https://doi.org/10.17895/ices.pub.9469

10

GROWTH OF COD IN THE NORTH SEA AND USE OF THE INFORMATION.

BY

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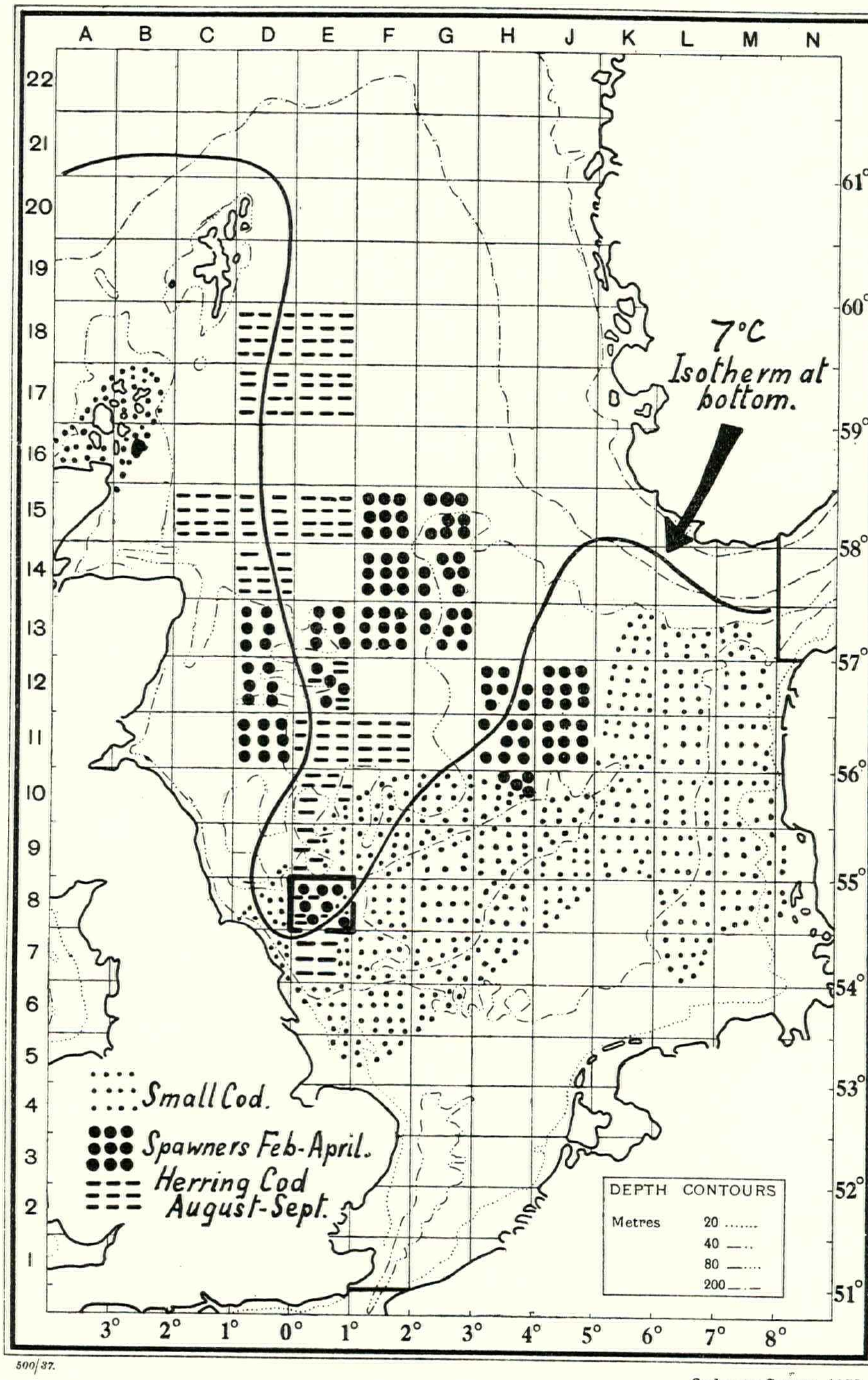


500/37.

Ordnance Survey, 1930.

Fig. 1

Note. Figures in the calculations on pp. 62—65 are subject to small corrections, too little significant to justify resetting the type. Final figures of the more important results are recorded on p. 66.

Introduction.

At the outset I wish to thank Professor Hjort and Dr. Russell for reading the notes on which this memorandum is based and making valuable suggestions.

So far as we know all stages in the life history of cod are represented within the North Sea. A general review of what is known has been published in brief form in an earlier paper (Graham 1934 b). As an example, we show here in Fig. 1 spawning grounds, small cod grounds, and grounds for cod feeding on herring. Such information depends, for its comprehensiveness, on statistics of catches with the trawl (Graham *et al.* 1924, Sec. 4; Graham 1934, pp. 45, 69, 74). Trawl statistics do not show one important feature of the life of the cod, namely dispersal after breeding. In May and June the large cod disperse widely to feed heavily on animals of the bottom. This is shown by statistics of line fishermen (Graham *et al.* 1924, Chart. 11; Graham 1934, Fig. 3C). Because the generalisation of all this information is by statistics, the description can only refer to the population of cod that is sampled by the fishery of which the statistics have been used. Thus, if there are cod in areas that are less easy to fish with the trawl than others, those cod have made a less contribution to the generalised statement than have the cod of fair grounds. The same principle applies in the study of growth.

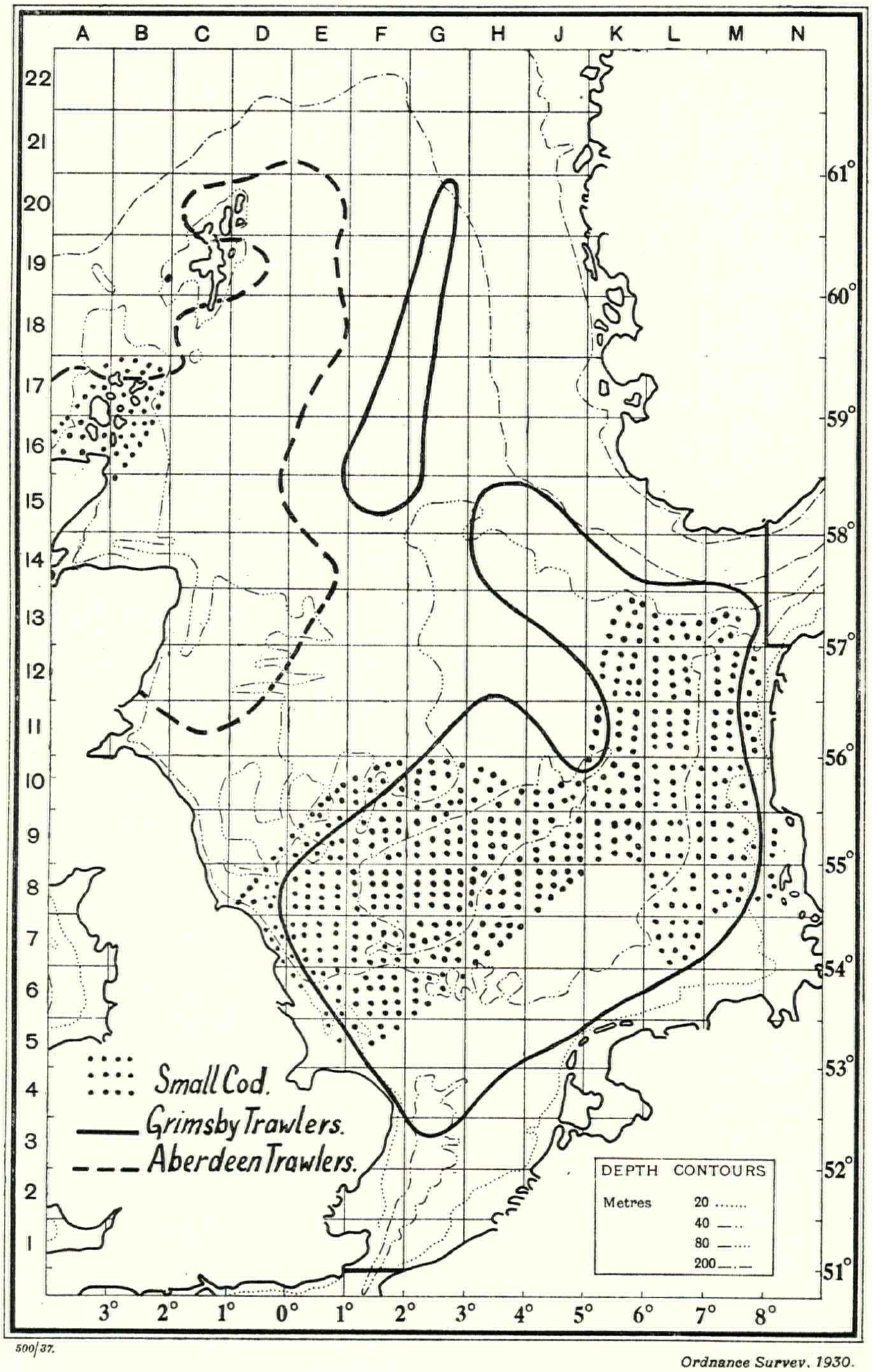
Growth up to 2 Years Old, mainly of Pre-Marketable Cod.

The frontispiece of an earlier paper shows how the age of young North Sea cod is read from the scales (Graham and Lumby 1929, Fig. 1). The scale in question was read as being just over two years old. Nothing, however, follows from this one determination. A cod 18 months old may be only 16 cm. long, weighing less than 100 grammes, while another cod of the same age from the same sample may be nearly 30 cm. long and weigh about 250 grammes (Graham and Lumby 1929, Fig. 20, p. 50; Russell 1922, p. 75). In 1924—1926 the research vessel "George Bligh" was used repeatedly to take samples of some very small codling that were then to be found on the Inner Herring Trawling Ground. The scales of these fish were all examined and tracings reproduced in Graham and Lumby (1929). This collection was the best, from the point of view of continuity, that is likely to be made for very small North Sea cod. It was published 5 years before the results for the rest of the Southern North Sea. Had there been no further publication than the description of growth on the Inner Herring Trawling Ground, the only information for the North Sea would have been the following:—

Age in months	6	12	18	24	30	36
*) Modal length (cm.)	8½	14	19	20	27	29

Now, in spite of the excellent collection on which this table is based and the great care that was taken in proper interpretation of the scales, these figures are unsuitable as a basis for generalisation for great fisheries in the North Sea, because they show exceptionally slow growth. (The collection was made and used as a check on the method of age determination). The Inner Herring Trawling Ground lies in the northern part of rectangle E. 8 and in rectangle E. 9, which, as is shown in Fig. 1, lies north of the common position of the isotherm of 7 degrees of temperature on the bottom in the summer. This isotherm has been taken as a convenient boundary of the area that suffers a thermocline in summer, which lies to the north and west of the isotherm. Now it was found that the samples of scales of all I-group and II-group cod that were collected from under this thermocline showed a growth similar to that of the Inner Herring Trawling Ground, whereas the samples from the area where there is commonly no thermocline showed faster growth. One or two samples from near the boundary showed intermediate or mixed growth. The difference in growth between the two main areas is considerable. At two years old the slow-

*) Approximate average of determinations of modes in samples. Graham 1934, p. 43.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3° 2° 1° 0° 1° 2° 3° 4° 5° 6° 7° 8°
Small Cod.
Grimsby Trawlers.
Aberdeen Trawlers.
DEPTH CONTOURS
Metres
20
40
80
200
500/37.
Ordnance Survey. 1930.

Fig. 2

growing codling would be about 20 cm. in modal length, whereas the fast-growing would be 36 cm., weighing about four times as much (Graham 1934, pp. 42, 46).

Turning again to Fig. 1, it is observed that the smallest statistical category of trawled cod lies densest in an area that is mainly not subject to a thermocline. It was also known that the fry first reach bottom in an area, which, if anything, lies still further to the south and east (Graham, Carruthers and Goodchild 1926). It was, therefore, assumed that the fast growth described applied to the codling that supply the trawl fishery.

Growth within the Trawled Population and "NWG".

So far we have mainly dealt with growth of cod before and just after they become marketable. (Graham 1934, pp. 140, 141). Thereafter the investigation falls into two parts. The first is the establishment of a table of age at a given length for the population landed by trawlers at Grimsby. This was founded on measurements made at sea on commercial vessels from 1919—1927. The second is the maintenance of observations of length-distribution of this same population on the market at Grimsby. This work is done regularly.

Here we may begin by showing Fig. 2. Had it been possible to add any further lines to Fig. 1, it would have been better to have put the contours representing the areas where the greater part of the trawling from Grimsby and Aberdeen lies upon Fig. 1, to show several ways in which the populations of cod landed at the two ports are not the same. However, it is sufficient to show only the area of Small cod, by way of illustration. It is at once clear that the population of cod landed at Grimsby will be expected to have a larger proportion of Small among it than the cod landed at Aberdeen. Similarly it has been shown that the trawlers of Lowestoft, Hull, Scarborough, Hartlepool, North Shields, Granton, and Dundee have characteristic but overlapping areas and those of the great-liners and seiners are different again (Graham 1934, p. 12). It would require a large staff of observers to sample cod from all these markets, so no attempt has been made to obtain generalised data for the whole North Sea trawl fishery. Instead, inquiry has been restricted to the population that is trawled and landed at Grimsby. These steam trawlers at Grimsby landed in 1928 about one third of all the cod that came from the North Sea, by any fishing method of any country (Graham 1934, p. 20). The next English port landed less than one quarter of the landing at Grimsby (Graham 1934, p. 112). There is no question that the work concerns the largest fishery for cod in the North Sea.

According to the theory expounded by Russell (1931) the crop or steady yield of a given stock depends, among other things, on the growth-rate. Growth makes a contribution to this crop, recruitment another, whereas natural mortality levies a toll. Calculation based on this reasoning was made in an earlier paper (Graham 1935), where the calculation had a particular form, to demonstrate that there was overfishing. The form was difficult, because only the order of magnitude of the rate of natural mortality could be assumed, not any exact value. For the present purpose this difficulty does not arise. For the calculation, growth is best defined in a certain way. Let N fish in a stock be distributed according to age so that there are:—

at age	$1^1/_2$	$2^1/_2$	$3^1/_2$	.... years
	$n_{1^1/_2}$	$n_{2^1/_2}$	$n_{3^1/_2}$	.... fish
weighing	$w_{1^1/_2}$	$w_{2^1/_2}$	$w_{3^1/_2}$	.... grammes
and let	$g_{1^1/_2}$	$g_{2^1/_2}$	$g_{3^1/_2}$	.... be calculated

according to the formula of perpetual compound interest, that is

$$g_{1^1/_2} = \frac{\log w_2 - \log w_1}{1}$$

and other values of g be calculated similarly.

Now if the stock be in equilibrium with fishing, so that, excluding fluctuations, N and $n_{1^1/_2}\, n_{2^1/_2} \ldots$ have no tendency to increase, decrease, or alter their relative proportion, then the total contribution of growth to the crop, in *grammes per annum* is given by

NWG

which Mr. Ottestad tells me should be written Σ_{nwg}.

It will be observed that G, the weighted average growth-rate of the fish in the stock, is not the same as *G*, used by Russell for the sum of all the increments of weight of the fish in the stock, although we have adopted Russell's equation as applicable to the processes measured in this way. (Graham 1935).

It is proposed to estimate NWG for different states of equilibrium, of the stock of cod and fishing by the trawlers from Grimsby. The estimates cannot be exact, because they will assume g at any age unchanged. This is thought, however, not to detract from their usefulness, because the changes in NWG are, nevertheless, estimated to be so considerable as to have a high significance.

Although NWG has absolute form, kilogrammes per annum, it will be calculated for a given quantity of stock, that is for the quantity taken in 100 hours fishing of a 1st class steam trawler.

Since G and W are averages, depending on the ratio of values of n at different ages, it is clear how important it is in this calculation to define the population that is being studied. For example, the stock serving Aberdeen trawlers will contain proportionally more older fish than that of the Grimsby trawlers, as can be seen in Figs. 1 and 2. Consequently neither W nor G can be the same in the two populations, although the distribution of the thermocline and some direct data lead to the conclusion that g is the same.

It is seen that the two parts of the investigation of this section may be redescribed. The first leads to determination of g, at different ages. This has been done, once only. In the second, data are collected continuously for determination of n at different ages, so that current values of NWG shall be available.

It is hoped to redetermine g sufficiently to make sure that there has been no great change since the period 1919—1927 to which the former determination applied. In the meanwhile we rely on the former determination, which may now be described. In cod of these ages in the North Sea age determination by scales has many difficulties. We finally started from the age as given by scales in the younger fish and thereafter proceeded by analysis of statistics of length, of which there was a very fine collection made in the area south and east of the thermocline on board commercial steam trawlers. The analysis was guided by recorded growth of marked fish and supported by the period of successive waves of abundance in the statistics of market categories. (Graham 1934, Sections 3 and 4). The analysis is tabulated on pages 137—139 of Graham (1934). All the observations of the whole period were taken together. For every month except February, for which the data were poor, there is a table showing the length-distribution of each age-group. For example:—

Cod, 2 years old in March. (Graham 1934, p. 137).

							Total
Length (5 cm. groups)	25—	30—	35—	40—	45—	50—	
No. per mille	21	100	176	122	50	4	473

These frequencies are per 1,000 of the whole stock. The average length is 38·5 cm. A fish of 38·5 cm. would weigh 506 grammes, gutted, according to the average of more than 5,000 determinations (Russell 1922, p. 75). There is no objection to the data for conversion referring to gutted fish, for it is the crop of fish, gutted, in which we are interested. The figure of 506 grammes is the weight of the fish of average length. The average weight, however, is found, in a different manner, from the same data:—

Length (5 cm. groups) ..	25—	30—	35—	40—	45—	50—	
Weight (grammes)	183	302	469	680	933	1,262	
Frequency	21	100	176	122	50	4	473
Products	3,843	30,200	82,544	82,960	46,650	5,048	251,245

Dividing the last total by 473, the number of fish, the average weight works out at 531 grammes. Similarly, the average weight of a 3-year-old cod is 1,461 grammes. The determination of g is then as follows:—

$$\begin{array}{lr} \text{Napier's log } 1{,}461 = & 7{\cdot}2869 \\ \text{Napier's log } \phantom{1{,}}531 = & \underline{6{\cdot}2748} \\ & \underline{1{\cdot}0121} \text{ say } 1{\cdot}01 \end{array}$$

Continuing in the same way, we obtain the following series of figures. These all apply at the half years of age, i.e., in September.

Age, Exactly.

	Years					
	$1^1/_2$	$2^1/_2$	$3^1/_2$	$4^1/_2$	$5^1/_2$	$6^1/_2$
g	1·89	1·01	0·60	0·44	0·39	0·29

(Graham 1935, p. 268)

This first part presented us with figures for g that have been used ever since, and also with a table of conversion from length to age. This conversion table is used in the second part of the study to estimate the age composition, or distribution of n, from statistics of the length-distribution of the landings at Grimsby. These statistics are collected regularly and it may not be out of place to describe briefly how they are obtained. It is thought that such statistics are best if completely comprehensive, that is, refer to all the British 1st class steam trawlers that land their own catch at Grimsby from the North Sea. Referring first to the work on the market, the collectors of statistics keep special records of the quantities of each of the six trade sub-categories of cod that are landed. Two measurers do their best, amongst other duties, to measure 400 fish from each of the trade sub-categories every month.

These records of measurements of fish in each market sub-category are posted to Lowestoft monthly. The frequencies are arranged in 5 cm. groups. The weight of the fish that were measured in each sub-category is calculated, using average weights for 5 cm. groups from Russell's table (1922, p. 75). The weight of each sub-category landed (in cwts.) is supplied separately each month from Grimsby, and the ratios of these weights to those of the measured samples are the factors by which the length-frequency distribution tables are multiplied, giving estimated length-distribution of total landings for each sub-category. Addition of all these gives number of cod in each length-group landed during the year.

It is laid down in the work that observers should not follow blindly the designations of parcels that are given by the trade, but should maintain in their own minds a standard that they use in naming in the records, either measurements or quantities. There are two measurers, who also record some quantities, and three or four other recorders of quantities; so this standard, in so far as it attempts to correct the vagaries of market practice, which is fortunately only in a small part of the work, has to be common to the minds of half-a-dozen people.

The alternative is to have the fish measured at sea, before any sorting takes place, as was the practice from 1921—1930, when only a little time was spent by measurers on the market. The records were, however, found to be quite useless for estimating the length-distribution of the catch of cod in any particular year. Two measurers could only, that way, work one vessel at a time, sampling about 30 catches per annum and the variation from voyage to voyage rendered such small sampling inadequate. The same two measurers, with the collection of quantities, now sample the whole of the landing. Their scope is increased as many times as there are trawlers working in the North Sea from Grimsby, namely about 150 times. Naturally, the precision of the statistics is reduced, but this is less important.

Table I shows the length-distribution of the landings per 100 hours fishing in all years for which it is available, together with the weight of the fish in each length-group. Table II is the conversion table taken from the first part of this investigation and Table III gives figures for n ("No.") in 1921—1930 and in subsequent years including1936. We have now the information for calculating NWG, firstly for 1921—1930, secondly for some later period. The first calculation was the basis of the conclusion of an earlier paper (G r a h a m 1935, p. 268) except for one difference that may be discussed. It may have been observed that Tables I and II refer to the whole year. That is to say, there is no time during the year when the census would be found as in these tables, but that they represent averages for the whole calendar

Table I.

COD. (Grimsby)

Number and Weight (Kilograms) of Fish caught per 100 hours fishing, and landed by 1st class Steam Trawlers at Grimsby from the North Sea.

Range	Average 1921—1930		1931		1932		1933		1934		1935		1936		Average 1931—1936	
	No.	Wt. kg.	No.	Wt. kg.	No.	Wt. kg.	No.	Wt. kg.	No.	Wt. kg.	No.	Wt. kg.	No.	Wt. kg.	No.	Wt. kg.
cm.																
20— ..	2	0	3	0	8	1	4	0	1	0	0	0	1	0	3	0
25— ..	58	11	64	12	320	59	102	19	68	12	21	4	57	10	105	19
30— ..	144	43	169	51	534	161	519	157	190	57	82	25	182	55	280	84
35— ..	140	66	148	70	345	162	518	243	125	58	110	51	160	75	234	110
40— ..	110	74	118	80	163	111	356	242	89	61	92	62	102	70	153	104
45— ..	82	77	76	71	56	53	163	152	95	89	101	94	60	56	92	86
50— ..	68	86	41	52	42	53	77	97	104	131	71	89	33	42	61	77
55— ..	53	78	40	60	58	86	66	98	77	114	38	57	30	45	52	77
60— ..	36	74	52	108	56	116	64	133	78	160	24	50	27	56	50	104
65— ..	31	81	55	144	42	111	57	149	60	157	18	48	22	58	42	111
70— ..	26	84	31	101	31	100	32	104	29	96	19	62	16	51	26	86
75— ..	14	57	16	66	25	103	22	90	17	68	17	68	10	41	18	73
80— ..	12	60	8	42	15	75	15	76	11	56	13	63	8	40	12	59
85— ..	11	66	7	40	9	52	12	70	9	56	8	46	8	48	9	52
90— ..	13	89	9	61	7	46	9	66	8	59	6	42	8	54	8	55
95— ..	10	77	8	61	6	46	6	46	7	58	5	43	5	41	6	49
100— ..	6	52	5	40	5	41	4	33	4	39	4	32	4	31	4	36
105— ..	2	16	2	16	2	18	2	20	2	20	2	16	1	13	2	17
110— ..	0	0	1	6	1	8	1	8	1	8	0	0	1	6	1	6
115— ..			0		0	0	0	0	0	0	0	0	0	0	0	0
120— ..	0	0									0	0	0	0	0	0
Totals ..	818	1,091	853	1,081	1,725	1,402	2,029	1,803	975	1,299	631	852	735	792	1,158	1,205

Table II.

Age-Composition of Cod of given Length-Groups.

The following table of the average age composition of each length-group during 1919—1927 was prepared from Tables 30 and 31 of G r a h a m, 1934, interpolating for the month of February. The numbers in each age-group are expressed as percentages of the number in the length-group.

5 cm. Length-Group	Age-Group 0	I	II	III	IV	V	VI	VII	VIII
	%	%	%	%	%	%	%	%	%
20— ...	11	78	11	—	—	—	—	—	—
25— ...	1	84	15	—	—	—	—	—	—
30— ...	1	75	24	—	—	—	—	—	—
35— ...	—	55	45	—	—	—	—	—	—
40— ...	—	35	65	—	—	—	—	—	—
45— ...	—	15	77	8	—	—	—	—	—
50— ...	—	1	72	27	—	—	—	—	—
55— ...	—	—	43	57	—	—	—	—	—
60— ...	—	—	17	74	9	—	—	—	—
65— ...	—	—	3	62	35	—	—	—	—
70— ...	—	—	—	21	72	7	—	—	—
75— ...	—	—	—	—	65	35	—	—	—
80— ...	—	—	—	—	23	71	6	—	—
85— ...	—	—	—	—	—	64	36	—	—
90— ...	—	—	—	—	—	25	67	8	—
95— ...	—	—	—	—	—	—	75	25	—
100— ...	—	—	—	—	—	—	40	60	—
105— ...	—	—	—	—	—	—	—	100	—

year. In the earlier paper the calculation given in the text referred to the month of September, which is half-way through the year of life of the cod, assumed to start in March. I do not know which is the better procedure, but it is unlikely that either procedure will give misleading results in comparisons, so long as it is used throughout.

The value of NWG is the sum of the *nwg*'s for each age-group. Thus Table III shows 288 I-group fish per 100 hours fishing, in the period 1921—1930. By applying a conversion table to their length-distribution the column "Wt" was obtained showing that these 288 fish were estimated to weigh altogether 116 kg. This is *nw*. Turning back to the figure for $g\ 1\frac{1}{2}$, we find that the contribution to the crop of the growth of the I-group in the stock represented by 100 hours fishing of a 1st class trawler of Grimsby is $116 \times 1{\cdot}89$ or 219 kilogrammes per annum. Similar multiplications can be made for all the groups for which there is a value of *g*. When these are added together they come to 763 kilogrammes per annum. Three comments may be made here. In the first place this can be called *763 kilogrammes per annum per 288 recruits of the I-group* and of such older recruits as may be expected to join up with that number of I-group recruits. This is an alternative definition to that involving consideration of fishing time. Secondly, it will be noted that *g* was calculated from instantaneous data, but is here applied to average data. Perhaps there is some better procedure than this. Thirdly, it seems not possible to include the contributions of the oldest and youngest groups, owing to lack of data of *g*.

To recapitulate:— If the stock of cod was in equilibrium with fishing in 1921—1930, the contribution of growth to the yield was 763 kilogrammes per 288 I-group recruits.

Use of the Method to judge whether Fishing should be decreased for better Profit.

We have seen that other things come into the estimate of steady yield, or crop, than growth alone, and it has been decided in an earlier paper (G r a h a m 1935) that the fishing of 1919—1930

Table III.

COD. (Grimsby).

Numbers and Weights from Table I arranged according to Age-Groups, assuming that the Age Composition of any Length-Group is the same as in 1919—1927 (Table II).

Age Group	Average 1921—1930 No.	Wt. kg.	1931 No.	Wt. kg.	1932 No.	Wt. kg.	1933 No.	Wt. kg.	1934 No.	Wt. kg.	1935 No.	Wt. kg.	1936 No.	Wt. kg.	Average 1931—1936 No.	Wt. kg.
0	1	1	3	1	9	2	7	1	3	0	1	0	3	1	4	1
I	288	116	317	125	932	308	913	377	315	120	187	87	318	123	499	189
II	319	260	309	237	544	331	823	562	365	325	282	240	277	197	432	315
III	106	196	120	244	125	243	164	307	181	343	83	144	68	131	122	236
IV	46	147	59	189	63	208	67	217	63	199	36	127	32	99	54	174
V	25	131	19	100	29	138	30	153	24	120	23	111	17	91	24	119
VI	23	161	16	114	15	102	17	118	16	117	13	91	13	94	15	106
VII	10	79	10	71	8	70	8	68	8	75	6	52	7	56	8	65
VIII ...																
Totals ..	818	1,091	853	1,081	1,725	1,402	2,029	1,803	975	1,299	631	852	735	792	1,158	1,205

made less profitable use of the stock in the North Sea than it could, by giving the stocks too hard usage. What further information does Table III provide, for the years since 1930?

It has already been pointed out (Graham 1934 b) how the figures of "No." in Table III can be used to show the survival from one year to another of particular year-classes and so judge whether fishing is increasing or decreasing, compared with 1921—1930, where the average survival is given directly by the ratio of number in successive year-classes. The survivals which would be calculated from Table III differ somewhat for those already published for some of the years. This is due to some adjustments which we are now in a position to make, to correct the figures of 1931, 1932 and 1933 for the fact that measuring was only carried out during the quarter months of those years.

Suppose that it is decided to investigate how the fishing of 1933—1936 will affect the yield that would be steadily available, were the fishing of 1933—1936 steadily sustained. This seems a problem that is worth investigation, to which we will proceed. There is, however, one detail that needs attention first. The survival as II-group in 1934 of I-group in 1933 is only 40 per cent., whereas the two subsequent years, with mesh regulations in force, gave higher values, 90 and 148 per cent. It seems most useful to work with the average of the two later years only, in this age-group.

A new letter may conveniently be used here to represent the rate of general mortality, that is, natural mortality and fishing together. We have already (Russell 1931, Graham 1935) A for recruitment, G for growth and M for natural mortality in the whole stock, with small a, g, and m for the same at any given age, as well as C for the rate of capture or fishing. For the sake of short writing V has been used for natural increase, or $(A + G — M)$, and it is proposed to have Z and z for rate of "decrease", that is $(C + M)$.

Average values of z have been worked out from Table III. That from the II-group to the III-group may be given as an example:—

	1934/1933		1935/1934		1936/1935	
	Fy	C. logs	Fy	C. logs	Fy	C. logs
III	181	2·2577	83	1·9191	68	1·8325
II	823	2·9154	365	2·5623	282	2·4502
		—0·6577		—0·6432		—0·6177

$$—1{\cdot}9186/3 = —0{\cdot}6395$$
$$—0{\cdot}6395/0{\cdot}4343 = —1{\cdot}4725 = z$$

For the present purpose, the last step may be omitted, and the work carried out in common logs, that is with —0·6395 which may be indicated by z'.

Construction of the final stock that the rates of 1933—1936 would give rise to, from a number of I-group recruits, namely 288, equal to those of 1921—1930, is as follows:—

log 288 =	2·4594 =	log 288	I-group
z' =	0·0613		
	2·5207 =	log 332	II-group
z' =	—0·6395		
	1·8812 =	log 76	III-group
z' =	—0·5103		
	1·3709 =	log 23	IV-group
z' =	—0·4031		
	0·9678 =	log 9	V-group
z' =	—0·2624		
	0·7054 =	log 5	VI-group
z' =	—0·3407		
	0·3647 =	log 2	VII-group

Mere inspection of the two stocks, side by side, shows what a great change has taken place:—

	0	I	II	III	IV	V	VI	VII
1921—1930	1	288	319	106	46	25	23	10
1933—1936	1	288	332	76	23	9	5	2

If we take half the IV and all the older fish as "Large" and also as mature cod, we see that the place of 81 of these fish, valuable both to the present and future fisheries, is to be taken by only 28 fish, or nearly a third. A big reduction is also to be expected in the stock of medium-sized fish. It should be noted that the calculation has the full benefit of any improvement due to the present mesh regulations.

For the time being, however, we are only interested in the respective contributions to the crop of the growth in these two stocks.

The calculation of NWG for the new stock that the fishing of 1933—1936 will produce is generally similar to that for 1921—1930, differing only in one important detail. In 1921—1930 we were able to take the *nw*'s directly from a column of Table III ("Wt"), but for 1933—1936 Table III does not show the correct, permanent *n*'s, which have been found by prophecy in our text, not by observation. Consequently, *w*'s must be calculated separately to apply to the *n*'s. This has been done by dividing the "Wt's" for 1933—1936 in Table III by the "No.'s". The result is:—

	I	II	III	IV	V	VI
w (grammes)	408	758	1,865	3,242	5,053	7,119

The calculations are now the same as before, using the same *g*'s and multiplying to obtain *nwg*'s and adding *nwg*'s to give a new NWG. This works out at *623 kilogrammes per 288 I-group recruits.*

Fishing of the intensity current in 1933—1936 may therefore be expected to result in a substantial *reduction* in the contribution of growth to the crop of cod, as compared with 1921—1930, when fishing was already unprofitably intense.

The expected reduction in this contribution to the crop is of the order of 20 per cent.

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Addenda.

(1) Figures for 1937, corresponding to those of Table I, became available while this paper was in press. I am glad to say that they show substantial improvement in survival of cod, but sorry that this should have been brought about by economic distress in the industry.

(2) *Final Figures of more important Results.*

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	Year					
	$1^1/_2$	$2^1/_2$	$3^1/_2$	$4^1/_2$	$5^1/_2$	$6^1/_2$
g	1·89	1·04	0·57	0·44	0·39	0·28

p. 64 Table II has been finally corrected.
NWG amounts to 763 kilogrammes per 285 recruits of the I-group.

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	I	II	III	IV	V	VI	
w	407	762	1,915	3,269	5,010	7,048	grammes

NWG amounts to 620 kilogrammes per 285 recruits.