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# EXPERIMENTS

IN



## THE TRANSPLANTATION OF SMALL PLAICE TO THE DOGGER BANK,

BY

WALTER GARSTANG.

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WITH ONE CHART, TWO ILLUSTRATIONS IN TEXT (PAGES 53, 55), AND FOUR DETAILED TABLES AT  
END (PAGES 62-65).

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P81

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## § 1. INTRODUCTION.

The Dogger Bank is characterised by the large size of the Plaice found upon it, as well as by the great scarcity of small Plaice below 30 cm. (12 inches) in length. Comparatively with other regions of similar depth, Plaice of all sizes are scarce upon the Bank (*see* Trawling Investigations, pp. 83, 84).

The scarcity of small Plaice upon the Bank arrested our attention at an early stage of these investigations, and it was soon found that this scarcity could not be attributed to any lack of suitable food. Investigations with the dredge showed a great abundance of bivalve mollusks, which constitute the favourite food of Plaice in all localities. Moreover, although Plaice were found to be sparsely distributed, the trawl always brought up a great quantity of Dabs, small as well as large, upon the south part of the Bank, and these were found to be feeding principally upon the same kinds of mollusk (*Solen* and *Mactra*) which formed the chief food of the Plaice in the same region (*see* Mr. Todd's Report on the Food of Fishes, pp. 247-251). The bottom deposits were also found to consist for the most part of fine sand, which is favourable both for burrowing bivalves and small Plaice.

It was already well known that there is a marked difference between the Plaice and the Dab in regard to their reproduction. Young Dabs of the smallest sizes have been repeatedly found in the offshore as well as the inshore waters; the eggs and fry of the Dab do not need to be carried inshore in order to undergo successful metamorphosis. On the other hand, the youngest Plaice are never found in the offshore waters, and the eggs and fry of this species only undergo successful development if carried by the currents to suitable localities inshore.

It thus appeared that the absence of small Plaice upon the Dogger Bank was probably due, not to any unsuitability of the conditions, but to the fact that this region is surrounded by a barrier of deep water which interposes a physical obstacle to the immigration of young Plaice from the coastal grounds. The occurrence of a large indigenous population of Dabs, and the character of the food upon which they manifestly thrive, rendered it practically certain that small Plaice, if transplanted to the Bank, would meet with suitable conditions for their further growth.

## § 2. EXPERIMENTS MADE.

In April and May, therefore, of 1904 we made our first experiments in this direction. The first experiment, which consisted in transplanting about 450 small Plaice from the Dutch coasts, was rendered a failure by the bad weather which was experienced on the voyage. Most of the fish in the tanks were so injured by the movement of the ship that they were all moribund at the time of liberation. The other experiments were successful. On the 13th April 441 Plaice were transplanted from Bridlington Bay to the Eastermost Shoal (Experiment I.\*), and on the 25th and 26th May 706 Plaice were transplanted from the Horn Reef Grounds; of the latter 362 were liberated on the Tail of the Dogger (Experiment II.†), and 344 upon the Eastermost Shoal (Experiment III.†). The fish were transported in iron tanks on the deck of the *Huxley*, a circulation of sea water being maintained by the ship's pump and hose.

The positions of the places of liberation in these experiments are shown upon the chart.

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\* This experiment was carried out by Mr. J. O. Borley, assisted by Messrs. J. Potter and G. T. Atkinson.

† These experiments were carried out by myself, assisted by Messrs. Borley and Atkinson.



## § 3. MIGRATIONS OF THE TRANSPLANTED FISH.

Immediately after their liberation the Plaice in the first experiment distributed themselves over almost the entire area of the south part of the Bank, the contour which is shown in the chart as surrounding the positions of recapture of these Plaice up to the end of May being almost identical with the contour shown by the recaptures at the end of April. Few of these fish were recovered during the summer months after May, but a considerable number were reported during October. The broken contours shown upon the chart represent the total range of the wanderings of the transplanted fish up to the end of this month, two exceptional instances of more extensive migration being separately represented and connected independently with the contours corresponding to their respective experiments.

It will be seen from an inspection of the chart that up to the end of October the fish remained for the most part upon the Bank or in its immediate precincts. The fish liberated on the Eastermost Shoal are seen to have spread over nearly the whole Bank; those liberated on the Tail of the Dogger wandered almost exclusively in a south-westerly direction over the north part of the Bank. This latter feature is of interest in suggesting that during the summer months the Bank possesses a combination of features which exerts an attractive influence over the Plaice on the outlying portions.

After October a considerable exodus from the Bank appears to have taken place, as exemplified by the outlying position of most of the recaptures reported. As extreme samples of this winter scattering, I may draw attention to the case of a fish reported from the Horn Reef Grounds in November, another from Fair Island (between the Orkney and Shetland Islands) in December, and another from the Lowestoft deep water in January. All these records appear to be well substantiated.

The complete figures representing the frequency of recapture on and off the Bank from April to October, and from November to February, for each experiment are as follows:—

TABLE 1.

Experiment.	April to October.			November to February.			Total Recaught.
	On the Bank.	Off the Bank.	Locality not reported.	On the Bank.	Off the Bank.	Locality not reported.	
I. ... ..	33	5	9	1	8	4	60
II. ... ..	4	3	...	1	3	...	11
III. .... ..	7	2	1	5	4	5	24
Totals ... ..	44	10*	10	7	15†	9	95

\* 1 north, 5 south, 3 south-east, and 1 west of the Bank.

† 8 north, 2 south, 3 south-east, and 2 east of the Bank.

It follows from these facts concerning the movements of the fish that up to the end of October the rate of growth shown by the transplanted fish may be attributed almost exclusively to the influence of the Dogger Bank, and that any additional increments of growth after that month are mainly attributable to the influence of other localities, except in the case of experiment No. III.

## § 4. SIZES OF FISH LIBERATED AND PROPORTION RECAPTURED.

All the Plaice transplanted to the Bank were marked with numbered labels of thin brass, as used in the ordinary marking experiments previously described.



The numbers and sizes of the fish liberated in the three experiments are shown in the accompanying table. In each case the great majority of the transplanted fish were less than 25 cm. (10 inches) in length at the time of liberation. A few very small fish from 14 to 16 cm. ( $5\frac{1}{2}$  to  $6\frac{1}{2}$  inches) in length were liberated, but none of these have been reported as recaptured.

TABLE 2, showing the numbers and sizes of the Plaice transplanted, and the total number of recaptures reported to February, 1905.

Experiment.	Numbers Liberated.						Number Recaptured.	
	Length in cm.					Totals.	No.	Per cent.
	14	15-19	20-24	25-29	30+			
I. Bridlington Bay to Shoal ...	4	184	206	46	1	441	60	14
II. Horn Reef to Tail ...	...	144	209	9	...	362	11	3
III. Horn Reef to Shoal ...	...	140	187	17	...	344	24	7
I.-III.—Totals liberated ...	4	468	602	72	1	1,147	...	...
Totals recaptured ...	...	16	52	26	1	...	95	8
Percentage of Totals liberated ...	0.0	3.4	8.6	36.1	100.0	...	...	...

From April, 1904, to February, 1905, no month passed without yielding at least one recaptured fish. The greatest numbers were returned during April and May (24 fish), and during October and November (32 fish). To the end of February, 1905, 60 fish were recaptured from the Bridlington Bay experiment *i.e.*, 14 per cent. During the same period 24 fish were recovered from the Horn Reef experiment, (No. III.), yielding a percentage of 7.0 per cent. on the numbers originally liberated. In comparing these percentages of recovery, however, it must be borne in mind that the latter experiment was carried out six weeks later than the first experiment, and gave little opportunity for the recapture of any specimens prior to June; whereas in the first experiment more than a third of the total recaptures were reported during the months of April and May. The high percentage of recaptures among the largest fish liberated (36 per cent. for those originally exceeding 25 cm.) is worthy of notice.

§ 5. RATE OF GROWTH.

The fish liberated on the Tail of the Dogger have grown at a slower rate than those set free on the south part, but the number of recoveries is too small to show the average increase from month to month. Two fish recaptured in October showed an average growth of 8.2 cm. ( $3\frac{1}{4}$  inches), which represents the growth on the north part of the Bank in four and a half months. The paucity of recaptures from this experiment is largely attributable to the fact that the majority of the fishes liberated at this spot (208 out of 362) were derived from a haul on the Horn Reef Grounds, which, though short in duration, yielded a heavy catch of fish, the vitality of which was much impaired in consequence. Only the liveliest were marked in preparation for liberation; but there was a heavy mortality among these during the voyage to the Bank, and there can be no doubt that some of those ultimately set free were moribund at the time of liberation. The Plaice liberated in Experiment III. were derived from a different haul on the same grounds, which resulted in a lighter catch. Not a single death took place among this lot during the voyage to the Bank, although the other conditions were in all respects identical.



The results with regard to the remaining experiments are shown in the accompanying table, in which the average growth is shown from month to month for each experiment.

TABLE 3, showing the rate of growth of small Plaice transplanted to the Shoal of the Dogger Bank.

—		I. From Bridlington Bay.									III. From Horn Reef Grounds.					
Date of Liberation.		13th April, 1904.									26th May, 1904.					
Month of Recapture.	Number of Fish.		Initial Length (cm.).*			Growth (cm.).			Number of Fish.		Initial Length (cm.).*			Growth (cm.).		
	Caught.	In-cluded.	Mini-mum.	Maxi-mum.	Aver-age.	Mini-mum.	Maxi-mum.	Aver-age.	Caught.	In-cluded.	Mini-mum.	Maxi-mum.	Aver-age.	Mini-mum.	Maxi-mum.	Aver-age.
1904.																
April	...	...	14	14	17	27	23.9	0	1	0.2	...	...	...	...	...	...
May	...	...	10	10	19	27	24.5	0	1	0.4	...	...	...	...	...	...
June	...	...	5	4	20	28	25.5	1	3	1.7	1	1	...	...	20.2	0.0
July	...	...	3	2	23	28	26.5	3	3	3.0	...	...	...	...	...	...
August	...	...	3	3	22	29	26.3	4	7	5.4	1	1	...	...	21.75	3.75
September	...	...	1	1	...	...	19.0	...	...	9.0	...	...	...	...	...	...
October	...	...	11	11	17	27	21.5	9	14	11.8	8	7	19.5	24.75	21.7	10.2
November	...	...	6	6	19	25	20.8	10	15	13.2	7	5	20.75	23.5	21.8	8.2
December	...	...	1	1	...	...	20.0	...	...	13.0	1	1	...	...	24.0	11.3
1905.																
January	...	...	2	2	21	27	24.0	11	15	13.0	3	3	19.25	21.5	20.2	11.15
February	...	...	4	3	22	23	22.3	13	15	13.7 <sup>1</sup>	3	3	21.5	25.5	22.9	14.7

<sup>1</sup> One exceptionally large fish (31 cm. on liberation) has been excluded from this average.

<sup>2</sup> The two fishes reported to have been recaptured upon the Bank in November yield an average growth of 12.2 cm. (11.85-12.5).

<sup>3</sup> The two fishes reported to have been recaptured on the Bank in February showed a growth of 14.7 cm. in each case.

\* NOTE.—As fractions of a centimetre were neglected in Experiment I. when the initial lengths were recorded, they have also been neglected in calculating the average lengths on recapture in the same experiment; most of the average lengths are, therefore, probably 0.5 cm. too low. In Experiment III. the initial lengths were recorded to quarter of a centimetre; the average initial lengths are, therefore, probably too low in most cases by 0.125 cm., while the average lengths on recapture are exact, except in so far as they were reduced by shrinkage of the fish between recapture and remeasurement.

With regard to the first experiment, the transplanted fish are seen to have grown steadily, and at a very rapid rate up to the end of October, with a further increase, though of a less pronounced character, to the end of November. After that date the fish showed no marked increase of size to the end of the period under discussion. The average increase of length during the whole period amounted to about 13 cm. (5 inches), the maximum being 15 cm. (6 inches), and the minimum, for fishes below 30 cm. on liberation, 10 cm. (4 inches).\*

The Plaice transplanted from the Horn Reef Grounds had six weeks' less growth at the beginning of the period than those transplanted from Bridlington Bay. In spite of this the average growth to November amounted to about 11 cm. (4.4 inches). If allowance be made of about 1.5 cm. for the growth from April 13th to the end of May, it will be seen that up to November the rate of growth of the Horn Reef fish on the Shoal of the Dogger was approximately identical with that of the Bridlington Bay fish. It is noticeable, however, that the growth of the fish did not cease at this date, but continued throughout the winter, the average growth by February amounting to 13.7 cm. (5.4 inches). This feature is probably attributable to the circumstance that a majority of the fish recaptured during the winter months from this

\* The full years' growth, based upon 13 returns in April 1905, has since been shown to be 15.0 cm. (varying between 12 and 18 cm.), i.e. 6 ins.



experiment, concerning which full details are available, were reported to have been caught upon the Dogger Bank, whereas nearly all the fish recaptured during the same period from the first experiment (concerning which the locality of recapture was reported) were taken on grounds more or less remote from the Bank. Two fishes recaptured upon the Bank in February had each grown 14.7 cm. (5.8 inches).

§ 6. COMPARISON WITH RATE OF GROWTH ON COASTAL GROUNDS.

The rate of growth shown by these transplanted fish is considerably in excess of all previous records for young Plaice. The most rapid growth previously demonstrated was that of marked Plaice in Thisted Bredning (Limfjord), as shown by Dr. Petersen's experiments\* with marked fish in 1895. The growth of these fish from April to October showed an average increment of 3.75 Danish inches (from 8.83 to 12.58 inches), *i.e.*, about 9.5 cm. This growth is identical with Dr. Fulton's† estimate of the growth during the fourth year of Plaice in Scottish waters off Aberdeen, *viz.*, from 23 to 32.5 cm. in March. Off the Northumberland coast Mr. Meek‡ estimates the growth during the corresponding year at 2.9 inches (= 7.4 cm.), *viz.*, from 7.9 to 10.8 inches. Dr. Wallace, in his paper in the present volume, finds a maximum difference of 6.9 cm. between the average size of three-year-old and four-year-old fish in a series of four hauls between the Brown Ridges and the Dutch coast, *viz.*, from 20.2 to 27.1 cm.

It is desirable at this stage to see how far the existing estimates as to the normal growth of unmarked fish in particular localities correspond with the averages based upon marking experiments alone, since it is possible that the process of marking diminishes the rate of growth to some extent.

The following Table shows the average increase in length throughout an entire year for certain groups of marked fishes from different localities:—

TABLE 4.

Group.	Fish. §	Number of months' growth.			Number of Fish.	Initial length (cm.).		Approximately one year's growth (cm.).	
		XI.	XII.	XIII.		Range.	Average.	Range.	Average.
Flemish Bight and Leman Ground.	VI 76, VII 160, VIII 162, XXV 650, XXVIII 749.	1	1	3	5	23-24	23.8	1-7	3.8
	II 681, VII 148, XXIV 569, XXVIII 771, 737, XXIX 1,506.	2	2	2	6	26-29.5	27.6	1-6	3.1
	Total ... ..	3	3	5	11	23-29.5	25.9	1-7	3.4
N.E. Coast of England.	X 361, XV 883, XIX 88, XXI 171, XXII 253, XXIII 432, 458.	2	3	2	7	18-25	22.3	4.0-10.1	7.0
	XII 808, XXI 183 ...	2	...	...	2	26-28.6	27.3	4.4-8.2	6.3
	Total ... ..	4	3	2	9	18-28.6	23.4	4.0-10.1	6.8
Both Groups ...	Grand total ...	7	6	7	20	18-29.5	24.7	1.0-10.1	4.9

§ NOTE.—The Roman numerals in this column represent the reference numbers of the marking experiments, and the Arabic numerals the distinctive numbers of the fish as indicated by the labels.

\* Report of the Danish Biological Station, VI., 1896.

† 20th Annual Report of the Fishery Board for Scotland, III., 1902, p. 356.

‡ Report on Scientific Investigations for 1904. Northumberland Sea Fisheries Committee.



According to these data the average increase in length of small marked Plaice between 18 and 25 cm. in length in the Flemish Bight is about 3·8 cm., and along the Yorkshire and Northumberland coasts about 7·0 cm. in one year. The growth of marked Plaice in the Flemish Bight is thus only half as great as the estimated growth of unmarked fishes of a similar size ; on the other hand the growth of the marked fishes along the north-east coast of England is only about 0·4 cm. less than Mr. Meek's estimate of the normal growth. If about 0·5 cm. be allowed for the shrinkage of the marked fish between capture and re-measurement, the observed difference is insignificant. The correspondence between the two results in the latter case is probably more apparent than real, as Mr. Meek's estimates were admittedly based to some extent upon the results of marking experiments, and await substantiation ; but the discrepancy in the former case strongly suggests the conclusion that the growth of marked fishes is not a full measure of their natural growth. The difference in the case of the smaller group from the Flemish Bight amounts on the present data to 3·7 cm. (7·5-3·8) per annum ; and of this about 0·5 cm. must be attributed to the shrinkage of the marked fish after death, leaving about 3 cm. as the difference between the annual growth of marked and unmarked Plaice of the size under consideration (18-25 cm.). This figure must be taken as subject to revision when the results of later investigations become available for comparison.

Whatever should be the exact amount of the retardation of growth caused by the methods of marking, the fact of retardation does not affect the value of the method as a means of indicating differences in the rate of growth in different areas, provided the sizes of the fish compared and the methods of marking employed are identical.

A noticeable difference between our records of the growth of marked fish in the two areas under consideration is the frequent occurrence of cases of very slow growth in the southern area (*e.g.*, 1 cm. per annum), and their absence from the northern area. The maximum growth is also less in the southern than in the northern area for each of the size groups considered. The concordance of these results renders it probable that the more rapid rate of growth in the northern than in the southern area, as indicated by the averages in the table, is a valid and not an accidental feature.

The normal increments of growth from month to month in the case of marked fishes in the coastal waters of the English area cannot as yet be shown ; but, by the kindness of Dr. Petersen, Director of the Danish Investigations, I am able to add figures showing the rate of growth of Danish marked Plaice on the Horn Reef and Jutland Grounds, based on the Danish experiments of 1903. The fish were liberated off the west coast of Jutland, mostly near the Horn Reef, in April, 1903. The average growth of nine fishes recaptured in August was 1·6 cm. ; of four fishes caught in November, 3·0 cm. ; of five fishes caught in March, 3·9 cm. ; and of eight fishes recaptured in the following April, 4·5 cm. The monthly averages are for the most part sufficiently consistent with one another to render it fair to assume that they represent the average growth of small marked Plaice off the Danish coast.\* The figures are given in the accompanying table :—

\* In the Danish Report, which has been published since this account was prepared, it is shown that the growth in the Horn Reef area is even less than that shown by my figures, which represent the results of experiments along the entire west coast of Jutland. In the Horn Reef area alone the average growth of seven fish in one year was only 3·9 cm., and of two fish off the north-west coast of Jutland, 7·5 cm. This difference of growth in the southern and northern parts of the Jutland Bank is almost identical with the difference shown by the English experiments in the southern and northern parts of the English area. (Johansen : Contributions to the Biology of the Plaice. *Meddelelser fra Kommissionen for Havundersøgelser. Serie Fiskeri.* Bd. I., 1905, p. 22.)



TABLE 5, showing the average growth of small marked Plaice off the west coast of Jutland (Danish experiments : fish liberated during April, 1903).

Month of Recapture.	Number of Fish.	Average initial length. (cm.)	Average growth. (cm.)	Month of Recapture.	Number of Fish.	Average initial length. (cm.)	Average growth. (cm.)
May ... ..	...	...	0.0	October ... ..	2	28.0	2.0
June ... ..	28	26.6	0.6	November ... ..	4	21.5	3.0
July ... ..	11	28.0	1.2	December-January ... ..	3	23.3	3.3
August ... ..	9	25.4	1.6	March ... ..	5	22.2	3.9
September ... ..	3	26.7	1.3	April ... ..	8	23.3	4.5

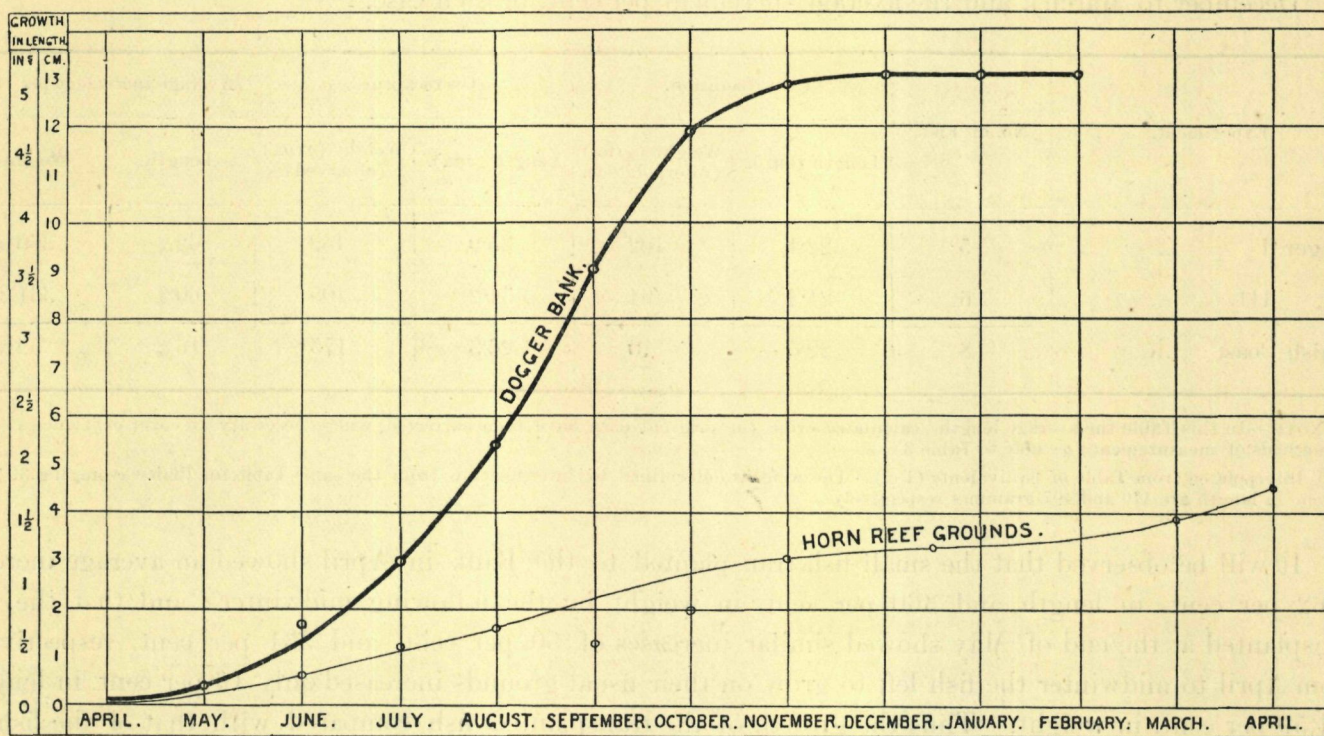


FIG. 1, illustrating the average rate of growth of small marked Plaice on the Dogger Bank and on the Danish coastal grounds respectively.

In the accompanying diagram the growth of marked Plaice off the Danish coast and that of the Bridlington Bay fish transplanted to the Dogger Bank are contrasted by means of curves, which represent the increments of growth from month to month. The results of the experiments are directly comparable with one another, since the dates of liberation, the initial sizes of the fish marked, and the methods of marking were practically identical in the two cases. It will be seen that by the end of the year, when growth was arrested during the winter, the average increment of the transplanted fish was four times as great as that of the fish on the Danish coastal grounds (13 cm. as against 3.3 cm.).

The difference in weight is still greater. The weight of the fishes recaptured after transplantation was determined in the Lowestoft Laboratory after their arrival, and the details are given in Tables A to D. It should be understood that the observed weights were in many cases affected by the varying states of



dryness in which the fishes were received after transmission by post and otherwise. They consequently represent the *minimum* weights, and not necessarily the true weights on recapture. The weights on liberation were not determined, but can be deduced with sufficient accuracy from the table of equivalents prepared by the Board of Agriculture and Fisheries.\*

The following table shows the average increase in length and weight of the marked fish recaptured during the winter months from the two transplantation experiments on the Shoal of the Dogger and from the Danish experiments on the Jutland coast respectively.

TABLE 6, showing on liberation and recapture the average length and weight of transplanted Plaice below 25 cm. in original length recaptured during the winter months (December to February); together with similar data from the Danish experiments off the Jutland coast (recaptures from December to March), and the average increment per cent. in each case.

Experiment.	No. of Fish.	On liberation.		On recapture.		Average increment per cent.	
		Length (cm.).	Weight (gram.) (interpolated).	Length (cm.).	Weight (gram.) (observed).	Length.	Weight.
Dogger I ... ..	5	22.1	102	35.9	469	62 %	360 %
„ III ... ..	6	21.4	94	34.2	405	60 %	331 %
Danish Coast ... ..	8	22.6	110	26.3	175†	16 %	59 %

NOTE.—In this Table the average lengths calculated from the original data have been corrected, where necessary, to cover deficiencies due to the methods of measurement (*see* note to Table 3).

† Interpolated from Table of equivalents (1 c.). The weights determined by interpolation from the same Table for Plaice averaging 35.9 and 34.2 cm. in length are 470 and 407 grammes respectively.

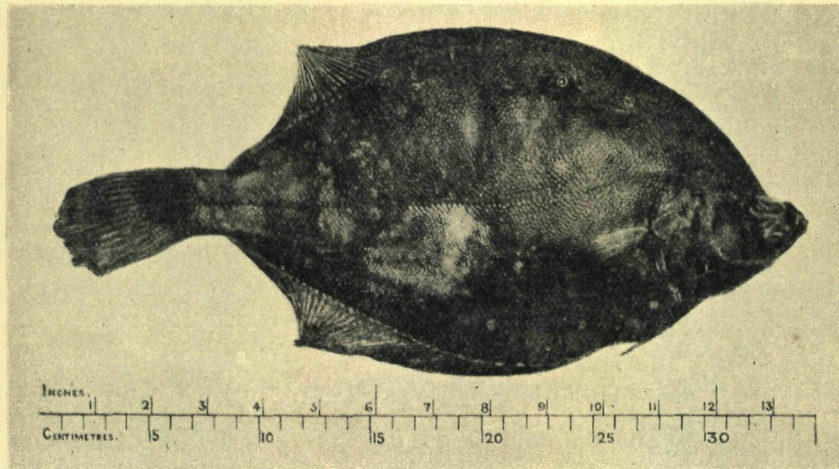
It will be observed that the small fish transplanted to the Bank in April showed an average increase of 62 per cent. in length, and 360 per cent. in weight by the following midwinter; and that the fish transplanted at the end of May showed similar increases of 60 per cent. and 331 per cent. respectively. From April to midwinter the fish left to grow on their usual grounds increased only 16 per cent. in length, and 59 per cent. in weight. Thus the growth of the transplanted fish compared with that of the fish on the coastal grounds was four times as great in length, and six times as great in weight.

#### § 7. PROPORTION RECAUGHT BY ENGLISH AND FOREIGN VESSELS.

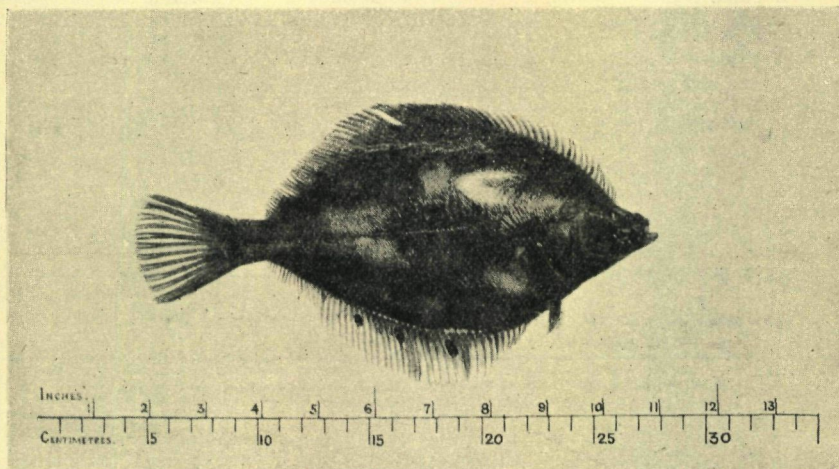
The following Table shows the number of transplanted fish caught by English and foreign vessels respectively during the summer and winter periods. Out of a total of 95 fish reported to the end of February, 75 were noticed by the fishermen at the time of capture and 20 were not recognised until the

\* Report from the Select Committee of the House of Lords on the Sea Fisheries Bill, together with Minutes of Evidence. London, 1904, p. 80. This Table represents the average weights of Plaice from the Eastern Grounds at successive intervals of length from 7½ to 14½ inches. The curve yielded by these data is very smooth, and permits the weights at intervening points to be determined by interpolation. The Tables previously published by Fulton (XXII. Report Scottish Fishery Board, Part III., pp. 141-205) and Meek (Report of the Northumberland Sea Fisheries Committee for 1905, pp. 40-41) show higher average weights for the most part than those in the Board's Table—probably indicative of local differences. The Table since published by Johansen (1 c., p. 19), which refers to the same area as that of the English Board, agrees precisely with the latter for lengths between 18 and 30 cm.

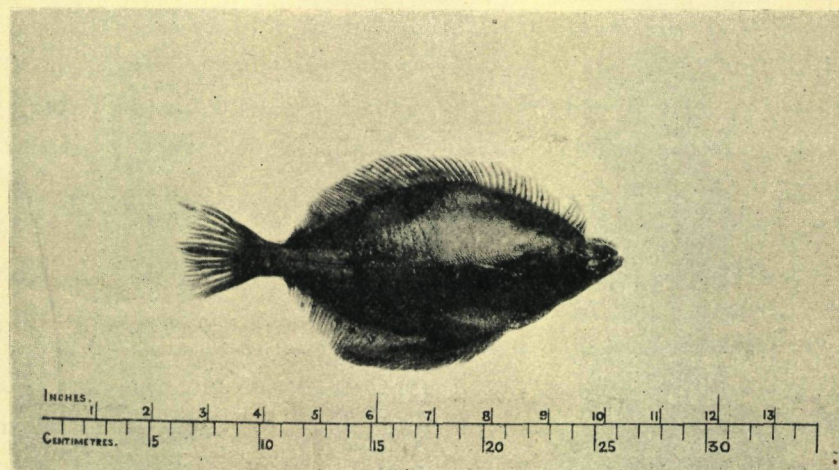




III. Dogger Bank (E. 2347).—Length on recapture in November after seven months' growth, 34.0 cm. ( $13\frac{3}{8}$  ins.); weight, 428 gm. (15 oz.).



II. Coastal Grounds.—Average length in November after seven months' growth, 23.3 cm. ( $9\frac{1}{8}$  ins.); weight, 120 gm. ( $4\frac{1}{5}$  oz.).



I. Original length of fishes II. and III. on liberation in April, 19.5 cm. ( $7\frac{3}{4}$  ins.); weight, 70 gm. ( $2\frac{1}{2}$  oz.).

FIG. 2, illustrating, by photographs on the same scale, the relative growth of small marked Plaice on the continental coastal grounds and on the Dogger Bank respectively.



fish were landed at the fish markets. Of the latter 17 were recognised at Grimsby and three at Billingsgate. One of the latter was landed by a carrier of the Red Cross (Hull) trawling fleet, one was received in a package from Grimsby, and another in a package from Lowestoft. With the exception of one fish landed at Lowestoft by a sailing trawler, all the fish reported directly by the fishermen were taken by steam trawlers. It has been assumed that all the fish discovered on the pontoon at Grimsby were landed by English steam trawlers. On this assumption it appears that 93 fish were caught by steam trawlers, one by a Lowestoft smack, and one by a Lowestoft trawler, which may have been either a steamer or a smack. It is interesting to note that the two fish landed at Lowestoft were caught in the winter months after the exodus of fish from the Bank had set in.

TABLE 7, showing the number of transplanted fish caught by English and foreign vessels respectively. With the two exceptions mentioned, all were caught by steam trawlers.

Experiment.	April-October.				November-February.				Total Period.			
	English.		Foreign.		English.		Foreign.		English.		Foreign.	
	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.
I. ... ..	44	94	3	6	11*	85	2	15	55	92	5	8
II. ... ..	7	100	0	...	4	100	0	...	11	100	0	...
III. ... ..	8	80	2	20	13†	93	1	7	21	88	3	12
I.-III. ... ..	59	92%	5	8%	28	90%	3	10%	87	92%	8	8%

\* One of these was found at Billingsgate in a box of fish from Lowestoft.  
 † One recapture by a Lowestoft smack.

Thus out of 64 fish recovered during the summer months from April to October, 92 per cent. were taken by English steam trawlers; and out of 31 recaptures during the winter from November to February, 90 per cent. were reported by English fishermen.

It would thus appear that the commercial transplantation of small Plaice on a large scale to the Dogger Bank would afford a direct means of increasing the total yield of fish from the North Sea, and that 90 per cent. of the profit yielded by the results of such transplantation would fall to the share of English fishermen, so long as the numbers of English and foreign steam trawlers working in the North Sea maintain their present ratio to one another.

#### § 8. PROPORTION RECAPTURED IN SUCCESSIVE PERIODS.

Any estimate drawn up at the present stage as to the practical results of commercial transplantation on the lines suggested must furnish but a rough approximation, but the data available are sufficiently consistent to warrant a preliminary calculation. It is above all things essential to the success of such an enterprise that the fish after transplantation should not be caught too soon after liberation; and, it is desirable, though not essential, that a sufficient portion of the profits should be realised by the fishermen at an early date, in order to provide a reasonable interest on the expenditure required to carry out the work.



It is necessary, therefore, to determine the intensity of fishing on the Dogger Bank and adjacent grounds at different seasons of the year. For this purpose the results of the transplantation experiments, and of other experiments with marked Plaice on the Dogger Bank in the same year, are available.

In using the results of the transplantation experiments for this purpose, however, it is necessary to restrict the calculations to the returns dealing with those fish which were of marketable size from the commencement. It has already been seen that a large proportion of the marked fish from these experiments which were landed at the ports had escaped the notice of the fishermen at sea (20 out of a total of 95 returned), and of these only two were less than 25 cm. in length when caught. It is easily intelligible that still larger numbers of the smaller fish may have been recaptured when of unmarketable size and shovelled overboard again with the small Dabs and other refuse without being recognised. This explains the relatively low percentage yielded by the returns of fish below 25 cm. at the time of liberation (*see* Table 2, p. 49). If the returns of recaptured fish be classified according to initial size, and also according to season of recapture, we find, on the other hand, that, although the returns of large fish exceeded those of small fish during the earlier months, the reverse was the case during the later months, when the small fish had grown to marketable size. Thus, in Experiment I, out of a total of 441 fish, 394 were below, and only 47 above, a length of 25 cm. at the time of liberation. Yet, from April to September, out of 36 returns, only 16 referred to the smaller fish, and as many as 20 to the larger class. From October to February, on the other hand, out of 24 returns, 19 referred to the class of small fish and only five to the larger. This reversion towards the original ratio between the numbers of the small and large fish can only be explained on the assumption that the small fish were too small during the earlier months after transplantation to attract the fishermen's attention, and only began to do so after they had completed their summer's growth. The proportion of small to large on liberation (taking 25 cm. as the limit between the two classes) was about 8 to 1; during the spring and summer the proportion yielded by the returns was 4 to 5, and during the following winter about 4 to 1. It remains to be seen whether the original proportions will be more fully realised by the returns during the spring months, when fishing is resumed upon the Bank itself. It is not improbable that the autumn emigration from the Bank was chiefly an emigration of the largest fishes.\*

On March 12th, 1904, a number of Plaice caught upon the south part of the Bank were marked and liberated in two localities. Only one was below 25 cm. in length. Excluding this from consideration, the remainder, 33 in all, ranged in length from 25 to 53 cm. To the end of February, 1905, 14 recaptures had been reported from these experiments, yielding a percentage of 42 per cent. on the numbers originally liberated, a result which is practically identical with that yielded by the transplantation experiments (I and III) in the same region for fish of 25 cm. and upwards at liberation, viz., 26 recaptures out of 64 liberated, or 41 per cent. The recaptures from these experiments, together with those of the larger fish from the transplantation experiments, have been classified according to certain seasons of recapture, and the numbers have been expressed as percentages of the stock available for capture in each period. The "available stock" in the first period is the number liberated; in the second season it is the number liberated *less* the number reported as caught during the preceding period, and so on.

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\* This expectation has been fully realised. The fish recaptured from the same experiment during the Spring of 1905 (March to May) had all attained marketable size (31 to 39 cm.), and, when classified according to their original lengths, yield a proportion of small to large which amounts to no less than 26 to 1. This result shows (1) that the scarcity of small fish among the returns in 1904 was not due to any excess of mortality, and (2) that the emigration from the Bank during the winter was more general among the larger than the smaller fishes.



TABLE 8, showing (1) the numbers of marketable Plaice marked and liberated on the south part of the Dogger Bank in the spring of 1904, (2) the numbers recaptured during the periods stated, and (3) the numbers recaptured expressed as percentages of the numbers available for capture at the commencement of each period.

	March-May.			June-September.			October-February.		
	Number liberated.	Number caught.	Per cent.	Number available.	Number caught.	Per cent.	Number available.	Number caught.	Per cent.
Transplanted (25-31 cm.) ... ..	47*	13	28 %	51†	7	14 %	44‡	6	14 %
Local fish (25-53 cm.) ... ..	33	7	21 %	26	2	8 %	24	5	21 %
Totals ... ..	80	20	25 %	77	9	12 %	68	11	16 %

\* Experiment I.

† Survivors from Experiment I. (34), together with 17 liberated from Experiment III.

‡ Survivors from Experiments I. and III.

It will be seen from the table that the two series of experiments yield seasonal percentages of capture which are fairly consistent with one another. As the total percentages of capture for the entire period are almost identical in the two series (41 per cent. and 42 per cent.), it seems probable that the differences shown by the two series in regard to the seasonal percentages are mainly irregularities caused by the small number of observations. The combination of the two series appears, therefore, to provide a fair basis from which to form an approximate idea of the average intensity of fishing during the three periods of the year which are of importance in connection with the problem of transplantation. Future experiments will doubtless determine the amount of fluctuation to which such figures are subject from year to year. It should be understood that the figures do not indicate the intensity of fishing on the Dogger Bank alone, or on any other prescribed area, but merely the frequency with which Plaice of marketable size liberated on the Dogger Bank in the spring of 1904 were subsequently caught and landed by the fishermen during the periods stated.\*

#### § 9. FORECAST OF THE COMMERCIAL RESULTS OF TRANSPLANTATION.

The rate of recapture being thus determined, we may approach the question as to the practical results which may be expected to follow from the transplantation of small Plaice to the Bank on a commercial scale. Taking one million Plaice, averaging  $8\frac{1}{2}$  inches in length, as a convenient unit, and assuming that these fish have been deposited in an uninjured condition upon the Bank during the early months of the year, we may estimate the numbers which are likely to be caught in successive periods, together with their weight and value, using the results of the marking experiments as a guide to their increase in length at successive periods, and determining the average weight of the fishes from their average length, in accordance with the data previously discussed.

The following Table shows two estimates prepared in this way, one for fish transplanted in April, in accordance with the results of Experiment I, and another for fish transplanted at the end of May, based on the results of Experiment III. The same three seasons are distinguished as in the previous section on the frequency of recapture, viz., April and May, which coincides with the intense spring fishery on the Bank ;

\* The relatively low intensity of fishing on the Dogger Bank during the summer months, which is indicated by Table 8 for the year 1904, is shewn with equal clearness, and to practically the same extent, by the returns from Experiments I. and III. during the following year. Out of 29 recaptures from April 1st to July 31st, 1905, in which the locality (mostly on the Bank) is specified, 20 were reported during April and May, and only 9 during June and July. Out of 43 returns altogether, 31 were reported during the former months, and only 12 during the latter. The chief condition essential for the success of commercial transplantation may thus be regarded as fairly well established in the present case.



June–September, a period when there is little trawling on the Bank, and the fish show little tendency to emigrate ; and October–February, when many of the Plaice are caught, partly on the Bank and partly on the outlying grounds, after completing their summer’s growth. The numbers estimated to be caught in the first period have been deducted from the original stock in order to obtain the numbers available for capture in the second period, and so on.

TABLE 9, showing the Estimated Yield and Value within the first year of a stock of one million small Plaice transplanted to the Dogger Bank (A) in the middle of April and (B) at the end of May—based on the results of Experiments I and III respectively :—

	Numbers available for capture.	Average.			Probable total catch.			
		Length (ins.).	Weight (ozs.).	Value per cwt.	Per cent.	Number.	Weight (cwts.).	Value.
A.—April–May ... ..	1,000,000	8·5	3·38	<i>s. d.</i> ..	25	250,000	471	£ ...
June–September ... ..	750,000	10·2	5·75	12 0	12	90,000	289	173
October–February ... ..	660,000	13·7	15·00	22 6	16	105,600	884	994
Total yield, June–February ... ..	...	...	...	...	...	195,600	1,173	1,167
Remainder uncaught ... ..	554,400	14*	16*	...	...	...	4,950*	...
B.—June–September ... ..	1,000,000	9·5	4·6	10 0	12	120,000	308	154
October–February ... ..	880,000	13·3	13·75	22 6	16	140,800	1,080	1,215
Total yield to February ... ..	..	...	...	...	...	260,800	1,388	1,369
Remainder uncaught ... ..	739,200	14*	16*	...	...	...	6,600*	...

NOTE.—The increases in length and weight indicated in this Table are probably somewhat below the increases which would be shown by unmarked fish (*see* p. 52).

\* Minimum estimate : the full year’s growth amounts to an increase of 6 ins. (*see* note, p. 50).

It appears from the estimates provided that if the transplantation is carried out in March or April 250,000 of the fish transplanted will be destroyed during the period of the spring fishery, when their size is too small to render them of marketable value ; during the summer months 90,000 will be recaptured at an average length of 10·2 inches, making a total weight of 289 cwts., and a total estimated value of £173 ; and during the autumn and winter 105,600 fish will be caught at an average length of nearly 14 inches, yielding 884 cwts., at an estimated value of £994. Thus up to the end of February the estimated total yield is 1,173 cwts., valued at £1,167. Rather more than half the original stock, amounting to 554,400 fish, at an average size of 14 inches and an average weight of one pound each, would still remain to be caught.

If the transplantation is deferred until the close of the spring fishery in May, the initial loss of so many small Plaice is avoided, and this saving more than compensates for the slight loss of growth during the spring months. The total yield to the end of February is estimated to amount to 1,388 cwts., valued at £1,369. There remain for capture nearly 750,000 fish, all of the best marketable size and weight.



These figures may be contrasted with the normal yield of a similar stock of small fish left to grow on the inshore grounds. The weight of one million Plaice averaging  $8\frac{1}{2}$  inches in length is about 1,886 cwts. The average increase in length from April to the following winter (according to Table 6, p. 54), is 16 per cent., which gives an average size of 9.9 inches. The average weight at this size is about 5.3 ounces. Even if none of the small fish were destroyed in the meantime, the gross weight of the original stock during the following winter would only amount to about 2,958 cwts. Owing to the intensity of fishing inshore, however, at least 25 per cent. of the original stock would have been prematurely destroyed when practically worthless, so that the surviving stock could not exceed a total of 2,220 cwts., at an average size of scarcely 10 inches, the nominal value of which at ten shillings per hundredweight would only amount to £1,110.

By transplantation to the Dogger Bank the whole of this amount would already have been realised by the fishermen, whether the transplantation took place in April or May; while about 5,000 or 6,000 cwts. of large fish, averaging 14 inches in length, would be still available for capture, instead of the 2,200 cwts. of small Plaice on the coastal grounds. Moreover, the transplanted fish would have been removed from the inshore grounds, where the capture of marketable fish involves the destruction of so many that are undersized; so that the capture of the surviving stock of transplanted fish would not be attended by the waste which must accompany the capture of the surviving stock of the untransplanted fish.

The case is not materially altered if allowance is made for the probable retardation of growth caused by the methods of marking (see p. 52), since any correction of the above figures under this head must increase the estimated weight and value of the transplanted as well as of the untransplanted stock. Assuming the full year's growth of small Plaice on the continental coastal grounds to be 7.5 cm. (3 inches—a figure which is probably above the average), the average length of the untransplanted stock would be almost exactly 11 inches during the following winter (October-February), and their average weight  $7\frac{1}{2}$  ounces. The "surviving stock" would thus yield a maximum total weight of 3,139 cwts. available for capture in March.

If the average weight of the transplanted fish be increased by the same amount, viz., 2.2 ounces (7.5 less 5.3 ounces), the total weight of the marketable fish estimated as caught during the winter months would be raised in estimate A from 884 to 1,014 cwts., and in estimate B from 1,080 to 1,253 cwts.; and the total weight of the "surviving stock" would be raised in estimate A to 5,636 cwts., and in estimate B to 7,507 cwts. For minute accuracy, of course, the additions to the figures in estimate B should be slightly less than in estimate A, owing to the difference in the date of transplantation; but, since corresponding deductions should also be made in regard to the growth of the inshore fish during the same period, refinement of the figures to this extent is scarcely necessary.

The figures appear to me to show that the proceeds of transplantation on the lines suggested would cover all working expenses within a year from each undertaking, and that such work, if repeated from year to year, would in a short space of time appreciably increase the marketable stock of Plaice in the North Sea area.

The full extent to which it would be advantageous to carry out the work of transplantation on any ground could only be determined by carrying out scientific experiments with marked fish simultaneously



with the commercial undertakings. It is possible that the addition of five or ten million Plaice to the Bank in any year would increase the local competition for food, and thus reduce the rate of growth.\* The work should, therefore, begin with a stock of not more than two or three millions, and should be increased from year to year until the most advantageous limit has been reached. This limit could easily be determined by the methods employed in the present investigations, which would reveal the amount of any decline in the rate of growth caused by the increased numbers of Plaice.

The subsequent determination of the relative numbers of transplanted and untransplanted Plaice on any ground would probably offer no serious difficulties, since the phenomenal rate of growth of the small Plaice deposited on the Bank brings about certain changes in the shape and structure of the hard parts of the body which are quite characteristic and easily recognisable upon investigation (*see* Dr. Wallace's paper in the present volume, pp. 222, 223). Trawling investigations at different seasons would provide sufficient material for determining the relative proportions of transplanted and untransplanted fish by laboratory analyses on these lines.

It is also possible that an appreciable change in the quantity of Plaice to be found on the Bank or on adjacent grounds, as a consequence of transplantation or other causes, might bring about changes in the seasonal intensity of fishing, which have not been provided for in the present estimates, and might exercise a different influence from that which has been forecasted. If some of the boats, which at present exploit the coastal grounds during the spring and summer months, should be diverted to the central grounds, that would be an event which would have its satisfactory side, and the attendant dangers could best be met when the character of any such change had clearly declared itself.

Experiments have been arranged for the current year to determine the effects of transplantation to other grounds which offer a prospect of satisfactory results.

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\* Mr. Todd shows elsewhere (*Report on the Food of Fishes*, this volume, pp. 256-260) that on the Dogger Bank Dabs and Haddock feed to a large extent on the same mollusks as the Plaice, a species which, in point of numbers, provides at the present time merely a fraction of the total *Solen*-eating population on the Bank (*see* Synoptic Table, *Trawling Report*, this volume, p. 110). Clearly the existing population of Plaice could be doubled or trebled without seriously influencing the local competition. Moreover, in any eventual competition for bivalve mollusks as food, the Plaice, in virtue of its special adaptations to this class of diet, is not likely to be worsted by the more omnivorous Haddock and Dab.

In my Provisional Report to the International Council (*Rapports et Procès-Verbaux*, Vol. III., 1905, Appendix H., p. 25) I estimated the total population of Plaice on the south part of the Dogger Bank as "not more than 15 or 20 millions," on the assumption that the intensity of fishing was about  $\frac{1}{3}$ th of the total population. The more complete data provided in the present report show that the intensity of fishing is about 40 per cent. per annum, *i.e.*,  $\frac{2}{3}$ th of the total population. Consequently we may roughly estimate the total population as not more than  $7\frac{1}{2}$  or 10 millions.

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## RECORDS OF FISHES RECAPTURED.

- Notes to Tables A.—D.* (1) All the vessels were steam trawlers unless otherwise described.  
 (2) Abbreviations:—After the weight, g=gutted; after the sex, im=immature, r=ripe, s=spawning, sp=spent. F=Female; M=Male.  
 (3) For explanation of Symbols of age, see Note (3), p. 36.

TABLE A.—TRANSPLANTATION EXPERIMENT I.

CAPTURED: 13th April, 1904 { 53° 58' N. to 54° 2' N.  
 0° 9' W. to 0° 11' W. LIBERATED: 441 Plaice, 54° 38' N., 2° 40' E.  
 of which 90 were marked with bone labels.

Date of Recapture.	No. of Label.	Original Length (cm.).	Locality Reported.	Calculated Position.	Vessel and Port of Register.	Depth (fms.).	Ultimate Length (cm.).	Weight (grams).	Sex and Maturity.	Age (years).	Remarks.
15/4/04	E 2,183	26	[Found on Pontoon, Grimsby]..	.. ..	.. ..	..	26.3	120	F.	VI.	
15/4/04	E. 2,132	27	54° 40' N., 2° 40' E. .. ..	.. ..	Hull ..	10	26.6	160	F.	V.	
15/4/04	E. 2,152	22	100 miles E.N.E. from Spurn ..	54° 34' N., 2° 34' E.	Grimsby ..	12	22.4	85	M.	V.	
15/4/04	797	24	100 miles E.N.E. from Spurn ..	54° 34' N., 2° 34' E.	Grimsby ..	12	23.8	106	M.	V.	Bone label.
16/4/04	E. 2,035	24	N.E. by E. ½ E. 75 miles from Spurn.	54° 24' N., 1° 45' E.	Grimsby ..	11	24.6	116	F.	V.	
16/4/04	E. 2,003	19	N.E. by E. ½ E. 75 miles from Spurn.	54° 24' N., 1° 45' E.	Grimsby ..	11	20	54	F.	V.	
18/4/04	E. 2,009	25	[Found on Pontoon, Grimsby]..	.. ..	.. ..	..	26.2	140 g	F.	V.	
23/4/04	E. 2,303	27	54° 40' N., 2° 35' E. .. ..	.. ..	Grimsby ..	11	27.2	145	M.	V.	
23/4/04	E. 2,221	27	120 miles N.E. by E. of Spurn ..	55° 4' N., 2° 33' E.	Hull ..	15	27.1	147	F.	V.	
25/4/04	E. 2,192	25	E. by N. 104 miles from Spurn ..	54° 21' N., 2° 54' E.	Grimsby ..	11	25.4	118 g	F.	IV.	
26/4/04	E. 2,190	25	[Found on Pontoon, Grimsby]..	.. ..	.. ..	..	25.9	138 g	M.	IV.	
26/4/04	E. 2,153	27	120 miles E. by N. of Spurn ..	54° 30' N., 3° 28' E.	Hull ..	22	26.8	157	F.	IV.	
27/4/04	E. 2,135	20	115 miles E.N.E. of Spurn ..	54° 45' N., 2° 54' E.	Hull ..	14	21.0	73	M.	IV.	
29/4/04	E. 2,094	17	100 miles N.E. by E. from Spurn	55° 51' N., 2° 10' E.	Grimsby ..	12	17.4	34	M.	III.	
3/5/04	E. 2,311	29	95 miles N.E. by E. from Spurn	55° 45' N., 2° 2' E.	Grimsby ..	11-12	29.6	175 g	F.	V.	
4/5/04	E. 2,159	19	97 miles E.N.E. of Spurn..	54° 36' N., 2° 18' E.	Grimsby ..	10-11	19.6	48	M.	V.	
4/5/04	E. 2,294	24	100 miles E.N.E. from Spurn ..	54° 35' N., 2° 30' E.	Grimsby ..	12	25.1	103 g	F.	V.?	
5/5/04	790	20	54° 38' N., 1° 55' E. .. ..	.. ..	Grimsby ..	12	20.2	27 g	F.	IV.	Rather dry. Bone label.
8/5/04	E. 2,308	27	100 miles E.N.E. of Spurn ..	54° 35' N., 2° 30' E.	Grimsby ..	13	27.0	141 g	F.	V.	
26/5/04	E. 2,299	25	100 miles E.N.E. of Spurn ..	54° 35' N., 2° 20' E.	Hull ..	..	26.1	115 g	M.	V.	
26/5/04	E. 2,275	24	[Found in Box on Pontoon, Grimsby].	.. ..	.. ..	..	23.8	82 g	F.	V.	
26/5/04	E. 2,208	27	Spurn L.V. bearing W. ½ N. 85 miles.	53° 47' N., 2° 40' E.	Grimsby ..	21	27.3	175	F.	V.	
30/5/04	E. 2,004	26	[Found on Pontoon, Grimsby]..	.. ..	.. ..	..	27.6	..	M.	V.	
31/5/04	E. 2,271	24	[Found on Pontoon, Grimsby]..	.. ..	.. ..	..	25.1	108 g	F.	V.	
13/6/04	E. 2,291	25	112 miles E. by N. from Spurn ..	54° 23' N., 3° 9' E.	Grimsby ..	25	26.3	145 g	F.	V.	
18/6/04	E. 2,053	27	70 miles E. by N. from Spurn Light.	54° 6' N., 2° 3' E.	Grimsby ..	..	30.6	234 g	M.	V.	
20/6/04	E. 2,064	20	160 miles E.N.E. from Spurn L.V.	54° 35' N., 2° 30' E.	Grimsby ..	10	..	..	M.	..	
27/6/04	E. 2,010	28	120 miles E. ½ S. from Inner Dowsing.	53° 37' N., 3° 55' E.	Boston ..	20	29.5	208 g	M.	V.	
29/6/04	E. 2,201	22	[Found in Box on Pontoon]	.. ..	.. ..	..	24.2	115 g	M.	IV.	
5/7/04	E. 2,119	25	60 miles E. from Spurn ..	53° 50' N., 1° 52' E.	Grimsby ..	25	28.5	210 g	M.	IV.?	
7/7/04	E. 2,177	23	54° 29' N., 3° 12' E. .. ..	.. ..	Hull ..	22	[22.7]	45 g	F.	..	Salted and dry. Master reports 9½ inches in length when caught. Tail dry.
14/7/04	E. 2,137	28	[Found on Pontoon, Grimsby]..	.. ..	.. ..	..	31.6	297 g	M.	..	
7/8/04	E. 2,039	28	110 miles E.N.E. from Spurn ..	54° 42' N., 2° 46' E.	Grimsby ..	14	35.5	464 g	F.	V.+	Tail dry.
9/8/04	E. 2,204	22	55° N., 3° 38' E. .. ..	.. ..	Grimsby ..	23	27.5	187 g	M.	V.+	



TABLE A.—continued.

Date of Recapture.	No. of Label.	Original Length (cm.).	Locality Reported.	Calculated Position.	Vessel and Port of Register.	Depth (fms.).	Ultimate Length (cm.).	Weight (grams).	Sex and Maturity.	Age (years).	Remarks.
*11/8/04	E. 2,215	29	54° 30' N., 1° 0' E. .. ..	.. ..	Grimsby ..	30	33.0	345 g	M.	V. +	
12/9/04	E. 2,318	19	80 miles E. ½ N. from Spurn L.V.	53° 58' N., 2° 22' E.	Grimsby ..	20	28.1	213 g	M.	IV. +	
10/10/04	E. 2,359	17	54° 31' N., 2° 12' E. .. ..	.. ..	Grimsby ..	8	31.5	338	F.	III. +	
20/10/04	E. 2,086	21	[Found on Pontoon, Grimsby]..	.. ..	.. ..	..	34.1	391 g	F.	V. +	Tail dry.
21/10/04	E. 2,378	24	Spurn, bearing S.W. 100 miles ..	55° N., 1° 35' E.	Hull ..	9	33.0	370	M.	..	
22/10/04	E. 2,284	22	54° 38' N., 2° 41' E. .. ..	.. ..	Grimsby ..	10	35.2	494	M.	III. +	
22/10/04	E. 2,080	25	54° 45' N., 1° 55' E. .. ..	.. ..	Belgian ..	..	37.5	..	F.	..	
24/10/04	E. 2,230	22	54° 38' N., 2° 43' E. .. ..	.. ..	(Ostende.) Grimsby ..	11	33.5	235	F.	V. +	
25/10/04	E. 2,220	21	ca. 55° 10' N., 2° 30' E. .. ..	.. ..	Dutch ..	17	31.4	412 g	F.	..	
29/10/04	E. 2,025	27	120 miles N.E. by E. from Spurn	55° 3' N., 2° 30' E.	(Ymuiden.) Grimsby ..	18	36.2	505	M.	..	Tail dry
29/10/04	E. 2,182	18	80 miles E.N.E. from Spurn ..	54° 24' N., 2° 4' E.	North Shields.	12	31.3	338 g	M.	III. +	
2-10/10/04	E. 2,169	20	About 54° 35' N., 2° 30' E. ..	.. ..	Belgian ..	..	33.0	..	M.	..	
*31/10/04	E. 2,231	21	54° 50' N., 130 miles E. by N. ½ N. of Spurn.	54° 50' N., 3° 25' E.	Hull ..	23	33.2	309 g	F.	..	
1/11/04	E. 2,066	19	55° 50' N., 7° 15' E. .. ..	.. ..	Grimsby ..	..	29.4	236 g	M.	IV. +	Tail dry.
10/11/04	E. 2,317	19	175 miles E. by N. of Spurn ..	54° 49' N., 4° 44' E.	Hull ..	25	34.0	428	F.	..	
11/11/04	825	19	[Found on Pontoon, Grimsby]..	.. ..	.. ..	..	34.1	432 g	F.	III. +	Tail dry. Bone label.
11/11/04	E. 2,368	25	54° 40' N., 4° 10' E. .. ..	.. ..	Belgian ..	..	36.0	..	M.	..	
15/11/04	E. 2,016	22	54° 10' N., 2° 8' E. .. ..	.. ..	(Ostende.) Belgian ..	..	37.0	..	F.	..	
*21/11/04	E. 2,355	21	[Found on Pontoon, Grimsby]..	.. ..	.. ..	..	34.8	436 g	M.	..	Tail dry.
11/12/04	E. 2,186	20	Off Fair Isle .. .. .	59° 30' N., 1° 0' W.	Hull ..	97	33.2	380	M.	..	Tail very dry.
22/1/05	E. 2,338	21	145 miles E. by N. from Spurn ..	54° 37' N., 4° 2' E.	Grimsby ..	23	36.8	462 g	M.	..	
30/1/05	E. 2,106	27	[Found at Billingsgate in a box of fish from Lowestoft.]	.. ..	[Lowestoft Smack ?]	..	38.0	527	M. s	V. +	
2/2/05	E. 2,136	23	150 miles N.E. of Spurn ..	55° 43' N., 2° 27' E.	Hull ..	41	36.7	486	M. s	..	
14/2/05	E. 2,073	22	53° 40' N., 1° 10' E. .. ..	.. ..	Grimsby ..	18	35.2	415	M. s	..	
17/2/05	E. 2,055	31	175 miles N.N.E. of Spurn ..	56° 28' N., 0° 56' E.	Hull ..	48	38.2	541	F. im	V. +	
28/2/05	E. 2,341	22	[Found on Pontoon, Grimsby]..	.. ..	.. ..	..	37.8	604	F. im	..	

\* Three additional Plaice, provided with bone labels, and almost certainly belonging to this experiment, were reported on August 17th, October 26th, and December 12th, 1904; but the numbers were quite illegible. All were taken on the Dogger Bank—the second by a Belgian trawler, the others by Grimsby boats. Their respective lengths were 28, 27, and 32 cm.

TABLE B.—TRANSPLANTATION EXPERIMENT II.

CAPTURED : { (a) 24th May, 1904. 55° 34¼' N., 7° 48¼' E. 208 Plaice marked.  
 (b) 24th May, 1904. 55° 38' N., 7° 43¾' E. 154 Plaice marked.

LIBERATED : 25th May, 1904. 55° 30¼' N., 4° 25½' E. 362 Plaice.

Date of Recapture.	No. of Label.	Original Length (cm.).	Locality Reported.	Calculated Position.	Vessel and Port of Register.	Depth (fms.).	Ultimate Length (cm.).	Weight (grams).	Sex and Maturity.	Age (years).	Remarks.
(a) 31/5/04	E. 2,448	21.25	S. edge of Dogger Bank 160 miles from Spurn, W.S.W.	56° 11' N., 3° 57' E.	Hull ..	..	20.7	58	M.	III.	Landed in London and forwarded by Fishmongers Co., London.
(b) 11/6/04	E. 2,675	25.25	120 miles E.N.E. from Spurn ..	54° 47' N., 3° 0' E.	Hull ..	10	25.1	130	F.	IV.	
(a) 3/7/04	E. 2,461	18.5	10 miles S.E. of Dogger Bank ..	56° 2' N., 4° 2' E.	Hull ..	23	[17.8]	..	M.	III.	Dried and salted.
(b) 10/8/04	E. 2,752	24.5	160 miles E. by N. ½ N. of Spurn	54° 57' N., 4° 14' E.	Hull ..	24	..	..	..	..	Fish not forwarded.
(b) 26/9/04	E. 2,709	22.5	6 miles W.N.W. of Sylt L.V. ..	54° 57' N., 8° 12' E.	Hull ..	7	..	..	..	..	" " "
(a) 10/10/04	E. 2,507	23.75	120 miles N.E. by E. of Spurn ..	55° 4' N., 2° 33' E.	Hull ..	15	32.1	354 g	F.	..	
(a) 13/10/04	E. 2,419	22.5	Lat. 55° 48' N., 4° 18' E. .. ..	.. ..	Hull ..	23	30.6	305	F.	IV. +	Landed in London and forwarded by Fishmongers Co.
(b) 20/12/04	E. 2,789	20.5	Lat. 55° 10' N., 5° 30' E. .. ..	.. ..	Grimsby ..	23	23.8	111	F. im	..	Tail very dry.
(a) 19/1/05	E. 2,498	19.75	Lat. 56° 30' N., 5° 30' E. .. ..	.. ..	Hull ..	32	27.7	200	F. im	III +	Tail dry. Found in trunk bought at Billingsgate from Red Cross Steam Fishing Co.
(b) 21/1/05	E. 2,800	28.75	N.E. by E. 150 miles from Spurn	55° 33' N., 3° 8' E.	Grimsby ..	29	32.6	342	M. im	..	
(b) 14/2/05	E. 2,796	21.25	Lat. 56° 20' N., Long. 4° 10' E. ..	.. ..	Hull ..	38	30.2	240 g	M. im	IV.	



TABLE C.—TRANSPLANTATION EXPERIMENT III.

CAPTURED: 24th May, 1904. 55° 34' N., 7° 48' E.

LIBERATED: 26th May, 1904. 54° 39' N., 2° 40' E. 344 Plaice.

Date of Recapture.	No. of Label.	Original Length (cm.).	Locality Reported.	Calculated Position.	Vessel and Port of Register.	Depth (fms.).	Ultimate Length (cm.).	Weight (grams).	Sex and Maturity.	Age (years).	Remarks.
12/6/04	E. 2,849	20.25	Lat. 55° 35' N., Long. 2° 57' E. ..	.. ..	Grimsby ..	18	20.2	56	F.	III.	
2/8/04	E. 2,577	21.75	[Found on Pontoon, Grimsby] ..	.. ..	.. ..	..	25.5	123 g	M.	IV.+	Tail dry.
7/10/04	E. 3,042	20.0	Lat. 54° 16' N., Long. 2° 10' E. ..	.. ..	Boston ..	15	30.2	270 g	F.	III.+	Tail dry.
7-12/19/04	E. 2,841	24.0	ca. 55° 10' N., 4° 0' E. ..	.. ..	Dutch (Ymuiden.)	16	35.0	580	F.		
10/10/04	E. 2,785	*	Lat. 55° 3' N., Long. 2° 40' E. ..	.. ..	Grimsby ..	17	28.2	245 g	M.	III.+	* Not recorded.
23/10/04	E. 3,026	19.25	130 miles N.E. by E. from Spurn	55° 25' N., 3° 9' E.	Boston ..	18-19	32.2	385	M.	III.+	Tail slightly dry.
25/10/04	E. 3,000	24.75	120 miles N.N.E. from Ostend ..	53° 14' N., 3° 19' E.	Belgian (Ostende.)	..	36	..	..	..	
26/10/04	E. 2,928	20.25	120 miles N.E. by E. from Spurn	55° 4' N., 2° 32' E.	Grimsby ..	18	30.9	295 g	M.	III.+	
31/10/04	E. 2,875	23.5	100 miles N.E. of Spurn ..	55° 2' N., 1° 43' E.	Hull ..	9	34.2	400	F.	IV.+	
31/10/04	E. 2,837	20.25	90 miles N.E. ½ E from Spurn L.V.	54° 48' N., 1° 47' E.	Grimsby ..	14	33.5	4.5	M.		
4/11/04	E. 3,101	22.5	Not known. Returned through Fishmongers Co.	.. ..	.. ..	..	..	..	M.	..	Came from Grimsby.
4/11/04	E. 2,924	18.0	82 miles E.N.E. from Spurn L.V.	54° 25' N., 2° 8' E.	Grimsby ..	9	..	..	..	..	Fish not forwarded.
8/11/04	E. 2,995	23.5	[Found on Pontoon, Grimsby] ..	.. ..	.. ..	..	33.4	410	F.	IV.+	Tail dry.
Between 1-8/11/04	E. 2,968	21.0	ca. 55° 10' N., 2° 30' E. ..	.. ..	Dutch (Ymuiden.)	17	33.5	430	M.		
17/11/04	E. 2,930	20.5	192 miles N.E. by E. from Spurn L.V.	55° 53' N., 3° 51' E.	Grimsby ..	13	28.7	245	F.	III.+	
30/11/04	E. 2,929	23.5	[Found on Pontoon, Grimsby] ..	.. ..	.. ..	..	33.6	370	M.	IV.+	Tail very dry.
27/11/04	E. 2,898	20.75	100 miles E.N.E. from Spurn L.V.	54° 34' N., 2° 31' E.	Grimsby ..	15	32.6	338	M.	III.+	Tail dry.
9/12/04	E. 3,017	24.0	[Found on Pontoon, Grimsby] ..	.. ..	.. ..	..	35.3	432 g	F.	IV.+	
22/1/05	E. 2,899	19.25	N.E. (Easterly) 105 miles from Spurn.	55° 6' N., 1° 48' E.	Grimsby ..	..	30.4	268	M.		
23/1/05	E. 2,599	19.75	[Found on Pontoon, Grimsby] ..	.. ..	.. ..	..	33.0	381	M.		
29/1/05	E. 2,529	21.5	34-35 miles S.E. of Lowestoft ..	52° 12' N., 2° 32½' E.	Lowestoft Smack.	24	33.7	365	M. r		
8/2/05	E. 3,056	21.5	Lat. 55° 7' N., 1° 10' E. ..	.. ..	Grimsby ..	30	36.2	504	M. im		
14/2/05	E. 2,857	21.75	Lat. 54° 50' N., 100 miles N.E. by E. of Spurn.	54° 50' N., 2° 10' E.	Hull ..	13	36.4	480	M. im		
19/2/05	E. 3,067	25.5	170 miles N.E. ½ E. from Spurn..	55° 50' N., 3° 12' E.	Grimsby ..	40	37.4	460 g	M. r	IV.+	

TABLE D.—SUPPLEMENTARY RETURNS TO JULY 31ST, 1905.

No. of Experiment.	Date of Recapture.	No. of Label.	Original Length (cm.).	Locality Reported.	Calculated Position.	Vessel and Port of Register.	Depth (fms.).	Ultimate Length (cm.).	Weight (grams).	Sex and Maturity.	Remarks.
I.	7/3/05	E. 2,147	24	150 miles N.E. from Spurn L.V.	55° 40' N., 2° 15' E.	Grimsby ..	44	37.9	560	M. sp.	
	7/3/05	E. 2,385	22	Lat. 54° 44' N., 1° 55' E. ..	.. ..	Grimsby ..	13	35.1	420	F. im.	
	9/3/05	E. 2,335	19.0	65 miles E. from Spurn L.V. ..	53° 53' N., 2° 0' E.	Grimsby ..	45	33.3	342	F. im.	
	9-13/3/05	E. 2,180	20	Found on Pontoon, Grimsby ..	.. ..	.. ..	..	31.8	298	F. im.	
	24/3/05	E. 2,129	23	170 miles N.E. of Spurn ..	56° 3' N., 2° 35' E.	Hull ..	42	35.5	380 g	M. s.	
	5/4/05	E. 2,047	19	N.E. by E. ½ E., 120 miles from Spurn.	54° 57' N., 2° 42' E.	Grimsby ..	13	37.8	571	F. im.	
	5/4/05	E. 2,223	15	100 miles E. ¼ N. of Spurn ..	54° 6' N., 2° 54' E.	Hull ..	27	..	..	F. ?	
	3-7/4/05	E. 2,181	23	Found on Pontoon, Grimsby ..	.. ..	.. ..	..	35.7	398 g	M. im.	
	11/4/05	E. 2,118	22	N.E. by E. ½ E. 90 miles from Spurn.	54° 36' N., 2° 5' E.	Grimsby ..	13	36.4	520	F.	
	12/4/05	E. 2,320	18	N.E. ½ E. 95 miles from Spurn L.V.	54° 50' N., 1° 45' E.	Grimsby ..	15	36.0	569	F.	
	13/4/05	E. 2,241	22	Lat. 54° 40' N., 1° 37' E. ..	.. ..	Grimsby ..	16	37.0	590	F.	
	16/4/05	E. 2,311	21	Lat. 55° 6' N., 2° 38' E. ..	.. ..	Grimsby ..	16	37	520	F.	Tail dry.
	17/4/05	E. 2,216	22	190 miles E. by N. ½ N. of Spurn	55° 14' N., 4° 41' E.	Hull ..	25	35.6	450	M.	
	14-18/4/05	E. 2,351	18	Found on Pontoon, Grimsby ..	.. ..	.. ..	..	35.0	461	M.	
	15-19/4/05	E. 2,054	19	Found on Pontoon, Grimsby ..	.. ..	.. ..	..	35.1	426	M.	
	15-19/4/05	E. 2,365	23	Found on Pontoon, Grimsby ..	.. ..	.. ..	..	35.3	447	F.	



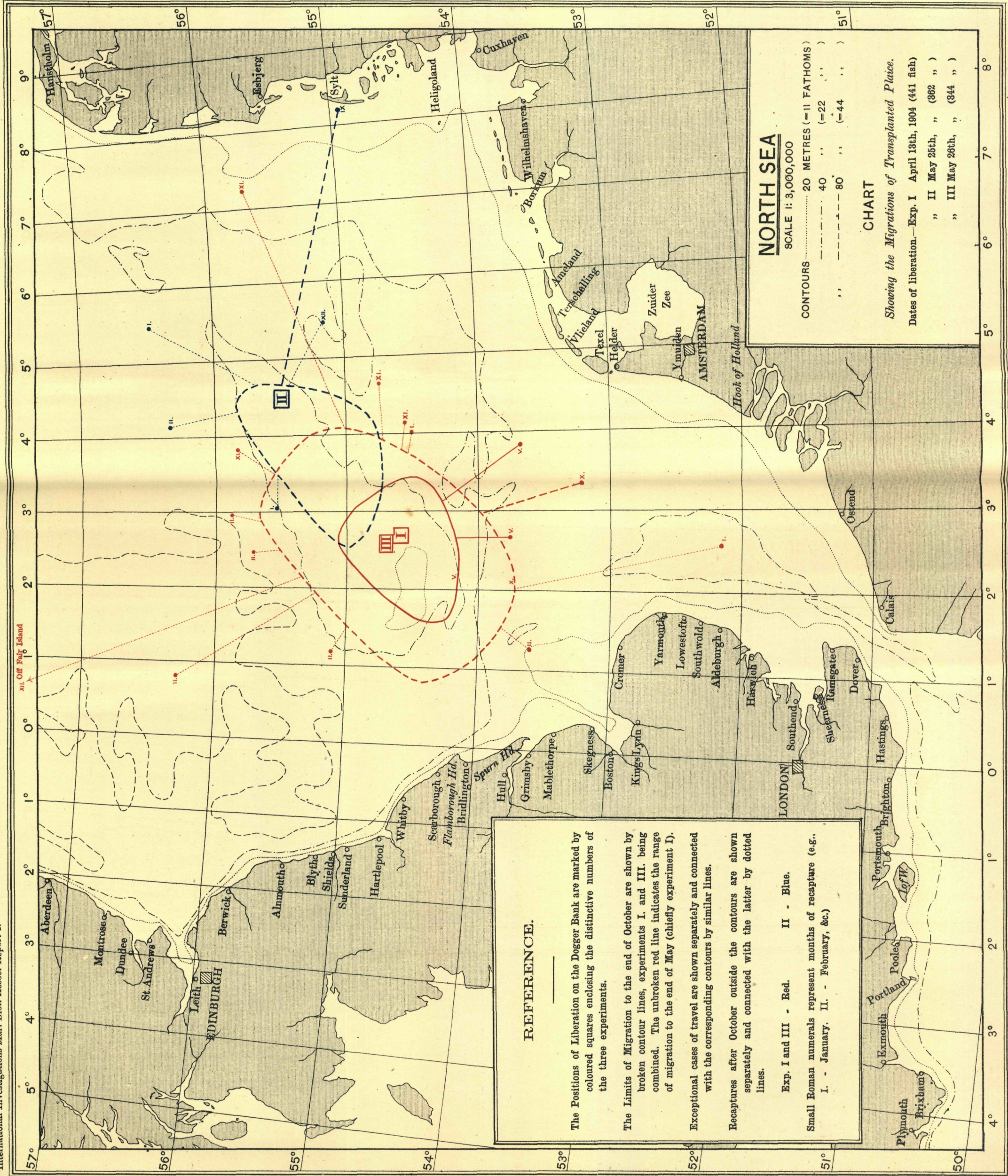
TABLE D.—SUPPLEMENTARY RETURNS TO JULY 31ST, 1905—continued.

No. of Experiment.	Date of Recapture.	No. of Label.	Original Length (cm.).	Locality Reported.	Calculated Position.	Vessel and Port of Register.	Depth (fms.).	Ultimate Length (cm.).	Weight (grams).	Sex and Maturity.	Remarks.
I.	17-21/1/05	E. 2,396	18	Found on Pontoon, Grimsby ..	.. ..	.. ..	..	33.1	328	F. im.	
	23/1/05	E. 2,032	22	115 miles N.E. of Spurn ..	55° 11' N., 1° 47' E.	Hull ..	20	36.0	401 g	M.	
	28/4/05	E. 2,008	20	70 miles E. by N. from Spurn L.V.	54° 5' N., 1° 59' E.	Grimsby ..	22	34.8	355	M.	
	4/5/05	E. 2,279	29	125 miles N.E. ½ E. of Spurn ..	55° 14' N., 2° 15' E.	Hull ..	21	43.5	706 g	M.	
	1-5/5/05	E. 2,217	17	Found on Pontoon, Grimsby ..	.. ..	.. ..	..	33.5	340 g	F.	
	6-10/5/05	E. 2,379	17	Found on Pontoon, Grimsby ..	.. ..	Grimsby ..	..	34.2	430 g	F.	
	8-12/5/05	E. 2,034	23	Returned by a fishmonger. Landed at Grimsby.	.. ..	.. ..	..	36.8	533	M.	
	13/5/05	E. 2,328	20	100 miles N.E. of Spurn ..	55° 0' N., 1° 35' E.	Hull ..	17	39.0	620	F.	
	17/5/05	813	18	Lat. 58° 37' N., 7° 45' E. ..	.. ..	Grimsby ..	16	31.5	320	M.	Bone label
	21-25/5/05	807	18	Found on Pontoon, Grimsby ..	.. ..	Grimsby ..	..	33.2	338 g	M.	Bone label.
	23-31/5/05	821	19	Found on Pontoon, Grimsby ..	.. ..	.. ..	..	34.2	363 g	F.	Bad label wound on upper surface.
	8/6/05	880	15	54° 20' N., 1° 20' E. ..	.. ..	Grimsby ..	28	28.0	191 g	M.	Bone label.
	10-14/6/05	E. 2,352	23	Returned by Fishmonger. Landed at Boston.	.. ..	.. ..	..	[26.4]*	470 g	F.	*Probably a mistake for 36.4 cm. [W.G.]
	10-14/6/05	E. 2,233	23	Found on Pontoon, Grimsby ..	.. ..	.. ..	..	40.0	655 g	F.	
	16-20/6/05	E. 2,141	19	Found on Pontoon, Grimsby ..	.. ..	.. ..	..	38.2	645	M.	
	28/6/05	E. 2,193	17	110 miles N.E. by E of Spurn L.V.	54° 57' N., 2° 15' E.	Hull ..	13	33.5	390 g	M.	
	2/7/05	E. 2,126	22	75 miles N.E. from Spurn L.V. ..	54° 38' N., 1° 15' E.	Grimsby ..	20	38.0	543 g	F.	Label wound large and very sore on both sides.
	16/7/05	E. 2,157	21	62 miles E. by N. ½ N. from Spurn L.V.	54° 7' N., 1° 40' E.	Grimsby ..	32	38.0	570 g	M.	Sore label wound on upper surface.
	22/7/05	791	18	120 miles N.E. by E. from Spurn L.V.	55° 4' N., 2° 24' E.	Grimsby ..	15-16	36.8	576 g	M.	Bone label.
	24/7/05	E. 2,295	18	130 miles E. by N. of Spurn ..	54° 3' N., 3° 28' E.	Hull ..	24	39	632 g	M.	
II. (a)	31/5/05	E. 2,637	21.25	55° 42' N., 4° 3' E. ..	.. ..	Hull ..	..	33.1	342	M.	Sore wound on blind side. Landed in London.
III.	16/3/05	E. 3,043	22.5	55 miles N.E. by N. from Spurn	54° 25' N., 0° 42' E.	Grimsby ..	33	34.6	385 g	M. r.	
	22/3/05	E. 2,990	23.75	Lat. 55° 42' N., 2° 0' E. ..	.. ..	Hull ..	45	35.7	414 g	M. sp?	
	27/3/05	E. 2,884	19.75	100 miles N.E. of Spurn ..	55° 0' N., 1° 35' E.	Grimsby ..	17	34.3	398 g	F. im.	
	7/4/05	E. 2,938	18.5	Lat. 54° 20' N., 1° 55' E. ..	.. ..	Grimsby ..	22	29.6	215 g	F.	
	8/4/05	E. 2,490	22.5	95 miles N.E. by E. from Spurn	55° 45' N., 2° 2' E.	Grimsby ..	15	38.8	545 g	F. im.	
	9/4/05	E. 2,883	20.5	110 miles N.E. by E. from Spurn L.V.	54° 57' N., 2° 15' E.	Grimsby ..	18	36.2	471 g	F.	
	7-11/4/05	E. 2,829	21.5	Found on Pontoon, Grimsby ..	.. ..	.. ..	..	36.1	455 g	F. im.	
	15/4/05	E. 3,073	27.25	45 miles N.N.E. from Spurn L.V.	54° 17' N., 0° 22' E.	Grimsby ..	32	29.3	518 g	M.	
	21/4/05	E. 2,880	19.25	95 miles N.E. by E. from Spurn L.V.	55° 45' N., 2° 2' E.	Grimsby ..	14	31.0	155 g	M.	
	27/4/05	E. 3,044	19.5	85 miles E.N.E. of Spurn ..	54° 26' N., 2° 5' E.	Grimsby ..	18-20	30.1	263	F.	Tail dry.
	16/5/05	E. 2,962	23.5	73 miles E.N.E. of Spurn L.V. ..	54° 19' N., 1° 50' E.	Grimsby ..	19	37.5	510	F.	
	19/5/05	E. 2,451	22.0	Lat. 55° 25' N., Long. 2° 5' E. ..	.. ..	Grimsby ..	22½	38.8	545 g	M.	
	9/6/05	E. 2,545	18.5	65 miles E. by S. from Spurn L.V.	53° 39' N., 2° 2' E.	Grimsby ..	14	[25.7]*	200 g	M.	*Tail mutilated, probably bitten and healed.
	18/6/05	E. 2,989	26.0	125 miles E.N.E. of Spurn ..	54° 50' N., 2° 56' E.	Grimsby ..	20	36.8	447 g	M.	Sore label wound on blind side.
	18/7/05	E. 2,845	19.75	N.E. by N. 85 miles from Spurn L.V.	54° 55' N., 0° 57' E.	Grimsby ..	17	35.0	418 g	F.	Tail stunted; if bitten, thoroughly healed.









**NORTH SEA**

SCALE 1: 3,000,000

CONTOURS

.....	20 METRES (= 11 FATHOMS)
-----	40 " (= 22 " )
-----	80 " (= 44 " )

**CHART**

Showing the Migrations of Transplanted Plaice.

Dates of liberation.—

Exp. I	April 18th, 1904	(441 fish)
II	May 25th, "	(862 " )
III	May 26th, "	(844 " )

**REFERENCE.**

The Positions of Liberation on the Dogger Bank are marked by coloured squares enclosing the distinctive numbers of the three experiments.

The Limits of Migration to the end of October are shown by broken contour lines, experiments I. and III. being combined. The unbroken red line indicates the range of migration to the end of May (chiefly experiment I).

Exceptional cases of travel are shown separately and connected with the corresponding contours by similar lines.

Recaptures after October are shown separately and connected with the latter by dotted lines.

Exp. I and III - Red. II - Blue.

Small Roman numerals represent months of recapture (e.g., I. - January. II. - February, &c.)



