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GENERAL REPORT

ON



P81

THE FISHERY INVESTIGATIONS,

BY

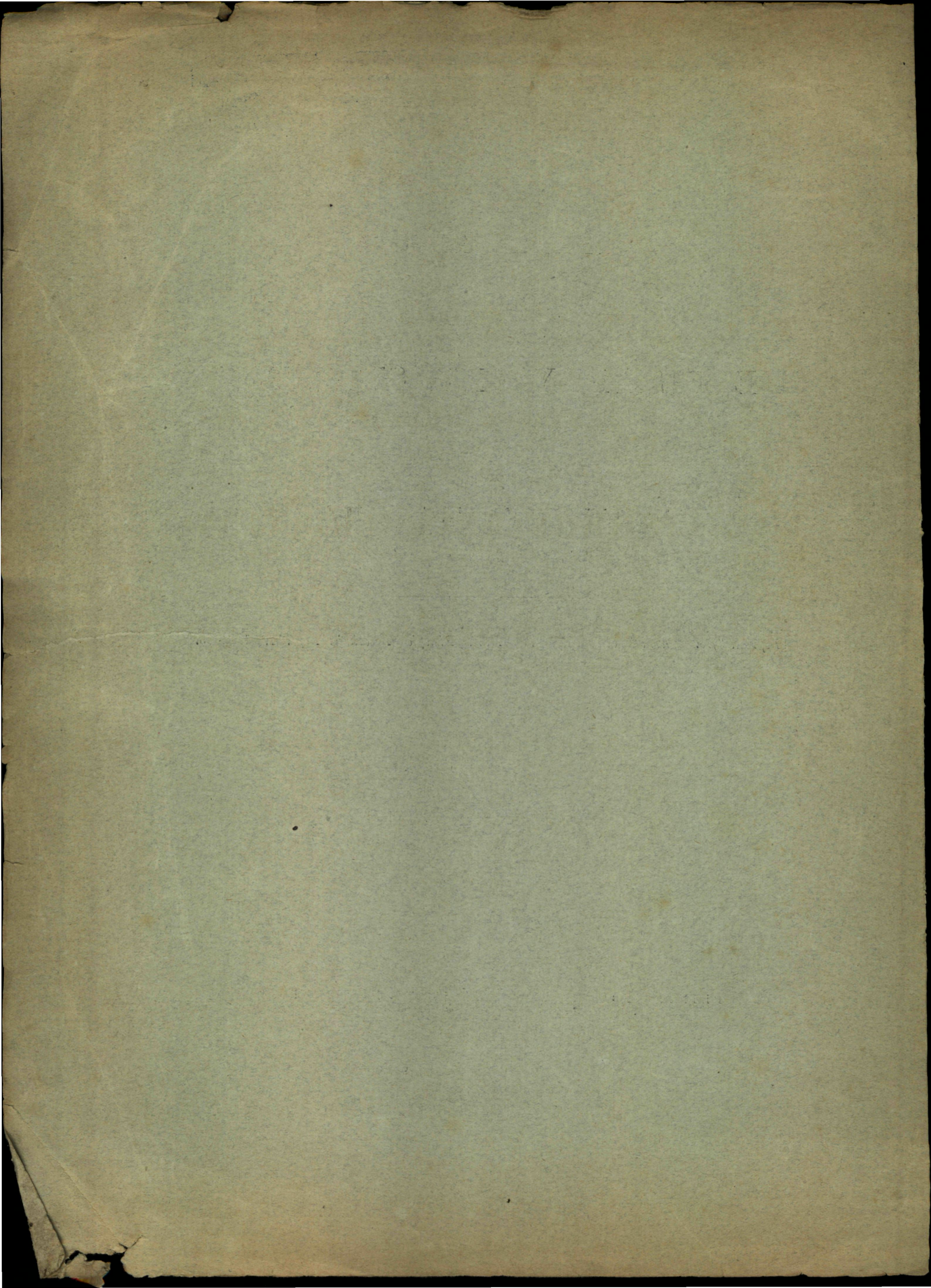
WALTER GARSTANG, M.A.,

Naturalist in charge of Fishery Investigations.

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The scientific fishery investigations carried out by the Association under the International Programme during the first year of their Commission (November, 1902, to December, 1903) consisted of the following parts :—

- (i.) A preliminary survey of the south part of the North Sea by means of the commercial trawl, for the purpose of determining the general differences between various parts of the area as regards the distribution of the different species and sizes of fish. This survey included a preliminary investigation of the inshore nurseries for flat fish along the English coast from Bridlington Bay to the Wash, as well as on the shallow grounds off the Dutch, German, and Danish coasts. Work during 1902-3.
- (ii.) A series of comparative trawling experiments by the s.s. *Huxley*, with the research steamers employed by Denmark, Germany, Holland, and Scotland, for the purpose of testing the comparability of the results obtained by the different steamers engaged.*
- (iii.) Experiments in the marking and liberation of flat fish, especially Plaice, to throw light upon their migrations and rate of growth, as well as upon the intensity of fishing in different areas.
- (iv.) Investigations on the food of fishes in different localities.
- (v.) Preliminary investigations on the rate of growth of fishes, especially the Plaice.

During the second year (1904) the same general lines of investigation were continued, but a number of special experiments were carried out in addition. These consisted of the following :— Work during 1904.

- (i.) Experiments in the transplantation of small marked Plaice from various inshore grounds to the Dogger Bank.
- (ii.) Experiments on the vitality of trawl-caught fish.
- (iii.) Experiments concerning the proportion of small fishes which escape through the meshes of the commercial trawl.
- (iv.) A special survey in June of the spawning grounds of the Sole, and of the distribution of the eggs of this species, in co-operation with the research steamers of Germany and Holland.
- (v.) A survey of the distribution and the sizes of fish in the Thames estuary during July by means of the s.s. *Oithona*.

In both years, in accordance with the recommendations of the Christiania Conference, the Association has been able to enlist the co-operation of reliable captains of commercial trawling vessels, in order to obtain additional data concerning the fish population of different grounds, and the seasonal changes in the abundance of fish. The information has been provided by specially selected fishermen upon printed forms, which distinguish, for each haul, the locality, depth, date, and duration of haul, and the total catch of each kind of fish, the commercial standards of size being further distinguished in certain cases. The boats employed fish from the ports of Lowestoft and Grimsby, and on an average three or four Lowestoft smacks, and four or five steam trawlers have been constantly employed since May, 1903, in providing this supplementary information. Trawlers' records.

* See Rapports et Procès-Verbaux des Réunions, Vol. II., Copenhagen, 1904 (Report of the Meeting of Committee B at Amsterdam, Appendix B).

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The fishermen's assistance has been cordial and efficient, and the information given has been of value in determining the regions for special investigations by the *Huxley* from time to time, as well as in providing independent information upon the distribution of fish.

Contents
of report.

The present report is accompanied by complete summaries of the trawling investigations, the investigations on the food of fishes and the experiments with marked fish carried out during the first year, the records of recapture of marked fish being brought down to December 31st, 1904. The report also includes an account of the first results of the investigations on the rate of growth of Plaice, and of the transplantation experiments carried out during 1904. The trawlers' records and the detailed records of the distribution of invertebrate species are reserved for treatment on a later occasion.

Experi-
ments with
marked
fish.

Plaice.

In the first year, *i.e.*, to the end of 1903, 1,463 Plaice were marked with numbered labels and set free in different parts of the North Sea—993 by the staff of the Association, and 470 by Mr. Meek, whose experiments on the Northumberland coast on behalf of the Northumberland Sea Fisheries Committee were carried out in co-operation with the Association. Of these 287 (19 per cent.) were recaptured to the end of December, 1904—225 (23 per cent.) from the Association's experiments and 62 (13 per cent.) from Mr. Meek's.

While it would be premature to speak of final conclusions so long as the extent of the variations occurring from year to year still remains to be determined, the results of the first year's experiments exhibit a consistent series of orderly movements of Plaice in various localities which throw considerable light on the observed distribution of the sizes of Plaice at different seasons of the year in the area investigated, and mark a distinct advance in our knowledge of the subject.

Summer
migration.

The southern bight of the North Sea, here called the Flemish Bight, which lies between the coasts of England, Holland, and Belgium, is essentially a fishing ground for Plaice. The "nurseries," where the small fish are reared in greatest numbers, lie on the eastern or Dutch shores of this area. The marking experiments in 1902-3 displayed an offshore movement of the Plaice from the nursery grounds during the spring and summer months, in a northerly direction from the north coast and in a westerly or north-westerly direction from the west coast of Holland. The movement was shown by Plaice of all sizes dealt with, from 20 cm. (8 inches) upwards, but the rate and distance of travel were greater for the larger than for the smaller fishes. The distance from the Dutch coast to the Leman Ground and Banks off the Norfolk coast was traversed in one case by April and in another by July by fish of 27 cm. ($10\frac{3}{4}$ inches) in original length liberated off the island of Ameland in the previous December.

The summer movement towards the Leman Ground and Banks was also shared by Plaice in the southern and central parts of the Flemish Bight during the spring and summer, so that it would seem fair to describe it as a general phenomenon within this area during the season mentioned.

Experiments on the Leman Ground in spring indicated a tendency of the smaller Plaice to remain on this ground, or among the neighbouring Leman Banks, during the summer months; but a continuance of the north-westerly migration was shown to a varying extent by most of the larger Plaice exceeding 30 cm. (12 inches) in length. In some instances the fish wandered as far as the grounds off the Yorkshire and Northumberland coasts, as well as to the Dogger Bank.

Winter
migra-
tions.

Experiments off the Lincolnshire and Northumberland coasts appear to indicate that this northward movement along the north-east coast of England was continued in certain cases during the winter months, though the Plaice on the inshore grounds in the northern part of this area showed remarkably sedentary habits as compared with those in the southern parts of the North Sea. Two of the Plaice from the

Northumberland experiments, and one from the Lincolnshire experiment, were subsequently recaptured in Scottish waters (St. Andrew's Bay and Firth of Forth). None were taken south of the localities of liberation.

On the other hand, the direction of migration from the Leman Ground and from the north-west coast of Holland (as inferred from the localities of the fishes recaptured) was changed in most cases during the later months of the year into a preponderating movement towards the southern parts of the Flemish Bight. This southward migration in winter was shared by all sizes of Plaice except the smallest, *i.e.*, all above about 23 cm. (9 inches) in length.

These results are in close agreement with those of the trawling experiments for 1903 in the same area. Observations on the Leman Ground in December showed a marked reduction in the numbers of Plaice during the later months of the year, which may be taken as indicating a cessation of the summer immigration, as well as the commencement of the winter emigration; while other investigations in the same month, off the N.W. coast of Holland, showed the disappearance of the small Plaice previously present in that locality and the arrival of a new population of large Plaice, as well as of Cod and Haddock, which could have only been derived from grounds to the northward.

Agreement with results of trawling investigations.

The southward migration in the Flemish Bight was indicated during the winter months both of 1902-3 and of 1903-4, so that it will probably be established ultimately as a normal winter phenomenon; but differences of detail exhibited by the two series of experiments render it possible that further investigations will show a close relation between this migration and the incidence and severity of winter gales.

Annual variations.

The details of the summer migration are of interest in suggesting the extent to which the chief Plaice fisheries along the English coast may be dependent upon the Dutch nursery grounds as their chief ultimate source of supply. This question cannot be settled from marking experiments alone, but the results of the first year's experiments support the provisional inferences drawn on this subject from the distribution of the sizes of Plaice as revealed by the trawling experiments.

Sources of supply.

The relations of the Plaice reared along the English coast north of the Wash are not yet clear; but the general continuity of the life-cycle over the whole central area between the southern boundary of the Dogger Bank and the southern boundaries of the Flemish Bight lends no support to the idea that any minor portions of this area are inhabited by local races of Plaice, and accords in this respect with the results of the latest published researches on the structural variations of this species.

Races of Plaice.

On the other hand, there are indications in the results of the marking experiments which point to the possibility that the average size of Plaice in the southern part of the North Sea is kept at a relatively low level by annual emigrations of the largest Plaice during the spring and summer months, which may not be fully counterbalanced by the winter immigrations.

Out of a total of 855 marked Plaice above 20 cm. (8 inches) in length liberated outside territorial limits, the number recaptured within twelve months from the date of liberation yields a total percentage of 21 per cent. The percentage is the same if the calculation is restricted to the fish exceeding 25 cm. (10 inches) in length (567 fish). From this result it is clear that the total annual catch of the fishermen no longer forms an insignificant proportion of the total stock of Plaice.

Intensity of fishing.

Experiments on the Dogger Bank in the spring of 1904 resulted in the recapture of more than 40 per cent. of the Plaice exceeding 25 cm. (10 inches) in length in less than twelve months.

Steam and sailing trawlers.

Some idea of the relative influence of steam trawlers and sailing trawlers in the southern part of the North Sea is furnished by the results of the experiments carried out in that region (Leman Ground, Dutch Coasts, and Flemish Bight). From these it appears that, out of 205 recaptures, 106 were reported by steam trawlers (52 per cent.), of which 18 were foreign, and 99 by sailing trawlers (48 per cent.), of which 26 were foreign. The recaptures by steam trawlers were mostly reported from the northern part of the region, *i.e.*, north of 53° N.

Transplantation experiments.

By the transplantation of over 1,100 small marked Plaice from the inshore grounds to the Dogger Bank in the spring of 1904 it has been shown that the rate of growth on the Bank is considerably greater than on the coastal grounds, which form the natural habitat of such fish—the average increase in weight of the transplanted fish by the following winter having been six times as great as that of similar fish living on the coastal grounds of the southern and eastern parts of the North Sea.

Up to the end of October most of the transplanted fish that were caught again were taken upon the Bank, but after that date most of the fish recaptured were taken on the outer slopes or away from the Bank altogether. The few which were caught upon the Bank during the winter months continued to grow, but those which left the Bank showed no general increase in length during the winter months in excess of the November average.

It is worthy of note that out of 64 transplanted fish recovered during the summer months from April to October, 92 per cent. were recaptured by English steam trawlers; and that the proportion of recaptures reported by English fishermen was not materially reduced during the winter months, when most of the fish had apparently left the Bank. 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 means of directly increasing the total yield (weight) 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.

Soles.

During August, 1903, 101 small Soles were marked with labels and set free in various parts of the district adjacent to the Lincolnshire and Norfolk coasts. Only two recaptures were reported to the end of 1904, one in June, 1904, near the original locality ten months after liberation, and one in February, 1904, off Scarborough six months after liberation. The latter fish had been set free in the Wash, and had travelled in a northerly direction about 85 miles. Neither of these fishes had grown since liberation.

During September, 1903, a few Soles were also marked and liberated off Terschelling, and of these one was recaptured in the following April in proximity to the Dutch coast.

Trawling investigations.

During the year ending 31st December, 1903, 244 hauls were made with the commercial trawls on board the *Huxley*, in different parts of the North Sea, and a complete register was kept of the sizes and numbers of all the fishes caught. The total number of individual measurements recorded at sea on these occasions amounts to 81,500, of which about 50,000 were flat fish.

In addition to these about 2,500 measurements were made of small fish, chiefly flat fish, caught with special nets in the inshore waters.

The measurements made of the Plaice are presented in full detail in an appendix to this report, and show the frequency of fish of each length, expressed in centimetres, at each haul of the trawl. (Detailed Measurements, Table VI., p. 122.)

In the case of other species it has been considered unnecessary at the present stage to publish the recorded measurements in the same detail. The size-frequencies of these species, as well as of the Plaice, are presented in units of ten centimetres, which are equivalent approximately to size-groups of four inches. An analysis of the total catch of each haul of the trawl upon this plan is submitted. (Summaries of Hauls, VIII., p. 158.)

In the case of six chief food-fishes (Plaice, Dab, Sole, Cod, Haddock, and Whiting) the average length of the fish (in centimetres) at each haul of the trawl is also provided, and the total catch of these species on each occasion has been reduced to a common standard (the catch per hour) to facilitate the study of local and seasonal differences in abundance. Two categories of size, varying according to the species, are also distinguished in the same table for each of the six species except the Cod, for which three categories of length are distinguished. (Synoptic Table, p. 106.)

In view of the co-operative character of the international survey, and of the biological continuity of the different regions of the North Sea under investigation, the data accumulated by the Association during the first year's work have been regarded in the main rather as a first instalment towards the common stock of material than as a sufficient basis for immediate or independent conclusions. Nevertheless on certain points a preliminary discussion of the data seems calculated to forward the attainment of general results, and it has been thought desirable on this account to submit an analysis of the first year's data concerning the distribution of Plaice according to size, as indicated by hauls of the commercial trawl.

The commercial nets employed during the survey have been of two kinds, viz., a 90-foot otter trawl, as used by many of the Grimsby steam trawlers, and a 43-foot beam trawl similar to that used by the Lowestoft trawling smacks.

The relative catching power of the two nets with respect to Plaice has been carefully studied in the light of special experiments. These indicate that the beam trawl, in spite of its smaller size, caught about 11 per cent. more of the smallest Plaice below 15 cm. (6 inches) in length than the otter trawl on the same ground and for the same time, doubtless because the wider meshes of the otter trawl enabled a larger proportion of the smallest fish to escape.

For Plaice above that size, however, the beam trawl caught in general only about two-thirds as many fish as the otter trawl in hauls of equal duration. The relative efficiency of the otter trawl was found to be greater on sandy than on muddy grounds, owing probably to the spread of the otter boards being impeded on soft grounds by their tendency to dig. Taking the catch of the beam trawl as the standard, in consequence of the equal spread of this net under all conditions, the relative catch of the otter trawl on sandy grounds, for hauls of equal duration, yielded an average ratio of 1.49 : 1, and on muddy grounds a ratio of 1.15 : 1.

These differences are not sufficiently great to affect the comparability of the figures showing the catch per hour of the two nets on different occasions for this species, since the important local and seasonal differences in the abundance of Plaice greatly exceeded a variation of 50 per cent., and the smallest Plaice, whose capture is influenced by the mesh of the net, are only found on the inshore grounds, where the beam trawl was almost always used. It has, therefore, been considered sufficient for present purposes to draw attention to the extent of the difference between the catch of the two nets, and to adopt a system of nomenclature by which the type of net employed is indicated in the reference number of every haul (*e.g.*, O. 120 = otter haul 120 ; B. 45 = beam haul 45).

Inshore areas.

Previous investigations having shown that the Lincolnshire coast and the Wash constitute probably the chief nursery for small flat fish along the English coast, a special investigation of this area was carried out in August, 1903, with the permission of the Eastern Sea Fisheries Committee and with the co-operation of the Committee's Inspector, Mr. Herbert Donnison. Large numbers of very young Plaice and Soles were taken with the shrimp trawl along the oozy shores of the Wash, but the larger sizes of immature Plaice were scantily represented in hauls of the large commercial trawl offshore. They were more numerous in the open waters off Saltfleet, as well as in Bridlington Bay, which was investigated with the permission of the North Eastern Sea Fisheries Committee. These facts suggest that the Plaice reared on the shores of the Wash emigrate from the estuary at an early age.

Local differences in abundance of small Plaice.

Compared with their abundance along the Continental shores, the numbers of small Plaice reared along the English coast were found to be exceedingly small. Another noteworthy feature of the distribution of small Plaice off the English coast was found to be their greater abundance on the Leman Ground, 50 miles offshore, than among the Leman Banks, which lie between this ground and the Norfolk coast. The circumstances suggest that the population of Plaice on the Leman Ground is mainly derived from other sources than the English coast, probably from the Dutch nurseries; but the difference in the numbers of small Plaice on the Leman Ground and Leman Banks respectively is not fully explained by this assumption, and appears to be mainly due to the marked differences between the two areas in regard to the nature of the bottom, which is fine sand on the Leman Ground and Dutch coasts, but coarse sand and gravel on the Leman Banks, as well as along the greater part of the English shores from Orfordness to Flamborough Head.

Sources of supply.

Influence of bottom.

Cause of local differences.

If this interpretation should be confirmed, the same principle may be expected to account more extensively than is commonly supposed for the marked contrast in the numbers of small Plaice on the eastern and western shores of the North Sea generally. This contrast is sometimes explained as due to a preponderating drift of the floating eggs of Plaice towards the Eastern grounds; but the abundance of very young Plaice in English areas where the sand is equally soft and fine (*e.g.*, the Wash) tends to show that this explanation is inadequate, and that the scarcity of small Plaice along the English coast of the North Sea generally is attributable, not necessarily to any scarcity of eggs, but chiefly to the small extent of coast which presents the necessary combination of characters favourable to their later development.

Analogy of the Devon Bays.

A very similar contrast on a smaller scale is presented by the Bays on the south-east coast of Devon, where the conditions have been elucidated by earlier investigations. In this case both Teignmouth Bay and Start Bay lie to the north-west of the spawning grounds, and probably receive an equivalent supply of floating eggs; but it is only in Teignmouth Bay, where the fine sands of the Exe and Teign estuaries provide suitable conditions, that the youngest Plaice are reared in significant numbers.

Although a definite solution of this problem is not provided by the results of the first year's work, it seems desirable to draw attention to the ascertained facts which bear upon this matter, which is important from its bearings on the efficacy of various means suggested for increasing the supply.

Offshore areas.

The trawling investigations have thrown a large amount of new light upon the range of size shown by the various species of fish on different grounds, as well as upon their relative abundance; and they have contributed a number of important data bearing upon the seasonal changes and migrations in different areas.

In the Flemish Bight, south of $53^{\circ} 30' N.$, small Plaice below 30 cm. (12 inches) in length were found to predominate in all parts of the area, and apparently at all seasons, though further observations are necessary.

On the outer grounds off the Dutch and Danish coasts these small plaice were abundant during the autumn, when they were clearly emigrating from the inshore waters, but were scarce in winter and spring. The subsequent disappearance of those fish during the winter months appears to be traceable to a reversal of the direction of migration which took place on the approach of winter, as shown by the marking experiments.

The trawling investigations off Terschelling in September and December provide corroborative evidence of the southward migration in winter which was indicated by the results of the marking experiments on Plaice. In the period mentioned a radical change took place in the character of the fish population. In September, Haddock and Cod were absent, and the Plaice consisted principally of small fish, which were present in great numbers. In December, large Haddock and Cod were present in fair numbers, the small Plaice had almost entirely disappeared, and a new population of large mature fish had arrived. The absence of Haddock in the Flemish Bight, together with the large size of the new immigrants, renders it probable that they had travelled southwards from more northern waters.

Evidences
of south-
ward
migration
in winter.

Plaice of 30 cm. (12 inches) in length and upwards were found to predominate on the Dogger Bank and adjacent grounds at all seasons, on the Terschelling grounds in the winter, and on the Horn Reef Outer grounds in spring. The change in average size which took place on the two latter grounds during the summer, when the small Plaice were emigrating from the inshore grounds, has already been mentioned. It is therefore worthy of note that on the Dogger Bank the results of the summer redistribution tended to raise, rather than to lower, the average size. The numbers of Plaice below 30 cm. (12 inches) in length were very small at all seasons, and showed no increase in the autumn, whereas the numbers of large fish doubled during the summer. As the fish from 30 to 34 cm. (12—13 inches) predominated throughout, it is clear that the great majority of immigrant Plaice were at least 30 cm. in length at the time of their arrival.

Dogger
Bank and
central
grounds.

Plaice of mature size, 35 cm. (14 inches) and upwards, were found to be generally distributed on the offshore grounds investigated, between the depths of about 15 and 35 fathoms. Their numbers were usually small on the coastal grounds (two or three per hour), but somewhat greater in the neighbourhood of the Dogger Bank. Little evidence was furnished during the year of any tendency on the part of the mature fish to form special local accumulations during the spawning season. They diminished in numbers on the Banks most exposed to disturbance by winter gales (*e.g.*, Dogger Bank, Leman Ground), but their migrations appear to have been of the same character as those of other Plaice not yet mature, and to have been influenced by size irrespective of maturity.

Spawning
grounds of
Plaice.

Dr. Wallace submits the first results of an investigation on the age and growth-rate of Plaice, based on an examination of the periodic rings shown by the otoliths (ear discs) of this species (Reibisch's method). He has confirmed the validity of this method as yielding a reliable index of age for individual fishes in their earlier years, and has investigated its utility as a means of determining the average growth-rate in particular areas.

Age and
growth-
rate of
Plaice.

On the inshore grounds, where the Plaice form a fairly stationary population, the average size of the fish for each of the first two or three years of age has been approximately determined by the otolith method for Bridlington Bay and the Thames Estuary. In July the two-year-old Plaice showed an average length of 13.5 to 13.8 cm. ($5\frac{1}{4}$ inches to $5\frac{1}{2}$ inches) in each locality, so that the rate of growth would appear to be approximately the same in the two regions. The three-year-old fish in Bridlington Bay showed an average length of 19.5 cm. ($7\frac{3}{4}$ inches) at the same time, so that the average growth during the third year may be estimated at about 5 to 6 cm. ($2\frac{1}{2}$ inches).

Inshore
grounds.

The measurements of over 1,800 small Plaice caught with the shrimp trawl during August along the shores of the Wash yield a frequency curve with three distinct cusps at 5.5, 10, and 14.5 cm., representing the average size of the first year, year-old and two-year-old fish respectively. These figures indicate a close agreement between the growth-rates in all three localities.

On the Eastern Grounds (Horn Reef and Sylt) the average length of the three-year-old fishes in May was found to lie between 19 and 20 cm. ($7\frac{1}{2}$ inches to 8 inches) in three different localities, a result which is in close agreement with an average of 17.9 cm. shown by the two-year-old fish on the same grounds in September, and with an average of 18-19 cm. shown by fish of the same year off the Dutch coast in November.

The growth-rate of small inshore Plaice would thus appear to be very similar on the English coasts south of Flamborough Head and on the continental grounds, but slightly greater on the latter than on the former.

This conclusion agrees closely with the results of direct observations of the growth of marked fishes, (see "Transplantation Experiments," pp. 51, 52).

English
Channel.

These remarks apply to the North Sea, but Dr. Wallace's observations in the western part of the English Channel off the south-east coast of Devon, satisfactorily indicate a much higher rate of growth of young Plaice in this region than in the southern parts of the North Sea. At the end of their third year, *i.e.*, when close upon three years of age, Plaice in this region were found to show an average size of about 27 cm. ($10\frac{1}{2}$ inches), showing an excess of 8 cm. ($3\frac{1}{4}$ inches) above the average size at the same age on the continental coasts of the North Sea (19 cm.) and an excess of at least 9 cm. ($3\frac{1}{2}$ inches) as compared with Plaice of the same age along the English coast between the Humber and the Thames.

The difference is possibly connected with the greater warmth of water, especially during winter, in the western parts of the Channel.

Offshore
grounds.

On the other hand, Dr. Wallace draws attention to the difficulties of determining the average sizes of fishes of subsequent years owing to various complications introduced by the migrations of the fish. In general the average size of Plaice of a given age has been found to be higher on the offshore grounds than in shallow water; and although there is good reason to believe that this difference is largely due in some cases to an increased rate of growth on the offshore grounds, it is partially attributable at any rate to the fact shown by the marking experiments that the larger fishes of a given year tend to emigrate offshore sooner, and to greater distances than the smaller fish of the same year. Reliable averages must consequently be based on series of samples collected along the main axes of migration in particular areas. The observations made up to the present are not sufficient to show the average rate of growth on particular offshore grounds. As Dr. Wallace remarks: "all that can be said at present is that the average size of Plaice of a given age is greater, or less, on one ground than on another"; and it must remain for further investigations, especially based on the age analysis of marked fish, to show to what extent these differences are attributable to the influence of different growth-rates and of "migratory selection" respectively.

Age and
size at first
maturity.

On the Leman Ground and Dogger Bank Dr. Wallace's observations show that female Plaice begin to spawn at the end of their fifth year, but the majority do not begin until the end of their sixth year, *i.e.*, when nearly six years old. The average size at first maturity on these grounds during the spawning season lies between 35 and 39 cm. ($13\frac{3}{4}$ and $15\frac{1}{2}$ inches), being somewhat higher on the Dogger Bank than on the Leman Ground. The males were found to become mature a year earlier than the females.

On the Leman Ground Plaice were found of all ages from the first to the eleventh years, but the majority were from three to four years old.

Age on
offshore
grounds.

On the south part of the Dogger Bank in March the youngest fish observed were three years old, but their numbers were insignificant. The majority were from four to five years old; and from the fact that their average size was no greater than on the Leman Ground it may be inferred that these fish were for the most part recent immigrants to the Bank.

Thus the Dogger Bank, in spite of its shallow depth and rich food supply, contains no indigenous stock of Plaice and depends for its supply upon the annual immigrations of fish from the coastal grounds. In view of the above-mentioned facts, and of the length of time required by the fish to complete the journey, the relative scarcity of Plaice upon the Bank at the present time would appear to be mainly attributable to the severity of the fishing in the intervening zone, which interferes with the natural supply of immigrant Plaice.

Depletion
of Dogger
Bank.

In former times, when the Plaice upon the Bank were far more numerous, according to the testimony of fishermen, than in recent years, the Bank must have played a more important rôle than at present in maintaining the average size of Plaice at a high level; and it is clearly a matter for serious practical consideration how its exceptional resources for the growth of Plaice may be utilised to the utmost.

In view of the above-mentioned considerations, it seems doubtful whether any method short of actual transplantation can be relied upon to effect this object under the existing conditions of the trawl fishery.

Mr. Todd's examination of the contents of the stomachs of over 3,600 fish belonging to 27 different species represents a valuable first instalment of data concerning the food of different species of fish on various grounds. The identification of the contents has been carried out in detail, because it is only in this way that exact ideas can be attained as to the competition between different species of fish for the available supply of food, while the determination of the relative value of various feeding grounds is calculated to throw additional light on the migrations and rate of growth of fishes in different areas, and thus to give greater precision to results on those subjects which may be arrived at by other methods of investigation.

Food of
fishes.

