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**INTERNATIONAL COUNCIL FOR THE  
EXPLORATION OF THE SEA**

C.M. 1975/F : 27  
Demersal Fish (N) Committee



**AN ASSESSMENT OF THE DUTCH NORTH SEA PLAICE FISHERIES**

by

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Desarrollo Pesquero URU/71/517  
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1. Introduction

The ICES North Sea Flatfish Working Group has dealt with the North Sea plaice on a number of occasions. At the present meeting the latest report of the Group will be presented (F:4) in which the situation in the plaice fishery will be fully discussed. In this report the North Sea plaice has been considered as consisting of one stock.

Bannistor (1973\*) has given an assessment of the plaice stock, using English data and dealing with that part of the plaice stock exploited by the Lowestoft and Grimsby fishermen.

In terms of the sub-stocks distinguished in the Dutch plaice research, the English fishermen exploit mainly the German Bight and the Transition area sub-stocks. The Dutch fishermen exploit the Southern Bight sub-stock throughout the whole year and the Transition area and German Bight sub-stocks seasonally. Recently, however, the exploitation of these two sub-stocks by the Dutch fishermen has increased so that they are exploited nearly the whole year.

The purpose of the present paper is to give more information on the Dutch part of the total fishing mortality on plaice, assess the influence of Dutch effort on the main sub-stocks, and give yield curves for these sub-stocks, based on Dutch growth data. A new virtual population analysis will be carried out based on total international catch instead of total landings as has been the case in the Flatfish Working Group report. This has been made possible by new information on the amount and survival rates of discarded plaice (de Veen, Huwae and Lavaleye, C.M. 1975/F:28).

Our paper should be considered as an addition to Bannister's paper and to the report of the Flatfish Working Group.

2. The Dutch plaice fishery

The part of the North Sea plaice landings caught by the Dutch fishermen has been constant up to 1961 (see table 1).

Since 1962 the percentage of the Dutch part of the total plaice landings has increased steadily from 20% to nearly 50% in 1974. This has been caused by the introduction of the beamtrawl, which is, beside being an excellent sole catching device, also able to catch large quantities of plaice.

Total landings have risen since 1961, among others by the increased level of recruitment including the very strong yearclass 1963. This rise has mainly gone to the Dutch fisheries. Table 1 shows that the rise in the landings of the other nations is much less pronounced.

3. Catch per effort in the Dutch fishery

The Dutch beamtrawlers increased the engine power of their motors and hence their efficiency in sole and plaice catching. The catch per hours fishing will then give a biased index of stock abundance. Sichone and de Veen (1973) have studied the changes in fishing power of the Dutch beamtrawlers and found that the relationship between fishing power (y) and brake horse power of the engine (x) being the main responsible factor, can be given by the equation:

$$\log_e y = 5.854 + \log_e x.$$

The following table gives the average brake horse power of the Dutch cutterfleet on the 1<sup>st</sup> of January in the years 1960 - 1975 together with the correction-factors for adjusting the catch per effort for the increase in the engine-power.

Table 2

year	1960	'63	'65	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75
average b.h.p.	194	240	258	274	291	324	378	425	452	471	513	621	747
correction factor for fish-power	1.14	1.03	1	0.97	0.95	0.90	0.84	0.80	0.77	0.76	0.73	0.67	0.62

The year 1965 was taken as standard.

When applying these correction-factors for the fishing power we arrive at an unbiased index of stock abundance as shown in figure 1. This figure shows that the highest catch per effort usually is made in the first three months of the year. On average the level of catch per effort has been fairly constant from 1962 - 1968. In 1969 catch p.e. in the first quarter increased and after maximum values in 1970 and 1971 catch p.e. slowly started to decrease again.

The catch p.e. data for Lowestoft trawlers (Bannister, 1973) are also shown in figure 1 as crosses.

The continuous increase in abundance given by the English data and caused by an increased level of recruitment including the very rich 1963 yearclass, is not shown in the Dutch data as a whole. However, when taking only the peaks in the Dutch curve there is reasonable agreement with the English data. This suggests that the first quarter data in the Dutch fishery, which are representative of all members of the population then aggregated on the spawning grounds and fully exploited, form a much better index of stock abundance than the data in other seasons when only the younger part of the population is covered by the Dutch fishery. If so, stock abundance has increased from 1962 to 1970-71 and is now again decreasing.

4.1. Mortality-rates Estimation of total mortality by catch p.e.

The total mortality rate  $Z$  for males and females were calculated for the three substocks Southern Bight, Transition area and German Bight from the annual age-compositions per 100 hours fishing corrected for changes in efficiency along the lines given in the preceding section (table 3). The values of  $Z$  are given in table 4. For the sake of comparison the age-groups were combined in three categories viz. A 4,5,6 years, B 7 - 11 and C 12,13,14 years. Mean values for these categories were calculated for males and females for the periods 1964 - 1969 and for 1970 - 1974. (table 5 and figure 2). The age-groups younger than 4 were not used because they are not fully recruited; and age-groups 15 and older were omitted because of their high variance and their minor importance in the age-composition.

As is evident from table 5 and figure 2 the general trend of  $Z$  is an increase with some exceptions for age-category C. However, the decrease in B for males in the Transition area is significant. Another feature of is that the values of  $Z$  for males are always higher than the corresponding values for females, except in age-category C in the Transition area, where total mortality in females is substantially higher than in the males. In the Southern Bight the average values of  $Z$  in both sexes is higher in A and B and lower in C. In the Transition area and in the German Bight total mortality in females increases from A to C. In males  $Z$  in the A group is less than in group B, but C has a very low  $Z$  value.

Comparing the values in the three sub-stocks, we find that  $Z$  in group A is highest both for males and females in the Southern Bight, intermediate in the Transition area and lowest in the German Bight. For group B the same is true for females but for males only in the period 1970-'74.

Group C in which  $Z$  has a high variance, total mortality is highest in males in the Transition area but lowest in females in this sub-stock.

4.2 Mortality rates, fishing mortality by virtual population analysis

De Veen and Rodenburg (1973) and de Veen, Huwae and Lavaleye (1975) have given information on the amount of discarding and of survival rates of discarded plaice.

In the present situation about 20% of the discarded plaice may survive. The high mortality rate is mainly due to the high fishing speed and the long duration of the hauls (6 knots and 2 hours resp). In former years, when fishing speeds were lower and damage to the fish less, survival may have been higher. For our purpose, however, we assume for the years 1967 at present (in 1967 the Dutch changed the minimum landing size from 25 cm to 27 cm) a survival rate of 25%.

The age compositions of the Dutch landings from 1967 onwards were adjusted for discarding. Furthermore we assumed that discarding on the scale as happens in the Dutch fisheries does not occur in the plaice fisheries of other countries. We then calculated new international age compositions of the total catch from the data for total landings given in the 1975 report of the Flatfish Working Group. (table 6). A new virtual population analysis has been carried out using the same terminal F-values as in the Flatfish Working Group but with constant  $M\delta = 0.15$  and  $M\phi = 0.10$ .

Table 7 shows the F values per year and per age and table 8 gives the corresponding stock sizes. When comparing the F and stock values thus calculated with those of the Working Group it is apparent that the differences are not large. Recruitment in the v.p.a. based on catches is slightly changed as compared with the landing v.p.a. data, to the effect that recruitment is somewhat lower for yearclasses 1960 - 1970 but somewhat higher for yearclasses 1971 and 1972. The general trends in recruitment remain unchanged.

We then have to split the total F values per age and per year from the new v.p.a. into a Dutch F and a "other countries" F. We owe Herman Becker, mathematician at our lab, the following equation for the splitting of the fishing mortality coefficient. The catch in one given year of one yearclass in number 5 from one country is  $C_1$ , and the corresponding catch by the other countries  $C_2$ . Assume M constant and N- the total member of the yearclass at the beginning of the year- also constant for both countries.

Then 
$$C_1 = \frac{F_1}{F_1+M} N (1 - e^{-(F_1+M)})$$

$$C_2 = \frac{F_2}{F_2+M} N (1 - e^{-(F_2+M)})$$

$$\frac{1 - e^{-(F_1+M)}}{1 - e^{-(F_2+M)}} = \frac{e^{F_2/2} (e^{(F_1+M)/2} - e^{-(F_1+M)/2})}{e^{F_1/2} (e^{(F_2+M)/2} - e^{-(F_2+M)/2})} = e^{(F_2-F_1)/2} \frac{\sinh(F_1+M)/2}{\sinh(F_2+M)/2}$$

$$\approx e^{(F_2-F_1)/2} \frac{F_1+M}{F_2+M}$$

$$\frac{C_1}{C_2} \cdot e^{(F_2-F_1)/2} \cdot \frac{F_1+M}{F_2+M} \cdot \frac{F_1}{F_2} \cdot \frac{F_2+M}{F_1+M} = e^{(F_2-F_1)/2} \cdot \frac{F_1}{F_2}$$

$$e^{(F_2-F_1)/2} = 1 + \frac{(F_2-F_1)}{2} + \frac{(F_2-F_1)^2}{8} + \frac{(F_2-F_1)^3}{2^3 \cdot 6} + \dots$$

The third and higher terms can be neglected

$$e^{(F_2-F_1)/2} = 1 + \frac{(F_2-F_1)}{2}$$

We then have two equations

$$\frac{C_1}{C_2} = \frac{F_1}{F_2} + \frac{F_1}{F_2} \cdot \frac{(F_2-F_1)}{2}$$

$$F_1 + F_2 = F$$

$$\frac{C_1}{C_2} = \frac{2(F-F_2) + (F-F_2)(2F_2-F)}{2F_2}$$

$$2F_2 \frac{C_1}{C_2} = 2F - 2F_2 - F^2 + 3FF_2 - 2F_2^2$$

$$- 2F_2^2 + (3FF_2 - 2F_2 - 2F_2 \frac{C_1}{C_2}) + (2F - F^2) = 0$$

We solve this equation

$$F_2 = \frac{-(3F-2-2 \frac{C_1}{C_2}) \pm \sqrt{(3F-2-2 \frac{C_1}{C_2})^2 + 4 \cdot 2 (2F - F^2)}}{-4}$$

Having  $F_2$  we find  $F_1 = F - F_2$ .

In this way we have split all F values in the v.p.a. grouping the data in the same categories A, B and C as in the preceding section gives the Dutch F and the "other countries" F per year and per age-group categorie.

is This shown in figure 3. "Other countries" F in category A (4-6 years) is more or less constant from 1958 - 1974 and Dutch F is increasing over the period. This increase is most pronounced in female plaice. In category B (7 - 11 years) "other countries" F in males decreased and Dutch F increased. In females "other countries" F remained constant with the exception of a peak in 1972 but Dutch F increased suddenly in 1971 to a much higher level than before.

In category C (12 - 14 years) "other countries" F is decreasing and Dutch F more or less constant in males. In females "other countries" F remained more or less constant with exception in 1972. Dutch F suddenly increased in females since 1971 as in category B.

5. Yield curves for three plaice sub-stocks

5.1. Recruitment - age

In order to construct yield curves for the sub-stocks exploited by the Dutch fisheries the average recruitment age has been calculated by means of recruitment ogives as described by Beverton and Holt (1957). Table 9 gives these ogives for year-class data in 1971 - 1975 for males and females for the three sub-stocks. The age-composition data for the 1<sup>st</sup> quarter of the year have been corrected for discarding.

Table 9 - Mean number of recruits per 100 hours fishing 1971 - 75  
in '000

Age years	Southern Bight		Transition area		German Bight	
	male	female	male	female	male	female
2.5	1275	992	393	540	278	190
3.5	4804	816	3340	2171	3001	2360
4.5	2706	680	3025	1313	3233	1790
5.5	0	0	0	0	791	0
6.5	0	0	0	0	0	0
mean age	3.7	3.4	3.9	3.7	4.1	3.9

Compared with the recruitment-age for plaice exploited by the English fishery (Bannister, 1973) the agreement is good.

5.2. Growth

For calculating growth parameters the average length at age of the three sub-stocks for 1966 - 1975 as given in figures 4, 5 and 6 have been used. For the calculations in general we used only length at age data for age group 4 and older.

5.3. Yield curves

The following parameters have been used for calculation of the Beverton and Holt yield per recruit curves .

Table 10

	Southern Bight		Transition area		German Bight	
	males	females	males	females	males	females
M	0.15,0.10	0.10	0.15,0.10	0.10	0.15,0.10	0.10
K	0.163	0.117	0.163	0.151	0.210	0.223
W (g)	706	1579	745	1200	571	1022
t <sub>o</sub> (yrs)	-4.63	-4.50	-4.38	-3.61	-2.67	0.00
t <sub>c</sub> (yrs)	3.7	3.4	3.9	3.7	4.1	3.9
t <sub>r</sub> (yrs)	3.7	3.4	3.9	3.7	4.1	3.9
t <sub>l</sub> (yrs)	25	36	25	36	25	36

For males we have used two values of M viz. 0.15 and 0.10 to demonstrate the influence of the M value on the position of F<sub>max</sub> in the yield curve. Table 11 and figure 7 shows the combined yield curves for the three sub-stocks. The choice of M for males influences the F<sub>max</sub> position. In case of M<sub>♂</sub> = 0.15 and M<sub>♀</sub> = 0.10 the M.S.Y. point is at a higher level of F than with M<sub>♂</sub> = 0.10 and M<sub>♀</sub> = 0.10.

Comparing the yield curves of the three sub-stocks it is obvious that the Transition area sub-stock shows a F<sub>max</sub> at F= 0.7 for M<sub>♂</sub> = 0.15 and M<sub>♀</sub> = 0.10. The Southern Bight sub-stock has an F<sub>max</sub> at F= 0.6 and the German Bight at 0.4,

The yields curve for Lowestoft and Grimsby trawlers given by Bannister (1973) is also shown in figure 7. Bearing in mind that the English fishermen exploit a mixture of the German Bight and Transition area sub-stocks Bannister's yield curves fit well in between the yield curves given for both sub-stocks.

The present Z values for males and females given in table 5 can give F values if we subtract M= 0.15 for male and M= 0.10 for females. The F's of sexes combined are near the M.S.Y. point in all three sub-stocks. When we take M<sub>♂</sub> = 0.10 there is M.S.Y.

fishing for the Southern Bight plaice and slight overfishing in the Transition area and German Bight sub-stocks. What level of sustained catch may be expected at M.S.Y. in the three sub-stocks? If we have average recruitment for the various sub-stocks this could be calculated from the yield per recruit M.S.Y. values. At the moment we are not in a position to split total recruitment into components for the sub-stocks. Maybe tagging experiments with juvenile plaice in all nurseries in the North Sea may throw more light on this problem in future. For the whole plaice stock average recruitment at an average t<sub>r</sub> of 3.90 for males and 3.67 for females (average over 1955 - 1970, with the exclusion of the exceptional 1963 yearclass) is 125 million males and 137 million females which makes a total of 262 million recruits.



The average M.S.Y. per recruit for the Southern Bight plaice is (for  $M_{\sigma} = 0.15$  and  $M_{\phi} = 0.10$ ) 667 grammes, for the Transition area 673 g and for the German Bight 538 g. The average of these values is 626 g. Average recruitment 262 million multiplied by 626 g gives 164 thousand tons.

The average total landings of the last 6 years is 121 thousand tons. The difference of some 40 000 tons may be due to discard plaice not landed.

## 6. Discussion

Total mortality estimates from catch per effort data of three sub-stocks indicate an increase from 1965 - '69 to 1970 - '74 for males in all sub-stocks and for females in the Southern Bight and Transition area sub-stocks but not for females in the German Bight group. Splitting total fishing mortality derived from virtual population analysis in a Dutch and an "other countries" component has shown (figure 3) that the increase in total mortality in males found by catch per effort is solely due to an increase in Dutch fishing mortality. "Other countries" fishing mortality on younger males remained constant but decreased for older males.

In females too the increase in total mortality as given by catch per effort for the Southern Bight and Transition area sub-stock is caused by an increase in fishing mortality in the Dutch fishery whereas "other countries" fishing mortality on females remained constant.

The continuous increase in Dutch F on younger and middle-aged males and younger females and the rather drastic increase of Dutch F on middle-aged and older females since 1971 is accompanied by a steady increase in Dutch fishing effort. Beside this an expansion of the Dutch plaice fishery into more deeper and northern parts of the North Sea took place (figure 8).

In this figure total annual landings of plaice in the Netherlands are given in 5 categories (0 - 99, 100 - 499, 500 - 999, 1000 - 3999, 4000 tons and over) are shown. The situation in 1968, prior to the rapid increase in Dutch F on female older than 6 years, developed into the picture of 1974 showing the expansion of the fishing area into NW, N and NE direction.

This expansion is in regions occupied by the Transition area and German Bight plaice. It will be in these sub-stocks, at present still near the M.S.Y. situation, that overfishing will be introduced when increasing parts of the total allowable catch for the North Sea plaice will by preference be fished in the expansion parts of the Dutch fishing area when the sole TAC has been fished and fishermen are looking for grounds where they can catch plaice with only minor quantities of sole as bycatch.

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TABLE I - Total international plaice landings, split in Dutch landings and landings of other countries by years.

Year	Total international landings nominal weight in tons	Dutch landings	% of Dutch landings	Other countries' landings
1950	73 525	13 641	18.6	59 884
1951	69 946	13 760	19.7	56 186
1952	74 394	14 204	19.1	60 190
1953	83 042	16 957	20.4	66 085
1954	69 897	13 100	18.7	56 797
1955	66 059	11 926	18.1	54 133
1956	66 889	13 492	20.2	53 397
1957	70 562	13 951	19.8	56 611
1958	73 346	13 991	19.1	59 355
1959	79 284	14 849	18.7	64 435
1960	87 493	15 213	17.4	72 280
1961	85 934	15 951	18.6	69 983
1962	87 943	19 094	21.7	68 849
1963	107 556	23 143	21.5	84 413
1964	109 987	24 594	22.4	85 293
1965	96 712	23 371	24.0	73 441
1966	100 129	25 682	25.6	74 447
1967	108 945	29 905	27.4	79 040
1968	111 468	33 236	29.8	78 232
1969	121 189	39 420	32.5	81 769
1970	129 979	46 080	35.5	83 899
1971	113 568	44 502	39.2	69 066
1972	122 774	52 048	42.4	70 726
1973	129 480	57 948	44.8	71 532
1974	108 819	53 369	49.0	55 450

TABLE III - Age-composition of the Dutch beam trawl catch per 100 hours fishing corrected for fish power in the first quarter by sexes of North Sea plaice for 3 sub-populations.

Southern Bight	1975		1974		1973		1972		1971		1970		1969		1968		1967		1966		1965	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
2	454	330	274	244	399	334	103	43	502	454	1680	954	46	79	6	23	96	46	1137	1234	210	133
3	1308	770	3050	1560	2283	1169	2454	888	2868	1089	1680	954	428	753	1849	1355	1004	898	3228	2193	1746	1168
4	1310	964	1223	906	1872	885	2463	678	1611	499	3927	1523	1710	572	2203	633	2776	2560	3228	2193	1746	1168
5	616	449	1491	824	566	401	1461	328	1704	512	2275	388	1102	441	3969	1951	1362	743	2849	1487	3393	1083
6	535	437	476	284	342	245	1281	258	1468	261	1372	591	1744	1189	571	357	565	317	2775	1274	3356	1081
7	155	147	240	210	283	173	1166	372	1334	324	4305	1383	290	224	123	202	577	323	1586	1419	1194	662
8	85	121	175	180	291	195	588	439	1481	577	209	242	58	148	558	377	140	225	684	676	572	192
9	37	74	182	127	153	121	868	635	300	218	26	96	566	545	70	83	163	242	416	251	59	53
10	59	55	108	123	315	416	51	125	273	158	375	253	16	45	261	249	32	81	115	98	74	162
11	36	33	182	379	9	32	57	94	168	145	43	34	137	467	38	32	16	111	-	69	130	18
12	46	227	29	48	9	80	26	141	22	34	47	82	-	45	39	38	5	64	114	181	-	52
13	-	36	-	66	6	86	21	40	53	121	-	6	24	207	127	56	-	50	37	113	7	9
14	-	56	36	76	10	81	20	106	19	12	-	61	-	22	11	29	9	56	-	56	171	10
15	-	33	3	74	-	37	-	17	9	19	-	-	14	129	-	17	34	39	-	-	-	9
16	-	49	1	51	7	16	-	28	-	12	-	2	-	50	9	14	-	17	-	48	7	15
17	-	7	5	55	-	33	-	2	27	23	-	24	7	145	-	16	-	51	-	19	-	-
18	-	7	-	15	-	2	-	17	-	10	-	-	-	-	-	-	-	-	-	-	-	-
19	-	6	-	22	-	-	-	1	-	17	-	-	-	-	-	-	-	-	-	-	-	-
20	-	4	-	-	-	2	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	2	-	-	-	1	-	4	-	-	-	-	-	-	-	-	-	-	-	-
Total nr..	8446		12703		10853		14776		16333		19898		11203		15265		12603		22058		45566	
Transition Area	1975		1974		1973		1972		1971		1970		1969		1968		1967		1966		1965	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
2	106	134	48	73	201	161	55	93	124	334	853	931	34	117	677	499	643	73	575	878	239	139
3	1365	832	1740	1094	2451	1751	974	916	1553	1246	2434	1488	1157	654	1228	1248	1457	585	1350	907	1345	894
4	940	599	1202	727	2305	1751	1541	860	1382	568	2434	1488	1157	654	1228	1248	1457	585	1350	907	1345	894
5	745	531	1282	1004	888	534	607	369	1954	818	2197	615	1508	1133	3760	2069	1161	422	1040	529	2119	526
6	727	865	613	585	439	276	581	513	1167	902	2034	921	4909	2397	634	336	878	472	1029	477	1569	615
7	244	344	389	329	466	353	729	524	1019	754	4734	3580	408	310	193	227	823	402	600	556	582	358
8	276	212	215	390	482	291	396	261	1029	1589	208	385	113	139	406	254	96	148	272	285	315	167
9	85	139	229	217	180	268	638	945	231	436	76	181	194	449	8	57	187	285	186	96	41	82
10	124	135	118	185	319	823	55	146	144	188	131	524	12	42	78	138	35	67	47	73	35	112
11	28	64	206	775	12	104	2	90	25	271	7	22	55	386	3	17	4	45	5	36	51	53
12	81	516	33	149	11	121	19	168	2	84	16	362	-	29	5	46	-	22	49	72	-	84
13	-	37	8	84	12	65	-	36	36	126	-	46	13	108	2	100	4	53	11	44	7	27
14	-	72	5	96	26	53	17	84	5	26	-	85	5	24	4	27	17	11	-	26	80	31
15	-	36	21	126	42	53	-	20	-	49	-	1	12	50	-	21	11	13	-	2	-	35
16	-	67	-	41	22	45	-	16	21	22	9	38	-	17	-	10	11	7	-	18	7	31
17	3	42	-	56	-	38	-	8	-	34	-	15	-	138	-	24	-	27	-	29	-	-
18	-	16	-	31	-	32	2	21	12	18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	12	-	2	-	18	-	-	-	15	-	-	-	-	-	-	-	-	-	-	-	-
20	-	7	-	16	-	4	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	6	-	-	-	6	-	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Total nr	9390		12090		14604		10686		16182		21892		15208		12070		7957		9190		9544	

TABLE III - Continued.

German Bight	1975		1974		1973		1972		1971		1970		1969		1968		1967		1966		1965	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
2	85	92	85	88	115	28	5	49	73	15												
3	1439	1307	1491	1026	1007	1769	665	811	1382	444	283	278	34	57	65	53	153	136	398	396	312	296
4	718	709	1154	844	2913	2204	1461	701	1331	377	1536	756	502	412	261	274	1248	1002	1240	826	1888	1173
5	1010	675	1968	956	1543	721	933	629	1492	611	1516	616	934	457	1746	682	1166	526	1092	790	2430	527
6	819	801	920	387	698	385	708	699	1615	954	1330	556	4041	2710	216	261	795	493	1270	905	951	554
7	413	335	468	381	526	306	1065	884	1312	923	3135	2493	286	318	156	190	558	548	692	977	339	248
8	201	339	283	246	408	537	538	554	1550	1879	168	260	127	139	88	241	125	220	378	702	203	147
9	76	216	351	262	234	234	391	1063	183	513	31	139	369	642	9	21	57	273	265	261	25	72
10	101	240	128	177	510	949	46	251	92	404	60	373	8	32	15	133	-	77	136	291	23	69
11	39	113	241	476	8	50	23	117	66	363	-	28	55	298	-	5	35	84	16	133	32	33
12	106	585	9	82	23	74	33	114	13	98	10	103	-	12	-	26	9	28	97	233	-	73
13	-	33	3	80	20	72	-	24	29	132	-	4	-	72	-	-	-	39	39	160	4	45
14	9	91	15	65	9	42	7	46	-	38	-	2	-	10	-	10	-	17	-	46	32	40
15	-	23	-	50	-	11	-	1	-	25	-	2	-	30	-	4	-	14	-	-	-	23
16	8	73	3	11	-	3	-	14	-	3	-	4	-	10	-	-	-	9	-	12	4	34
17	-	1	-	11	-	21	-	-	-	4	-	6	-	40	-	3	-	7	-	73	-	-
18	-	10	7	5	-	-	-	1	-	5	-	-	-	-	-	-	-	-	-	-	-	-
19	-	5	-	7	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	3	-	5	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	9	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-
Total nr.	10683		12284		15421		11833		15936		13690		11598		4460		7620		11426		9577	
Average of all 3 sub-stocks	<u>9506</u>		<u>12359</u>		<u>13626</u>		<u>12432</u>		<u>16150</u>		<u>18493</u>		<u>12670</u>		<u>10598</u>		<u>9393</u>		<u>14225</u>		<u>11562</u>	



TABLE IVb - North Sea Plaice ♀

Calculations of Z according to the age composition of the Dutch beam trawl catch per 100 hours fishing (corrected for fish power) in the first quarter.

## SOUTHERN BIGHT

Years	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
3	-2.80	-0.73	0.35	0.86	-0.70	0.65	0.47	0.00	0.26	0.48
4	-0.24	1.08	0.27	0.36	0.39	1.09	0.42	0.53	0.07	0.70
5	-0.16	1.55	0.73	0.50	-0.29	0.40	0.69	0.29	0.35	0.63
6	-0.27	1.37	0.45	0.47	-0.15	0.60	0.40	0.40	0.15	0.66
7	-0.02	1.84	-0.16	0.31	-0.08	0.87	-0.30	0.65	0.04	0.55
8	-0.27	1.03	1.00	-0.37	0.43	0.10	-0.10	1.29	0.43	0.89
9	-0.62	1.13	-0.03	0.61	0.77	-0.50	0.56	0.42	-0.02	0.84
10	0.85	-0.13	0.93	-0.63	0.28	0.56	0.52	1.36	0.09	1.32
11	-2.31	0.08	1.07	-0.34	1.74	0.00	0.03	0.16	-0.41	0.51
12	-0.78	1.29	0.13	-4.23	2.02	-0.39	-0.16	0.49	0.19	0.29
13	-1.83	0.70	0.55	0.93	1.22	-0.69	0.13	-0.71	0.12	0.16
14	-	0.36	1.19	-1.49	-	1.17	-0.35	1.05	0.09	0.83
15	-1.67	-	1.03	-1.08	4.17	-	-0.39	0.06	-0.32	0.41

## TRANSITION AREA

Years	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
3	-1.88	0.41	-2.84	-0.27	-1.14	0.49	0.37	-0.65	0.88	0.60
4	0.53	0.77	-1.26	0.10	0.06	0.60	0.43	0.48	0.56	0.31
5	0.10	0.11	0.23	-0.15	0.21	-0.38	0.47	0.29	-0.09	0.15
6	0.10	0.17	0.73	0.08	-0.40	0.20	0.54	0.37	-0.18	0.53
7	0.23	1.32	0.46	0.49	-0.22	0.81	1.06	0.59	-0.10	0.44
8	0.55	0.00	0.95	-0.57	-0.26	-0.12	0.52	-0.03	0.29	1.03
9	0.12	0.36	0.73	0.31	-0.15	-0.04	1.09	0.14	0.37	0.48
10	1.14	0.48	1.37	-1.03	0.65	0.66	0.74	0.34	0.06	1.06
11	-0.31	0.49	-0.02	-0.53	0.06	-1.34	0.48	-0.30	-0.36	0.41
12	0.65	0.31	-1.51	-0.85	-0.46	1.06	0.85	0.95	0.37	1.39
13	0.04	1.39	0.67	1.43	0.24	0.57	0.41	-0.39	-0.39	0.15
14	2.74	0.69	-0.65	-0.62	3.18	0.55	0.26	0.46	-0.87	0.98
15	0.67	-1.25	0.26	0.21	0.27	-3.09	1.12	-0.81	0.26	0.63

## GERMAN BIGHT

Years	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
3	-1.03	-0.93	-0.70	-2.05	-2.59	-0.31	-0.46	-1.00	0.74	0.37
4	0.40	0.45	0.39	-0.51	-0.40	0.21	-0.51	-0.03	0.84	0.22
5	-0.42	0.47	0.70	-1.38	-0.20	-0.44	-0.14	0.49	0.62	0.18
6	-0.57	0.50	0.95	-0.20	0.08	-0.51	0.08	0.83	0.01	0.14
7	-1.04	1.49	0.82	0.31	0.20	0.28	0.51	0.50	0.22	0.12
8	-0.57	0.95	2.35	-0.98	0.00	-0.68	0.57	0.86	0.72	0.13
9	-1.40	1.22	0.72	-0.42	0.54	-1.07	0.72	0.11	0.28	0.09
10	-0.66	1.24	2.73	-0.81	0.13	0.03	1.24	1.61	0.69	0.45
11	-1.96	1.56	1.17	-0.88	1.06	-1.25	1.16	0.46	-0.50	-0.21
12	-0.79	1.79	-	-1.02	1.10	-0.25	1.41	0.46	-0.08	0.91
13	-0.02	2.24	1.36	-	3.58	-2.25	1.05	-0.56	0.10	-0.13
14	-	1.19	1.45	-1.10	1.61	-2.53	3.64	1.43	-0.17	1.04
15	0.65	-	-	-0.92	2.02	-0.41	0.58	-1.10	0.00	-0.38



TABLE 5 - NORTH SEA PLAICE

Calculation of means values of Z, according to the age composition of the Dutch beam-trawl catch per 100 hours fishing (corrected for fish power) in the first quarter.

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MALES

Southern Bight  
1965-69 1970-74

Age-groups	4-6	0.489	0.663
	7-11	0.565	0.824
	12-14	-0.395	0.361

Transition area  
1965-69 1970-74

Age-groups	4-6	0.181	0.545
	7-11	0.880	0.737
	12-14	-0.005	0.130

German Bight  
1965-69 1970-74

Age-groups	4-6	0.251	0.344
	7-11	0.581	0.659
	12-14		0.347

FEMALES

Southern Bight  
1965-69 1970-74

Age-groups	4-6	0.404	0.492
	7-11	0.285	0.394
	12-14	0.005	0.148

Transition area  
1965-69 1970-74

Age-groups	4-6	0.092	0.285
	7-11	0.265	0.331
	12-14	0.483	0.423

German Bight  
1965-69 1970-74

Age-groups	4-6	0.017	0.133
	7-11	0.311	0.282
	12-14	0.949	0.271

TABLE VI - North Sea Plaice

Age composition of Total Catch 1952 - 1974 (thousands).

M A L E S																	
Years	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	1401	428	2350	1227	1558
2	3837	10954	3241	1675	2266	5390	5551	7427	5275	5749	9983	12180	18983	19097	21134	20459	13344
3	10521	18612	38948	18091	26154	17209	24448	26468	52345	21599	35602	31450	33690	32618	27210	42605	37533
4	30184	17198	25707	39245	49281	72995	43948	34481	37578	127793	29186	19508	34665	19316	25487	49090	38029
5	16225	20879	10361	16586	32518	47327	41645	30706	21365	30272	72334	19950	23372	11570	10177	21311	24172
6	7716	10287	11185	7646	12598	17947	22433	17681	13965	16838	8656	50692	18373	10455	7532	5686	9745
7	2705	5286	4976	6104	5252	7027	5968	7522	6938	12446	3530	3967	37089	6189	5968	2789	3472
8	2245	2175	2186	3208	3138	2766	2189	3337	3728	3440	4620	1913	2346	10683	3204	3331	2080
9	1649	1816	906	1788	790	1604	1227	1119	2256	2912	1007	4041	1155	1408	5720	1764	2123
10	742	1495	661	1057	587	879	697	1127	831	551	1621	1084	1396	1180	1213	4290	1182
11	682	714	406	496	419	453	448	1186	363	159	560	939	528	781	856	155	2512
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

F E M A L E S																	
Years	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	1653	2037	1546
2	4181	15772	4720	1581	1232	5731	16302	9839	7541	4304	9681	12726	13177	30364	18726	20719	15948
3	13204	19626	41141	28411	32428	18337	23265	24619	61643	26706	27601	31552	32757	30722	31420	41727	36951
4	27944	11286	19921	34133	31766	48921	26576	32253	26263	69475	42151	20574	31064	18753	22856	45671	26166
5	13735	17637	7132	12008	29275	29930	21419	17064	13286	18631	51863	13644	17208	11741	13039	20217	19609
6	8616	8477	11428	4869	11936	17473	13736	14871	9763	11388	7523	39886	13945	10398	10969	7935	8922
7	3495	6470	6398	6754	6142	6799	7014	9693	8531	8896	5122	5050	34679	7023	11437	6171	3538
8	4046	2738	4299	4992	6816	4299	2803	5207	6371	4279	5833	3091	4509	13864	11773	6375	3372
9	3266	3319	2344	3528	3857	4059	1993	2864	3677	5692	2494	4672	2747	3210	18503	5694	2902
10	2607	2976	3054	2157	3055	3173	2474	2095	2056	2289	3178	1868	3772	2471	4892	12955	1870
11	3049	2198	2094	2231	1659	2860	2095	2057	1608	1808	1309	3174	1522	2303	4635	2665	6641
12	1434	2312	1673	1765	1382	1984	1263	1802	1904	903	1336	933	2102	1536	5654	2099	1132
13	904	1270	1095	1438	1463	1505	1084	1483	1168	1342	630	990	752	1424	2687	1945	1130
14	513	657	621	1128	1161	1146	866	889	1073	769	840	362	721	627	2733	2836	915
15	329	384	508	607	545	673	527	872	589	671	489	687	320	742	1188	1150	843
16	220	306	195	255	324	456	505	633	663	322	576	348	373	346	1475	705	479
17	180	218	143	157	85	274	546	437	374	504	478	481	291	826	2459	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 VIII - North Sea Plaice, stock in numbers.

M A L E S																		
Years	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	
Age-groups	1	381302	455377	443704	373501	292362	293180	1018310	281804	270454	218824	180279	214556	282252	301504	244041	176542	84709
	2	190337	296958	354648	345557	290883	189102	190254	671661	190550	186725	157025	133265	184411	241638	266857	207870	150814
	3	96652	144859	221638	273348	267646	224546	157768	158610	571221	160307	155390	125900	103428	141455	190299	210119	159979
	4	106408	66037	96487	138486	196986	185478	159757	113183	112045	450428	117997	100862	79333	57961	91367	128624	141483
	5	50896	63736	40964	59320	82985	124047	92442	96947	65615	64083	269772	74613	68784	36401	32082	55122	74083
	6	28764	28846	35609	25692	35752	41488	63187	41278	55129	36948	27340	165433	45806	37662	20662	18229	27821
	7	14426	17636	15350	20335	15060	19164	19202	33716	19264	34635	16323	15551	95636	22514	22768	10845	10466
	8	9456	9916	10303	8624	11872	8123	10021	11024	22072	10189	18344	10788	9722	48166	13667	14087	6760
	9	7919	6066	6526	6848	4468	7322	4442	6603	6410	15551	5599	11524	7517	6202	31589	8804	9049
	10	2884	5292	3546	4779	4244	3115	4820	2691	4649	3439	10693	3888	6195	5402	4037	21901	5948
	11	1890	1797	3176	2441	3137	3110	1870	3504	1279	3233	2450	7704	2346	4042	3559	2356	14886
	12	261	999	890	2358	1642	2312	2258	1196	1923	766	2636	1592	5762	1532	2758	2273	1884
	13	264	128	364	647	1616	588	1948	1664	805	1146	584	1959	739	4346	973	1694	1606
	14	592	165	24	117	355	1286	321	1498	1260	392	773	320	1492	353	3290	561	1203
	15	219	510	119	12	83	196	1037	166	723	996	172	527	77	1173	136	2513	243

F E M A L E S																		
Years	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	
Age-groups	1	327464	312586	308089	245543	209353	225591	674690	214759	197530	186961	150358	169509	233710	190176	265496	179783	163259
	2	166122	268105	256145	252242	181967	155531	168389	509012	167777	156109	152130	126298	153371	210737	171621	238659	160737
	3	96552	132234	205274	205452	205090	163480	135282	136878	451220	146393	137162	128454	102190	126257	161851	137502	196263
	4	124477	74825	101016	146699	158921	154786	130505	100324	100485	358951	107114	97917	86303	61425	85102	116630	84867
	5	86059	86120	56989	72498	100359	113653	93696	92867	68718	67736	258858	75902	69077	48669	37805	55331	62295
	6	60054	64829	61189	44792	54199	63057	74455	64460	67834	49678	43625	185008	55728	46183	32901	21856	30919
	7	30911	46158	50610	44520	35905	37717	40490	54333	44218	52163	34147	32332	129558	37199	31923	19377	12261
	8	30945	24650	35622	39717	33870	26657	27674	29979	39962	31914	38754	26034	24461	84345	26993	18053	11686
	9	26094	24157	19704	28149	31197	24179	20039	22378	22183	30110	24813	29528	20621	17854	63157	13287	10296
	10	18796	20509	18707	15602	22120	24565	18025	16239	17529	16532	21843	20083	22282	16050	13108	39607	6635
	11	17976	14532	15731	14027	12069	17114	19214	13960	12704	13908	12830	16746	16397	16581	12177	7228	23563
	12	11948	13371	11062	12246	10574	9345	12770	15395	10679	9968	10867	10366	12140	13391	12816	6629	4016
	13	9031	9449	9904	8421	9405	8256	6573	10355	12219	7855	8162	8564	8493	8990	10658	6248	4009
	14	4528	7313	7343	7921	6254	7121	6042	4919	7961	9946	5834	6786	6809	6970	6782	7095	3810
	15	2102	3610	5993	6055	6096	4557	5355	4644	3607	6185	8269	4481	5796	5476	5711	3550	3735
	16	783	1590	2902	4940	4902	4998	3485	4345	3375	2704	4959	7018	3402	4941	4250	4040	2122
	17	345	500	1148	2440	4228	4127	4089	2673	3330	2424	2141	3940	6019	2724	4142	2449	2987
	18	1215	142	246	903	2059	3745	3474	3182	2004	2658	1715	1484	3108	5170	1682	1428	1362
	19	203	1043	47	134	714	1820	3190	2754	2344	1524	2250	1419	1173	2648	4386	937	904
	20	408	143	872	0	66	607	1556	2604	2129	1820	1247	1909	1092	971	2229	3619	574

TABLE XI - Beverton and Holt yield per recruit for three North Sea plaice sub-stocks for males (two M values) and females and for sexes combined.

		SOUTHERN BIGHT			
F	$\delta_1$ (M = 0.15)	$\delta_2$ (M = 0.10)	♀ (M = 0.10)	$\delta_1 + \text{♀}$	$\delta_2 + \text{♀}$
0.1	170.08	223.21	341.95	<u>512.03</u>	<u>565.16</u>
0.2	226.14	274.04	395.65	<u>621.79</u>	<u>669.69</u>
0.3	250.53	290.11	402.95	<u>653.53</u>	<u>693.06</u>
0.4	263.20	296.13	400.67	<u>663.87</u>	<u>696.80</u>
0.5	270.45	298.47	396.35	<u>666.80</u>	<u>694.82</u>
0.6	274.94	299.25	391.89	<u>666.83</u>	<u>691.14</u>
0.7	277.88	299.32	387.80	<u>665.68</u>	<u>687.12</u>
0.8	279.88	299.06	384.18	<u>664.06</u>	<u>683.24</u>
0.9	281.30	298.65	381.02	<u>662.32</u>	<u>679.67</u>
1.0	282.33	298.17	378.27	<u>661.60</u>	<u>676.44</u>
1.2	283.66	297.20	373.72	<u>657.38</u>	<u>670.92</u>
1.4	284.45	296.30	370.17	<u>654.62</u>	<u>666.47</u>
1.6	284.93	295.49	367.33	<u>652.26</u>	<u>662.82</u>
1.8	285.24	294.79	365.01	<u>650.25</u>	<u>659.80</u>
2.0	285.44	294.18	363.10	<u>648.54</u>	<u>657.28</u>
2.2	285.57	293.65	361.48	<u>647.05</u>	<u>655.13</u>
2.4	285.66	293.18	360.10	<u>645.76</u>	<u>653.28</u>
2.6	285.71	292.76	358.92	<u>644.63</u>	<u>651.68</u>
2.8	285.75	292.39	357.88	<u>643.63</u>	<u>650.27</u>
3.0	285.77	292.06	356.98	<u>642.75</u>	<u>649.04</u>
		TRANSITION AREA			
F	$\delta_1$ (M = 0.15)	$\delta_2$ (M = 0.10)	♀ (M = 0.10)	$\delta_1 + \text{♀}$	$\delta_2 + \text{♀}$
0.1	171.05	224.59	324.79	<u>495.84</u>	<u>549.38</u>
0.2	227.26	275.50	386.19	<u>613.45</u>	<u>661.69</u>
0.3	251.69	291.46	399.76	<u>651.45</u>	<u>691.22</u>
0.4	264.25	297.37	401.53	<u>665.78</u>	<u>693.90</u>
0.5	271.44	299.61	399.85	<u>671.29</u>	<u>699.46</u>
0.6	275.88	300.31	397.18	<u>673.06</u>	<u>697.49</u>
0.7	278.77	300.32	394.35	<u>673.12</u>	<u>694.67</u>
0.8	280.74	300.00	391.65	<u>672.39</u>	<u>691.65</u>
0.9	282.12	299.54	389.17	<u>671.29</u>	<u>688.71</u>
1.0	283.12	299.03	386.94	<u>670.06</u>	<u>685.97</u>
1.2	284.41	297.99	383.14	<u>667.55</u>	<u>681.13</u>
1.4	285.15	297.04	380.08	<u>665.23</u>	<u>677.12</u>
1.6	285.60	296.20	377.57	<u>663.17</u>	<u>673.77</u>
1.8	285.88	295.46	375.50	<u>661.38</u>	<u>670.96</u>
2.0	286.06	294.83	373.77	<u>659.83</u>	<u>668.60</u>
2.2	286.17	294.27	372.29	<u>658.46</u>	<u>666.56</u>
2.4	286.29	293.78	371.03	<u>657.27</u>	<u>664.81</u>
2.6	286.27	293.35	369.93	<u>656.21</u>	<u>663.28</u>
2.8	286.30	292.97	368.97	<u>655.27</u>	<u>661.94</u>
3.0	286.31	292.63	368.12	<u>654.43</u>	<u>660.75</u>
		GERMAN BIGHT			
F	$\delta_1$ (M = 0.15)	$\delta_2$ (M = 0.10)	♀ (M = 0.10)	$\delta_1 + \text{♀}$	$\delta_2 + \text{♀}$
0.1	149.81	195.91	275.74	<u>425.55</u>	<u>471.65</u>
0.2	199.86	241.91	315.27	<u>515.13</u>	<u>557.18</u>
0.3	221.59	256.52	314.42	<u>536.01</u>	<u>570.94</u>
0.4	232.61	261.82	305.60	<u>538.21</u>	<u>567.42</u>
0.5	238.78	263.66	295.84	<u>534.62</u>	<u>559.50</u>
0.6	242.45	264.05	286.82	<u>529.27</u>	<u>550.87</u>
0.7	244.75	263.79	278.91	<u>523.66</u>	<u>542.70</u>
0.8	246.23	263.25	272.07	<u>518.30</u>	<u>535.32</u>
0.9	247.21	262.60	266.16	<u>513.37</u>	<u>528.76</u>
1.0	247.86	261.91	261.05	<u>508.91</u>	<u>522.96</u>
1.2	248.60	260.57	252.70	<u>501.30</u>	<u>513.27</u>
1.4	248.91	259.37	246.21	<u>495.12</u>	<u>505.58</u>
1.6	249.01	258.32	241.05	<u>490.06</u>	<u>499.37</u>
1.8	249.01	257.42	236.87	<u>485.88</u>	<u>494.29</u>
2.0	248.95	256.63	233.42	<u>482.37</u>	<u>490.05</u>
2.2	248.86	255.95	230.52	<u>479.38</u>	<u>486.47</u>
2.4	248.76	255.35	228.05	<u>476.81</u>	<u>483.40</u>
2.6	248.65	254.83	225.94	<u>474.59</u>	<u>480.77</u>
2.8	248.55	254.36	224.10	<u>472.65</u>	<u>478.46</u>
3.0	248.44	253.94	222.48	<u>470.92</u>	<u>476.42</u>

Fig. 1 Dutch monthly landings of North Sea plaice per 100 hours of the beamtrawl, corrected for changes in fishing power  
English catch per 100 hrs. fishing (Bannister, 1973)

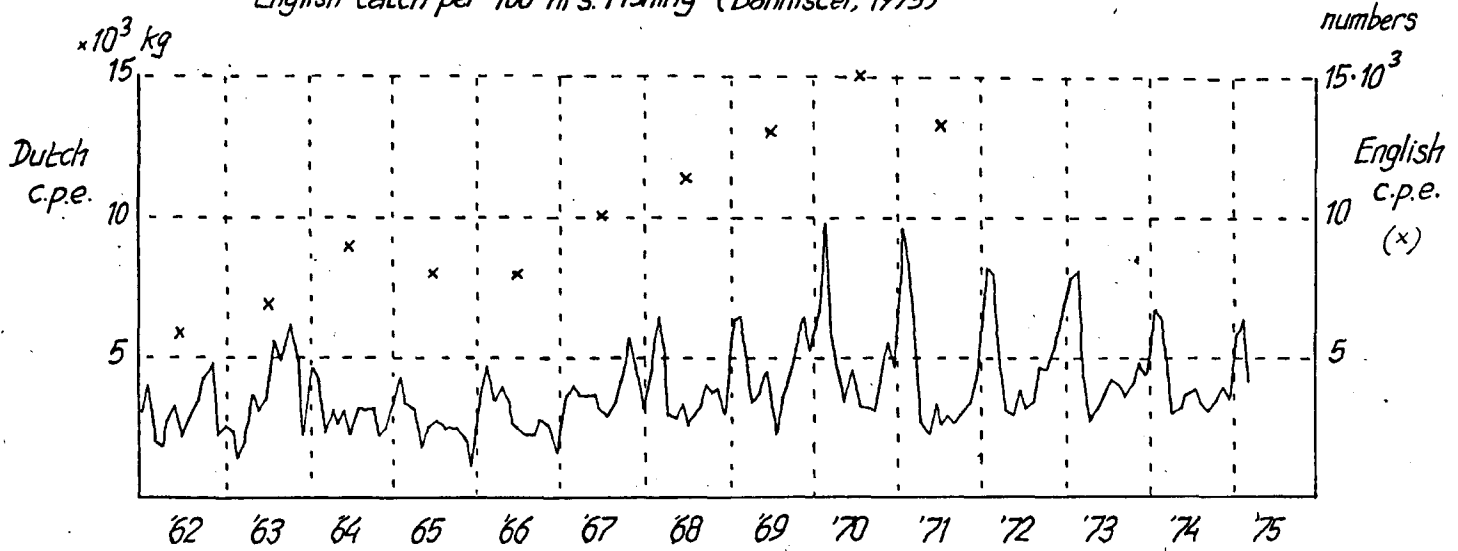


Fig. 2 average total mortality rates  $Z$  for three sub-stocks of plaice for both sexes for 4-6 year (A), 7-11 year old (B) and 12-14 year (C) old fish in two periods

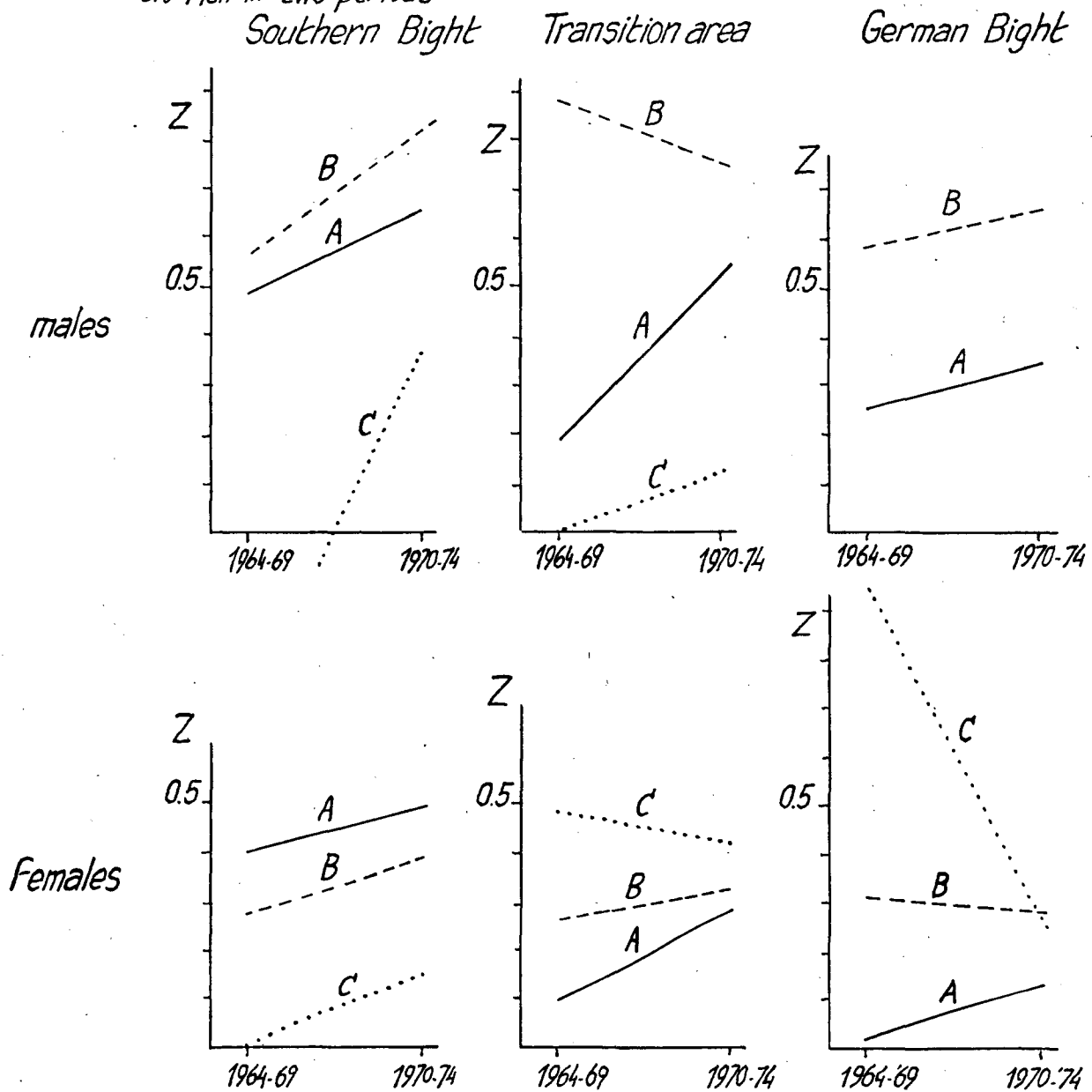
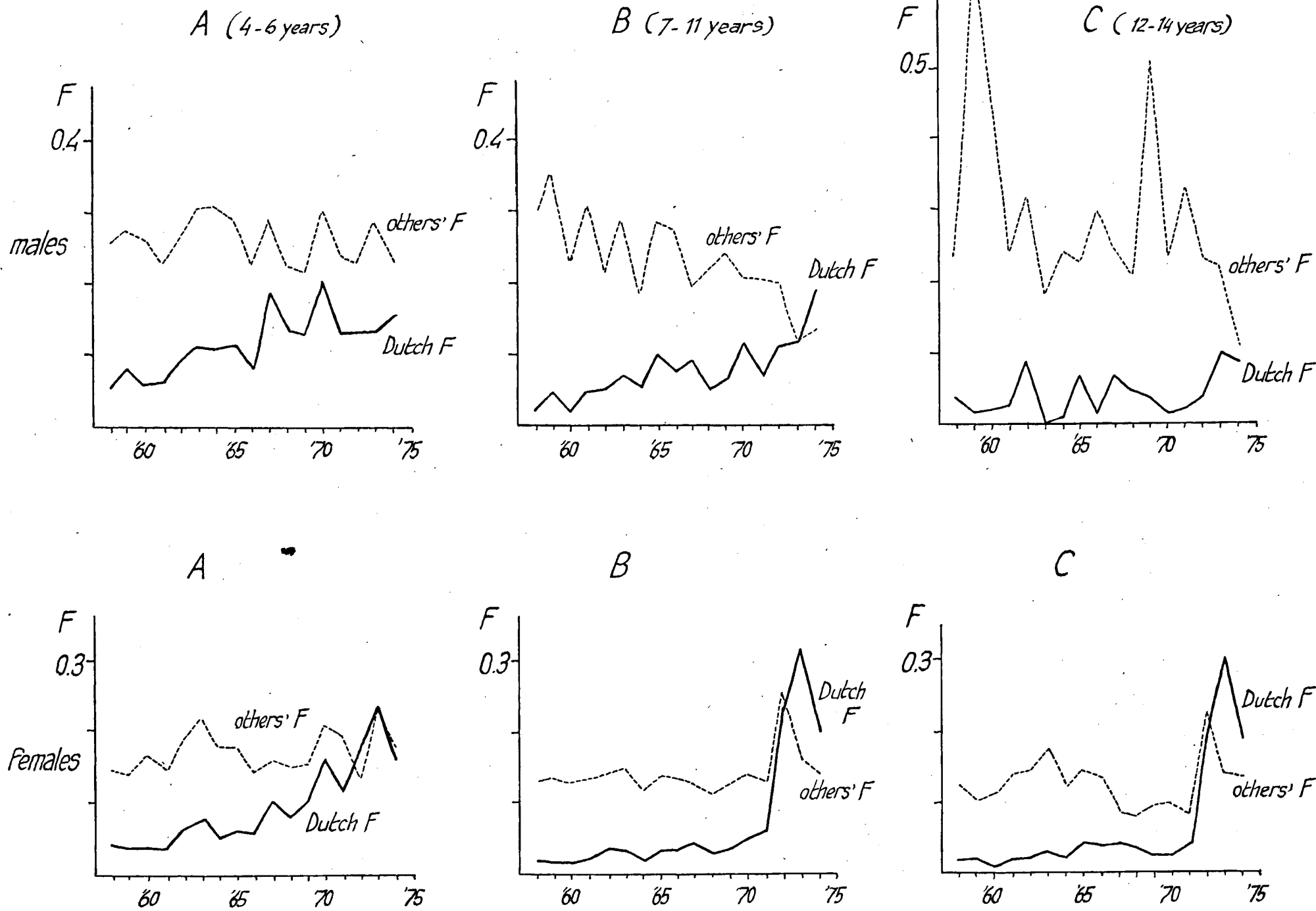
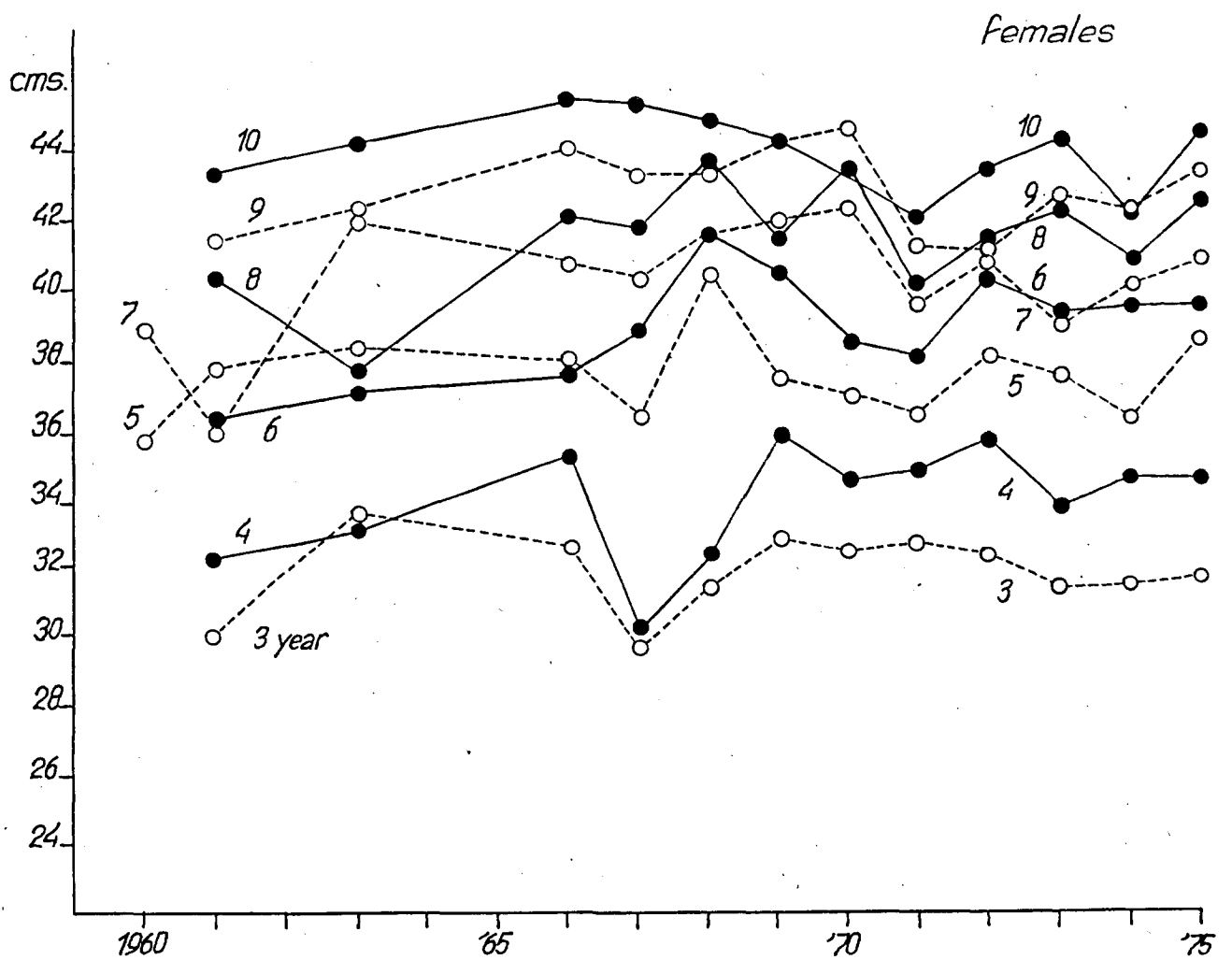
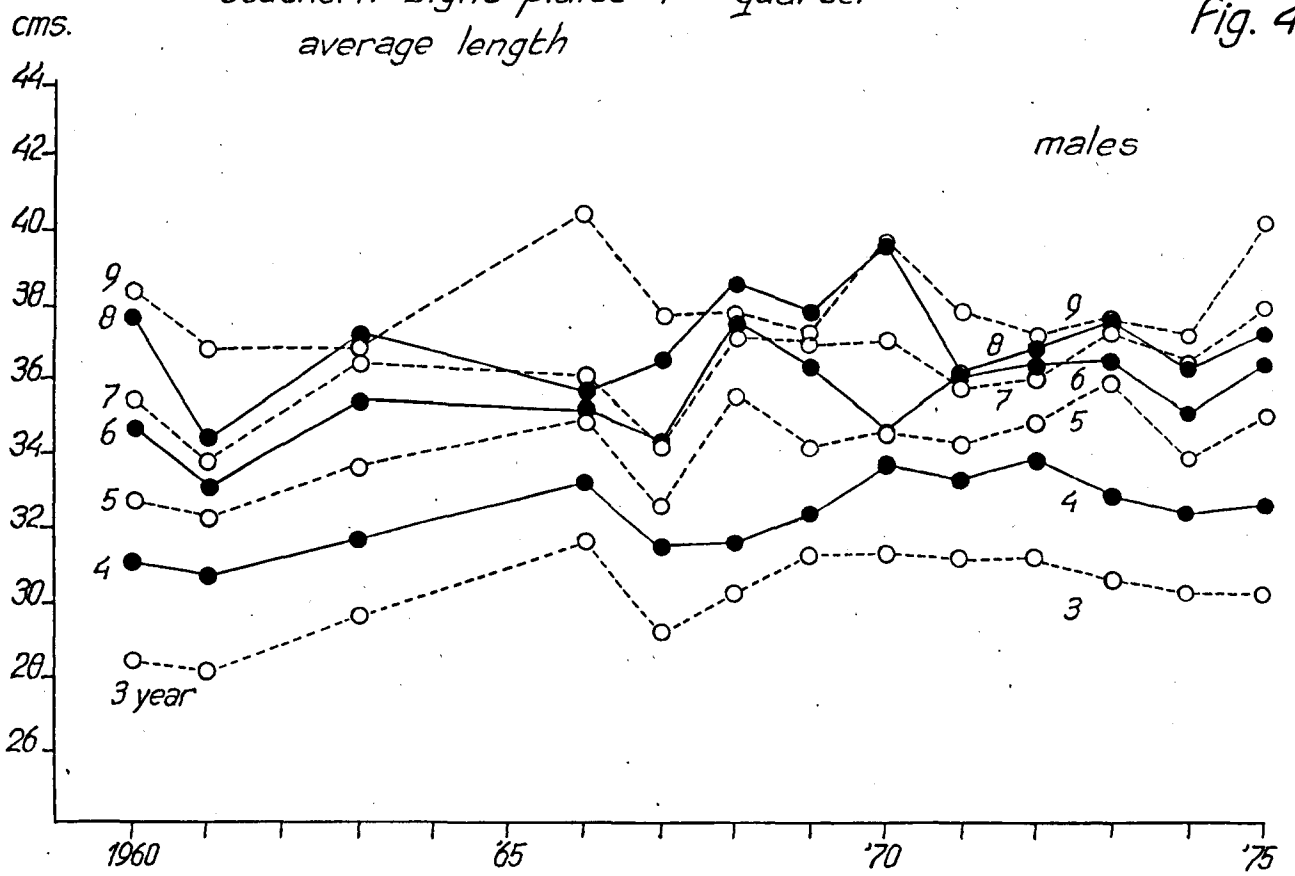


Fig. 3 Dutch F and other countries F for age-categories A, B and C for male and female North Sea plaice



Southern Bight plaice 1st quarter  
average length

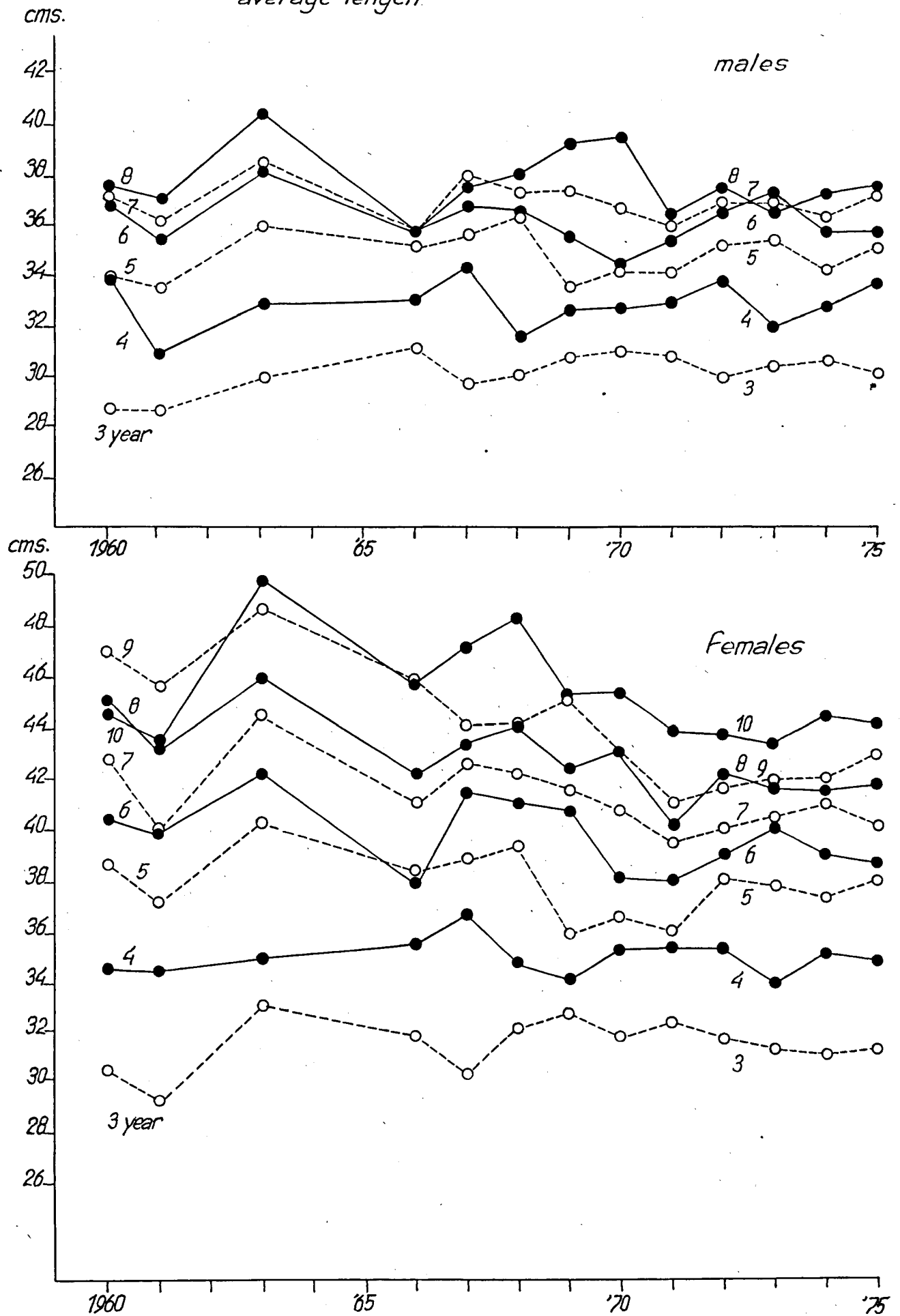
Fig. 4





Transition area plaice 1st quarter  
average length.

Fig. 5



German Bight plaice 1<sup>st</sup> quarter  
average length

Fig. 6

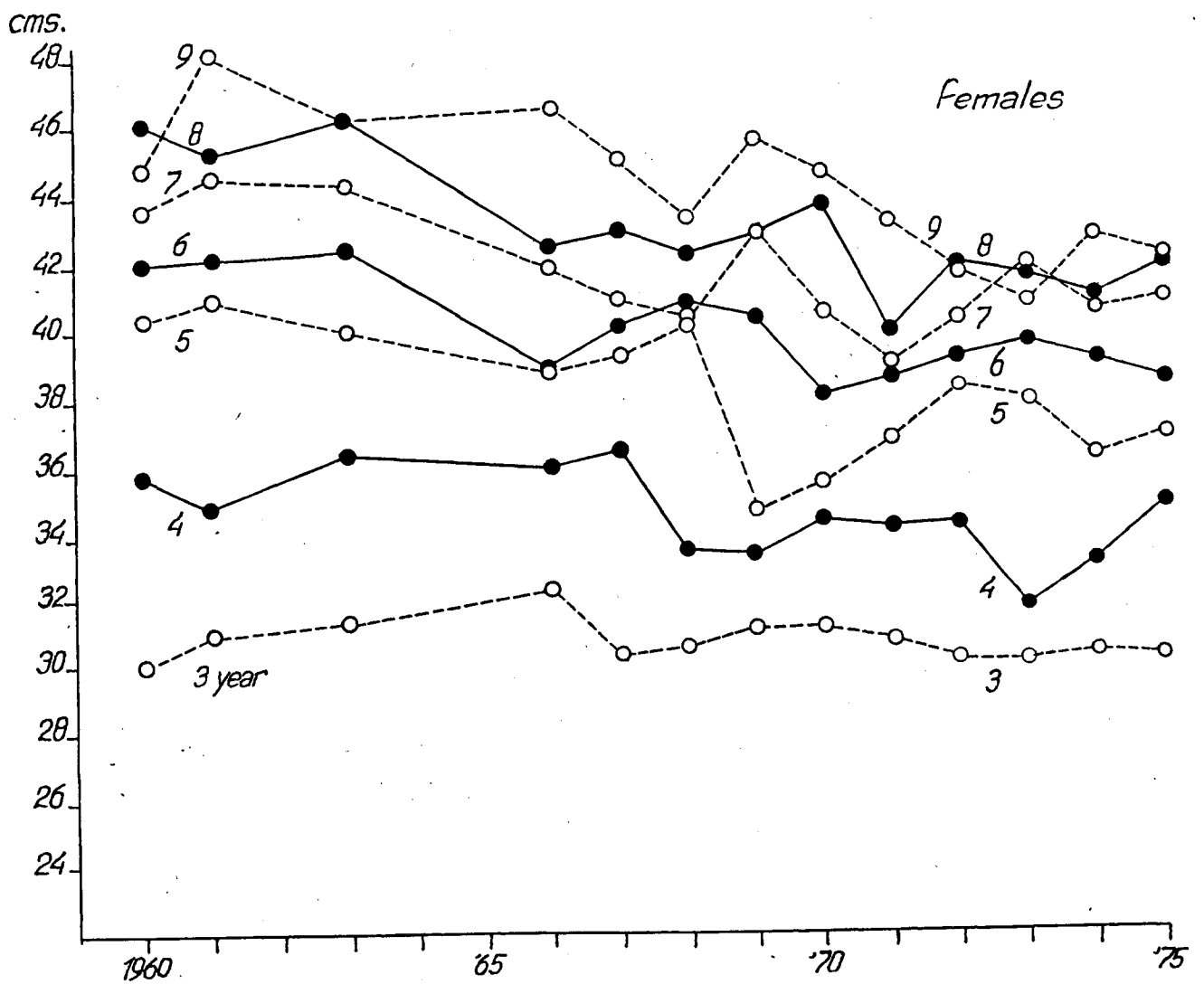
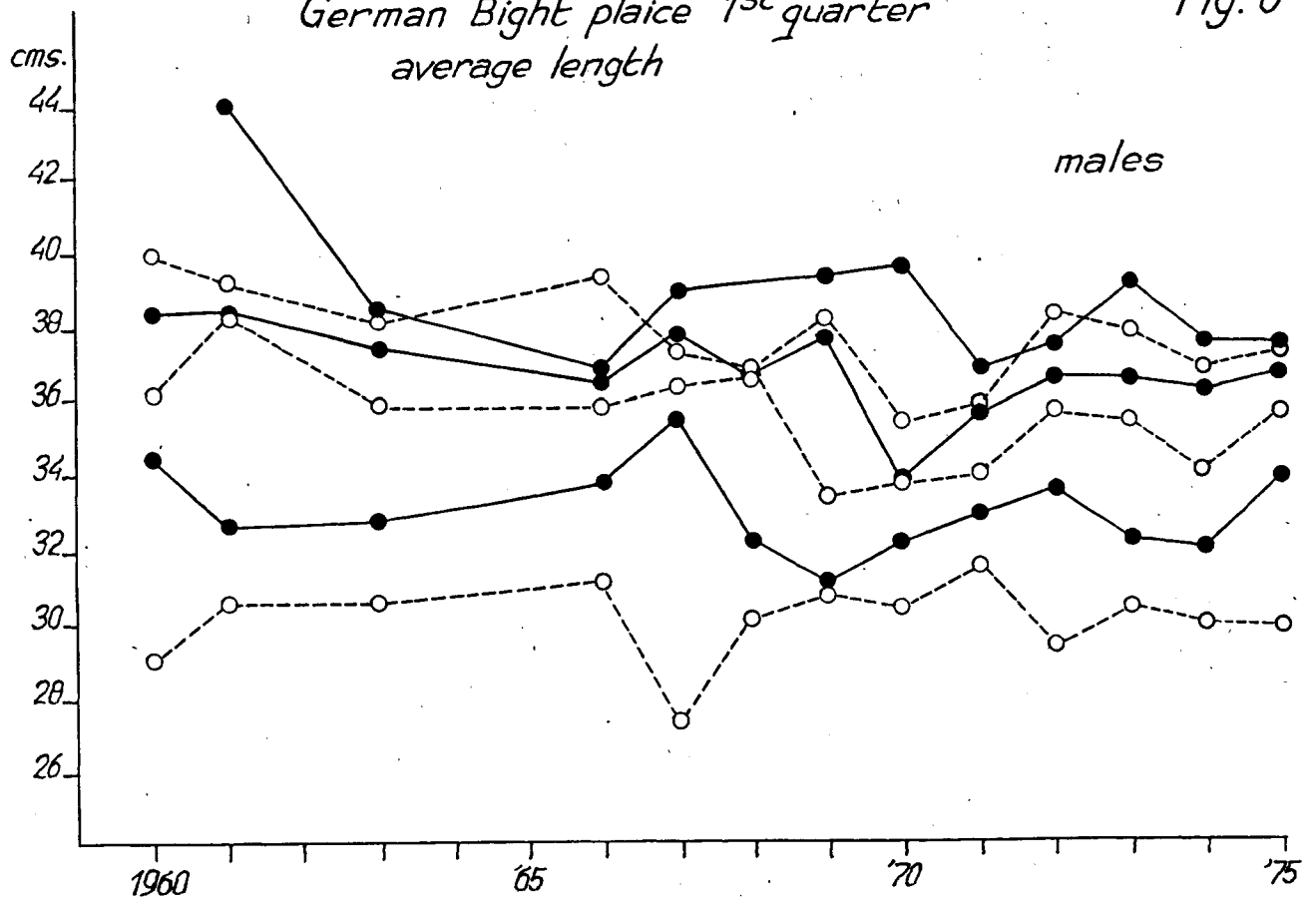
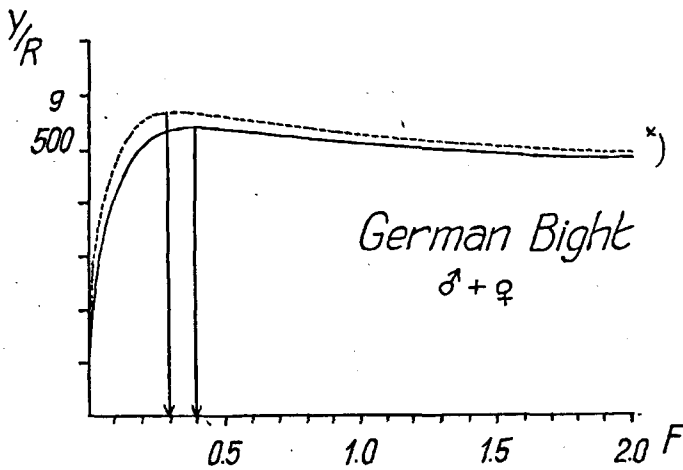
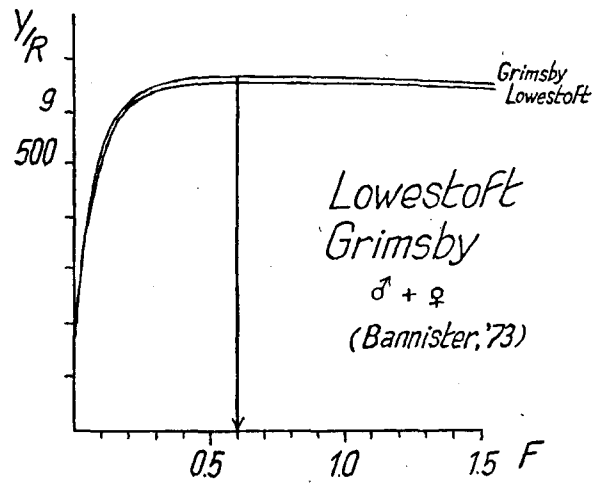
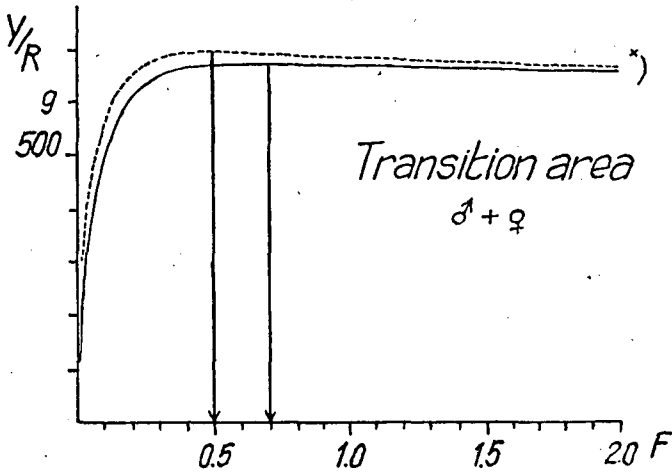
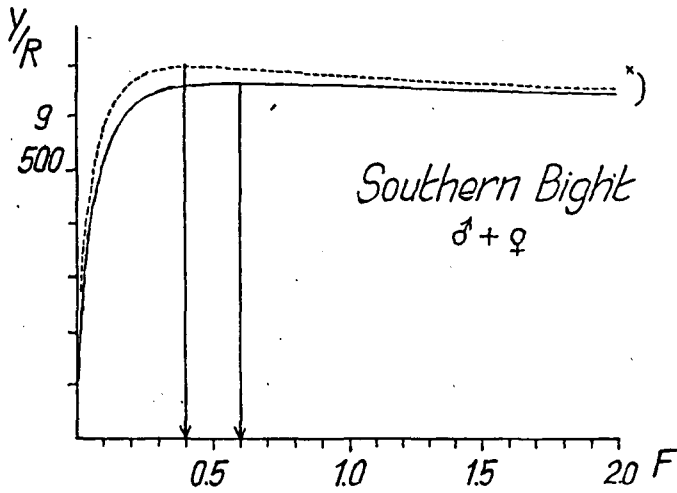
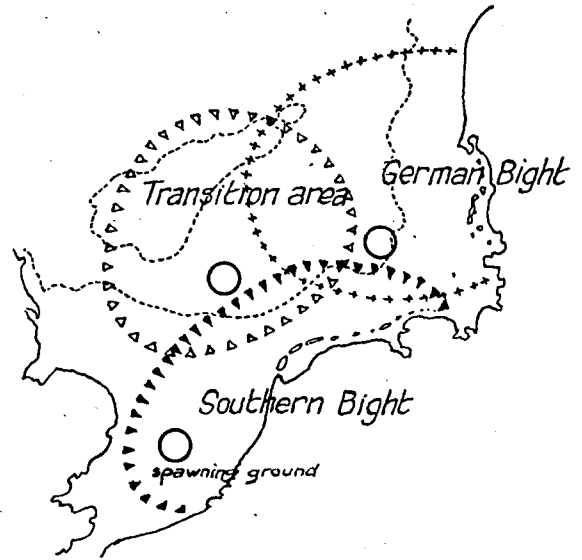
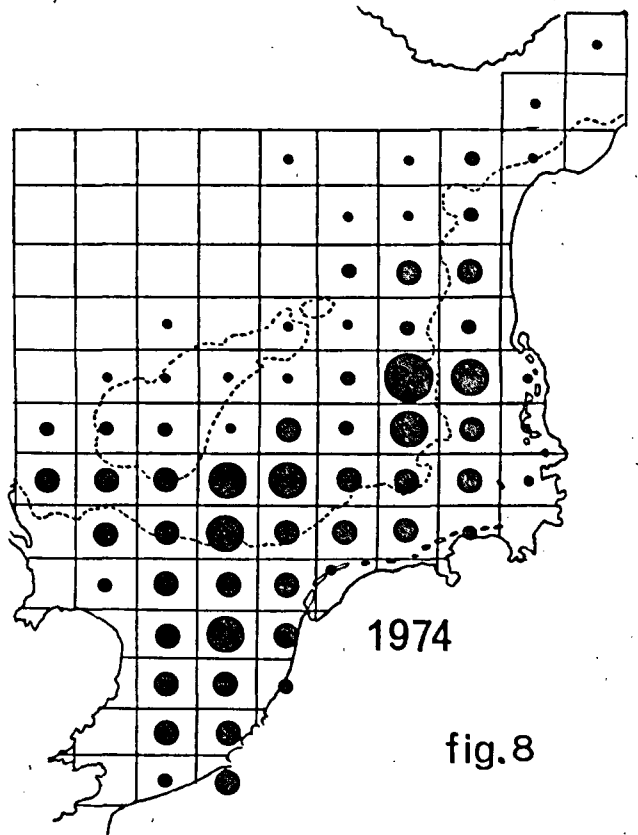
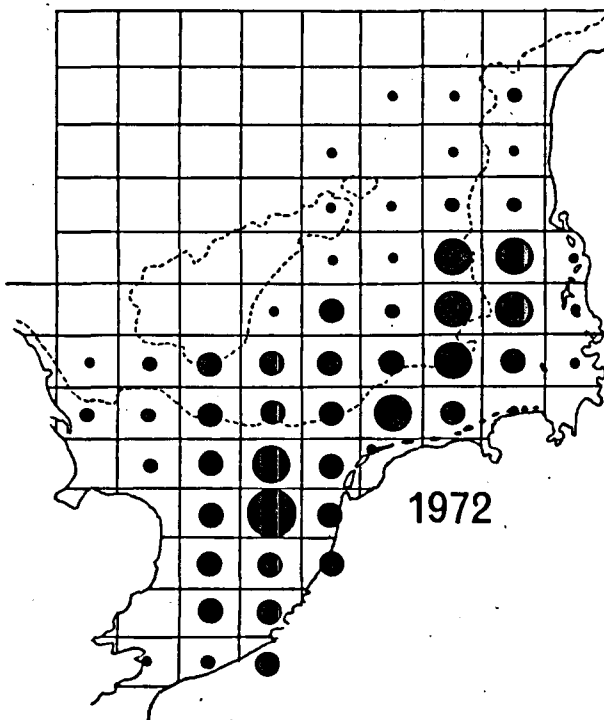
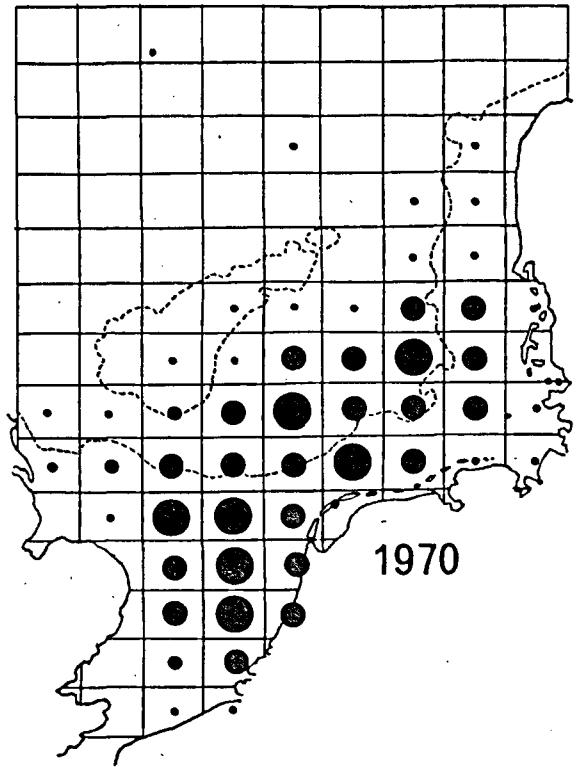
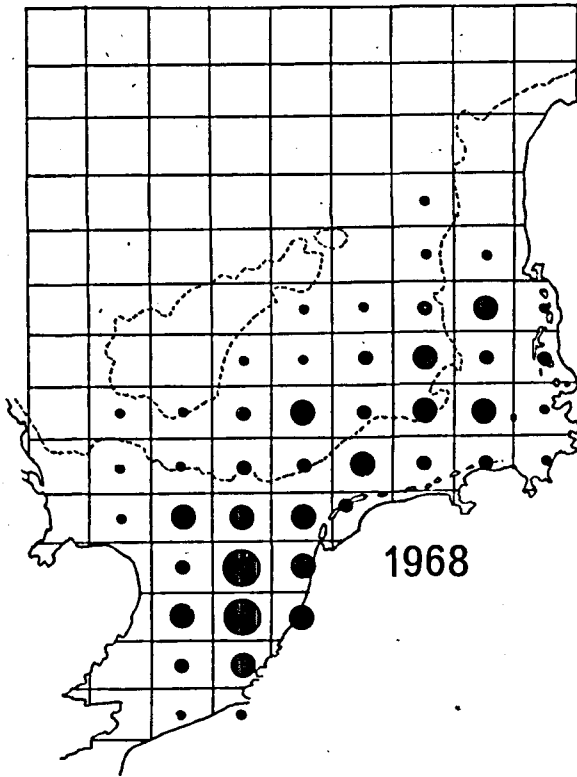


Fig. 7 yield per recruit for three plaice sub.stocks, sexes combined, based on Dutch data and yield per recruit based on Lowestoft and Grimsby data (Bannister, '73)



\*) - the solid yieldcurve is for  $M_{\delta} = 0.15$  and  $M_{\text{q}} = 0.10$   
the broken yieldcurve is for  $M_{\delta} = 0.10$  and  $M_{\text{q}} = 0.10$



Total annual Dutch landings  
of North Sea plaice

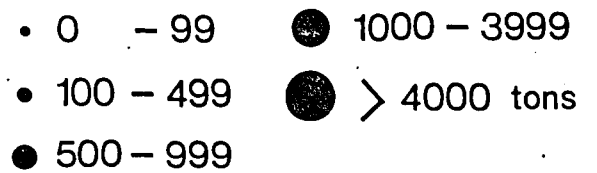


fig. 8