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Growth and Mortality in the Bank Stock

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Since 1948 a major sampling programme has been conducted on that part of the summer spawning Bank herring which have their spawning places off the Yorkshire coast near Whitby. During the period up to about 1955 the herring landed at Whitby and Scarborough were mainly ring net caught fish; since then a return to drifting has taken place. Throughout the whole period drifters from North Shields have also worked these grounds. The percentage age compositions of the fish landed from these spawning areas have been raised by the North Shields drifter catch per shot, thus giving abundance estimates. (Richardson 1956)

It has been suggested that the population spawning off Whitby should not be taken as representative of the Dogger Bank spawning stock. If, however, similar changes in growth, mortality and racial characters take place in timing and in magnitude then it is likely that the Whitby stock is reflecting the changes in abundance of the Bank stock as a whole.

Figure 1 shows the mean lengths of 3, 4 and 5 year old fish in the Whitby and East Anglian fisheries. In addition the mean lengths of Dogger 3 year olds given by Zijlstra (1958, 1961) are also shown. It is clear that the growth of the Whitby and Dogger fish is very similar and follows the same changes. The same trends can be seen in the Belgian data from the Dogger Bank given in Figure 2.

A second feature of note in these figures is the timing of the increase in length for age. It will be recalled that in the Downs stock a jump in mean length of the 3 year olds took place in 1950 followed by all the other age groups in 1951. In the case of the Bank stock it can be seen in the figures that no such increase took place in 1950 in the 3 year olds but that all ages showed the increase in 1951. Thus, a fundamental difference in feeding areas of the two stock almost certainly exists, as has been postulated by Cushing (1955) and Burd (1961a). Certainly the absence of an increased growth increment in the 3 year olds of the Bank stock strongly suggests that the pre-recruits occupy a different area in the North Sea to that of the Downs herring. Burd (1961a) also produced evidence that the area of increased Calanus abundance was, in 1950, limited in the Downs stock to the area of feeding of the recruiting 3 year olds, for no increase in l_1 took place in the nursery areas that year. As the

Blåden fishery covers most of the area south-east and east of the Dogger Bank and as few 3 year old fish occur in these catches, the feeding area of the 3 year old pre-recruit Bank herring must lie north of the Dogger. North-west of the Dogger the stock is predominantly Downs. The recruit areas for Bank herring can only lie in the Scottish north-east coast fishery or the area off the Norwegian deep water in the north-east North Sea. It is likely that this latter area is the main feeding area as the majority of the 3 year old recruits off the Scottish north-east coast appear to be Buchan spawners.

The variations in length for age of the Whitby fish have been shown to be similar to those on the Dogger. Thus, if similarity exists in age, mortality and vertebral counts we may regard this spawning group as representative of the Bank stock.

As in the Downs herring prior to the increase in mean length for age, partial recruitment as 3 year olds also took place in the Bank stock and Cushing (this meeting) has shown that recruitment may not have been complete till 5 years of age. From 1952-7 almost full recruitment took place as 3 year olds with completion by 4 years of age. Since 1958 a retrogression has taken place and again we have only partial recruitment at 3 years of age Burd (1961a). The changes in the relative proportions of 3 and 4 year olds in the Whitby spawners can be seen in Figure 3 where the data have been split into three periods.

In addition to the English data, age and catch per effort data are available for the Belgian Dogger catches and for some years from the Dutch trawl catches. Mortality rates have been calculated for various combinations of these data as follows:-

(a) Belgian % age composition x Belgian catch/effort
(Using October data only, when specified)

(b) Whitby % age composition x drifter catch/effort

(c) Whitby + Belgian % age composition x drifter catch/effort

(d) Whitby % age composition x Dutch catch/shot

In summarising these data three periods have been taken:-
(1) pre 1952 when the length change took place and when a change in recruitment also occurred, (2) 1952-1958 when growth reverted and a further recruitment change took place, and (3) post 1958.

The total mortalities so obtained are shown below in Table 1.

Table 1. Total mortality on Bank herring

	a		b		c		d	
Years \ Ages	3-9	5-9	3-9	5-9	3-9	5-9	3-9	5-9
Pre 1952	0 .07	0.27	0.50	0.52	0.24	0.30	0.36	0.42
1952-58	0 .31	0.46	0.52	0.42	0.48	0.53	0.50	0.64
Post 1958	0 .91	1.05	1.30	1.38	1.29	1.37	no data	

All sets of data show a big increase in Z after 1958. Both Belgian and Dutch catch per effort data give increased total mortalities after 1952, as does the combined Whitby and Belgian age data when raised by the drifter catch per shot. The only exception is the English data (b) where the high mean of the period 1948-1952 is due to a high apparent mortality in 1951/2. The most consistent set of mortalities is that using the combined Whitby and Belgian age data and the drifter catch per effort. In Figure 4 these mortalities, as means of 5-9 year old fish, have been shown in time sequence together with the 'Dogger' catch as given by Cushing (1961). The Dogger catch is that taken from the area bounded by 54°N and 56°N and 4°E in August, September and October. This total will include an unknown quantity of Downs herring on migration through the area and will underestimate the Bank stock by the quantity caught in the northern North Sea. It is interesting, however, to observe that while there is high yield of herring in the early 1950s the total mortality on the Bank herring is low. During the period of rapidly declining catch in the late 1950s a very high total mortality is observed. Using the drifter catch per shot the total equivalent drifter effort has been calculated and it can be seen that this follows the same trend, but in these data the maximum effort is seen in the period 1951-1954 when the total mortality is low.

The mortality rates given for the Bank herring are based on fish in spawning condition at Whitby; in the Belgian data, which are mainly from October, 50% of the fish are in maturity stages VI, VII and VII/II. Both sets of age compositions can then be taken as representative of the relative abundances of the different year classes in the summer spawning herring. The mortality rates, whether calculated from catches per effort of the North Shields drifters, the Belgian trawlers or the Dutch trawlers are in reasonable agreement.

One would expect that high mortalities would coincide with high effort and low mortality with low effort. In the 'Dogger' catch data shown in Figure 4 this is not the case. Three explanations are possible. Firstly, that the mortalities are hopelessly wrong, which would seem unlikely. Secondly, that the Dogger catch as a whole grossly overestimates the size of Bank stock in the period 1949-1958. Thirdly, that in the period 1958-61 the total Dogger catch is a gross underestimate of the Bank stock. Taking the last point first, during the period 1952-7 with a relative low mortality rate the Dogger catch averaged about 200 thousand tons. The drops in Dogger catch and increased mortality post 1957 might be caused by heavy fishing on this stock in other areas. The proportion of Dogger spawners in the mixed fisheries in the northern North Sea have been discussed by Cushing (this meeting). In his Table VI the proportions of Dogger fish in the Buchan pre-spawning and Fladen fisheries are given as:-

1950-60	Ages	Catch per effort data
Buchan pre-spawning	3-4	50%
	5-7	36%
Fladen	3-4	37.2%
	5-9	58.1%

The period from 1959-61 has been characterised by relatively poor catches in both these fisheries, so it is unlikely that the high mortality would be generated from this source.

Coming to the second point that the Bank stock is overestimated in the period up to 1958 this would imply that this was a mixed fishery with a considerable proportion of Downs or other herring. Cushing (this meeting) has given the proportion of Downs herring for the period 1930-50 as 36%. The evidence for the occurrence of Downs fish in these catches and their relative abundance will be further examined.

From data published in Annales Biologiques by Hempel, Gilis and Schubert the relative proportions of spawning and non spawning fish in the September/October Dogger samples have been calculated. Bank herring have been defined as maturity stages VI, VII, VII/II and II, Downs herring as maturity stages III and IV; stage V are shown separately and the percentages of these three groups have been recalculated leaving out fish in Stage I. The values obtained are given overleaf.

Table 2. Percentages of Bank and Downs herring in Dogger samples

Year	Bank	Downs	V	Source (Annal. biol.)
1948	61	16	23	Hempel
9	42	25	33	Hempel
50	46	17	37	Gilis
1	32	30	38	Gilis
2	39	22	39	Gilis
3	54	1	45	Gilis
4	52	6	42	Gilis
5	53	7	40	Gilis, Schubert
6	35	24	41	Schubert
7	68	13	20	Gilis, Schubert
8	36	32	32	Gilis, Schubert
9	59	23	18	Schubert
1960	57	34	9	Schubert

In the same manner and using the same maturity stages as far as possible, mean vertebral counts have been calculated, Table 3.

Table 3. Mean Vert. N. of Bank and Downs herring in Dogger samples

Year	Bank	Downs	V
1954	56.43	56.51	56.56
1955	56.4	56.48	56.49
1956	56.31	56.61	56.57
1957	56.48	56.52	56.50
1958	56.51	56.76	56.58
1959	56.47	56.53	56.50
1960	56.41	56.57	56.52

Iles (this meeting) has shown that stage V on the Dogger could contain both Bank and Downs herring. Burd (in press) showed that in the Haisborough catches stage V was indeed a mixture of Bank and Downs fish. It is seen that in most cases the stage V mean vert.s.lies between the two 'stock' counts. Using the technique used by Burd (1959_a) for calculating mixing rates it is possible to make an estimate of the mixing rate of Bank and Downs fish in stage V. In the case when the means are close together this method is inapplicable and a 50% mixture has been assumed. The same proportion has been taken for 1954. The percentages of Downs herring in Stage V are:-

1954	50%
1955	50%
1956	87%
1957	50%
1958	28%
1959	50%
1960	77%
Mean	56%

The percentages of stage V in Table 2 may then be distributed in accordance with the percentages above. For the period prior to 1954 the mean has been used.

Table 4. Proportion of Bank and Downs herring in Dogger catches

Year	Bank	Downs
1948	71	29
1949	57	43
1950	58	38
1951	49	51
1952	56	44
1953	74	26
1954	73	27
1955	73	27
1956	40	60
1957	78	23
1958	59	41
1959	68	32
1960	59	41

It would appear from these data that after 1952 the proportion of Bank spawners in the samples from the Dogger trawl fisheries increased by about 10%. For the period 1948-52 the mean was 58%, biassed upwards by the value for 1948, while that for the period 1953-60 was 66%, biassed downwards by the value for 1956. The mean for the whole period was 63%.

It should be remembered that these data are derived from trawl catches on the Dogger Bank in what could be described as the spawning fishery.

Further, in most cases data for October catches have been used. One would expect that the main bulk of the Downs herring would be south of the Dogger by that time, as has been shown from the echo surveys made in East Anglia, Tungate (1958) and Burd (1959 and 1961). Thus taking the whole period of Dogger catch from August to October the proportion of Downs herring is likely to be greatly underestimated by this method. Hence underestimates are likely of any change in proportion of Bank and Downs fish in the catches designated as 'Dogger' in the figure.

The period means of 63% mixing rate of Bank and Downs fish on the Dogger obtained above may be compared with the value obtained by Cushing (1961). Correlating catches per effort in East Anglia with that on the Dogger for the period 1930-50 he estimated the proportion of Downs herring at 36.1% giving a Bank component of 63.9% which is almost identical with that obtained above.

A further set of estimates of the proportions of Bank and Downs herring in the catches of the Dutch luggers may be made from the 'sorting' charts published in Annales Biologiques by Zijlstra. Six categories of herring are shown:

1. Matjes) Downs
2. Matjes and Fulls)
3. Fulls
4. Fulls and Spents)
5. Matjes,Fulls and Spents) Bank
6. Spents)

Though these trade categories cannot be regarded with the same degree of reliability as Maturity stage data each category is well defined and the fish are carefully selected. During the months August to October matjes can be hardly anything else than Downs herring, the second category can also be ascribed to Downs fish. The groups of categories including spents are designated 'Bank'. Fulls will be fish in stage V, in the main, and will be a mixture of Bank and Downs fish.

Taking the area bounded by 54°N and 50°N and 3°E the total number of rectangles fished and the relative numbers of 'Bank', 'Downs' and Fulls have been calculated from the charts.

Table 5. 'Bank' and 'Downs' fish in Dutch Lugger catches

Year	Total Squares	'Bank		Fulls		'Downs'	
		%		%		%	
1949	283	75	27	96	33	112	40
50	191	46	24	59	31	86	45
51	175	9	5	131	75	35	20
52	141	28	20	40	28	73	52
53	210	43	20	81	39	86	41
54	199	47	24	98	49	54	27
55	186	34	18	112	60	40	22
56	220	83	38	81	37	56	25

Using the same proportions of Fulls as stage V fish used above, the relative proportions of Bank and Downs fish are:-

Years	1949	1950	1951	1952	1953	1954	1955	1956
Bank %	42	38	38	32	37	49	48	43
Downs %	58	62	62	68	63	51	52	57

Comparing these data with the previous maturity analysis, it is seen that the proportion of Downs herring is rather larger. This might be expected when the differences in extent of area of the two data sources are considered. Though the method using commercial categories may not be as precise as the previous maturity technique, the weight of

data in area and in quantity probably fully compensates for any shortcomings.

These lugger data cover the whole area for which the catch data of the 'Dogger' are calculated and though not weighted by catch probably give a more comprehensive picture of the relative abundances in space and time.

Again there are indications of a change in proportion of Bank and Downs herring in the catches. The mean for 1954-6 of the Bank stock was about 47% while that for the previous period was about 37%, again a 10% increase.

Discussion

The anomalous observation of the change in mortality of spawning herring of the Bank stock, apparently unrelated to the Dogger catch, has been noted. It would seem that over the post-war period a Downs component of some 40% is present in the catches from the central North Sea in August, September and October. This estimate is observed from two separate sets of maturity data and from the catch per effort data by Cushing (1961).

Some slight evidence has been produced which suggests that after about 1952 an increase has taken place in the proportion of Bank stock caught. This may again have fallen in the past two years when the recruitment pattern set back.

With the increased intensity of fishing in the Dogger area from 1952 there would be a gradual increase in knowledge where concentrations of fish might be found. With spawning fish being concentrated and selective of locality it would be expected that these would form an increasing part of the total 'Dogger' catch. Such changes in the proportion of Bank and Dogger herring as described above, could quite easily arise. In addition, the observed increases in total mortality in spawning Bank herring might be correlated with the 10% increase in the proportion of Bank stock in the total. For the 10% would represent a high fishing rate on unmixed stock resulting in a high mortality on the spawning fish.

It is of interest to compare these Bank mortality rates with those of the Buchan spawners, Parrish and Craig (1961). Taking the same periods as given in Table 1 Buchan mortalities for the ages 5-10 have been calculated and are given below.

	Bank	Buchan
pre 1952	0.30	0.34
1952-8	0.53	0.55
post 1958	1.37	0.67

At first sight there is little difference between the two sets save a lower mortality Buchan spawners in the most recent period. However, it is when these data are compared in time sequence that important difference appear. In the Bank spawners the increase in mortality took place in 1957/8. The jump in mortality in Buchan spawners took place in 1956/7; it was in September 1955 that the big increase in effort on the Fladen occurred. The data have been regrouped below where another feature can be seen, namely the low total mortality of Buchan spawners up to 1956. This is in contrast to the higher value in the Bank stock.

	Bank	Buchan	Downs
pre 1956	0.32	0.25	0.70
1956-9	1.19	1.18	1.19
post 1959	1.13	0.36	0.80

The mortalities in both these fisheries are very low compared with that for the Downs in the pre-1956 period. This was the time of high catches on the Dogger, and in the light of these mortality rates a mixing rate of Downs herring of some 40% is not unlikely.

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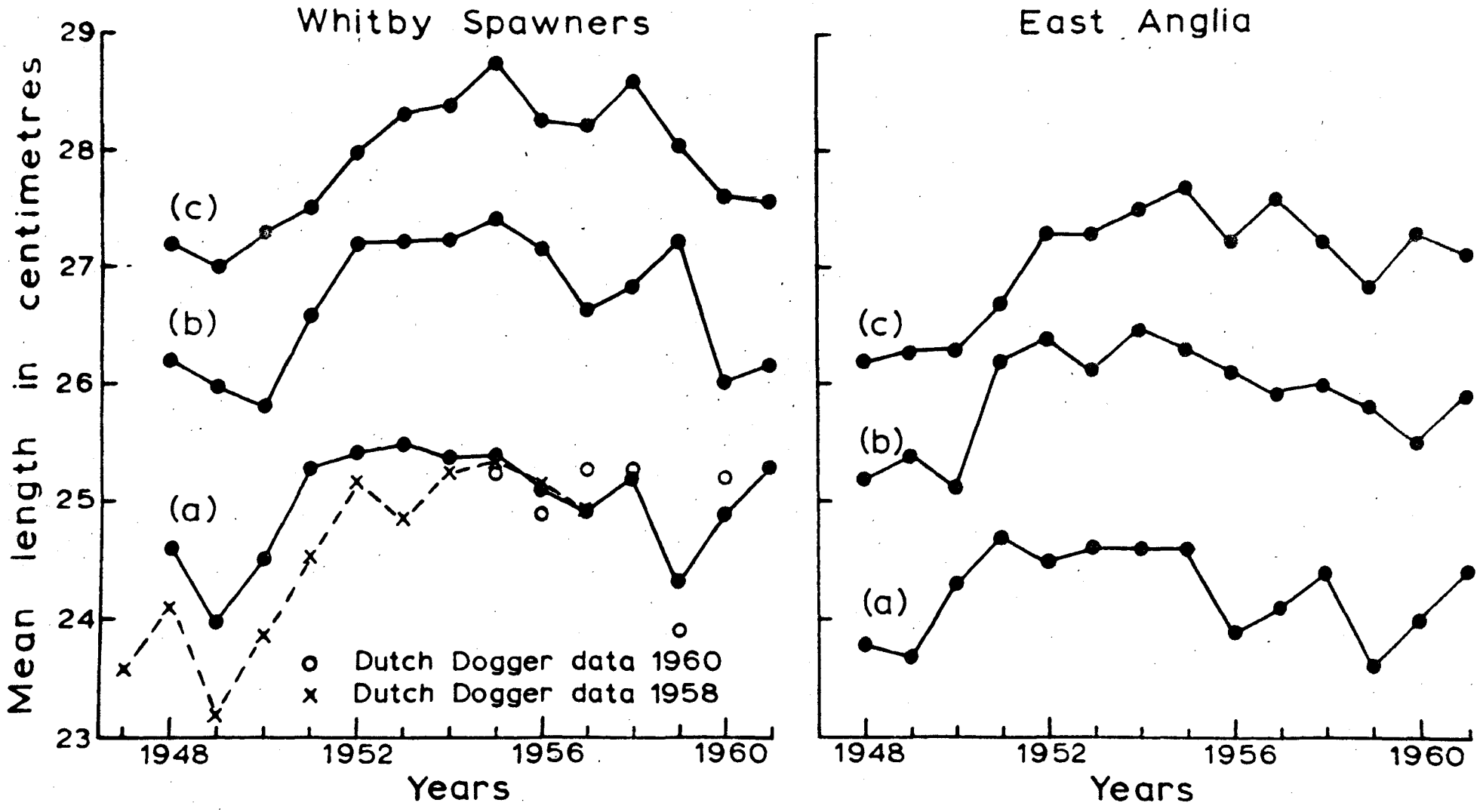

Figure 1. Mean lengths for age of Bank and Downs herring. Dutch data from Zijlstra 1958 and 1960.

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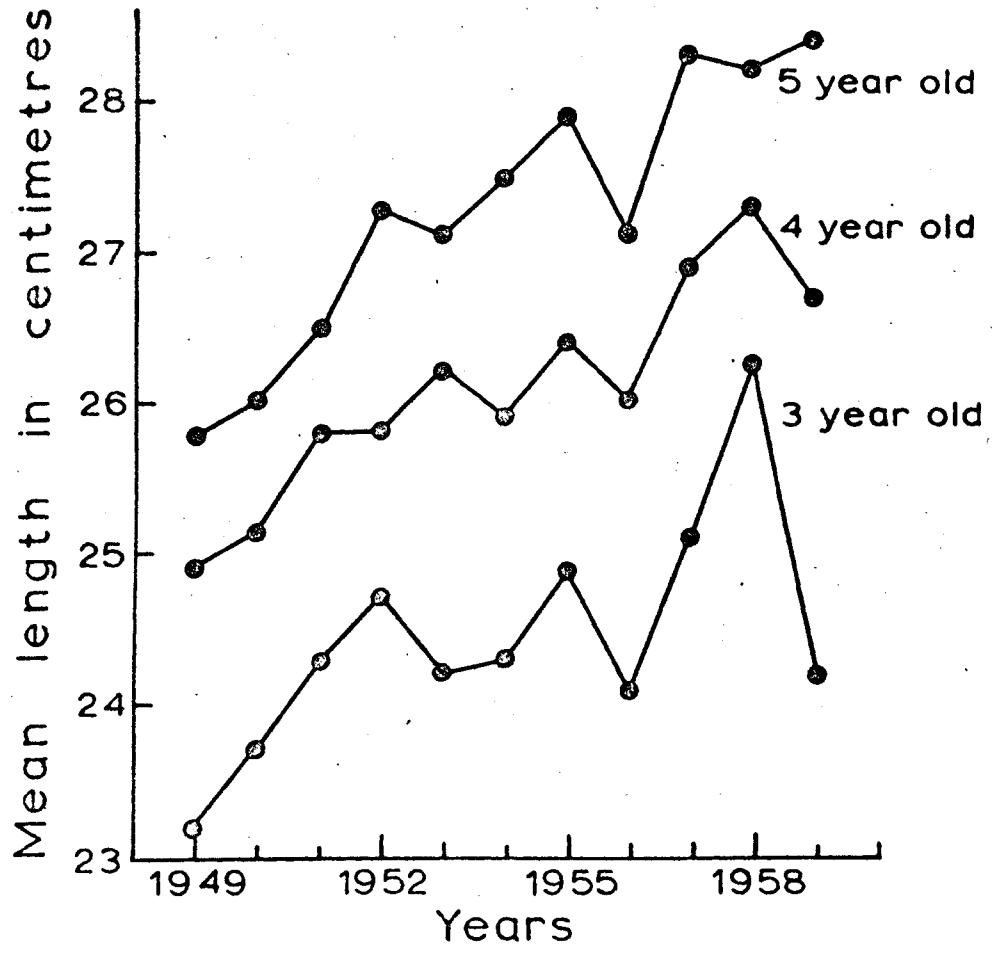

Figure 2. Mean lengths for age of Belgian Dogger herring samples (Gilis)

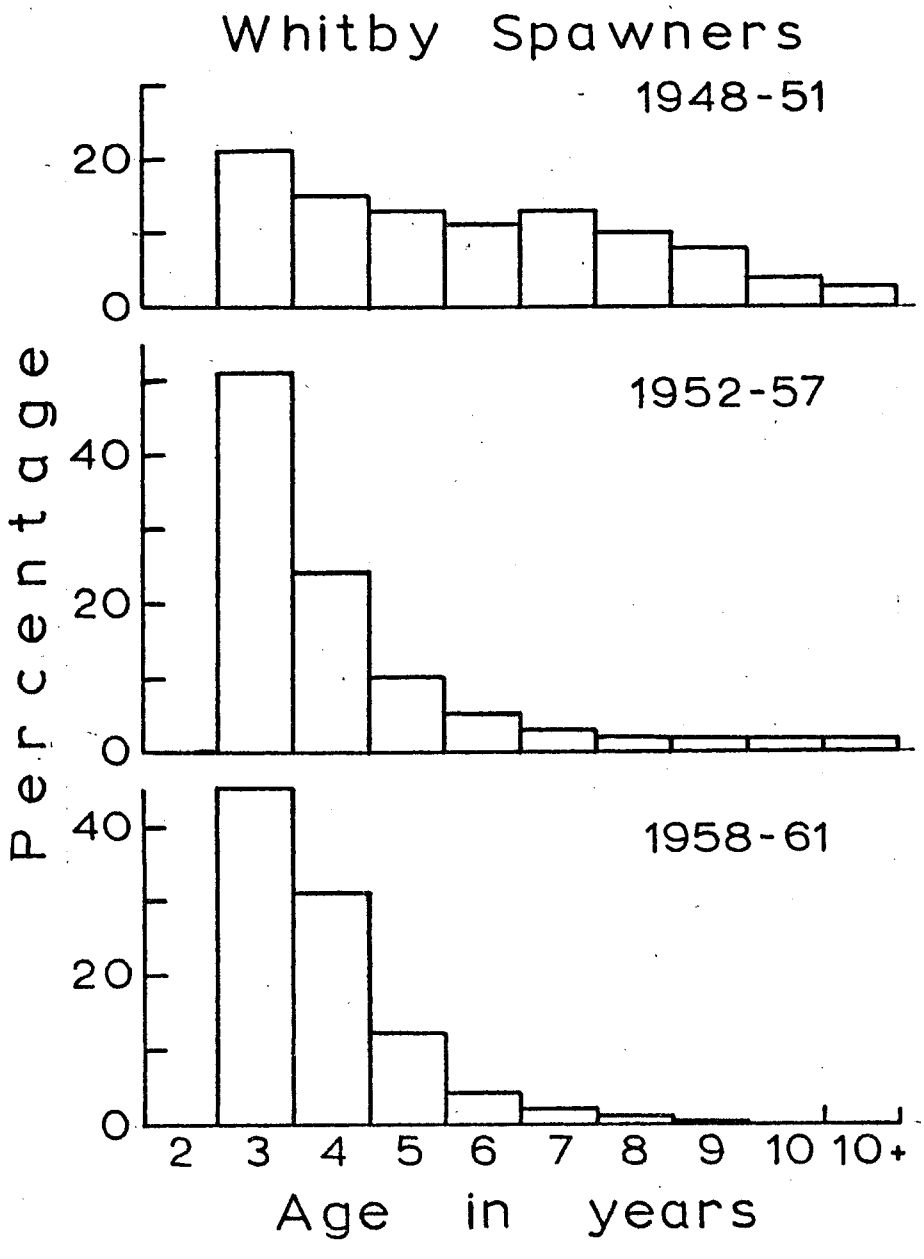

Figure 3. Percentage age distributions of Whitby spawners.

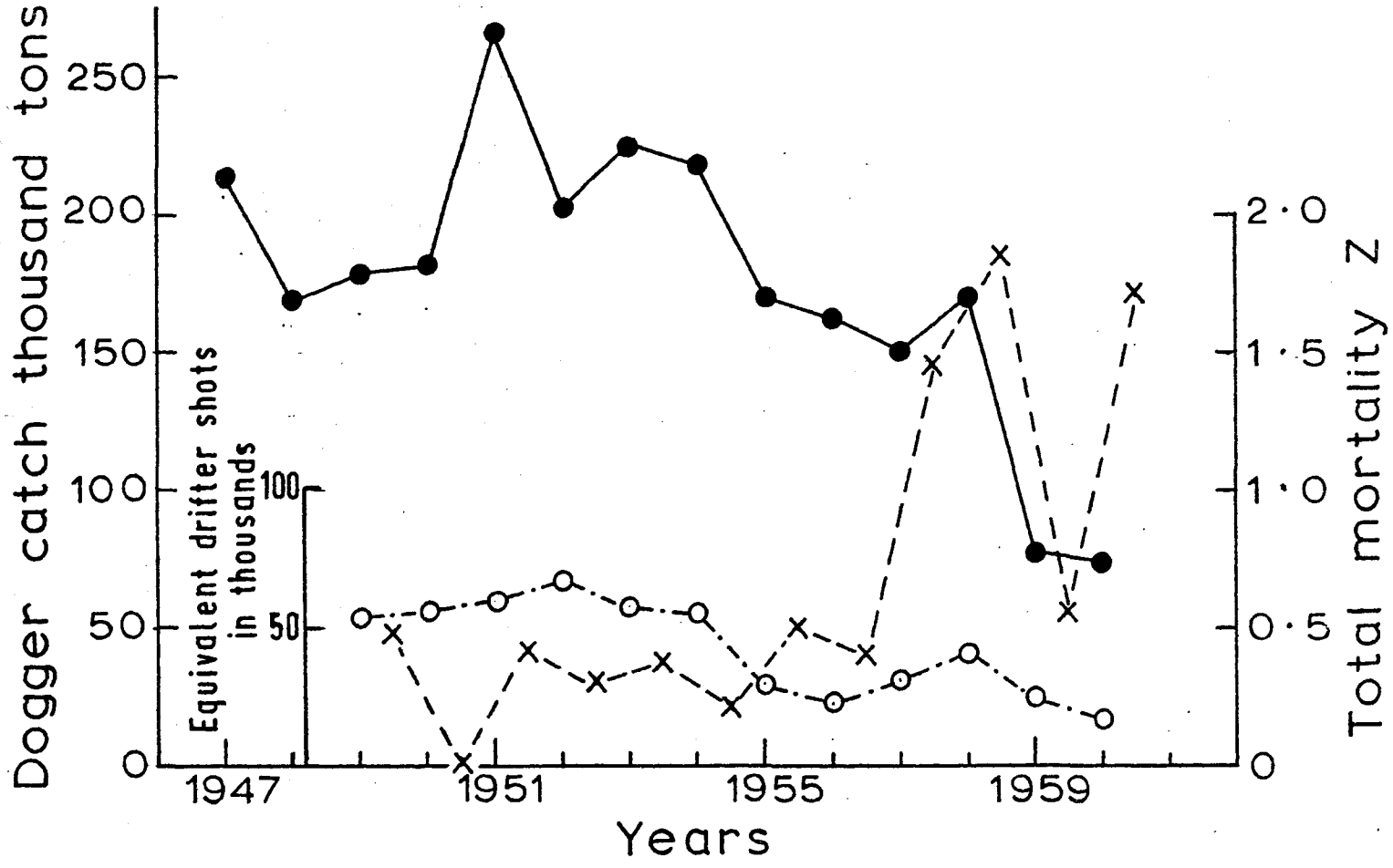

Figure 4. •—• Total 'Dogger' catch in tons

o—o Total effort as equivalent drifter shots

x - x Total mortality of Bank spawning fish