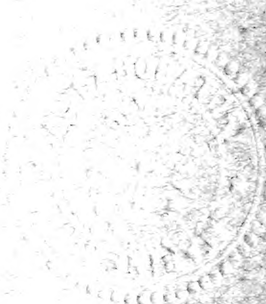

New Series, III.

DOVE MARINE LABORATORY,

CULLERCOATS, NORTHUMBERLAND.

REPORT

For the year ending June, 1914.

Edited by ALEXANDER MEEK,

Professor of Zoology, Armstrong College, in the University of Durham,

and

Director of the Dove Marine Laboratory.

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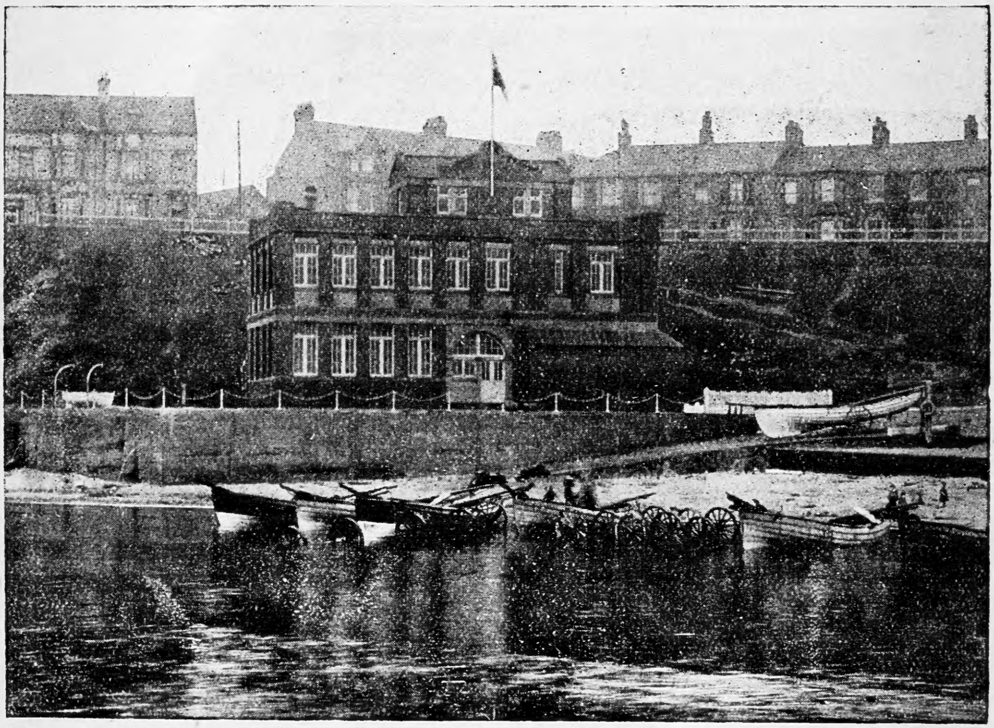

Dove Marine Laboratory, Cullercoats.

SUMMARY AND GENERAL REPORT.

A short account is given of the results of the trawling experiments and of the marking experiments.

These experiments have been reviewed for the whole period they have been made in Northumberland in an attempt to show that the fish along the east coast are distributed definitely according to a law. It has been shown that each species is resolved into schools which migrate outwards and inwards to winter and summer grounds. There are species which winter offshore to the north of the summer feeding ground (northern migrants), and species which winter offshore to the south of the summer feeding ground (southern migrants). The result of the annual migration is to determine the species in each case to the north or the south of the inshore summer ground. The law may be stated therefore as follows : The species which frequent the inshore (in summer at least) are distributed so that a northern migrant predominates at the northern part of the summer inshore region, and the sub-divisions thereof, and a southern migrant predominates at the southern part of the summer region, and the sub-divisions thereof.

The contribution to the subject in this report gives the results of an analysis of the trawling experiments with reference to size and period of the year. From this it is clearly evident that the schools are composed of the young and immature, and the periodicity of the immigration and emigration is better defined. A consideration of the results of marking experiments bears this out, and affords evidence of the conspicuous migrations in a definite direction of the mature. It is becoming evident that plaice are divided into a southern race and a northern race, each resolved into schools, and that dabs, so far as we know, present only the characters of a southern race. This has been made the basis of an attempt to indicate the probable origin of the migrations in the early post-glacial period.

The large number of herring measured last year, together with the smaller numbers examined in previous years, have enabled us to state that there is a difference between the trawl caught herring of the Dogger Bank region and the summer drift net herring of the east coast. The age composition of the samples throws little light on the subject, and it is evident that a determination of race will depend mainly on a consideration of the measurements.

Further recaptures of the crabs marked by the late Mr. J. Douglas, Beadnell, towards the end of 1912 have been reported. The results illustrate the migration of mature females northwards, and indicate clearly that the migration is caused by the ripening of the ovaries.

An attempt has been made by means of statistics furnished by the Board of Agriculture and Fisheries to state the drift of lobster larvæ in the Northumberland district. The examination of the figures leads to the conclusion that the drift is only some ten miles south of the protected region, and that there is probably a northward migration at some period of the life of the lobster. The figures further show that the protecton of the berried lobster is far more important for the encouragement of the lobster fishery than imposing a size limit.

With the question of the protection of the lobster is involved that of lobster culture. As has been shown in previous reports, artificial hatching can be accomplished with a great measure of success. But our experiments have led to the conclusion that ordinary tank methods are not adapted to rearing. It is therefore recommended that further experiments should be made on the American plan, and reference is made to a place on the Northumberland coast which could be used for experiments, and if these are successful, for finally being adapted for the purposes of the district.

The transplantation of mussels at Holy Island has been as successful as could be expected, since the beds were not under supervision. The bouchots were not strong enough to withstand the heavy seas and currents. A consideration is given of the drift of mussel larvæ along the coast, and this appears to point to a passive migration of larvæ to the south.

The question of the pollution of the Tyne has been the subject of an important conference in Newcastle. The results of the examination of samples taken by the "Evadne" in the river show that the region opposite Newcastle is in a particularly bad condition. This polluted zone is practically devoid of oxygen, and is never entirely removed, only moving up and down with the tide. Our experiments are fairly conclusive, but it would be desirable on a succession of dates to sample a cross section of the river at intervals during twelve hours.

Miss Robson has prepared a Catalogue of the Hydrozoa of the Cullercoats region, incorporating the records of Dr. Johnston, Berwick, and Joshua Alder, Newcastle, with those she has made during the past two years. She has not obtained twenty of the species of the earlier lists, but she has added twenty-one, one of which is a new species.

Faunistic Notes are given by Mr. B. Storrow, and Mr. Whitehead has written a short account of his observations on Amphidinium.

Thanks again to the anonymous donor and other friends, arrangements have been made for the College purchasing the Laboratory.

ALEXANDER MEEK.

31ST JULY, 1914.

TRAWLING EXPERIMENTS.

BY ALEXANDER MEEK.

In 1913, from May to November, a series of trawling experiments were made at the usual stations, and in all respects in parallel with those of previous years.

The general conditions are indicated in Table I. (including the determinations of salinities of the surface water by G. Sisson), and the details of the catches in Table II. In Table III. a summary is given showing the catch at each experiment per one hour's trawling.

There are several points of interest which may be briefly refered to. Firstly, with regard to the large numbers of gurnards, especially in Alnmouth Bay. Gurnards certainly vary considerably in numbers according to season, but whether in large or in small numbers they always predominate in Alnmouth Bay, and there are more to the south of Alnmouth Bay than at the northern stations. This feature of distribution is well illustrated in this year of plenty. The species invaded the bay in the spring, reaching a maximum in July. A second maximum occurred in August, and the gurnards practically left the bay in November. The July maximum is seen in most seasons, and also the departure between September and November. Druridge Bay to the south of Alnmouth Bay also presents two maxima, in July and September. Blyth Bay received gurnards in numbers only in August. At the northern end of the district the gurnards as usual were small in numbers, reaching a maximum in September, and a comparison with the results of previous years bears this out.

The gurnards are for the most part young and immature, and their distribution is similar to that described in this report for plaice and dabs as the result of a seasonal migration. The experiments for a large number of years show that they practically leave the inshore waters in October, and return like the other summer migrants in the spring. There appears to be little doubt therefore that the wintering ground of the gurnards of south Northumberland is to the north of Alnmouth Bay, and that the species is distributed inshore by migration in a southerly direction, appearing first in Alnmouth Bay and spreading to the other bays. It is probable that the gurnards of the northern half of Northumberland belong to the southern minimum portion of a school to the north, and that Alnmouth marks the northern limit of a school which from its numbers is of more particular Northumberland interest. If this be correct, gurnards belong to the class which I have called northern migrants.

Second, the experiments in Druridge Bay now carried on further to the south of the bay than in former years illustrate the character of the bays which I have pointed out with reference to the distribution of plaice and dab. It has been shown that plaice tend to the northern part of the bays and the dab to the southern. The figures in many cases show this even for individual hauls. With a view to testing the point the November experiments were so arranged that the first haul was made in the northern half of the bay and the second in the southern half, and it will be seen that in spite of the lateness of the season and the short period given at Druridge Bay more plaice were caught in each case in the northern portion of the bays. In the case of Alnmouth, where each experiment was continued for an hour, there were more dabs in the southern part of the bay.

Third, it may be said that with the exception of Druridge Bay the stations received this year about the average numbers of the various species.

In Table IV. the results of the examination of a number of the fish caught at the trawling experiments are given. The food is very similar to that obtained by the fish as reported upon in former years, see Report for 1905, page 44.

TABLE I.—TRAWLING EXPERIMENTS.

Place.	Date	Experiment. Began.	Experiment. Ended.	Time.	Temperature. Air.	Temperature. Water.	Salinity.	Wind.	Sea.	Weather.	Condition of Ground.
	1913.										
Skate Roads ...	June 25	7.30 a.m.	8.40 a.m.	1 hr. 10 mins.	55	52	34·06	N.	Swell ...	Dull ...	Clean.
Do. ...	„ 25	9 a.m.	10.10 a.m.	1 hr. 10 mins.	55	52	34·06	N.	Swell ...	Dull ...	Clean.
Do. ...	Sept. 9	2.45 p.m.	3.45 p.m.	1 hour ...	60	56	34·35	N., light ...	— —	Fine, clear	Net full of weed
Do. ...	„ 9	4.5 p.m.	5.5 p.m.	1 hour ...	60	56	34·35	N., light ...	— —	Fine, clear	Net full of weed
Alnmouth Bay	May 29	12.5 p.m.	1.5 p.m.	1 hour ...	—	49	—	Light	Calm ...	—	Clean.
Do. ...	June 11	11·40 p.m.	12·45 p.m.	1 hr. 5 mins.	50	48	34·00	N.W., moderate to strong	—	Squally ...	Clean.
Do. ...	July 11	12 noon	1 p.m.	1 hour ...	60	53·5	34·05	S.E., light ...	Smooth ...	—	Clean.
Do. ...	„ 11	1.25 p.m.	2.25 p.m.	1 hour ...	60	53·5	34·05	S.E., light ...	Smooth	—	Clean.
Do. ...	Aug. 1	11.50 a.m.	12.55 p.m.	1 hr. 5 mins.	57	57	34·05	S., light ...	Calm ...	Fine, sunny	Clean.
Do. ...	1	1.15 p.m.	2.20 p.m.	1 hr. 5 mins.	57	57	34·05	S., light ...	Calm ...	Fine, sunny	Clean.
Do. ...	„ 13	11·40 a.m.	12·40 p.m.	1 hr. ...	65	56	34·28	W.N.W., light	—	Cloudy ...	Clean.
Do. ...	„ 13	1 p.m.	2.15 p.m.	1 hr. 15 mins.	65	56	34·28	W.N.W., light	—	Cloudy ...	Clean.
Do. ...	Sept. 10	8.40 a.m.	9.55 a.m.	1 hr. 15 mins.	59	56	34·38	N., light ...	Light swell	Fine ...	Clean.
Do. ...	„ 10	10.15 a.m.	11.15 a.m.	1 hour ...	59	56	34·38	N., light ...	Light swell	Fine ...	Clean.
Do. ...	Nov. 1	11.25 a.m.	12.25 a.m.	1 hour ...	53	51	34.45	W.S.W. ...	—	Fine ...	Clean.
Do. ...	„ 1	12·40 p.m.	1·40 p.m.	1 hour ...	53	51	34·45	W.S.W. ...	—	Dull ...	Clean.
Druridge Bay...	May 29	2.20 p.m.	3.25 p.m.	1 hr. 5 mins.	—	49	—	Light, variable	Smooth ...	—	Clean
Do. ...	„ 29	3.45 p.m.	4.55 p.m.	1 hr. 10 mins.	—	49	—	Light, variable	Smooth ...	—	Clean
Do. ...	June 11	3.45 p.m.	4.45 p.m.	1 hour ...	54	48	34·05	N.W., moderate	—	—	Clean.
Do. ...	July 11	3.25 p.m.	4.25 p.m.	1 hour ...	65	54	34·28	W.	Smooth ...	—	Lot of weed.
Do. ...	Aug. 1	3·30 p.m.	4·30 p.m.	1 hour ...	56·5	56·5	34·28	—	—	—	Lot of weed.
Do. ...	„ 13	3·40 p.m.	4·40 p.m.	1 hour ...	66	56	34·30	W.N.W. ...	—	Dull ...	Clean.
Do. ...	Sept. 10	12·15 p.m.	1·15 p.m.	1 hour ...	59	56	34·43	W., light ...	Slight swell	—	Clean.
Do. ...	Nov. 1	2·40 p.m.	3·40 p.m.	1 hour ...	52	51	34·45	S.	—	Dull ...	Clean.
Do. ...	„ 1	3·55 p.m.	4·20 p.m.	25 mins. ...	52	51	34·45	S.	—	Dull ...	Clean.
Blyth Bay ...	May 29	6 30 p.m.	7.30 p.m.	1 hour ...	—	49	—	S. by E., light ...	Calm ...	—	Clean.
Do. ...	June 11	6·20 p.m.	7·30 p.m.	1 hr. 10 mins.	49	48	34·18	N.W.	Slight swell	Squally ...	Clean.
Do. ...	July 11	5·55 p.m.	7.5 p.m.	1 hr. 10 mins.	64	54	34·05	W.S.W. ...	Smooth ...	—	Clean.
Do. ...	Aug. 1	6·15 p.m.	7·15 p.m.	1 hour ...	52	56·5	34·43	—	—	—	Clean.
Do. ...	„ 13	6 p.m.	7·15 p.m.	1 hr. 15 mins.	62	56	34·35	W.N.W. ...	—	Dull	Clean.
Do. ...	Sept. 10	2·45 p.m.	3·45 p.m.	1 hour ...	59	56	34·30	W., light ...	Slight swell	—	Clean.

TABLE II.—TRAWLING EXPERIMENTS.

FIRST HAUL.—29th May, 1913. ALNMOUTH BAY. Began 12·5 p.m., ended 1·5 p.m. Time, 1 hour.

CENTIMETRES.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Total.
Plaice ...	—	—	—	—	—	1	2	1	—	—	—	—	1	—	—	—	2	—	—	1	—	—	—	—	—	—	—	—	—	—	—	8
Dab ...	—	—	—	—	—	—	1	1	2	7	5	6	3	2	—	1	1	2	1	1	—	—	2	—	—	—	—	—	—	—	—	35
Whiting ...	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Gurnard ...	—	—	—	—	1	19	13	14	5	10	8	13	1	2	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	90
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FIRST HAUL.—29th May, 1913. DRURIDGE BAY. Began 2·20 p.m., ended 3·25 p.m. Time, 1 hour 5 minutes.

Name of Fish.	13	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	44	46	60	Total
Plaice ...	—	3	—	2	1	—	—	—	—	—	—	—	—	—	—	—	1	—	1	2	—	1	2	1	1	—	—	1	1	—	1	18
Dab ...	—	—	2	—	1	—	2	1	4	1	—	1	2	—	1	—	—	—	—	—	2	—	1	—	—	—	—	—	—	—	—	18
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1
Gurnard ...	1	1	2	1	3	1	5	6	2	3	5	1	1	3	—	—	—	2	—	—	1	—	—	—	—	—	—	—	—	—	—	38
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	1	1	—	—	—	—	1	—	—	—	1	—	6
																																81

SECOND HAUL.—29th May, 1913. DRURIDGE BAY. Began 3·45 p m., ended 4·55 p m. Time, 1 hour 10 minutes.

Name of Fish.	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	48	54	66	65	Total.
Plaice ...	—	2	2	2	3	4	1	1	—	—	1	—	1	2	1	1	—	2	—	—	1	—	3	2	—	4	1	—	—	—	—	34
Dab ...	1	—	—	2	6	1	4	3	5	5	3	—	2	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	34
Lemon Dab	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1
Gurnard	—	—	2	—	7	2	4	13	11	6	4	3	2	1	—	1	4	1	1	3	—	1	—	1	—	—	—	—	—	—	—	67
Thornback ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	1	4
																																143

TABLE II.—TRAWLING EXPERIMENTS (*continued*).

FIRST HAUL.—29th May, 1913. BLYTH BAY. Began 6·30 p.m., ended 7·30 p.m. Time, 1 hour.

CENTIMETRES.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	53	Total.
Plaice ...	—	—	—	—	—	—	3	2	—	—	—	—	—	—	—	2	—	1	—	2	—	2	—	—	1	—	—	—	—	—	—	13
Dab ...	—	—	—	—	—	—	1	1	2	1	3	3	2	3	2	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	20
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Brill ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	2
Gurnard ...	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	1	—	—	1	—	5
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	1	—	—	3
																																45

FIRST HAUL.—11th June, 1913. ALNMOUTH BAY. Began 11·40 a.m., ended 12·45 p.m. Time, 1 hour 5 minutes.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Total.
Plaice ...	—	—	—	—	2	5	3	3	3	2	1	—	—	—	—	—	1	2	1	2	2	—	—	1	—	1	1	—	—	—	—	30
Dab ...	—	—	—	—	—	1	3	3	11	9	17	9	6	5	5	2	2	2	—	1	1	—	—	—	—	—	—	—	—	—	—	77
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	3
Haddock ...	—	—	—	—	—	—	—	—	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
Gurnard ...	—	—	—	—	3	23	25	17	6	8	3	11	3	3	3	2	2	4	—	1	—	—	—	—	—	—	—	—	—	—	—	114
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	1	—	3
																																230

FIRST HAUL.—11th June, 1913. DRURIDGE BAY. Began 3·45 p.m., ended 4·45 p.m. Time, 1 hour.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	-8	29	30	31	32	33	34	35	36	37	38	39	40	Total.
Plaice ...	—	—	—	—	—	—	2	1	—	3	—	2	1	—	3	—	—	1	—	1	1	1	—	1	1	1	1	—	—	—	—	20
Dab ...	—	—	—	—	—	1	3	6	4	4	6	1	4	2	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	34
Haddock ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Gurnard ...	—	—	—	—	2	9	5	—	2	—	5	5	5	3	—	2	—	—	—	—	2	1	—	—	—	—	—	—	—	—	—	41
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	2	—	—	—	—	—	3
																																99

TABLE II.—TRAWLING EXPERIMENTS (*continued*).

FIRST HAUL.—11th June, 1913. BLYTH BAY. Began 6·20 p.m., ended 7·30 p.m. Time, 1 hour 10 minutes.

CENTIMETRES.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	53	Total.
Plaice	—	—	—	—	2	5	6	3	2	1	1	3	1	1	3	1	2	4	5	—	3	2	1	1	2	—	1	—	1	1	—	52
Dab ...	—	—	—	—	—	—	1	1	2	—	2	1	—	—	3	1	1	1	—	—	—	—	1	—	—	—	—	—	—	—	—	14
Turbot ...	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Flounder ...	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1	—	—	2	—	—	—	1	—	—	—	—	5
Gurnard ...	—	—	—	—	—	—	1	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	1	—	1	4
Crab ...	—	—	—	—	—	2*	—	1*	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
																																83

* Berried females.

FIRST HAUL.—25th June, 1913. SKATE ROADS. Began 7·30 a.m., ended 8·40 a.m. Time, 1 hour 10 minutes.

Name of Fish.	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	43	46	Total.
Plaice ...	1	1	6	14	9	6	5	1	2	—	—	1	2	1	1	1	2	—	—	2	4	—	3	3	1	1	2	2	—	1	1	73
Dab ...	—	—	—	—	—	1	2	2	2	1	—	—	—	—	—	1	2	—	—	—	—	—	2	—	—	—	—	—	—	—	—	13
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Gurnard ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
																																89

SECOND HAUL.—25th June, 1913. SKATE ROADS. Began 9 a.m., ended 10·10 a.m. Time, 1 hour 10 minutes.

Name of Fish.	9	10	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	44	46	Total.
Plaice ...	—	—	1	5	7	10	4	3	3	—	1	1	2	1	1	2	—	—	2	—	1	5	2	—	—	1	1	3	1	1	—	—	58
Dab ...	1	—	—	—	1	—	—	—	3	3	1	—	1	1	—	—	3	3	1	1	—	—	—	2	—	—	—	—	—	—	—	—	21
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Flounder ...	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	1	4
Gurnard ...	1	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	4
Skate ...	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	—	—	—	1	—	—	3
Catfish ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1*
																																	93

* 76 cm.

TABLE II.—TRAWLING EXPERIMENTS (*continued*).

FIRST HAUL.—11th July, 1913. ALNMOUTH BAY. Began 12 noon, ended 1 p.m. Time, 1 hour.

CENTIMETRES.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Total.
Plaice ...	—	—	—	—	2	6	12	12	7	5	1	2	1	—	—	—	2	3	2	1	1	1	5	3	3	1	3	4	2	2	—	81
Dab ...	—	—	—	1	—	7	15	16	10	12	17	11	9	6	2	3	1	2	1	1	—	—	—	—	—	—	—	—	—	—	—	114
Flounder ...	—	—	—	—	—	—	—	—	—	—	1	1	1	—	2	—	—	1	2	—	—	1	—	—	—	—	—	—	—	—	—	9
Whiting ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
Gurnard ...	—	—	3	—	9	38	82	46	20	5	8	5	3	3	1	1	1	2	3	—	—	1	1	—	—	—	1	—	—	—	—	233
																																438

SECOND HAUL —11th July, 1913. ALNMOUTH BAY. Began 1·25 p.m, ended 2·25 p.m. Time, 1 hour.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	78	Total.
Plaice ...	—	—	—	—	—	2	8	7	9	7	4	3	2	—	1	1	3	1	—	4	1	1	—	—	—	—	1	—	—	—	—	55
Dab ...	—	—	—	—	6	7	24	16	22	17	20	19	14	3	2	—	1	1	—	—	—	—	—	—	—	—	—	1	—	—	—	153
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Whiting ...	—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
Gurnard ...	—	—	—	1	27	129	152	84	34	19	22	15	7	1	4	2	1	—	1	—	—	1	—	—	—	—	—	—	—	—	—	500
Catfish ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Skate ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
																																715

FIRST HAUL.—11th July, 1913. DRURIDGE BAY. Began 3·25 p.m., ended 4·25 p.m. Time, 1 hour.

Name of Fish.	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	48	56	Total.
Plaice ...	—	—	1	—	5	5	13	8	5	1	7	2	1	2	3	2	1	2	2	2	6	5	5	4	6	2	—	3	1	—	—	94
Dab ...	—	—	5	8	7	9	3	10	6	6	3	2	3	1	—	1	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	66
Sole ...	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	1	—	—	—	—	—	—	—	—	—	3
Gurnard ...	—	—	1	9	12	9	5	5	4	4	14	11	8	5	3	3	11	1	3	2	1	4	4	1	—	—	—	—	—	—	—	120
Whiting ...	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	1	1	4
																																289

TABLE II.—TRAWLING EXPERIMENTS (*continued*).

FIRST HAUL.—11th July, 1913. BLYTH BAY. Began 5·55 p.m., ended 7·5 p.m. Time, 1 hour 10 minutes.

CENTIMETRES.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Total.
Plaice ...	—	—	—	3	3	3	7	6	9	4	7	3	3	2	3	1	3	—	3	—	—	1	—	—	—	—	—	—	—	—	—	61
Dab ...	—	—	—	—	1	3	—	3	7	6	5	7	4	10	4	2	3	1	1	—	—	—	—	—	—	—	—	—	—	—	—	57
Sole ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Flounder ...	—	—	—	—	—	—	1	1	2	—	3	1	1	1	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	12
Gurnard ...	—	—	—	—	—	2	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
Trachinus vipera	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
																																137

FIRST HAUL.—1st August, 1913. ALNMOUTH BAY. Began 11·50 a.m., ended 12·55 p.m. Time, 1 hour 5 minutes.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	41	Total
Plaice ...	—	—	—	1	—	2	3	7	7	1	4	2	1	1	2	—	—	2	1	1	4	1	1	—	—	1	1	—	1	1	—	45
Dab ...	—	—	—	—	4	1	5	22	20	29	19	20	18	2	8	2	—	2	—	—	2	—	1	—	—	—	—	—	—	—	—	155
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	2
Brill ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	2
Gurnard ...	—	2	1	1	9	26	43	50	18	4	3	—	8	1	4	1	4	3	2	2	2	1	—	2	—	2	—	—	—	—	—	189
Whiting ...	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
																																396

TABLE II.—TRAWLING EXPERIMENTS (*continued*).

SECOND HAUL.—1st August, 1913. ALNMOUTH BAY. Began 1·15 p.m., ended 2·20 p.m. Time, 1 hour 5 minutes.

CENTIMETRES.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	40	46	Total.
Plaice ...	—	—	—	—	—	2	3	3	3	2	2	1	—	—	—	—	2	—	—	—	—	1	—	2	3	—	1	1	1	1	—	28
Dab ...	—	—	—	—	—	1	3	8	1	6	2	4	1	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	28
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	2
Sole ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Flounder ...	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Gurnard ...	—	—	—	—	5	3	18	34	15	9	6	2	7	4	3	3	3	—	1	—	—	3	—	—	—	—	—	—	—	—	—	116
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1
																																178

FIRST HAUL.—1st August, 1913. DRURIDGE BAY. Began 3·30 p.m., ended 4·30 p.m. Time, 1 hour.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	40	44	Total.
Plaice ...	—	—	—	—	—	—	1	1	2	1	—	1	3	1	1	—	1	—	—	—	—	1	—	—	—	—	—	—	—	1	1	15
Dab ...	—	—	—	—	—	—	—	—	1	3	1	4	1	3	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	15
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	3
Codling ...	—	—	—	—	—	—	—	—	1	—	2	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	4
Gurnard ...	—	—	—	—	—	—	—	—	—	—	1	2	2	1	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	8
																																46

FIRST HAUL.—1st August, 1913. BLYTH BAY. Began 6·15 p.m., ended 7·15 p.m. Time, 1 hour.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	37	38	39	43	44	45	47	Total.
Plaice ...	—	—	—	—	1	—	2	5	5	4	6	3	3	4	4	—	—	—	—	1	3	2	1	2	1	2	1	1	—	—	—	—	—	51
Dab ...	—	—	—	—	1	5	12	23	9	13	3	3	3	1	3	1	3	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	82
Sole ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	2	1	2	1	1	8
Gurnard ...	1	3	1	3	12	17	59	41	26	5	8	9	4	6	6	5	1	1	1	1	—	1	—	—	—	—	—	—	—	—	—	—	—	211
Whiting ...	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Dragonet ...	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Crab ...	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
																																		356

TABLE II.—TRAWLING EXPERIMENTS (*continued*).

FIRST HAUL.—13th August, 1913. ALNMOUTH BAY. Began 11·40 a.m., ended 12·40 p.m. Time, 1 hour.

CENTIMETRES.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	40	41	Total.
Plaice ...	—	—	2	—	1	—	3	3	1	6	5	1	4	2	1	2	—	2	4	—	—	1	1	1	—	—	—	—	—	—	1	41
Dab ...	—	—	—	—	—	5	10	30	29	21	23	17	7	4	2	1	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	151
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
Flounder ...	—	—	—	—	—	—	—	1	1	1	—	—	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1	—	6
Gurnard ...	1	—	1	2	8	42	140	266	202	70	39	28	34	19	21	5	4	4	—	1	—	1	—	1	—	—	—	—	1	—	—	890
Whiting ...	—	—	—	—	—	1	1	3	3	1	—	—	—	1	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	12
																																1101

SECOND HAUL. 13th August, 1913. ALNMOUTH BAY. Began 1 p.m., ended 2·15 p.m. Time, 1 hour 15 minutes.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	41	47	Total.
Plaice ...	—	—	—	2	3	3	8	8	10	12	7	6	3	2	4	—	5	3	1	2	1	1	2	4	2	5	1	3	1	1	—	100
Dab ...	—	—	—	—	—	7	20	15	14	18	16	14	3	3	2	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	114
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1
Sole ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
																																1
Flounder ...	—	—	—	—	—	—	—	4	2	6	8	—	2	3	1	—	1	1	—	1	2	—	4	1	2	—	—	—	—	—	—	38
Gurnard ...	—	4	2	3	2	31	198	378	449	185	95	83	98	61	38	23	11	8	5	1	2	4	3	1	1	1	1	1	—	—	—	1689
Whiting ...	—	—	—	—	—	—	1	—	3	1	1	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8
																																1951

FIRST HAUL.—13th August, 1913. DRURIDGE BAY. Began 3·40 p.m., ended 4·40 p.m. Time, 1 hour.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Total.
Plaice ...	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	2
Dab ...	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Gurnard ...	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
																																6

TABLE II.—TRAWLING EXPERIMENTS (*continued*).

FIRST HAUL.—13th August, 1913. BLYTH BAY. Began 6 p.m., ended 7·15 p.m. Time, 1 hour 15 minutes.

CENTIMETRES.

Name of Fish.	9	10	11	12	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	46	47	48	Total.
Plaice ...	—	—	—	—	1	2	—	4	4	5	10	2	4	7	2	5	—	1	2	—	1	2	2	2	3	4	2	1	1	2	1	—	—	—	—	—	70
Dab ...	—	—	—	—	—	1	4	14	16	12	9	3	1	1	2	—	—	1	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	66
Sole ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	2
Gurnard ...	1	1	1	3	1	5	36	55	58	30	25	17	14	5	6	5	4	3	2	3	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	277
Whiting ...	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	2	—	1	—	—	—	—	1	1	—	1	—	7
Herring ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Crab ...	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
																																					426

FIRST HAUL.—9th September, 1913 SKATE ROADS. Began 2·45 p.m., ended 3·45 p m. Time, 1 hour.

Name of Fish.	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	Total.
Plaice ...	—	—	—	—	4	8	8	1	1	4	7	14	5	4	2	1	2	1	2	2	—	—	—	—	—	—	—	—	—	—	—	66
Dab ...	3	3	2	—	1	—	2	—	—	2	2	3	3	3	3	—	1	—	2	2	—	3	—	—	2	—	1	1	—	—	—	39
Brill ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	2
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Gurnard ...	—	1	1	—	1	—	2	2	8	6	8	4	2	2	5	3	4	1	2	—	—	—	—	—	—	—	—	—	—	—	—	52
																																160

38 small edible crabs. 1 living, 3 dead Cyprina islandica.

SECOND HAUL.—9th September, 1913. SKATE ROADS. Began 4·5 p.m., ended 5·5 p.m. Time, 1 hour.

Name of Fish	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	43	Total.
Plaice ...	—	—	—	1	5	2	1	2	5	9	18	6	7	2	3	1	3	1	3	—	—	—	—	1	—	—	—	—	—	—	—	70
Dab ...	—	—	1	4	5	2	2	2	3	2	1	3	3	—	1	2	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	34
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Gurnard ...	—	—	—	1	1	—	—	—	—	—	1	1	1	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	7
																																113

21 small crabs (edible). 2 living Cyprina islandica.

TABLE II.—TRAWLING EXPERIMENTS (*continued*).

FIRST HAUL.—10th September, 1913. ALNMOUTH BAY. Began 8·40 a.m., ended 9·55 a.m. Time, 1 hour 15 minutes.

CENTIMETRES.

Name of Fish.	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	38	42	43	45	48	Total.
Plaice ...	—	4	2	4	1	2	4	5	6	11	5	2	1	1	—	2	1	—	1	1	—	—	1	1	—	1	—	1	1	—	—	58
Dab ...	—	—	—	1	—	2	—	5	2	2	7	4	6	1	—	2	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	34
Turbot ...	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Sole ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	1	—	—	—	—	—	1	—	—	—	—	—	—	1	—	6
Gurnard ...	—	—	—	—	—	2	2	2	2	1	2	2	1	1	3	2	1	2	1	2	1	1	2	1	—	—	—	—	—	—	—	31
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
																																132

SECOND HAUL.—10th September, 1913. ALNMOUTH BAY. Began 10·15 a.m., ended 11·15 a.m. Time, 1 hour.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	42	Total.
Plaice ...	—	—	—	2	2	1	1	2	3	4	7	6	1	1	—	—	3	—	—	—	—	1	1	—	1	1	1	—	—	—	—	38
Dab ...	—	—	—	1	—	—	—	2	2	9	2	2	3	2	3	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	29
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2
Gurnard ...	—	—	—	—	—	—	4	9	13	20	5	11	22	14	9	5	5	6	—	2	1	—	—	—	—	—	—	—	—	—	—	126
																																195

FIRST HAUL. 10th September, 1913. DRURIDGE BAY. Began 12·15 p.m., ended 1·15 p.m. Time, 1 hour.

Name of Fish.	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	42	Total.
Plaice ...	—	—	—	—	1	1	2	3	1	4	4	2	3	—	—	—	1	—	—	1	—	1	2	2	1	3	2	3	2	2	—	41
Dab ...	—	—	—	—	—	—	1	1	3	2	3	2	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16
Turbot ...	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	4
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	2
Gurnard ...	—	—	—	—	—	—	—	3	7	3	5	12	10	9	5	8	11	1	—	6	1	4	1	1	—	—	—	—	—	—	—	87
Whiting ...	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	—	1	3
																																155

TABLE II.—TRAWLING EXPERIMENTS (*continued*).

FIRST HAUL.—10th September, 1913. BLYTH BAY. Began 2·45 p.m., ended 3·45 p.m. Time, 1 hour.

CENTIMETRES.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	44	47	Total.
Plaice ...	—	—	—	—	—	—	1	4	3	8	3	4	5	2	—	1	1	1	1	1	2	3	—	—	—	—	2	1	2	—	—	45
Dab ...	—	—	—	—	—	1	3	6	5	6	3	3	3	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	32
Turbot ...	—	—	—	—	—	1	2	2	3	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10
Soles ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2	2	5
Gurnard ...	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	—	—	2
																																96

FIRST HAUL.—1st November, 1913. ALNMOUTH BAY (Northern Half). Began 11·25 a.m., ended 12·25 p.m. Time, 1 hour.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Total.
Plaice ...	—	—	—	—	—	1	1	—	1	4	8	4	1	2	1	—	2	—	—	—	—	1	—	—	1	—	1	—	—	—	1	29
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Dab ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—	3
Gurnard ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	4
Skate ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	2
																																39

SECOND HAUL.—1st November, 1913. ALNMOUTH BAY (Southern Half). Began 12·40 p.m., ended 1·40 p.m. Time, 1 hour.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Total
Plaice ...	—	—	—	—	—	—	—	—	1	—	2	1	3	—	—	2	—	1	1	—	1	—	—	—	—	—	—	—	—	—	—	12
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
Brill ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
Dab ...	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	5
Gurnard ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	4
Skate ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	2
																																25

TABLE II.—TRAWLING EXPERIMENTS (*continued*).

FIRST HAUL.—1st November, 1913. DRURIDGE BAY (Northern Half). Began 2·40 p.m., ended 3·40 p.m. Time, 1 hour.

CENTIMETRES.

Name of Fish.	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Total.
Plaice ...	—	—	1	—	—	1	—	—	—	1	3	3	—	1	1	—	1	2	1	—	1	2	2	1	2	2	4	2	—	—	2	33
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
Brill ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
Dab ...	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	2	—	—	—	2	—	—	—	—	—	—	—	—	—	—	6
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	2
Skate ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1
																																44

SECOND HAUL.—1st November, 1913. DRURIDGE BAY (Southern Half). Began 3·55 p.m., ended 4·20 p.m. Time 25 minutes.

Name of Fish.	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	43	Total.
Plaice ...	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	1	—	2	—	—	4	2	2	—	—	—	13
Turbot ...	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Sole ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Gurnard ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	1	—	—	—	—	—	—	—	—	—	—	—	3
																																18

TABLE III.

CATCH PER ONE HOUR'S TRAWLING.

Place.	Date.	Turbot.	Brill.	Sole.	Plaice.	Dab.	Flounder.	Total Flat Fish.	Cod.	Haddock.	Whiting.	Gurnard.	Angler.	Catfish.	Thornback.	Total.
	1913															
Skate Roads	June 25	—	—	—	62	11	1	74	—	—	—	1	1	—	—	76
	,,	1	—	—	50	18	3	72	—	—	—	3	3	1	1	80
	Sept. 9	—	2	—	66	39	1	108	—	—	—	52	—	—	—	160
	,,	1	—	—	70	34	1	106	—	—	—	7	—	—	—	113
	Mean ...	1	1	—	62	25	1	90	—	—	—	16	1	—	—	107
Alnmouth Bay	May 29 ...	—	—	—	8	35	—	43	—	—	1	90	—	—	—	134
	June 11	—	—	—	28	71	3	102	—	3	—	105	3	—	—	213
	July 11	—	—	—	81	114	9	204	—	—	1	233	—	—	—	438
	,,	—	—	—	55	153	1	209	—	—	4	500	—	1	1	715
	Aug. 1 ...	2	1	—	42	143	2	190	—	—	1	174	1	—	—	366
	,,	2	—	1	26	26	2	57	—	—	—	107	1	—	—	165
	Aug. 13	1	—	—	41	151	6	199	—	—	12	890	—	—	—	1101
	,,	1	—	1	80	92	30	204	—	—	6	1351	—	—	—	1561
	Sept. 10	1	—	1	46	27	5	80	—	—	—	25	1	—	—	106
	,,	2	—	—	38	29	—	69	—	—	—	126	—	—	—	195
	Mean ...	1	—	1	44	84	6	136	—	—	2	360	1	—	—	499
	Nov. 1 ...	1	—	—	29	3	—	33	—	—	—	4	—	—	2	39
	,,	1	1	—	12	5	—	19	—	—	—	4	—	—	2	25
Druridge Bay	May 29 ...	1	—	—	14	14	—	29	—	—	—	31	5	—	—	65
	,, *	1	—	—	29	29	1	61	—	—	—	57	3	—	1	122
	June 11	—	—	—	20	34	—	54	—	1	—	41	3	—	—	99
	July 11	—	—	1	94	66	3	164	—	—	1	120	4	—	—	289
	Aug. 1 ...	1	—	—	15	15	3	34	4	—	—	8	—	—	—	46
	Aug. 13	—	—	—	2	2	—	4	—	—	—	2	—	—	—	6
	Sept. 10	4	—	—	41	16	2	63	—	—	2	87	3	—	—	155
	Mean ...	1	—	—	31	25	1	58	1	—	—	49	3	—	—	111
	Nov. 1	1	1	—	33	6	2	43	—	—	—	—	—	—	1	44
	,,	1	—	1	26	—	—	28	—	—	—	6	—	—	—	34
Blyth Bay	May 29 ...	1	1	—	13	20	2	37	—	—	—	5	3	—	—	45
	June 11	1	—	—	46	12	4	63	—	—	—	2	3	—	—	68
	July 11	—	—	1	52	49	10	112	—	—	—	3	1	—	—	116
	Aug. 1	—	—	8	51	82	—	141	—	—	1	211	—	—	—	353
	Aug. 13	—	—	2	56	53	—	111	—	—	1	221	5	—	—	338
	Sept. 10	10	—	5	45	32	—	92	—	—	—	2	2	—	—	96
	Mean ...	2	—	3	44	41	3	93	—	—	—	74	2	—	—	169

* 1 Lemon Dab.

TABLE IV.—MATURITY, FOOD, ETC.

Place.	Date.	Name of Fish.	Lgth.	Sex.	Mature or Immature.	Food.
Druridge Bay	29 v., 1913	Dab ...	28	F.	Imm.	Siphons of Solen (2), Trophonia.
		,, ...	21	F	Imm.	Empty.
		,, ...	22·5	F.	Mat.	Fragments of Molluscs.
		,, ...	23	F.	Imm.	Siphons of Solen (2), Hermit crab.
		,, ...	27·5	F.	Mat.	Siphon of Solen.
		,, ...	21	F.	Imm.	Molluscs, indistinguishable.
		,, ...	26·5	F.	Imm.	*Gobius minutus*, Siphon of Solen.
		,, ...	34	F.	Imm.	Siphons of Solen (2).
		Plaice	33	F.	Imm.	Fragments of shells of Venus.
		,,	36	M.	Imm.	*Tellina tenuis* (6).
		,,	33	F.	Imm.	*Tellina tenuis* (several).
Skate	25 vi., 1913	,,	37	M.	Imm.	Nepthys, *Donax vittatus*, *Tellina tenuis.*
		,,	43	F.	Imm.	*Donax vittatus*
		,,	38	F.	Imm.	*Donax vittatus*
		,,	46	F.	Imm.	*Donax vittatus* (many).
		,,	37	M.	Imm.	Sand eels, Nephthys, *Donax vittatus*, *Tellina tenuis.*
		,,	40	M.	Imm.	*Tellina tenuis.*
		,,	38	F.	Imm.	*Tellina tenuis.*
		,,	36	F.	Imm.	*Tellina tenuis.*
		Dab ...	34	F.	Imm.	*Portunus holsatus.*
		Flounder	37	F.	Imm.	Sand eel, *Portunus holsatus.*
		,,	44	F.	Imm.	*Tellina tenuis.*
		,,	46	F.	Imm.	Sand eels (4) Portunus (2).
		Catfish	76	F.	Imm.	Portunus (12), *Corystes cassivelaunus* (1).

MIGRATIONS OF FLAT FISH.

BY ALEXANDER MEEK.

The opportunity was taken at the trawling experiments to mark and liberate a number of flat fish, principally dabs. I am not enamoured of the plan of catching such for experimental purposes in one place and liberating them in another, but the work was so arranged that this was inevitable.

The results may be grouped as (*a*) dabs caught during their annual sojourn in inshore waters, 11 examples ; (*b*) dabs caught during their emigration from the inshore waters, 4 examples ; (*c*) dabs caught during their immigration, one example ; and (*d*) dabs which have migrated to the north—in all cases in the direction of the locality of capture, 5 examples. The last are interesting since they exhibit a northern migration which theoretically should take place, but, unfortunately, there is the complication that they were not liberated where caught. In the case of number 1302, the migration was some 15 miles beyond the place of capture, and 21 miles from the place of liberation ; and the fish was caught at a time when the majority of the dabs had not yet returned from their winter migration. Another example which apparently had remained in inshore waters after migrating 19 miles north is No. 1370. No. 1451 migrated from the place of liberation to the place where it was originally captured.

The recaptured plaice had evidently not been long in inshore waters after the winter migration, see page 27.

Since the above was printed I have received from the Board particulars of recaptures relating to the dab (see page 28). The results already tabulated bear evidence of a northern migration of dabs which the considerations in the paper on the subject in this report showed ought to take place. One of those now given, No. 1380 migrated northwards to St. Andrews, and according to the information had spawned. It is possible therefore that a northern race of dabs also occurs in the North Sea, or that dabs when they become mature migrate northwards.

MIGRATIONS—DAB.

Where Caught.	Where Liberated	Date.	Nos.	No.	Size.	Where Captured.	Date.	Size.	Increase.	Sex.	Migration.
		1913.			Cm.			Cm.			
Druridge Bay	Druridge Bay ...	May 29 ...	360-370 11	369	25×14	Druridge Bay, 1 mile from shore	June 6th, 1913	25×14	0 in 8 days ...	F., imm.	Nil.
Skate Roads ...	Skate Roads ...	June 25	384-387 4	385	34×20	½ mile E. from Waren Bar	Oct. 18th, 1913	34×19·5	0 in 115 days ...	F., imm.	Nil.
Skate Roads ...	E. of Holy Island	June 25	388-396 9	—	—	—	—	—	—	—	—
Alnmouth Bay	Druridge Bay ...	July 11 ...	1301-1359 59	1302	22×12	1 mile E. of Bamborough Castle	Feb. 3rd, 1914	23·5 ×12·5	1·5×0·5 in 207 days	F., imm.	21 miles N.
				1305	25×15	Druridge Bay ...	Aug. 9th, 1913	—	—	F. ...	Nil.*
				1309	26×15	Druridge Bay ... Chevington Drift	July 30th, 1913	—	—	F. ...	Nil.*
				1329	25×14	Druridge Bay ...	Aug. 26th, 1913	25×14	0 in 46 days ...	F. ...	Nil.
				1335	22×11	Newbiggin Bay	Oct. 6th, 1913	—	—	F. ...	6 miles S.†
				1354	21×11	N. end of Druridge Bay	Aug. 2nd, 1913	—	—	F. ...	Nil.*
Alnmouth Bay	Between Hauxley and Bondicar	Aug. 1 ...	1360—1371 and	1367	20×10	Druridge Bay ...	March 30th, 1914	—	—	F. ...	5 miles S.*
			1373—1393 29	1370	24×13	2½ miles N.E. of North Sunderland Harbour	Jan. 19th, 1914	24·7×13·4	0·7×0·4 in 171 days	F., imm.	19 miles N.
Druridge Bay	Cresswell	Aug. 1 ...	1394—1400 6	—	—	—	—	—	—	—	—
Alnmouth Bay	N. of Newbiggin ...	Aug. 13	1401	—	—	—	—	—	—	—	—
Do.	E. of Newbiggin ...	,, ...	1402—1408 6	1408	22×12	1½ miles E.S.E. of Wansbeck	Sept. 12th, 1913	22·4×?	·4×? in 30 days ...	F. ...	1½ miles S.
Do. ...	Cambois Bay ...	,,	1409—1432 14	1410	23×15	4 miles E.S.E. of Coquet	Nov. 14th, 1913	23·5×?	0·5×? in 93 days...	F. ...	10½ miles N.
				1419	22×12	½ mile N. of Coquet	Jan. 1st, 1914	22·5×?	0·5×? in 141 days	F. ...	12 miles N.

* Label only. † Label attached to line.

MIGRATIONS—DAB—*continued.*

Where Caught.	Where Liberated.	Date.	Nos.	No.	Size.	Where Captured.	Date.	Size.	Increase.	Sex.	Migration.
Skate Roads ...	Skate Roads ...	1913. Sept. 9 ...	1433—1449 17	1433	Cm. 30×16	1 mile N.E. of Budle	Oct. 3rd, 1913	Cm. 30×16·5	0×0·5 in 24 days...	F. ...	Nil.
				1435	33×?	2 miles S.E. of Holy Island	Dec. 13th, 1913	33·4×?	0·4×? in 95 days...	F. ...	Nil.
				1437	30×16	1 mile N. of Waren Bar, ½ mile from shore	Oct. 18th, 1913	30×16	0 in 39 days ...	F. ...	Nil.
				1438	30×16	2 miles E.N.E. from North Sunderland	Dec. 12th, 1913	31×16	1×0 in 94 days ...	F. ...	5½ miles S.
				1444	27×14	2 miles N.E. from North Sunderland	Dec. 9th, 1913	28×14	1×0 in 91 days ...	F. ...	4½ miles S.
Skate Roads ...	E. of Newton ...	Sept. 9 ...	1450—1456 7	1450	30×17	E. of Newton Point	Sept. 20th, 1913	30×17	0 in 11 days ...	F. ...	Nil.
				1451	31×17	1 mile N.E. of Budle	Oct. 3rd, 1913	30·8×17	0·8×0 in 24 days...	M. ...	7½ miles N.
Alnmouth Bay	Alnmouth Bay ...	Sept. 10	1458—1487 30	1475	21×11	Alnmouth Bay...	April 22nd, 1914	21·5×?	0·5×? in 224 days	F. ...	Nil.
Do.	Druridge Bay ...	,, ...	1489—1504 15	—	—	—	—	—	—	—	—

MIGRATIONS—PLAICE.

Skate Roads ...	Skate Roads ...	June 25 1913	371—382 12	377	32×19	1 mile E. of Budle Burn	March 4th, 1914	38×22·3	6×3·3 in 252 days	F., imm.	Nil.

DAB.

Where Caught.	Where Liberated.	Date.	No.	Size.	Where Captured.	Date.	Size.	Increase.	Sex.	Migration.
Alnmouth Bay	Druridge Bay ...	1913. Aug. 1 ...	1380	Cm. 27×15	2 miles E.S.E. from St. Andrews	May 27, 1914	Cm. 29·2	2·2 cm. in 299 days	F. spent	80 miles N.
* Do. ...	Off Cambois Bay...	„ 13 ...	1418	18×10	20 miles N.E. by N. of Tyne, 34 fths—trawl	Oct. 3, 1913	—	—	M.	13 miles N.E. by E.
Skate Roads ...	Skate Roads ...	Sept. 9 ...	1443	22×12	2½ miles S.E. of Holy Island, 4 fths.—line,	April 2, 1914	24·8	2·8 cm. in 205 days	F.	2 miles E.
Alnmouth Bay	Druridge Bay ...	„ 10 ...	1504	19×10	1½ miles S.E. of Bridlington, 6 fths.—line	July 2, 1914	20·8	1·8 cm. in 295 days	F.	90 miles S.

* Label only.

THE MIGRATIONS OF PLAICE AND DAB IN THE NORTH SEA, AND THEIR ORIGIN.

By ALEXANDER MEEK.

CONTENTS.

1.—Introduction.

In a paper " On a Law of Distribution of Inshore Fish," * it was pointed out that plaice and dabs particularly were distributed along the east coast of England and Scotland in regions of successive maxima and minima, and the suggestion was made that such a distribution could be explained by the migrations of the species to and from a wintering ground correlated with each region. In a given region the species predominates in that part of the region nearest to the wintering ground or the place where the bulk of the species retire for the winter, and the numbers sink gradually to a minimum at the distal portion of the region. It would appear therefore that the various species which utilise the inshore waters as a portion of their feeding ground are divided into a series of groups or schools, each of which winters offshore and returns to the same region inshore for the summer.

The problem has already been presented with reference to the broad results of trawling and marking experiments. It is now proposed to consider it in rather more detail with a view to indicating still more definitely the nature of the schools and their origin, and the origin of migrations in the North Sea in general.

* Meek, Intern. Rev. d. Ges. Hydrob. u Hydrogr. Bd. vi., 1914.

2.—Periodic Migration of the Schools.

Reduced to the standard of mean catch per hour's trawling, the plaice and dabs captured at the Northumberland trawling experiments are indicated in Table I.

TABLE I

PLAICE.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Goswick	—	—	—	—	—	80	—	—	—	—	—	—
Skate Roads ...	—	—	—	—	—	60	—	92	120	—	—	—
Alnmouth ...	5	—	0	20	36	54	43	64	57	78	24	—
Druridge	9	16	8	24	34	48	39	50	40	28	20	—
Cambois	—	—	—	—	—	44	34	45	22	—	—	—
Blyth	21	28	—	34	43	24	42	67	76	64	42	—

DAB.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Goswick	—	—	—	—	—	2	—	—	—	—	—	—
Skate Roads ...	—	—	—	—	—	5	—	8	11	—	—	—
Alnmouth ...	0	—	1	0	7	33	35	68	35	61	1	—
Druridge	0	1	1	2	14	25	46	75	50	38	1	—
Cambois	—	—	—	—	—	37	63	79	81	—	—	—
Blyth	3	0	—	0	6	16	29	54	67	27	3	—

It need not be stated that they are incomplete. Moreover, the winter figures refer in most cases to one, in a few cases to two experiments; those for the summer months are the averages for the experiments made since 1899. They are sufficient to indicate, however, that every year in spring and summer the inshore waters of Northumberland receive an immigration of plaice and dabs, and that the majority retire from the region towards the end of the year. It is also evident that the dabs depart more completely from the shore than the plaice.

Fortunately far more information has been gathered with reference to the school immediately to the north of the Northumberland one—the Firth of Forth school. From the table on page 17 of the report by Prof. D'Arcy W. Thompson * on the experiments made

* Fifth Report on Fishery and Hydrog. Investigations. Fish. Bd. for Scot., 1913.

by the "Goldseeker" in the Firth of Forth, 1905-1910, the numbers of plaice caught per hour's trawling will be found to be as follows :—

Jan.-Mar.		April-June.		July-Sept.		Oct.-Dec.
15·1	...	48·4	...	66·8	...	38·4

These numbers are represented graphically in fig. 1, along with a somewhat modified adaptation of the diagrams given by Fulton in the same report, showing the catches of plaice made by trawlers in the region immediately off the Forth. The diagram is based principally on that given for small plaice, and a comparison of this diagram with those for medium and large plaice will indicate that the summer diminution offshore is not due to absence of fishing, and at the same time make it clear that the migrations at present under consideration affect mainly the small plaice.

From the same table in the above report we learn that the average distribution of plaice each quarter during the same period was:—

			Jan.-Mar.		April-June.		July-Sept.		Oct.-Dec.
Station	6	...	63·7	...	113·4	...	230·1	...	142·9
,,	2	...	21·8	...	113·6	...	91·2	...	44·2
,,	4	...	16·2	...	39·6	...	11·5	...	13·0
,,	7	...	7·9	...	35·3	...	25·1	...	29·9

These figures are reproduced in diagrammatic form in fig. 2, From these we have good reason for concluding that the immigration and the emigration take place *via* the northern station, Station 6.

Similar conclusions with regard to the distribution of plaice on the Northumberland coast will be derived from a consideration of the lower part of fig. 3. This has been constructed from the information in Table I. It will be observed that in this and the succeeding figures the stations are indicated by a series of steps ; in the case of plaice they are viewed from north to south, and in the case of dabs from south to north. The wave of plaice which arrives early at the northern station is continued southwards, reaching a maximum in the southern bays about August as a rule. The return migration doubtless contributes to the later maximum at Skate Roads in the northern part of Northumberland. Blyth Bay has been left out of this diagram for the reason stated in the previous paper that it is influenced by the northern limit of a school to the south of that now under consideration. Blyth Bay has an early spring maximum, in April-May, and more than likely this is also the case at Skate Roads, though we have no record of it, and with this in mind an indication of it has been suggested in the diagram.

It is scarcely necessary to draw attention to the fact that such experiments are apt to be marred by many factors of variation. The state of the tide (*v.* Northumberland Report for year ending May, 1901) influences the inshore flat fish ; the season may be relatively rich or poor, late or early. It has been thought desirable therefore to choose from the "Garland" experiments a single season's results in St. Andrews Bay practically chosen at random, except that the year chosen (1889) seemed to present a fairly representative series of hauls spread over the various seasons of the year. The results of that year's experiments are indicated in the upper part of fig. 3 (viewed as in the figure below from north to south). From this diagram it is again plain that the main body of plaice enter St. Andrews Bay from the north, and the return migration brings them into the northern part of the bay again.

What has been said with reference to plaice applies equally to dabs, but as will be seen from Table I. and fig. 4 the migrants enter the Northumberland and the other districts from the south and relatively few reach the northern part of the several regions. In the light of what has already been stated for plaice the diagrams shown in fig. 4 require little explanation. The upper two diagrams refer to a single year's experiments of the "Garland" in the Firth of Forth and in St. Andrews Bay, the third diagram is based on the average figures of Table I. In the case of St. Andrews, it will be seen that in 1889 the dabs were particularly prominent in the two southern bays. That they pass outside that area is shown by the fact that their disappearance from the inshore waters is associated with their appearance in large numbers at Station 5, outside the territorial waters in October and November. It may be noted here also that the dabs of Station 5 at this season are mostly small in size.

The trawling experiments therefore indicate with reference to the two schools which have been considered (1) that plaice enter these regions from the N.E. and return in the same direction, that dabs enter the regions from the S.E. and return also in a S.E. direction ; (2) that the migrations are periodic ; (3) that the migration is a partial one. In both regions a larger number of plaice and a smaller number of dabs pass the winter in the inshore areas. Fig. 1 illustrates the relative conditions of the inshore and offshore areas as the result of this periodic migration, and may serve to picture the conditions generally around the coast, that is, with reference to other schools as well as those considered. Another point has emerged from the diagrams with regard to the dabs of the Forth region, viz., that they evidently enter the region in either two schools or by the splitting of one school so as to reach the south side of the Forth and St. Andrews Bay. It will be found later that the latter explanation is the more probable one. It might be said also that apparently the migrants arrive earlier and depart later in the Forth school than in that of Northumberland. And it ought also to be stated that while there is a remarkable similarity year after year as to the period of the migration it varies with regard to time and intensity.

3—The Sizes of the Migrants.

Passing now to consider the migrations with reference to size, the following table prepared from McIntosh's * summary tables of the "Garland" experiments may first be presented. It gives the average results per haul for the years 1886-95.

TABLE II.

St. Andrews Bay.

Plaice.

Size.—In.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
19 + ...	—	—	—	—	—	—	6	—	—	—	—	—
12—18	5	9	26	32	28	55	26	37	34	27	14	3
7—11	—	1·5	32	20	42	52	43	152	85	53	36	0·5
Small	—	—	1	0·5	4	26	26	65	11	24	5	—
	5	10	59	52	74	133	101	254	130	104	55	3

Dab.

Size.—In.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
12 + ...	—	0·2	0·3	0·3	0·3	2	0·2	1	1	1	0·2	0 4
7—11	1	2	4	12	35	49	31	101	97	44	50	4
Small	0·5	3	2	11	27	79	13	90	34	35	40	4
	1	5	6	23	62	130	44	192	132	80	90	8

* Resources of the Sea.

A few large plaice annually visit the bay, usually towards the end of the summer, and this is also the case on the coast of Northumberland. The winter plaice apparently are practically altogether the larger inshore sizes, but such also join conspicuously in the movement which more particularly affects the smaller sizes. The latter enter the bay in March, and evidently practically leave the area entirely in November.

Few dabs of over 12 inches as would be expected are evidenced, and below that size the migration affects the 7-11 ins. dabs, and the dabs below 7 inches in nearly equal degree.

Returning to Northumberland, Tables III. and IV. and the diagrams in fig. 5 may be considered. The tables are made up as in Table I., but in this case the catches are arranged according to size, and although the figures usually represent catches per hour's trawling this has not been strictly adhered to. The diagrams show graphically the sizes during the months June (thin dotted line), July (thick dotted line), August (thin line), and September (thick line).

Plaice.—The tables and the chart bring out again the fact that while all sizes participate in the migrations the predominant numbers are the small and the immature. There is a more or less gradual decline in numbers according to size, an expression of the natural relationship of the numbers according to size, and which would be still more perfect if our trawl net could catch more of the smaller sizes. In Northumberland, so far as our few experiments go, it cannot be said that there is any special size left predominantly during the winter. If there is any evidence of preference it is of plaice of from 8 to 12 inches.

At the proximal end of the region, Skate Roads, the spring arrivals consist almost entirely of small plaice. The autumn maximum is brought about by the late arrival of large numbers of plaice of 25-35 cms. at a period also when plainly the small plaice are beginning to leave. There is a slight degree of evidence for a still later appearance in the region of plaice of over 35 cms. to 45 cms. And the evidence is clearer that at the period of their arrival the fish below them in size have begun to leave the bay. The diagrams for the southern bays of Northumberland illustrate the point already demonstrated that they do not participate so largely in the inshore movement. It is interesting to note that while the small fish are arriving in July in the northern area, in the southern during the same month they have suffered regression, recovering again in the succeeding months. In this respect Cambois is exceptional, and it is probable therefore that it like Blyth comes under the influence of the next school, that in other words, over-lapping occurs. The wave of plaice appears like that of the dab to consist of an inshore larger body of small and an offshore smaller body of large.

DAB.—The small number of winter dabs in the inshore waters consists for the most part of those about 25 to 35 cms. The table and the chart indicate very distinctly that the wave of dabs which enter the region is made up of an advance and inshore assemblage of small dabs followed by larger sizes which also enter the region further north. It will be noted also that the small and the larger dabs arrive in numbers which come to maxima in successive months at the different stations from south to north. It is also plain that while all sizes take part in the summer migration the large majority are small and immature.

A similar analysis has been prepared of the "Garland" results in St. Andrews Bay and the Firth of Forth, but there is no need to present further evidence to illustrate the main facts of this summer inshore migration. The winter plaice in St. Andrews Bay appear to be as the summary table on page 33 indicated mainly 30 to 40 cms. In the Firth of Forth a larger body of plaice winter than in the more exposed regions of St. Andrews and Northumberland.

It may be concluded from this approach from the statistical point of view that :—

PLAICE.—(1) There is a periodic migration of schools between correlated offshore winter grounds and inshore summer grounds The migration is subject to seasonal variation as to time and intensity.

(2) The majority of the plaice taking part in the movement are young and immature. This is illustrated also by the presentation of sizes by Prof. D'Arcy W. Thompson * with regard to the Forth school.

(3) In the inshore waters of the regions which have been particularly examined there is a predominance of plaice as stated in the "law" at the northern part of the region and of the subdivisions thereof. The presumption therefore is that the migration

* *Loc. cit.*

TABLE III.

PLAICE.

SKATE ROADS.

In.	Cm.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
6	15	—	—	—	—	—	44	28	26	10	—	—	—
8	20	—	—	—	—	—	36	56	40	24	—	—	—
10	25	—	—	—	—	—	16	15	58	38	—	—	—
12	30	—	—	—	—	—	11	10	46	34	—	—	—
14	35	—	—	—	—	—	4	3	22	18	—	—	—
16	40	—	—	—	—	—	1	1	1	4	—	—	—
18	45	—	—	—	—	—	—	—	1	1	—	—	—

ALNMOUTH.

6	15	—	—	—	21	1	11	8	25	41	48	1	—
8	20	1	—	—	5	9	23	12	18	20	28	8	—
10	25	3	—	—	3	13	5	8	24	19	16	14	—
12	30	2	—	—	2	7	10	7	17	18	7	7	—
14	35	2	—	—	6	1	5	2	11	6	2	1	—
16	40	—	—	—	2	—	1	2	3	3	1	1	—
18	45	—	—	—	—	—	—	1	1	—	—	—	—

DRURIDGE BAY.

6	15	3	1	—	10	3	12	3	7	7	8	2	—
8	20	2	—	—	8	12	15	5	10	8	7	4	—
10	25	4	12	1	20	9	3	6	15	12	1	7	—
12	30	3	2	8	5	9	6	10	17	10	5	4	—
14	35	2	7	4	5	3	5	8	13	2	14	6	—
16	40	—	2	—	—	3	4	2	4	1	4	6	—
18	45	—	—	—	1	1	1	1	1	1	1	1	—

CAMBOIS BAY.

6	15	—	—	—	—	—	2	12	16	2	—	—	—
8	20	—	—	—	—	—	7	28	16	9	—	—	—
10	25	—	—	—	—	—	4	12	13	5	—	—	—
12	30	—	—	—	—	—	8	6	9	2	—	—	—
14	35	—	—	—	—	—	10	2	4	1	—	—	—
16	40	—	—	—	—	—	1	1	1	1	—	—	—

BLYTH BAY.

6	15	2	8	3	8	3	7	6	2	10	10	—	—
8	20	3	5	9	10	12	13	14	16	8	20	5	—
10	25	7	7	6	11	5	9	12	15	15	19	5	—
12	30	4	1	10	7	5	14	10	5	12	5	2	—
14	35	5	2	6	6	1	6	2	5	6	7	2	—
16	40	—	—	1	—	—	3	1	2	1	3	—	—

TABLE IV.

DABS.

SKATE ROADS.

Cms.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dce.
15	—	—	—	—	—	2	1	1	3	—	—	—
20	—	—	—	—	—	3	7	4	2	—	—	—
25	—	—	—	—	—	1	3	3	4	—	—	—
30	—	—	—	—	—	1	2	2	2	—	—	—
35	—	—	—	—	—	1	1	1	2	—	—	—
40	—	—	—	—	—	1	—	1	1	—	—	—
45	—	—	—	—	—	—	—	—	—	—	—	—

ALNMOUTH.

Cms.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dce.
15	—	—	—	—	—	2	10	7	2	2	1	—
20	—	—	—	—	9	33	30	42	1	31	1	—
25	—	—	—	—	10	19	13	19	26	22	1	—
30	—	—	1	—	3	4	2	4	2	6	1	—
35	—	—	—	—	1	—	1	—	1	1	1	—
40	—	—	—	—	—	—	—	—	—	—	—	—
45	—	—	—	—	—	—	—	—	—	—	—	—

DRURIDGE BAY.

Cms.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dce.
15	—	—	—	—	1	4	3	3	1	1	—	—
20	—	—	—	1	5	13	31	48	28	8	1	—
25	—	1	—	1	6	8	12	41	28	21	1	—
30	—	1	1	1	2	—	2	6	5	6	2	—
35	—	—	—	—	1	1	1	1	1	—	—	—
40	—	—	—	—	—	—	—	—	—	1	—	—
45	—	—	—	—	—	—	—	—	—	—	—	—

CAMBOIS.

Cms.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dce.
15	—	—	—	—	—	3	17	9	5	—	—	—
20	—	—	—	—	—	27	60	58	10	—	—	—
25	—	—	—	—	—	12	13	12	7	—	—	—
30	—	—	—	—	—	3	4	1	1	—	—	—
35	—	—	—	—	—	—	1	1	—	—	—	—
40	—	—	—	—	—	—	—	—	—	—	—	—
45	—	—	—	—	—	—	—	—	—	—	—	—

BLYTH.

Cms.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dce.
15	—	—	—	—	—	—	2	1	5	—	—	—
20	—	—	—	—	6	6	26	31	28	15	—	—
25	—	—	—	—	6	5	11	13	10	10	1	—
30	1	—	—	1	1	2	1	3	1	2	—	—
35	2	—	—	—	1	1	—	1	—	—	—	—
40	—	—	—	—	—	—	—	—	—	—	—	—

is from and to an offshore area to the north of the summer feeding ground. The migrants appear first in the proximal part of each region, and depart later therefrom.

(4) The first arrivals are the small plaice, and these are followed by larger and larger sizes of inshore plaice, together with mature examples. They depart in the same order, the smaller leaving the inshore region first.

(5) A number of plaice occur in the inshore region during the winter, evidently either not migrating or being such as have arrived late to winter there.

The trawling experiments of the "Garland" and our own in Northumberland gave evidence of a smaller spring and a larger autumn maximum. This does not appear from the "Goldseeker" results, at least in the form in which they have been published. In the cases in which they have been demonstrated they are plainly associated with the appearance of the young plaice in the spring, and with the return migration of these and the arrival of the larger plaice in the autumn.

DAB.—(1) There is a similar periodic migration of schools between offshore winter and inshore summer grounds, subject also to seasonal variation.

(2) All sizes participate in the movement, from small and immature to large and mature, but again the majority are the small.

(3) In the inshore feeding ground, dabs predominate at the southern part of the region and of the sub-divisions thereof, and it is concluded therefore that the migration is from and to an offshore area to the south of the summer feeding ground.

(4) The early arrivals are the small dabs, and these are followed by larger dabs, which arrive for the most part still higher along the coast. It is more than probable therefore that the wave of dabs is segregated on the whole according to size, the smaller being inshore.

(5) Dabs leave the shore feeding grounds much more completely than the plaice.

(6) In the case of the Forth school the dabs evidently divide in their immigration into a group which enters the Firth on the south side, and a group which crosses the Forth to enter St. Andrews Bay on its south side.

4.—Marking Experiments.

In the light of the foregoing conclusions from an examination of the results of trawling experiments we ought to get some evidence from marking experiments of such a general annual migration inshore and offshore. But in seeming contradiction thereto the Northumberland marking experiments disclosed an apparent sedentary condition of plaice of the size of those which according to statistical evidence should have migrated. The records therefore deserve a closer examination.

Plaice.—In 1903, 470 plaice were marked between June 23rd and September 9th. Two of these which were liberated in Druridge Bay on September 9th were recaptured on October 1st and October 23rd respectively in the same area. Four marked at Blyth in July were recaptured in August in Blyth Bay or about a mile to the south. One was recaptured on November 5th in St. Andrew's Bay, 40 miles north. The others were caught in the area of liberation, or from 4 to 5 miles north or south in the following March to May—a few in September and October of that year (1904).

The question naturally arises therefore, why were the marked plaice not captured in the Northumberland region between October and March? Only two, as has been stated, were captured in October of the year of liberation, the large majority being caught in the following spring.

Fig. 6 will help us to understand the reason of the apparent want of migration. The diagram shows (*a*) the total catches of white fish or line-caught fish by the fishermen in the inshore waters of Northumberland from October, 1903, to September, 1904, and (*b*) the catches of plaice during the same period. The former serves to indicate that line fishing was prosecuted throughout the year, and the latter the periods when plaice formed part of the catches. With regard to both it is necessary to point out that line fishing suffers a relapse in the summer owing to the men devoting their energies to herring, and particularly to salmon fishing during that season. But it will be seen that between October and March line fishing was, as is the case every year, at its height. Nevertheless, this is the season when plaice leave the district as is shown by the curve, and this is the yearly experience as shown by statistics and by trawling experiments. We can see the beginning of the annual summer wave of plaice in the inshore waters although it is not taken advantage of, because, as has been said, other and more lucrative fishing may then be resorted to.

The conclusion is obvious therefore that a few of our marked plaice are liable to be caught in October and even in November, and again in February to May, but not in the intervening months for the reason that with few exceptions they are not there to catch. The plaice were captured for the most part after their arrival from the winter migration.

The same will be found to apply to a seeming absence of migration in the case of the Huxley experiments in inshore regions further south.

In this connexion it ought also to be stated that while marked fish have been sometimes recaptured on the day when the fish were being marked, such were never recaptured in the same season when the area was revisited. But in the next year (1904) four were recaptured in July, August and September, and as in the other cases evidencing no migration.

If the above considerations be deemed sufficient to indicate that such results as ours bear only an apparent negative significance, we are led to the conclusion that the return migration to the same area evidences a strong homing tendency, if such an expression may be used in this case. There are exceptions, however. At the proximal end of the region the fish may proceed next year still further south, and the same is true of Blyth, which, as has been said, is at the proximal end of another school. An earlier return is also indicated at Blyth, one specimen having been caught as early as February 16th. Two Druridge Bay examples were recaptured further north in March and May, and were evidently therefore returning from the winter migration.

In addition to the one mentioned which had migrated conspicuously to the north, others were got in 1904 and 1905 far to the north of the place of liberation. These will be referred to presently.

The fact that more of the marked plaice were not recaptured by trawlers tends to show that the plaice do not go beyond the territorial waters, at least in Northumberland. This may be associated with the large area at the northern end brought about by the Farne Islands.

It is not proposed here to analyse and restate at length the results obtained by other investigators, but those made with reference to the Forth school deserve some degree of attention. Fulton's paper * dealing with the marking experiments made in St. Andrews Bay and the Firth of Forth showed evidence of a more or less northerly tendency which the later results of the "Goldseeker" experiments, also described by Fulton,† served to neutralise. But if both be reconstructed with the above considerations in mind, the apparent contradictions will be found to disappear to a large extent.

But it is first necessary to state with regard to marking experiments that all we know for certain in each case is that the fish was marked on a given day in one place and was recaptured at a given date in another. We cannot assume therefrom that the movement was merely from the one place to the other in the time indicated. If the movement is such as to contradict the evidence of statistics and trawling experiments then the presumption is that the marking experiment is at fault or is susceptible of explanation. In the light of the information presented in the foregoing sections we expect evidence from the marking experiments to show a practically complete migration of small plaice to and from the inshore waters, and evidently in a northerly direction, and a later migration of the larger immature; but in the case of those of mature size when they are not actually undertaking a spawning migration it is difficult to say yet when and how they migrate. With regard to these latter and the larger immature we do gain some information from marking experiments, but the small plaice have been only to a slight extent utilised for such experimental work. It will be necessary to mark these offshore at the beginning of the year to gain the facts we desire with regard to the direction of the immigration into the shore grounds.

In the case of the "Garland" results, the plaice re-caught in the St. Andrews region showed (1) no migration, (2) a migration to the south of 3 and 22 miles, (3) a migration to the north (36 examples) of from 2 to 12 miles. The one which migrated 22 miles south was liberated in April and recaptured in August, thus during its immigration. The examples which indicated a northerly migration were really returning from the winter migration, having

* 11th Ann. Rep. Fish. Bd. for Scot., 1893

† Fifth Rep. on Fish. and Hydrog. Investig., Fishery Bd. for Scot., 1913.

been caught from January to May. The emigration in autumn is illustrated by recaptures in October and December. One example is interesting, since it migrated northwards from St. Andrews into the Firth of Tay between October and December. It is therefore possible that such a region attracts a number of the winter migrants.

The "Goldseeker" experiments evidence the southerly migration of the larger sized plaice. From March four migrated from near the Carr Lightship into St. Andrew's Bay, where they were caught in December and January. Thirteen migrated between June and the following October to March from Carnoustie to St. Andrew's Bay. The subsequent experiments in the region show that such large plaice may migrate as late as October in this direction, so that the winter residents may not necessarily be a remnant of the summer population, but include at least such large plaice which migrate there to replace the winter migrants. An example in the "Garland" experiments serves to indicate that these large plaice may migrate northwards from the inshore regions at the time that the smaller plaice are moving inshore. This one was marked in December and captured in March.

The Forth plaice must be left out of consideration in the meantime. Both northerly and southerly migrations were evidenced. As has been said, a large body of plaice winter in the region. At the same time the statistical evidence proves that the area gains and loses like the proximal part of the region to the north. The marking experiments have demonstrated also migrations from the north into the area and from the Forth to the north of that area.

The marking experiments made in the southern part of the North Sea as reported by Garstang * and by Reichard † for the Heligoland district show on the other hand that the plaice in that part of the North Sea migrate southwards (or westwards) for the winter, and northwards (eastwards) for the summer. This appears to be clearly established from migration experiments. It cannot yet be definitely stated that the movement produces a corresponding reversed series of maxima and minima, nor can the limits of the schools be at present indicated.

It has long been supposed that North Sea plaice consisted of a northern and a southern race; the opinion, which has been

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* North Sea Fish. Investig. Comm., Reps. 2 and 3.
† II. Bericht, Arb. d. Deutsch. Wiss. Komm. f. d. Intern. Meeresfor.

expressed by several writers, being especially based on the slower rate of growth of the plaice of the southern portion of the North Sea, and the smaller size at which maturity is reached. The opinion therefore receives strong support from a consideration of the migrations. But the contrast between the two races is even more strikingly evident when the behaviour of the mature plaice is brought under review.

Attention has already been drawn to the fact that the advent of maturity impels the plaice of Northumberland and of the east coast of Scotland to migrate far to the north of the school to which they belong. The mature plaice of the Northumberland region migrate to the Firth of Forth, to St. Andrews, even to the Moray Firth; those of the Firth of Forth region to Aberdeen and to the Moray Firth; the plaice of the Moray Firth in many cases actually reach the Atlantic.* The mature plaice of the southern race migrate in the direction of the Channel, those of the Heligoland region migrating far as a rule to the west, and those of the southern portion of the North Sea in many cases gaining the Channel.

DAB.—The dabs marked on the Northumberland coast did not yield a large percentage of recaptures, but these in the light of the preceding statistical examination illustrate well the general migrations.

Many of the recaptures were made not long after liberation, and these indicated either no migration or a slight migration to the south. Three captured in October had moved from 12 to 20 miles to the south, one was got in January 60 miles, and one in February 40 miles to the south. In June, one was caught 13 miles to the south, and two, one in April and one in May, in the neighbourhood of the place of liberation. The last three illustrate the return of the migrants from the winter migration, the first three were evidently caught during the emigration from the Northumberland region, and the January and February captures serve to indicate to what a distance south and east the migrants may travel. It is quite possible that these illustrate the migrations of the mature. But in either case it is gratifying to obtain from marking experiments evidence in support of the conclusions arrived at from a consideration of statistics. There can be no doubt that the dabs of Northumberland migrate to and from a region to the south-east.

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* Fulton, *loc. cit.*

A similar southerly migration of the dabs of the Forth school was evidenced in the earlier Scottish experiments.* Those recaptured in February were 12 to 37 miles south of the place of liberation; one returned in April was 3 miles and another in July 4 miles from the place of liberation. An interesting exception was an example which was recaptured 12 miles north of St. Andrews in February. It is not proposed, however, to suggest obvious explanations of this case until further evidence is available (p. 51).

The Scottish experiments indicated also that the dabs migrated either from St. Andrews across the Firth of Forth to the south side or into the Firth on the north side, and also that the Forth dabs migrate from the Firth eastwards along the south side. It is thus evident, as was suggested in the preceding section, that the Forth school of dabs splits into two streams of immigration and emigration, one entering the Firth and the other crossing it.

The few records we have point therefore also to a "homing" tendency. The dabs of the Forth school and of the Northumberland school belong to a race which has the habit of the southern race of plaice. Whether the habits change still further north there is no evidence yet to say. So far as we know then the dabs of the greater part of the North Sea may be said to belong to a southern race.

5.—The Probable Origin of the Migrations.

The foregoing considerations have led to the conclusion that the plaice of the North Sea belong to two races, a northern and a southern, each of which is again resolved into schools. The schools have probably originated in association with as many spawning grounds. On the east coast of England and Scotland the wintering area of the schools of the northern race is to the north of the inshore summer grounds. At the southern end of the east coast the schools of the southern race have their wintering areas to the south of the inshore summer grounds. On the continental aspect of the North Sea the schools of the same race have their winter quarters to the west of the feeding grounds. Each school consists of young and immature plaice for the most part which migrate each season between the winter and the summer grounds, and which appear to have a strong tendency to remain in the school to which they belong. On reaching maturity, however, they migrate in the

* Fulton, *loc. cit.*

direction of the winter grounds, but reach a position usually much beyond that region. In the case of the mature of the northern race the migrants pass north and in some cases west to or towards the Atlantic. The mature of the southern race migrate towards the Atlantic *via* the Channel.

The migrations of the schools, and particularly those of the mature plaice must obviously be associated with the origin of the two races. The northern race must have entered the North Sea from the north and the southern race by the Channel.

THE ICE AGE.—Whatever the history of the plaice may have been prior to the existence of the North Sea in an approach to its present condition, it will be acknowledged that during the glacial period the species and indeed the whole fauna and flora were excluded from the area. It is not yet quite clear in fact whether the North Sea, owing to a culmination of the general uprising of the land which is generally supposed to have occurred during the Pliocene period, had not as such practically disappeared.

Jukes Browne * does not believe that the low level of the preglacial valleys necessarily means that the land stood at a higher level, but rather that the North Sea and the Irish Sea occupied deep valleys which during the ice age were filled with glacial drift. That such valleys as did occur in the North Sea prior to the ice age were filled with glacial detritus there can be no doubt. The Norwegian deep may indeed be post-glacial in origin and associated with the formation of the Baltic, but the whole of the North Sea has not had such an origin, for it seems to be an established fact that pre-glacial fossils have repeatedly been dredged from its bottom in the neighbourhood of the Dogger Bank. There was a period, my colleague, Professor Lebour, assures me, that Crag fossils of various kinds were regularly obtained by fishermen, and examples are scattered in North Shields and doubtless occur in the collections of the late Curator of the Hancock Museum, R. Howse. The Dogger Bank probably marks therefore a portion of the land which in early post-glacial times still connected England with the Continent.

Such considerations as these, and facts of distribution † which point to important land connections in north-western Europe

* The Building of the British Isles, 1911.
† Scharff, European Animals.

support the general opinion that during the Pliocene period the land gradually rose to a higher level, and this affected not merely the area now under consideration but the whole of the North Atlantic region. But whatever was the cause it is now clear that during the glacial period the Wyville-Thomson ridge occupied a higher level, so much so as to prevent the passage of Atlantic water beyond it.* It was evidently during Pliocene time that the change of level gradually took place, so as more and more to prevent Atlantic water crossing into the Arctic Ocean, thus producing the advancing cold climate of that epoch, and as a culmination, when the Atlantic water was altogether prevented from crossing the ridge, the glacial period.

The Arctic Ocean was thus converted into a land-locked sea, with a small opening to the Pacific if the Behring Strait existed then. The prevention of the passage of the Atlantic water into this region would obviously have been sufficient to bring about a glacial epoch in the northern hemisphere.

During the glacial period the land, or the bank and island, connexion between Scotland and Greenland was occupied by or fronted by an ice barrier,† which must have extended along the coast of Ireland for some distance (fig. 7). North and east of this the whole area under consideration was covered by ice. It is probable, however, that an overflow of Atlantic water nay have occurred at intervals during the period of glaciation, causing variations of climatic conditions and of the extent of the ice covering.

It is not at all likely therefore that plaice or any other living creature occupied the North Sea during the ice age. If, as seems to have been the case, the Arctic Ocean was covered by ice continuous with the land ice all round its borders, it is not any more likely that there was a fauna and flora in the whole marine area involved in the glaciation. It will be assumed in what follows that such was the case.

The results of the migration experiments, as has been seen, point to the conclusion that plaice entered the North Sea from the Atlantic. It may be concluded therefore that during the ice age they were confined to such portion or portions of the continental

* For a description of glaciated stones from the crest of the Wyville-Thomson Ridge, *see* Murray, "The Physical and Biological Conditions of the Seas and Estuaries about North Britain. Proc. Phil. Soc., Glasgow, vol. XVII., pp. 311-312, 1886.

† Murray and Hjort, Depths of the Ocean.

shelf as were available in the Atlantic, south of the ice shelf. It is difficult in the present state of our knowledge, when conflicting views exist as to the level of the land, to point specifically to likely areas. But it is probable that plaice and many other species competed for the space at their disposal south of Ireland, and in such a bay as the Channel may have presented. Rockall may have suited some, the south of Iceland was also a possible region, and the Greenland and American coasts must have been fully occupied.

POST-GLACIAL CHANGES.—For the same reason it is just as difficult to picture the North Sea when it emerged at the end of the glacial period from the ice. The change of level which allowed the Atlantic water finally to gain access to the Arctic Ocean, thereby bringing about a warmer climate and the retreat of the ice, probably led at the same time to the extension of the North Sea bay. It was very probably a shallow sea at this early period of its recent history, possibly deepening on the Norwegian side, open to the north, and extending as far south as say the 57th or 56th degree, being still widely separated from the Channel by the land connexion which existed at this period. The valleys of this region and the North Sea bay would have been filled with glacier drift. According to Pettersson, a fairly definite estimate of the time which has elapsed since this took place may now be given. He refers to an unpublished paper of de Geer who made a study of the peat bogs of Norway and concluded therefrom that the beginning of the melting of the ice in Norway occurred not more than 13,000 years ago.* This must have succeeded the melting of the ice in the North Sea area, a process which must have taken many years to accomplish.

It is only necessary now to state for the purposes of this paper that during the post-glacial period the North Sea Bay gradually extended, and was finally put into communication with the Channel. The gain of the sea was evidently for a period in excess of that which is its present condition, for raised beaches point to a submergence of some 100 feet in Scotland and Ireland, rather less further south and east, and steps in the elevation which followed have been traced at 50 and 25 feet. It was probably during the submergence that the Straits of Dover were formed and Ireland definitely cut off from Scotland.†

* Der Atlantische Ozean während der Eiszeit. Intern. Rev. d. ges. Hydrob. u. Hydrog. B. 6, 1913.

† Nansen discussed the probable effects of such a submergence in Norwegian North Polar Expedition, vol. III., p. 420.

The preceding sketch has been made not with a view of attempting to explain the ice age, but to draw attention to what appears to be a natural conclusion that the present distribution and migratory habits of the fauna of the North Sea and Arctic Ocean are post-glacial in origin, and at the same time to form a background for the consideration of these. It is obvious also that while the passing of the glacial period began a new era for the fauna of the North Sea and Arctic Ocean, the causes which brought about the epoch, brought to an end a not very different fauna in the preceding period.

Migrations of Plaice.—It was therefore during the time that the early post-glacial changes were happening that the North Sea received its first fauna and flora. The Atlantic water which was bringing about the climatic change would carry into the region and into the Arctic Ocean plankton as it does to-day. It is probable that early in post-glacial times all may have perished, for the winter conditions for a time may have been too severe, and in summer, owing to the melting of the ice, the North Sea would have been occupied by water of low salinity, but with the amelioration of the climate such would be able to successfully winter in the region, and would therefore form fresh centres of dispersal. Only the more active on attaining maturity would be able to retreat to the Atlantic for spawning purposes.

Among these latter for a period, it may with reason be presumed, were the plaice. As soon as the conditions permitted, it is fairly evident that plaice would spread along the plateau to the west of Scotland, both actively in the adult condition and passively by the eggs and larvæ carried by the new direction of the current. From a spawning ground in that region eggs and larvæ would be similarly carried into the North Sea, and sooner or later the young plaice would be able to pass the winter there. During the period of their growth to maturity they would form a school migrating outwards to the deeper water for winter, and inwards again with the pulsations of the Atlantic stream. But on reaching maturity they would have to migrate to the Atlantic for spawning.

The plaice at this post-glacial period of the history of the North Sea would have been therefore practically in the condition of the eel at the present day. Every year the larvæ of the eel are carried around the north of Scotland into the North Sea, and are able to retain their larval state until they get into the neighbourhood of the coast and water of low salinity which probably supplies the stimulus for the change. As is now well known the eels remain in the fresh waters of north-western Europe until maturity impels them to migrate to the spawning region in the Atlantic.

With the further extension and deepening of the North Sea, and perhaps still further hydrographical changes, it would no longer be necessary for the plaice to migrate into the Atlantic on reaching maturity. In addition to the passive migration of the species in the larval condition, active migrations would tend to spread the plaice still further south and east. New spawning areas would therefore be formed within the North Sea, and these would become fresh centres of dispersal. It may also be inferred that during the period of submergence plaice were compelled to adopt the coastal distribution which so characterises the species in the North Sea at the present time.

Such passive and active migrations would in similar manner bring about the present distribution of plaice along the Norwegian coast to the Barents Sea. Iceland and the Faroes may have already been occupied by schools in these regions. Whether the Alaskan plaice are pre- or post-glacial in origin cannot yet be said.

During the same period Atlantic plaice would have penetrated into the Channel bay, and when the bay was connected with the North Sea, a second invasion of plaice into the latter area would occur. The history would be similar to that just sketched for the northern race, only in this case the feeding migration would be north and east, and the winter migration south and west. This southern race would also have penetrated into the Irish Sea, although it is possible also that a second invasion came from the north.

Migration experiments have demonstrated, as has been stated, that at maturity plaice migrate in many cases if not always outwith the region of the school in which they were reared. This means in the case of the northern North Sea race that the spawning grounds are to a large extent if not completely recruited from the schools to the south. Two questions arise from this. The first is: do the plaice after spawning remain in association with the school near which they happen to be, or do they return to the school to which they belong? Fulton has recorded examples which have migrated long distances to the south from the Forth region. There is therefore some evidence to show that mature plaice may return southwards, but not enough to show that they actually return to their respective schools, and such plainly it would be very difficult to get.

The other question is, do the migrations of the mature plaice so far to the north bear any reference to migrations at a previous stage to the south ? We have before us on the one hand the fact of the succession of schools, and the reasonable assumption that these have their origin in the products of a spawning ground in each case, and on the other a migration of mature which is apparently neither related to the school nor to any particular spawning ground. As has been seen, mature plaice may still leave the North Sea for the Atlantic by way of the Pentland Firth. The Atlantic water may possibly still carry larvæ from a spawning ground off the north-west of Scotland into the North Sea, and from the successive spawning grounds on the east coast to positions further south than the limits of the school. But the most liberal allowance of distance for the passive migration of the larvæ would not account altogether for the migrations of the mature.

The passive migration of larvæ may be stated in general terms. The southerly tidal current off the north-east coast may be said to be from $1\frac{1}{2}$ to 2 miles stronger than the northerly one. It will be intensified by northerly winds and reduced or neutralised by southerly winds. Leaving this latter factor and taking the lesser figure of the former factor, it may be said that the eggs and larvæ will each day, after a double tidal pulsation, be removed about 3 miles to the south. In 28 days therefore the passive migration would amount to 84 miles, more or less. The effect of this would be to determine the larvæ from a particular spawning ground along a strip of coast, related thereto, a general average distance to the south.

In other words, the mature plaice may migrate further than the migrations of the larvæ appear to demand. It will very likely be found to be the fact therefore that in addition to the larval migration there is a migration to the south of the older plaice which form the schools. Of this there is already some evidence from the "Goldseeker" experiments.

It is more than probable, as has been suggested above, that such an active migration took place in addition to the planktonic one in the early history of the North Sea, and may still be the means of determining the plaice to the south. There is therefore some degree of evidence of a rotation along the coast, whatever its beginning and its end may be. And if such be the case it will not be necessary to look for morphological features to distinguish the schools of plaice.

In this connexion it would be desirable to know more about the migratory habits of the plaice of the west coast. The few, mostly large plaice, marked at Broad Bay in connexion with the "Goldseeker" experiments do not throw much light on the question.

Migrations of the Dab.—It may be concluded from the above considerations that the dab entered the North Sea by the Channel, along with or about the same time as the southern race of plaice. This was probably, as has been suggested, during the period of submergence. It has been said that it was at this period that the plaice were likely compelled to leave the middle of the North Sea and to approach the shore. And this change would allow of the dabs pressing into the deeper regions. They are thus later arrivals than the plaice, but the North Sea area has favoured the species, for apart from the shore they occupy a prominent position.

We have now to consider the fact that they have spread independently of current far north into the North Sea, and particularly the annual migrations of the species in a reverse direction to that of the plaice, one manifestation of which we have been able to trace on the coast of Northumberland. The schools in this case cannot be said to arise from a spawning ground in the direction of which the winter migration takes place. In spite of the later period of the spawning presumably the small dabs of the Northumberland coast proceed from larvæ carried to the region from the north. Yet these form themselves into schools which migrate southwards for winter. If the larvæ have thus a tendency to be carried south it will probably be found that the older stages will migrate beyond the limits of the school in a northerly direction.

In the case of dabs therefore we have strong presumptive evidence of distribution by active migration, and doubtless the dab is not singular in this respect. And unless it can be shown by further hydrographical work that currents at the period of spawning favour a north-east distribution of the larvæ we must conclude that schools may migrate without reference to the spawning grounds. The dabs of the Channel and the southern part of the North Sea are still under the influence of the Channel Atlantic water. But those of the east coast further north must receive the impulse for the summer migration from the northern stream.

Both plaice and dabs thus exhibit in the migrations of the schools and of the mature a strong tendency to migrate in the direction of their entrance into the North Sea, the movements of the former being suggested by an annual change which presumably is caused by the pulsations of the Atlantic water, and of the latter by the ripening of the gonads.

The migrations of the schools are of particular interest to fishermen, and since the migratory habits have evidently originated in association with the coming of the species from the Atlantic, and are still more than probably profoundly affected and controlled by the pulsations of the Atlantic water in the North Sea area, the variations in the stream will bring about not merely the occurrence but the abundance and scarcity of seasons.

Migrations in General.—So far as the North Sea is concerned it may be taken as a law that the direction of the migrations of the schools, and particularly that of the mature indicate whether they have entered by the north or by the Channel. It has already been demonstrated that the relative numbers of the schools in different areas of the summer feeding ground also allows of this being determined.

It is not necessary to attempt to give now an exhaustive list of migrants, but examples of which there is evidence from marking experiments or otherwise may be quoted. The sole has already been mentioned. It is a late arrival from the south which the North Sea owes to the Channel, and it is still confined to the southern part of the North Sea. Turbot may have entered the Channel, but those of Northumberland, and presumably all to the north thereof, came from the north. The same is true evidently of brill. The flounder also entered by the north. It is possible also that further south a subsequent entry of flounders took place; of that we have yet no evidence. But the flounders of Northumberland arrived from the north. It is interesting to recall in connexion with the discussion attempted on page 50 that mature flounders migrate from Northumberland mainly to St. Andrews and the Forth, but have also reached to near Aberdeen. It will be found from a consideration of the facts of distribution that the vast

EXPLANATION OF FIGURES.

Fig. 1.

Diagram showing the catches of plaice of the Firth of Forth school, on left, inshore (from "Goldseeker" experiments), on the right, offshore (from the trawling statistics).

Fig. 2.

Diagram indicating the catches of plaice ("Goldseeker" experiments) at the Firth of Forth stations indicated, Station 6 being the northern one, and Station 7 the southern one of the group.

Fig. 3.

Plaice.—Diagrams illustrating results of trawling experiments, the lower one in Northumberland, the upper one in St. Andrews Bay in 1889.

In each case the stations are viewed from north to south in successive steps.

Fig. 4.

Dabs.—A similar series of diagrams to the previous one, indicating the results of trawling experiments, viewed from south to north, in Northumberland, St. Andrews Bay, and the Firth of Forth.

Fig. 5.

Diagrams illustrating the catches of dabs, on left, plaice, on right, at four of the trawling stations of Northumberland, as indicated.

The different lines indicate—dotted line ········ June, dark dotted line ▪▪▪▪▪ July, thin line ——— August, and dark line ━━━ September.

Fig. 6.

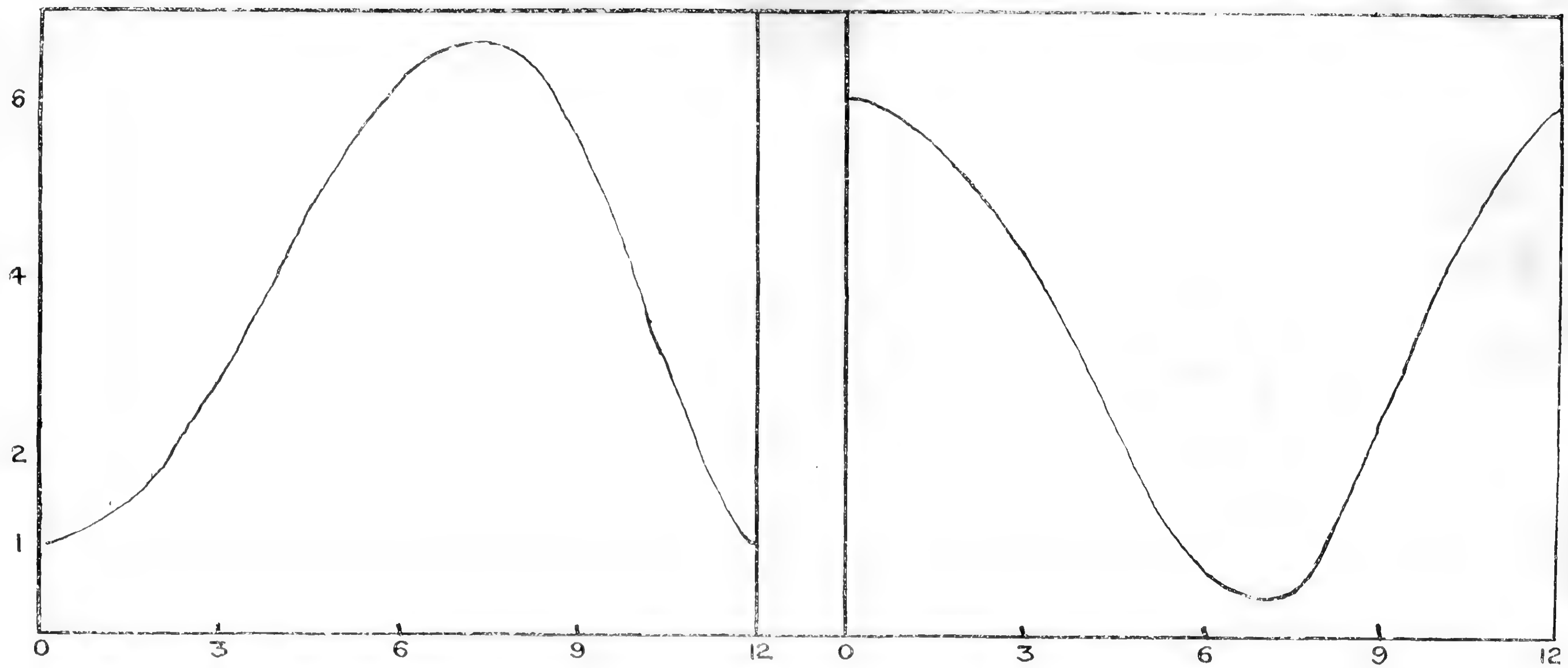
Diagram illustrating the catches by inshore fishermen in Northumberland, from October, 1903, to September, 1904.

(*a*) of white fish.
(*b*) plaice.

Fig. 7.

An attempt to indicate the conditions during the Ice Age.

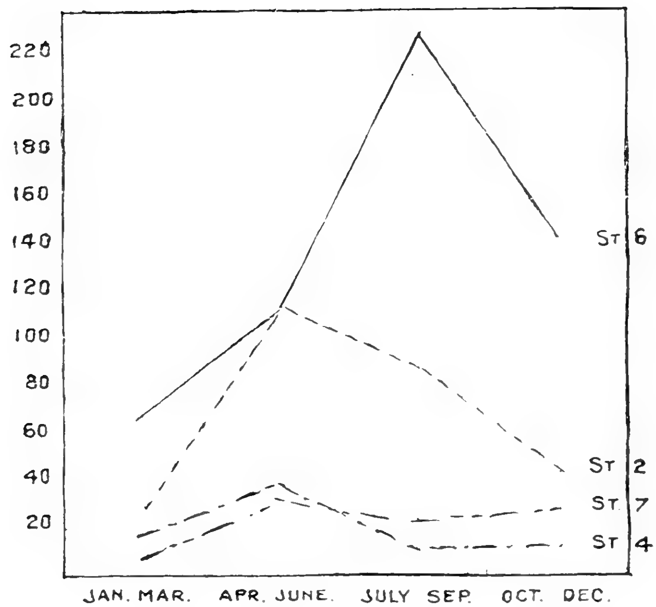
A line is drawn showing the probable extent of the ice barrier, which extended between Greenland and Scotland, its continuation to the west of Ireland, and the limits of the ice covered region of the land.



PLAICE

FIG I.

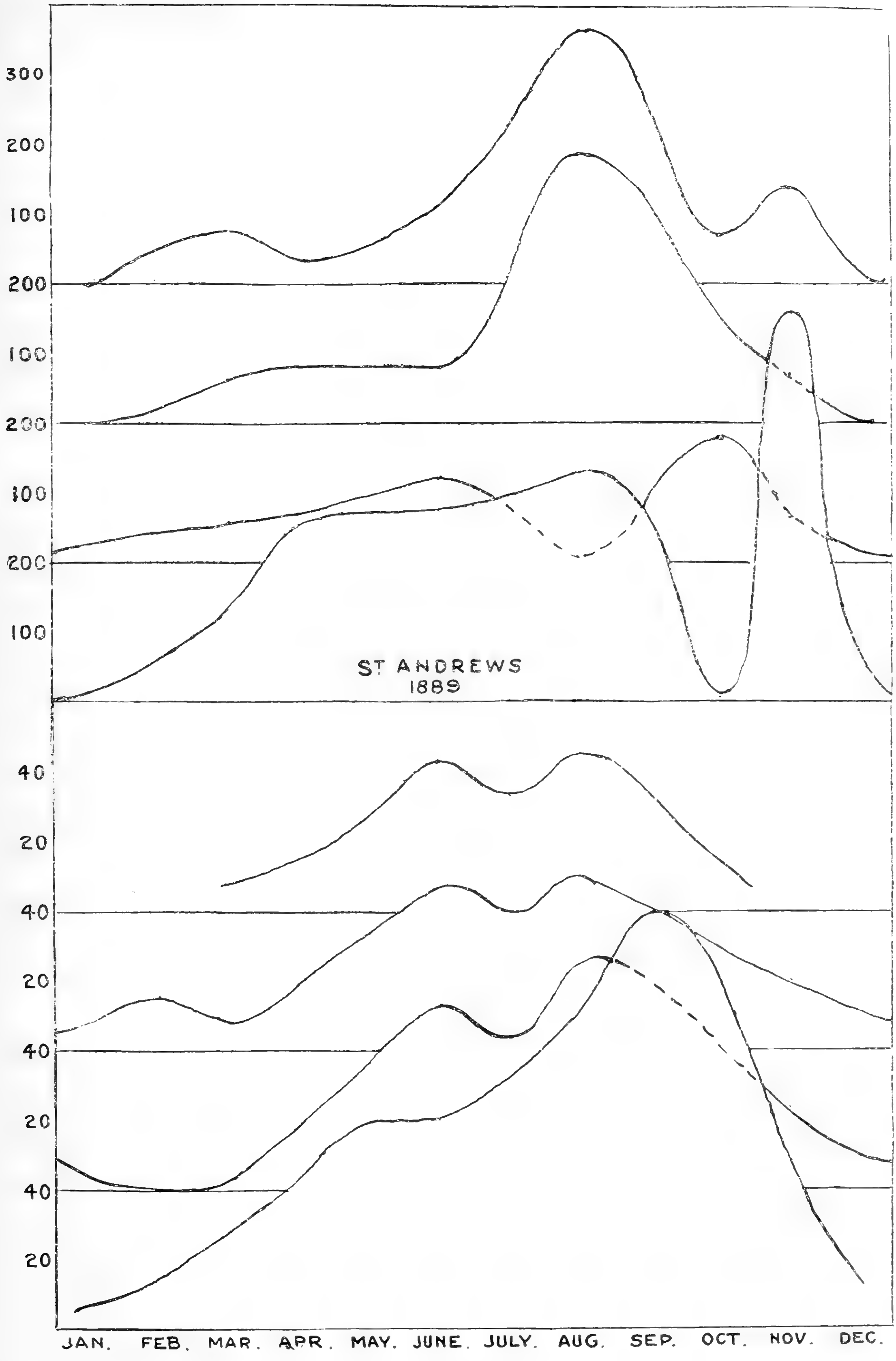
FIRTH OF FORTH SCHOOL.



PLAICE.

GOLDSEEKER, FIRTH OF FORTH.

FIG 2



PLAICE

NORTHUMBERLAND.

FIG 3

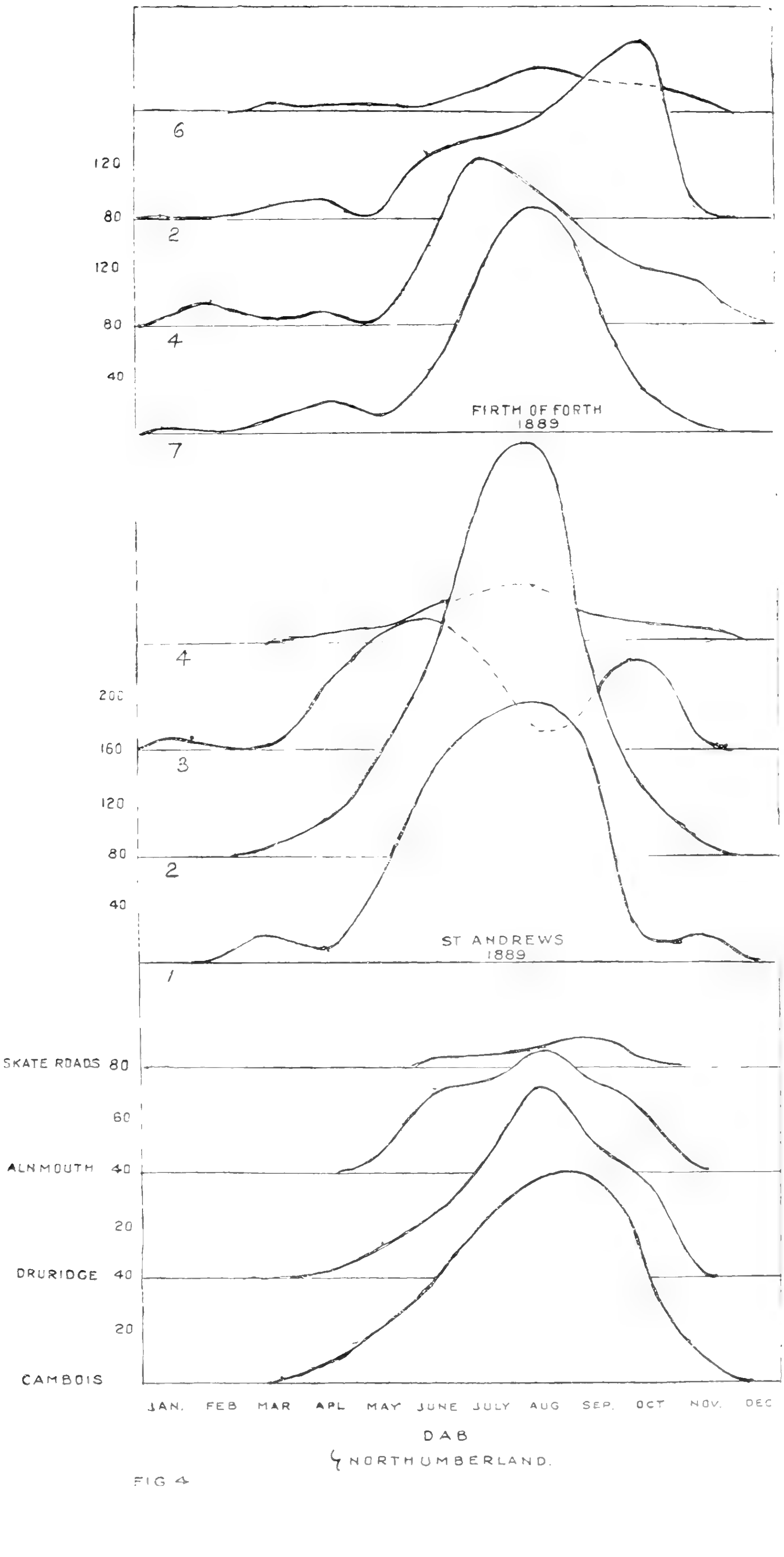

6
120
80
2
120
80
4
40
FIRTH OF FORTH
1889
7
4
200
160
3
120
80
2
40
ST ANDREWS
1889
1
SKATE ROADS 80
60
ALNMOUTH 40
20
DRURIDGE 40
20
CAMBOIS
JAN. FEB MAR APL MAY JUNE JULY AUG SEP. OCT NOV. DEC
DAB
NORTHUMBERLAND.

FIG 4

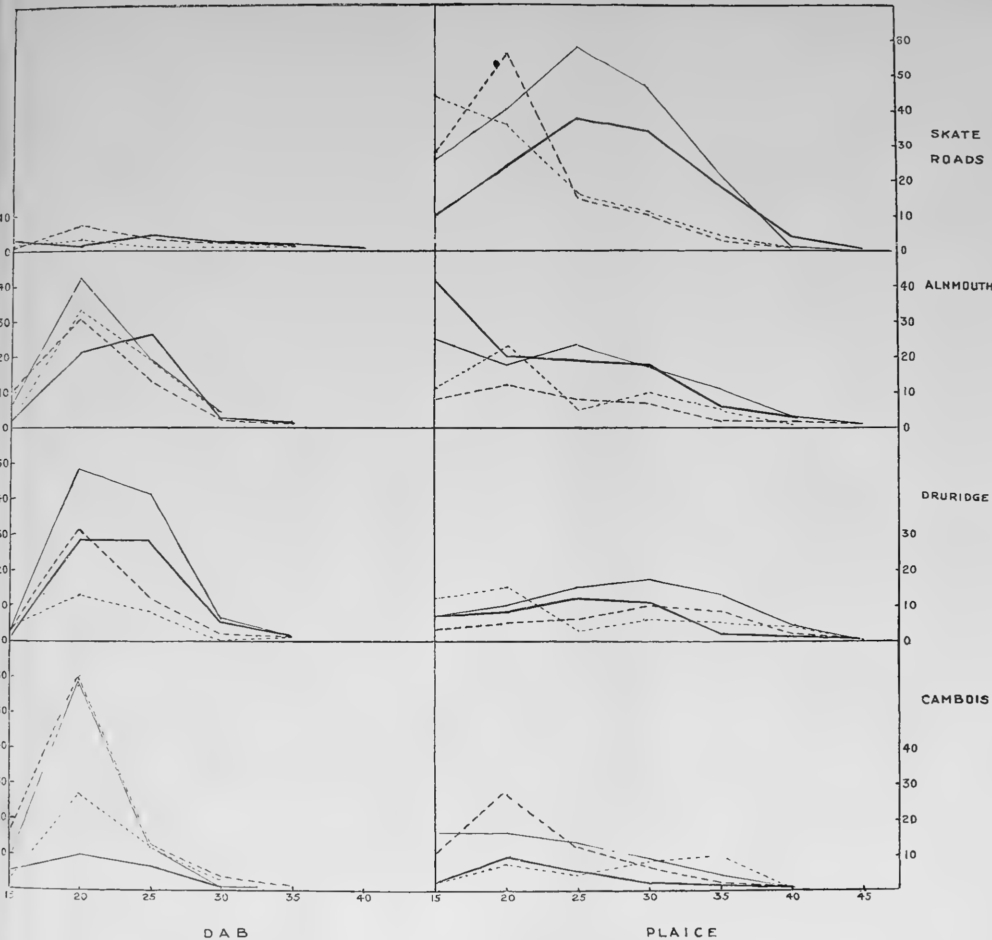
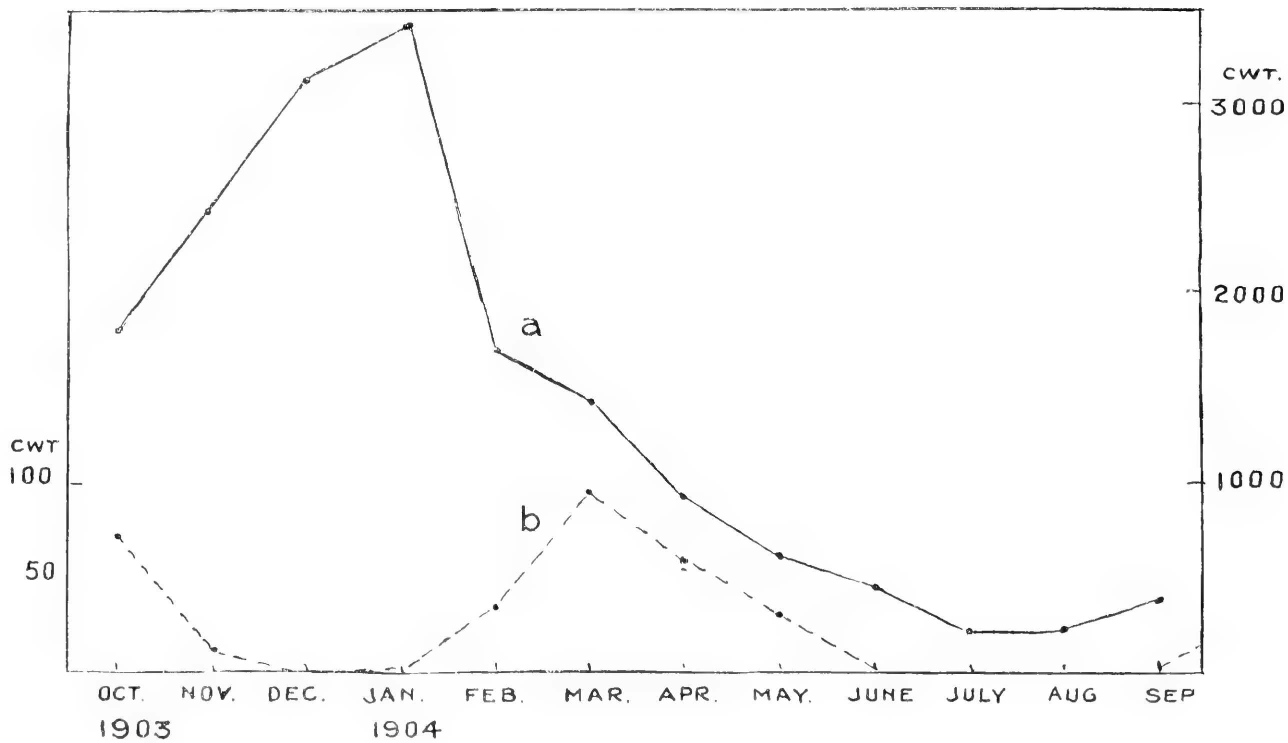


FIG 5



CATCHES OF (a) WHITE FISH AND (b.) PLAICE BY INSHORE FISHERMEN FROM OCT. 1903 TO SEP. 1904.

FIG 6.

ICE AGE.

FIG. 7

HERRING RACES.

PRELIMINARY WORK.

A.—Morphological Features.

By ALEXANDER MEEK.

In the report for the year ending June 30th, 1912, a table was given of the measurements of samples of herrings caught by trawlers in September and October, 1911, and also of a small number (30) of herrings caught in November, and obtained from Yarmouth.

In 1912, samples were similarly examined of trawl-caught herring from the same Dogger Bank region, some 120 miles east of the Tyne, and extending N.E. and S.W. over an area of about 50 miles. The fishing began in August, and ended on October 22nd. The number of trawl-caught herring measured was 110, and during the same season two samples of drift net herring, caught (*a*) September 6th, 60 miles E. ½ N., and (*b*) September 10th, 30 miles E. ½ N., were examined, these latter samples numbering together 78.

In 1913, 1,503 drift net and 1,708 trawl herring were obtained from the localities and on the dates shown in the following table (Table 1). The localities of capture of these and of the herrings caught in the previous two seasons are indicated in the chart.

The measurements made were, total length, length of head (to edge of operculum), scale covered portion of the body (from edge of operculum to beginning of tail, along same line as total length), and from the level of the anterior end of the head, mouth closed, measurements were made to the inner angle of anterior end of the pelvic fins, to the ventral (anal) fin, and to the anterior and posterior ends of the dorsal fin. Besides observations were made as to the condition of the gonads, and as to the number and relative position of the winter rings of the scales.

The measurements are therefore not exactly the same as those of Heincke and other previous investigators, but it is easier to measure by means of a mechanical board along parallel lines, and it is more than likely that differences due to degree of development are to a large extent obviated by this method.

In the time at our disposal it was found impossible to give the figures the analysis which they certainly deserve, but as an effort is being made at present to determine the races of herring the whole of the tables have been sent to the Board of Agriculture and Fisheries in order that they may be treated in parallel with those obtained from other sources.

What has been done is this—and it will be found to be an adaptation of a scheme for rapid analysis given in the report for 1903, under the heading " A Contribution to our Knowledge of the Growth of Plaice "—to bring together the whole of the measurements on a chart. The method has the advantage of determining rapidly whether any difference is exhibited, the variations, obvious mistakes, and especially in the case of differences, the measurements which deserve more careful mathematical investigation.

Briefly the method is as follows : A basal measurement, preferably total length is taken as the basal or " x " line, and all other measurements of the sample or groups of samples are expressed on the chart by dots with reference to the basal measurement. In the case of the herring measurements, as it was believed that the total length was not to be relied upon with the same confidence as the length of the scale-covered portion of the body, the latter measurement was chosen as the one in terms of which the others were to be expressed.

If this be done it will be found that the measurements practically resolve themselves into groups along lines originating in *o*. After the sample has been thus charted, a line is drawn as nearly as judgment will permit through the groups from *o*, and it is easy then to express the results as tangents of the angles thus obtained. In the table which will be submitted presently the tangents were calculated by noting where the respective lines cut the upright from the 22 cm. measurement of the basal line.

DRIFT NET.

	Sex.	Head.	Pelvic.	Ventral.	Length.	Dorsal.		* Range of Size.
						Ant.	Post.	
								Cm.
1911—Yarmouth ...	—	·2727	·6773	·9636	1·45	·6364	·7818	16—22
1912—North Shields ...	—	·2727	·6727	·9636	1·4409	·6318	·7773	14·7—20
1913—North Sunderland								
A, B, C, D, E ...	F	·2682	·6773	·9682	1·4318	·6318	·7818	13·5—18·7
North Shields								
F, G	F	·2636	·6773	·9682	1·4318	·6318	·7818	15·6—21·5
	M	·2636	·6773	·9682	1·4273	·6318	·7818	15·2—20
H, I, J	F	·2636	·6773	·9682	1·4273	·6318	·7727	14·6—21·2
	M	·2636	·6773	·9682	1·4227	·6318	·7727	15—21

TRAWL.

	Sex.	Head.	Pelvic.	Ventral.	Length.	Dorsal Ant.	Dorsal Post.	* Range of Size.
1911—North Shields	—	·2773	·6818	·9818	1·4591	·6455	·7955	12·5—21·3
1912— Do. ...	—	·2818	·6818	·9818	1·4455	·6455	·7955	12—21·5
1913— Do.								
Q, U, V, W, X	F	·2727	·6773	·9772	1·4545	·6409	·7909	12—21·1
	M	·2727	·6727	·9818	1·45	·6364	·7909	12·7—20·8
N, O	F	·2681	·6773	·9772	1·45	·6409	·7909	13·7—21·1
	M	·2681	·6727	·9772	1·4545	·6364	·7886	14·3—20·1
P, R, S, T ...	F	·2636	·6727	·9682	1·4364	·6318	·7727	15—21
P	M	·2591	·6727	·9682	1·4318	·6318	·7773	16—21

* Scale-covered portion of body

The tangents of the measurements give numbers which do not differ markedly, but it will be at once seen that where there is a difference, the difference remains constant, that there are in fact one or two characters which serve to define the trawl from the drift net herring. The dorsal fin on the whole is placed further back, and is certainly longer in the trawl herring. The ventral fin is also more posteriorly situated in the trawl herring. The smaller length of the drift net herring is also brought out. An attempt has been made with reference to certain of the samples to find out whether there is also a sexual difference, but the method is evidently not sufficiently fine to indicate the small amount of difference between the sexes.

The results so far as distribution is concerned of the samples examined are indicated in the accompanying chart, the Dogger Bank race being distinguished by *.

It is concluded therefore that the summer herring of the east coast of Northumberland and Yorkshire belong to a race which presents a uniformity of character, serving to define them as such. The race may be caught up to a distance of 60 miles at least from the coast. It is also plain that the small sample of drift net herring obtained from Yarmouth in 1911 agree in character with this race. So that probably the whole of the summer east coast herring belong to one race.

If the attempt now being made to define the races sustains the broad results of this examination it will follow that the annual migration from the Atlantic is taken part in by the general enormous body of herring which becomes segregated during the migration into a succession of spawning schools. This will affect merely the mature fish. It has been shown in another part of this Report, page 50, that the mature of other fish when they receive the impulse for ths spawning migration do not migrate to a particular spawning ground, and it is not any more likely that herring are able to time their spawning season as to arrive at a particular spawning ground. The whole of the east coast region of the North Sea may be looked upon as the spawning ground of the herring, particular areas of which are especially suitable for the purpose of affording attachment to the eggs, and there is a great deal of evidence to show that these are by no means constant.

The trawl or Dogger Bank herring belongs to a race which probably hails from a more northern deep sea winter region.

The important point with reference to our enquiry is, however, the demonstration that the race is evidently distinct from the east coast race of summer herring. If the trawl fishermen therefore confine their attention exclusively to this race, which they can do by refraining from trawling for herring in other regions than that frequented by the race, they cannot be blamed for injuring the drift net or east coast race of summer herring. That they did not do so in 1913 is shown by the analysis which we have made of the samples. The herring of the Dogger Bank region all belonged to the race of trawl herring as above defined. But the P, R, S, T samples trawled from off the Yorkshire coast were herring belonging to the east coast race. The only exceptions were the samples marked N, O from near the same region, which, I was surprised to find, belonged to the Dogger Bank race. The latter appears therefore to extend further in a S.W. direction than has been stated, or does so in some seasons, and trawl fishermen found at the time in this region shoals which exhibited the tendency of the Dogger Bank race to remain at the bottom.

It will be interesting in this connexion to state that the first sample of herring examined this year (1914) bears evidence of the existence of still another race. The herrings were caught on 30th April, 100 miles E. of the Tyne, and consisted for the most part of recovering spent herring. They were measured according to an agreed upon system, in connexion with the national enquiry now being made, and in so far as the measurements are practically the same as those used before, the results are as follows :—

Head.	Pelvic.	Ventral.	Dorsal. Ant.	Dorsal. Post.	Range.
·2705	·6727	·9591	·6454	·8	14—21

The measurements are different therefore from both the summer east coast and the Dogger Bank races. It will probably be found that these herring belong to that school of the winter race which frequents the Firth of Forth.

Lastly, the following table may not be without interest to those who have been expressing the rings of the scales of samples in terms of length, and have found therby an apparent contraction in size in successive years.

	Scale.			Herring		
	Size.	Gain.	Growth %	Length.	Gain.	Growth %
	mm.			mm.		
1 winter ring...	1·83	—	183	160	—	16,000
2 do.	3·2	1·37	75	215	55	34
3 do.	3·93	0·73	23	245	30	14
4 do.	4·4	0·47	12	260	15	6

B.—Size, Age, Growth and Maturity.

By B. STORROW.

The main object of the investigations during the summer and autumn of 1913 was to see it there was any difference between the herrings raptured by the two methods of fishing, the drift net and trawl. That there are differences is evident, but it cannot be said that the particulars relating to size, age, growth and maturity show as marked a difference between the two classes of trawled herring, those from the vicinity of the Dogger Bank and the Yorkshire coast, as is found between the drift net and trawled herrings or between the two classes of trawled herrings as is revealed by a consideration of the measurements made.

A complete examination of the data has not been possible owing to the undertaking of further herring investigations at the request of the Board of Agriculture and Fisheries, but as much as it has been possible to do in the time is here given.

Samples.—Samples of drift net herrings were obtained from North Sunderland in June, July and August, and in August and September from North Shields. These were ordinary commercial samples of the catches landed and taken without any sorting, and may be considered as representative of the herrings caught by the drift nets.

The classifying of the trawled herrings into the trade categories of large, medium and small made it more difficult to obtain a true sample of the fish landed, but the practice of first ascertaining from the skipper of the trawler the number of crans of each category contained in his catch, and taking various proportions of the samples from each class has probably overcome this difficulty to a large extent. It cannot be said with certainty that this method gave a true sample of the herrings caught, for the small brought poor prices and were not always brought to port. Evidence of the small herrings being thrown overboard was difficult to obtain owing to the feeling existing between those interested in the different methods of fishing.

SIZE.—In Table II. will be found particulars relating to the size of the herrings examined. The fish have been grouped to the nearest centimetre, 20·5 to 21·4 cm. being counted as 21 cm., and the numbers thus obtained are expressed as percentages.

In the samples from North Sunderland the size varied from 20 to 27 cm., the greatest number having a length of from 23 to 25 cm. in June, from 22 to 25 cm. in July, and from 24 to 25 cm. in August. The North Shields samples obtained in August and September contained on the whole larger herrings, the bulk of them being from 24 to 25 cm. long, and in this respect like the August samples from North Sunderland, but there were more herrings of 26 cm. and over.

Sample M which seems to stand by itself with regard to size contained a large number of herrings with two winter rings.

The trawled herrings had a similar range in size to those landed at North Shields and captured by drift nets, but on the whole they contained greater numbers of larger fish, the highest percentages obtaining from 24 to 28 cm. Yet some of the samples, those taken towards the end of the herring trawling season and coming from the Dogger Bank region, contained a higher percentage of smaller herrings than any of the drift net samples. At this time the small herrings could be sold at North Shields, and commanded a fair price.

If the averages be taken for the samples from North Shields the following result is obtained :—

CENTIMETRES.

Samples.	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Drift. F to M	—	—	0·1	1·7	3·7	10·5	27·4	34·3	14·5	3·4	2·2	1·4	0·5	0·1
Trawl. Q, U, V, W, X	0·4	0·6	2·6	5·6	8·6	9·9	10·8	19·4	14·8	8·8	7·6	7·0	2·9	0·4
P, R, S, T ...	—	—	—	0·2	1·2	3·0	8·0	15·5	17·5	20·7	20·0	9·0	4·5	0·2
N, O ...	—	—	0·5	1·5	3·5	6·25	13·0	28·5	17·5	13·0	10·0	4·5	1·25	—

This clearly shows a marked difference between the drift and trawled herrings for size, and to a less extent a difference between the two classes of trawled herrings. The N and O samples, the first samples of trawled herrings examined, are more in agreement with the Dogger Bank than the Yorkshire coast trawled herrings, which latter are of greater size.

The difference in size between the drift and trawled herrings will be found expressed graphically on Chart 2.

Age.—The age has been determined by examination of the scales. Such difficulties as the presence of so-called secondary rings and very faint, in some cases almost invisible, first winter rings have been encountered, but it is hoped that by an examination of a large number of scales when these difficulties occurred that a correct reading of the scales has been obtained. As a general rule nine scales from each herring were examined under a projection microscope; if these proved unsatisfactory further scales were examined until either the sample of scales was exhausted or the number of winter rings could be made out. It is for a small number only that the age could not be determined with certainty. Table III. gives the number and percentage of herrings having different numbers of winter rings in each sample.

The greater part of the drift net herrings were fairly young fish, very few having more than five winter rings, and the highest percentages were found having three and four winter rings, the former class predominating.

The North Sunderland samples contained no herrings with more than five winter rings, and those from North Shields only from 4 to 5 per cent. The age composition of the samples from these two ports was practically the same if the small number of older herrings in the North Shields samples be neglected.

No herring having one winter ring only was found in the drift net samples. This may be due to such fish not being present in the shoals, or to the drift net, on account of the size of the mesh, being selective. The latter is probably the reason, as in two of the trawled samples herrings with one winter ring were obtained.

The trawled herrings were older fish, the predominant year class being that with four winter rings, and the number having more than five winter rings was considerably greater than in the case of the drift net herrings.

When the two classes of trawled herrings are separated and the average percentages obtained from the tables, the Yorkshire coast samples are found to contain older herrings than those from the Dogger Bank region or the N and O samples.

WINTER RINGS.

Samples.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Drift.														
A to E	—	15·2	49·2	27·1	8·6	—	—	—	—	—	—	—	—	—
F to M	—	13·2	48·0	29·4	5·0	1·8	1·4	0·5	0·1	0·1	0·1	0·1	0·1	—
Trawl.														
Q, U, V, W, X	1·6	18·8	15·2	26·4	16·9	4·8	4·5	3·3	3·2	2·1	1·0	1·4	0·7	0·4
P, R, S, T ...	0·2	2·7	11·9	30·2	17·6	10·2	12·0	4·3	5·1	2·3	1·6	0·6	1·0	—
N, O ...	—	6·1	19·0	41·0	14·0	6·4	8·0	2·9	1·6	0·5	0·3	—	—	—

GROWTH.—Table IV. gives the average sizes of the herrings for the various ages. These show a difference between the drift net and trawled herrings for those having two and three winter rings, which difference is accentuated somewhat when the time of year the herrings were caught is considered. If the averages be taken for the North Shields drift net samples landed from 28th August to 13th September, and the trawled samples which were landed from 15th September to 6th October, practically three weeks later, the figures run as follows :—

Winter Rings.	2	3	4	5
North Shields—				
Drift ...	23·3 ...	24·5 ...	25·3 ...	26·1 cm.
Trawled ...	22·4 ...	24·1 ...	25·4 ...	26·4 cm.

At the time that the scales were examined for age a linear representation of them was made, and following the method of Hjort, Pub. de Circ., No. 53, p. 36, the size at the formation of the different winter rings was then calculated for herrings having two, three, four and five winter rings. The older herrings have not been dealt with in this way as the main object of the work, as before, stated, was comparison between drift and trawled herrings, and amongst the former the number having more than five winter rings was so small as to be of little use for this purpose.

The average sizes at the formation of the winter rings were next obtained for each year group in the samples, and these will be found in Table V.

It is perhaps worth pointing out that as the herring becomes older the first summer ring of the scales decreases gradually in value when expressed in terms of the total length of the herring, and therefore what comparison is made must be made between herrings of the same age.

It cannot be said that this part of the investigations throws much light on the difference between the drift and trawled herrings.

But if the increment of growth for 1913 be examined some points of interest appear.

For the drift net herrings the 1913 increments are here given :—

SAMPLES.

Winter Rings.	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.
2	2·1	1·7	2·7	2·8	3·3	3·4	3·7	3·7	3·3	3·4	3·6	3·7	4·2
3	1·3	1·4	1·8	2·1	2·3	2·3	2·4	2·6	2·6	2·4	2·1	2·4	2·5
4	0·8	0·8	1·1	1·1	1·3	1·2	1·1	1·4	1·4	1·5	1·3	1·4	1·4

For the herrings having two winter rings there is a steady increase of growth until sample I is reached, and then another gradual increase to sample L, and finally almost a jump from L to M. Sample B may be neglected as it contained only four herrings of this year class, and each had made little growth for the year.

Herrings with three and four winter rings show a fairly steady increase of growth until reaching samples J and K respectively, when there are decreases, with subsequent gradual increases.

These variations are taken as showing a change in the composition of the herring shoal off our coast.

In the first week of September and the beginning of the second week, immigrants with a smaller increase of growth for 1913, and probably later migrants into the North Sea joined the shoal, the younger herrings coming first. The new arrivals with three winter rings were not present in great numbers in sample J, 6th September, but in sample K, 8th September, they, together with those immigrants having four winter rings, had become the chief fish of these year classes.

The herrings with five winter rings were present in such small numbers that a similar immigration cannot be shown for them.

At the end of the second week of September, sample M, there was to the E.S.E. of the Tyne another change in the composition of the shoal, which may have accounted for the sharp change in the 1913 growth increment of the herrings with two winter rings and the high percentage, ca. 43 per cent., of this year class of herrings.

For the Dogger Bank and Yorkshire coast trawled herrings the 1913 growth increments for those with two, three and four winter rings show too much variation to allow of a distinction being drawn between them. But the herrings of three and four winter rings have a smaller increase than have the drift net herrings of the same age, and are probably still later migrants into the North Sea than those which joined the drift net herrings in the beginning of September.

The 1913 growth increments for the trawled herrings here follow :—

SAMPLES.

Winter Rings.	N.	O.	P.	Q.	R.	S.	T.	U.	V.	W.	X.
2	—	3·7	—	3·6	3·2	3·9	4·3	3·6	4·0	4·2	3·7
3	2·1	2·3	2·3	2·3	2·0	2·3	2·2	2·0	2·2	2·3	2·3
4	1·2	1·2	1·2	1·2	1·1	1·1	1·2	1·0	1·1	1·0	1·2

The numbers of individuals of each year group in the samples will be found in Table 3.

Maturity.—Table VI. The state of the gonads was expressed according to Hjort's method, Pub. de Circ., No. 53, p. 35. In the table, stage 7-2, recovering spents, of which there are few, are classified as stage 7, spents.

In the first samples, those examined in June from North Sunderland, the greater number of the herrings were virgin fish, and the remainder, except two, at stage 2. As the season advanced the gonads increased in size, and towards the end of August and the beginning of September from 40 to 50 per cent. were at stage 4, and a small number of spawning fish appeared, samples I to M.

During the first and second week of September a change appeared in the shoal, and the herrings were at a lower stage of development. This change, which became more marked in the later samples, K to L, affords further reason for considering that there was an immigration of later North Sea migrants into our local shoals. The change as regards maturity in samples K and L coincides with the change shown for the same samples by growth increments for 1913 for herrings having three and four winter rings. Sample M which had such a large number of herrings at a low stage of development, and as will be seen from the other tables of young fish of smaller size than the average run, probably points to the maturing herrings leaving our waters and continuing their southerly migration.

In sample A, taken 19th June, it will be observed that there was present a herring having the body cavity filled with the gonads, that is at stage 5. The question arises, where has this fish come from ? It may possibly be one of the spring herrings which has not developed and spawned with the rest, and has joined the shoal of summer herrings.

A somewhat similar herring, but further developed, the eggs being transparent, was found this year in June when examining a sample caught on the 8th, 15 miles E.N.E. of the Tyne.

The number of spawning and spent fish found in the drift net samples was very small, and cannot be said to point to our local waters being used to any great extent as a spawning area during 1913. And it is probable that no great amount of spawning has taken place in our waters since August, 1911, for this was the last year when haddocks gorged with herring eggs, and locally known as spawny haddocks, were caught in any quantity.

The samples of trawled herrings, with the exception of Q, and the last three samples, contained ca. 50 per cent. of fish at stage 4 and further advanced. Two of the samples contained as high as 30 per cent. of spents. Compared with the drift net herrings the trawled fish had on the whole reached a slightly higher stage of maturity. The last three samples, which contained a large number of herrings at stages 1 to 3, no doubt point to the beginning of the dispersal of the shoal.

The chief differences then between the drift and trawled herrings landed at our local ports are as follows:—The drift net herrings were younger fish, the predominant year class being that with three winter rings, whereas the predominant year class for the trawled herrings had four winter rings, and older fish were more numerous in the samples. The trawled herrings, as shown by the growth increment for 1913, differ markedly from the drift net herrings, and are in all probability later migrants into the North Sea.

This opportunity is taken of expressing sincere thanks for help given by Mr. R. Dawson, of North Sunderland, and by Messrs. I. Turnbull, R. Boyle and A. Bewick, of North Shields.

TABLE I.—DRIFT NET.

Samples.	Numbers.	Date.	Locality.
A ...	1—69	6th June ...	10 miles E. Longstone.
B ...	70—135	19th June ...	Do.
C ...	136—242	16th July ...	10-12 miles E. Dunstanborough Castle.
D ...	243—325	17th July ...	Do.
E ...	326—403	19th August ...	15 miles E. by S. Seahouses.
F ...	404—500	28th August ...	24 miles E.½S. Tyne.
G ...	501—600	29th August ...	24 miles S.E. by E. ,,
H ...	601—700	1st Sept. ...	20 miles E. ,,
I ...	701—799	2nd Sept. ...	23 miles E. by N. ,,
J ...	800—997	6th Sept. ...	20 miles E. by N. ,,
K ...	998—1195	8th Sept. ...	18 miles E.N.E. ,,
L ...	1196—1398	12th Sept. ...	17 miles S.E.¼S. ,,
M ...	1399—1503	13th Sept. ...	25 miles E.S.E. ,,

TRAWL.

N ...	1504—1698	15th Sept. ...	85 miles S.E. by E.¼E. Tyne
O ...	1699—1864	16th Sept. ...	80 miles S.E. by E.½E. ,,
P ...	1865—2052	17th Sept. ...	80 miles E.S.E. southerly ,,
Q ...	2053—2212	18th Sept. ...	120 miles E.½N. ,,
R ...	2213—2307	19th Sept. ...	62 miles E.S.E. ,,
S ...	2308—2467	22nd Sept. ...	75 miles E.S.E. ,,
T ...	2468—2618	23rd Sept. ...	75-79 miles S.E. by E.½E. ,,
U ...	2619—2776	25th Sept. ...	125 miles E.¼N. ,,
V ...	2777—2936	29th Sept. ...	125 miles E.¼N. ,,
W ...	2937—3052	3rd October ...	122 miles E. by N. ,,
X ...	3053—3211	6th October ...	118 miles E.½N. ,,

TABLE II.—SIZE.

Centimetres.

Sample.	18	19	20	21	22	23	24	25	26	27	28	29	30	31
A ...	—	—	—	4	19	35	15	20	7	—	—	—	—	—
B ...	—	—	—	5	11	36	24	18	5	2	—	—	—	—
C ...	—	—	2	9	19	39	19	8	4	—	—	—	—	—
D ...	—	—	—	7	13	30	23	17	6	4	—	—	—	—
E ...	—	—	—	—	—	18	44	32	5	1	—	—	—	—
F ...	—	—	—	—	1	7	19	41	25	4	2	—	—	1
G ...	—	—	—	—	1	9	30	39	18	2	1	—	—	—
H ...	—	—	—	—	—	5	29	34	16	6	5	4	1	—
I ...	—	—	—	1	4	12	29	32	9	4	2	4	2	—
J ...	—	—	—	0·5	1	6·5	30	36	15·5	5	4	0·5	1	—
K ...	—	—	—	0·5	3·5	15·5	35	31	9·5	2	2	1	—	—
L ...	—	—	—	0·5	3	8	28	39·5	15	3	2	1	—	—
M ...	—	—	1	11	16	21	19	22	8	1	—	1	—	—
N ...	—	—	—	—	—	1·5	13	35	23	15	8	4	0·5	—
O ...	—	—	1	3	7	11	13	22	12	11	12	5	2	—
P ...	—	—	—	—	—	1	7	17	19	20	23	9	4	—
Q ...	—	—	—	6	10	13	14	23	11	8	6	6	1	1
R ...	—	—	—	—	1	2	4	18	16	23	21	8	6	—
S ...	—	—	—	1	3	8	11	11	17	21	17	10	1	—
T ...	—	—	—	—	1	1	9	16	18	19	19	9	7	1
U ...	—	—	1	3	6	8	10	12	13	11	16	13	7	—
V ...	—	—	1	6	3	4	8	29	25	11	7	5	3	—
W ...	2	3	11	16	16	13	9	11	10	2	3	3	—	—
X ...	—	—	—	2	8	11	13	22	15	12	6	8	3	1

TABLE III.—AGE.

Winter Rings.

Sample		1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	Nos.	—	7	33	25	4	—	—	—	—	—	—	—	—	—
	%	—	10·2	47·8	36·2	5·8	—	—	—	—	—	—	—	—	—
B	Nos.	—	4	28	20	14	—	—	—	—	—	—	—	—	—
	%	—	6·1	42·4	30·3	21·2	—	—	—	—	—	—	—	—	—
C	Nos.	—	28	59	18	2	—	—	—	—	—	—	—	—	—
	%	—	26·2	55·1	16·8	1·9	—	—	—	—	—	—	—	—	—
D	Nos.	—	14	42	22	5	—	—	—	—	—	—	—	—	—
	%	—	16·8	50·6	26·4	6·2	—	—	—	—	—	—	—	—	—
E	Nos.	—	13	39	20	6	—	—	—	—	—	—	—	—	—
	%	—	16·7	50·0	25·6	7·7	—	—	—	—	—	—	—	—	—
F	Nos.	—	7	43	35	11	1	—	—	—	—	—	—	—	—
	%	—	7·2	44·3	36·1	11·3	1·0	—	—	—	—	—	—	—	—
G	Nos	—	9	40	44	6	—	1	—	—	—	—	—	—	—
	%	—	9·0	40·0	44·0	6·0	—	1·0	—	—	—	—	—	—	—
H	Nos.	—	6	50	27	3	9	3	2	—	—	—	—	—	—
	%	—	6·0	50·0	27·0	3·0	9·0	3·0	2·0	—	—	—	—	—	—
I	Nos.	—	6	53	30	3	1	2	1	1	1	—	1	—	—
	%	—	6·0	53·0	30·0	3·0	1·0	2·0	1·0	1·0	1·0	—	1·0	—	—
J	Nos.	—	13	94	66	16	3	5	1	—	—	—	—	—	—
	%	—	6·5	47·0	33·0	8·0	1·5	2·5	0·5	—	—	—	—	—	—
K	Nos.	—	28	112	47	6	3	1	—	—	—	—	—	1	—
	%	—	14·0	56·0	23·5	3·0	1·5	0·5	—	—	—	—	—	0·5	—
L	Nos.	—	31	95	65	9	1	—	1	—	—	1	—	—	—
	%	—	15·3	46·8	32·0	4·5	0·5	—	0·5	—	—	0·5	—	—	—
M	Nos.	—	44	49	10	1	—	1	—	—	—	—	—	—	—
	%	—	41·9	46·7	9·5	1	—	1	—	—	—	—	—	—	—
N	Nos.	—	—	25	98	39	13	11	4	4	1	—	—	—	—
	%	—	—	12·6	50·3	20·0	6·7	5·7	2·1	2·1	0·5	—	—	—	—
O	Nos.	—	20	42	52	13	10	17	6	2	1	1	—	—	—
	%	—	12·2	25·6	31·7	7·9	6·1	10·3	3·7	1·2	0·6	0·6	—	—	—
P	Nos.	—	—	17	60	38	17	25	13	8	1	3	1	5	—
	%	—	—	9·1	32·1	20·0	9·1	13·4	7·0	4·3	0·5	1·6	0·5	2·7	—
Q	Nos.	—	20	36	49	28	5	9	3	2	—	2	4	1	—
	%	—	12·6	22·6	30·8	17·6	3·1	5·7	1·9	1·3	—	1·3	2·5	0·6	—
R	Nos.	—	2	8	32	15	14	10	4	7	2	—	—	1	—
	%	—	2·1	8·4	33·7	15·8	14·7	10·5	4·2	7·4	2·1	—	—	1·1	—
S	Nos.	1	12	28	40	30	10	23	5	4	5	1	1	—	—
	%	0·6	7·5	17·5	24·4	18·8	6·3	14·3	3·1	2·5	3·1	0·6	0·6	—	—
T	Nos.	—	2	19	46	24	19	15	4	9	5	6	2	—	—
	%	—	1·3	12·6	30·5	15·9	12·6	9·9	2·7	6·0	3·3	4·0	1·3	—	—
U	Nos.	—	16	23	35	20	13	16	9	7	8	5	4	1	1
	%	—	10·1	14·6	22·2	12·7	8·2	10·1	5·7	4·4	5·1	3·2	2·5	0·6	0·6
V	Nos.	—	22	14	63	33	12	2	3	7	1	—	1	2	—
	%	—	13·8	8·8	39·4	20·6	7·5	1·3	1·9	4·4	0·6	—	0·6	1·3	—
W	Nos.	9	53	16	17	11	4	1	2	1	1	—	—	1	—
	%	7·8	44·8	13·8	15·5	9·5	3·4	0·9	1·7	0·9	0·9	—	—	0·9	—
X	Nos.	—	20	26	38	38	3	7	8	7	7	1	2	—	2
	%	—	12·6	16·4	24·1	24·1	1·9	4·4	5·1	4·4	4·4	0·6	1·3	—	1·3

TABLE IV.—SIZE AND AGE.

WINTER RINGS.

Sample.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A ...	—	22·0	23·2	24·1	25·3	—	—	—	—	—	—	—	—	—
B ...	—	22·1	23·2	24·0	24·6	—	—	—	—	—	—	—	—	—
C ...	—	22·1	23·0	24·5	25·8	—	—	—	—	—	—	—	—	—
D ...	—	21·9	23·6	24·5	26·1	—	—	—	—	—	—	—	—	—
E ...	—	23·4	24·2	24·9	25·2	—	—	—	—	—	—	—	—	—
F ...	—	23·2	24·9	25·4	26·4	31·1	—	—	—	—	—	—	—	—
G ...	—	23·7	24·3	25·2	25·8	—	26·8	—	—	—	—	—	—	—
H ...	—	24·1	24·7	25·3	26·2	27·9	27·9	29·1	—	—	—	—	—	—
I ...	—	22·9	24·3	25·2	26·8	28·7	28·0	30·0	29·3	29·2	—	30·0	—	—
J ...	—	23·7	24·4	25·4	26·1	27·9	28·9	27·2	—	—	—	—	—	—
K ...	—	23·2	24·3	25·4	26·0	26·6	27·5	—	—	—	—	—	29·3	—
L ...	—	23·5	24·6	25·3	26·4	28·6	—	26·7	—	—	29·3	—	—	—
M ...	—	22·3	24·4	25·2	25·5	—	29·0	—	—	—	—	—	—	—
N ...	—	—	24·5	25·3	26·3	27·7	28·1	28·9	27·7	29·4	—	—	—	—
O ...	—	22·2	23·9	25·5	26·6	27·3	28·4	28·7	29·3	28·0	28·1	—	—	—
P ...	—	—	24·6	25·8	26·7	27·6	28·0	28·5	29·0	29·0	29·2	28·6	29·5	—
Q ...	—	21·9	23·1	25·0	26·2	26·4	28·2	28·8	28·9	—	29·0	29·9	31·2	—
R ...	—	23·1	25·0	25·8	27·1	27·7	28·4	28·4	28·7	29·3	—	—	30·2	—
S ...	21·4	22·9	24·1	26·0	26·9	27·8	27·8	28·7	28·6	28·9	29·5	29·0	—	—
T ...	—	23·7	24·5	25·8	26·8	27·5	27·9	29·1	29·2	29·2	29·5	29·5	—	—
U ...	—	22·0	23·4	25·3	26·4	27·7	28·0	28·6	29·1	29·0	29·3	29·7	29·2	29·1
V ...	—	22·1	24·7	25·4	26·3	27·5	29·0	28·8	28·7	29·0	—	29·8	29·7	—
W ...	18·4	21·6	23·3	24·6	25·8	26·4	28·3	28·9	28·0	29·0	—	—	29·0	—
X ...	—	22·5	23·7	25·3	25·7	27·5	27·9	28·1	28·6	28·9	28·1	30·3	—	29·3

TABLE V.

Sample.	Winter Rings.	Size.	Size at formation of Winter Ring.					Increase for 1913.
			1	2	3	4	5	
A ...	2	22·0	11·4	19·9	—	—	—	2·1
	3	23·2	9·3	17·4	21·9	—	—	1·3
	4	24·1	8·5	16·1	21·0	23·3	—	0·8
	5	25·3	7·7	15·1	20·6	23·2	24·8	0·5
B ...	2	22·1	11·5	20·4	—	—	—	1·7
	3	23·2	9·9	17·5	21·8	—	—	1·4
	4	24·0	8·4	16·3	21·0	23·2	—	0·8
	5	24·6	8·0	15·6	20·0	22·7	24·2	0·4
C ...	2	22·1	10·6	19·4	—	—	—	2·7
	3	23·0	8·6	16·1	21·2	—	—	1·8
	4	24·5	7·8	15·3	20·7	23·4	—	1·1
	5	25·8	7·3	15·0	19·6	23·4	25·2	0·6
D ...	2	21·9	10·1	19·1	—	—	—	2·8
	3	23·6	8·4	16·5	21·5	—	—	2·1
	4	24·5	7·9	15·4	20·9	23·4	—	1·1
	5	26·1	9·2	17·0	21·9	24·2	25·5	0·6
E ...	2	23·4	10·9	20·1	—	—	—	3·3
	3	24·2	9·4	17·4	21·9	—	—	2·3
	4	24·9	9·0	16·5	21·5	23·6	—	1·3
	5	25·2	7·6	14·9	20·4	23·2	24·5	0·7
F ...	2	23·2	10·5	19·8	—	—	—	3·4
	3	24·9	9·8	18·1	22·6	—	—	2·3
	4	25·4	8·6	16·2	21·8	24·2	—	1·2
	5	26·4	8·0	15·8	21·3	23·9	25·5	0·9
G ...	2	23·7	11·0	20·0	—	—	—	3·7
	3	24·3	9·2	17·4	21·9	—	—	2·4
	4	25·2	8·6	16·4	21·4	24·1	—	1·1
	5	25·8	7·6	15·6	21·3	23·6	25·0	0·8
H ...	2	24·1	10·8	20·4	—	—	—	3·7
	3	24·7	9·6	17·2	22·1	—	—	2·6
	4	25·3	8·7	15·7	21·4	23·9	—	1·4
	5	26·2	10·1	16·9	21·9	24·0	25·5	0·7
I ...	2	22·9	11·5	19·6	—	—	—	3·3
	3	24·3	9·4	17·0	21·7	—	—	2·6
	4	25·2	8·5	15·8	21·3	23·8	—	1·4
	5	26·8	8·0	15·6	22·1	24·7	26·1	0·7
J ...	2	23·7	11·4	20·3	—	—	—	3·4
	3	24·4	9·1	17·3	22·0	—	—	2·4
	4	25·4	7·9	15·6	21·4	23·9	—	1·5
	5	26·1	7·6	15·0	20·9	23·7	25·2	0·9
K ...	2	23·2	10·7	19·6	—	—	—	3·6
	3	24·3	9·1	17·2	22·2	—	—	2·1
	4	25·4	8·3	16·7	21·6	24·1	—	1·3
	5	26·0	8·6	16·2	21·3	23·9	25·3	0·7
L ...	2	23·5	10·7	19·8	—	—	—	3·7
	3	24·6	9·0	17·3	22·2	—	—	2·4
	4	25·3	8·0	16·0	21·4	23·9	—	1·4
	5	26·4	8·9	16·7	22·2	24·3	25·7	0·7
M ...	2	22·3	9·4	18·1	—	—	—	4·2
	3	24·4	8·8	16·9	21·9	—	—	2·5
	4	25·2	8·4	15·9	21·3	23·8	—	1·4
	5	25·5	8·3	15·4	19·7	22·7	24·6	0·9
N ...	3	24·5	9·6	18·0	22·4	—	—	2·1
	4	25·3	8·5	16·6	21·8	24·1	—	1·2
	5	26·3	8·2	16·0	21·4	24·1	25·4	0·9

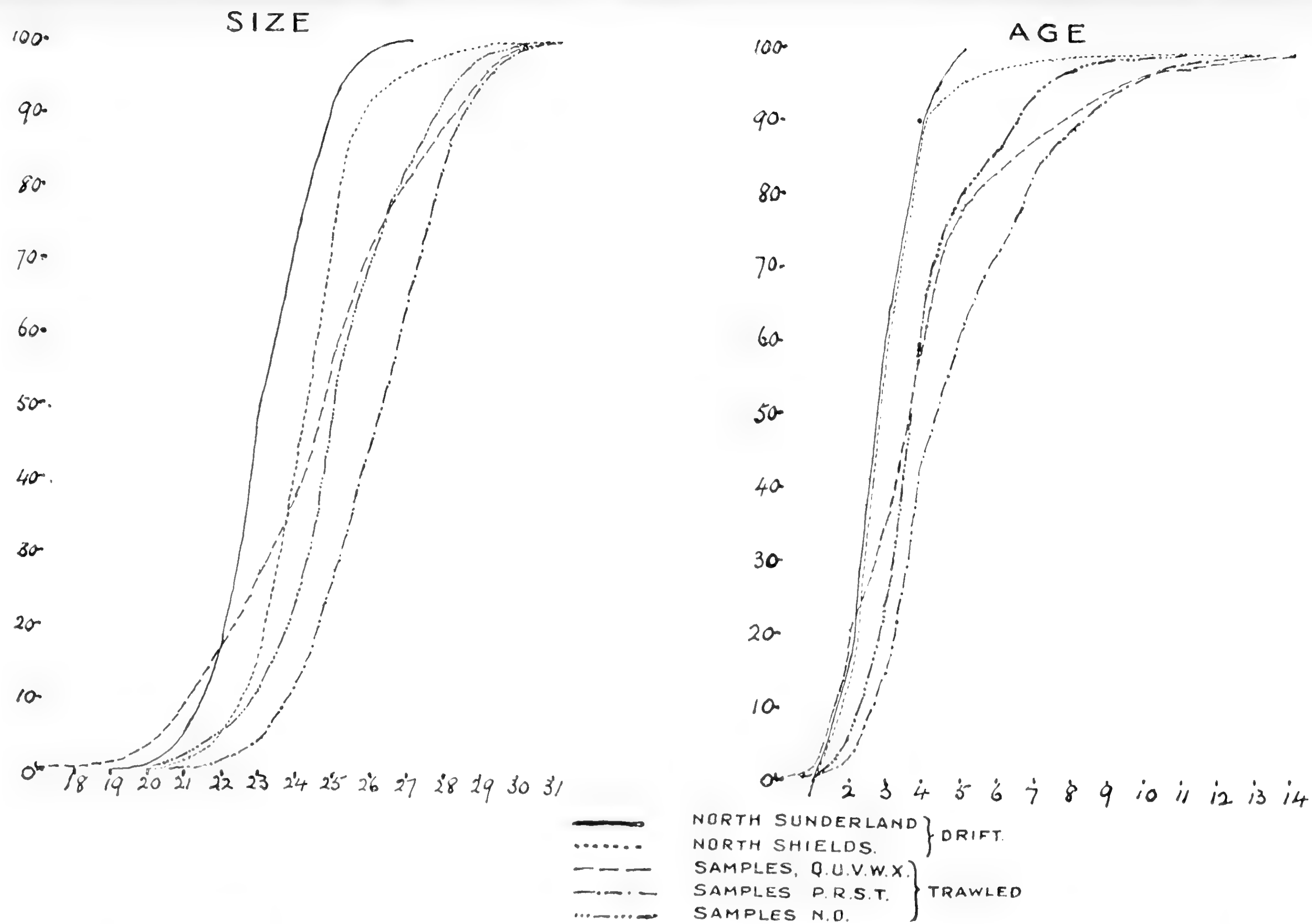
TABLE V.—*Continued.*

Sample.	Winter Rings.	Size.	Size at formation of Winter Ring.					Increase for 1913.
			1	2	3	4	5	
O ...	2	22·2	9·6	18·5	—	—	—	3·7
	3	23·9	8·9	16·8	21·6	—	—	2·3
	4	25·5	8·7	16·6	22·0	24·3	—	1·2
	5	26·6	8·2	16·6	21·9	24·4	25·8	0·8
P ...	3	24·6	9·1	17·1	22·3	—	—	2·3
	4	25·8	8·7	16·9	22·3	24·6	—	1·2
	5	26·7	8·3	16·4	21·9	24·6	25·9	0·8
Q ...	2	21·9	9·8	18·3	—	—	—	3 6
	3	23·1	8·2	15·9	20·8	—	—	2·3
	4	25·0	8·4	16·0	21·5	23·8	—	1·2
	5	26·2	8·0	15·8	21·2	23·9	25·3	0·9
R ...	2	23·1	10·8	19·9	—	—	—	3·2
	3	25·0	9·7	18·3	23·0	—	—	2·0
	4	25·8	8·9	17·0	22·4	24·7	—	1·1
	5	27·1	8·8	16·4	22·4	24·9	26·3	0·8
S ...	2	22·9	10·3	19·0	—	—	—	3·9
	3	24·1	9·2	16·9	21·8	—	—	2·3
	4	26·0	9·0	17·5	22·6	24·9	—	1·1
	5	26·9	8·7	16·8	22·3	24·8	26·2	0·7
T ...	2	23·7	10·0	19·4	—	—	—	4·3
	3	24·5	9·3	17·5	22·3	—	—	2·2
	4	25·8	8·7	17·0	22·2	24·6	—	1·2
	5	26·8	8·8	16·8	22·2	24·7	26·1	0·7
U ...	2	22·0	9·8	18·4	—	—	—	3·6
	3	23·4	9·1	16·8	21·4	—	—	2·0
	4	25·3	8·6	16·7	22·0	24·3	—	1·0
	5	26·4	9·5	17·2	22·2	24·6	25·8	0·6
V ...	2	22·1	9·9	18·1	—	—	—	4·0
	3	24·7	8·7	17·1	22·5	—	—	2·2
	4	25·4	9·1	17·1	22·1	24·3	—	1·1
	5	26·3	8·4	16·2	21·8	24·4	25·6	0·7
W ...	2	21·6	9·3	17·4	—	—	—	4·2
	3	23·3	8·9	16·5	21·0	—	—	2·3
	4	24·6	8·9	16·8	21·5	23·6	—	1·0
	5	25·8	8·7	16·4	21·4	23·9	25·1	0·7
X ...	2	22·5	10·2	18·8	—	—	—	3·7
	3	23·7	9·0	16·6	21·4	—	—	2·3
	4	25·3	8·6	16·7	21·9	24·1	—	1·2
	5	25·7	8·3	15·8	21·1	23·8	25·0	0·7

TABLE VI.—MATURITY.—EXPRESSED IN PERCENTAGES.

Sample.	1	1—2	2	2—3	3	3—4	4	4—5	5	6	7
A ...	65	—	33	—	—	—	—	—	1	—	—
B ...	45	—	49	5	—	—	—	2	—	—	—
C ...	39	—	31	10	12	2	5	2	—	—	—
D ...	28	5	39	7	7	4	6	4	—	—	—
E ...	6	1	10	21	31	6	10	5	9	—	—
F ...	1	1	15	11	9	4	13	16	25	2	—
G ...	2	1	13	12	11	19	19	7	15	1	—
H ...	7	—	9	5	17	8	15	19	15	5	—
I ...	—	2	8	14	19	11	15	18	7	3	2
J ...	—	1	9	11	17	13	21	18	6	4	—
K ...	5	2	24	22	17	10	9	6	4	3	—
L ...	8	—	15	12	27	6	12	8	3	2	7
M ...	27	3	19	17	12	7	6	1	—	—	8
N ...	—	—	4	6	17	7	23	23	13	+	8
O ...	8	+	10	3	16	3	10	16	4	—	30
P ...	—	—	2	4	22	4	18	32	5	+	13
Q ...	6	+	12	6	29	8	19	14	2	+	4
R ...	—	—	4	6	21	4	16	42	—	1	5
S ...	6	+	8	2	17	—	17	14	+	+	35
T ...	—	—	1	1	21	1	15	41	1	3	17
U ...	4	+	8	+	18	4	21	35	8	+	2
V ...	11	—	10	9	32	4	14	17	+	2	2
W ...	40	5	14	3	20	—	14	4	—	—	—
X ...	8	—	13	11	25	2	32	4	1	—	4

HERRING RACES.—CHART I., showing localities of capture of the samples of drift net and trawl herring, 1911-1913.
The Dogger Bank race is indicated by *



HERRING RACES.—CHART II.

MIGRATIONS OF THE CRAB.

By ALEXANDER MEEK.

In continuation of the paper on this subject in the last Report, page 13, a number of additional recaptures have to be recorded. These are shown in detail in the following table.

MIGRATION OF CRABS.

Liberated at Beadnell	Captured.			
Date.	No. of Label.	Date.	Sex.	Place and Migration.
7 x., 1912 ...	12	2 ii., 1914 ...	M.	6 miles S.E. of Beadnell.
	14	1 xi., 1913 ...	F. (19 c.m.)	1½ miles N.W. of St. Abb's Head, 40 fathoms, 29 miles N.
9 x., 1912 ...	36	6 viii., 1913 ...	——	1 mile S. of Longstone.
	41	17 x., 1913 ...	F.	4 miles S.E. of Beadnell.
	88	26 vii., 1913	F.	1 mile E. of Beadnell.
10 x., 1912 ...	135	21 vii., 1913	F. (19 cm.)	½ mile off Fifeness, 55 miles N.
11 x., 1912 ...	160	15 ix., 1913 ...		Claw with label found at London in barrel of crabs from Holy Island.
	179	18 vii., 1913	F. (14·5 cm.)	Beadnell.
12 x., 1912 ...	217	31 vii., 1913	F. (17 cm.)	1½ miles S. of Burnmouth, 21 miles N.
	222	7 viii., 1913 ...	F. 15·5 cm.)	1 mile S.E. of Johnshaven (Montrose), 79 miles N.
15 x., 1912 ...	233	11 x., 1913 ...	M.	5 miles S.S.E. of Beadnell.
	238	21 viii., 1913...	F. (17 cm.)	¼ mile S.E. from Whiting Ness, Arbroath, 67 miles N.
16 x., 1912	255	3 ix., 1913 ...	F. (16 cm.) ...	600 yards off Todhead, Catterline, Stonehaven, 82 miles N.
	258	24 ix., 1913 ...	F. (17·5 cm.)	1 mile N. from Eyemouth, 27 miles N.
	284	23 viii., 1913	M.	1 mile S.E. from Beadnell.
17 x., 1912 ...	289	8 viii., 1913 ...		¾ mile E. of Longstone.
	300	7 viii., 1913 ...	F.	Innerwick, 38 miles N.
	302	17 iii., 1914 ...	M.	2 miles E. of Beadnell.
18 x., 1912 ...	347	18 x., 1913 ...	F. (16·5 c.m)	¾ mile N.E. from Eyemouth, 27 miles N.
18 x., 1912 ...	349	26 iii., 1914 ...	M (13 cm.)....	Beadnell.
7 xi., 1912 ...	372	6 viii., 1913 ...	F. (16 cm.) ...	1 mile S.E. from Craster.
	376	8 viii., 1913 ...	F. (15·5 cm.)	¼ mile N.E. from Berwick, 18 miles N.
	384	25 vii., 1913 ...	F. (18·7 cm.)	1 mile N. from Burnmouth, 24 miles N.
16 xi., 1912...	394	26 vii., 1913 ...	F.	1½ miles N.E. from Berwick, 19 miles N.
	399	4 x., 1913 ...	F. (14·5 cm.)	1½ miles S.E. from St. Abb's, 27 miles N.
2 xii., 1912	469	23 viii., 1913...	F.	1½ miles E. from Beadnell.
3 xii., 1912 ...	486	16 ix., 1913 ...	F. ...	2 miles N.N.W. from Emmanuel Head, Holy Island.

The original number marked between October and December at Beadnell was 500. In the last report 113 recaptures were reported and the above 27 bring the total to 139. Leaving out the three caught early in 1914, the 137 recaptured during the year of liberation represent 27·4 per cent. Up to June 30th the percentage of recaptures was 22. The small number caught since that date may be accounted for by the summer and autumn fishing for crabs being so much less than at other seasons, and also by circumstances tending to loss. It may safely be concluded that the intensity of fishing is about 30 per cent. of the population over gauge size. This includes 42 females which migrated north from the Beadnell region, and in practically every case left Northumberland. The females which did not migrate were at least 64, but the presumption is that very soon all would have similarly left the district, their places being taken by migrants from the south.

The results again indicate the migration of the mature females to the north, and that the migration may in many cases not take place until the second season after that of ecdysis. The recapture of females in the Beadnell region as late as July and October points to the conclusion that the ripening and the migration may be postponed for still another season.

In a footnote to the last report the results of investigations were given to show that the conspicuous migration of the females was due to the ripening of the ovaries. Since then a number of observations have been made which confirm this.

	Non-migratory Female.				Migrating Females.		
No.	Spermathecæ.	Ovary.	Ova.	No.	Spermathecæ.	Ovary.	Ova.
			mm.				mm.
179	Full	Small	22—·28	14	Full ...	Large	·45—·5
				135	,, ...	,,	—
				217	,, ...	,,	·4—·5
				222	,, ...	,,	—
				238	,, ...	,,	—
				258	,, ...	,,	·4—·5
				300	,, ...	Mod.	·28—·3
				347	,, ...	Large	·4—·48
				376	,, ...	,,	·3—·4
				384	,, ...	,,	·3—·36
				399	,, ...	,,	·4—·52

No. 363 which was recaptured at Burnmouth on July 4th, 1913, came to us alive. It was kept in a tank, and spawned on November 5th, 1913. It died on December 1st, and the few eggs left in the ovary measured ·46-·52 mm. The spermathecæ were then empty.

No. 480 which was recaptured one mile south of the Longstone in the Beadnell region on February 26th, 1913, was likewise kept in a tank. It spawned on March 3rd, but did not retain the ova more than a few days. This specimen is still alive.

These observations clearly indicate that the females which have migrated and are approaching the spawning period have large ovaries and practically fully developed ova. Those which were caught in August have the ova and the ovaries well developed, larger at all events than the one which was caught in the Beadnell region. It is more than likely that this example would have migrated almost immediately if it had not been caught. In this example, however, the ovaries were small and light in colour as compared with those which had migrated.

The impulse therefore for the migration northwards is due to the ripening of the gonads. It is an impulse, however, which in this case only affects the female.

In the paper in this report on the "Migrations of the Plaice and Dab," page 52, it has been pointed out that the impulse for the conspicuous migrations of these and other fish is likewise due to the ripening of the gonads, but it affects both sexes. It will be at once apparent that there is a fundamental difference between the two cases. The crab carries with her the sperms in her spermathecæ, often for a long period before they are called into requisition. In the case of the common food fish fertilization takes place by the male shedding his milt at the time that the female is spawning.

I should like to refer here to page 50 of this report, and to say in connexion with what is there stated that the larvæ emanating from the female crabs which migrate to the north of the Northumberland region will be carried southwards along the coast. The young crabs will come to rest on the southern part of the east coast of Scotland, the Northumberland district, and possibly even to the south of the Tyne. As they grow they join in the seasonal migration offshore and inshore, and in this respect and in their relative numbers along the coast they may be said to behave exactly as a school of plaice or other northern migrant.

It has already been stated in previous papers that the northern district of Northumberland supports a much larger number of crabs than the southern, and a glance at the returns will show that similarly such successive regions of relative abundance and scarcity occur all along the east and other coasts. It might therefore be thought that the crabs of the east coast were resolved into a series of schools presenting the respective maxima and minima of a northern migrant. Our experiments, however, indicate that the seasonal migration is restricted to an offshore and inshore movement, and there is no evidence of a migration along the coast.

In the meantime therefore I am inclined to the opinion that the crabs of the east coast as far south say as the Wash belong to one school, and that the distribution is to be explained from the physical and other differences in the various localities tending to be favourable or unfavourable to the species.

THE DRIFT OF LOBSTER LARVÆ AND THE PROTECTION OF THE LOBSTER.

BY ALEXANDER MEEK.

In previous reports I have drawn attention to the gratifying increase in the catches of lobsters in the Northumberland district, and I suggested that the increase was due to the protection of the berried lobster. This conclusion was arrived at from a comparison of Northumberland with the neighbouring districts to the north and south where the berried lobster is not protected. The Northumberland by-law was passed in 1899, and five years thereafter Northumberland advanced into the position of being the district landing most lobsters on the east coast of England. The statistics in proof of this statement have been given in former papers, and in so far as the figures refer to the comparison which is now to be made with the North-Eastern district the following may be added :—

		Northumberland.		North-Eastern.
1912	...	58,301	...	44,396
1913	...	86,765	...	75,406

There was a general increase all along the east coast during the past two years, which does not fall to be considered in the local problem now before us.

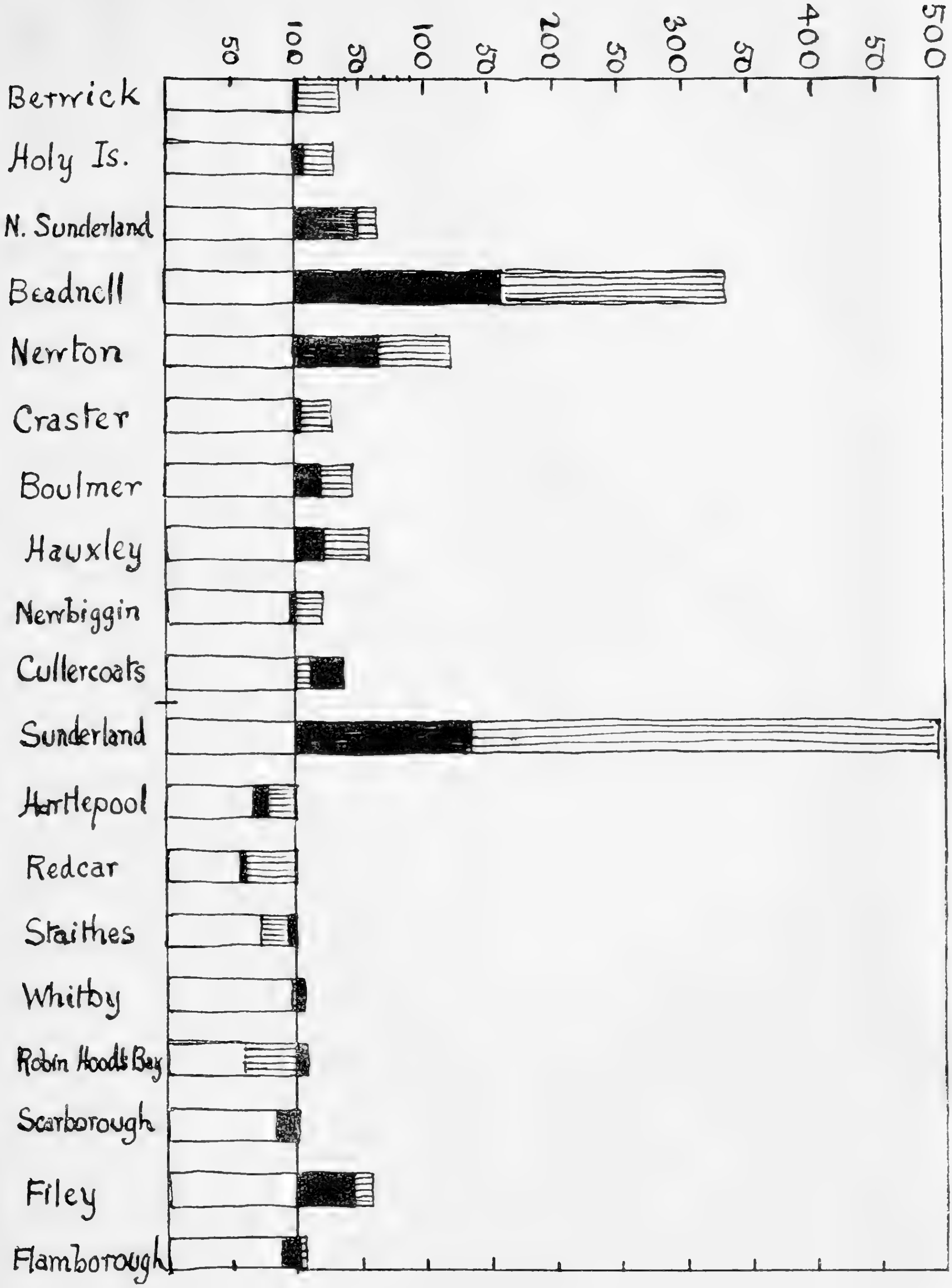
If it be the fact then that Northumberland has gained in productiveness of lobsters, and the only reason which can be specified is the protection of the berried lobster, a more detailed consideration of the contrast between the Northumberland and the North-Eastern districts may be expected to throw light upon the important problem of the drift of larvæ.

I have to thank Mr. Maurice, Under Secretary, and the Statistical Branch of the Board of Agriculture and Fisheries for a table showing the catches of lobsters from 1899 to 1913 at all the fishing stations from Berwick to Grimsby, and for arranging these with averages into five-year periods, 1899-1903, 1904-1908, 1909-1913. The by-law was passed as has been said in 1899, and thus the first period of five years may be considered as a basis in relation to which the gain or loss at the respective stations may be expressed. Only those stations have been utilised at which statistics have been completely obtained during the fifteen years.

In the following table the averages are expressed as gain or loss per cent. as compared with the first period of 1899-1903, and the results are represented graphically in the accompanying chart.

	1899-1903.	1904-08.	1909-13.
Berwick	100	+ 1·5	+ 35·8
Holy Island	100	+ 7·6	+ 32·4
North Sunderland	100	+ 49·9	+ 65·7
Beadnell...	100	+ 166	+ 333·5
Newton	100	+ 642	+ 121·4
Craster	100	+ 3·2	+ 28·1
Boulmer	100	+ 19·7	+ 45·1
Hauxley	100	+ 22·4	+ 56
Newbiggin	100	— 5·7	+ 20·1
Cullercoats	100	+ 36·1	+ 11·6
Sunderland	100	+ 134	+ 488
Hartlepool	100	— 33·6	— 22·7
Redcar	100	— 44·5	— 40·5
Staithes	100	— 10·6	— 28·7
Whitby	100	+ 6	— 3·7
Robin Hood's Bay	100	+ 8·5	— 41·6
Scarborough	100	— 15·6	+ 0·8
Filey	100	+ 44·8	+ 59·1
Flamborough	100	— 15	+ 4·5

It will be seen that from Berwick to Sunderland there has been an increase over the stock of the first five-year period, from Hartlepool to Scarborough a decrease, and again an increase at Filey. This is not exactly what was expected. What one would naturally expect would be a gradual increase from north to south in Northumberland, succeeded by a gradual decrease in the North-Eastern district. The drift of the larvæ therefore is not so great as theoretically it ought to be, or there is a general migration northwards at some period or periods of the lobster's life. The latter assumption receives support from the fact that Berwick and Holy Island share in the increase, and that the southern stations as a whole do not present a greater gain, except Sunderland, which port, for whatever reason, has increased more than any other, and is only approached in this respect by Beadnell. On the other hand, it may be conceded that the larvæ in the neighbourhood of the coast will tend to sink into mid-water, and even towards the bottom, and thus may not drift southwards during the period of their pelagic existence as far as calculation of current would show.



DRIFT OF LOBSTER LARVÆ.

It is a problem therefore which cannot be answered without further enquiry. It will be sufficient in the meantime to draw attention to what appears to be substantiated that the benefit of the by-law is confined to Northumberland and to a distance of say 10 miles south of the area protected.

From their own experiences during the last ten years the Northumberland fishermen are convinced that the improvement in the lobster fishing is due to the protection of the berried lobster, and certainly no other reason for the improvement than that which I have given has been advanced. It will be seen also that were it not for the improvement at Sunderland the condition of the North-Eastern district would be much worse than it is. The protection of the berried lobster in Northumberland and in other districts has been long enough in operation to afford a useful and important indication of its efficacy. Yet in spite of these local lessons in legislation the Board proposes to protect lobsters by making a general size limit of $8\frac{1}{2}$ inches, and to increase the limit as experience may determine. In Northumberland and in the North-Eastern district the limit at present is 9 inches. It is interesting in this connexion to point out that in the Eastern district (to the south of that of the North-Eastern Committee) the limit is only 8 inches, the berried lobster, however, being protected. In that district the productiveness has steadily increased if not so rapidly as in Northumberland. A consideration of this ought to show that the protection of the berried lobster is far more important than gradually raising the size limit.

As I have stated more than once before, the protection of the berried lobster is a sensible step which the fishermen understand and approve of. It is easily carried out, and if made universal would improve the productiveness of the lobster fisheries around the coast. The only objection which has been urged against it, and which seems to have appealed to those in authority, is that the fishermen would try to evade it by stripping the berries from the lobsters. If it were made illegal to land a berried lobster by an Act I am convinced that this would not happen, and in any case it ought to be made public that the berries cannot be removed without so injuring the lobster that the offence can be readily detected.

LOBSTER CULTURE.

BY ALEXANDER MEEK.

Another method of protecting the lobster is by providing hatcheries where the berried lobsters may be retained until the larvæ are hatched, and where the larvæ may be reared to the lobsterling stage. To do this effectually it is desirable in the first place to protect the berried lobster, so that arrangements may easily be made for obtaining a supply of berried lobsters. It has already been ascertained—see our last two reports—that a plentiful supply of larvæ can be obtained by keeping the berried lobsters in large tanks or ponds. But no practical gain to the fisheries would result from this being done, if the berried lobster were protected, unless the larvæ could be reared to the stage when they begin to interest themselves more particularly in the bottom.

During the season of 1913 our experiments were directed to contrasting various kinds of rearing tanks in and outside the Laboratory, and it must be confessed with disappointing results. Towards the end of May twenty-five berried lobsters were placed in one of the supply tanks of the Laboratory, and when the larvæ appeared on July 9th, experiments were instituted in tanks of various sizes at the Laboratory, and an attempt was also made to test a floating tank at the Farne Islands.

The results of the Laboratory experiments are indicated in the following table :—

Tank.	Size.	Capacity.	Number of Larvæ.	Number of Lobsterlings.	Per cent.
	Feet.	Cub. ft.			
Outside—A	$19 \times 11\frac{1}{2} \times 7{\cdot}9$	1748	1000	70	7·0
B	$15 \times 8 \times 2\frac{1}{3}$	280	1000	25	2·5
C	$20 \times 8 \times 2\frac{1}{2}$	400	1000	10	1.0
Inside—D	$9 \times 3 \times 3\frac{1}{2}$	$94\frac{1}{2}$	1000	7	0·7
E	$14\frac{1}{2} \times 4 \times 4\frac{1}{4}$	$246\frac{1}{2}$	500	13	2·6
F	$5\frac{1}{4} \times 4 \times 4\frac{1}{2}$	$94\frac{1}{2}$	250	2	0·8

The water in the outside tanks was renewed during pumping, and in the inside tanks water was running constantly ; and as there was a fair amount of plankton present no food was given. It is possible that better results might have followed if feeding at intervals had been done, but not to such an extent as to enable us to say that some modification of the Laboratory tank method could be recommended for rearing lobster larvæ.

A floating tank was tried at the Farne Islands. It consisted of a wooden frame covered with stout cotton, and was anchored in the only relatively safe place in the region. On July 12th, 750 larvæ were placed in it, and these were fed on plankton every day. Everything went on quite satisfactorily until July 23rd, when a north-east gale tore the cloth from the frame, and allowed the larvæ to escape. The frame was next lined with sailcloth, and 500 larvæ placed in it, but heavy weather again brought about a submersion of the tank at intervals, and the escape of the larvæ.

Although this last experiment was unfortunately unsuccessful, I am becoming more and more convinced that some modification—that is, to suit differences of locality—of the floating tank system is what ought to be aimed at in elaborating an apparatus for rearing lobsters. In Dr. Meade's hands the method has reached a high degree of success. It allows of an adequate exchange of water, the maintenance of a low equable temperature, and a complete control over the work.

There is only one place in Northumberland which at a moderate expense could be utilized for the purpose, the quarry pond at Amble, described in the Report for 1905. This place would allow of an experiment in hatching and in rearing being made on as large a scale as may be desired. The raft with the floating tanks would be amply protected, and to begin with, the whole pond could be used for obtaining the larvæ. At all events, I feel we have gone far enough in laboratory experiment, and what is wanted now is a demonstration on a large scale of the floating tank system.

The hatching tank was emptied on August 8th, and 37 lobsterlings were found. All the berried females, except two, had completely hatched out their larvæ, and one had cast her shell.

Nineteen of the berried females after hatching cast in the Laboratory. These were marked as soon as it was possible to handle them, and were liberated in Cullercoats Bay with the following results :—

Liberated.	Captured		
Date.	No of Label.	Date.	Place and Migration.
1913. 18th Ang. ...	135	11th Sept., 1913 ...	E. of Convalescent Home, Whitley Bay, 1½ miles N.
22nd Aug. ...	391	22nd Sept., 1913 ...	Crab Hill Rocks, Cullercoats.
5th Sept. ...	394	25th March, 1914 ...	12 fathoms E. of Cullercoats.
,, ...	217	30th April, 1914 ...	15 fathoms E. of Whitley Bay, 1 mile N.
,, ...	378	29th May, 1914 ...	14 fathoms E. of Brown's Point, Cullercoats.
28th Oct. ...	347	6th June, 1914 ...	10 fathoms E. of Cullercoats.

All had migrated therefore a short distance to the north or east of Cullercoats.

MUSSEL CULTURE.

BY ALEXANDER MEEK AND B. STORROW.

In the report for last year it was stated that the mussel culture experiment had been continued, and that more mussels from Blyth and Fenham Flats had been transplanted on the Oyster Scaup, and that in order to see if spatting could be encouraged two bouchots had been erected, one on the Oyster Scaup, the other on Fenham Flats.

The transplanted mussels have grown as well as in previous years. The beds are very much thinner than in June of last year, and the Blyth mussels, now of a size large enough to form a fair bait, have disappeared more rapidly than those transplanted from Fenham Flats.

The fences although erected strongly as described have not been able to withstand the sea. That on the Oyster Scaup did not stand longer than June, 1913, and although what was left of it was again fastened as securely as possible it has now disappeared. The fence on Fenham Flats became covered with a great deal of weed. It was found standing in December of last year, now it is down.

The beds of young mussels on the Oyster Scaup referred to in the last report are growing well, and if able to remain will form a valuable source of bait for the fishermen of the immediate neighbourhood.

The fishermen of Holy Island in a few cases form small scaups by transplantation, and these because they are looked after do well. They serve to show that the area responds to transplantation, as our experiments have done, and that no hesitation need be exhibited in declaring that an opportunity for forming a mussel farm is offered, which has every prospect of being successful. The ground would require some degree of preparation, and there are plenty of mussels which could be transplanted in the immediate neighbourhood.

At Easter we enquired as to the distribution of mussels generally on the coast. In addition to the regions which are favourable to mussels, there are places all along the coast where spat lodges, but which are quite unfavourable to growth. On the Northumberland coast the more or less favourable situations are Berwick, Holy Island (Snook and Fenham), Budle, Amble, Blyth and Tynemouth. Small stunted mussels occur often in large numbers near Emmanuel Head, Holy Island, at Bamborough, Wideopen (Farnes), both sides of North Sunderland harbour, Beadnell, Craster, Howick, Boulmer, Alnmouth, Cresswell, Newbiggin and Cullercoats. The presence of these all along the coast shows to what an extent mussel larvæ are distributed by the currents, and that the spat of a particular mussel bed may be carried far away from its place of origin. Considering the fact that the larvæ may take a week or a fortnight to settle, and the completeness with which the drainage of a mussel scaup may remove the water at each tide the problem of the origin and distribution of the spat is an important one, which involves not merely the area in question, but another, as on the east coast, to the north of it. St. Andrews mussels may depend on the Tay, Fenham mussels on the Tweed.

It is a little more difficult to understand the apparent or real rapid growth of the mussels gathered from the chains of coastal buoys. These, we are led to understand, are renewed every year, and at every time of replacement are found to be covered with large bait mussels of good quality. This points either to a marvellously rapid growth or to a migration, wherever from, which it is difficult to explain.

The Budle Bay mussel beds have now been leased to the fishermen of Sea Houses. We have recommended them to utilize the oyster pond as a spatting area, and if they do this the results will have an important bearing on the question of mussel culture.

POLLUTION OF THE TYNE.

BY A. MEEK AND G. SISSON.

In view of the interest which has been aroused on this subject, and the conference of representatives of local authorities and interests which is to be held in Newcastle under the chairmanship of Mr. C. E. Fryer, I.S.O., Chief Inspector of Fisheries of the Board of Agriculture and Fisheries, we venture here to submit briefly the results of the examination of samples of water from the Tyne taken in October, 1912, and August, 1913. The samples were taken at the places mentioned in Winchesters, held at arm's length beneath the surface, and from three positions, viz., in the centre and near each side of the river. They give therefore a fair analysis of the whole body of water moving past each place

The results show that there is in particular a polluted zone opposite Newcastle, which moves up and down with the tide, but is never entirely removed, even under the most favourable conditions. This zone is very deficient in oxygen, and is usually characterised by a strong smell. It is brought into this condition by the discharge of sewage and trade effluents into the river and the neighbouring streams. Both these effluents take up oxygen; and the absence of dissolved oxygen naturally causes the water to be unable to support fish life. The dissolved and suspended matters have also an actively poisonous effect on fish.

The result is seen in the regrettably large number of salmon which annually perish in attempting to pass up the river to the spawning grounds.

A.—16TH OCTOBER, 1912.

No.	Time p m.	°F	Place.	Per Litre. Occ.	Per Litre. Ncc.	Per Litre. CO_2cc.	Per Litre. NaCl. gms.
1	12·45	50	Opposite Blaydon Brick Works ...	6·0	18·0	9·3	1·85
2	12·55	51	Opposite Blaydon Manure Co. ...	4·5	16·3	9·0	2·80
3	1·10	51	Entrance Blaydon Burn	5·8	16·8	7·9	3·53
4	1·20	50	Coal Staiths, Dunston	5·8	16·3	7·9	5·85
5	1·30	51	Entrance Derwent River	5·4	17·2	5·4	1·86
6	1·55	54	Entrance Team River	3·1	15·9	17·3	1·46
7	2·0	51	Fifty yards above Redheugh Bridge ...	4·0	17·0	7·9	9·94
8	2·5	51	Under King Edward Bridge	2·7	16·5	7·8	10·40
9	2·15		Newcastle Quay Landing Stage ...	Nil.	16·6	28·6	7·02

REMARKS.

Nos. 1, 2, 3, 4, 5, on standing deposited a small amount of sediment, and did not show any unpleasant odour.

Nos. 6, 7, 8, on standing deposited a considerable amount of sediment. No unpleasant odour except No. 8 which smelt slightly of paraffin oil.

No. 9—taken not far from sewer outfall—deposited a large quantity of sediment, and had a very putrid odour.

The tide began to flow about 1·30, consequently Nos. 7, 8, 9 samples are of water backed up by the incoming tide.

The figures show that the river water is well aerated and not much polluted at low water, from Derwent outflow upwards. As the tide rises, however, the grossly polluted water from the lower reaches, from Scotswood downwards will be backed up and cause pollution up past Blaydon.

B.—August 5th, 1913.

No.	Place.	O Per Litre.	% Sea Water.
1	Four samples opposite Swan & Hunter's	1·5	65
2	Three samples opposite Holzapfels	1·0	65
3	Four samples opposite St. Anthony's	Nil.	64
4	Three samples opposite Langdale's	Nil.	64
5	Dunston Staiths	4·0	53
6	Ryton	5·0	18

NOTES.

Nos. 1 and 2 contain a very deficient quantity of oxygen.

Nos. 3 and 4.—In these places the oxygen has been removed by organic and other matter.

No. 4.—Very putrid and contains sulphuretted hydrogen.

This proves that 30 or 40 % of the river water is sufficient to make the whole mass putrid, assuming that the sea water is fairly pure which we know it to be.

CATALOGUE OF THE HYDROZOA OF THE NORTH-EAST COAST.

(NORTHUMBERLAND AND DURHAM.)

BY J. H. ROBSON, B.SC.

Two catalogues * of the Zoophytes of Northumberland and Durham have been published by the Tyneside Naturalists' Field Club, followed by additional lists and notes in the Transactions of the Natural History Society of Northumberland, Durham and Newcastle-on-Tyne. In the present paper these separate accounts are gathered together to form a complete catalogue, and the list has been brought up to date by the addition of notes made at the Laboratory during 1912 and 1913. The arrangement followed in this catalogue is that adopted by Professor Hickson in the Cambridge Natural History (1906). The name printed in italics after the present title is that under which the species appeared in Alder's catalogue.

A number of species (20) appearing in the earlier records have not been obtained in the recent investigations; these are chiefly Calyptoblastea. On the other hand, eight Calyptoblastea, six Leptomedusæ, and seven Gymnoblastea (including one new species) have been added to the list. These are indicated by an asterisk.

The material has been obtained from a variety of sources, and includes preserved specimens dredged by the "Evadne" during the summer months (reported on in a previous paper); living material from the rocks and pools near Cullercoats, and from the fishing boats; while the Laboratory tanks furnished a number of the medusoid forms.

HYDROZOA.

FAMILY BOUGAINVILLIIDÆ.

The new species of Hydrozoa described on page 104 will probably be included in this family.

* Those of Dr. Johnston (1832) and Joshua Alder (1858).

1. PERIGONIMUS REPENS, T. S. Wright. *Atractylis repens* Wright.

On *Dentalium entalis,* the operculum of Fusus, and other shells. Alder.

Common on operculum of Buccinum (and on the shell itself), and on Dentalium, Turritella, Hyas, &c.; dredged at Stations 1, 7, 9; 30 miles east of Cullercoats, and 5½ miles east of Blyth.

Gonophores in July, medusoids liberated September-February.

2. PERIGONIMUS LINEARIS (Alder). *Atractylis linearis,* Alder.

On Turritella, *Astarte danmoniæ* and other shells from deep water, Cullercoats. Alder.

3. DICORYNE CONFERTA (Alder). *Eudendrium confertum,* Alder.

On Buccinum and Fusus from deep water, Cullercoats. Alder.

Large colonies on Dentalium and the operculum of Buccinum dredged from Stations 4, 6, 8, and 8 miles E.½S. of Cullercoats.

Gonophores: August.

4. BOUGAINVILLIA RAMOSA (Van Beneden). *Atractylis ramosa,* Van Beneden.

From the deep water fishing boats. Alder.

From 14 fathoms east of Cullercoats, growing on Flustra, also on Turritella, 5½ miles east of Blyth (Kramp).

Gonophores: medusoids liberated July-October.

A few abnormal medusoids were noticed, having the following peculiarities:—

(1) Three labial tentacles and five tentacular bulbs, one of which possessed only one tentacle, another having three (with three black ocelli).

(2) Four labial tentacles, one of which was branched; only one tentacle springing from each of the four bulbs, but two black pigment spots on each bulb.

5. ATRACTYLIS ARENOSA, Alder.

Occasionally at Tynemouth and Cullercoats, on the underside of stones. Alder.

6. EUDENDRIUM RAMEUM (Pallas).

Not infrequently brought in on the fishing lines at Cullercoats. Alder.

From Station 7, 26 miles east of the Longstone (very small specimens).

7. EUDENDRIUM RAMOSUM (Linn.).

In the coralline zone, Cullercoats, rare. Alder.

Small specimens growing on other zoophytes from Stations 3 and 4.

8. EUDENDRIUM CAPILLARE, Alder.

On *Antennularia ramosa*, Embleton Bay. R.E.

(? Sp.), from Station 7.

FAMILY PODOCORYNIDÆ.

1. PODOCORYNE CARNEA, Sars.

Hincks quoted Cullercoats as a locality for this species with Alder as his authority, but I cannot find it in Alder's own lists.

It is common from deep waters on *Buccinum undatum* (both the shells inhabited by the mollusc and old shells occupied by hermit crabs), *Neptunea antiqua*, Cydaria, *Volsella modiolus* and *Tritonofusus gracilis*.

Gonophores: medusoids in February, April and May.

In all the specimens I observed the characteristic spines were extremely rare; in every case the medusoid had eight tentacles when liberated; some colonies were deep rose colour, others almost white. I observed several branched hydranths bearing two or even three heads on one stalk (Plate IV. *b*).

2. PODOCORYNE AREOLATA (Alder). *Hydractinia areolata*, Alder.

On a dead shell of *Natica alderi* from the boats, Cullercoats. Alder.

Dredged from 30 fathoms east of Cullercoats, and 8 miles E.½S. of Cullercoats, growing on *Hyas coarctatus*.

3. CORYNOPSIS ALDERI (Hodge). *Podocoryne alderi*, Hodge.

Deep water, Seaham Harbour, Durham; on Serpula. Hodge.

4. HYDRACTINIA ECHINATA (Fleming).

Frequently on old univalve shells. Alder.

Very common on *Buccinum undatum*, and a dead shell of Natica.

Gonophores: September and November.

Many of the specimens obtained were very dense colonies, and the crowded hydranths were growing up the sides and on top of the spines. These colonies also showed the remarkably large swollen hydranths (scattered amongst the normal hydranths) noted by Marktanner in connection with another species of Hydractinia. These zooids measure four times the diameter of normal hydranths and twice or three times the height. The entoderm is folded into convoluted ridges, which sometimes gives the zooid a striated appearance externally.

Family Cladonemidæ.

* CLADONEMA sp.

A medusoid was described under this title in the report of 1912. Four specimens have since been obtained, and more complete observation of the structure has been possible. It now appears that this is not the young medusoid of Cladonema (as then thought possible) but, considering the presence of four distinct marginal sense-organs (represented in the drawings, but overlooked in comparing it with Cladonema) it seems probable that it is a Leptomedusa. The number of oral lobes, indistinguishable in the first specimen, is now known to be four.

The hydroid from which this medusoid originated has not yet been discovered.

* STAURIDIUM PRODUCTUM, Wright.

Growing on stones in the Laboratory tanks.

The four "false tentacles" appear at the same time as the second verticil of capitate tentacles and not with the first verticil, as supposed by Hincks.

Family Tubulariidæ.

1. TUBULARIA INDIVISA, Linnæus.

Not uncommon at and beyond low water, and in deep water. Alder.

Commonly brought in on the fishermen's lines, and dredged from Stations 1, 3, 4, and 7; 6 miles east of the Longstone, 5½ miles east of Blyth, and 40 miles north-east of Shields (45 fathoms).

Gonophores: December-April.

Great variation in size was shown, the diameter of the hydranths being from 7 mm. to 20 mm.

2. TUBULARIA CORONATA, Abilagaard. *Tubularia gracilis*, Harvey.

Generally on a muddy bottom, in the coralline zone and deep water, frequent. Alder.

Dredged at Stations 5, 7, 8, and 8 miles east by south of Cullercoats (on a muddy bottom).

Gonophores: September.

3. TUBULARIA SIMPLEX, Alder.

On shells, &c., from deep water. Alder (also Embleton and Johnston).

Dredged from Station 4.

4. TUBULARIA LARYNX, Ellis and Solander.

On stones near low-water mark, frequent. Alder.

5. CORYMORPHA (HALATRACTUS) NANA (Alder).

From the fishing boats at Newbiggin, very rare. Two living individuals at Cullercoats. Alder.

6. CORYMORPHA NUTANS, Sars.

Seaham Harbour, Durham, not uncommon in from 6-12 fathoms (G. Hodge). Alder.

Family Pennariidæ.

VORTICLAVA HUMILIS, Alder.

On *Corallina officinalis* in a rock-pool between tide-marks, Cullercoats. Alder.

Family Corynidæ.

1. CORYNE PUSILLA, Gaertner. *Coryne ramosa*, Ehrenberg.

In rock pools, Tynemouth (R. Howse). Alder.

Large colonies in shallow pools, Cullercoats, both branching and simple forms.

A distinct cup is usually present at the base of the hydranth (see Plate IV. *a*).

Gonophores in May, June and September.

2.* CORYNE VAN-BENEDENII, Hincks (?).

In the trawl net of the "Raider," 1911, 40 fathoms east of Coquet Island, growing on *Cellepora avicularis*.

Gonophores : July.

Species doubtful, as the specimens obtained (in spirit) were poor and shrivelled, and it was impossible to identify them with certainty.

3. SYNCORYNE EXIMIA (Allman). *Coryne listeri*, Van Beneden.

Very abundant. Alder.

In pools at Cullercoats, not very common.

The larval sacs of the Pycnogon, *Phoxichilidium femoratum* were observed on one colony of *S. eximia*, with larvæ very well developed in October.

4. * SYNCORYNE GRAVATA (T. S. Wright).

A small colony growing on a bottle brought by a boat from 21½ fathoms east by south of Marsden, Durham.

Gonophores : developing in February.

5. SYNCORYNE SARSII, Lovén.

On Laminaria roots, Cullercoats ; rare. Alder.

At the beginning of May I found in a shallow pool a colony of *Syncoryne sarsii* bearing the interesting type of gonozooid described by Agassiz in connection with *S. gravata*, and by Lovén with *S. ramosa*, Ehrenberg (*S. lovéni*, Sars.) and *S. sarsii*.

Instead of the normal medusoid with its globular bell, four long tentacles and short manubrium, the medusiform bodies were ovate, with a long manubrium (reaching to the base of the bell) inflated with ova, and the tentacles were represented by small pigmented bulbs (Plate III.).

The zooids were borne sometimes at the base of the polypite (which never appeared partially atrophied) sometimes quite solitarily at the end of a long stalk, in which case there was no trace of any polypite. They pulsated most actively, but I have never observed them to drop off and swim away, and have come to the conclusion that they do not do so. Towards the end of the breeding season the umbrella had degenerated, and the ova were being set free from the manubrium *in situ*.

The medusoids "*Sarsia tubulosa*" were very abundant in the supply tanks in July (with a few ova remaining at the end of the long manubrium), also in June in the open sea, and sometimes cast up on shore.

6.* SARSIA PULCHELLA, Allman.

Very common in the Laboratory tanks on stones, &c.
Gonophores : medusoids liberated December-April.

7. SYNCORYNE sp.

Small Syncoryne, probably young forms, were found growing on other Hydroid stems, dredged from Stations 2, 3, 7 and 8.

8. ZANCLEA IMPLEXA (Alder). *Coryne implexa, Coryne pelagica, Tubularia implexa.*

On an old anchor from 40 fathoms, 30 miles east of Holy Island (Howse). On shells of *Fusus antiquus* from deep water, Cullercoats. Alder.

On Anomia from 45 fathoms, 40 miles north-east of Shields.
Gonophores : buds present in April.

Family Clavidæ.

1. CLAVA MULTICORNIS (Forskaal).

Not uncommon between tide-marks. Alder.
Not very common ; in rock-pools, &c.
Gonophores in May, June and September.

2.* CLAVA SQUAMATA (Müller).

Very rare, washed up on *Fucus vesiculosus* at Cullercoats, 1912.

Gonophores in October.

3. TUBICLAVA CORNUCOPEIA, Norman.

On *Dentalium entalis*. Alder.

CALYPTOBLASTEA—LEPTOMEDUSÆ.

Family Thaumantiidæ.

A small number of medusæ, apparently belonging to this family, were obtained in the tow-net by the "Evadne" in June, 1912, but as they were only observed in the preserved state they could not be identified with certainty. Three species were distinguished.

1.* THAUMANTIAS sp. (Plate V., 1*a*, 1*b*.)

One specimen in good condition (excepting for the sense organs) from the Kettle (Farne Islands), June 27th, 1912. This was the largest specimen, with a diameter of one inch, and with the peculiarity that the mouth appeared not to have been broken through. That is to say, the large stomach was produced into a conical peduncle, which, instead of opening to the exterior by a definite manubrium, was covered by an extremely thin membrane-like layer, apparently continuous with the sub-umbrella.

Description: Umbrella shallow, sub-umbrella much depressed. Radial canals conspicuous, narrow, four in number. Gonads at distal end of the radial canals, four, long. Marginal tentacles 36 in each quadrant, making about 144 in all, short, spirally coiled and smooth. Marginal vesicles indistinguishable. Velum extremely narrow. Manubrium absent; stomach large and square, peduncle conical and ending blindly.

2.* THAUMANTIAS THOMPSONI, (?) Forbes. (Plate V., 2*a*, 2*b*, 2*c*.)

From north-east of Newbiggin, 15 fathoms, June 26th, 1912. A few specimens measuring about $\frac{1}{4}$ inch diameter.

The umbrella shallow, sub-umbrella depressed; four very delicate radial canals; 16 marginal tentacles roughened by rings of thread-cells, springing from large bulbs; marginal vesicles, two on each side of the adradial tentacles, making 16 in all; manubrium with four frilled lobes, the margin of which is conspicuous (*cf.* the "fibrous cells" described by Forbes).

3.* THAUMANTIAS sp. (*T. hæmispherica*, Forbes ?). (Plate V., 3*a*, *b*, *c* and *d*.)

Two specimens from the Kettle (Farne Islands), June 27th, 1912, measuring half-an-inch in diameter.

Umbrella depressed, four radial canals with four ovate gonads at their distal ends, marginal tentacles springing from rather square bulbs, 28 in one specimen, 32 in the other, with buds growing out between ; the marginal vesicles were not present, having probably been destroyed ; the manubrium was four-lobed.

4.* AGLANTHA ROSEA (Forbes).

From all Stations in October, 1912, and especially from Station 3.

Family Plumulariidæ.

Group I.—Eleutheroplea.

1. PLUMULARIA PINNATA (Linn.).

Not uncommon from low water to deep water. Alder.

Dredged from Station 8, and 6 miles east of the Longstone.

Gonophores : capsules in July.

2. PLUMULARIA SETACEA (Ellis).

Frequent at low water and in shallow water. Alder.

Dredged from Stations 4 and 7 (17 fathoms and 35 fathoms), and from the lines, 22 fathoms east of Cullercoats.

Gonophores : full and empty capsules in January.

3. PLUMULARIA CATHARINA, Johnston.

Frequent on Zoophytes and Ascidia from deep water. Alder.

Dredged from Stations 7 and 8, and 6 miles east of the Longstone.

Gonophores : capsules in July.

4 PLUMULARIA ECHINULATA, Lamarck.

Not rare, Cullercoats and Ryhope. Alder.

Dredged from Stations 7 and 9, and 8 miles E.½S. of Cullercoats.

5. PLUMULARIA HALECIOIDES, Alder.

Not common, Cullercoats and elsewhere. Alder.

Cullercoats, on sides of rock pools and Laminaria roots, rather rare.

6. PLUMULARIA FRUTESCENS (Ellis and Sol.)

Rare, Cullercoats and Whitburn. Alder.

The Plumularian described in the 1912 Report as an uncertain species is most probably *Plumularia frutescens*, with which the gonophores (subsequently observed) are identical. Rather rare, from Stations 7 and 8.

Gonophores : in February.

7. ANTENNULARIA ANTENNINA (Linn.).

Frequent, from the coralline zone and deep water. Alder.

Washed up, dredged from Stations 3, 7, 8, 9, &c. and very commonly got from the lines.

8. ANTENNULARIA RAMOSA, Lamarck.

Same situations as the last, but less frequent. Alder.

Dredged from Station 7, north-east of St. Mary's Island, and occasionally got from the lines.

Group II.—Statoplea.

1. AGLAOPHENIA PLUMA, Linn. *Plumularia cristata*

Whitburn Bay, Durham, a single specimen obtained by Miss Dale. Alder.

2. AGLAOPHENIA MYRIOPHYLLUM, Linn. *Plumularia myriophyllum*, Linn.

A single specimen from Embleton Bay (R. Embleton). Alder.

Family Campanulariidæ.

1. CAMPANULARIA VOLUBILIS (Linn.)

On other Zoophytes from deep water, frequent. Alder.

Common, dredged from Stations 1, 2, 3, 4, 6, &c.

2. CAMPANULARIA HINCKSII, Alder.

Rather rare, on shells and stones from deep water. Alder.

Dredged from Stations 4 and 7, 6 miles east of the Longstone, and on Buccinum shells with hermit crabs, rare.

3. CAMPANULARIA INTEGRA, Macgillivray.

On roots of Laminaria and Ascidians, low water, Bamborough. Alder.

4. CAMPANULARIA VERTICILLATA (Linn.)

Not rare, deepish water. Alder.

Commonly dredged, Stations 2, 3, 7, 5½ miles east of Blyth, 8 miles east by south of Cullercoats, and washed up.

6. CAMPANULARIA FLEXUOSA, Hincks. *Laomedea flexuosa* Hincks.

Frequent on rocks and seaweed. Alder.

On the rocks at Cullercoats, common.

7. CAMPANULARIA NEGLECTA, Alder. *Laomedea neglecta,* Alder.

Between tide-marks. Alder.

Growing on Hyas, dredged from Station 4 (Dunstanborough).

Gonophores: capsules with sporosacs in the marsupia in June.

8. CAMPANULARIA RARIDENTATA, Alder.

Occasionally on other Zoophytes, Cullercoats. Alder.

A few calycles occasionally on other Zoophytes from Stations 1 and 8. This species is a little uncertain, as some of the margins had up to eight teeth, and may have been young specimens of some other form.

9.* GONOTHYREA GRACILIS (Sars).

Common; small quantities dredged from Stations 8 and 9, 8 miles east by south of Cullercoats, 6 miles east of the Longstone, and 40 miles east of Shields, growing on Cyprina and Mytilus. Mr. Kramp records it from the rocks at Cullercoats.

Gonophores: capsules partially full in September and April.

10. GONOTHYREA LOVÉNI, Allman.

On stones between tide marks, Cullercoats. Alder.

11.* GONOTHYREA HYALINA, Hincks.

Very common, dredged from Stations 3, 4, 8 and 9; from 8 miles east by south of Cullercoats, in 17 fathoms east of Howick Burn, and 6 miles east of the Longstone.

12. LAFOËA DUMOSA (Fleming). *Campanularia dumosa,* Fleming.

Common in deep water. Alder.

Both varieties (*L. dumosa* var. *robusta* and *L. dumosa* var. *B.*) very common on Zoophytes, Ascidians, shells, &c.

13. LAFOËA FRUTICOSA, Sars. *Campanularia gracillima*, Alder.

Occasionally. Alder.

Not very common, from Stations 3, 4, 7 and 8, and a fine colony on Cyprina, from 40 miles north-east of Shields.

14. CALYCELLA PYGMEA (Alder). *Lafoëa pygmea.*

Tynemouth. Alder, MS.

15. CALYCELLA SYRINGA (Linn.) *Campanularia syringa*, Linn.

Not uncommon. Alder.

Extremely common from all stations.

Gonophores : capsules with sporosacs in the marsupia in June.

16. CUSPIDELLA HUMILIS, Hincks. *Campanularia humilis*, Hincks.

Occasionally. Alder.

Rare, on other Zoophytes from Stations 7 and 8.

17.* CUSPIDELLA GRANDIS, Hincks.

Occasionally, on old Pecten and Mussel shells, and roots of *Sertularia argentea*, from Stations 7, 8 and 9, and 22 fathoms east of Cullercoats (from the lines) ; on Cyprina from 40 miles north-east of Shields.

18. FILELLUM SERPENS (Hassall). *Reticularia serpens*, Hassall.

Common from deep water. Alder.

Very common on other Zoophytes

Gonophores : coppinia masses in January and February.

19. SALACIA ABIETINA (Sars). *Grammaria ramosa*, Alder.

Rather rare, from the boats, Coquet and Berwick Bay. Alder.

20. HALECIUM HALECINUM (Linn.)

Common in the coralline zone and deep water. Alder.

Common from deep water, Stations 3, 4, 7 and 8 ; in 30 fathoms east of Cullercoats, and 8 miles E.½S. of Cullercoats.

Gonophores : male capsules in June, female capsules in September.

21. HALECIUM BEANII, Johnston.

From the boats, rather rare. Alder.

With vesicles in January. J. Coppin.

Dredged from Stations 1 and 7 (small colonies), and 40 miles north-east of Shields.

Gonophores: female capsules in September.

22. HALECIUM MURICATUM (Ellis and Sol.)

Abundant at Cullercoats (Coppin), Seaton (Hodge), Cullercoats and Whitburn, occasionally. Alder.

Not common, dredged from Station 7, and got from the lines occasionally, on other Hydroids. A fine branch was obtained by a trawler off Whitby (Yorkshire).

23. HALECIUM LABROSUM, Alder.

Deep water, Northumberland. Alder.

24. HALECIUM TENELLUM, Hincks. *H. labrosum* (young) Alder.

On other Zoophytes from deep water, occasionally. Alder.

Frequently met with on other Hydroids, but generally very small colonies, and often unbranched forms. Dredged from Stations 3, 5, 6, and 7.

FAMILY EUCOPIDÆ.

1.* PHIALIDIUM VARIABILE, Haeckel.

Often recorded in June from Druridge Bay, Inner Farnes, Cambois, &c.

2. CLYTIA JOHNSTONI (Alder). *Campanularia johnstoni*, Alder.

Common between tide-marks to deep water. Alder.

Very common in pools and from all stations, growing on other Hydroids, shells, Polyzoa, Crustaceans and seaweeds.

Gonophores: capsules containing medusoids in April and June. Medusoids in the Laboratory tanks from August to December, occasionally in January and February.

3. CAMPANULARIA ACUMINATA (Alder.) *Laomedea acuminata*, Alder.

On an old shell of *Fusus antiquus* from deep water, Cullercoats, Alder.

One large colony on an old shell of Cyprina from 45 fathoms, 40 miles north-east of Shields.

Gonophores: medusoids in Laboratory tanks August-December and occasionally in May.

4.* CAMPANULARIA REPENS, Allman.

Three fine colonies on other Hydroids, from Station 4 or Station 9, and 6 miles east of the Longstone.

Gonophores: June (?).

5.* CAMPANULARIA TURRITA, Hincks.

The localities from which this species and *C. repens* were obtained have unfortunately been confused. *C. turrita* is rare, and (I think) was obtained from Station 3 and 9, in very small quantities.

6. OPERCULARELLA LACERATA (Johnston). *Laomedea lacerata*, Johnston.

Berwick Bay, also at Cullercoats. Alder.

Very common on Sertularians, Nymphon, &c., from Stations 2, 3, 4, 6 and 9.

7. OBELIA GENICULATA (Linn.) *Laomedea geniculata*, Linnæus.

Very common. Alder.

Common in pools, and from 8-12 fathoms (Stations 5 and 6).

Gonophores: capsules (full of medusoids) September and May.

8.* OBELIA FLABELLATA, Hincks.

Very common, washed up on seaweeds, and dredged from Stations 6 and 7, and 8 miles east by south of Cullercoats.

Gonophores: medusoids set free in October.

9. OBELIA DICHOTOMA (Linn.) *Laomedea dichotoma* Linnæus).

In pools between tide marks, Bamborough, rare. Alder.

Small colonies from Stations 4, 6, 7, 8, and 6 miles east of the Longstone, also 8 miles east by south of Cullercoats.

Gonophores: capsules in September.

10. OBELIA LONGISSIMA (Pallas). *Laomedea longissima*, Pallas.

Northumberland, frequent. Alder.

11.* OBELIA PLICATA, Hincks.

Fairly common, dredged from Stations 1, 4, 7, 8 and 9, growing on shells, stones and worm tubes.

Gonophores : capsules (with medusoids) in June.

Family Sertulariidæ.

1. SERTULARELLA POLYZONIAS (Linn.)

Not uncommon from beyond low water to deep water. Alder.

Dredged in abundance from Station 8, 6 miles east of the Longstone, also from Station 7, on the root-clump of Antennularia got from the lines, and growing on a living *Buccinum undatum.*

Gonophores : empty capsules found in September.

2. SERTULARELLA GAYI (Lamouroux). *Sertularia gayi*, Lamouroux.

Occasionally in deep water. Alder.

3. SERTULARELLA TRICUSPIDATA, Alder.

From the deep water boats during spring, not rare. Alder.

4. SERTULARELLA RUGOSA (Linn.)

Low water to deep water, frequent. Alder.

Growing on the point behind the north breakwater, Cullercoats ; dredged from Stations 3 and 6 ; 6 miles east of the Longstone, and 40 miles north-east of St. Mary's Island.

5. SERTULARELLA TENELLA, Alder.

On other Zoophytes, not common. Alder.

Dredged from Stations 2, 6, 7 and 8.

6. DIAPHASIA ROSACEA (Linn.) *Sertularia rosacea*, Linn.

Occasionally from deepish water and low water, Bamborough. Alder.

Common, dredged from Stations 3, 4, 7, 8 and 9, 6 miles east of the Longstone, and north-east of St. Mary's Island.

Gonophores : capsules with sporosacs in July.

7. DIPHASIA FALLAX (Johnston). *Sertularia fallax*, Johnston.

Frequent, deepish water. Alder.

8. DIPHASIA PINASTER (Ellis and Sol.) *Sertularia pinaster* Ellis and Solander.

Embleton Bay, deep water (R. Embleton). Alder.

9.* DIPHASIA PINNATA (Pallas).

Station 9 (4 miles east of Newbiggin).

10. SERTULARIA PUMILA Linn.

Between tide marks and a little beyond; common. Alder.
As above and dredged from Station 7.
Gonophores: capsules in June.

11. SERTULARIA OPERCULATA, Linn.

On Laminaria at and beyond low water, common. Alder.

Enormous colonies washed up on Laminaria stalks; dredged from Station 3.

Gonophores: capsules November to February (empty).

12. SERTULARIA FILICULA, Ellis and Sol.

On shells, &c., from deepish water, frequent. Alder.

Growing on Brown's Point and the Bear's Back rocks, Cullercoats. Dredged Stations 4, 7 and 8, and frequently washed up.

13. SERTULARIA ABIETINA, Linn.

Common in deep water. Alder.

Commonly washed up and dredged from Stations 1, 2, 3, 4, 5 and 6; 6 miles east of the Longstone, &c.

14. SERTULARIA ARGENTEA, Ellis and Sol.

Beyond low water, not uncommon. Alder.

Commonly washed up and dredged Stations 1, 2, 3, 4, 5, 6, 7, &c.

Gonophores: capsules with sporosacs in May.

15. SERTULARIA CUPRESSINA, Linn.

Cullercoats, rare (J. Coppin), Tynemouth (Miss Forster), Seaton (J. Hodge). Alder.

Dredged from Station 4, between Coquet and St. Mary's Island, and 5½ miles east of Blyth (on Hyas).

Gonophores : capsules with sporosacs in July.

16. SERTULARIA FUSCA, Johnston.

Dunstanborough (R. Embleton), Cullercoats. Alder.

Dredged from Stations 7 and 8, and from the fishermen's lines.

17. HYDRALLMANIA FALCATA (Linn.) *Plumularia falcata*, Linn.

Very common. Alder.

Extremely common from all stations, and washed up.

Gonophores : capsules (full) in July.

18. THUJARIA THUJA, Linn.

Frequent from deep water. Alder.

Very common, washed up and dredged from Stations 1, 2, 3, 4, 7, 8, &c.

Gonophores : capsules (full) in December.

19. THUJARIA ARTICULATA (Pallas).

Deepish water, rare. Alder.

A NEW GYMNOBLASTIC HYDROID.

By J. H. Robson, B.Sc.

A new species of Gymnoblastic Hydroid, which has not been assigned to any existing genus, was discovered at Cullercoats in 1914; it will probably be necessary to create for it a new genus, which, however, cannot be done satisfactorily until the adult medusoid has been obtained. At present the medusoid has only been observed in a very young state, but as the observations on the hydroid form are fairly complete, I give here a description and drawings of the latter (Plate II.).

The characteristics of the genus will probably be :—

Stem simple, unbranched, rooted by a reticulated stolon, invested by a thin perisarc. Zooids entirely naked, elongated, shaped much like a "ninepin," with a single verticil of filiform tentacles round the base of a conical proboscis Gonozooid a free-swimming medusa (incompletely observed.)

Description of the Species.

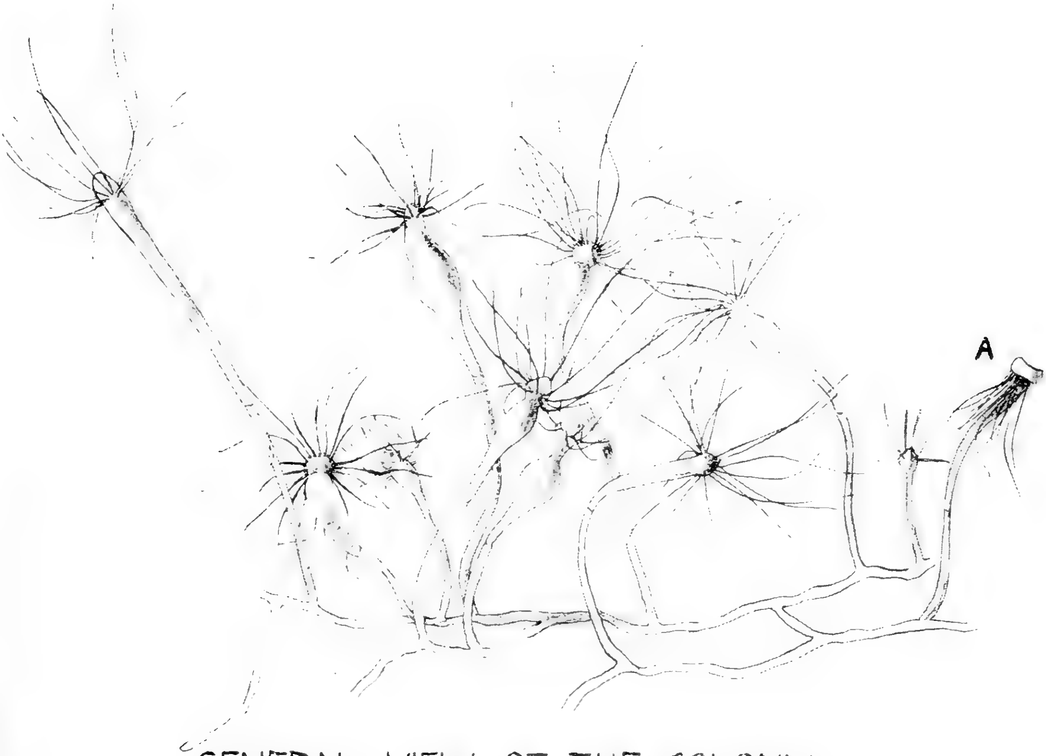
Stem.—Erect, simple, unbranched, the finest specimens 0·5 cm. in height; rooted by a stolonic network. Perisarc smooth, occasionally with a few irregular wrinkles, extremely thin and transparent, with the milky-white cœnosarc showing through its colourless walls.

Hydranth.—White, long and slender; the proximal half attenuated, swelling out gradually into a large stomach region, which is separated from the conical hypostome by a constriction below the tentacles (Plate I.).

Tentacles.—Filiform, irregularly studded with large oval thread cells; 10-20 arranged in a single verticil; when fully extended they are alternately elevated and depressed, and then appear to be in two circlets.

Hypostome.—Conical when at rest. The mouth opening generally appears as a small round aperture, but I have seen it expand for a few seconds, closing again rapidly; when expanded the mouth showed seven well-defined lobes in several cases, and these

PLATE I.



GENERAL VIEW OF THE COLONY.

PLATE II.

SYNCORYNE SARSII.

PLATE III.

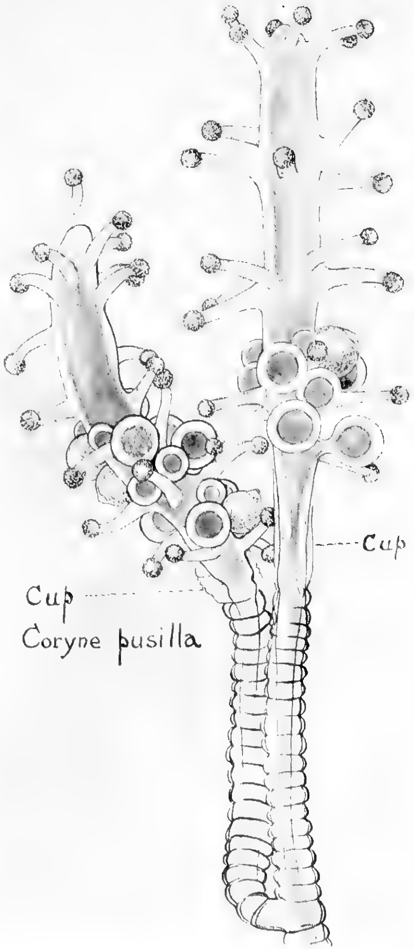
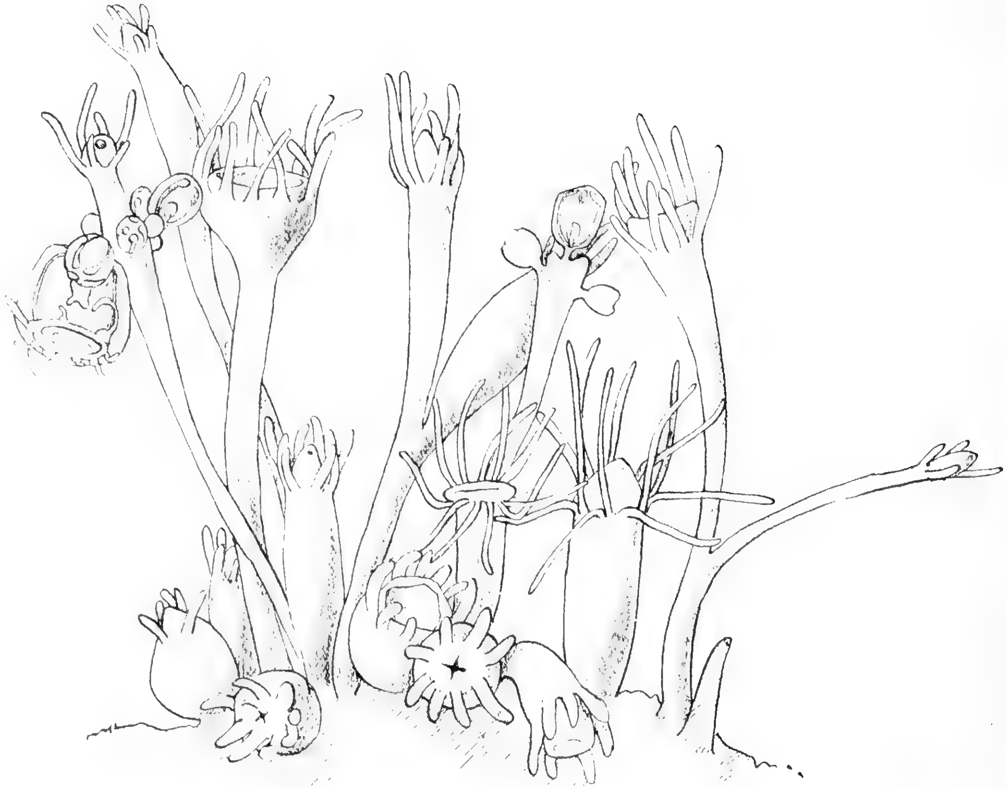


PLATE IV. (A).



PODOCORYNE CARNEA, SHEWING BRANCHED HYDRANTHS.

PLATE IV. (B).

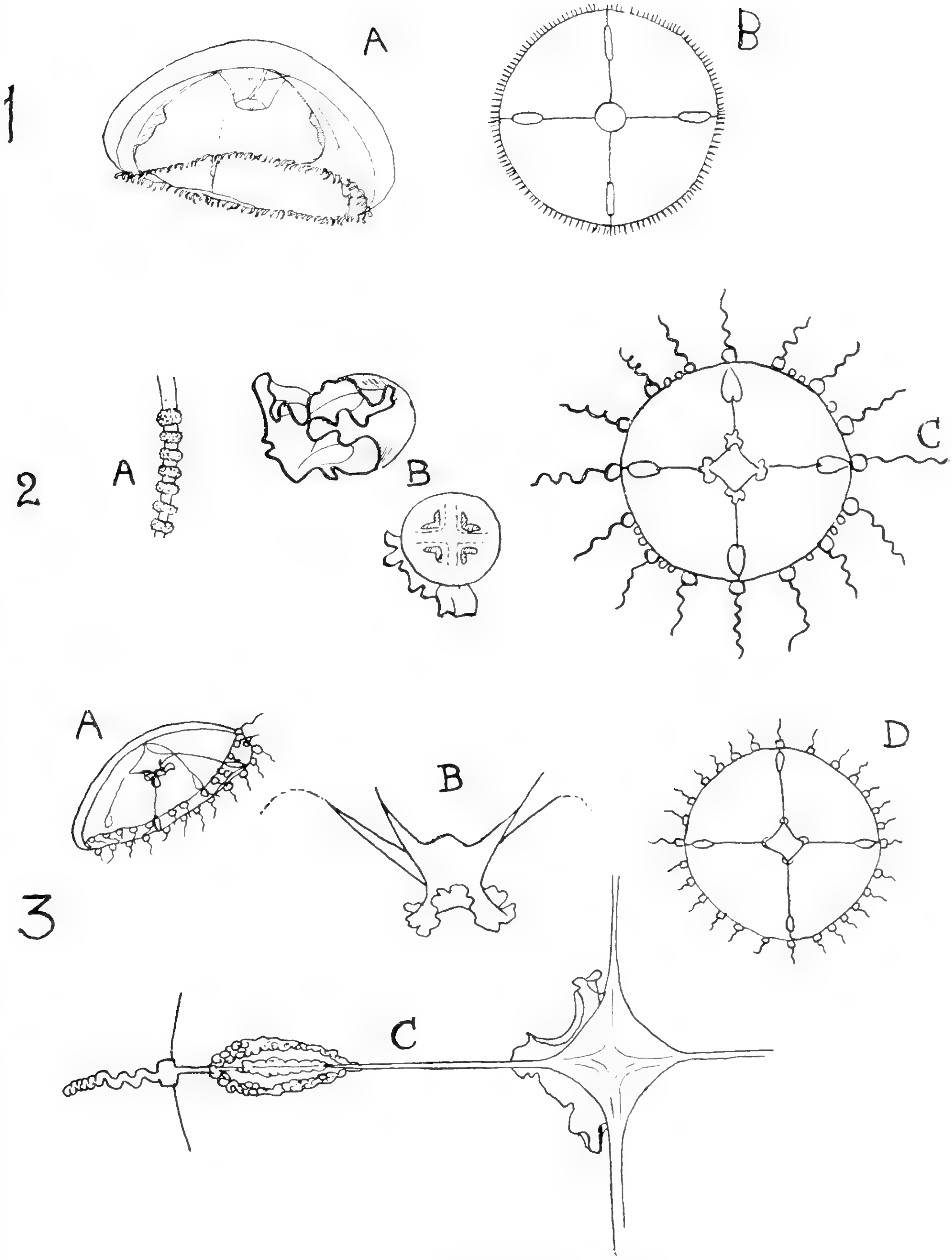


PLATE V.—THAUMANTIDÆ.

lobes seem to be indicated by faintly marked lines on the closed proboscis. The hypostome is also occasionally everted, covering the base of the tentacles (fig. *a*, Plate II.)

The whole of the hydranth is, in fact, extremely mutable, bending in all directions, and instantaneously contracting to less than half its full height when touched. When fully extended the tentacles appear as delicate gossamer-like threads, sparsely studded with large thread-cells, but in the contracted state they become short and thick, with the thread-cells closely packed together. Large oval thread-cells are present also on the body of the hydranth.

Gonophores.—Borne on the stem on a short stalk ; from one to three in number, in the latter case alternate, with the youngest at the distal end of the stem ; a single medusoid is produced in each. The gonophore is large, cylindrical, with a rounded apex and flattened base, and the gonotheca is thickly studded with large ovoid bodies resembling the thread-cells of the umbrella (Plate I.a). The young medusoid is of an extremely simple type (Plate I.b), with bell-shaped umbrella, short cruciform manubrium, four broad radial canals, four long and four short tentacles springing from pale yellow non-ocellated bulbs. The velum is wide and projects inwards ; there is no sign of any gonads, so that it is impossible to place the medusoid with certainty in any group, but it will probably prove to be one of the Tiarinæ (Oceanidæ). Further research on this point is necessary, however.

Gonophores produced from February-June.

Locality and Habitat.—From 40 miles N.E. of Shields, in 45 fathoms, growing on an old shell of *Volsella modiolus* ; and on stones in the Laboratory tanks, where large colonies were observed setting free medusoids.

Since writing the above I have received from Dr. E. Stechow, of the Zoological Museum, Munich, his interesting paper " Ein thecenloser Hydroid, der mit einer Leptomeduse in Generationswechsel steht " (reprinted from the " Zoologischer Anzeiger," Bd. XLI., Nr. 13, April, 1913), describing the gymnoblastic Hydroid *Campanopsis dubia* reared from the Leptomedusa " *Octorchis* " (*Eutima campanulata*, Claus, 1876).

Campanopsis dubia bears a considerable resemblance to the species I have described. Dr. Stechow's description of *C. dubia* is as follows :—

" Hypostome conical. Tentacles in one whorl, 14-18 in number " (in the preserved material a membrane between the roots of the " tentacles is no longer visible).

" Hydranths, when contracted, spindle-shaped; when extended, " with a distinct neck ; a deep waist not far below the wreath of " tentacles, as in the Haleciid Ophiodes ; the lower part of the " hydranth not always sharply marked off, but often ending with " a peculiar narrower part. Hydrocaulus unbranched, about half " the length of the hydranth, with a distinct ' periderm,' sharply " separated from the body of the hydranth, distinctly ringed ; " springing from the hydrorhiza only at wide intervals. Theca " (cup) entirely absent. Hydrorhiza reticulate, surrounded by a " periderm. Medusa : an (*Octorchis*) *Eutima*-type."

LOCALITY.—The northern part of the Mediterranean.

Dr Stechow refers to the specimens bred by Claus from an " Octorchis " (Claus, Arb. Zool. Inst. Wien, 1881) similar to the above, but with a smooth periderm slightly developed instead of the well-developed and " distinctly ringed " periderm of *Campanopsis dubia.* In this feature my specimen resembles that of Claus, but differs from it in the entire absence of a membrane at the tentacle bases. Claus obtained medusa buds on the body of the Hydranth, whereas in my specimens they arise from the Hydrocaulus on a short stalk ; Dr. Stechow's specimens unfortunately had no gonophores developed. The young medusoids I obtained certainly appeared to be anthomedusan.

In view of these facts I am inclined to think that, despite the undeniable resemblance between *Campanopsis dubia,* Claus' specimen and mine, the three specimens are quite distinct.

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NOTES.

Labrax lupus, Linn. A specimen, 25·5 cm. long, was landed at North Shields, 3rd February, 1914, by a trawler which had been fishing 15 miles N.E. of Longstone.

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B. STORROW.

I have to record the occurrence of *Amphidinium operculatum*, Claparéde and Lachmann, on the foreshore at Cullercoats in much larger numbers than last year.

The organism, which was first noticed in May, 1913, occurred as a practically pure culture in two separate patches N.E. and E. of the Laboratory respectively.

The patches were a few feet below high water mark, and persisted until the end of September. In both cases the *Amphidinia* were not very active, a large number of encysted forms being present.

On October 7th and 9th, after the disappearance of the main patches, scrapings of sand from various parts of the foreshore showed a small number of very active forms of *Amphidinium*, together with a much larger number of Diatoms of the Navicula type.

I was able to confirm the observation of Professor Herdman (Marine Biological Station, Port Erin, XXVI. Annual Report) as to the considerable variation in shape of these *Amphidinia* from the typical form of *Amphidinium operculatum*, but no alternation of *Amphidinium* and Diatoms in the same patches was observed.

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