel (VIIf) plaice. Total mortality estimates from catch and effort data.

Plaice VIIa Female		1964/5	1965/6	1966/7	1967/8	1968/9	1969/70	1970/1	1971/2	1972/3	1973/4
England + Wales (Fleetwood)		0.72	0.34	0.86	1.32	0.41	0.47	0.50			
Belgium	Otter Trawl								0.23	1.14	0.73
	Beam Trawl								0.38	1.01	0.52
Male											
England + Wales (Fleetwood)		0.20	0.34	0.93	1.61	1.59	0.47	0.63			
Belgium	Otter Trawl								0.43	0.56	1.20
	Beam Trawl								0.60	0.56	1.10
Plaice VIIf Female											
Belgium	Otter Trawl								1.11	-0.12	0.63
	Beam Trawl								0.49	0.53	0.50
Male											
Belgium	Otter Trawl								1.55	0.19	1.07
	Beam Trawl								0.80	0.85	0.92

Table 23. Nominal catches of Sole in the Irish Sea (VIIa) and Bristol Channel (VIIf), 1960 - 1974.

Year	Belgium		Ireland		France		Netherlands		U.K. (England/Wales)		Total	
	VIIa	VIIf	VIIa	VIIf	VIIa	VIIf	VIIa	VIIf	VIIa	VIIf	VIIa	VIIf
1960	531		25	-	90		-	-	756		1 402	
1961	406		25	-	60		-	-	682		1 173	
1962	40	335	37	-	45	45	-	-	464	215	586	595
1963	64	174	25	-	43	61	-	-	323	122	455	357
1964	938	471	40	-	242	77	-	-	380	111	1 600	659
1965	1 025	498	29	-	228	72	13	-	344	75	1 639	645
1966	407	248	14	-	367	150	-	-	288	112	1 076	510
1967	307	451	22	-	361	83	-	-	320	209	1 010	743
1968	332	292	23	-	125	179	-	-	456	127	936	598
1969	841	289	34	-	97	194	3	-	417	168	1 392	651
1970	1 142	567	25	-	115	118	235	-	291	145	1 808	830
1971	883	595	45	-	45	40	552	-	356	131	1 881	766
1972	561	343	50	-	38	82	514	-	278	123	1 441	548
1973	793	416	27	-	12	240	281	-	315	122	1 428	778
1974*	690	561	25	-	(25)	(80)	321	-	209	105	1 270	746

* Preliminary figures as reported. No report was received from France, and estimates were made as shown by the bracketed figures.

Table 24. Irish Sea (VIIa) and Bristol Channel (VIIf) Sole.
Length and weight (gutted) per age. (Belgian data).

Age	Irish Sea				Bristol Channel			
	♀		♂		♀		♂	
	Length (cm)	Weight (g)	Length (cm)	Weight (g)	Length (cm)	Weight (g)	Length (cm)	Weight (g)
2	24.7	136	24.5	119	25.4	148	25.1	140
3	26.4	173	24.8	135	29.1	226	26.5	159
4	29.0	238	25.7	148	31.6	297	28.1	190
5	31.1	293	26.7	172	33.4	344	23.8	235
6	33.0	363	28.1	206	35.0	415	30.9	260
7	33.8	389	28.4	204	36.1	447	31.6	284
8	34.8	427	28.6	210	37.7	517	32.2	293
9	35.6	460	29.1	221	38.8	559	32.4	299
10	36.3	499	29.7	237	32.0	578	34.4	366
11	36.3	500	29.8	238	40.8	629	34.2	355
12	37.6	537	31.0	278	40.3	629	35.1	384
13	38.3	584	30.5	263	40.1	620	35.9	403
14	37.8	556	30.2	255	41.2	692	35.6	407
15	38.9	628	32.2	310	41.4	688	35.3	372
16	37.5	566	31.0	276	41.5	660	37.1	428
17	40.3	626	32.0	329	43.0	736	34.8	417
18	40.2	719	34.1	357	42.4	709	36.8	453
19	41.1	726	33.0	358	44.1	827	37.0	475
20	38.3	599	32.4	358	42.1	740	35.3	383
21	41.5	690	32.0	337	45.3	863	38.4	495
22	40.7	650	33.3	340	42.3	739	38.7	551
23	37.8	534	34.1	402	45.2	976	37.5	437
24	41.6	729	34.5	460	40.6	760	41.0	682
25	39.5	618	33.8	386	46.0	962		
26	39.0	602						
27	38.0	567						
28	40.3	607						
29	40.5	551						
30								
31								
32					55.0	1 142		

Table 25. Irish Sea (VIIa) and Bristol Channel (VIIf) Sole.
Parameters used in the yield equation.

	Irish Sea		Bristol Channel	
	♀	♂	♀	♂
W_∞	590.6	370.1	807.0	529.5
L_∞	39.6	33.8	42.9	39.4
K	0.329	0.152	0.217	0.174
t_o	0.7	-4.2	-0.1	-0.6
t_c	3.7	4.4	3.9	5.0
t_r	3.0	3.0	3.0	3.0

Table 26. Irish Sea (VIIa) and Bristol Channel (VIIf) Sole. Total mortality estimates from catch and effort data.

		1964/65	1965/66	1970/71	1971/72	1972/73	1973/74	Mean Z (1970-74)
Irish Sea								
Males and Females								
England & Wales (Fleetwood)		0.36	0.27	0.09	0.61	0.52	-	
(Milford)		-	-	0.29	0.39	0.50	-	
Males								
Belgium	Beam Trawl	-	-	0.37	0.66	0.23	0.30	0.370
	Otter Trawl	-	-	0.27	0.35	0.42	0.36	
Females								
Belgium	Beam Trawl	-	-	0.65	0.05	0.51	0.24	0.345
	Otter Trawl	-	-	0.55	-0.11	0.65	0.22	
Bristol Channel								
Males and Females								
England & Wales (Milford)		-	-	0.14	0.36	1.22	-	
Males								
Belgium	Beam Trawl	-	-	0.32	0.93	0.27	0.30	0.505
	Otter Trawl	-	-	0.31	0.87	1.11	-0.07	
Females								
Belgium	Beam Trawl	-	-	0.17	0.48	0.44	-0.05	0.231
	Otter Trawl	-	-	0.12	0.10	1.23	-0.64	

Table 27. Nominal catch (metric tons) of Plaice in the English Channel, 1964 - 1973 (Bulletin Statistique).

Year	U.K. (England/Wales)	France	Belgium	Netherlands	Total
1964	1 038	1 393	28	-	2 459
1965	1 286	2 130	33	-	3 449
1966	1 748	2 700*	25	-	4 473
1967	1 805	2 905	11	-	4 721
1968	1 354	1 920	30	-	3 304
1969	1 029	1 681	30	-	2 740
1970	1 517	2 161	183	6	3 867
1971	1 465	2 635	180	-	4 280
1972	1 182	1 866	177	17	3 242
1973	1 256	1 735	144	-	3 135

* Figure from Revue des Travaux de l'Institut des Pêches Maritimes raised to round fresh weight.

Table 28. English Channel Plaice. Catch per unit of fishing effort (kg gutted wt/100 hours fishing), 1969 - 1974.

	1969	1970	1971	1972	1973	1974
England (Brixham)	5.7	4.0	3.2	2.6	2.1	
Belgium (Beam Trawl)				3.5	6.9	8.3

Table 29. Statistical News Letter No.61 (1972) catch (by statistical rectangles) for which fishing effort data are available.

Country	Fishing area	News Letter		Bulletin Statistique		A/C	B/D
		A) Plaice (tons)	B) Sole (tons)	C) Plaice (tons)	D) Sole (tons)		
Belgium	IV	4 313	1 693	5 531	1 834	.78	.92
	VIIa	178	559	179	561	.99	1.00
	VIId,e	174	149	177	153	.98	.97
	VIIf	135	339	137	343	.99	.99
Denmark	IV	9 768	-	24 494	671	.40	-
Netherlands	IV	53 906	17 242	52 048	17 662	1.04*	.98
	VIIa	45	481	48	514	.94	.94
Total	IV	67 987	18 935	123 150	21 093	.60	.90
	VIIa	223	1 040	5 165	1 450	.04	.72
	VIId,e	174	149	3 242	1 360	.05	.11
	VIIf	135	339	624	548	.22	.62

*For IVb the coverage is 97%. A quantity of almost 3 000 tons more than the Bulletin Statistique figure for IVc was reported to the News Letter.

Table 30. Statistical News Letter No.61 (1972), stock record section. Catch (by statistical sub-area or division) for which fishing effort data are available.

Country	Fishing area	News Letter		Bulletin Statistique			
		A) Plaice (tons)	B) Sole (tons)	C) Plaice (tons)	D) Sole (tons)	A/C	B/D
Belgium[1]	IV	4 109	1 695	5 531	1 834	.74	.92
	VIIa	172	559	179	561	.96	1.00
	VIId,e	30	56	177	153	.17	.37
	VIIf + SE Ireland	198	542	...	...	...	...
Denmark	IV	-	526	24 494	671	-	.78
Netherlands[3]	IV	50 461	16 185	52 048	17 662	.97	.92
	VIIa	-	451	48	514	-	.88
U.K.[2] (England/ Wales)	IV	30 126	288	31 642	449	.95	.64
	VIIa	2 390	199	3 366	238	.71	.84
	VIId,e	212	145	1 182	523	.18	.28
	VIIf	178	62	377	123	.47	.50
Total	IV	84 696	18 694	123 150	21 093	.69	.89
	VIIa	2 562	1 209	5 165	1 450	.50	.83
	VIId,e	242	201	3 242	1 360	.07	.15
	VIIf + SE Ireland	376	604	624	548	.60	1.10

1) Belgium reported gutted weight. Conversion factor used here - plaice and sole 1.08.

2) England/Wales reported gutted weight. Conversion factor used here - plaice and sole 1.12.

3) Netherlands data refer only to beam trawl.

Table 31. Best total coverage in Tables 1 and 2.

Fishing area	News Letter		Bulletin Statistique		A/C	B/D
	A) Plaice (tons)	B) Sole (tons)	C) Plaice (tons)	D) Sole (tons)		
IV	98 113	19 751	123 150	21 093	.80	.94
VIIa	2 785	1 239	5 165	1 450	.54	.85
VIId,e	386	294	3 242	1 360	.12	.22
VIIf	313	401	624	548	.50	.73

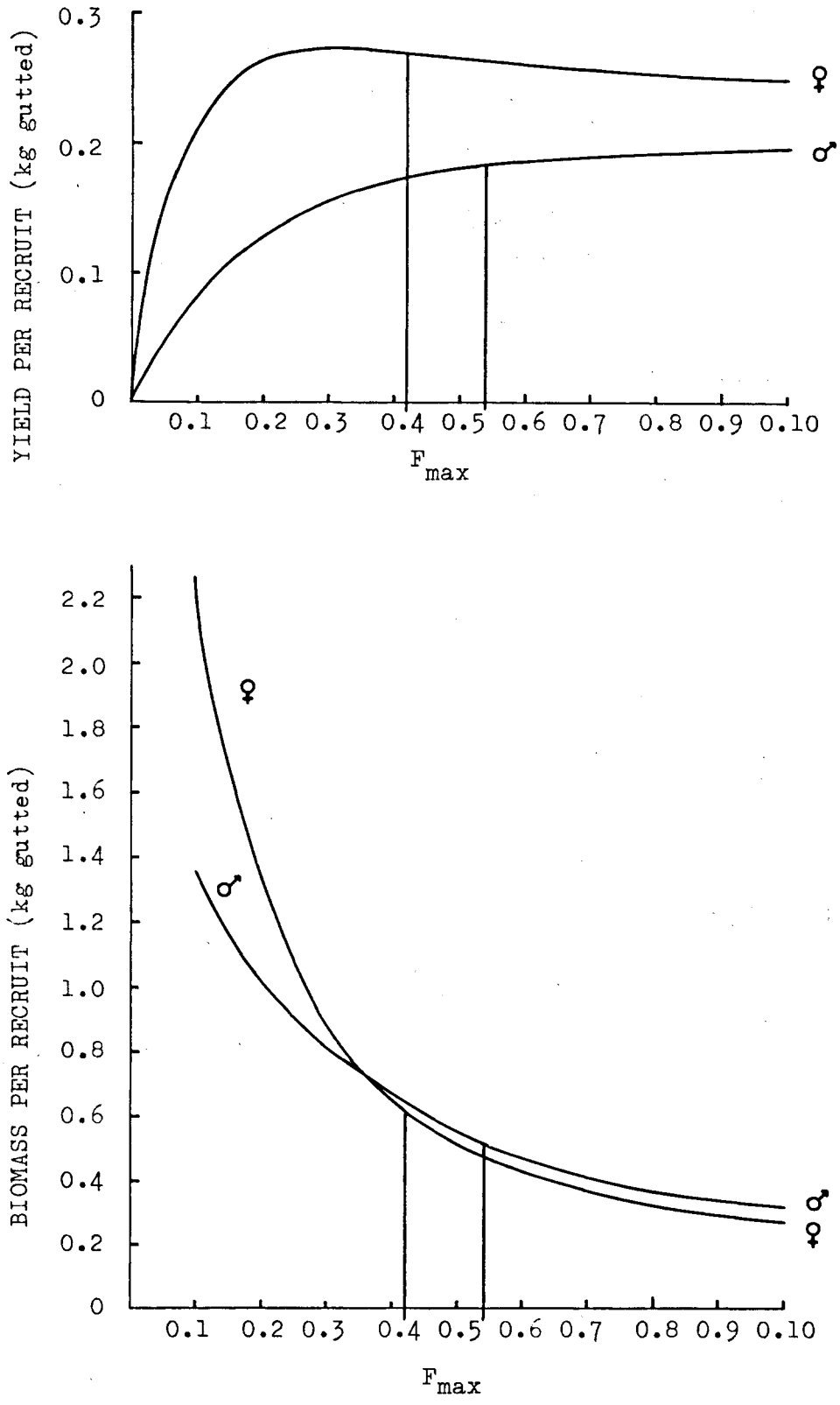


Figure 1. North Sea Plaice.

Relation between yield per recruit and biomass per recruit against steady-state F_{max}.

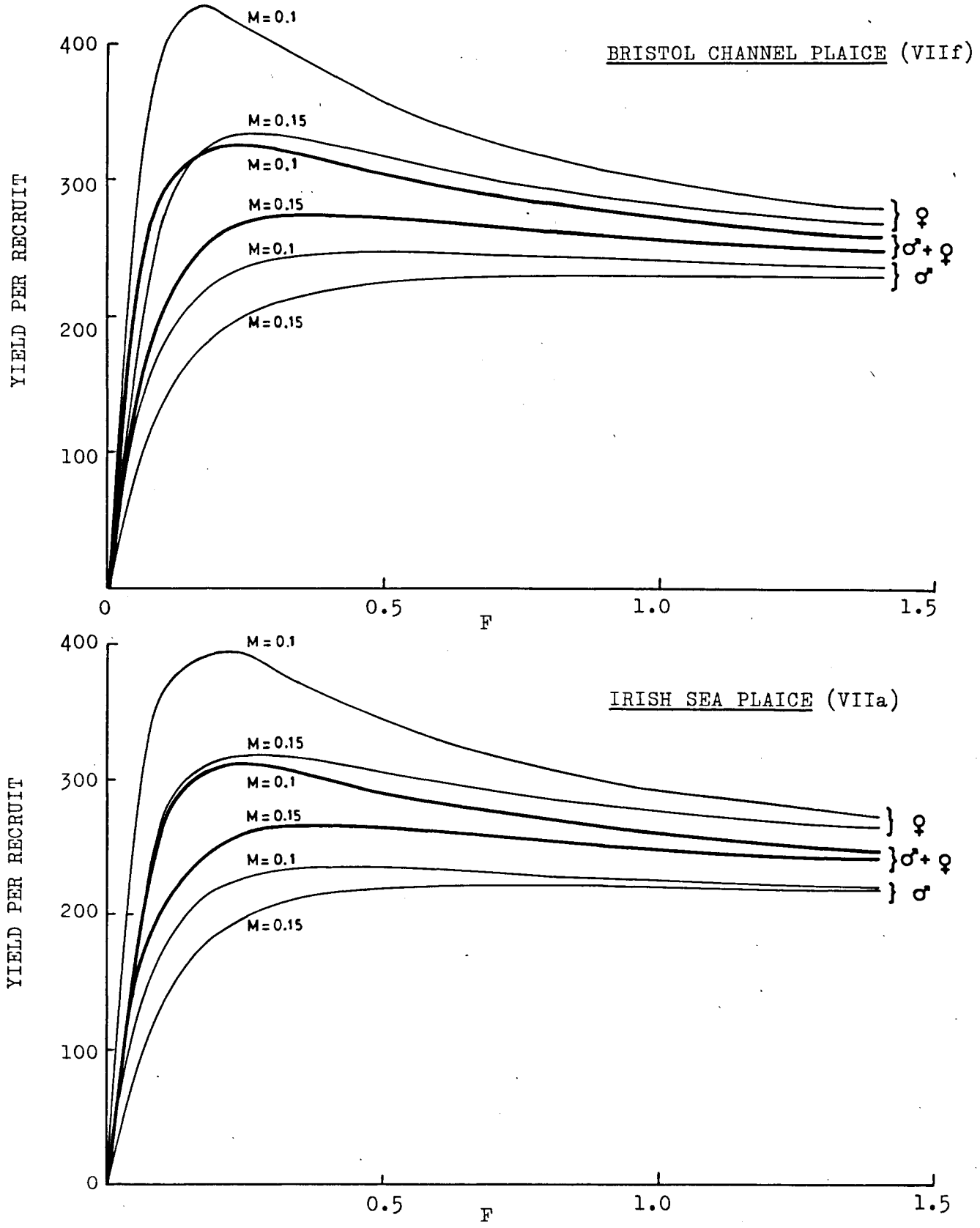


Figure 2. Irish Sea and Bristol Channel Plaice.

Yield per recruit against F at different levels of M.

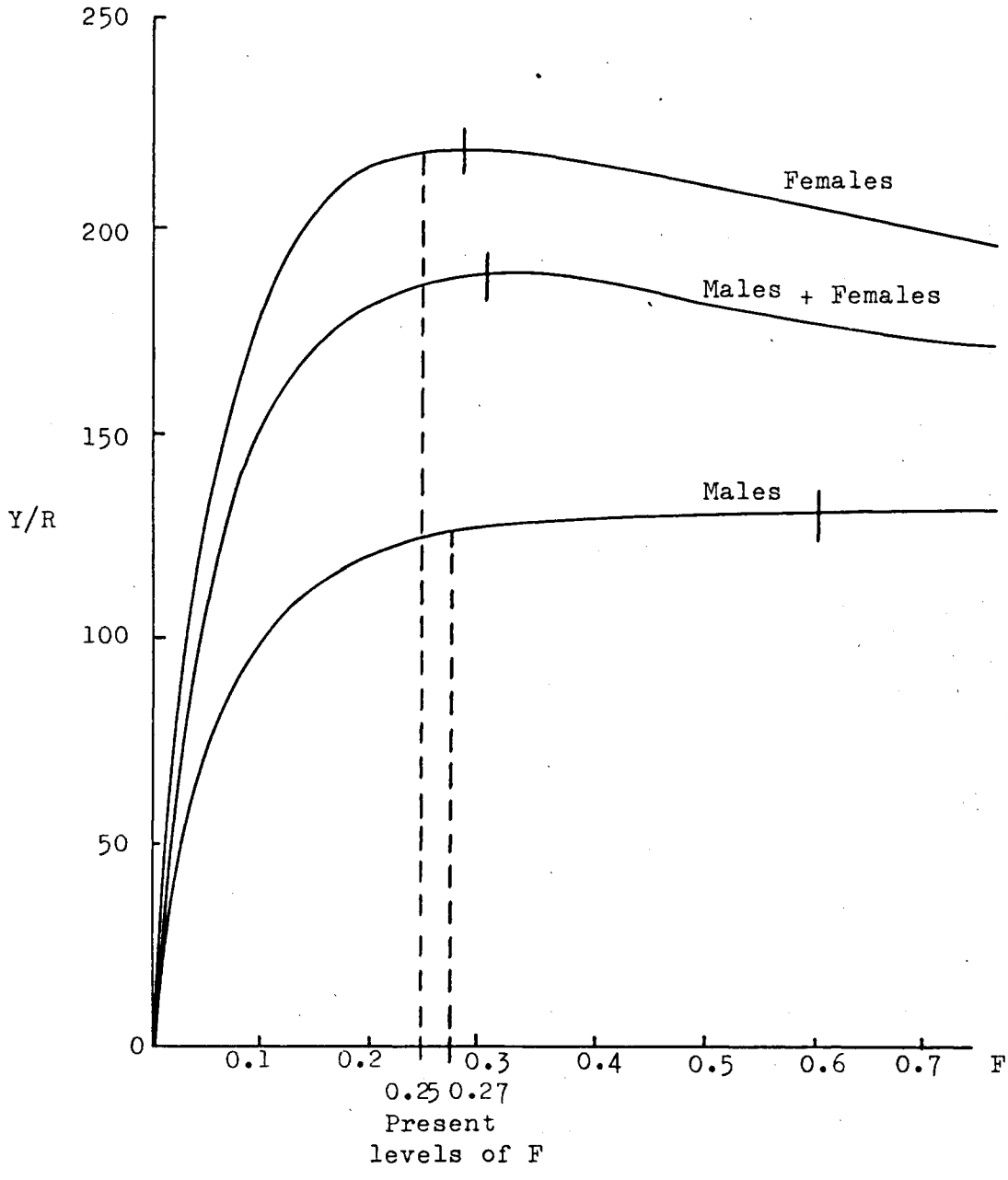


Figure 3. Sole in the Irish Sea.
Yield curve for males and females.

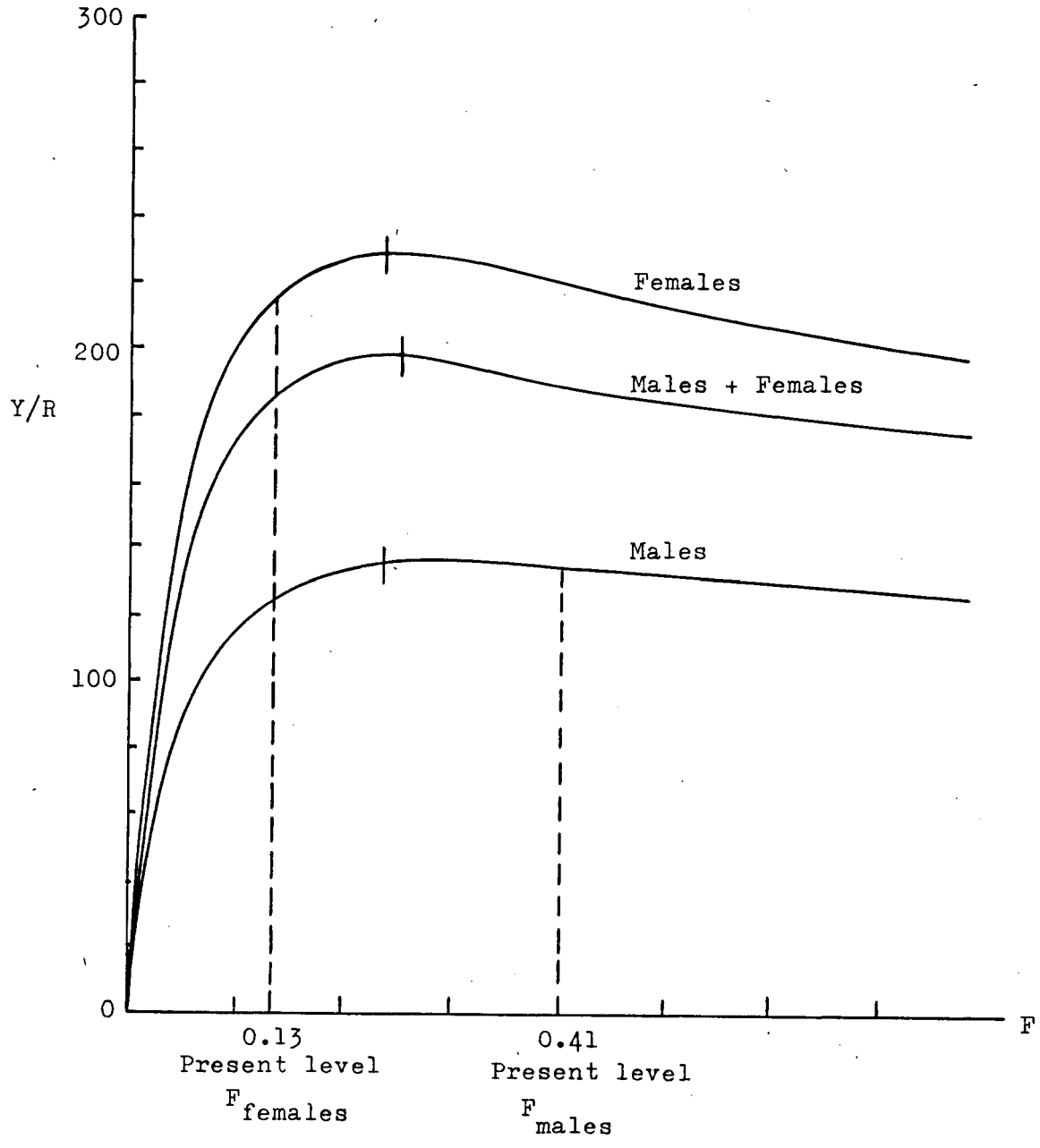


Figure 4. Sole in the Bristol Channel.
Yield curves for males and females.

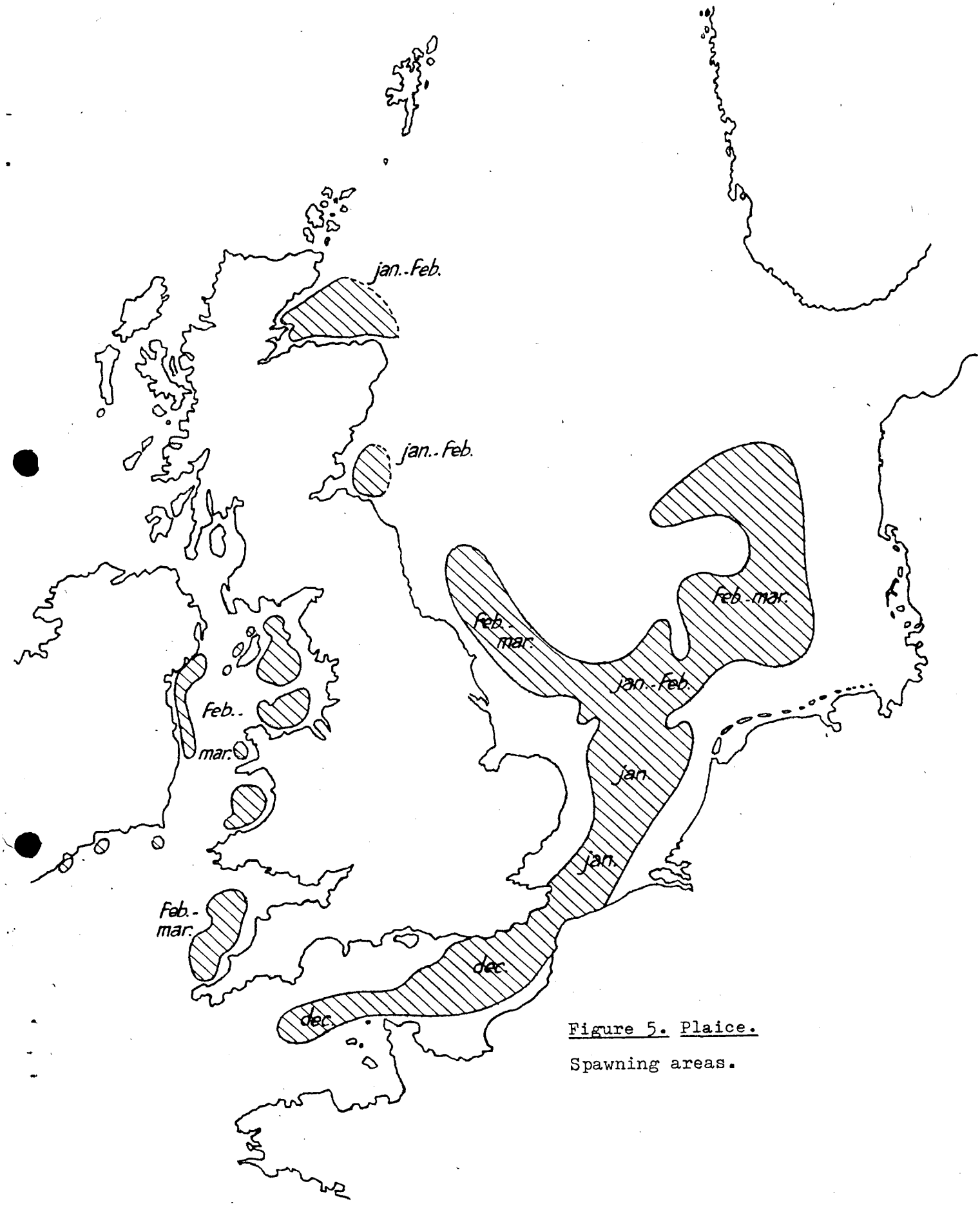


Figure 5. Plaice.

Spawning areas.

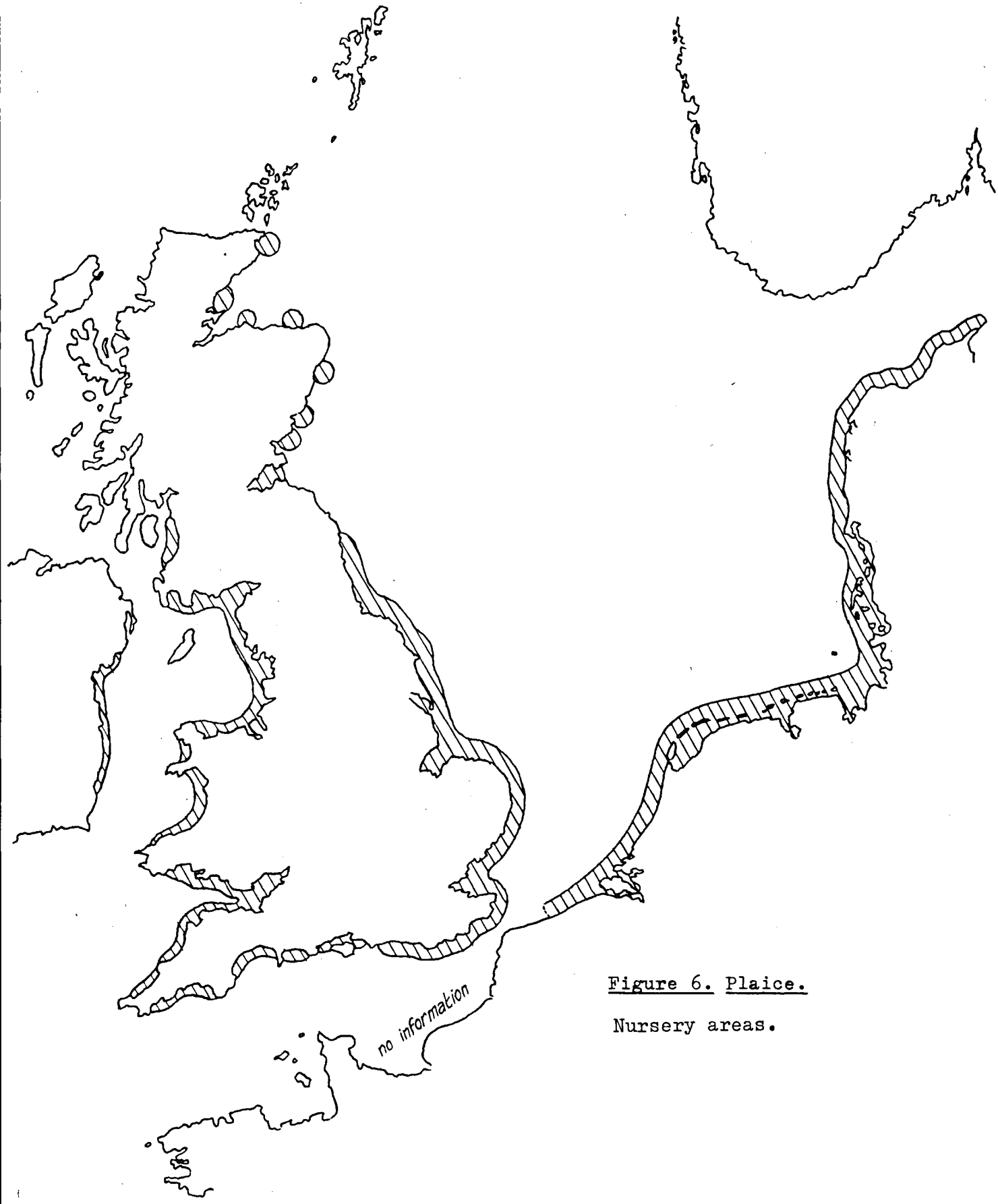


Figure 6. Plaice.

Nursery areas.

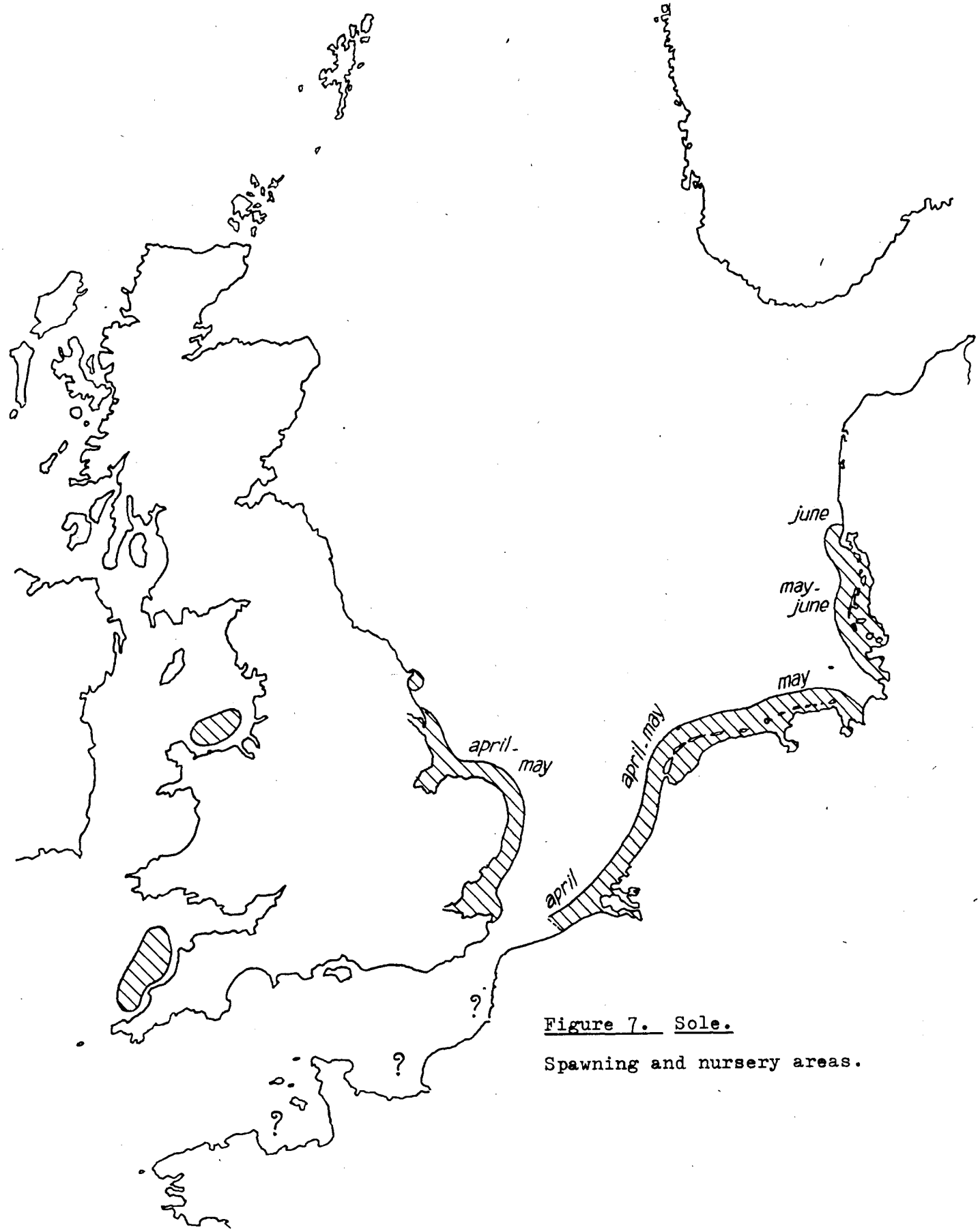


Figure 7. Sole.

Spawning and nursery areas.

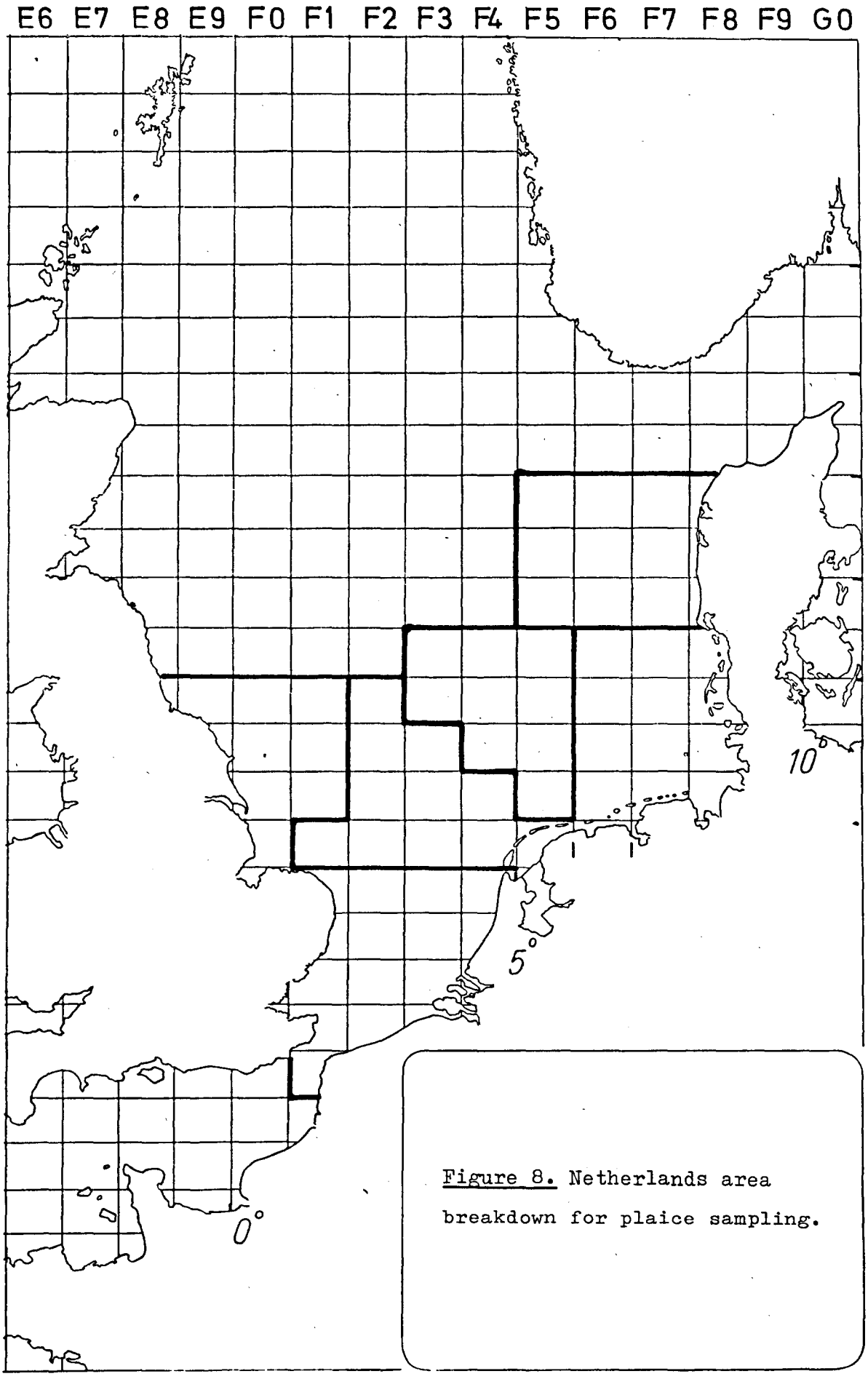


Figure 8. Netherlands area breakdown for plaice sampling.

APPENDIX I

Summary of National Sampling Systems

1. Denmark

1.1 Plaice

Monthly samples of landings in Esbjerg (20 kg from each of 4 size categories) are aged and raised on a quarterly basis to total Danish North Sea landings. As the fleets from other west coast ports partly exploit different fishing grounds, this procedure may give a biased composition of the Danish landings.

1.2 Sole

From the landings in the port of Hvide Sande in the second quarter of the year a random sample of about 2 000 sole is measured. Another sample of about 500 sole is aged (otoliths are burned). The age/length key is applied to the measured sample which is then raised to the Danish total.

2. Netherlands

2.1 Sole and plaice

The Dutch flatfish cutter fleet operates in a wide area covering the southern and most of the central North Sea. On a small scale they also seasonally exploit the Irish Sea sole stock. Place and sole are landed throughout the year in a number of fishing ports, of which IJmuiden takes the bulk followed at some distance by Urk.

2.2 Sampling procedure and working up of the data

2.2.1 Sampling for biological purposes (length, weight, age) is carried out throughout the year and the whole area exploited is covered on a sub-area basis. For plaice and sole intensive sampling is carried out during the spawning season and biological parameters for population studies are collected. In the other seasons a minimum of six samples for age determination are taken for plaice and a minimum of twelve samples for sole.

2.2.2 For sole no length measurements are carried out in the fish market since all soles are allocated to one of the five market size categories with the aid of a measuring board. The limits of these categories are the same throughout the country and thus the total of all market categories in all fish market gives an unbiased statistic. For age reading, samples of the market categories are purchased by the laboratory, and since the total weight and number in the samples are known the average weight can be calculated. Each sample produces a percentage age distribution for the relevant market category. Summing all the samples per stratum and dividing the total weight of the samples by the number of sole gives an unbiased average weight. Raising this average weight to the observed total weight in the commercial category statistics and multiplying this by the average percentage age distribution of the sum of the samples gives an estimate of the observed age composition of the total landings in the relevant market category. Summing up these raised age distributions for all market categories gives the estimated age composition of the total catch.

2.2.3 For plaice the situation is not so favourable. Allocation of landings to the various market categories is done by hand without a measuring board, and may be biased by personal factors. The length distribution of the landed plaice also may influence the sorter's views on the limits of the various market categories.

2.2.4 For this reason, plaice are measured on the fish market and samples are bought for assessing the length, age, weight and other parameters.

2.2.5 Through age/length keys the estimated length distribution is transformed into an age distribution whereby the weight of the samples is later raised to the total weight of the ship's catch sampled. Later the total of all ships sampled is raised to the Netherlands total landings. For sole as well as for plaice, sampling for age and for length is spread over the various fish markets, thus eliminating the effect of different fishing areas exploited by fleets landing in different ports.

2.2.6 Age reading for sole is carried out using the Møller Christensen burning technique, and for plaice a modified burning technique is used in difficult cases (mostly old fish). Sole otoliths are mounted in plasticine and kept in boxes. Plaice otoliths are kept in paper sacs and later read with transmitted light.

3. Federal Republic of Germany

3.1 Plaice

Most of the plaice caught by the Federal Republic of Germany cutters originate from the eastern North Sea (northern and southern Schlickbank). The majority of the plaice caught are landed at Hamburg fish market throughout the year. Sampling of the length/age data is carried out at least once a month.

3.2 Sampling procedure

3.2.1 The sampling of plaice is done on landing. Throughout the whole landing operation baskets of unsorted gutted plaice are measured by sex.

3.2.2 During one night approximately 400 - 1 000 specimens are measured. Once a month 200-500 otoliths of plaice, separated by sex, are taken from unsorted landings. Occasionally some additional otoliths, especially of the larger cm-groups, are taken.

3.3 Working up of the data

All otoliths are mounted on a dark background in polyester resin and read by reflected light. After all otoliths have been read, the age distribution per cm-group is raised to the total yearly length distribution. An average weight/length relationship per cm-group and sex is used to estimate the total weight of the samples for the year. (This weight/length key for all cm-groups and both sexes is derived from about 10 000 plaice weighed individually during the period 1969-74 during all months of the year). The age distribution (numbers per age group) is then raised to the total German landings.

4. Belgium

4.1 Sole and plaice

The Belgian flatfish landings originate from the North Sea (mainly Southern Bight), the English Channel, the Irish Sea and the Bristol

Channel. In the two latter regions, fishing takes place mainly during the spawning season of the soles. The landings are sampled in the three Belgian fishing ports, Ostende, Zeebrugge and Nieuwport.

4.2 Sampling procedure and working up of the data

The sampling is carried out throughout the year, except for the plaice in Divisions VIIa and VIIf where samples are only taken during the first quarter of the year (spawning season). The catch in the Belgian ports is divided into a number of size categories for sole and plaice. From each of these categories samples are taken on a weekly basis for length measurements. For age reading, samples are taken from every category of every region for both species. For the age reading of sole the Møller Christensen burning technique is used and for plaice the transmitted light technique. The length distribution of the total catch of each category is derived on a quarterly basis from the length measurements in the fish market. The estimation of the age composition is carried out by transforming the age distribution of the samples to the length composition of the total catch per quarter.

5. Scotland

5.1 Estimation of length frequency

5.1.1 For each vessel sampled, all the fish in a 1 cwt (50.8 kg) box of each category landed by that vessel are measured. The total weight of each category landed by the vessel is recorded, and the ratio:

Weight of category landed by vessel/Weight measured

is used to raise the category length frequencies. The category length frequencies are then added to give a vessel length frequency.

5.1.2 This operation is repeated each month for up to 4 seiners, trawlers, and light trawlers from each market sample area. Monthly boat length frequencies for each vessel type within each market sample are then added and the results raised by the ratio:

Total weight landed by vessel type during month/Weight represented by vessel length frequencies

to give the total length frequency for each vessel type for the month.

5.2 Age/length keys

While measuring fish for the estimation of length frequencies, up to 10 otoliths per cm-group are collected for each gear/area combination in each month.

6. Ireland

6.1 From 1962 to 1966 the commercial catch was examined both on the Dublin fish market (no sales took place at the port of landing) and at sea aboard the vessels. No size grading of the commercial catch was carried out at sea, nor on the market, and so no stratification of sampling was possible on that basis. Furthermore the extent of the overlap in length range between the different age groups present was so great that sub-sampling from the normal 45 kg fish box, or even from the catch of one boat, was

not reliable for the purposes of assessing the age distribution of the landed catch. Consequently, whole boat catches were the smallest samples examined, and length data (by sexes) were collected monthly at first and later quarterly. The total weight of each sample was recorded. On commercial vessels at sea, the whole catch was examined for length and sexual maturity, and otoliths were taken from all fish. The same practice was carried out on research vessel catches.

6.2 A new catch sampling programme will commence shortly.

7. England

7.1 Since 1955 routine English market sampling of North Sea plaice landings has followed the principle of a random selection of the available strata at Grimsby and Lowestoft, the ports which account for most of the landings.

7.2 The length sampling programme involves measuring plaice in a 10-stone (64 kg) box from each of four size categories from four landings in each week of each month of the year. The sample length distributions are raised to the total category landing of each ship, combined by categories for the sixteen sampled ships each month,and raised to the total month by category landing. Finally, the raised measurement for all categories are combined. Subsequently, the monthly length distributions are combined on a quarterly basis for use with the age/length key. All together about 6 000 plaice are measured each month and the overall intensity of sampling is about one measured sample per 71 tons landed. The most important grounds fished by each sampled vessel are usually known, so that the length samples can be ascribed to particular areas of origin. However, the samples are actually taken at random and without prior reference to the area of origin and the final length distribution is therefore nominally representative only of the whole area fished by Lowestoft and Grimsby vessels in each quarter.

7.3 The length distributions are aged on a quarterly basis using age/length keys derived from otoliths selected at random from the landings, but stratified by length group. The target is some 150 fish per month at each port, comprising 25 fish per 5 cm length group, and representing a sampling intensity of one otolith per 22 tons landed. Otolith samples can be attributed to a specific rectangle of origin but as before the actual areas represented are not pre-determined at the time of sampling.

7.4 The annual age composition represents the sum of four quarterly age compositions, summed for Lowestoft and Grimsby and raised to the total annual English North Sea plaice landings.

APPENDIX II

Virtual Population Analysis for North Sea Plaice with Special Reference to Young Plaice Fisheries, and Assuming M Varying with Age

by E. Ursin

Danmarks Fiskeri- og Havundersøgelser, Charlottenlund

The assumptions underlying the present application of the VPA method differ in two respects from those adopted by Bannister (C.M.1973/F:31). The raising of available data to account for the entire plaice fishery in the North Sea is made differently in order to obtain a more realistic representation of the young plaice fishery and hence of the young plaice stock. The natural mortality is guessed after some reasoning on the probable causes of mortality and their effects on individual age groups. The data was processed with a recent release of the VPA programme for the NOVA 1200 computer in Charlottenlund, written by H. Lassen and P. Sparre.

Table 3 has the age composition of total landings as calculated in the present paper. Table 4 is the estimated fishing mortality rates and Table 5 the estimated stock numbers. Tables 6 and 7 summarise Tables 4 and 5 for five year periods. Figure 1 illustrates the strength of individual year classes.

Terminal F values were selected to produce fairly constant F values for fish 8-11 years old within each year of observation. This was achieved by putting terminal F equal to 0.4 in most cases. Age groups 1-14 are included in the analysis.

Comments on underlying assumptions are given below followed by a comparison of the present results with Bannister's.

Raising Numbers Caught in Some Fisheries to Total North Sea Catch

The method used by Bannister is as follows :

1. Lowestoft (and Grimsby ?) age compositions were raised to total British catch (Bulletin Statistique).
2. For the years 1947-1957 British data were raised for the total North Sea catch.
3. Since 1958 Dutch catches (age composition in Statistical News Letters) were added to British catches and then raised to total North Sea catch.

The procedure is consistent with the assumption that until 1958 all North Sea effort was distributed as British effort. Since 1958 Britain and the Netherlands fished more or less separate areas while other nations fished both of these areas.

Although having the merit of simplicity these assumptions are perhaps not the most realistic ones possible. A different and perhaps more realistic approach can be based on a paper by Gulland (Journal du Conseil, Vol. 31, p.305; 1968) who stresses the difference in size(and age) composition of British, Dutch and Danish catches as published in Statistical News Letters : British fishing mainly on the offshore stock of adult plaice with a sprinkling of immature plaice from Dutch and German coastal waters; Dutch fishing in the Southern North Sea with a large proportion of immature

plaice; and Danish fishing in the Eastern North Sea, mainly on immature plaice. There is no clear indication that these patterns underwent major changes since the war except that English effort withdrew from the continental coast about 1950 (Gulland)and that quite recently Danish effort may have spread over a larger area.

In order to visualise the assumptions necessary to utilise this information, consider the age composition data available :

1. British landings since 1948 (courtesy of Dr Bannister);
2. Dutch landings since 1958 (Statistical News Letters);
3. Danish landings in Esbjerg in 1960 and 1961 (Statistical News Letters).

As in Bannister's approach, the raising procedure must use the age compositions of British catches as reference. This can be done on two assumptions :

1. Year class strength is the same throughout the North Sea.
2. Such trends as there may have been in British age compositions due to changing market demands, fishery regulation measures, etc. were reflected in other landings too.

The realism of these assumptions should be appraised if possible. Suffice to say for the time being that they are inherent in Bannister's raising procedure as well.

On the said assumption a raising procedure as described below can be adopted. Table 1 shows the age composition of 1 000 kg of plaice landed in 1960-61 in Lowestoft-Grimsby and in Esbjerg. Column D shows the ratio for each age group. There were 15 times as many group II plaice in Danish as in English landings and 20 times as many old plaice in English landings as in Danish. Multiplication of these ratios by, for any year, the corresponding numbers landed in Britain and the ratio between British and Danish total yields provides an estimate of the age composition of Danish landings in that year, reflecting the year class strength in the British age compositions. The two right hand columns of Table 1 show an example.

A similar procedure was followed to simulate Dutch age compositions before 1958. Table 2 shows the raising factors calculated from the first three years of Dutch statistics (1958-1960). The age composition of Dutch landings are more or less intermediate between those of British and Danish landings. Landings by other countries than Great Britain, Netherlands and Denmark were pooled and assumed to have the same age compositions as Dutch landings.

The calculated age compositions of total landings 1948-1972 are given in Table 3. As already mentioned with reference to Gulland the figures for 1948-1949 are not reliable because of a pronounced change in the distribution of British effort.

Several means of improving the realism of the age compositions should probably be considered :

1. The Lowestoft-Grimsby landings might make a better source of reference if recalculated as the sum of e.g. 100 hours catch from each of the areas distinguished in Gulland's paper (his Figure 4). That would remove most of the effects of English effort moving between areas from one year to the next.

2. A more realistic simulation of Danish landings probably could be obtained by including information on the age composition in 1973-1974 (data being processed at the moment). There has been some change in the distribution of effort since 1960 and the minimum legal size was increased from 26.0 cm to 26.5 cm in 1962, and again to 27.0 cm in 1967. The effects on age composition are not reflected in Table 3.

3. It is not quite clear if Dutch statistics (Statisticial News Letters) include in some years fish discarded at sea. A discrepancy between Statistical News Letter data and Bulletin Statistique might be due to that :

	1967	1968
Statistical News Letters	29 785	33 535
Bulletin Statistique	21 250	30 140

Also, the Dutch figures for 1967 in Statistical News letters might be looked into: catch/effort and total catch were very low, yet the numbers caught were high even though the plaice do not seem to have been particularly young (small) that year.

4. It should be possible to make separate estimates for males and females as Bannister did. Dutch and British data are presented for each sex and Danish catches probably could fairly safely be distributed according to the sex ratio of each age group in British and Dutch age compositions.

Natural Mortality

Beverton and Holt (1957, page 242) found $Z = 0.06/\text{year}^{-1}$ a slightly underestimated value for the total mortality rate of adult plaice in the North Sea during the war 1940-1945 when little fishing was going on. As a cautious estimate they put $M = 0.1$ which figure has been used by most workers ever since. Daan (C.M.1973/F:38) found that the numbers of young fish of several species consumed by cod in the North Sea are not much below the recruit numbers of slightly older fish. Plaice is one of these species. Odds are that natural mortality has generally been underestimated for young fish and overestimated for old fish. Also to remember is the result of the North Sea Herring Working Group who estimated $M = 0.07$ for adult herring although herring is a fairly small species more vulnerable than plaice to predation in the adult phase. Plaice, therefore, may be expected to have a natural mortality lower than that of herring unless they suffer from important diseases to which herring is immune, or unless adult plaice tend to leave the North Sea.

Experience with a multi-species Beverton and Holt model (C.M.1973/H:20, C.M.1974/H:40) shows that under the general assumption on food consumption and predation mortality underlying that model (assumptions apparently consistent with the results obtained by Daan referred to above) a natural mortality varying as outlined above is easily simulated, whereas a constant M is difficult to achieve unless it is arbitrarly decided that an appropriate number of plaice drop dead for no apparent reason.

The M values used in the present VPA are as follows :

Age	I	II	III	IV	V	VI+
M	0.43	0.22	0.21	0.09	0.05	0.04

They are supposed to include Waddensea fishing mortality, discard mortality, and natural mortality due to disease (assumed 0.02 through-

out) and predation. They are as much guesses as the traditional M = 0.1, but seem to account for the numbers in the shrimp fisheries (C.M.1972/F:2) or discarded at sea (C.M.1971/B:11) and to leave ample opportunity for predators to feed.

Comparison with Bannister's Results

Tables 6 and 7 contain 3 sets of estimated fishing mortality coefficients and stock numbers for 1961-1965. They are :

1. Present investigation, M varying with age (see above);
2. Present investigation, M = 0.1;
3. Bannister's estimates, M = 0.1, different data raising procedure.

Using for the moment case 1. as reference point we find that the introduction of a constant M = 0.1 (case 2.) reduces the estimates of F for the older year classes, but not for the youngest ones. Stock number estimates are lower for young fish, slightly higher for old fish.

Introducing also Bannister's raising procedure (a larger part of the fishery assumed placed on the adult stock) has similar yet stronger effects : the stock of old plaice would be larger, that of young plaice smaller, fishing mortalities lower for all ages; later recruitment.

Recruit number estimates at age 2 years are shown in Figure 1 for the two extreme cases : Bannister against the present investigations with varying M. The correlation is generally good, with 30% higher numbers in the present investigation. The only discrepancy is that Bannister has high estimates for the year classes 1964-1967. The effect is the impression that recruitment stabilised itself at a higher level in 1957 whereas the present investigation has a temporary and perhaps accidental increase in 1957-1962 and, of course, in 1963 when recruitment was exceptional. The cause of the disagreement on recruitment numbers in 1964-1967 is not obvious. It is introduced by applying the different raising techniques, not by changing M.

By and large the two sets of estimates, Bannister's and the present one, are comfortably like each other in spite of conspicuous differences in data raising procedure, M, and terminal F. The immediate effect is to increase confidence in the VPA method. Yet it should cautiously be remembered that the decision that a VPA has been concluded is that the results seem sensible, i.e. are not different from the investigator's preconceived ideas. Because most workers in a field of investigation are likely to have ideas to some extent similar, it is perhaps not a complete surprise that they arrive at similar results in such circumstances.

Table 1 Example of procedure for estimating age compositions in Danish landings.

Age Group	No. in 1 ton in 1960-1961			Landings in thousands, 1955	
	Lowestoft-Grimsby	Esbjerg	Ratio	British	Estimated Danish
A	B	C	$D = \frac{C}{B}$	E	$\frac{D \times E \times 18\,771}{25\,196}$
1	0	0.7	-		
2	7.5	114.6	15	187	2 090
3	199.8	1 667.5	8.3	4 412	27 282
4	429.5	2 018.4	4.7	6 516	22 816
5	269.0	221.0	0.82	14 966	9 143
6	241.2	47.9	0.20	8 942	1 332
7	184.9	30.6	0.17	5 369	680
8	118.9	14.1	0.12	5 966	533
9	74.3	4.3	0.058	2 382	103
10	60.4	4.4	0.073	1 688	92
11	51.0	2.2	0.043	923	30
12	38.6			660	25
13	29.3	111.1	5.5	511	19
14	17.1			424	16
15+	26.1		0.050	375	14
Total No.,	1 747.0	4 131.2		53 321	64 175
Tons	1	1		25 196	18 771
Average weight grams	572	242		473	292

Table 2 Dutch/British age composition ratios,: c.f. Table 1

Age Group	No. in 1 ton in 1958-1960		Ratio
	Lowestoft-Grimsby	Netherlands	
A	B	C	D = C/B
1			
2	21.3	308.7	14.5
3	189.8	876.3	4.6
4	379.9	695.5	1.8
5	358.4	387.2	1.1
6	306.8	206.2	0.67
7	167.0	98.1	0.59
8	114.1	49.4	0.43
9	87.1	40.0	0.46
10	73.0	33.4	0.46
11	61.0	24.4	0.40
12	42.2	16.1	0.38
13	25.4	9.2	0.36
14	13.3	4.1	0.31
15	24.2	3.6	0.28
16		1.7	
17		1.1	
18+		0.4	
		6.8	
Total No.,	1 863.5	2 755.4	
Tons	1	1	
Average weight grams	537	363	

Table 3 North Sea Plaice Catches as calculated by E. Ursin (6.2.1975) Millions

Input data catch in numbers by year and by age

Age	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
1	0	0	0	0	0	0	0	0	0	0	0	0
2	17.6	4.9	1.9	6.0	18.0	1.6	10.3	4.4	9.8	2.7	11.0	28.4
3	202.6	114.7	55.6	36.0	57.7	39.4	43.7	47.6	44.0	60.4	38.1	57.2
4	161.0	259.5	118.1	130.7	59.4	88.8	80.5	38.3	83.6	67.1	98.9	44.1
5	45.0	39.3	52.9	50.0	58.9	29.6	30.1	36.8	15.4	34.0	29.3	35.3
6	10.4	9.2	9.9	19.0	22.0	31.9	12.0	14.9	14.4	7.8	13.4	15.0
7	5.0	3.6	4.7	4.9	9.9	13.7	16.7	8.5	8.4	8.8	4.9	9.6
8	3.2	2.7	2.1	2.1	12.7	6.4	6.2	8.5	5.0	5.6	5.2	3.9
9	3.1	2.1	2.3	0.9	1.6	2.6	3.7	3.3	5.2	3.8	3.8	4.1
10	2.3	2.4	2.1	0.8	1.3	1.6	1.6	2.4	2.5	3.5	2.5	3.6
11	1.7	1.9	2.0	0.7	1.1	1.5	0.8	1.2	1.4	2.0	2.9	2.3
12	1.4	1.1	1.6	1.0	1.0	1.1	0.7	0.9	0.7	1.0	1.2	2.3
13	0.8	1.1	0.7	0.8	0.6	0.8	0.9	0.7	0.5	0.6	0.8	1.1
14	0.5	0.5	0.6	0.7	0.3	0.7	0.5	0.5	0.3	0.5	0.4	0.6
15+	0.4	0.6	0.7	2.9	0.4	0.6	1.0	0.5	0.4	0.7	0.7	1.0
Sum	455.0	443.6	255.2	256.5	244.9	220.3	208.7	168.5	191.6	198.5	213.1	208.5

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0	0	0	0	0	0	0	0	0	2	1.6	0.8	1.3
2	8.7	4.1	2.2	7.9	25.3	17.7	8.1	5.7	13.3	19.4	31.8	50.6	32.3
3	115.2	58.5	62.9	45.3	89.6	95.6	124.9	46.2	61.1	58.6	90.4	98.6	70.1
4	86.1	112.5	108.8	147.8	133.3	105.6	98.7	243.6	64.7	53.0	90.8	60.7	87.3
5	16.6	26.9	48.8	59.1	53.4	41.5	31.9	42.2	116.3	31.6	37.2	16.0	21.8
6	17.4	9.0	17.1	24.6	25.8	23.1	17.4	19.9	13.3	73.9	24.9	19.1	14.8
7	8.9	9.6	7.0	9.7	10.2	12.7	11.4	14.7	7.2	7.6	59.6	11.8	13.4
8	5.1	6.0	6.7	4.8	3.9	6.4	7.5	5.7	7.6	4.3	5.3	23.3	12.3
9	7.9	3.8	3.3	4.0	2.3	2.9	4.4	6.2	3.0	6.2	3.1	4.1	19.2
10	2.8	2.4	2.6	2.7	2.4	2.2	2.3	2.2	3.8	2.7	3.9	3.3	4.6
11	1.9	2.1	1.5	2.3	1.9	2.3	1.4	1.5	1.6	3.1	1.6	2.8	4.2
12	1.4	1.7	1.7	1.4	1.2	1.4	1.9	0.8	1.3	1.5	2.3	1.7	4.8
13	1.1	1.2	1.2	1.3	0.9	2.6	1.2	1.2	0.7	1.0	0.9	1.7	2.4
14	0.5	0.8	0.9	0.9	0.8	1.0	0.9	0.7	0.8	0.5	0.7	0.7	2.4
15+	0.9	1.0	0.9	2.0	3.2	3.4	3.3	2.5	2.5	2.8	2.2	3.3	5.9
Sum	274.5	239.6	265.6	313.8	354.2	318.4	315.3	393.1	297.2	266.4	356.3	298.5	296.8

Table 4 Virtual Population Analysis

North Sea Plaice

Fishing Mortalities Row 14 and column 1972 : terminal F

Age	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.04	0.01	0.01	0.02	0.06	0.01	0.03	0.02	0.03	0.01	0.03	0.06	0.02
3	0.38	0.35	0.16	0.20	0.25	0.18	0.33	0.21	0.22	0.24	0.29	0.26	0.36
4	1.06	1.19	0.69	0.62	0.55	0.71	0.63	0.50	0.65	0.59	0.70	0.59	0.73
5	1.00	0.68	0.70	0.61	0.53	0.50	0.47	0.56	0.33	0.52	0.47	0.50	0.40
6	0.57	0.46	0.30	0.48	0.49	0.51	0.32	0.37	0.37	0.23	0.33	0.39	0.41
7	0.35	0.33	0.37	0.20	0.41	0.52	0.45	0.33	0.31	0.33	0.19	0.34	0.35
8	0.29	0.27	0.27	0.24	0.89	0.41	0.39	0.36	0.27	0.29	0.28	0.19	0.26
9	0.29	0.27	0.32	0.15	0.24	0.36	0.37	0.30	0.32	0.29	0.27	0.30	0.56
10	0.30	0.32	0.38	0.14	0.27	0.33	0.33	0.36	0.33	0.31	0.26	0.36	0.29
11	0.33	0.36	0.40	0.18	0.25	0.47	0.22	0.36	0.30	0.39	0.38	0.33	0.27
12	0.32	0.31	0.48	0.29	0.34	0.36	0.34	0.35	0.31	0.31	0.36	0.48	0.29
13	0.34	0.38	0.28	0.38	0.24	0.41	0.45	0.55	0.28	0.39	0.35	0.53	0.36
14	0.40	0.30	0.30	0.40	0.20	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40

Age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.01	0.01	0.02	0.06	0.02	0.02	0.02	0.04	0.07	0.08	0.18	0.10
3	0.18	0.18	0.14	0.32	0.35	0.16	0.19	0.28	0.28	0.50	0.40	0.40
4	0.67	0.54	0.77	0.71	0.74	0.69	0.50	0.43	0.40	0.85	0.70	0.70
5	0.45	0.59	0.55	0.60	0.43	0.44	0.61	0.40	0.33	0.46	0.29	0.50
6	0.33	0.48	0.56	0.40	0.47	0.27	0.45	0.32	0.39	0.39	0.37	0.40
7	0.34	0.37	0.45	0.39	0.29	0.37	0.31	0.24	0.26	0.52	0.27	0.40
8	0.35	0.35	0.39	0.27	0.37	0.24	0.27	0.22	0.19	0.24	0.33	0.40
9	0.26	0.27	0.30	0.27	0.27	0.39	0.26	0.18	0.23	0.17	0.25	0.40
10	0.27	0.23	0.31	0.24	0.37	0.30	0.28	0.21	0.21	0.19	0.22	0.40
11	0.30	0.23	0.28	0.31	0.32	0.35	0.27	0.28	0.22	0.15	0.17	0.40
12	0.34	0.36	0.29	0.19	0.33	0.40	0.29	0.33	0.38	0.21	0.20	0.40
13	0.35	0.35	0.42	0.25	0.65	0.43	0.39	0.37	0.37	0.34	0.20	0.40
14	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40

Table 5 Virtual Population Analysis

North Sea Plaice

Stock in Numbers

Age	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
1	824	424	563	539	335	546	471	625	327	547	857	779	815
2	555	536	276	366	351	218	355	307	407	213	356	558	506
3	700	430	426	220	289	266	173	276	242	318	168	276	422
4	256	386	246	295	146	182	180	101	181	157	203	102	173
5	73	81	107	112	146	77	82	88	56	86	80	92	52
6	24	25	39	51	58	81	44	49	48	39	49	47	53
7	17	13	15	28	30	34	47	31	32	32	29	34	31
8	13	12	9	10	22	19	20	29	21	23	22	23	23
9	12	9	9	7	8	9	12	13	19	16	17	16	19
10	9	9	7	6	6	6	6	8	9	13	11	12	11
11	6	6	6	4	5	4	4	4	5	6	9	8	8
12	5	4	4	4	4	4	2	3	3	4	4	6	6
13	3	4	3	3	3	2	3	2	2	2	3	3	4
14	2	2	2	2	2	2	2	2	1	2	1	2	2

Age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	743	699	732	1 830	570	538	536	519	689	537	581	1 600
2	530	484	455	476	1 191	371	350	349	338	448	348	377
3	398	422	386	358	360	940	290	276	268	254	331	234
4	239	270	285	272	210	206	650	194	169	165	125	180
5	76	112	144	120	122	92	95	362	115	104	64	57
6	33	46	59	79	63	76	56	49	231	79	63	46
7	34	23	27	32	51	38	56	34	34	150	52	41
8	21	23	15	17	21	36	25	39	26	25	85	38
9	17	14	16	10	12	14	28	18	30	21	19	59
10	10	13	10	11	7	9	9	20	15	23	17	14
11	8	7	10	7	8	5	6	7	16	11	18	13
12	6	6	6	7	5	6	3	5	5	12	9	15
13	4	4	4	4	6	3	4	2	3	3	9	7
14	2	3	3	2	3	3	2	2	2	2	2	7

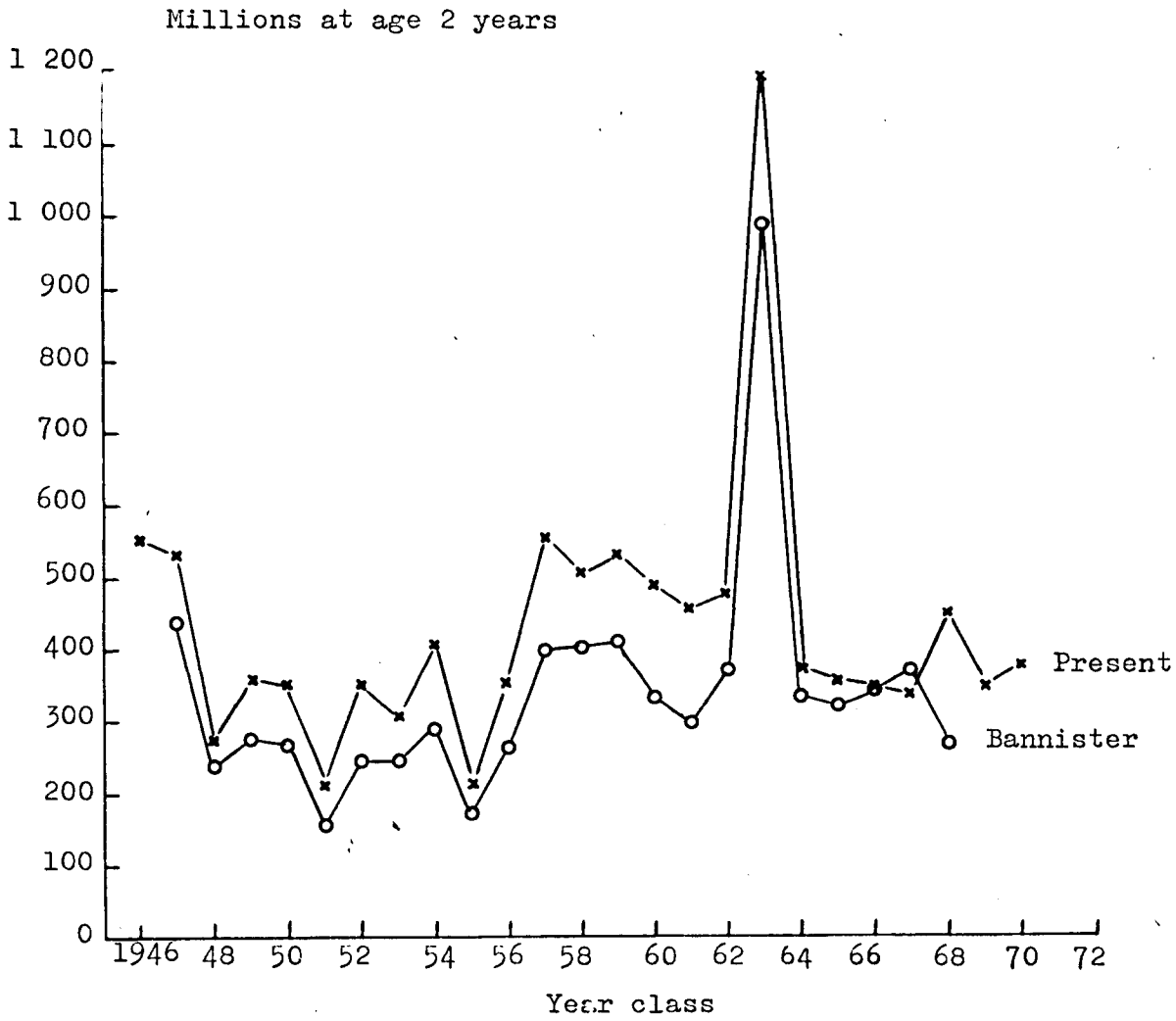
Table 6 Mean fishing mortality corefficients for five year periods, and for 1951-1970. Bannister's results for comparison

Age group	Present investigation M function of age				1951-70	M=0.10	Bannister	
	1951-55	1956-60	1961-65	1966-70		1961-65	1961-65 Males	1961-65 Females
2	0.03	0.03	0.02	0.05	0.03	0.03	0.02	0.02
3	0.23	0.27	0.23	0.28	0.25	0.23	0.12	0.13
4	0.60	0.65	0.69	0.57	0.63	0.61	0.39	0.25
5	0.53	0.44	0.52	0.45	0.49	0.45	0.52	0.26
6	0.43	0.35	0.45	0.36	0.40	0.37	0.53	0.25
7	0.38	0.30	0.37	0.34	0.35	0.31	0.43	0.21
8	0.46	0.26	0.35	0.23	0.33	0.29	0.37	0.19
9	0.28	0.35	0.27	0.25	0.29	0.23	0.31	0.17
10	0.29	0.31	0.28	0.24	0.28	0.25	0.30	0.17
11	0.30	0.33	0.29	0.25	0.29	0.26	0.26	0.18
12	0.34	0.35	0.30	0.32	0.33	0.28	0.21	0.19
13	0.41	0.38	0.40	0.38	0.39	0.39	0.15	0.22
(14)	(0.36)	(0.40)	(0.40)	(0.40)	(0.39)	(0.40)	0.16	0.21
Average 8-11	0.33	0.32	0.30	0.24	0.30	0.26	0.31	0.18

Table 7 Mean stock numbers (millions)in five year periods. Figures in brackets omit the exceptionally strong year class of 1963

Age group	Present investigation M function of age					M=0.10	Bannister
	1951-55	1956-60	1961-65	1966-70	1951-70	1961-65	1961-65
1	503	665	915(686)	564	662(600)	567(426)	-
2	319	408	627(486)	371	431(391)	540(419)	480
3	245	285	385	406(272)	330(298)	374	322
4	181	163	255	277(184)	219(196)	278	238
5	101	73	115	154(102)	111(98)	133	170
6	57	47	56	98(65)	65(56)	66	97
7	34	32	33	62(40)	40(34)	40	62
8	20	22	19	30	23	23	42
9	10	17	14	22	16	17	31
10	6	11	11	15	11	12	23
11	4	7	10	9	8	9	19
12	3	5	6	6	5	7	15
13	3	3	4	3	3	4	11
14	2	2	3	2	2	3	9
Sums:							
1-14	1 488	1 740	2 453(2 083)	2 019(1 685)	1 926(1 741)	2 073(1 811)	-
2-14	985	1 075	1 538(1 397)	1 455(891)	1 264(1 141)	1 506(1 385)	1 519
5-14	240	219	271	401(294)	284(256)	314	479

Figure 1 Estimated recruit numbers



APPENDIX III

Formulas and Calculations used in the Prognosis Program

by
H. Lassen

The basis for the assessments presented are the Beverton and Holt model, which may be formulated .

$$N_{a+1}^{y+1} = N_a^y \exp\left\{- F_a^y - M_a\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$C_a^y = N_a^y \frac{F_a^y}{Z_a^y} \left(1 - \exp\left\{- Z_a^y\right\}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$Z_a^y = F_a^y + M_a$$

$$Y^y = \sum_a W_a C_a^y \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where N_a^y is the number of fish in the stock at the beginning of year y at age a

C_a^y is the number of fish caught during year y at age a

Y^y is the catch in weight, yield, taken during year y

F_a^y is the instantaneous fishing mortality to which the N_a^y fish are exposed during year y.

M_a is the instantaneous natural mortality to which the N_a^y fish are exposed during year y.

W_a is the mean weight in the catch of fish at a years of age

The Beverton and Holt yield curve is

$$Y^y = \sum_a W_a C_a^y$$

$$W_a = W_\infty \left(1 - \exp\left\{- k(t - t_o)\right\}\right)^3$$

where W_∞, k and t_o are parameters. The yield curve is based on constant recruitment and $F_a^y = F$ and $M_a = M$ $a \geqslant t_r$ the recruiting age which obsoletes the superscript

$$Y = \sum_{a = t_r}^{t_\lambda} W_a C_a$$

where t_λ is the maximal age. Often this yield curve is presented as yield per recruits, Y/N_{t_r} .

The age distribution of catch C_a^y is observed, and an estimate of F_a^y is made on the basis of available information on fishing effort. M_a is only estimated once per decade and has to be assumed as being constant from year to year. Solving (2) with respect to N_a^y and applying (1) advances the calculation by one year. The catch weight is calculated using (3).

The fishing mortality at age array F_a^y is presented as F_{max} · relative F where relative F at age a = $F_a^y \cdot F_{a\ max}^y$

where y is the most recent year and the distribution is assumed to apply to the coming years.

The long-term biomass is calculated by

$$B^y = \sum_a W_a' \ N_a^y$$

where

W_a' is the mean weight at the beginning of the year, of fish of age a

B^y is the biomass of the stock at the beginning of year y

$$B = \sum_a W_a' \ N_a$$

where B is the biomass in the steady state situation,
with N_a as the solution of (1) when the recruitment is constant over all years and F_a^y and M_a are independent of y. The long-term effect is presented as

$$(B - B^{y_s})/B \times 100\%$$

y_s being the year when the regulatory measure investigated first takes effect, in the present Report 1976.