NEW SERIES X.

DOVE MARINE LABORATORY,

CULLERCOATS, NORTHUMBERLAND.

REPORT

For the year ending June 30th, 1921.

EDITED BY ALEXANDER MEEK, D.Sc.,

PROFESSOR OF ZOOLOGY, ARMSTRONG COLLEGE, IN THE UNIVERSITY OF DURHAM,
AND
DIRECTOR OF THE DOVE MARINE LABORATORY.

Published by the Marine Laboratory Committee of Armstrong College.

Price = = Five Shillings.

Newcastle-on-Tyne:
CAIL & SONS, PRINTERS, 29 AND 31, QUAYSIDE.

1921.

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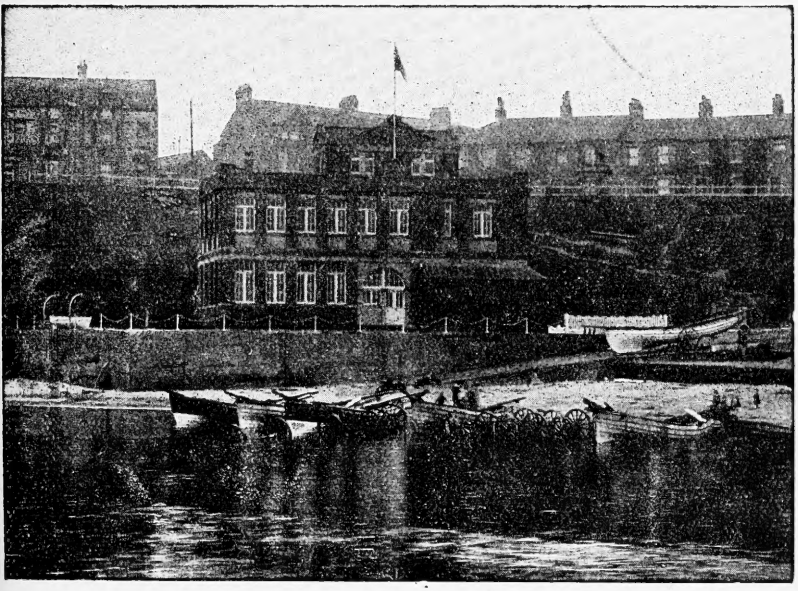

Dove Marine Laboratory, Cullercoats.

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SUMMARY AND GENERAL REPORT.

The past year has been one of reconstruction. The laboratory required a complete overhaul involving the building and the equipment. The roof was coated with asphalte, the pipes and electric fittings were repaired and where necessary renewed, and the woodwork and ironwork painted. The apparatus, reagents and nets have been to a large extent replaced. The specimen room has been altered into a chemical laboratory and fitted for the work of the Biochemist. The motor boat, which suffered considerable loss at the hands of depredators in Blyth Harbour, has been reconditioned and her stores renewed, and the opportunity was taken to fit her with a " Kitchen " rudder.

The investigations accomplished during the period and reported upon in the following pages refer in the main to trawling experiments and to a continuation of the researches relating to herring fisheries.

The trawling experiments which were suspended since 1913 were renewed in 1920 with a view to finding out whether the years of the war have produced any change. The results showed that the distribution of the fish, which we had found to be so constant in inshore waters, was maintained, but there were certain peculiarities. Plaice with two winters behind them were abundant in the northern part of the Northumberland area, but three-winter plaice and probably also four-winter plaice were just represented. Moreover the two-winter plaice were conspicuously below the pre-war size. The conclusion is then that the spawning season of 1917, and probably also that of 1916, was a poor one or that the fry resulting from it were subjected to unfavourable conditions. There was evidence besides that the food inshore was not at all abundant. Whether this be due to a general cause or not, it is evident that the flooding of an area such as the Northumberland inshore waters with oil during the pelagic period of the eggs and fry and food would lead to a great deal of destruction. The effects were seen during the

the war years on several occasions by the presence of oil on the surface of the sea and on the rocks and beach. The oil caused the death of many sea birds, and if at such a time the surface waters are occupied by pelagic eggs and larvae of fishes, and by the planktonic stages of the food of the fishes the effect may be of serious importance. Our experiments go to show that while the hydrographical conditions of the spawning season have an influence on the success of the spawning and therefore on the abundance of the year group concerned the absence of food and the stunted growth are traceable to such accidents as the spreading of oil over the sea at all events in territorial waters. The effects are fortunately local and transient.

In reviewing the experiments of 1920, and comparing them with pre-war years it was found necessary to present a general report on the results of the Northumberland Trawling Experiments. The results bring out important facts relating to the distribution and migrations of fishes and the relationships of these to the currents of the North Sea.

Mr. Storrow has contributed an account of his work on herrings during the year. He draws attention again to the important fact that herrings in their fourth year form the most important constituent of the summer fishery along the east coast of Britain. It is obvious therefore that the fluctuations in this important fishery depend largely upon the success of the spawning and the rearing of the season four years before that of fishing

The samples from the Autumn shoals of 1920 showed that fish with six and seven winter rings were comparatively abundant and the scarcity of herrings with five winter rings was a marked feature of the shoals sampled. The same year classes occurred in the samples from shoals of spring herrings in 1921, and their abundance and scarcity were practically the same as was found in the Autumn shoals.

The data with regard to the maturity of the shoals which give the East Anglian herring harvest point to the shoals being composed of full fish which assemble previous to a migration for spawning in the spring. From the age composition and the growth data, it is concluded that some of these herrings return again to the same locality as spents and give rise to the Yarmouth fishery for spring herrings.

The samples of Irish herrings, together with those from the North of Scotland and the samples of 1920 from the Shetlands, give good grounds for concluding that the Atlantic waters from Donegal Bay to the North West of the Shetlands are populated by shoals of oceanic herrings which resemble one another very much in age composition and growth, and differ from the shoals of the North Sea.

Mrs. Cowan adds to the account of the herring investigations a paper on the size of the herrings.

A short account is given of the destruction of smolts in the Tyne in 1921 owing to the dry season.

Several interesting occurrences have been recorded under the head "Faunistic Notes." These papers are by no means as exhaustive as we should like them to be, but the problem of the cost of printing is becoming highly important. Other papers have had to be kept back in the hope that conditions in this respect will improve.

Recurring to what I said last year regarding the accomodation of workers at Cullercoats, I am more than ever convinced that a hostel at or near Cullercoats would be very useful. It is obvious that if the rooms were not entirely taken up by workers at the Laboratory they could be let to visitors and others who desire to live at the seaside.

ALEXANDER MEEK.

3*rd August*, 1921.

NORTHUMBERLAND TRAWLING EXPERIMENTS.

By ALEXANDER MEEK.

1.—NORTHUMBERLAND, 1920.

Trawling experiments were conducted in the bays of the Northumberland coast during the years 1892 to 1913, and the desire was expressed by the Ministry of Fisheries and by the Northumberland Sea Fisheries Committee that they should be repeated with a view to pointing out whether the inshore water had changed with respect to the food fishes during the years of the war. It was expected that a change would be indicated, as the North Sea generally had undergone a period of relative rest from fishing since the end of 1914, and deep sea fishing is not yet restored to pre-war conditions. During the years of the war, however, the inshore fishermen fished the territorial waters to an increased degree, and this was due to the demand for fish and the ever increasing prices. All classes of fish were landed, but especially round fish, during the colder months of the year, and the season of white fishing was extended.

The experiments were commenced on July 29th and the trawl net and gear employed were similar to and in most respects

the same as those used just before the war ; the tug " Sentinette " was engaged, and proved to be well suited for the work, the crew assisting the staff of the Marine Laboratory in launching and hauling in the net. They were continued on August 5th, August 12th and September 2nd. The weather was favourable on each occasion, and until the last day of the experiments the work was done without event. The experiments came to an end on September 2nd, after incidents which go to illustrate the fisherman's attitude with respect to luck and the superstitions relating to his calling. At Skate Roads the fishing was successful and normal. But at the end of the haul in Alnmouth Bay the trawl caught an anchor or wreck, with the result that the beam was broken close to the iron. The beam was replaced and the net mended on our passage to Druridge Bay, but for some reason the net failed to fish, evidently not reaching the ground, and the total catch was a Cyanea. The experiment had therefore to be repeated, and at a slower rate, and with more warp the fishing was a success. Then we proceeded to the last bay of the series, Blyth Bay, and the net was only down for twenty minutes when it was caught on a wreck, as we found when we attempted to release the net. During the process the rope was accidentally cut, and the trawl left at the bottom. Next day at low water the wreck was quite conspicuous, and, in fact, there are two of them lying north and south of one another, about equally distant from the shore. We escaped the wrecks on the days of our previous visits by fishing according to the state of the tide just outside them, but on the day in question, at about high water of a spring tide, we approached a little nearer the shore. With the aid of a water telescope, which I got made at the College, the net was discovered and marked, and as soon as the "Evadne " is ready we propose to make an attempt to raise it. It would take too much time to prepare fresh gear, and as it happens we have the information we require, and there need not therefore be any delay in presenting and considering it.*

The results in detail are given in the following table (Table I.)

* This paper was presented in outline at the October meeting of the Northumberland Sea Fisheries Committee.

TABLE I.—THE NUMBERS AND SIZES OF THE FISH CAPTURED AT EACH HAUL.

FIRST HAUL.—29th July, 1920. ALNMOUTH BAY. Began 12·15 p.m., ended 1·15 p.m. Time, 1 hour.

	Air.	Water.
Temperature (Fahrenheit)	66°	53°

Last of Flood.

Name of Fish.	CENTIMETRES. 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	36	37	38	39	40	45	50	Total.
Plaice ...	—	—	1	—	—	—	2	—	1	3	5	4	1	3	1	1	2	—	—	1	—	—	—	—	—	—	—	—	—	—	—	25
Dab ...	—	—	—	2	1	5	9	20	21	15	8	6	4	3	1	1	1	—	2	1	—	—	—	—	—	—	—	—	—	—	—	100
Gurnard ...	—	—	—	—	1	9	18	14	6	2	2	2	—	1	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	56
Angler ...	—	—	—	—	—	—	—	—	—	—	2	1	—	—	1	2	2	3	1	—	2	2	—	1	1	1	2	1	1	1	1	25
Whiting ...	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Grand Total ...																															...	208

FIRST HAUL.—29th July, 1920. DRURIDGE BAY. Began 2·20 p.m., ended 3·20 p.m. Time, 1 hour.

Second Quarter Ebb.

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	34	36	37	40	41	42	45	50	Total.
Plaice ...	—	—	—	—	—	—	—	—	—	—	—	1	3	—	1	—	—	—	—	—	—	1	1	—	—	—	1	1	—	—	1	10
Dab ...	—	—	—	—	1	—	1	3	5	1	3	—	1	1	1	—	1	1	—	—	1	—	—	—	—	—	—	—	—	—	—	20
Sole ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Gurnard ...	—	—	—	—	—	1	5	1	2	1	1	—	1	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	14
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	3	2	1	—	2	1	3	3	1	1	—	1	—	1	20
Haddock ...	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Grand Total ...																															...	66

TABLE I. (continued).

FIRST HAUL.—29th July, 1920. BLYTH BAY. Began 5·55 p.m., ended 6·55 p.m. Time, 1 hour.

	Air.	Water.
Temperature (Fahrenheit)	66°	53°

Last of Ebb.

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	33	34	37	38	39	43	46	48	50	Total.
Plaice ...	—	—	—	—	—	—	—	1	—	2	3	4	4	2	2	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19
Dab ...	—	—	1	—	—	1	1	2	9	6	2	3	2	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	29
Sole... ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
Gurnard ...	—	3	1	1	1	5	3	4	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20
Angler ...	—	—	—	—	—	—	—	—	—	—	1	—	1	—	2	1	1	2	2	1	1	2	1	3	1	1	1	1	—	1	—	23
Haddock ...	—	—	—	—	—	—	—	—	1	3	—	—	2	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8

Grand Total. 100

FIRST HAUL. 5th August, 1920. ALNMOUTH BAY. Began 12·40 p.m., ended 1·40 p.m., Time, 1 hour.

	Air.	Water.
Temperature (Fahrenheit)	65°	53°

First Quarter Flood.

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	40	41	49	50	Total.
Plaice ...	—	—	—	—	—	—	2	—	2	4	13	6	15	1	3	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	48
Dab ...	—	2	1	2	3	8	6	20	30	21	17	6	17	7	7	4	4	1	3	—	—	—	—	—	—	—	—	—	—	—	—	159
Gurnard ...	—	—	1	1	—	5	10	22	18	3	1	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	64
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	1	—	3	—	1	1	1	2	1	2	—	—	—	—	—	—	—	—	—	14

Grand Total 285

TABLE I. (continued).

FIRST HAUL.—5th August, 1920. DRURIDGE BAY. Began 2·55 p.m., ended 3·55 p.m. Time, 1 hour.

Temperature (Fahrenheit) ... Air. 65° Water. 53°

Half Flood

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	1	3	3	4	—	—	1	—	1	—	1	—	—	—	—	—	—	—	—	—	—	16
Dab ...	—	—	—	1	7	5	13	18	20	8	9	5	3	2	—	—	1	3	—	—	1	—	—	1	—	—	—	—	—	—	—	97
Gurnard ...	—	—	—	—	1	3	13	15	7	6	1	1	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	49
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	3
Haddock ...	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Grand Total																																166

FIRST HAUL.—5th August, 1920. BLYTH BAY. Began 5·30 p.m., ended 6 p.m. Time, 30 minutes.

High Water.

Plaice ...	—	—	—	2	2	1	—	1	3	—	3	6	7	7	5	1	2	—	—	2	1	2	1	1	2	—	1	—	—	—	—	50
Dab ...	—	—	1	—	1	2	4	7	3	3	11	4	3	2	4	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	47
Gurnard ...	—	—	—	—	—	1	3	8	8	2	2	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	26
Angler ...	—	—	—	—	—	—	1	—	1	—	—	—	1	1	3	—	1	1	—	—	2	—	—	1	4	—	2	1	1	—	1	21
Lesser Weever ...	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Grand Total																																146

FIRST HAUL.—12th August, 1920. SKATE ROADS. Began 6 a.m., ended 7 a.m. Time, 1 hour.

	Air.	Water.
Temperature (Fahrenheit)	65°	54°

First Quarter Flood.

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	45	Total.
Plaice ...	—	8	64	64	33	15	7	4	3	1	—	2	3	5	7	7	3	5	3	3	2	3	—	5	4	1	2	—	—	—	—	254
Dab ...	1	—	3	2	2	1	3	—	2	—	3	3	2	1	3	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	27
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	1	1	—	—	—	1	—	—	1	6
Turbot ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	2
Gurnard ...	—	—	—	—	—	—	—	—	—	2	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	2	2	1	—	—	1	1	—	3	3	1	—	1	1	1	—	18
																															Grand Total	311

FIRST HAUL.—12th August, 1920. ALNMOUTH BAY. Began 10·20 a.m., ended 11·20 a.m. Time, 1 hour.

Last Quarter Flood.

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	62	67	Total.
Plaice ...	—	—	—	—	1	1	1	1	—	2	3	3	4	—	1	2	1	—	—	—	1	—	—	1	—	1	—	—	—	—	—	23
Dab	—	—	3	—	2	1	4	6	11	10	8	5	7	9	4	4	3	2	1	3	—	—	2	1	—	—	—	—	—	—	—	86
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Gurnard ...	—	—	—	—	—	—	—	4	5	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	1	—	1	—	1	1	1	—	—	—	1	—	—	1	—	9
Whiting ...	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Haddock ...	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
Cod	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
																															Grand Total	136

TABLE I. (continued).

FIRST HAUL.—12th August, 1920. DRURIDGE BAY. Began 12·20 p.m., ended 1·20 p.m. Time, 1 hour.

	Air.	Water
Temperature (Fahrenheit)	65°	54°

First Quarter Ebb.

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	36	37	40	41	43	44	45	48	51	54	Total.
Plaice ...	—	3	12	5	9	4	—	—	1	—	7	8	8	6	4	2	1	1	1	—	1	1	—	1	1	1	2	1	1	1	—	—	1	1	84
Dab ...	1	—	2	—	1	2	5	9	8	11	5	6	6	6	1	2	—	1	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	68
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Sole	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1	1	—	—	3
Gurnard ...	—	—	—	—	—	—	—	1	—	—	—	3	—	1	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	7
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2	—	2	1	—	—	—	—	2	1	—	—	—	—	—	—	—	—	—	9

Grand Total 173

FIRST HAUL.—12th August, 1920. BLYTH BAY. Began 2·50 p.m., ended 3·50 p.m. Time, 1 hour.

Half Ebb.

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	42	Total.
Plaice ...	—	—	—	1	—	1	—	—	—	—	—	1	—	2	—	2	1	—	—	1	—	—	1	—	—	—	—	—	—	—	—	10
Dab ...	—	—	—	—	—	—	1	1	3	4	5	3	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18
Sole	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1	2
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	1	1	1	1	—	—	—	1	1	—	—	1	—	9

Grand Total 39

TABLE I. (continued.

FIRST HAUL.—2nd September, 1920. SKATE ROADS. Began 6·10 a.m., ended 7·10 a.m. Time, 1 hour.

	Air.	Water.
Temperature (Fahrenheit) ...	65°	54°

Half Ebb.

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	39	40	41	45	Total.
Plaice ...	—	12	41	33	27	9	6	2	1	1	1	2	3	3	5	5	3	6	6	5	4	1	2	1	—	—	—	1	1	1	—	182
Dab ...	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	3
Flounder ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	1	—	1	—	2	1	—	—	—	1	8
Gurnard ...	—	—	—	—	1	—	1	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
Grand Total																																197

FIRST HAUL.—2nd September, 1920. ALNMOUTH BAY. Began 10·25 a.m., ended 11·25 a.m. Time, 1 hour.

Beginning Flood,

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 ...	—	—	—	—	—	4	2	—	2	—	1	3	4	2	1	—	—	1	—	—	—	—	1	—	—	—	1	1	—	—	1	24
Dab ...	—	—	3	2	2	4	2	3	7	10	11	9	9	3	4	5	3	2	1	—	—	3	1	1	—	—	1	—	—	—	—	86
Flounder ...	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Gurnard ...	—	—	—	—	1	—	2	3	1	1	3	3	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	—	—	16
Angler ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
Whiting ...	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Grand Total																																130

TABLE I. (continued).

SECOND HAUL.—2nd September, 1920. DRURIDGE BAY (S.) Began 1·15 p.m., ended 2·15 p m. Time, 1 hour.

	Air.	Water
Temperature (Fahrenheit) ...	65°	58°

Half Flood.

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	—	1	—	—	—	—	—	1	1	—	1	—	1	—	10
Dab ...	1	1	1	3	—	4	3	7	12	11	9	9	6	11	7	—	5	2	—	—	1	—	1	—	—	—	—	—	—	—	—	94
Sole	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
Gurnard ...	—	—	—	—	—	2	14	27	57	42	22	10	7	10	5	3	2	1	—	1	—	—	—	—	—	1	—	—	—	—	—	204
Haddock ...	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Grand Total																																310

The table shows the actual numbers captured and the sizes of the fish, but the character of the different stations visited will be better displayed by the following summaries :—

TABLE II.

TOTAL CATCHES OF EACH SPECIES PER HOUR'S TRAWLING

	Skate Roads.		Alnmouth Bay				Druridge Bay.				Blyth Bay.		
	1	2	1	2	3	4	1	2	3	4	1	2	3
Plaice	254	182	25	48	23	24	10	16	84	10	19	50	10
Dab	27	3	100	159	86	86	20	97	68	94	29	47	18
Flounder	6	8	—	—	1	2	—	—	2	—	—	—	—
Turbot	2	—	—	—	—	—	—	—	—	—	—	—	—
Sole	—	—	—	—	—	—	1	—	3	1	1	—	2
Gurnard	4	4	56	64	11	16	14	49	7	204	20	26	—
Angler	18	—	25	14	9	1	20	3	9	—	23	21	9
Whiting	—	—	2	—	2	1	—	—	—	—	—	—	—
Haddock	—	—	—	—	3	—	1	1	—	1	8	—	—
Cod	—	—	—	—	1	—	—	—	—	—	—	—	—

Besides the individual peculiarities it will be observed that there is a great contrast between the northern bay, Skate Roads, and the southern bays, Alnmouth to Blyth Bay. The plaice-dab relationship for each of the bays from north to south is Skate Roads, 218:15 ; Alnmouth Bay, 30:108 ; Druridge Bay, 30:70 ; Blyth Bay, 26:32. These numbers and the general catches are very like those obtained as the result of the pre-war experiments. The distribution, in other words, tends to be a constant one each season.

The fish at the period of the experiments are all immature, whatever their size ; they include young fish which have not yet reached maturity and spent fish which have migrated into inshore waters after spawning.

Reverting again to Table I. it will be observed that at Skate Roads on both occasions large numbers of very small plaice were caught, measuring from about 11 to about 19 cm., and culminating in a size of 12 to 13 cm. Fortunately in the case of the latter of the two hauls at that station, attracted by the small size of the fish, all the small up to 19 cm. were retained contrary to our usual habit of returning such to the sea, and they were submitted by Mr. Storrow to a careful analysis with respect to age, both otoliths and scales being used for the purpose. The result was :— Group I., range 10·7 to 13·8 cm., the mean size being 11 cm. or

under = 13 fish ; Group II., range 10·8 to 19·2 cm. (50 per cent., 12·3 to 14·1 cm.), mean about 13 cm. = 116 fish ; Group III., one fish measuring 13·9 cm., which indicated the three winters on both scales and otoliths. Two only were rejected as doubtful.

It will be observed that at both experiments there was a very small number of fish with three and perhaps four winter "rings" of the size 18-20 cm. There was some indication of their presence at Druridge Bay on the 2nd September, but with this exception all the bays showed a similar absence of the group, and indeed of small plaice generally. The small plaice were encountered also at Druridge Bay on August 12th, and there also indicated a mean size of 13 cm. It will be found when we proceed to compare the results with those of pre-war years that the size of the small plaice is much below the mean size of the groups mainly represented, Group II., but this is emphasised by the absence of Group III.

Dabs were present in 1920 in greatest numbers at Alnmouth, where they averaged 108 per haul, and ranged from 12 to 36 cm. in length. As in the case of the plaice then, the inshore waters in depths of about three fathoms or even two fathoms receive each year all sizes from the youngest stages of the year of spawning to spent fish. At Alnmouth Bay small dabs were encountered, which probably had a mean size not very different from that of the plaice, but the most conspicuous group measured on the average about 18 cm., and the probability therefore is that these were a year older than the plaice. If they were normal in size they would be called Group III. fish. The dabs as in previous years predominated in the southern bays, and were poorly represented at the northern station.

The other flat fish refer, as has been our usual experience in the past, to large fish. It is to be noted that prime fish were this year uncommon, and brill altogether absent.

The distribution of the gurnard, and the species we catch in the Northumberland area is the grey gurnard, *Trigla gurnardus*, and seldom any other species, is remarkably similar to that of the dab, as will be seen from the summary table above. The angler, *Lophius piscatorius*, was obtained at most of the hauls, and it is evident that during the course of the experiments it was in the process of leaving the inshore waters. The anglers ranged in size

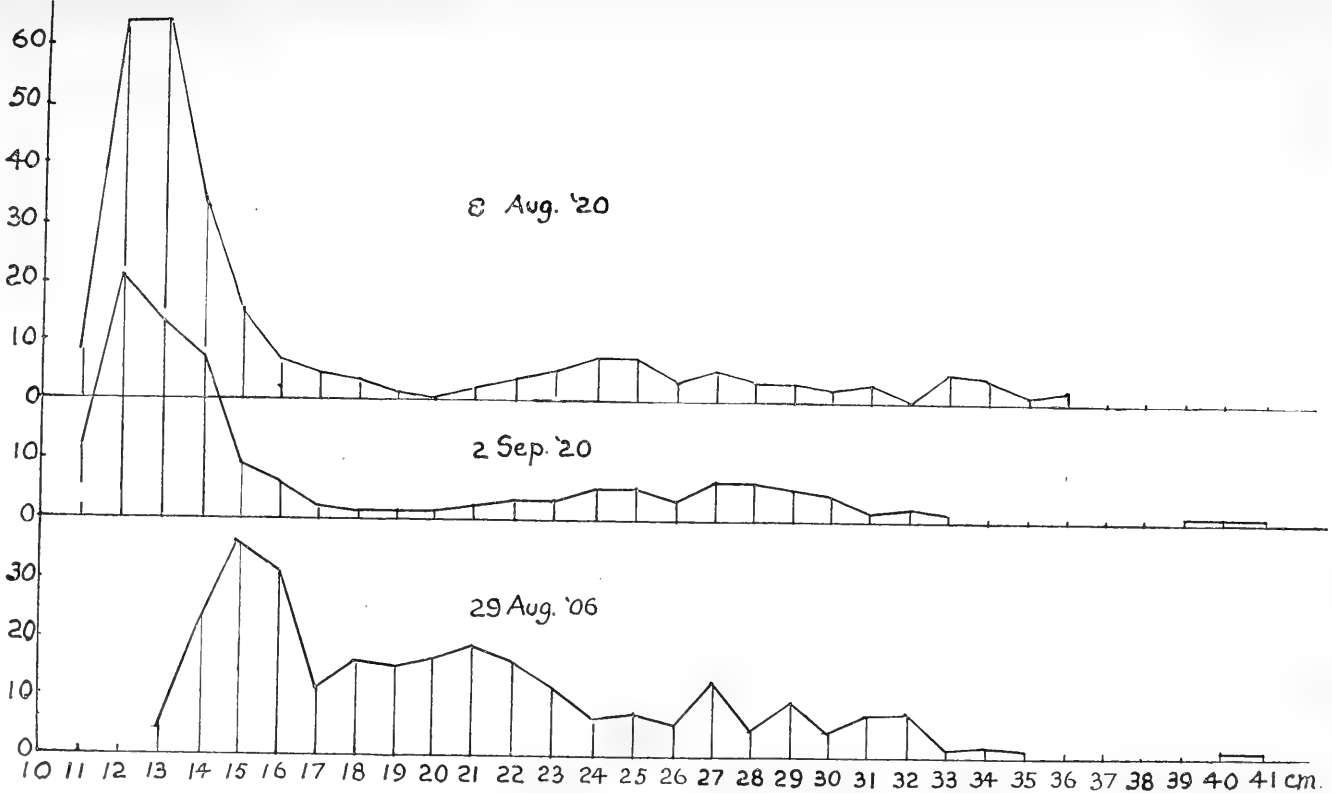


FIGURE 1.

Diagram showing number of plaice caught per hour each cm. of size at Skate Roads in 1920 and 1906.

from 16 to 62 cm., and thus included juvenile and adult examples. A few small whiting and haddocks were captured at the southern stations, and near the rocks at the north end of Alnmouth Bay a cod was included in one of the hauls. See Table I.

This presentation of the results for 1920 goes to show that the bays along the coast of Northumberland continue to receive important contributions of food fish, that in the case of most of the species the territorial waters are a nursery for the young during the early period of growth, that this year, as in past years, the young and the adults were distributed in the bays and along the coast generally in a manner which is maintained from season to season with remarkable constancy. But this year the plaice emanating from the spawning of 1916 and 1917 were either poorly represented or very late in appearance. The condition this year with reference to plaice is shown graphically in figure 1. The two upper curves indicate the catches at Skate Roads, and for comparison a similar catch made in 1906 is added. The small size of the young fish and the almost complete absence of the plaice, with a mean length of about 20 cm., are at once apparent. It will be observed also that the plaice above 24 cm. are approximately normal.

Food.—A table, Table III., is subjoined to indicate the food found in the stomachs of a number of the fish. Other examples were examined and gave similar results. The food mostly in evidence was sand eel. *Portunus holsatus* appeared to be common, but was not employed to the extent found in former years. Mollusca apparently were very scarce. But what impressed us most was the large number of fish with empty stomachs, and the stomachs of several were found to contain sand with a very few amphipods. Species endowed with the power of movement as fish and Crustacea were present, but demersal life generally appeared to be scarce in the inshore waters.

The fish examined on the three first dates were obtained for the most part in Alnmouth Bay, and those of September 2nd from Skate Roads. In comparison with our past experiences the food which is practically absent is molluscan food, so commonly found in previous years.

We have found in pre-war experiments that in general the number of fish with nothing in their stomachs increased in pro-

TABLE III.

FOOD OF EXAMPLES OF THE FISH CAPTURED.

Date.	Species.	Size	Sex.	Food.
1920.		Cm.		
July 29 ...	Angler	40	m.	Angler measuring 23 cm.
		27	m.	Sandeels.
		25	m.	Sandeels.
	Plaice	29	m.	Nephthys.
		26	m.	Mollusc.
		25	m.	Amphipod, Mollusc.
	Dab	25	f.	0
		22	m.	*Tellina tenuis.*
		20	f.	0
		26	f	Sandeel. *P, holsatus.*
August 5 ...	Angler ...	50	f.	0
		41	f.	0
		30	f.	0
		28	m.	0
	Plaice	25	m.	0
		24	f.	0
		22	f.	0
		28	f.	0
	Dab	24	f.	*Tellina tenuis.*
		23	f.	Sand and one or two amphipods.
		22	f.	*Portunus holsatus*, sand and amphipod.
August 12 ...	Angler ...	39	m.	Plaice (1) sandeels.
		37	m.	Plaice (2) sandeels.
		35	m.	Sandeels.
	Plaice	35	m.	0
		34	m.	Amphipods.
		33	m.	Sandeels.
	Dab	25	f.	0
		24	f.	Sandeels.
		22	f.	Sandeels and part of empty shell of Echinocardium.
		21	f.	0
	Flounder ...	45	f.	0
		36	f.	0
		33	f.	Sandeels.
		31	f.	0
	Turbot ...	38	f.	Sandeels.
		33	m.	Sandeels.
	Gurnard ...	26	f.	Sandeels, shrimp.
September 2	Plaice	40	f.	Sandeels, Nephthys.
		28	f.	Nephthys.
		25	m.	Sandeels.
	Dab	30	m.	Sandeels, *Donax vittatus*
		22	f.	Sandeels.
	Flounder ...	45	f.	Sandeels.
		35	f.	Sandeels.
		31	m.	0
		28	m.	Sandeels.

portion to the numbers caught, in other words, that in good years a large percentage of fish were recorded as empty. If therefore a comparison were made with the experiments of past years, isolated years of plenty could be pointed out which were in no worse condition than this year. This year, however, is far below the average of our records of food, and the food used is different. This may be illustrated in the following manner. The first line in each case gives the order of preference of food in the pre-war experiments and the second line the order in 1920.

PLAICE :—	Mollusca, Fish, Worm, Crustacea, Fish, Worm, Crustacea, Mollusca.
DAB :—	Crustacea, Mollusca, Fish, Worm, Fish, Crustacea, Mollusca.
FLOUNDER :—	Mollusca, Fish, Crustacea, Worm, Fish.

The other species are practically unchanged, feeding mainly on fish, and fish in our tables means nearly always sandeels. The dab appears to be more adaptable to changes in food supply than the plaice and flounder.

Seeking for an explanation of the peculiarities of 1920 one naturally recalls the reports which repeatedly were made of the inshore surface waters being covered with oil, and on one or two occasions so thickly that guillemots, gulls and other birds of similar habits were entangled in the oil. It is obvious that the presence of oil at the surface would have a disastrous effect on pelagic life and on the pelagic stages of demersal life. When the first submarine was sunk off the Farnes in 1915 the oil was observed on the surface from Holy Island to the Coquet. The rocks of the Farnes were covered with oil between tide marks, and seabirds were picked up on the beach, dead or helpless from the effect of the oil on their feathers. Early in 1918 a large part of the southern region of the Northumberland coast was heavily charged with oil, and the effects were the same on the bird life, large numbers perishing. In this connexion it may be remarked that Despott writing on the decrease of certain of the inshore fish of Malta stated that the oil from the ships was one at least of the causes of the decrease

2.—NORTHUMBERLAND, 1892-1920.

We have now to compare the results obtained in 1920 with the results of the pre-war experiments. The experiments were commenced by the late Ald. John Dent in 1892 with a view to demonstrating the effect of the by-law prohibiting trawling in the territorial waters of the Northumberland district. The procedure to begin with was to visit a given bay or station, and to trawl for a fairly constant number of hours. The trawl was hauled in at each end of the bay as a rule, the small fish were returned to the sea, and the larger or marketable fish were counted and tabulated at the end of the experiment. When the experiments came under my charge in 1896 I deemed it advisable to allow them to be carried on as before, so that the previous results would not be lost sight of. They had a value of their own, for the long period of the experiment neutralised to a large extent the variations produced by tide and other influences. In 1899 I began to measure the first haul in detail, and subsequently this more accurate method was adopted at first in association with the earlier usage, and finally all the fish captured were recorded in this manner.

The trawl net used during the whole period was a beam trawl, measuring 22 feet. The earlier experiments were conducted with tug steamers belonging to the late Ald. Dent, and usually by tug steamers hired for the purpose after the late Chairman's death in 1907. In 1910 our motor boat was employed for the work, and satisfactorily.

In the earlier reports, when the measuring was introduced, the two classes of records were distinguished as "complete experiment" and "first haul," for, as has been said, only the first haul to begin with was measured. The "complete experiments" were carried on with almost uninterrupted regularity from 1892 to 1906. The measured hauls have been recorded since 1899, and provide a series from 1899 to 1910, and were repeated in 1913 and in 1920.

Marketable Fish.

The earlier experiments refer only to the larger fish, and our records with regard to them may be first presented. To render

the results of equal value they have been expressed in catch per one hour's trawling. The catches of flat fish are most interesting to us, and if in the results conclusions appear to be based on small numbers, it must be borne in mind that they deal merely with marketable sizes and with experiments which lasted in each case from seven to ten hours.

The total catches of flat fish at each station each year were as follows :—

TABLE IV.—MARKETABLE FLAT FISH.

	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06
Skate Roads ...	—	—	29	13	24	21	20	24	24	18	—	64	—	28	45
Alnmouth	—	23	21	24	37	28	33	36	37	45	32	34	43	23	25
Druridge	24	18	20	20	28	25	22	25	28	31	53	44	42	26	41
Cambois	16	11	10	8	17	24	21	27	19	24	29	33	29	23	27
Blyth	9	12	14	18	16	29	46	39	40	12	58	58	36	18	39
Mean	14	16	20	17	24	25	25	26	32	29	38	45	36	24	37

With the exception of plaice and dabs, the flat fish captured are few in number, and the results may therefore be considered with reference to these species. The catches are arranged in Table V. to indicate the difference between those of June and July and those of August and September, for the experiments were made almost constantly from the end of June to the beginning of September.

From this table it will be observed that the character of the bays with reference to the general distribution even of marketable fish has been remarkably constant during the whole of the period, and it still remains so in this year of 1920. The northern station always yields a relatively large number of plaice and very few dabs. The station to the north of Holy Island is similar to Skate Roads. It was visited on a few occasions only, owing to the many wrecks which occur along the shore region. The following are the results of three experiments for a number of hours, each expressed in catch per hour's trawling.

GOSWICK BAY

		Plaice	Dabs	Flat Fish.
1898	August ...	68 ...	4 ...	77
1899	June ...	7 ...	1 ...	10
1903	June ...	6 ...	2 ...	13

TABLE V.—PLAICE AND DABS. CATCH PER HOUR EACH YEAR, AND FOR JUNE-JULY AND AUGUST-SEPTEMBER.

	MARKETABLE PLAICE.															MARKETABLE DABS.													
	'92.	'93.	'94.	'95.	'96.	'97.	'98.	'99.	'00.	'01.	'02.	'03.	'04.	'05.	'06.	Mean.	'92.	'93.	'94.	'95.	'96.	'97.	'98.	'99.	'00.	'01.	'02.	'03.	'04.	'05.	'06.	Mean.
Skate Roads																																
June-July	—	—	37	12	14	11	11	16	—	16	—	—	—	—	22	17	—	—	2	4	1	2	4	1	—	2	—	—	—	—	3	2
Aug.-Sept.	—	—	9	8	18	14	17	21	16	11	—	51	—	15	33	19	—	—	3	1	1	3	2	5	6	1	—	8	—	7	2	4
	—	—	23	10	16	12	14	18	16	13	—	51	—	15	28	18	—	—	3	3	1	3	3	3	6	2	—	8	—	7	3	3
Alnmouth																																
June-July	—	15	16	14	25	7	19	10	14	20	17	13	41	10	11	17	—	13	8	10	15	8	11	10	17	17	17	14	4	7	3	11
Aug.-Sept.	—	9	8	14	19	32	—	30	19	35	13	10	15	11	6	17	—	6	5	7	6	5	—	17	17	14	12	13	6	9	21	11
	—	12	12	14	22	19	19	20	16	27	15	12	29	11	9	17	—	9	6	8	10	7	11	13	17	16	14	13	5	8	12	11
Druridge Bay																																
June-July	—	—	16	13	17	14	9	7	14	12	23	11	21	11	14	14	—	—	6	4	7	4	13	7	7	6	13	12	10	11	6	8
Aug.-Sept.	15	9	5	14	14	11	9	19	14	17	38	24	24	10	9	15	8	6	4	8	10	11	8	17	14	18	25	20	20	9	33	14
	15	9	11	13	15	12	9	13	14	15	30	17	22	10	11	15	8	6	5	6	9	7	11	10	11	12	19	16	15	10	20	11
Cambois																																
June-July	—	6	—	5	9	10	—	—	4	6	13	8	8	7	3	7	—	2	—	2	5	7	—	—	12	6	13	8	13	6	20	9
Aug.-Sept.	9	6	3	—	8	10	8	14	—	19	—	13	7	9	10	10	6	5	2	—	8	17	12	10	—	12	—	11	14	14	16	11
	9	6	3	5	8	10	8	14	4	13	13	10	7	8	6	8	6	3	2	2	6	11	12	10	12	9	13	9	14	10	18	10
Blyth																																
June-July	—	—	7	—	9	—	26	—	30	6	—	35	—	9	29	19	—	—	2	—	4	—	17	—	8	5	—	20	—	4	10	9
Aug.-Sept.	6	5	—	8	6	16	—	20	—	—	41	31	24	5	15	16	3	2	—	8	8	10	—	19	—	—	13	18	10	10	8	10
	6	5	7	8	7	16	26	20	30	6	41	33	24	7	22	18	3	2	2	8	6	10	17	19	8	5	13	19	10	7	9	9

Besides bringing out the fact with respect to marketable fish that Goswick Bay agrees with Skate Roads, it incidentally shows that the large fish usually appear late at Goswick, but the other results in the above table for the district as a whole indicate that the appearance of the large plaice varies with season. They may predominate in early summer or in late summer, and in some seasons there is relative equality, and it will be observed that when this last is the case all the district is involved. This is a point, however, which will be better discussed with reference to the size of the fish.

It is gratifying to notice that during the period of the complete experiment the district on the whole has improved with respect to the numbers of flat fish.

The long experiments in each bay and the records they furnish of the changes in the marketable fish have been valuable for the variations likely to affect a short experiment were to a large extent eliminated. They were made during the season, June to September, when the shore waters receive their maximum numbers of summer migrants, at stations of an average depth of three fathoms, and lasted long enough to cover at least one tidal phase. The information they yielded has been published in detail in the annual reports of the Dove Marine Laboratory, and further details of a summary character will be found in the reports for 1905 and 1906.

Marketable and Small Flat Fish.—The points which have been illustrated with reference to the marketable fish gain in clearness, and others emerge from a consideration of the detailed records when all sizes come under review.

Plaice and Dabs.—A. Character of the Bays.—Turning once more to the tables of catches made in 1920, the size of the plaice and dabs may be presented as follows, the numbers referring in each case to the fish measuring up to 15 cm., from 16 to 20 cm., and so on.

TABLE VI.—PLAICE, 1920.

Size. Cm.	Skate Roads.	Alnmouth.	Druridge Bay.	Blyth
15	153	2	8	2
20	13	11	2	4
25	21	14	13	14
30	20	2	3	3
35	4	1	2	2
40	2	0·5	2	0·3
45	1	0·2	1	—
50	—	—	0·2	—
55	—	—	0·5	—

This brings into relief the great contrast already pointed out between the bays, not merely with reference to the number of plaice but as to the size. If we were to restrict our view to the larger plaice, those above 30 cm. (12 inches), the stations would appear to be little different from one another. It is the young plaice which this year particularly marks out the northern station, Skate Roads. In the southern bays the predominant size is 21 to 25 cm.

The facts for the dabs are just as striking, but in a different way.

TABLE VII.—DAB, 1920

Size. Cm.	Skate Roads.	Alnmouth.	Druridge Bay.	Blyth.
15	4	10	7	2
20	4	60	40	21
25	5	29	18	8
30	1	7	5	1
35	—	2	1	—
40	—	0·2	—	—

The dab is not only more prevalent in the southern part of the district, but is so at all sizes. In this case the predominant size is 16 to 20 cm., and it will be observed how sharply the dabs of that size stand out in the results for the three southern stations.

These results agree in the main with those of the pre-war years, but there are certain peculiarities. The 1920 experiment refer, it may be said, to the month of August, and the average results for that month from 1899 to 1913 are submitted for comparison (Report, new Series III., pp. 36-37).

TABLE VIII.—PLAICE AND DABS, 1899-1913.

PLAICE.

Size. Cm.	Skate Roads.	Alnmouth.	Druridge Bay.	Blyth
15	26	25	7	2
20	40	18	10	16
25	58	24	15	15
30	46	17	17	5
35	22	11	13	5
40	1	3	4	2
45	1	1	1	—

DAB.

15	1	7	3	1
20	4	42	48	31
25	3	19	41	13
30	2	4	6	3
35	1	—	1	1
40	1	—	—	—

The same kinds and sizes of fish are present in the inshore waters in the month of August, but in 1920 small plaice were conspicuously abundant in the northern part of the district, and there was a scarcity of plaice throughout the Northumberland district of the sizes above, and markedly of a size about 20 cm. (8 inches). Dabs, on the other hand, were not very different in 1920 from the average conditions of the pre-war years.

For the sake of comparison the detailed records reduced to catch per hour's trawling are given in parallel with the table referring to the marketable fish. There ought to be a degree of resemblance between the plaice and dabs recorded by the former above, say, 20 cm., and the marketable sizes of these species. The detailed records refer to the period 1899 to 1920, and the years common to both kinds of experiment are 1899-1906. The mean for each bay with reference to catches of marketable plaice and dabs and for the plaice and dabs over 20 cm. of the detailed hauls are :—

	PLAICE.		DAB.	
	Marketable.	Over 20 cm.	Marketable.	Over 20 cm
Skate Roads	24	30	5	4
Alnmouth	17	28	12	16
Druridge Bay	16	36	15	29
Cambois ...	9	17	12	14
Blyth ...	23	35	11	13
Mean	18	29	11	15

The plaice and dabs over 20 cm. of the measured hauls are more numerous than the number recorded in the earlier experiments, except at Skate Roads, where large dabs, although small in number, are yet prominent. There must obviously be, however, a degree of relationship between the two kinds of experiment, and the general trend of the results from year to year may be indicated by superimposing the figures derived from each, as has been done in figures 2 and 3. In these figures the first or complete experimental results begin in 1892 and the measured hauls in 1899. Much more variation is exhibited in the short experiment, but neither result can be said to indicate much change. The change, such as it is, could be expressed by saying that the improvement indicated about 1895 has on the whole been maintained. Indeed, if we take it that we can measure the annual population of the plaice by Skate Roads and that of the dabs by Alnmouth Bay and Druridge Bay we should say that a distinct improvement has taken place. This, on the whole, has been the experience of the fishermen during the period represented in figure 2 with reference to plaice, but according to their catches the dab appears to be becoming scarce in the district. One must discount to some extent the large catches of plaice made during the years of the war, but it is surprising to notice to what a slight extent the dabs have been captured by the fishermen in the years concerned.

In addition to the experiments in the regular bays, measured hauls were made at Goswick Bay, and the results are summarised in the following statement :—

		Plaice.	Dab.	Flat Fish.
1899	June ...	26 ...	1 ...	28
1901	„ ...	134 ...	3 ...	162
1902	„ ...	24 ...	4 ...	32
	Mean ...	59 ...	2 ...	70

The incidence of the small fish under 20 cm. is even more important. It will be noticed that the small plaice are conspicuously more numerous than the large at Skate Roads, but are fewer to a slight extent usually in the southern bays. In the case of dabs, on the other hand, the small under 20 cm. far outnumber the large at all the southern stations. This is to say, that the

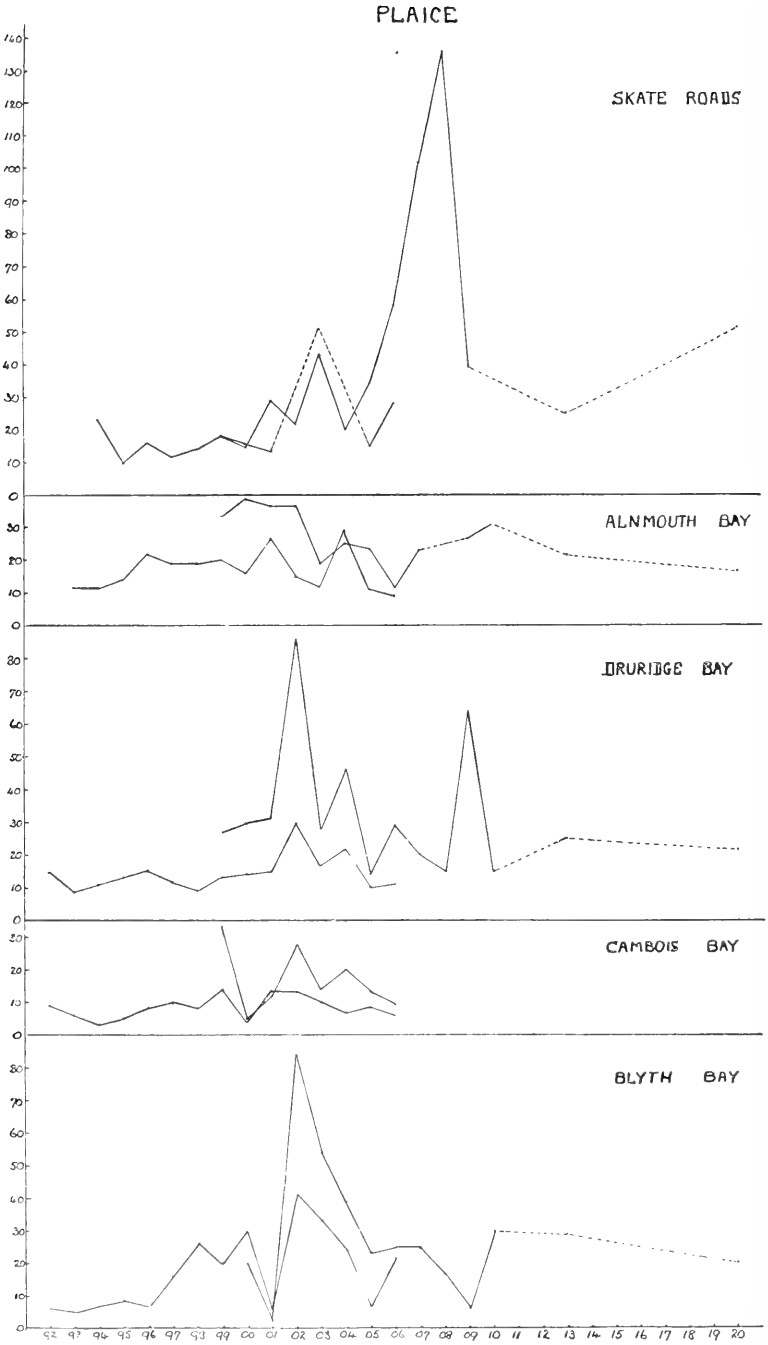


FIGURE 2.

Chart showing catch per hour of marketable plaice (1892-1906), and of plaice over 20 cm. (1899-1920).

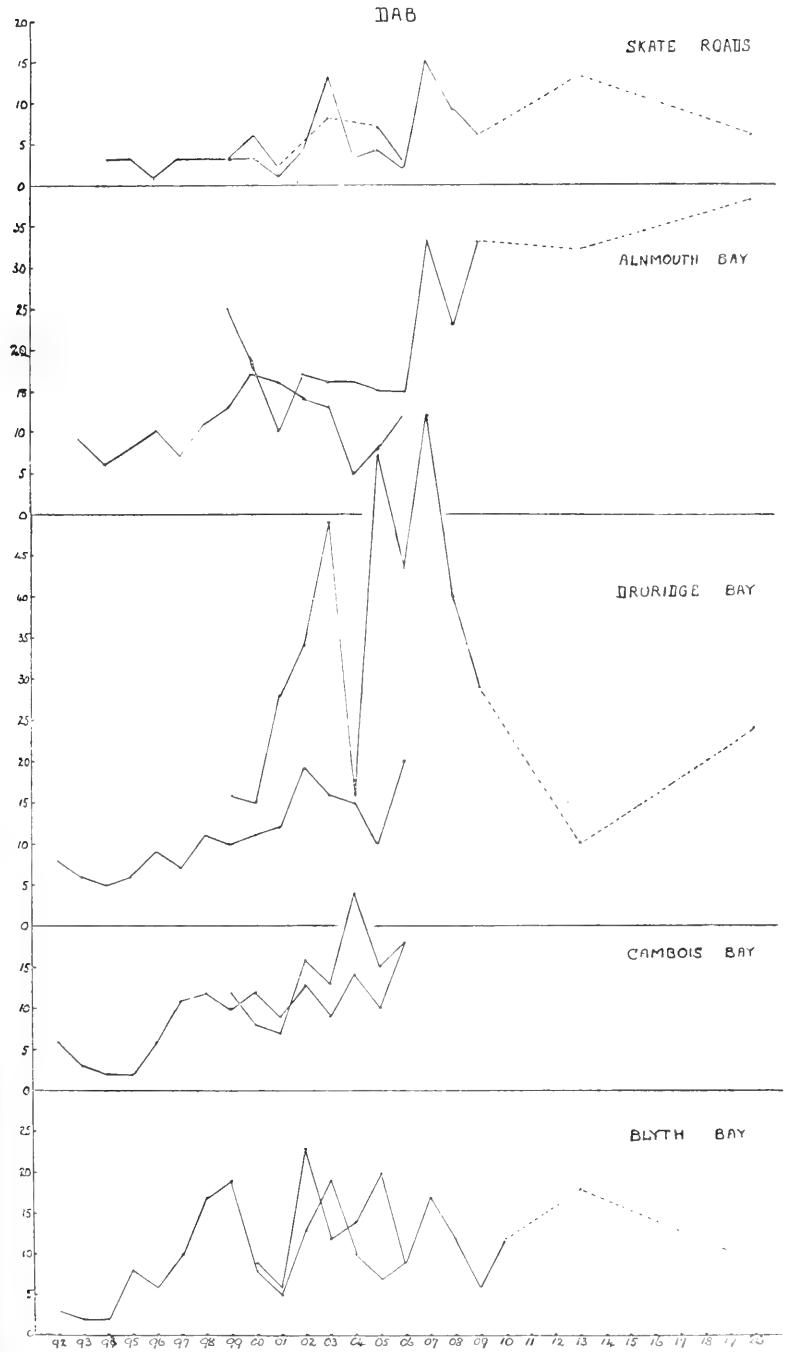


FIGURE 3.

Similar chart to the foregoing with reference to dabs.

TABLE IX—PLAICE AND DABS. CATCH PER HOUR OF ALL THE FISH CAPTURED.

A.—Over 20 Cm.

	Plaice (over 20 cm.)															Dabs (over 20 cm.)													
	'99.	'00.	'01.	'02.	'03.	'04.	'05	'06.	'07.	'08.	'09.	'10.	'13.	'20	Mean.	'99.	'00.	'01	'02.	'03.	'04.	'05	'06.	'07.	'08	'09.	'10	'13.	'20.	Mean.
Skate Roads—																														
June ...	15	—	34	11	57	—	23	25	—	—	—	—	26	—	27	2	—	2	3	4	—	4	1	—	—	—	—	10	—	4
Aug.-Sept. ...	21	15	24	33	28	20	44	91	102	136	39	—	23	52	48	5	3	0	5	23	3	4	3	15	9	6	—	17	6	8
	18	15	29	22	43	20	34	58	102	136	39	—	25	52	37	3	3	1	4	13	3	4	2	15	9	6	—	13	6	6
Alnmouth Bay—																														
June-July ...	19	39	14	30	23	22	23	12	—	—	25	—	22	—	23	34	14	4	17	15	10	13	15	—	—	24	—	37	—	18
Aug.-Sept. ...	47	40	60	45	14	27	22	—	23	—	28	31	22	17	31	16	21	17	17	17	21	16	—	33	—	21	33	26	38	23
	33	39	37	37	19	25	23	12	23	—	27	31	22	17	27	25	18	10	17	16	16	15	15	33	—	23	33	32	38	20
Druridge Bay—																														
June-July ...	13	23	18	43	30	53	15	39	—	—	28	—	35	—	30	12	7	14	13	25	47	15	9	—	—	13	—	14	—	17
Aug.-Sept. ...	40	33	44	129	26	38	14	20	20	15	99	15	15	22	38	20	22	18	43	43	51	17	105	44	62	66	29	7	24	39
	27	30	31	86	28	46	14	29	20	15	64	15	25	22	34	16	15	16	28	34	49	16	57	44	62	40	29	10	24	28
Cambois—																														
June-July ...	—	5	6	30	10	33	17	4	—	—	—	—	—	—	15	—	8	6	16	7	40	9	12	—	—	—	—	—	—	14
Aug.-Sept. ...	33	—	17	—	17	6	9	13	—	—	—	—	—	—	16	12	—	8	—	19	7	21	23	—	—	—	—	—	—	15
	33	5	12	30	14	20	13	9	—	—	—	—	—	—	16	12	8	7	16	13	24	15	18	—	—	—	—	—	—	15
Blyth—																														
June-July ...	—	24	2	—	46	23	31	12	—	—	11	—	25	—	22	—	10	6	—	16	1	8	9	—	—	7	—	24	—	10
Aug.-Sept. ...	—	17	—	84	62	53	15	38	25	16	2	30	33	20	33	—	8	—	23	8	27	31	8	17	12	4	12	11	9	14
	—	20	2	84	54	39	23	25	25	16	6	30	29	20	27	—	9	6	23	12	14	20	9	17	12	6	12	18	9	12

TABLE IX.—B.—UNDER 20 CM.

	PLAICE (under 20 cm.)															DABS (under 20 cm.)													
	'99.	'00.	'01.	'02.	'03.	'04.	'05.	'06.	'07.	'08.	'09.	'10.	'13.	'20.	Mean.	'99.	'00.	'01.	'02.	'03.	'04.	'05.	'06.	'07.	'08.	'09.	'10.	'13.	'20.	Mean.
Skate Roads—																														
June ...	5	—	129	39	20	—	9	33	—	—	—	—	39	—	39	0	—	13	8	4	—	0	4	—	—	—	—	7	—	5
Aug.-Sept. ...	61	93	65	82	85	4	1	102	36	24	30	—	45	166	61	6	10	4	5	21	1	0	0	1	4	3	—	21	8	6
	33	93	97	61	52	4	5	68	36	24	30	—	42	166	50	3	10	9	7	12	1	0	2	1	4	3	—	13	8	6
Alnmouth Bay—																														
June-July ...	10	38	9	41	27	10	12	8	—	—	21	—	34	—	21	35	26	26	98	22	11	20	16	—	—	23	—	78	—	35
Aug.-Sept. ...	46	37	72	31	16	14	13	—	19	—	9	51	29	13	29	24	36	25	118	51	16	58	—	9	—	31	21	60	70	43
	28	37	42	36	22	12	13	8	19	—	15	51	31	13	25	30	31	26	108	37	14	39	16	9	—	27	21	69	70	39
Druridge Bay—																														
June-July ...	4	49	13	3	21	2	10	6	—	—	27	—	22	—	16	33	10	38	40	59	10	13	12	—	—	13	—	36	—	26
Aug.-Sept. ...	37	24	28	14	5	1	2	19	23	20	11	7	8	10	15	29	25	9	114	83	23	23	100	23	71	41	9	4	47	50
	22	36	20	9	13	2	6	13	23	20	19	7	15	10	15	31	18	23	77	71	17	18	56	23	71	27	9	20	47	38
Cambois—																														
June-July ...	—	22	37	65	12	12	10	7	—	—	—	—	—	—	24	—	72	29	80	24	67	9	117	—	—	—	—	—	—	57
Aug.-Sept. ...	33	—	25	—	21	5	8	24	—	—	—	—	—	—	19	35	—	15	—	97	32	53	156	—	—	—	—	—	—	65
	33	22	31	65	17	9	9	16	—	—	—	—	—	—	22	35	72	22	80	60	50	31	136	—	—	—	—	—	—	61
Blyth—																														
June-July ...	—	35	10	—	30	4	7	10	—	—	29	—	31	—	20	—	13	11	—	85	2	19	17	—	—	8	—	16	—	21
Aug.-Sept. ...	—	35	—	31	2	4	14	13	15	14	12	17	23	6	16	—	33	—	42	14	19	44	5	10	10	22	102	49	23	31
	—	35	10	31	16	4	11	11	15	14	20	17	27	6	18	—	23	11	42	50	11	32	11	10	10	15	102	33	23	26

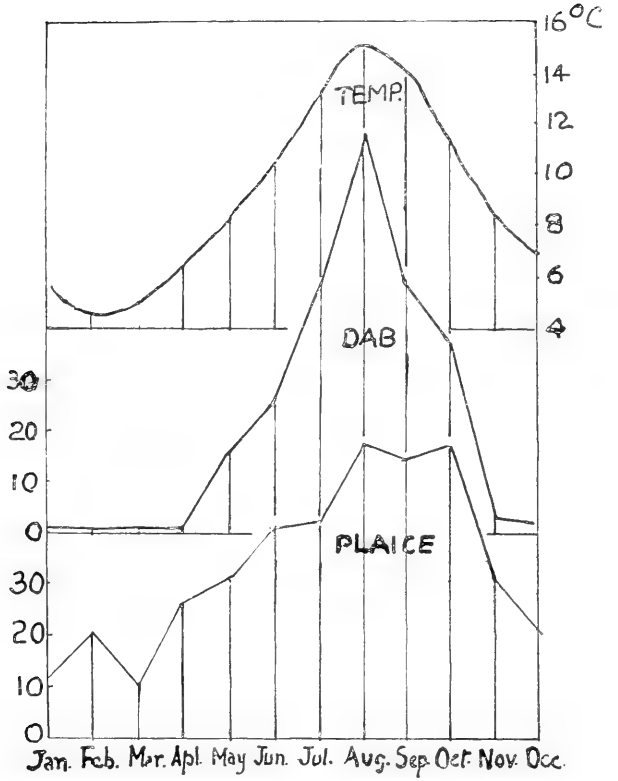


FIGURE 4.

Mean catch per hour of plaice and dabs during the year, with relation to the surface temperature of the sea.

young plaice are found numerously only in the northern part of the district, and small dabs in the southern.

Seasonal Changes.—We have so far considered the results of the experiments made during the period June to September, and even so it has already been apparent that we are not dealing with a static population confined to territorial waters, the protection of which would be bound to lead to improvement. But this becomes abundantly plain when the same stations are trawled over in the colder part of the year. During the summer the inshore waters are rich in plaice and dabs, and receive also other flat fish, but in winter they undergo a conspicuous relapse in all kinds of flat fish. A number of experiments have been made to demonstrate this, and when the results are brought into relation with the summer experiments the general trend of the population during the year is found to follow closely the changes in the temperature of the water (figure 4).

SEASONAL VARIATION, 1899-1913

1.—PLAICE.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Alnmouth	5·3	—	0	19·5	22	51	41	64	60	79	25	—
Druridge	9·3	16	7	24·5	42	45	42	46	39	29	26	—
Blyth ...	21	23	24	33·6	28	27	45	61	62	64	42	—
	12	20	10	26	31	41	42	57	54	57	31	—

DAB.

Alnmouth	0	—	—	0	21	37	58	76	35	48	3	—
Druridge	0	1·3	2	1·5	13	23	45	84	61	39	2·3	—
Blyth ...	3	0	0	0	13	18	41	73	50	27	3	—
	1	·7	1	·5	16	26	48	78	49	38	3	—

The seasonal changes will gain in clearness by an inspection of the following table, Table X., which gives with reference to size the results of successive visits to the various bays.

We have now the evidence before us to demonstrate certain important points relating to the plaice and dabs of the shallow waters close to the shore on the Northumberland coast, and the evidence could be made still more impressive by a fuller statement of the results.

TABLE X.—DETAILS OF SELECTED CONSECUTIVE HAULS TO SHOW SEASONAL CHANGES.

PLAICE.

SKATE ROADS

	15	20	25	30	35	40	45	50	50+
1901.									
June 10th, 26th, 28th ...	57	41	15	8	3	1	—	—	—
August 6th	59	6	4	19	1	—	—	—	—
1902.									
June 26th	25	14	4	3	4	—	—	—	—
July 30th	28	112	28	14	3	—	—	—	—
September 3rd	10	13	6	9	5	—	—	—	—
1903.									
June 25th, 26th ...	4	16	22	27	8	1	—	—	—
August 4th	24	35	17	2	—	—	—	—	—
1906.									
June 27th	11	22	11	8	5	1	—	—	—
August 6th	13	43	22	26	19	—	1	1	—
August 29th	63	85	58	34	18	1	1	—	—
1907.									
August 29th	3	10	69	57	25	2	1	—	—
September 4th	19	21	26	24	11	1	—	—	—
September 27th ...	14	39	17	27	25	4	1	—	1

TABLE N. (Continued).

PLAICE.

ALNMOUTH BAY.

	15	20	25	30	35	40	45	50	50 +
1901									
July 24th	4	5	7	7	—	—	—	—	—
August 14th	47	25	37	14	8	—	1	—	—
1902.									
July 30th	22	30	11	13	10	1	—	—	—
August 27th	11	20	24	10	7	2	2	—	—
1903.									
July 1st	10	17	8	10	2	3	—	—	—
August 19th	9	7	7	7	—	—	—	—	—
1908.									
October 15th	23	27	19	2	2	1	—	—	—
November 12th	1	7	21	10	1	—	—	—	—
1909.									
January 5th	—	1	3	2	2	—	—	—	—
April 8th...	21	5	3	2	6	2	—	—	—
May 20th	1	15	26	11	1	—	—	—	—
July 16th	2	20	11	11	2	1	1	—	—
August 13th	5	8	14	18	11	2	1	—	—
August 27th	1	3	3	1	1	—	—	—	—
1910.									
September 30th ...	37	14	15	16	—	1	—	—	—
October 6th	49	21	8	8	1	—	—	—	—
1911.									
March 6th	—	—	—	—	—	—	—	—	—
1913.									
May 29th	1	3	1	3	—	—	—	—	—
June 11th	7	12	—	8	2	1	—	—	—
July 11th	8	37	3	9	12	11	—	—	—
August 1st	3	22	6	8	3	3	—	—	—
August 18th	6	34	12	9	9	5	1	—	—
September 10th ...	11	23	9	5	2	1	2	—	—
November 1st	1	9	7	3	2	1	—	—	—

TAALE X. (continued).

PLAICE.

DRUIDGE BAY.

	15	20	25	30	35	40	45	50	50+
1901.									
July 10th	6	6	7	3	7	1	1	—	—
July 31st	6	8	7	4	4	1	1	—	—
September 4th	11	8	2	4	1	—	—	—	—
September 12th ...	13	23	51	29	—	—	—	—	—
1902.									
July 16th	1	2	15	17	12	—	—	—	—
August 20th	6	8	35	44	44	4	1	1	—
1903.									
July 15th	10	11	3	16	10	1	—	—	—
August 12th	1	3	1	10	12	3	—	—	—
September 9th	1	5	10	10	5	—	1	—	—
1906.									
July 4th	1	5	6	15	11	6	—	1	—
August 22nd	1	5	8	3	1	1	—	—	—
September 5th	8	24	13	7	4	3	—	—	—
1907.									
August 19th	8	5	4	8	1	3	—	—	—
September 4th	6	7	2	5	1	—	—	—	—
September 14th ...	15	7	5	8	2	—	—	—	—
1908.									
September 16th ...	5	15	9	3	2	1	—	—	—
November 12th	1	3	6	3	3	3	1	—	—
1909.									
January 5th	2	1	3	2	1	—	—	—	—
February 18th	1	—	8	1	5	1	—	—	—
April 8th...	5	4	10	3	3	—	1	—	—
May 20th	2	11	12	9	2	1	—	—	—
July 16th	3	25	10	17	1	—	—	—	—
August 13th	1	10	35	42	19	4	—	—	—
1910.									
September 30th ...	6	1	1	4	4	5	1	—	1
October 6th	5	5	1	3	9	3	1	1	1
1911.									
March 6th	—	—	1	3	3	—	—	—	—
1913.									
May 29th	24	7	1	4	3	5	1	—	1
June 11th	—	6	6	3	4	1	—	—	—
July 11th	1	36	13	10	22	12	—	—	—
August 1st	—	5	6	1	1	1	1	—	—
August 13th	—	1	—	—	—	1	—	—	—
September 10th... ...	1	11	9	2	6	12	—	—	—
November 1st	2	4	5	5	9	8	—	—	—

TABLE X (continued).

PLAICE.

CAMBOIS BAY.

	15	20	25	30	35	40	45	50	50+
1901.									
July 3rd	18	19	4	2	—	—	—	—	—
August 28th	18	23	18	11	1	—	—	—	—
September 4th	3	6	2	1	—	—	—	—	—
1902.									
June 28th	11	34	13	12	3	—	—	—	—
July 2nd	24	53	19	6	1	1	—	—	—
July 23rd	13	59	26	8	2	—	—	—	—
1903.									
July 9th	3	9	3	3	4	—	—	—	—
August 26th	4	17	12	5	—	—	—	—	—
1906.									
July 25th	1	6	2	1	1	—	—	—	—
September 2nd	2	22	8	4	1	—	—	—	—

TABLE X. (Continued).

PLAICE.

BLYTH BAY.

	15	20	25	30	35	40	45	50	50+
1903.									
July 23rd	4	26	25	16	5	—	—	—	—
September 2nd	1	2	10	38	14	—	—	—	—
1904.									
June 30th	—	2	2	8	2	—	—	—	—
July 20th	—	6	14	17	5	2	—	—	—
August 17th	2	2	7	33	11	—	1	—	—
1905.									
July 26th	2	5	15	13	2	1	—	—	—
August 23rd	4	10	13	1	1	—	—	—	—
1906.									
June 20th	6	9	4	4	3	—	—	—	—
July 25th	—	4	4	5	2	1	—	—	—
August 1st	1	15	25	17	4	2	—	—	—
September 12th ...	6	4	13	7	6	1	—	—	—
1907.									
September 6th	20	10	11	11	1	—	—	—	—
September 20th ...	7	6	7	9	6	1	1	—	—
1908.									
September 4th	5	7	13	2	1	—	—	—	—
October 8th	10	20	19	5	7	3	—	—	—
November 12th	—	10	10	4	4	—	—	—	—
1909.									
January 5th	2	3	7	4	5	—	—	—	—
February 18th	8	5	7	1	2	—	—	—	—
April 8th...	8	10	11	7	6	—	—	—	—
May 20th	7	19	9	8	—	—	—	—	—
July 16th	3	26	4	8	1	—	—	—	—
August 13th	2	10	2	—	—	—	—	—	—
1910.									
September 2nd	16	1	3	6	4	—	—	—	—
1911.									
March 2nd	2	6	4	7	4	1	—	—	—
1913.									
May 29th	—	5	2	3	3	—	—	—	—
June 11th	7	13	9	14	6	3	—	—	—
July 11th	9	33	12	6	1	—	—	—	—
August 1st	1	22	14	4	8	2	—	—	—
August 13th	3	23	20	4	13	7	—	—	—
September 10th ...	—	19	12	6	3	5	—	—	—

TABLE X. (continued).

DAB.

ALNMOUTH BAY.

	15	20	25	30	35	40	45
1901.							
July 24th	9	17	4	—	—	—	—
August 14th	5	20	13	3	1	—	—
1902.							
July 9th	26	81	9	3	1	—	—
July 30th	25	65	20	—	—	—	—
August 27th	12	106	15	2	—	—	—
1903.							
July 1st	7	15	13	2	—	—	—
August 19th	4	47	15	2	—	—	—
1908.							
October 15th	3	45	13	5	—	—	—
November 12th	1	6	20	9	1	—	—
1909.							
January 5th	—	—	—	—	—	—	—
April 8th	—	—	—	—	—	—	—
May 20th	—	1	2	1	—	—	—
July 16th	1	22	15	7	2	—	—
August 13th	1	54	34	3	—	—	—
August 27th	1	2	3	1	—	—	—
1913.							
May 29th	—	16	12	5	2	—	—
June 11th	1	43	27	6	—	—	—
July 11th	10	90	35	4	—	1	—
August 1st	5	95	50	4	1	—	—
August 13th	5	113	31	2	—	—	—
September 10th ...	1	15	13	3	—	—	—
November 1st	1	—	2	1	1	—	—

TABLE X. (continued).

DAB.

DRURIDGE BAY.

	15	20	25	30	35	40	45	50	50+
1907.									
August 19th	—	12	33	6	—	—	—	—	—
September 4th	1	15	35	7	4	—	—	—	—
September 14th	1	36	37	6	1	—	—	—	—
1908.									
September 16th ...	1	75	62	10	1	—	—	—	—
November 12th	—	—	1	—	—	—	—	—	—
1909.									
January 5th	—	—	—	—	—	—	—	—	—
February 18th	—	—	1	1	—	—	—	—	—
April 8th	—	1	1	1	—	—	—	—	—
May 20th	—	2	7	1	—	—	—	—	—
July 16th	—	13	7	5	1	—	—	—	—
August 13th	—	41	57	8	1	—	—	—	—
1910.									
September 30th ...	—	9	27	2	—	1	—	—	—
October 4th	1	7	22	8	—	1	—	—	—
1911.									
March 6th	—	—	—	1	—	—	—	—	—
1913.									
May 29th	—	10	7	3	2	1	—	—	—
June 11th	1	23	10	—	—	—	—	—	—
July 11th	13	35	15	2	1	—	—	—	—
August 1st	—	5	8	2	—	—	—	—	—
August 13th	—	1	—	—	—	—	—	—	—
September 10th ...	—	7	9	—	—	—	—	—	—
November 1st	—	1	1	2	—	—	—	—	—

TABLE X, (continued).

DAB.

Blyth Bay.

	15	20	25	30	35	40	45	50
1907.								
September 6th	1	10	16	4	2	—	—	—
September 20th ...	3	21	23	4	1	—	—	—
1908.								
September 4th	1	10	8	1	—	—	—	—
October 8th	—	15	10	2	—	—	—	—
November 12th	—	—	2	—	—	—	—	—
1909.								
January 5th	—	—	—	1	2	—	—	—
February 18th	—	—	—	—	—	—	—	—
April 8th...	—	—	—	—	—	—	—	—
May 20th	—	3	3	—	—	—	—	—
July 16th	—	8	7	—	—	—	—	—
August 13th	—	22	4	1	—	—	—	—
1910.								
September 2nd	8	94	11	1	—	—	—	—
1911.								
March 2nd	—	—	—	—	—	—	—	—
1913.								
May 29th...	—	8	10	1	1	—	—	—
June 11th	—	6	5	2	1	—	—	—
July 11th	4	21	27	5	—	—	—	—
August 1st	6	60	11	5	—	—	—	—
August 13th	1	55	7	1	2	—	—	—
September 10th ...	1	23	7	1	—	—	—	—

1. These species are not sedentary but enter and leave the regions in question, and there is a conspicuous annual immigration and emigration. In the case of plaice the minimum condition is reached in February and March, and maxima are usually apparent in June and August and September. Dabs almost entirely disappear from the shore waters from November to April, and reach a summer maximum in July or August, and a double maximum is sometimes evidenced.

2. Large numbers of immature and small numbers of those approaching maturity and spent fish take part in the periodical seasonal migrations.

3. The annual inshore migration presents the peculiarity that the plaice of all sizes predominate in the northern part of the area, and the dabs in the southern, and finer analysis shows that what is true of the district as a whole is true also of the subdivisions. In each bay it has been found that the plaice tend to the north end, and the dabs to the south end. It will be observed that in chart 8, which illustrates the catches of the fishermen in the respective areas with some degree of overlapping that the distribution is equally well brought out, that is to say, that the catches even by line illustrate the general distribution and relative proportions of the species.

Our trawling experiments have reference therefore to a fluctuating population, subject to daily movements with relation to tidal and other influences and to a conspicuous annual seasonal migration, associated with temperature changes. Obviously the fish cannot move in winter inshore for our trawling has been done close to the shore, and it may be presumed therefore that they move offshore or into estuaries. This population of plaice and dabs is recruited each season by arrivals from the spawning grounds. Our results therefore bear witness to the success of the spawning seasons and of the conditions of growth and food supply at the size when from 10 to 15 cm. (4 to 6 inches) they are liable to be caught in the trawl. At these sizes they are in their second and third summers for the most part and are already, as the evidence shows, undergoing the seasonal change of position. It will be seen that with increase of size and strength the seasonal migrations become more and more extensive.

3.—DISTRIBUTION OF SPECIES OTHER THAN PLAICE AND DAB.

It will be seen later that Northumberland does not stand alone with respect to the distribution of the plaice and dab, but it will help us to understand the problem if we first consider the other species we capture at our experiments on the Northumberland coast.

Too much stress certainly cannot be laid on small catches of prime flat fish, but so far as it goes the evidence points to turbot and brill being more common in the north, soles in the south, and the catches of the inshore fishermen agree with this. The flounder is generally distributed, although as a rule scarce in the districts trawled in, but it also may be said to predominate in the north, as is evidenced from this year's catches. It is natural to expect that the attraction to fresh or brackish water would produce an effect, and as a fact flounders occur in fair numbers, for example, in certain years in Alnmouth Bay and in Blyth Bay.

Flounder.—Tables XI. and XII. give the numbers caught per hour's trawling during the years of the complete experiment and the years of the detailed records. The species only rarely appears in the region of the trawling stations, and, it will be observed, may be absent altogether during a day's visit to one of the stations. But in Table XI. the figures for flounders for the first four years are doubtful. The marketable flounders were obtained most commonly at Skate Roads and at Alnmouth, and the flounder exhibits, generally speaking, like its congeners, a rise and fall during the summer. During the winter a few large flounders were obtained at Druridge Bay and Blyth Bay, but they were absent from Alnmouth. It will be noticed that the young, which were only represented in numbers on a few occasions, were confined practically to the southern bays, and from this point of view (Table XII.) the distribution centres at Alnmouth. The distribution then has the peculiarity that the large sizes predominate in and characterise the northern part of the coast, including Goswick, while the young are more conspicuously present in the south. The district as a whole receives in addition spent fish. It will be observed also that if a change

TABLE XI.—FLOUNDER (1892-1906). MARKETABLE FISH.

	1892.	1893.	1894.	1895.	1896.	1897.	1898	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	Mean.
Skate Roads—																
June-July ...	—	—	1·9	0	3·4	2·1	0·7	2.0	—	2·8	—	—	—	—	3·4	1·8
Aug.-Sept. ...	—	—	0·9	0	3·8	1·0	0·8	1·4	0	0	—	2·8	—	0	8·8	1·8
	—	—	1·4	0	3·6	1·5	0·7	1·7	0	1·4	—	2·8	—	0	6·1	1·8
Alnmouth Bay—																
June-July ...	—	0	1·1	0	0·4	0·1	1·4	1·5	2·0	0	0·7	0·7	3·8	0·5	0·4	0·9
Aug.-Sept. ...	—	0	0·9	0	0·4	0·6	—	1·1	1·6	0·8	0·6	1·3	4·5	1·7	1·3	1·1
	—	0	1·0	0	0·4	0·4	1·4	1·3	1·8	0·4	0·7	1·0	4·2	1·1	0·8	1·0
Druridge Bay—																
June-July ...	—	—	0·3	0·2	0·1	0·3	0·2	0·1	0	0·1	0·1	1·0	0	0	0·9	0·3
Aug.-Sept. ...	0	0	0·2	0	0·1	0·3	0·2	0·3	0·3	0·1	0·8	0·2	0·6	0·2	0·8	0·3
	0	0	0·3	0·1	0·1	0·3	0·2	0·2	0·1	0·1	0·5	0·6	0·3	0·1	0·8	0·3
Cambois Bay—																
June-July ...	—	0	—	0	0	0	—	—	0·2	0·2	0·7	0	0·8	0·8	0	0·2
Aug.-Sept. ...	0	0	0 2	—	0	0	0·1	0·1	—	0·9	—	0·1	0	0	·05	0·2
	0	0	0 2	0	0	0	0·1	0·1	0·2	0·6	0·7	0·05	0·4	0·4	0·2	0·2
Blyth Bay—																
June-July ...	—	—	0·5	0	0	—	0·2	—	0·2	0	—	2	—	1·4	3·0	0·8
Aug.-Sept. ...	0	0	—	0	0·2	1·4	—	0	—	—	0·3	1·5	2·0	0	2·8	0·7
	0	0	0·5	0	0·1	1·4	0·2	0	0·2	0	0·3	1·7	2·0	0·7	2·9	0·8

TABLE XII.—FLOUNDER. DETAILED RECORD DISTINGUISHING SIZE UNDER 20 CM. AND OVER 20 CM.

		1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1913.	1920.	Mean.
Skate Roads	— 20	1	0	1	2	1	0	0	1	0	0	1	—	1	0	0·6
	+ 20	2	1	2	3	4	1	5	12	6	17	3	—	2	7	5·0
		3	1	3	5	5	1	5	13	6	17	4	—	3	7	2·8
Alnmouth Bay	— 20	14	28	19	5	2	7	1	1	1	—	2	0	5	1	7·0
	+ 20	9	13	4	4	0	2	1	3	4	—	4	0	8	1	4·0
		23	41	23	9	2	9	2	4	5	—	6	0	13	2	5·5
Druridge Bay	— 20	1	0	1	0	1	1	0	3	0	0	1	0	1	0	0·6
	+ 20	1	1	1	1	1	2	0	7	1	0	3	1	2	1	1·6
		2	1	2	1	2	3	0	10	1	0	4	1	3	1	1·1
Cambois Bay	— 20	2	26	1	11	1	5	1	0	0	—	—	—	—	—	5·2
	+ 20	1	2	1	5	0	2	1	1	0	—	—	—	—	—	1·4
		3	28	2	16	1	7	2	1	0	—	—	—	—	—	3·3
Blyth Bay	— 20	—	1	2	0	1	5	1	2	1	1	1	0	2	0	1·3
	+ 20	—	0	2	0	1	5	2	8	4	1	1	0	2	0	2·0
		—	1	4	0	2	10	3	10	5	2	2	0	4	0	1·6

may be deduced from our catches it points to the species declining on the Northumberland coast.

Turbot.—These are for the most part large immature and mature specimens which penetrate into the shallow waters of Northumberland during the summer. A few, measuring 15 to 20 cm., have been captured, showing that even young stages are present, but most measure 25 to 30 cm., and some reach the size 45 to 50 cm. (18 to 20 inches). The distribution is tolerably plain from Table XIII., and it will be noticed that it is the same as that of the plaice, and this is borne out by a consideration of the detailed hauls. They appear in the inshore waters in April and May, and leave in November. Turbot are captured mainly by the northern fishermen of the district, and "brat" nets were used up to recent times for their capture in the autumn at several of the stations until they finally disappeared at Craster. Like the plaice, the turbot predominate in the southern and eastern part of the North Sea, and their seasonal behaviour there is the same as the plaice.

Brill.—The brill are large as a rule, and occur much less plentifully in the inshore waters of Northumberland, a fact which is also brought out in the statistics of the catches of the fishermen, but it will be noticed from Table XIV. that their distribution is like that of the turbot. They are rare in the North Sea generally.

Sole.—During the years of the complete experiment, 1892-1906, soles were obtained in small numbers, but constantly, and, indeed, during the period an improvement in the numbers was evidenced. The distribution in the case of the marketable sole is remarkably like that of the dab. They predominate at the southern stations, especially at Cambois, the bay between Newbiggin and Blyth. The size of the captures is indicated in Table XVI., which gives a synopsis of the detailed records, and from this it will be observed that the soles are mainly large, immature and spent. It is seldom that soles under 20 cm. (8 inches) are captured, but a fair number has been got between 20 and 30 cm. (8 to 12 inches), and between 30 and 40 cm. (12 to 16 inches)., Soles over 40 cm. are obtained at all the stations, but mainly, like the other sizes, in the southern bays. Statistics again bear out the distribution. They are summer visitors, and include

TABLE XIII.—TURBOT (1892-1906.—MARKETABLE FISH.

	1892.	1893	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	Mean.
Skate Roads—																
June-July ...	—	—	2·8	0·4	0·4	4·4	2·6	0·1	—	2·8	—	—	—	—	1·1	1·8
Aug.-Sept. ...	—	—	1·8	0·1	5·9	3·3	0·8	2·2	0	2·1	—	2·2	—	5·7	1·1	2·3
	—	—	2·3	0·3	3·0	3·8	1·7	1·2	0	2·4	—	2·2	—	5·7	1·1	2·0
Alnmouth Bay—																
June-July ...	—	1·1	1·6	0·8	1·6	0·7	1·2	0	0·3	0	0·2	2·7	0·1	1·9	3·5	1·1
Aug.-Sept. ...	—	0·4	1·7	0·4	1·3	1·0	—	0·9	0·3	0·3	1·8	2·2	1·7	2·1	1·4	1·2
	—	0·7	1·6	0·6	1·4	0·9	1·2	0·4	0·3	0·1	1·0	2·5	0·9	2·0	2·4	1·2
Druridge Bay—																
June-July ...	—	—	2·9	0·5	0·9	2·4	1·0	0·2	1·5	0·2	0·8	0·8	1·1	2·1	4·1	1·4
Aug.-Sept. ...	0	0·9	0·8	0·2	1·4	2·0	0·9	1·1	0·5	0·5	1·2	2·3	1·4	2·5	2·0	1·2
	0	0·9	1·8	0·4	1·1	2·2	0·9	0·6	1·0	0·3	1·0	1·5	1·2	2·3	3·0	1·3
Cambois Bay—																
June-July ...	—	0·2	—	0·4	0·3	0·5	—	—	0·4	0·4	0·1	0·1	0	0·5	1·2	0·4
Aug.-Sept. ...	0·2	0·4	0·1	—	0·8	0	0·3	0·6	—	0·3	—	1·2	0·6	0·3	0·5	0·4
	0·1	0·3	0·1	0·4	0·6	0·3	0·3	0·6	0·4	0·3	0·1	0·6	0·3	0·4	0·9	0·4
Blyth Bay—																
June-July ...	—	—	0·2	0·2	0·7	—	0·2	—	0·1	0	—	2·1	—	0·8	2·0	0·7
Aug.-Sept. ...	0·1	0·5	—	0·4	0·2	0·6	—	0	—	—	0	0·4	0	0·2	0·7	0·3
	0·1	0·5	0·2	0·3	0·5	0·6	0·2	0	0·1	0	0	1·3	0	0·5	1·4	0·5

TABLE XIV.—BRILL (1892-1906.—MARKETABLE FISH.

	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1999.	1900.	1901.	1902.	1903.	1904.	1905	1906.	Mean.
Skate Roads—																
June-July ...	—	—	0	0	0	0·7	0·6	0	—	0·7	—	—	—	—	0	0·2
Aug.-Sept. ...	—	—	0	0	0·1	0·2	0·1	0	0	0·1	—	0·8	—	0	0·1	0·1
	—	—	0	0	0·05	0·5	0·3	0	0	0·4	—	0·8	—	0	0·05	0·2
Alnmouth Bay—																
June-July ...	—	0	0	0	0	0	0·1	0·1	0·1	0	0	0	0	0	0	0·02
Aug.-Sept. ...	—	0	0	0	0·1	0	—	0	0	0	0·1	0·1	0	0	0	0·02
	—	0	0	0	0·05	0	0·1	0·05	0·05	0	0·05	0·05	0	0	0	0·02
Druridge Bay—																
June-July ...	—	—	0	0	0	0·1	0·2	0·1	0·1	0	0	0·1	0·1	0·2	0·1	0·1
Aug.-Sept. ...	0	0	0	0	0	0	0	0·1	0·1	0·1	0·1	0	0·1	0	0	0·03
	0	0	0	0	0	0·05	0·1	0·1	0·1	0·05	0·05	0·05	0·1	0·1	0·05	0·06
Cambois Bay—																
June-July ...	—	0	—	0	0	0	—	—	0·2	0	0·04	0	0	0	0·2	0·04
Aug.-Sept. ...	0	0	0	—	0	0	0	0·05	—	0	—	0	0	0	0	·004
	0	0	0	0	0	0	0	0·05	0·2	0	0·04	0	0	0	0·1	0·02
Blyth Bay—																
June-July ...	—	—	0	0	0	—	0	—	0	0·5	—	0·1	—	0	0·1	0·03
Aug.-Sept. ...	0·1	0	—	0	0	0	—	0	—	—	0	0	0	0	0	0·01
	0·1	0	0	0	0	0	0	0	0	0·5	0	0·05	0	0	0·05	0·04

TABLE XV.

SOLE (1892-1906).—MARKETABLE FISH.

	1892.	1893	1894.	1895	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	Mean.
Skate Roads—																
June-July ...	—	—	0·1	0	0·2	0·5	0·1	0	—	0	—	—	—	—	0·6	0·2
Aug.-Sept. ...	—	—	0·1	0·3	0·2	0·6	0·2	0	2	0	—	0·6	—	0·3	0·1	0·4
	—	—	0·1	0·1	0·2	0·5	0·2	0	2	0	—	0·6	—	0·3	0·3	0·3
Alnmouth Bay—																
June-July ...	—	1·0	1·5	0·5	3·7	2	0·2	0·1	1·9	0·3	1·7	6·9	3	3	1·5	1·8
Aug.-Sept. ...	—	1·4	1·0	1·0	1·1	1·2	—	1·0	2·5	1·7	5·2	4·5	1·4	4·7	0·8	2·1
	—	1·2	1·3	0·7	2·4	0·7	0·2	0·6	2·2	1·0	3·4	5·7	2·2	3·9	1·2	1·9
Druridge Bay—																
June-July ...	—	—	0·5	1·0	2·3	4·0	0·5	0·2	1·0	2·1	3·5	8·2	4·0	1·1	0·8	2·2
Aug.-Sept. ...	1·4	2·8	3·9	1·2	2·8	1·6	0·3	2·1	2·7	0·8	1·5	4·5	2·1	3·5	3·5	2·3
	1·4	2·8	2·2	1·1	2·5	2·8	0·4	1·9	1·9	1·5	2·5	6·3	3·1	2·3	2·2	2·2
Cambois Bay—																
June-July ...	—	0·4	—	0·6	1·7	3·2	—	—	1·7	0·7	2·0	15·2	6·7	1	0·7	3·1
Aug.-Sept. ...	0·5	1·6	4·9	—	2·4	2·3	1·0	2·0	—	0·3	—	10·5	7·0	5·9	3·0	3·4
	0·5	1·0	4·9	0·6	2·1	2·8	1·0	2·0	1·7	0·5	2·0	12·9	6·8	3·4	1·8	3·3
Blyth Bay—																
June-July ...	—	—	4·3	2·0	0·5	—	2·7	—	1·5	1·0	—	3·3	—	3·2	0·9	2·2
Aug.-Sept. ...	0·1	4·0	—	2·1	3·6	0·9	—	0	—	—	3·2	3·0	1	1·5	3·7	2·1
	0·1	4·0	4·3	2·0	2·0	0·9	2·7	0	1·5	1·0	3·2	3·2	1	2·3	2·4	2·1

TABLE XVI.—SOLE.

		1899	1900.	1901	1902	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1913.	1920.
Skate Roads	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30	0	1	0	1	1	0	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	40+	0	1	0	1	0	0	0	0	1	0	0	0	0	0
		0	2	0	2	1	0	0	0	1	0	0	0	0	0
Alnmouth Bay	20	0	1	0	0	0	0	0	0	0	—	0	0	0	0
	30	0	1	1	3	8	3	0	0	1	—	1	1	0	0
	40	0	2	1	0	2	5	3	2	0	—	2	0	0	0
	40+	0	1	0	0	1	0	0	1	0	—	1	1	1	0
		0	5	2	3	11	8	3	3	1	—	4	2	1	0
Druridge Bay	20	0	0	1	0	1	0	0	0	0	0	0	0	1	0
	30	0	1	2	2	7	2	1	1	1	1	0	0	0	1
	40	1	1	1	0	2	2	3	3	3	2	0	1	0	1
	40+	2	1	1	0	1	0	1	2	1	2	2	2	1	2
		3	3	5	2	11	4	5	6	5	5	2	3	2	4
Cambois Bay	20	0	0	0	1	0	0	0	0	0	—	—	—	—	—
	30	1	2	1	5	13	4	1	1	0	—	—	—	—	—
	40	2	0	0	1	2	7	5	2	1	—	—	—	—	—
	40+	2	0	0	0	1	1	1	1	0	—	—	—	—	—
		5	2	1	7	16	12	7	4	1	—	—	—	—	—
Blyth Bay	20	—	0	1	0	0	0	0	0	0	0	0	0	0	0
	30	—	1	1	3	3	2	0	1	1	1	0	0	1	1
	40	—	0	0	1	0	1	2	1	2	2	0	2	1	0
	40+	—	0	0	1	1	1	0	0	1	2	1	0	3	1
		—	1	2	5	4	4	2	2	4	5	1	2	5	2

immature and spent fish, which leave about October or November and return about June. It was found, however, that one or two of the older fish may remain during the winter, as was proved by trawling at Alnmouth in January, April and May.

A consideration of the rarer groups serves to indicate the nature of the annual invasion of the more common species. They are all summer visitors, and all include young and adult fish. The complete or practically complete disappearance from the shallow waters along the coast shows that a seasonal migration takes place which affects all. In all cases the Northumberland waters almost to the shore present every stage from the young to the old, although not as a rule reaching the maximum size. The conclusion is inevitable therefore that if the young do not migrate far they are joined by larger, older fish, and some of the latter may remain in shallow water even during the winter. The main population takes part in the seasonal migration, which follows so closely the rise and fall of the temperature of the sea. The degree of the retreat and the advance is thus correlated with size and strength. Now, in addition to this movement there appears to be another or a modification of the seasonal migration which brings about the distribution which we have found to characterise the different species.

The gurnard and the angler, although not so valuable as the foregoing, yet occur in sufficient numbers to be of importance.

Gurnard.—In 1920 the catches arranged so as to bring out the numbers with relation to size are :—

TABLE XVII. GURNARD, 1920.

Cm.	Skate Roads.		Alnmouth.				Druridge.				Blyth.		
15	0	1	10	7	0	1	1	4	0	2	11	1	0
20	2	2	42	54	10	10	10	42	1	162	8	23	0
25	2	1	3	3	1	3	1	3	4	35	0	2	0
30	0	0	0	0	0	1	1	0	1	4	1	0	0
35	0	0	1	0	0	1	1	0	1	1	0	0	0

The mean size of the young at Blyth on July 29th was 10 and 15 cm. ; at Alnmouth, 16·5 cm. ; in August at all the bays, 17·5 cm. ; and in September at Druridge, 19·5 cm.

The distribution is like that of the dabs, and it agrees in this respect with the results of past years. During the summer each year gurnards arrive in the inshore waters in variable numbers,

but in all cases the bays to the north of the southern half of the district receive the greatest numbers. The invasion begins about May, and the wave of arrivals gradually increases until the latter part of August when the return to deeper water begins. They leave the inshore waters finally about October or November. The sizes most in evidence from the results of the trawling are 14 to to 28 cm., but even the predominant sizes during the season pass gradually from 15 or 16 to 18 cm., and at the end of the season only a few large gurnards still occupy the bays. As with the other species considered therefore the summer immigration consists mainly of young immature fish, which are joined by a number of spent fish after the spawning season.

But there is a difference. Normally and usually the dabs increase in numbers towards the south, reaching a maximun at Cambois. The gurnards are most numerous at Alnmouth and Druridge, and tail off to the south. The distribution is therefore more like that of the plaice ; the difference is that instead of the headquarters being in the neighbourhood of Holy Island it is in the region of Coquet Island.

This is borne out by a consideration of the school of gurnards of the Scottish waters adjacent. It has its headquarters to the east of the coast of Fifeshire, and tails off to the south in the Firth of Forth, and we evidently do not meet another school to the south of the Forth school until we come to that of the Northumberland coast. It appears to be obvious therefore that in the case of the gurnard we have schools derived from isolated spawning assemblages. The spawning season is April to August, and the eggs are pelagic. In the case of the Scottish school just mentioned, the spawning ground must lie to the north-east of the area which receives the bulk of the " O " group, and in that of the Northumberland school to the north-east of the Farne Islands. In each case the products of the spawning are assembled on a recruiting ground, and move inwards to gain a position in shallow water. There they are joined during the next summer by the older groups and spent fish, especially by the immature, which have immediately preceded them as occupants of the region. These come into the shore region each summer in an ever increasing crowd; and during each season the mean size of the predominant migrants gradually increases. This may be in some

degree associated with an increase in length due to the summer feeding, but it is plainly correlated with a succession of migrants according to size. The conclusion is therefore that with increasing strength and size the outward migration is more and more offshore. It follows from such a conclusion that the tendency in the summer is to concentration inshore and in the winter to segregation offshore. The evidence furthermore of the details of the annual inshore incidence in the respective bays points to a southward tendency of the migrants when they reach coastal waters, and a northward tendency when they are leaving.

Angler.—The following table shows the occurrence of this species in the shallow waters of Northumberland since 1899.

TABLE XVIII.—ANGLER.

	99	00	01	02	03	04	05	06	07	08	09	10	13	20	Mean.
Goswick	0	—	2	11	—	—	—	—	—	—	—	—	—	—	4
Skate Roads	1	1	1	1	1	0	1	17	2	3	0	—	1	9	3
Alnmouth	1	4	0	5	6	3	12	16	7	—	1	2	1	12	5
Druridge	1	1	1	6	2	1	9	17	6	5	2	3	20	20	5
Cambois	1	0	1	10	1	3	8	8	1	—	—	—	—	—	4
Blyth	—	2	0	0	0	0	0	22	1	0	1	4	2	18	4

It is generally distributed along the coast, and was most successful in 1906 and again in 1920. It is remarkably inconstant in its history in Blyth Bay, but in both of the years of plenty Blyth Bay participated in the wave of immigration. This species is distinctly a summer visitor, appearing in May and persisting to October or November. A reference to Table I. will show that all sizes are caught from about 15 cm. (6 inches) to 50 or even 60 cm. (20 to 24 inches).

The interesting feature of the species is that the egg masses are pelagic, and are carried, it is believed, down the coast from some distant spawning ground to the north. The masses have been captured off the Northumberland coast in herring nets, and the larvæ have been captured in local plankton.

It is very rarely then that the eggs are found and the larvæ. The young stages up to the period of those caught as in our trawling experiments are still less seldom seen. These facts, together with the evidence of the long pelagic drift of the larvæ, point to the spawning taking place for the most part in the Atlantic. There can be little doubt from the work of Agassiz, the observations of Murray and Hjort off Newfoundland, and the occurrences

recorded by Schmidt of the larvæ in the region where the eel larvæ were procured that the larvæ are transoceanic in distribution. Nevertheless the records of the occurrence of the egg-bands as far south in the North Sea as off Northumberland shows that spawning occurs in the northern North Sea at least. When they arrive in coastal waters they still migrate contranatantly, and they form, for example, a regular feature of the summer population of the Northumberland coast. The seasonal migration of the immature we know, but the spawning migration is usually evidently a long contranatant one.*

Spur Dogfish.—In the early days of the Northumberland experiments young spur dogs, *Aacnthias vulgaris*, were obtained in shallow water at the trawling stations in fairly large numbers. This was certainly the fact in 1893 and 1896, but since then they have not been observed. The records point to the females migrating inshore to liberate the young, but that usually they do not migrate so far inshore as in the years mentioned. They were simply recorded as "small," but the size was such as to indicate they were in their second summer for the most part. The young of the year were procured inshore at Hartley in November, 1896. The species has not, however, declined in numbers. We have frequently observed that large numbers have been landed by trawlers, and of a size which points to the young not migrating so far inshore. On August 25th, 1911, the North Shields trawlers had large catches from the grounds about eight miles off the coast. One of the vessels had from three to four cartloads, and in another the gear was broken when hauling the catch on board. Again, in 1915, large numbers of spur dogs were landed during the latter part of the year, and especially in October. Most were obtained about 70 miles north-east by east of the Tyne, smaller numbers from the North-East Bank and still smaller numbers nearer the coast. A sample was measured and was found to consist of 50 males, 24 to 31 cm. in length, and 12 females, 20 to 28 cm. in length. They were therefore small in size and young fish, but it is interesting to note that even so marked a segregation according to sex was manifested. The segregation of the adult females is understandable from the fact that they migrate inde-

* 1920, Bowman. Fish. Bd. for Scotland. Sc. Invest.,1919, No. 1.

pendently of the males to give birth to the young, and this is an inshore migration, but the congregation far from the shore in large numbers in October shows that the young speedily become vigorous contranatant migrants, keeping, however, together in shoals.

This year, 1921, dogfish were numerous in May and June. In May 30 cwts. were captured by North Shields trawlers; in June, 205 cwts. Some were obtained about 150 miles E.N.E. of the Tyne, but the bulk of the catches were made in local waters north and south of the Tyne, at a distance of about 14 miles.

4.—DISTRIBUTION OF PLAICE AND DAB.

The foregoing results indicate that the shallow waters of 2-5 fathoms on the coast of Northumberland annually receive an immigration of important flat and round fish, that the immigrants on the whole gradually increase in size during the summer, and that most leave the inshore waters close to the shore in the winter. It has also been apparent that the immigrants are distributed along the Northumberland coast with remarkable constancy each season.

The " Garland " and the more recent " Goldseeker " trawling experiments of the Scottish Fishery Board indicate that the distribution of the species is similar on the Scottish coast and in deeper water. In the region extending from the north of the Firth of Tay to the south of the Firth of Forth there is a similar assemblage of plaice and dabs to that of Northumberland. The estuary of the Tay is a plaice area, that of the Forth a dab area. Forty years ago a " bag " of plaice could be easily obtained during a flood tide fishing on the sandbanks at Broughty Ferry, and the same is likely the case to-day.

The plaice caught per hour's trawling by the " Garland " and by the " Goldseeker " illustrate with great clearness that in depths of 6 to 20 fathoms the conditions of the Forth school with respect to distribution are the same as those of Northumberland in depths of 2-3 fathoms.

The figures show also that plaice and dabs are subject to the same seasonal change. But at all seasons the plaice and dabs

while retaining their relative proportions do not leave the region so completely. There are more dabs, and especially more plaice, which winter at 20 fathoms than at 3 fathoms. The mean size at the greater depth is larger than at the less depth, and as we have found in Northumberland the younger and smaller plaice predominate in the north of the region.

FIRTH OF FORTH SCHOOL.

Stations.	Per Hour.	D —	Mean.	D +
Carnoustie	272 ...	21 ...	27 ...	33
St. Andrews	138 ...	20 ...	27 ...	33·5
Firth of Forth—				
VI.	124 ...	30 ...	36 ...	43
II.	77 ...	27 ...	33 ...	39
IV.	23 ...	24 ...	32 ...	43
VII.	19 ...	26 ...	33 ...	43

The stations are arranged according to position ; the average depth is about 10 fathoms ; stations VI. and II. are situated on the northern side, and IV. and VII. on the southern side of the Firth of Forth. In the Forth school of plaice the largest numbers appear in the north of the region, and the small plaice are found for the most part likewise in the northern part of the region. This is as we have observed exactly what occurs in Northumberland.

In addition to the stations mentioned trawling took place at other stations in the deeper water of the middle of the Forth. Stations I. and III. lie close together between stations II. and IV. up the Firth, station V. between stations VI and VII. at the mouth of the Firth, and VIII. and IX. still further out. The results for these stations were as follows ;—

	Fathoms.	Per Hour.	D —	Mean	D +
I.	10—16 ...	14 ...	28 ...	34 ...	42
III. ...	8—10 ...	3·5 ...	26 ...	33 ...	40
V.	20—30 ...	7·4 ...	31 ...	38 ...	48·5
VIII. ...	20—30 ...	2 ...	27 ...	35 ...	45
IX. ...	29—32 ...	2 ...	26 ...	34 ...	48

It is evident therefore that fewer and somewhat larger plaice are captured in the deeper water of the estuary.

But it is the seasonal variation in numbers which brought into comparison with that of the Northumberland school is of importance. For the Firth of Forth stations the results are arranged as follows :—

Station.	Jan.-Mar.	April-June.	July-Sept.	Oct.-Dec.
VI.	64 ...	113 ...	230 ...	143
II.	22 ...	113 ...	91 ...	44
IV.	16 ...	40 ...	12 ...	13
VII.	8 ...	35 ...	25 ...	30

At station VI. on the north side of the Forth the plaice arrive in April to June, reach a maximum from July to September, and during October to December suffer a loss which becomes sharply marked in the early months of the year. This is also the Northumberland experience, but it is evident that a large number of plaice remain in the greater depth just outside that of the Northumberland experiments.

The figures are interesting otherwise as indicating the method of immigration and emigration, but the point which it is wanted here to emphasise is better brought out in three stations of the Moray Firth, the stations of Burghead Bay. The lines trawled over were parallel to one another and with the shore, and the depths respectively of the three stations were *a* 10, *b* 10-20, *c* 20-34 fathoms.

The plaice caught per hour's trawling were as follows :—

	Jan.-Mar.	April-June.	July-Sept.	Oct.-Dec.
a	86 ...	198 ...	267 ...	646
b	90 ...	36 ...	46 ...	327
c	37 ...	17 ...	42 ...	95

The outward migration from the shore is correlated with a gathering of plaice in winter in depths of about 10 fathoms. It is also manifested at the greater depths, but is somewhat later in its incidence, and the change to the winter maximum offshore is clear. The mean size of the plaice at station "*a*" is 26 cm., of "*b*" 27 cm., and of "*c*" 34 cm., and this indicates that the inshore congregation is followed by an offshore segregation, a fact which is further illustrated by the catches in deep water off the Forth and in the deeper water of the Moray Firth. The emigration is partial and not to a great distance, from, say, about 2-5 fathoms to about 10-15 and so on, and an intimate relationship is thus maintained to the greatest depth.

Besides this inshore and offshore movement, the latter to increasing distances with age and size, another tendency is at work which brings about a determination at all stages of the plaice at the north end of the school, or, in other words, the contranatant

end of the school. The opposite condition characterises the dabs. This is the law of distribution which I stated in 1905—Report for that year, page 31—and tried to explain, Report for 1914, and in the Inter. Rev. d. ges. Hydrob. u. Hydrogr., Bd. VI., 1914.

Another point comes into view by a further inspection of the Forth and the Moray Firth experiments of the Fishery Board for Scotland. From the "Goldseeker" results, with reference to the mid-Forth stations, it is at once apparent that the shore plaice have only a partial relationship to them. The migration appears to take place along the shore rather than outwards by way of the deeper water of the Firth. Even if the deeper stations at the mouth of the Firth be considered it is evident that the departure and return take place in relatively shallow water. This leads to the conclusion that the immigration is from north to south, and the emigration in the opposite direction. With this is correlated the fact of the inshore manifestation of the migration in the warm months of the year, and the deeper water maximum immediately offshore. With increase in size the plaice tend to migrate not so far into shallow water in the summer, and the evidence indicates a later appearance of the migrants which do penetrate into territorial waters. The result of such movements is plainly indicated for the three parallel stations of Burghead Bay. (See the above table.) It goes to show moreover that the autumn and the winter maximum is due not only to a migration from the inshore of the smaller plaice but also to the coincident inshore migration of the larger plaice.

It is thus clear that the inshore regions of maximum, such as those of the Tay and Holy Island, are contrasted with regions of minimum during the summer in deeper water, but this contrast is naturally not so apparent in the intervening regions south of the Forth and south Northumberland, which approach more to the conditions outside.

Along the east coast of Scotland and the north-east coast of England plaice are arranged in groups, two of which are especially here referred to, and there can be little doubt that each is related to a spawning assemblage on the current side of the school. The largest school is that of the southern North Sea. From the spawning grounds to the south of the Dogger, which are known to be enormous, the eggs and larvæ are carried towards the con

tinental coast, and the young plaice are obtained in immense numbers in and to the north of the Heligoland Bight, but are spread from the coast of Holland to beyond Esbjerg of Denmark. Outside this region the small plaice present distinct spring and autumn maxima, pointing as in the other schools to an inward and outward movement. This gradually gives place in mid-North Sea to the less densely populated regions of the northern part of the North Sea. Nevertheless there are many reasons apart from those of distribution to show that this enormous school of plaice or mingling of many schools of plaice of the south North Sea is relatively self-contained and migrates with growth each season more and more towards the English coast, the large plaice occurring near the coast of England.

In the deeper North Sea the plaice is so reduced in numbers that in comparison the dab rises to a place of importance, which it maintains because of direct increase in numbers in the southern part of the North Sea.

5.—STATISTICS OF PLAICE AND DAB.

The catches made by the Northumberland inshore fishermen are given in the following table. The details were presented in the Laboratory report for the year 1905, when a review of the white fisheries of the county was published. The table now submitted is meant only to show in summary fashion the annual catches for the two districts of the county during the years 1895 to 1920.

TABLE XIX.—Annual catches in cwts. of plaice and dabs by inshore fishermen in the northern and southern districts of Northumberland.

	Northern.		Southern.	
	Plaice.	Dab.	Plaice.	Dab.
1895-1905 ...	339 ...	105 ...	19 ...	71
1906-1913 ...	311 ...	41 ...	31 ...	61
1913	219 ...	51 ...	52 ...	27
1914	406 ...	44 ...	33 ...	13
1915	359 ...	46 ...	64 ...	31
1916	631 ...	88 ...	118 ...	69
1917	619 ...	26 ...	49 ...	48
1918	889 ...	17 ...	101 ...	27
1919	412 ...	18 ...	81 ...	29
1920	359 ...	0 ...	44 ...	6

The figures are indicated graphically in figure 8, and the table and the diagram show that the proportion and distribution already

demonstrated from the results of the trawling experiments are borne out by the statistics of the fishermen's catches. An analysis of statistics, even with respect to line fishing, is sufficient to indicate the broad distribution of the fishes in the inshore waters. In figure 8 the two divisions of the county are indicated by the letters N and S, and it is plain, as has already been shown, that plaice are more plentiful in the north and dabs, at all events, are more common in the south. It will be observed that during the period dabs have suffered a decrease and plaice especially show the effects of the more intense fishing of the years of the war. It is remarkable that during these years so few dabs were obtained. By means therefore of an appeal to statistics it is possible to show that not merely in the Forth and the Northumberland regions such a series of maxima and minima as we have found obtain, but that it is a general fact of distribution. The condition is not altogether due to fitness of ground, for it has been found that plaice always tend to the north end of the bays and the dabs to the south. So perhaps universally it may be said that even with respect to small areas the plaice occur on the contranatant side and the dabs on the denatant side, and other species could be named which could be similarly contrasted.

In the report for the year 1903 it was stated with regard to plaice that growth took place proportionally, the breadth and other measurements being proportional to length. The weight is proportional to the cube of the length, and can be found from the formula $w = kl^3$, where w = weight in ounces, $k = \cdot0067$ and l = length. This formula also allows of an estimate being made of the number of fish of a known mean size in a given weight. The plaice caught by the Northumberland fishermen measure on the average $9\frac{1}{2}$ inches, and the mean annual catch since 1895 has been 350 cwts. The number of plaice caught each year by the fishermen is found to be $= \frac{350 \times 112 \times 16}{\cdot0067 \times 9{\cdot}53} = 109{,}300$. The number of plaice landed on the Northumberland coast thus is on the average about 109,300 each year.

The constant k with reference to the dab is $\cdot0061$, and the number of dabs may be similarly stated to be = 80,000. The average size of dabs landed in Northumberland is 8 inches.

The relationship of measurement to weight has been established since the formula was introduced for other species, even to round fish. It is especially interesting with reference to the latter to find that the general "straight line" relationship of the various measurements is a fact of growth.

This estimate of the population of the inshore fishes has another importance. It was found in the case of plaice that the number of marked fish returned from the captures made by fishermen amounted to 14 per cent. This is doubtless a small number, and the Scottish and other marking experiments with reference to larger plaice show that 40 or even 50 per cent. of the marked fish may be returned. Suppose we assume that in the inshore waters the line fishermen capture 20 per cent. of the population about 9½ inches, then the Northumberland population of plaice of the larger immature sizes is about 546,500. The plaice concerned are for the most part of three to six winters. They are the survivors of the two preceding groups, Groups 1 and 2. Now, if we take the analysis of the experiment made this year at Skate Roads on September 2nd, which showed that 130 were captured of 1 and 2 groups and 52 of the older groups, as indicating the degree of survival, this amounts to 40 per cent.. Let us say 30 per cent., for the smaller of the younger stages are less likely to be captured, and it can be said that the young plaice of the inshore waters of Northumberland amount to some 1,821,700. The inshore waters then must be looked upon as performing an important function in receiving and supporting, and to some extent protecting, a large population of the food fishes.

An inspection of our previous experiments shows that the survival above 20 cm. is variable, but is usually above 30 to 35 per cent., so that the above computation is likely not far from the truth. In a good year it may be said that the inshore plaice of Northumberland amount to over two million.

If this be an indication of the wealth of the North Sea, in a small narrow tract like the territorial waters of Northumberland, how much more must the plaice population of the important nurseries in the southern North Sea be regarded. From the immense spawning grounds of the southern part of the North Sea large crowds of larvæ are carried to the continental coast and give rise to an inshore population which must be reckoned in millions.

It is necessary to realise to some extent the wealth of the annual contributions, the death rate at different stages, and the sampling done by fishing as that by experimental work.

1915. Buchanan Wollaston. Report on the Spawning Grounds of the Plaice in the North Sea. *Fish. Invest.*, Ser. II., v. 2.

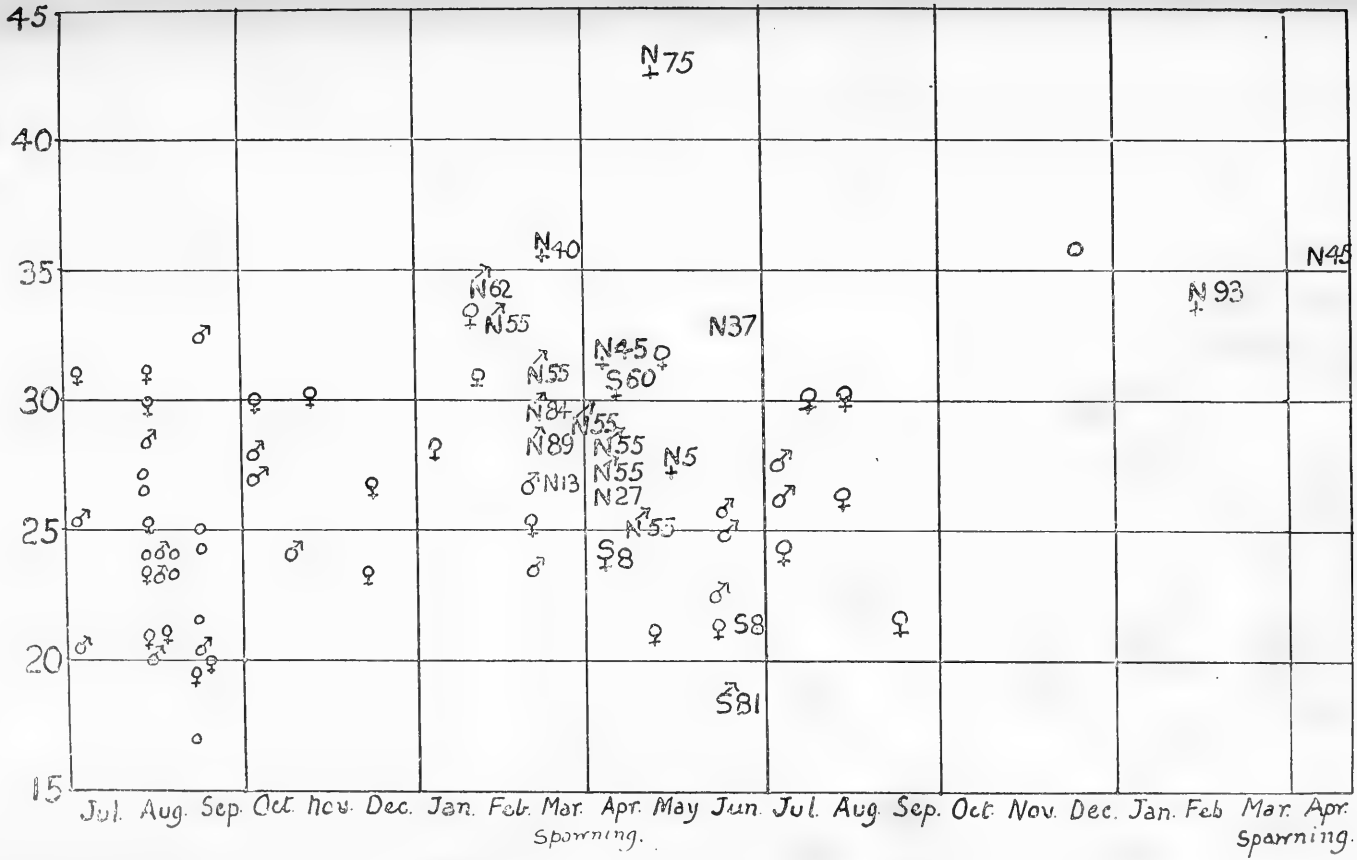
Rosa M. Lee. Review of Commercial Trawler Statistics. Fish. Invest., Ser. II., v. 2.

1915. Wallace. Report on the Age, Growth and Sexual Maturity of the Plaice in certain parts of the North Sea. Fish. Invest., Ser. II., v. 2.

6.—MARKING EXPERIMENTS.

The preceding presentation of the facts has served to state the nature of the seasonal migrations and their effects in determining the location of the inshore fishes and their relationship to the distribution in general in the North Sea. The variations produced by tides and the variation brought about by the conditions of successive seasons have also been indicated. But our knowledge of the movements of these fish has been greatly extended by marking experiments. During a number of years samples of the fish captured in the trawl net were retained and marked and liberated. The fish were measured, usually weighed as well, and when they were recaptured we obtained not merely information as to migration but as to growth, and the experiments enabled an estimate being made as to the effect of fishing on the total population of marketable fish.

Flounder.—The accompanying chart (figure 5) exhibits in a graphic manner the results of the marking experiments with respect to flounders. The basal line marks the time from that of marking to recapture, and the vertical lines the size. The flounders were marked and liberated during the summers 1904-07. It will be observed that the flounders captured not long after marking in the first quarter showed, as we should expect, little or no migration. What little migration was exhibited was to the south for a short distance, but in winter and spring the recaptures were somewhat to the north of the place of liberation. This goes to indicate that the inward movement is to the south as well as inshore, and the winter offshore movement is to the north. But from February to June, and especially in March and April, which is the season of spawning, the flounders were captured for the



FLOUNDER.

FIGURE 5.

Chart to indicate, with relation to time, the recapture of marked flounders. O = sex not stated, ♂ = male, ♀ = female, N = north, S = south, and the figures indicate the miles between the place of liberation and that of recapture.

most part in the Firth of Forth and opposite the coast of Fife, and this region marks therefore an important spawning region of this species The journey involved varied from 13 to 89 miles, the average distance being 53 miles. It will be observed in the chart that the direction is indicated by a letter, and the distance by the number of miles The flounders which performed this migration were found to be mature, spawning or recently spent fish. The southerly migration of the spent fish is exhibited by other examples, as will be noted, and the persistent denatant tendency of the immature is illustrated by the examples which migrated 8 miles and 81 miles in that direction. It will be observed also that the flounders captured in the subsequent summer had either not migrated or had returned to the region where they were marked ; and those which emerged from the immature, like their predecessors, migrated to Scottish waters to spawn, one of them to a distance of 93 miles—it was captured just north of Aberdeen, and had probably therefore attached itself to the spawning assemblage of another school The other example was captured in the Firth of Forth, and there was still another, the sex of which was not stated, which in December had not apparently migrated

This goes to show that there is a conspicuous difference between the immature and the mature with respect to migration. We have to take note of the fact that the immature and some of the spent fish appear to be stationary or to migrate to the south, and that the mature with approaching maturity are forced to perform a migration on the average of over 50 miles to reach and join the spawning assemblage, that they may indeed go far enough to reach a spawning ground beyond that to which the majority go. It is evident also that all the mature flounders do not migrate, that a spawning season may be passed without a migration taking place. The majority may be said to ripen at the spawning season, but a few which from size may be regarded as being of the necessary age have evidently not joined in it. The migration of the mature is so remarkably constant as to make it clear that it is performed in response to an imperative call, and it takes place during the winter preceding the spawning.

Turbot.—The recaptured turbot were so few, about 7 per cent., that the particulars may be given in detail.

	Liberated.		Recaptured.		Increase in Size From. cm.	To. cm.	Sex.
	1905.		1905.				
1.	Aug 7.	Skate Roads ...	Sept. 14.	Skate Roads ...	28·4	30	f.
2.	Aug. 2.	Druridge ...	Dec. 7.	4 miles E.S.E. Coquet, 28 fs. ...	29 8	32·8	m.
			1906				
3.	Aug. 2.	„ ...	Nov. 17.	E.N.E. Coquet ...	27	26·2	m.
			1908.				
4.	Aug. 2.	„ ...	May 20.	55·39 N. 1·41 E. ...	27	40·9	m.
			1909.				
5	Aug. 2.	„ ...	April 2.	20 miles N.E. by N. Flamborough ...	31	52	f.
	1907.		1909.				
6.	Aug. 29.	Skate Roads ...	July 16.	48 miles E. ½ S. Aberdeen ...	29	43·8	f.
	1909.		1912.				
7.	July 29.	„ ...	June 28.	30 miles E. ½ N., Isle of May ...	29	49·5	m.

Fifteen turbot were marked on August 2nd at Druridge, and, as will be observed, four were returned to us, but this was the best result. The first (1) of the recaptured fish showed no migration during the same summer, the second (2) an outward and northerly migration in the ensuing winter, the others were captured after a longer period of absence. Spawning does not appear to take place to any marked extent in the northern North Sea, nevertheless our inshore waters receive young and spent fish in summer. The spawning season is April to August, and at or about that season the fourth example was got 110 miles E. by N. of the place of liberation. No. 5 was obtained after an absence of nearly four years 75 miles to the south. Nos. 6 and 7 were recaptured off the east coast of Scotland.

The evidence is not complete enough to establish definitely the migrations, but taken with that of the distribution before described, it is evident that the outward migration is to the north-east, and the spawning migration to the north. The spent fish, as No. 5 indicates, may perform a long migration to the south, but how far and in what direction it had migrated during its years of absence one cannot say.

A few soles and other species were marked, but no recaptures were reported.

Plaice.—Large numbers of plaice were marked in the years 1903, 1904, 1909 and 1913. The results so far as the recaptures are

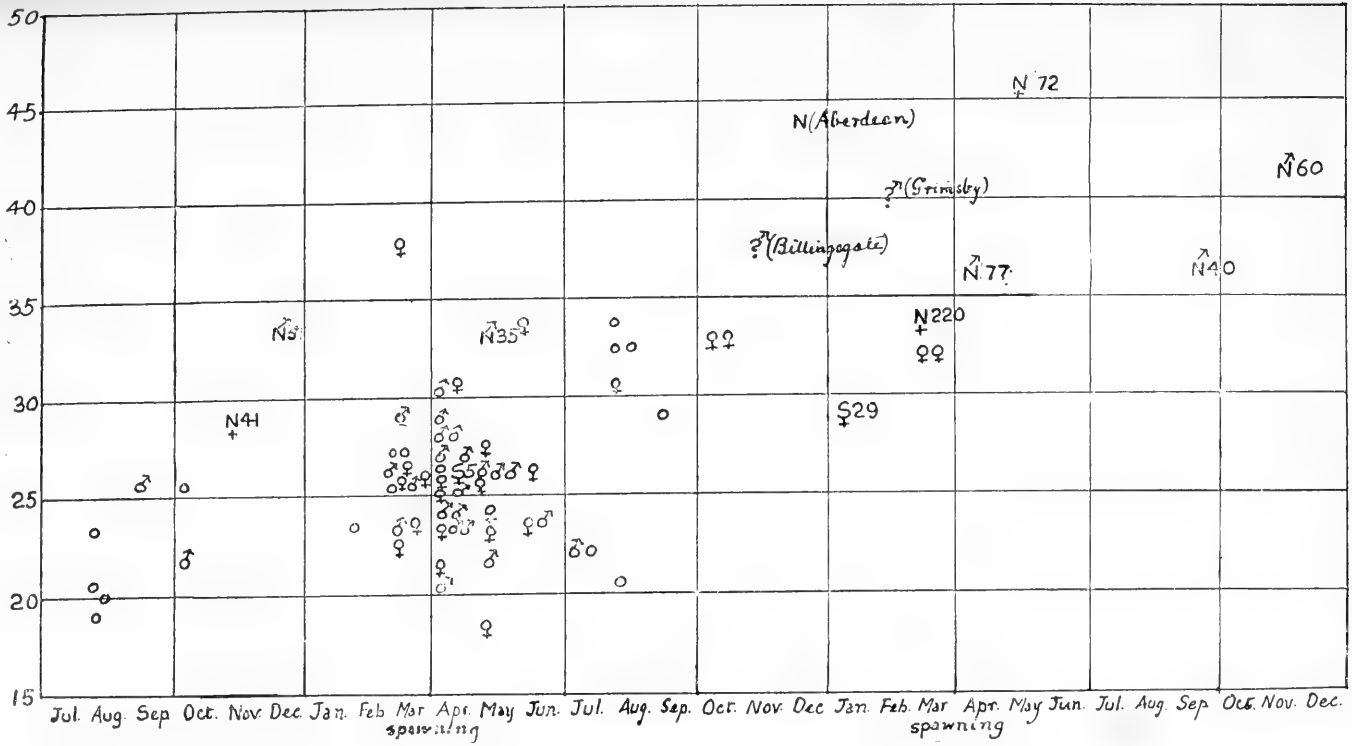


FIGURE 6.

Similar chart to Fig. 5 with reference to plaice.

concerned are displayed in figure 6. The plaice marked were on the whole small and immature, as will be noted from the size of the examples captured and returned to us. From a consideration of those caught in the season of marking and in the following winter and summer it is plain that little or no migration takes place. There is a practical blank from November to January each year, coinciding with that displayed by our trawling results and the captures of the inshore fishermen, but their reappearance in February and their persistence in territorial waters during the summer is amply illustrated by the returns as displayed in the chart. The migrants either returned to the bay where they were marked or showed a slight tendendy to a southerly migration. They are relatively sedentary, however, in the sense that the seasonal migration is not to a great distance, as has already been proved by an appeal to statistics and trawling experiments, and the return is to the same feeding ground.

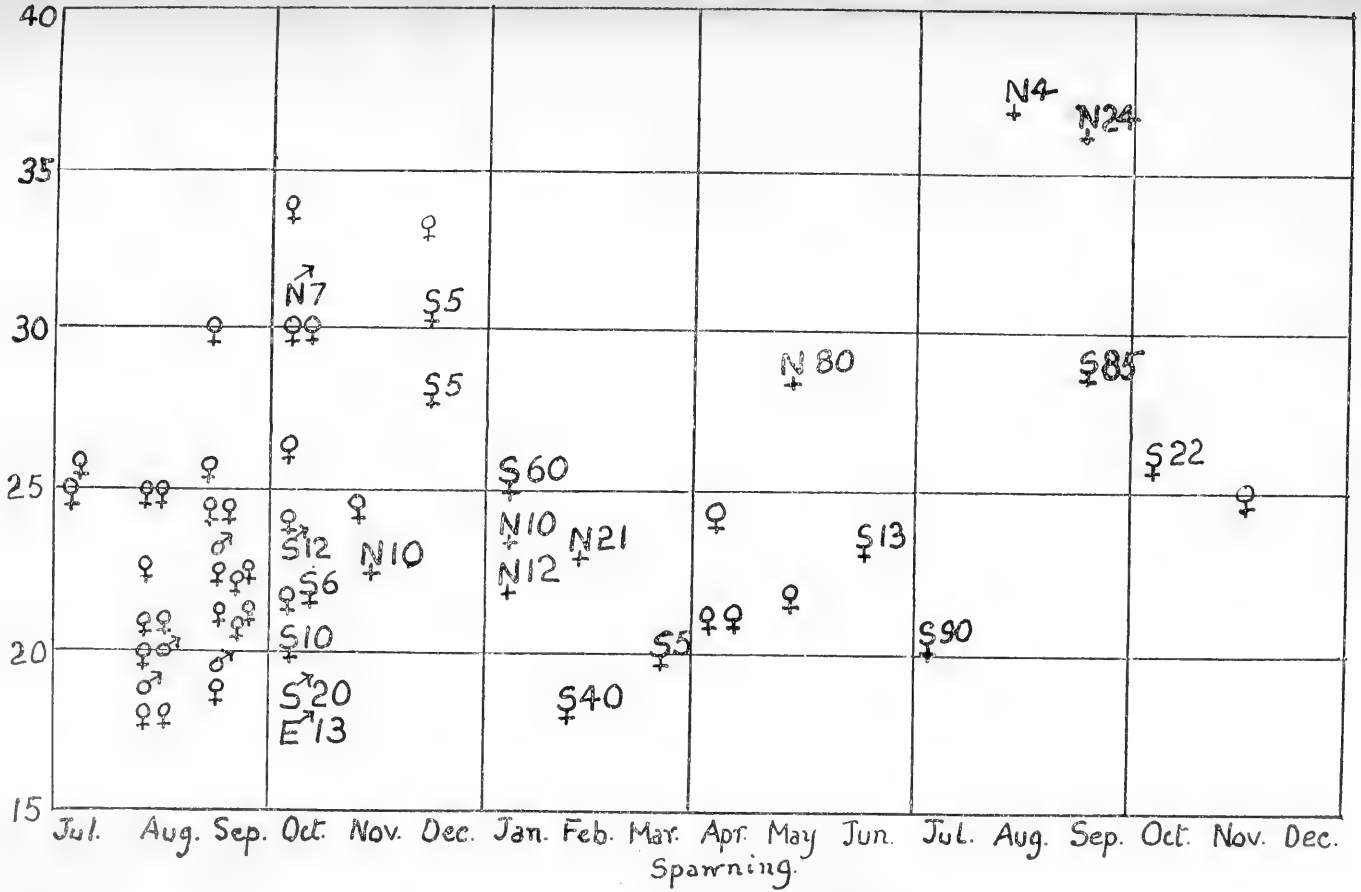
During the first winter after marking, two were returned which had migrated far to the north, and another was obtained from Scottish waters in the following spring. Again, after the lapse of more than a year, in the second winter of liberation, three were returned to us from Aberdeen, Grimsby and Billingsgate markets, but no information was obtained as to place of capture ; it is evident that they must have migrated a considerable distance to have been captured by other than local trawlers. Note must be made of two females which in March had apparently not migrated during a long period of liberation and of a size which pointed to maturity. With this exception all the plaice which had in the meantime reached mature size were recaptured after about (or more) than two year's liberation far to the north, one as far as the Moray Firth. This is so consistent that we are justified in concluding that the plaice of the Northumberland coast on approaching maturity, when they measure usually over 30 cm. (12 inches) migrate to join the spawning assemblages of the Firth of Forth, of the Aberdeen Bank, and even of the Moray Firth. The marking experiments made in Scottish waters have proved that the mature plaice of the Forth region may migrate far to the north, to the Moray Firth and still further north and west, and the Moray Firth plaice even to the Atlantic, *via* the Pentland Firth. The difference between the migrations of the immature

and the spent fish and the migrations which result from the call of maturity is again prominent.

The "Goldseeker" experiments as well as the earlier "Garland" experiments in Scottish waters have been analysed by Fulton.* They evidence a general contranatant migration. Our results illustrate the relatively static condition of the immature, the summer inshore migrants. The deeper waters just outside the depths of the Northumberland experiments are shown by the Scottish results to contribute still more intensively to the contranatant spawning migrants. They indicate also that with increase in size the large immature plaice migrate inshore for winter, and usually denatantly. They may remain inshore from December to May, and still tending to move southwards, returning northwards and offshore later in the summer. The winter maximum in moderate depths is thus contributed to by migrants from the shore and by larger migrants from offshore. In still deeper water the spawning migrants are more numerously represented amongst the large sizes marked, and the non-spawning migrants are winter inshore migrants for the most part.

We gather from these experiments, viewed as a whole, that the young plaice after their denatant pelagic journey are gathered together on a recruiting ground, actively moving inshore to the shore region or in that direction. They retreat to the region beyond tide marks in winter. They remain in relatively the same region during the ensuing summer or migrate inshore (Group 1). Next winter they move out into still deeper water, and migrate inshore in summer (Group II.). This seasonal migration is repeated in the case of Group III., but the incidence of the inshore appearance is somewhat later. Group IV. do not appear until late in summer, and spend the winter in shallower depths. This is almost precisely the migratory sequence of the gadoids. The spawning migration, as we have seen, is a contranatant one, and after spawning the seasonal migrations are resumed. The plaice then become inshore denatant migrants, and are found frequently far to the south in the region of the eastern North Sea.

* 1913, 5th Rep. Fish. and Hydrogr. Invest., Fish Bd. for Scotland, 1919, Sci. Invest., No. 1, Fish. Bd. for Scotland.



DAB.

FIGURE 7.

Similar chart to Fig. 5 with reference to dabs.

Dab.—The dabs marked in 1903, 1904, 1905, 1906, 1907 and 1913 have given results which are rather different. Those caught shortly after marking (see figure 7) made little or no migration, but during the subsequent winter a strong tendency to a southerly or denatant migration was shown. In the October following marking, out of twelve examples recaptured six females were stationary, 1 male had migrated north for 7 miles, two males and two females to the south and one to the east. In the following winter months similar results are apparent, three having been got to the north and three to the south, and the southing is to a greater distance in the case of two of these. In the early part of the succeeding summer, four females had apparently made no migration, one female had migrated far to the north and two to the south. Later in the summer, two large dabs were got to the north, and the dabs under 30 cm. to the south. In November, after an absence of more than a year, a female of 25 cm. was got about the same place where marking took place. It may be said then that the immature and the spent fish are decidedly denatant. The probability is that the northerly migrants, as has indeed been found on enquiry, are mature fish.

The strong tendency to a southerly migration of the immature, especially during the winter, is in remarkable contrast to that of the other species. During the winter they move south and east, and winter for the most part in depths of about 30 fathoms.

There is or usually is a conspicuous migration of the dabs from the inshore waters, and in spite of the great distance travelled during the winter, the return appears to be usually to the same bay or one in the immediate neighbourhood. We at once associate the southerly migration with the peculiar distribution of this species in the bays and in the district as a whole.

The plaice and especially the flounder during their sojourn in the inshore region are liable to enter fresh water. The flounder moves into rivers in October, and may remain in estuaries during the winter. Plaice in many cases have been proved to enter brackish water on their return from the offshore migration, that is to say, from February to April. Indeed, in both cases they may remain for a longer period at least in estuaries. Whatever the attraction may be in these species, it is probably a general one affecting all to some degree. A potamotaxis has been observed

to direct the movements of the larvæ and young to dilute water, and while it has been found that the migrations each season are closely related to temperature an additional impulse to the shore region may be provided. It is not universal in its influence, for at the period that plaice and flounder in the immature state are found in brackish water, the same species of about the same size may be procured beyond territorial waters. We can only say then that during the winter some of the immature plaice and flounders migrate offshore, and that both may migrate into estuaries at the same period of the year.

In complete contrast to the seasonal migrations of the immature, are the migrations of these species when they receive the call of maturity. Then the migration is to a great distance, and it appears universally to be a contranatant migration. The flat fish of the Northumberland coast, so far as our information extends, migrate with approaching maturity far to the north to join spawning assemblages off the east coast of Scotland, and the Scottish marking experiments, so fully reviewed by Fulton, plainly indicate that the flat fish of the east coast of Scotland similarly migrate to the north and contranatantly, and may, many of them, reach the north of Scotland, even the Atlantic. In this case it is evident that the migration is performed in response to an impulse brought about by the change in the gonad. During its development the gonad gives rise to an internal secretion, which carried by the blood has special effect upon the nervous system.

That this is the fact is at once clear when we recall the migration of the eel at maturity to the western side of the North Atlantic, and the many anadromous migrants in and into fresh water. In these cases the blood by the internal secretion is able to control the nervous system, and a striking migration results. But it is evident that more or less all fish are similarly affected. In certain cases the internal secretion is able to produce somatic effects as well, as in the dragonet, elasmobranchs and the salmon in which secondary sexual characters are developed. It is worth recalling also that the migratory effects are not confined to fishes, for the common crab behaves with oncoming maturity almost exactly as the plaice and flounder. As every inshore fisherman knows, the crab migrates each season with the greatest regularity inshore in summer and offshore in winter, and the fact has been proved

by marking experiments. Marking experiments have demonstrated also that as the females become mature they migrate from the Northumberland coast to the region of the Firth of Forth, some still further to the north, and they may attain to the Moray Firth. It is after migration that the females come into berry, as the act of spawning is termed. After the ova are hatched, ecdysis takes place, and with ecdysis, pairing. It is evident therefore that the crabs at this stage are once more in the condition of those marked originally on the Northumberland coast, and that therefore when they become mature, that is when the gonad once more commences to develop, the migration will be still again in a contranatant direction. The interesting feature of difference in the crab as compared with the fish is that the female only migrates for spawning. As has been said, pairing takes place during the ecdysis of the female, and the gonad of the female may not commence to develop until long after the event. It is then that the hormone is produced. The ripening of the male gonad is not accompanied by migration, and it would be interesting to know whether this is due to the hormone being withheld or its effects inhibited.

We are led to conclude therefore that the spawning migration is due to the action of an internal secretion, and is a special manifestation produced by the same or a similar cause as that which makes a buck mad in November and a hare in March. In many cases somatogenetic results are produced, but the effect we have to note in fishes is the contranatnat migration which brings about congregation. We have seen reason to conclude also that the stimulation is not the same with reference to the sexes, and indeed may be very different, but with fishes as a rule it is complimentary. It has been observed in several cases of assembling for spawning that the males arrive first and occupy the region during the spawning season, while the females enter the region when about to spawn, and leave after the operation is ended. The spawning event, however, of the female is not continuous, but is spread over one or two weeks, a succession of spawnings being separated by several days of rest.*

Spawning therefore is concentrated in particular regions which have been specified and more or less well demarcated from

* Report, 1911, p. 24.

investigation, and that such assemblages do occur follows from the consideration that fertilization is external and pelagic and especially from the consistent results from year to year of the distribution from them. It may be added that the difference in habit of the males and females is a general one and is not confined to fishes. In my paper on the generative organs of the porpoise I gave reasons for supposing that the sexes behaved just as they have been proved to do in fishes.*

There are one or two points of more theoretical interest which may be briefly touched upon before we leave the consideration of the blood control of the nervous system and internal secretions.

Fishes are conspicuously contranatant in the adult condition, and especially when migrating for spawning. In the young state they are denatant, and the denatation is not confined to the drifting period, but still dominates the movements even when the power of contranatation has been acquired. Contranatation first definitely emerges amongst the fishes and is not thereafter lost, but amongst the groups below fishes it has only been discovered by the larger and active Mollusca and by the Crustacea. The rest are permanently denatant whether they be holoplanktonic or meroplanktonic. The interesting feature which is to be remarked is that in fishes and in Crustacea and probably also in Cephalopoda, which have become capable of contranatation, the stimulus to a contranatant migration is provided.

Ontogenetically and phylogenetically then contranatation arises from denatation. During the denatant period the larvæ tend to congregation also, and we are led to enquire whether this is due to the accident that they have emerged from the same area, and are carried by the same currents to the same place or to an agency which promotes the congregation. The same general fact is true of holoplankton and meroplankton. Whilst admitting the trend of the common factors in bringing about the congregation, it is probable that the tendency to crowd together is due to the action of a primitive hormone which is not at all unlike that of the spawning migration, a primitive physiological attraction, as old as cell division and dating from the Protista.

Whether this be the fact or not, it is obvious that at all stages fish and their predecessors are responsive to environment. The

* 1918, Jour. of Anatomy, v. 52, p. 197.

young are attracted to dilute water, and the succeeding stages make their seasonal migrations in almost direct relationship to temperature. Fish and other larvæ are frequently transported across the oceans, and are peculiarly modified to promote the long pelagic life. It is when they reach continental waters that they change into the adult. It may be presumed therefore that in such cases something is at work which inhibits the change until the conditions are favourable. The environment may in this case be said to be the degree of salinity. The change, it may be suggested, is under the control of an organ which has the power of retaining the larval phase, or, in other words, of inhibiting the next phase of life. Those who are familiar with the morphology and physiology of the lower creatures will be able to suggest organs the purpose of which has remained obscure, but with regard to fishes we feel that at all events the adolescent period is controlled by the thymus, and that when the gonad is permitted by the thymus to grow the thyroid is able to control maturity. It is obvious that some such control must take place, for it is not sufficient that a state of ripeness be attained, the periodicity of the spawning calls for a seasonal, common culmination of the process of ripening.*

7.—SUMMARY AND GENERAL CONSIDERATIONS.

Plaice.—The large spawning grounds of the southern North Sea contribute annually immense numbers of young plaice to the continental shallow waters. The seasonal migrations of these schools, and even the spawning migrations, are mainly confined to the south. On the eastern and western borders of the North Sea, other than those occupied by the southern plaice, the spawning assemblages are smaller and more distinctly isolated; the products therefore form well-defined schools. The Northumberland school is associated with the spawning ground off the Firth of Forth, the Forth school with that off the coast near Aberdeen. In the former the young plaice are spread along the coast of Northumberland, in the latter from Forfarshire to the north and south coasts of the Firth of Forth. It will be observed that the distance and the area concerned are much the same in each case. Spawning

* 1920. Meek. Nature, v. 106, p. 532.

takes place from about the middle of January to May, and recruiting, as evidenced by the presence of young plaice near the shore, plaice of about 1 cm. in length, from March to August. The spread of the larvæ in the currents results in an inshore and an offshore distribution. The former quickly become demersal, some even before hatching, and undergo their changes more rapidly than the latter, and all stages between these extremes may be presumed. During the drift the larvæ are orientated head to current, but this factor may be neglected for the direction is, reversed four times a day. The larvæ during the denatation are attracted to shore water, and the young after their transformation are still liable to continue the denatation by becoming pelagic. The result is a gathering in a known area of the young of the year. The gathering is particularly dense in one part of the area near the proximal end. From this region the population of recruits diminishes rapidly next the spawning ground, and tails off more gradually distally. The normal conditions are liable to be changed by winds and the modifications they produce in the currents at the surface, and this factor must be regarded as an important one in determining the result of the annual spawning. But even under normal conditions it is evident that the larvæ spread over deeper water are carried into regions beyond those of the school, and that such are absorbed into a school or schools on the denatant side of that to which the products of the spawning ground are as a whole relegated.

It is important to realise the dynamic forces at work if we are to understand the distribution. Granting that in all cases, such as that of the plaice, the floating egg and the helpless larva are carried from the spawning ground to the recruiting ground, that the spawning ground and the recruiting ground are related in a down current direction, as is proved by the constancy with which the products are distributed, it follows that the distribution of plaice and of other species of similar habit is produced by the aperiodic currents. A succession of spawning grounds occur along the path of the current, and therefore the plaice of the northern current of the North Sea are distinct from the plaice of the southern North Sea. Not exclusively, for where the currents merge opportunities for mingling will be presented. Both the northern and the southern currents are derived from

the Atlantic, and both may be said therefore to be related, but the contranatant powers of the adults tend to correct the early distribution. With developing powers of contranation and with increasing individuality the older fish press beyond the realms of the two currents. The two races may be said therefore to be more liable to mixing in the neighbourhood of the Dogger Bank than elsewhere, even than in the Atlantic.

The young plaice of the year so familiar in shore pools in the summer arrive at a size of a little over 1 cm. They are carried into shallow water, to the shore and into estuaries. During the summer they grow rapidly, and in October attain a size of 5 to 10 cm., the range depending on the above circumstances. The inshore members of the recruits then migrate from the shore, and the winter is spent in shallow waters and in estuaries. During the second summer they still occupy much the same ground and progress in size, 11 to 18 cm. At the end of the summer a partial migration takes place into slightly deeper water—partial in the sense that those outside migrate a short distance into deeper water, their places being taken by those inside and so on. The shore waters at this period are almost completely deserted. A return migration of a similar nature takes place in the spring. They are now in Group II., and the procedure is again very similar to that of the previous summer. Groups II. and III., plaice which have had two and three winters, form in numbers the main bulk of the plaice captured in shallow waters, and our trawling records show that they are accompanied by the succeeding immature groups, together with spent fish. Our experiments have been conducted in shallow depths of about 3 fathoms or even less, and they therefore demonstrate with great clearness how closely the seasonal migrations follow the annual trend of the temperature of the sea. The experiments have shown also that the migration is out and in with reference to the coast, and that at the same time the species does not merely tend to maintain its position to the coast but actually during the migrations makes some degree of progress contranatantly. This has been demonstrated with reference to both the Forth and the Northumberland schools. It might be urged that the original distribution of the young would explain the fact that the distribution affects the district in each case as a whole and the sub-divisions thereof,

but the distribution of the dab points to another factor being at work.

The Northumberland plaice therefore during the years of immaturity remain in or near the territorial waters, partially migrating inshore and offshore according to season. They do not leave the district, but the figures in detail indicate that they are liable to be joined by others from deeper water. We have not enquired carefully as to the age when maturity takes place. The majority of the plaice marked during the summer of various years ranged from 13 to 30 cm., but the most only 20 to 24 cm.. The majority would therefore be of Groups II. and III., with a few of IV. and V. The smallest female which migrated from the district for spawning measured 29 cm., and probably belonged therefore to Group IV. It was not until the following season, and the second season after that of the marking, that the plaice had grown sufficiently to become mature. Such measured 30 to 34 cm. (females), and 33 to 45 cm. (males). The examples are not numerous, but they point to maturity arriving when the fish are in Groups IV. and VI. Wallace found from an examination of the plaice of the Channel and the southern North Sea up to and including the Dogger Bank that the age at maturity increased with latitude, that of the Channel being three years (males) and four years (females), southern North Sea five years (males) and six years (females), and of the north-east part of the Dogger six years (males) and seven years (females). At the time of spawning the Northumberland school would probably range from four to six years, and are thus more like the plaice of the southern North Sea. It may be found that the plaice of the northern current present a similar succession as that shown by the Channel plaice and those of the southern North Sea.

Maturity brings about a conspicuous migration differing totally from that of the immature. Many of the Northumberland plaice join the spawning assemblage off the Forth, but some migrate as far contranatantly as the Moray Firth. Fulton has shown in his account of the marking experiments on the coast of Scotland that the Moray Firth plaice may migrate to the Atlantic. It is evident therefore that if originally the products of the spawning grounds are liable to be carried beyond the limits of the school the migrations of the mature are not necessarily confined to the school.

After spawning, the spent fish migrate denatantly as a rule, and many of them enter territorial waters.

The migrations of the southern race of plaice are similar at maturity, but the direction is towards the English coast or the Channel. It is again a contranatant migration.

It will not be necessary to review at length the life histories of the remaining species, for it is obvious that with reference to fish with similar habits the sequence of events is bound to be much the same.

The flounders of the Northumberland coast also come from a spawning ground off the coast of Fife ; other spawning grounds are situated to the north and the south of the Tyne, but these contribute to schools in the North Eastern district. The spawning takes place in March and April, and the recruits appear inshore in June. During the years of immaturity the flounder in spite of its marked predilection for fresh water behaves much as the plaice. It does not migrate from the district, and not for a great distance within the district. Maturity occurs at a size of about 25 cm., and the flounders from that size to over 40 cm. migrate, the most of them, to the east coast of Scotland. But as with other species all the adults do not become mature every season. The spent fish may migrate to a great distance denatantly, and are common inshore.

Amongst the other flat fish, turbot and brill are similar in distribution and habit to the plaice and flounder.

The dab is different at all stages. Spawning takes place from March to May ; the young appear inshore about June, but they are spread over wide areas of various depths. The inshore dabs are markedly periodic at all events as illustrated by our experiments in regions close to the coast ; their seasonal migrations are distinctly related to temperature. At the same time, they exhibit a strong tendency to denatation, even at a size of between 15 and 20 cm. As a result they are distributed along the coast of Northumberland and in the region of the Forth in a manner exactly opposite to the plaice. They predominate in the southern parts of these regions, and tail off to the north. The fact that such a distribution is repeated on the adjacent regions of the east coast of Scotland and Northumberland plainly proves that we have nevertheless to deal with two schools derived from

two spawning grounds situated not very differently from those of the species already referred to, but the products which grow up from the recruits are so denatant in the case of the dab as to produce a totally different concentration of the immature. We understand therefore generally the distribution and the life of the dab of the east coast of Scotland and of Northumberland. It is necessary and important to obtain information with respect to this species in the southern North Sea. The sole amongst the flat fish behaves apparently in similar manner to the dab, but in our district of Northumberland it is near the northern limit of its distribution on the east coast.

In addition to the species described in this report many round fish, some of which are referred to herein, are similarly carried into territorial waters, and grow there during the years of immaturity, remaining in or near the district. All these beginning during their early pelagic life as plankton feeders gradually turn more and more to the demersal life of the district, and attention has been drawn to the great population supported within the district. It has also been seen that untoward circumstances, such as the liberation of oil over the surface waters of the area, may have a profound influence on the amount of food available, even on the pelagic stages of the fish. The effect, however, fortunately is local and transient. In addition, also, the annual migrations of immature and spent fish from the south bring species like the mackerel into the Northumberland region.

It has not been deemed necessary to draw particular attention to species other than those which are illustrated in the results of the trawling experiments. It will be observed that the purpose of the experiments was to obtain a knowledge of the origin, distribution, food, growth and migrations of the species concerned. This summary of the results of the experiments which have been conducted since 1892, and with which I have been indentified since 1896, deals therefore with a section only of the work done in connexion with the Cullercoats Laboratory, and it may be remarked that the experiments have been made at little cost to the community. It may be asked whether the knowledge derived is worth having from the point of view of administration and of the fishermen. There are people identified with both aspects of the question who think that it is unnecessary to have such

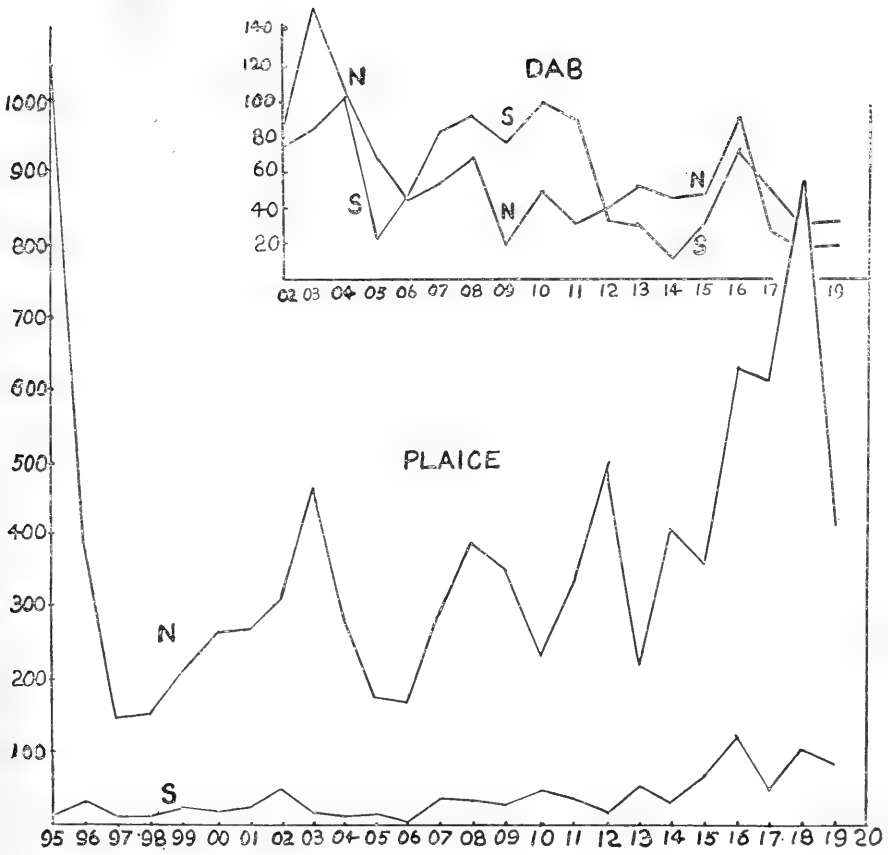


FIGURE 8.

Catches in cwts. of plaice and dabs made by the inshore fishermen of Northumberland each year from 1995 to 1920.

N = Northern District. S = Southern District.

knowledge, and there are others who grant the desirability of getting the information, but say that it is a bad way to do so by removing fish from the district, which ought to be considered the property of the fishermen. With regard to the latter it is obvious that such forget how small the sample removed for scientific work is compared with the fishermen's catches, and how small the fishermen's catches, though significant, are compared with the population supported by a district of some 200 square miles.

With reference to the former contention, a few further remarks may be made. To begin with, we have to note that the inshore waters are rich in immature fish, and receive also mature fish, including many of the important species of the North Sea. During the winter migration these do not leave the territorial waters to any great extent, and the area and the fish are reserved for the fishing operations of the inshore fishermen. Our results, together with the statistics, go to show that the protection tends to preserve as large a stock as the area may be said to be able to support. It has had during the last quarter century its ups and downs, but as a whole it has improved, and it is reasonable with all the facts before us to conclude that the protection has done and is doing good. This is what the Northumberland Sea Fisheries Committee wanted to know, and thus from an administrative point of view the work has been a success. It is important to know that the young fish do not leave the region of the Northumberland coast, with some exceptions which have been pointed out, that the survivors from stage to stage remain in the district. This is a gratifying result, not merely from the view of administration but to the inshore fisherman.

The trawl fishermen, excluded from the territorial waters, obtain the benefit of the growth and protection afforded by the inshore waters, for the fish after attaining the size of maturity leave the district. They migrate to the north and to deeper water. This concerns us in two ways. First, it shows that the strip of territorial waters of the North Eastern district contributes to the extra-territorial waters of the Northumberland region as the Northumberland inshore waters do to those of Scotland. There is a complete inter-relationship between the coastal and the deeper North Sea in succession all along our coast, and the

condition once realised indicates to some extent the importance of the knowledge gained, especially as to the extent to which the inshore waters contribute to the catches of fishermen in extra-territorial waters. Secondly, it demonstrates the national importance of administration. In our case it happens that our district is intimately related with the east coast of Scotland, as far to the north as, say, the Tay. We may feel, and with right, that our local protection produces a benefit locally, but the fact of the relationship of such a general nature clearly points to administration and legislation being national in character and scope. It has been shown that the products of the northern current of the North Sea tend to remain distinct from those of the southern current. This ought to be kept in mind, for while it may be necessary to consider detrimental changes in the one it might be found that no action was necessary with respect to the other.

Apart from the light which has been shed upon such general questions, the experiments have yielded material used for extending our knowledge of growth and other problems of technical importance, and with the aid of experimental work in the laboratory for enquiries into problems of pure science dealing with the more fundamental facts relating to the life of the sea.

HERRING INVESTIGATIONS.

I.—HERRING SHOALS.

By B. STORROW.

The object of the investigations during the past year was to obtain further records of the shoals of herrings extending from Stornoway and the Shetlands in the north to Yarmouth in the south. The age composition of the early summer shoals was shown in the Report of last year to depend largely upon the presence of fish with three winter rings on their scales. Whilst fish of this age were comparatively few in number in the samples from the Shetlands, it appeared, from the account given of the fishery in the waters about the Shetlands and Orkneys,* that in some years young fish were present in large numbers in shoals to the south of those sampled in 1919. It was thought that a regular and frequent examination of the catches landed at North Shields would indicate the comparative abundance of fish with three winter rings, and from the experience gained in previous years, the examination of the catches as displayed at the sale ring was relied upon to furnish the necessary information. The samples examined were taken, therefore, late in the season of 1920 with the intention of obtaining a record of the autumn spawning shoals. Spring spawning shoals were sampled in 1921, and the investigations were carried into Irish waters in order to ascertain to what extent, if any, the shoals of the north-west of Ireland differed from those of Scottish waters.

It is due to the kindness of friends in various fishing ports that the sampling of the shoals has been possible. The Fishery Board for Scotland has given help and information whenever requested to do so, and the opportunity is here taken of stating that many of the persons who supplied the information about the fishing grounds given in the Report of last year, were officers of the Fishery Board. To the Department of Agriculture and

* Report, New Series, IX., pp. 14 and 15.

Technical Instruction for Ireland, Fisheries Branch, I am indebted for the samples of Irish herrings and much information relating to the herring fishery of Ireland. As in previous years, Mrs. Cowan has given considerable help in the investigations.

The season during 1920 was peculiar. Catches were very irregular, and at most of the ports there was little opportunity for sending the samples of autumn spawners. This was the case in the Shetlands and at Stornoway where transport difficulties had to be considered in order that the samples should arrive in a condition which would allow of examination.

A list of the samples examined is here given. For each fish the length, sex, state of gonads and age have been recorded, and from the scale records the yearly growth has been calculated. The whole of these data is not given in the tables, as much of it is of the same nature as the data tabulated in the Report of last year. In the case of samples from fishing grounds not previously examined, or of samples taken at different seasons of the year, as the Yarmouth spring sample of 1921, the growth data are given in Table III.

Port.	Date of Capture.	Origin.	Catch.	Number Examined.
Stornoway ...	16th Feb., 1921 ...	Off Cellar Head	12 crans	191
	2nd March, 1921 ...	Broad Bay	10 crans	195
Lerwick	30th June, 1920 ...	12 miles E. of Bressay ...	(?)	180
	25th Aug., 1920 ...	18 to 20 miles S.E. of Bard of Bressay	(?)	196
	12th Feb., 1921 ...	5 to 8 miles off Noss Head (east of Bressay)	8 crans ...	183
	20th May, 1921 ...	15 miles E. by S. of Bressay ...	6 crans ...	169
Wick	24th Aug., 1920 ...	18 miles E.N.E. of Wick ...	60 crans	189
Peterhead ...	25th Aug., 1920 ...	16 miles N.E. of Peterhead ...	(?) ...	200
	26th Feb., 1921 ...	9 miles off Cape Wrath ...	(?)	154
Firth of Forth ...	10th Feb., 1921 ...	Between Rosyth and Charlestown	(?)	229
Great Yarmouth	17th Nov., 1920 ...	24 miles E. by N. of Yarmouth	56 crans	225
	9th March, 1921 ...	42 miles E. of Yarmouth ...	23 crans	171
IRISH SAMPLES—				
Buncrana ...	1st Feb., 1921 ...	4 miles off mouth of Lough Swilly	20¼ crans	153
	17th Feb., 1921 ...	10 miles off mouth of Lough Swilly	(?)	137
Killybegs ...	12th April, 1921 ...	5 miles S.E. of Carrigan Head	23 crans	171
		Total examined ...		2,743

Age and Maturity.—From the beginning to the end of the season the catches landed at North Shields were subject to frequent examination. The general practice was to examine a number for age from the samples exposed in the sale ring, and afterwards to inspect the landings made by a number of the vessels to ascertain if the general quality of the catch was represented correctly by the sale ring samples. As in previous years the fishery commenced with mixed catches, in which recovering spents were high in number. These mixed catches were taken some distance from the port, and towards the end of April were most plentiful about 60 to 70 miles off the Tyne ; beyond this distance and up to 100 miles the herrings were fewer in number. On the 8th of May a large number of recovering spents were in the vicinity of the Coquet, but it was not until the young summer fish arrived, after the middle of May, that any catch worthy of notice was made on the grounds of the summer shoals.

The catches from the summer shoals were composed chiefly of fish with two, three and four winter rings, but the fishery was very irregular. Occasionally a vessel would land a good catch, but other vessels which had been fishing in practically the same waters returned to port with a few crans only. Further, there was never throughout the season any time when the vessels landed good catches from the same grounds two nights in succession. This was most noticeable after the stoppage of the fishery from 11th to 21st of June, when it was expected the catches would be heavier.

In the beginning of July, there was a high number of fish with two winter rings in the samples, and fishermen informed me that fish of this size and quality were more plentiful to the south of the Tyne. Fish of this age were commoner than usual until the end of July, when herrings with three winter rings became more abundant, but even then the catches made were below those of the previous season. Six crans would be the average quantity landed per vessel, and this is about a third only of what one would expect in an average season.

The grounds were invaded by shoals of larger herring in the first week in August, and large numbers of fish with four winter rings were included in the catches. These fish had gonads at stages III., IV. and V. They remained on the grounds until

10th August, and on the following morning the catches landed consisted of smaller fish in which there was a high number of fish with two winter rings. In the middle of August catches were generally light, and consisted of 2, 3 or 4 crans. One or two landings contained herrings of a quality to be expected at this time of the year, but others contained large numbers of fish with two winter rings. The fishery remained in this condition until 4th September, when observations were concluded.

North Shields was not the only port where irregular and small catches marked the fishery. Mr. Brown has informed me that the season at Lerwick was peculiar, and that he never had a chance of sending me a sample of young herrings. Mr. Duncan MacIver, writing in July, stated that at Stornoway they had no real summer, fat matties, and that most of the herrings were coarse and more like winter herrings. Information received from fishermen, who had fished out of Wick and Peterhead, and from trade papers, points to the East Coast fishery of Scotland being characterised by irregular and small catches. Occasional large catches were landed, but the fishery gave no evidence of there being extensive shoals off the coast.

Fishermen have reported the extremely large number of jellyfish which fouled their nets during the herring season, and as late as 13th November large quantities were noticed by a North Shields trawler 130 miles N.E. of the Tyne. Statements that the sea was "dirty" were common from men who had fished from the different ports of the east coast. The Fishery Board for Scotland has furnished me with particulars as to the unusual catches of trawled herrings landed at Aberdeen from the Fladden Grounds from the end of August to the beginning of October. These grounds though regularly fished by trawlers have not previously yielded herrings in quantity. To begin with, the fish were full of milt and roe, but later were mixed with spent fish, and it would appear that the area was used as a spawning ground.

Whilst hydrographical conditions may have been unusual there is no evidence to hand to state that this was so, and that it would account for the comparative failure of the summer fishery. The whole of the evidence available points to the fishery being a failure because of the comparatively small number of fish with

three winter rings. Fish of this age were shown by the investigations of 1919 to form the greater part of the matties caught, and from Wick to Scarborough they constituted from fifty to nearly seventy per cent. of the samples examined. Further, the continuous investigations which have been made on the Northumberland shoals point to the importance of herrings with three winter rings in the summer fishery. A shortage of fish of this age would account for the small landings made, the small extent of the shoals as evidenced by the varied landing made by vessels fishing in practically the same waters, and the comparatively high number of fish with two winter rings found in the North Shields catches.

It is not thought that any hydrographical condition during 1920 would account for the shortage of fish with three winter rings as fish a year younger were present in comparatively high numbers. It is more probable that the conditions which obtained when the young fish were hatched, and shortly afterwards, were the cause of the scarcity. If this be so, our summer fishery for 1920 was determined by the conditions obtaining in the autumn of 1916 and the spring of 1917.

The age composition and the state of maturity of the samples examined will be found in Tables I. and II.

No sample of autumn spawners in a spawning condition was received from any of the ports. The samples which were obtained consisted of mixed herrings, a large number of which were spents.

The Lerwick samples of 30th June and 25th August were old fish. The majority of them had six or more winter rings, and they were mostly spents or recovering spents. The sample of 30th June is especially interesting in that it points to a very early spawning of some shoals in Shetland waters in 1920. As no evidence is to hand to show that so early a spawning season is a common occurrence in Shetland waters, it is impossible to say whether spawning in northern waters as early as June would have any effect on the catches of autumn spawners made further south along the east coast in August and the beginning of September. This sample contained few fish with less than six winter rings. The August sample contained more of the younger herrings, and the percentage with five winter rings gives indication of the short-

age of this year class which was found in the Yarmouth samples of 1919 and the samples from spring spawning shoals in 1920.

The sample from Wick, 24th August, consisted chiefly of spent fish, and only 15 out of a total of 189 were at or below stage IV. It would appear from this that the sample can be taken as representing the herrings spawning off Wick. The numbers under different ages point to the sample containing herrings which had developed in the summer feeding shoals and also older fish which had invaded the grounds for the purpose of spawning. It is worthy of notice that this sample, like the August sample from Lerwick, had a small percentage of fish with five winter rings.

The number of fish which had not developed to stage IV. or beyond in the sample from Peterhead, 25th August, makes it impossible to regard this sample as representing the autumn spawning shoals. In addition, 10 per cent. of the sample was composed of recovering spents, and since there is a scattering of the shoals after spawning these herrings may have spawned on grounds some considerable distance from where they were caught. Of fish with two winter rings there was 28 per cent., and this is a much higher percentage than was found in any of the samples from Peterhead in 1919. Attention was drawn in the Report of last year to the variation in age at which herrings reach maturity, and in this connexion the following data from the Peterhead sample are worthy of notice :—

Winter Rings	2	3	4	5	6
Below Stage V.	38	17	7	3	1
Stage V. or above ...	18	51	13	13	5

Mr. Beazor was unable to obtain any sample of spawning fish from the Yarmouth shoals during the East Anglian herring harvest. Occasionally catches of spawning fish are landed during this fishery, but the bulk of the herrings caught are full or filling fish which, doubtless, become spring spawners. The sample of 17th November represents the Yarmouth fishery of that date, and is of value as indicating that the shortage of fish with four winter rings found in the sample of 1919 was a real shortage and not due to accidental sampling. For purposes of comparison the age composition of the samples of 1919, 1920 and 1921 is here given :—

WINTER RINGS (PERCENTAGES).

		2	3	4	5	6	7	8	9	10
1919	6th November	2	13	**17**	21	24	13	5	4	1
1919	20th November ...	4	30	**10**	21	17	11	3	2	1
1920	17th November ...	3	4	35	**14**	21	14	8	—	0·4
1921	9th March	—	1	3	27	**15**	17	24	11	2

The same year class shows a shortage for three consecutive years.

The sample of 9th March, 1921, is the first sample we have examined from the Yarmouth spring fishery. It contained three fish only which were not spents or recovering spents, and its age composition is very like that of the sample of 17th November, 1920, except for the high percentage of fish with eight winter rings. An indication of this high number of fish with eight winter rings is given, however, in the sample of 6th November, 1919, in which fish with six winter rings were more plentiful than those with five winter rings.

The samples of 1920 and 1921 both contained a very low percentage of fish which in 1920 had three winter rings. Whilst this may be due to some extent to the small number of herrings examined, it supports the opinion already expressed with regard to the shortage of fish with three winter rings in the fisheries of the Northumberland coast and the east coast of Scotland.

The samples of winter herrings caught in 1921 can be divided into two classes, those containing a high percentage of young fish, and those in which older fish formed a more important portion of the samples.

The samples containing large numbers of young fish came from Stornoway and the Firth of Forth. They are of little use for the purposes of the age composition of the older fish, though the sample caught off Cellar Head and that from the Firth of Forth point to a shortage of fish with six winter rings. Their chief value lies in the high percentage of fish with three winter rings, and they indicate, as did the samples of last year from the same localities, that both Broad Bay and the Firth of Forth are the home of a large number of young herrings during the winter months.

From the age composition of the samples and the growth data it was stated that in 1920 more than one shoal of herrings frequented the waters of the Firth of Forth during the early months of the year, and it was hoped this year to obtain further evidence

with regard to these shoals. But Mr. Walker was unable to find any difference in the catches landed, and towards the end of February informed me that all landings had been similar to the sample he had sent me. It would appear from this and from information supplied by fishermen that either no shoals of large and older herrings entered the Firth during the winter fishery, or the numbers of young herrings were so great, comparatively, as to hide the presence of the older fish. The probability of the latter being the case will be seen from the age composition of the sample examined.

The high percentage of fish with three winter rings is remarkable, but the data as given in Table I. do not fully represent the abundance of fish of this age. When the sample arrived it was evident it contained two classes of fish, and was dealt with accordingly. The largest of the herrings, 79 in number, were picked out and examined, and then rather more than half the remainder was dealt with, 150 out of 260. If the 110 herrings which were not examined be considered as having the same age composition as those of the smaller herrings which were examined, we have the the following result :—

	WINTER RINGS.									
	3	4	5	6	7	8	9	10	11	Total.
Large examined ...	27	5	10	6	17	6	6	1	1	79
Small examined ...	121	27	2	—	—	—	—	—	—	150
Small not examined ...	89	20	1	—	—	—	—	—	—	110
Total	237	52	13	6	17	6	6	1	1	339
Percentages ...	70	15	4	2	5	2	2	+	+	

All the information which has been obtained points to there being a large number of herrings with three winter rings in the waters of the Firth of Forth during January and February of this year. The shoals extended from above the Forth Bridge to off Eyemouth, 36½ crans being landed by a vessel at North Shields on 29th January from 6 miles N.E. of St. Abbs. The herrings of this catch were similar to those of the sample of 10th February.

The condition of the gonads of the herrings in the sample from the Firth of Forth is not without interest. Of the 148 fish with three winter rings seven only were not developed as far as

stage III., 60 were at stage III., 59 at stage IV., and 22 at stages V. and VI. It is evident that a large number of these would become spring spawners, and it is difficult to imagine that even those at stage III. in the beginning of February would postpone their spawning until the following autumn.

Summer shoals have been shown to consist largely of maturing herrings with three winter rings, and it is possible that the spawning of large numbers of herrings with three winter rings in spring may have an effect on the summer shoals of the same year. It is desirable that our knowledge of the factors which influence maturity be extended with the object of ascertaining the causes of spring and autumn spawning, and also the causes of variation in age when maturity is reached.

The samples of winter herrings from Lerwick were taken from the east of the islands, and not as in 1920 from the grounds between Flugga and the Ramna Stacks. These grounds were little fished during the past winter fishery, and on the few occasions when catches were there made the sailing of the steamer to the mainland made it impossible for Mr. Brown to forward samples.

The sample of 12th February consisted of spawning fish from grounds to the east of Bressay, and that of 20th May of recovering spents from much the same locality. The latter sample had suffered somewhat in transit, and it was difficult to tell with exactitude the true condition of the gonads. It is certain the fish were recovering spents, but it is doubtful if they were sufficiently recovered to allow of them being placed at stage II. as in Table II. Both these samples show a shortage of fish with six winter rings, and over 30 per cent with seven and eight winter rings. The February sample had 31 per cent. of fish with five winter rings, and points to the fish which had three winter rings in 1919 being fairly plentiful in some of the Shetland shoals.

One sample only was received from the shoals off the north coast of Sutherlandshire, 26th February, 1921, and this was considered by Mr. John Sutherland to be a fair sample of the herrings landed at Peterhead from these grounds during the winter fishery. The condition of the gonads points to the fish being spring spawners. Fish with seven and eight winter rings comprised over 40 per cent. of the catch. The same shortage of fish with six winter rings as has been observed in other samples was present, but there was also

a very small number of fish with five winter rings. In this respect the sample differs from any of the North Sea samples, and is more in keeping with those from the north-west of Ireland. Fairly young fish with three and four winter rings were present in numbers, but they were not so plentiful as older fish with seven and eight winter rings.

The samples from the north-west of Ireland were from the spring spawning shoals, which give the fishery from Buncrana, and from the shoals of Donegal Bay. The first sample contained a large number of full fish nearly ready for spawning, and the two later samples consisted of spents. Herrings with seven and eight winter rings formed an important part of the samples, and there was a fairly high percentage of fish with four winter rings. But the chief point of interest is the small percentages of fish with both five and six winter rings. This points to a difference from North Sea shoals and a resemblance to the shoals off the north coast of Sutherlandshire. The sample of 17th February differed from the other two in that it contained a higher percentage of fish with six winter rings and not so many older fish.

Growth.—For all the samples the length of the fish has been expressed in terms of the position of the winter rings of the scale. The data thus obtained have been tabulated to the nearest centimetre, *e.g.*, 8·6 to 9·5 cm. being counted as 9 cm.

As many of the samples came from the same fishing grounds and were taken at the same season as those reported upon in the Report of last year, their growth data are not included in the present paper.

Two of the Lerwick samples differ from any previously examined. That of 30th June, 1920, came from a shoal which, from the maturity data, had spawned in June. Herrings spawning so early in the season are worthy of record, and the growth data of this sample will be found in Table III. The sample from east of Bressay, 12th February, 1921, was from a spawning shoal. The samples examined last year came from the grounds between Flugga and the Ramna Stacks, and an examination of the growth data given in Table III. and that given in the Report of last year will show that these shoals differ somewhat as regards growth. Fish with six winter rings were plentiful in the samples of 1920,

and those with seven winter rings comprised 17 per cent. of the 1921 sample. The fifth year growth of these fish is given below :—

NUMBERS AT CENTIMETRES

Sample.	Winter Rings.	26	27	28	29	30	31	32	Total.
21/2/20	6	—	—	3	22	21	17	4	67
12/2/21	7	1	4	11	14	2	—	—	32

Such a difference in growth is considered to point to the spring spawning herrings of the north-west of the Shetlands being different from the shoals which frequent the waters of the east coast of the islands.

The samples from Great Yarmouth, 9th March, 1921, is the first we have examined from the shoals of spents which appear off Yarmouth in the spring. Of the 171 herrings comprising the sample, 168 were spents or recovering spents. In the November sample, 1920, most of the fish were at stages III. and IV., 195 out of 225. The percentage of herrings with four winter rings, the last winter ring being inside the edge of the scale, was 35 in the November sample, and in the March sample 27 per cent. had five winter rings, the last winter ring coinciding with the edge of the scale. The growth of these fish is so similar that it is given below, and it is considered it points to a return of herrings to Yarmouth waters after spawning has taken place.

FIRST YEAR GROWTH.

NUMBER AT CENTIMETRES

Sample.	Winter Rings	6	7	8	9	10	11	12	13	14	15	Total.
17/11/20	4	1	6	17	28	8	10	5	1	2	1	79
9/3/21 ...	5	—	1	11	15	9	6	2	1	—	1	46

SECOND YEAR GROWTH

NUMBER AT CENTIMETRES

Sample.	Winter Rings.	14	15	16	17	18	19	20	21	Tota
17/11/20	4	2	7	14	15	16	13	11	1	79
9/3/21 ...	5	2	1	12	9	11	1	9	1	46

THIRD YEAR GROWTH.

NUMBER AT CENTIMETRES.

Sample.	Winter Rings.	19	20	21	22	23	24	25	Total
17/11/20	4	—	6	14	26	25	8	—	79
9/3/21 ...	5	1	—	10	17	10	7	1	46

FOURTH YEAR GROWTH.

NUMBER AT CENTIMETRES.

Sample.	Winter Rings.	22	23	24	25	26	27	Total.
17/11/20	4	1	8	27	32	10	1	79
9/3/21 ...	5	1	4	17	19	5	—	46

The sample from the Firth of Forth, which was composed chiefly of herrings with three winter rings, is of interest in that the growth of fish with four winter rings differs from that of fish a year younger. Generally speaking, the growth of the herrings with four winter rings was lower every year than that of fish with three winter rings, but the difference is most marked in the third and fourth year growths. The data given below are taken as supporting the hypothesis that herrings previous to reaching maturity shoal according to size.

NUMBERS AT CENTIMETRES

Winter Rings.	Year Growth.	5	6	7	8	9	10	11	12	13	14	Total.
3	1	1	1	1	14	20	42	38	22	7	2	148
4	1	3	5	2	4	4	8	4	2	—	—	32

NUMBERS AT CENTIMETRES.

Winter Rings.	Year Growth.	13	14	15	16	17	18	19	20	21	22	Total.
3	2	—	—	—	—	6	20	29	52	34	7	148
4	2	2	3	—	3	—	9	11	3	1	—	32

NUMBERS AT CENTIMETRES.

Winter Rings.	Year Growth.	19	20	21	22	23	24	25	26	27	28	Total.
3	3	—	—	—	12	30	54	36	14	2	—	148
4	3	1	3	6	9	8	4	—	1	—	—	32
4	4	—	—	—	2	3	11	12	3	—	1	32

The samples from the north-west of Ireland have a growth (Table III.) very like that found in the samples of last year from north-west of the Shetlands and the north coast of Scotland. The sample of 17th February differs from the other two samples in that growth has been a little more rapid. This may be due to the shoals living under slightly different conditions before migrating to the spawning grounds off the Donegal coast.

The growth and age composition of the three samples, together with similar data * from the shoals of the north of Scotland and west of the Shetlands, point to oceanic shoals of herrings extending from the Atlantic coast of Ireland north to the Shetlands, and living under almost similar conditions. The southern limit of these herrings would be of interest, and it is possible the shoals to the west of the Hebrides, those observed about the Flannan Islands, and the summer shoals to the west of the Shetlands are of a similar nature. Statistics are not available to allow of a comparison being made with regard to the fluctuations in the catches from these shoals.

"Spawny Haddocks."—Haddocks gorged with herring spawn were landed by North Shields trawlers as follows :—

1920.		Cwts.	Where Caught.
11th September	...	151	38 miles N.E. of Tyne.
		89	46 miles N.E. by E. of Tyne.
13th September	...	92	20 miles S.E. of Longstone.
14th September	...	168	40 miles E. of Tyne.

The last locality given above is rather unusual, as generally "spawny haddocks" are most frequent in the vicinity of the Longstone and Berwick Bank.

Herring eggs obtained from haddocks landed on 11th September contained well advanced embryos ; the eyes showed boldly, and the body encircled the yolk.

Some were brought to the Laboratory with the object of hatching them out. But no movement was noticeable inside the eggs, and evidently the eggs were dead when the haddocks were landed.

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* Report, New Series, IX., Table III.

TABLE I.—AGE.

WINTER RINGS (Percentages).

Port and Date.	2	3	4	5	6	7	8	9	10	11	12	13	Total
1920.													
Lerwick—													
30th June ...	—	3	9	9	19	30	18	7	3	1	—	—	189
25th August ...	4	2	18	12	19	18	12	11	3	—	0·5	0·5	199
Wick—													
24th August ...	7	22	41	9	10	6	3	3	—	—	—	—	189
Peterhead													
25th August ...	28	34	10	8	3	5	5·5	5	1	0·5	—	—	200
Great Yarmouth—													
17th November	3	4	35	14	21	14	8	—	0·4	—	—	—	225
1921.													
Stornoway—													
16th February	—	30	35	17	4	7	6	—	—	0·5	—	—	191
2nd March ...	—	50	23	9	9	3	4	2	0·5	—	0·5	—	195
Lerwick—													
12th February	—	10	19	31	7	17	14	1	0 5	—	—	—	183
20th May	—	11	12	17	12	25	9	8	4	1	—	1	169
Peterhead—													
26th February	—	17·5	17·5	8	12	22	19	3	—	—	—	—	151
Firth of Forth—													
10th February	—	65	14	5	3	7	3	3	0·4	0·4	—	—	229
Great Yarmouth—													
9th March ...	—	1	3	27	15	17	24	11	2	—	—	—	171
IRISH SAMPLES.													
Buncrana—													
1st February ...	—	8	29	17	8	20	12	5	1	0·7	—	—	153
17th February	—	7	28	18	19	20	6	1	—	1	—	—	137
Killybegs—													
12th April ...	—	5	19	6	6	28	25	6	3	2	0·6	—	171

TABLE II.—MATURITY.

Port and Date.	I.	II.	III.	IV.	V.	VI.	VII.	VII.-II.	Total.
1920.									
Lerwick—									
30th June	—	28	12	1	—	22	72	45	180
25th August	2	1	1	—	3	6	152	31	196
Wick—									
24th August	2	—	10	3	1	14	152	7	189
Peterhead—									
25th August	12	13	33	11	3	12	96	20	200
Great Yarmouth—									
17th November ...	—	24	140	55	—	1	4	1	225
1921.									
Stornoway—									
16th February ...	3	1	7	9	54	98	6	13	191
2nd March	2	—	6	5	40	82	49	11	195
Lerwick—									
12th February ...	—	—	—	2	10	168	3	—	183
20th May	1	164	1	—	—	—	3	—	169
Peterhead—									
26th February ...	2	—	3	18	46	73	10	2	154
Firth of Forth—									
10th February ...	4	6	79	98	21	21	—	—	229
Great Yarmouth—									
9th March	2	1	—	—	—	—	126	42	171
IRISH SAMPLES.									
Buncrana—									
1st February	—	1	6	12	92	14	12	16	153
17th February ...	—	—	—	3	6	5	114	9	137
Killybegs—									
12th April	1	1	—	—	—	—	159	10	171

TABLE III.—GROWTH.

LERWICK SAMPLES.—FIRST YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	6	7	8	9	10	11	12	13	14	15	16	Total
12/2/21 ...	3	—	—	—	—	2	2	3	5	2	2	2	18
30/6/20 ...	3	—	—	—	1	—	—	1	2	2	—	—	6
12/2/21 ...	4	—	1	—	2	6	2	10	7	5	1	—	34
30/6/20 ...	4	—	—	3	1	3	5	2	3	—	—	—	17
12/2/21 ...	5	3	1	4	9	11	8	15	3	2	1	—	57
30/6/20	5	—	2	—	3	4	1	4	3	—	—	—	17
12/2/21	6	—	—	2	1	2	1	4	2	1	—	—	13
30/6/20 ...	6	—	2	7	4	3	5	4	5	1	3	1	35
12/2/21 ...	7	—	—	3	—	9	6	2	8	3	—	1	32
30/6/20 ...	7	—	1	5	5	11	11	10	6	2	3	—	54
12/2/21 ...	8 and +	—	2	3	1	5	4	2	9	3	—	—	29
30/6/20 ...	8	—	3	4	6	5	5	4	3	—	2	1	33

YARMOUTH SAMPLES.—FIRST YEAR GROWTH.

9/3/21 ...	4	—	—	—	1	1	2	1	—	—	—	—	5
	5	—	1	11	15	9	6	2	1	—	1	—	46
	6	—	1	5	6	7	3	3	1	—	—	—	26
	7	—	2	3	8	5	7	2	2	—	—	—	29
	8	3	2	8	12	7	5	2	1	—	1	—	41
	9 and 10	1	3	8	5	4	1	—	—	1	—	—	23

TABLE III. (continued).

LERWICK SAMPLES.—SECOND YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	13	14	15	16	17	18	19	20	21	22	23	24	25	Total.
2/2/21	3	—	—	—	—	—	—	1	—	3	9	2	2	1	18
0/6/20	3	—	—	—	—	—	—	1	—	4	—	—	1	—	6
2/2/21	4	—	—	—	—	1	2	2	5	8	6	5	5	—	34
0/6/20	4	—	—	1	—	1	1	6	3	1	3	—	1	—	17
2/2/21	5	—	1	2	4	3	12	6	10	10	3	4	1	1	57
0/6/20	5	—	—	—	3	2	2	1	2	3	3	—	—	1	17
2/2/21	6	—	—	1	—	3	—	2	1	4	2	—	—	—	13
0/6/20	6	—	—	4	4	3	3	4	9	2	5	—	1	—	35
2/2/21	7	—	—	1	2	2	3	7	5	8	3	1	—	—	32
0/6/20	7	—	3	—	3	7	6	14	10	6	3	2	—	—	54
2/2/21	8 and +	1	—	3	1	2	4	7	4	3	3	1	—	—	29
0/6/20	8	—	3	2	5	6	3	4	4	3	2	1	—	—	33

YARMOUTH SAMPLE.—SECOND YEAR GROWTH.

3/21 ...	4	—	—	—	—	—	1	2	2	—	—	—	—	—	5
	5	—	2	1	12	9	11	1	9	—	1	—	—	—	46
	6	—	—	1	4	8	6	4	2	1	—	—	—	—	26
	7	—	—	—	7	10	4	4	2	2	—	—	—	—	29
	8	—	3	12	5	4	8	6	1	1	—	1	—	—	41
	9 and 10	—	2	5	6	3	5	2	—	—	—	—	—	—	23

TABLE III. (continued).

LERWICK SAMPLES.—THIRD YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	18	19	20	21	22	23	24	25	26	27	28	29	Total
12/2/21	3	—	—	—	—	—	—	—	5	6	3	3	1	18
30/6/20	3	—	—	—	—	—	—	1	3	1	1	—	—	6
12/2/21	4	—	—	—	—	1	1	3	8	13	6	2	—	34
30/6/20	4	—	—	—	—	3	3	2	2	3	3	—	1	17
12/2/21	5	—	—	—	—	4	6	20	13	9	3	1	1	57
30/6/20	5	—	—	1	—	3	2	4	3	3	1	—	—	17
12/2/21	6	—	—	—	1	—	2	4	2	2	2	—	—	13
30/6/20	6	—	—	4	4	1	5	8	5	6	2	—	—	35
12/2/21	7	—	—	1	1	2	7	7	9	5	—	—	—	32
30/6/20	7	—	2	2	1	7	20	13	5	4	—	—	—	54
12/2/21	8 and +	—	2	1	—	4	11	2	5	3	1	—	—	29
30/6/21	8	1	1	4	5	6	5	6	4	1	—	—	—	33

YARMOUTH SAMPLE.—THIRD YEAR GROWTH.

9/3/21 ...	4	—	—	—	—	2	3	—	—	—	—	—	—	5
	5	—	1	—	10	17	10	7	1	—	—	—	—	46
	6	—	—	2	4	11	7	2	—	—	—	—	—	26
	7	—	—	3	6	10	8	1	1	—	—	—	—	29
	8	1	3	7	8	15	4	2	—	1	—	—	—	41
	9 and 10	—	1	3	8	4	5	2	—	—	—	—	—	23

TABLE III. (continued).

LERWICK SAMPLES.—FOURTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	20	21	22	23	24	25	26	27	28	29	30	31	Total.
2/2/21	4	—	—	—	—	—	1	2	9	14	8	—	—	34
0/6/20	4	—	—	—	—	1	2	1	6	—	6	—	1	17
2/2/21	5	—	—	—	—	—	1	14	18	12	9	1	2	57
0/6/20	5	—	—	—	—	1	3	3	4	5	1	—	—	17
2/2/21	6	—	—	—	—	—	—	3	3	5	2	—	—	13
0/6/20	6	—	—	1	2	4	9	3	7	6	3	—	—	35
2/2/21	7	—	—	—	—	1	4	9	12	4	2	—	—	32
0/6/20	7	—	—	1	2	11	8	13	11	7	1	—	—	54
2/2/21	8 and +	—	—	—	2	2	5	8	7	4	1	—	—	29
0/6/20	8	1	—	2	5	4	10	5	3	2	1	—	—	33

YARMOUTH SAMPLE.—FOURTH YEAR GROWTH.

/3/21 ...	4	—	—	—	—	4	1	—	—	—	—	—	—	5
	5	—	—	1	4	17	19	5	—	—	—	—	—	46
	6	—	—	—	3	10	10	3	—	—	—	—	—	26
	7	—	—	2	3	14	7	3	—	—	—	—	—	29
	8	—	2	5	8	18	7	—	1	—	—	—	—	41
	9 and 10	—	—	2	5	8	6	2	—	—	—	—	—	23

TABLE III. (continued).

LERWICK SAMPLES.—FIFTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	23	24	25	26	27	28	29	30	31	32	33	Total.
12/2/21	5	—	—	—	—	4	19	19	10	3	1	1	57
30/6/20	5	—	—	1	1	4	3	2	4	2	—	—	17
12/2/21	6	—	—	—	—	—	3	7	3	—	—	—	13
30/6/20	6	1	1	2	7	8	5	7	4	—	—	—	35
12/2/21	7	—	—	—	1	4	11	14	2	—	—	—	32
30/6/20	7	—	1	6	10	13	11	7	5	1	—	—	54
12/2/21	8 and +	—	—	—	4	7	8	8	2	—	—	—	29
30/6/20	8*	—	3	5	11	5	4	2	2	—	—	—	33

* 1 under 22 cm.

YARMOUTH SAMPLE.—FIFTH YEAR GROWTH.

9/3/21 ...	5	—	1	16	18	11	—	—	—	—	—	—	46
	6	—	2	8	12	3	1	—	—	—	—	—	26
	7	—	3	9	13	4	—	—	—	—	—	—	29
	8	3	9	17	10	1	1	—	—	—	—	—	41
	9 and 10	2	2	8	9	2	—	—	—	—	—	—	23

TABLE III, (continued).

IRISH SAMPLES.—FIRST YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total.
1/2/21 ...	3	—	—	—	—	—	—	3	4	4	1	—	—	—	—	12
17/2/21	3	—	—	—	—	—	—	—	3	—	3	—	2	1	1	10
12/4/21	3	—	—	—	—	—	1	1	1	3	2	—	—	—	—	8
1/2/21 ...	4	—	2	1	5	2	6	8	9	9	1	1	—	—	—	44
17/2/21	4	—	—	—	—	2	2	1	12	12	7	1	2	—	—	39
12/4/21	4	—	—	—	—	3	3	6	3	7	5	4	1	1	—	33
1/2/21 ...	5	—	—	—	1	2	4	4	7	8	—	—	—	—	—	26
17/2/21	5	—	—	—	1	1	2	3	6	3	6	2	—	—	—	24
12/4/21	5	—	—	—	—	—	1	1	2	2	2	—	2	—	—	10
1/2/21 ...	6	—	—	—	—	—	1	3	1	2	3	2	—	—	—	12
17/2/21	6	—	—	—	—	1	2	6	7	8	2	—	—	—	—	26
12/4/21	6	—	—	—	1	—	2	1	2	1	1	1	1	—	—	10
1/2/21 ...	7	—	—	—	—	2	3	3	7	6	9	1	—	—	—	31
17/2/21	7	—	—	—	—	1	2	4	7	6	2	4	2	—	—	28
12/4/21	7	—	—	1	3	1	4	9	10	9	7	3	—	1	—	48
1/2/21 ...	8	—	—	—	1	2	1	4	4	1	4	1	—	—	—	18
17/2/21	8 and +	—	—	—	1	1	1	2	1	3	1	—	—	—	—	10
12/4/21	8	1	—	3	1	2	2	3	6	15	5	4	—	—	—	42
1/2/21 ...	9 and +	—	—	—	1	1	—	4	1	2	1	—	—	—	—	10
12/4/21	9 and +	—	—	2	2	2	2	2	1	5	4	—	—	—	—	20

TABLE III. (continued)

IRISH SAMPLES.—SECOND YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Tot
1/2/21 ...	3	—	—	—	—	—	—	—	2	1	4	2	3	—	—	12
17/2/21	3	—	—	—	—	—	—	—	—	1	3	4	1	—	1	10
12/4/21	3	—	—	—	—	—	1	1	2	1	1	1	1	—	—	8
1/2/21 ...	4	—	—	—	—	3	1	4	6	12	13	4	1	—	—	44
17/2/21	4	—	—	—	—	—	3	2	6	11	9	4	3	1	—	39
12/4/21	4	—	—	—	—	—	1	6	8	8	3	6	1	—	—	33
1/2/21 ...	5	—	—	2	—	2	2	2	4	7	5	2	—	—	—	26
17/2/21	5	—	1	—	1	1	3	3	—	3	6	4	2	—	—	24
12/4/21	5	—	—	—	—	—	—	—	3	5	1	1	—	—	—	10
1/2/21 ...	6	—	—	—	—	1	—	1	4	3	2	1	—	—	—	12
17/2/21	6	—	—	—	—	1	2	3	2	6	8	2	2	—	—	26
12/4/21	6	—	—	1	—	—	—	2	1	5	—	1	—	—	—	10
1/2/21 ...	7	—	—	—	—	4	2	6	8	6	3	2	—	—	—	31
17/2/21	7	—	—	—	—	1	1	4	8	6	5	2	1	—	—	28
12/4/21	7	—	1	1	2	1	3	8	10	15	7	—	—	—	—	48
1/2/21 ...	8	—	—	1	—	2	2	3	5	2	1	2	—	—	—	18
17/2/21	8 and +	—	—	1	—	5	—	2	—	1	1	—	—	—	—	10
12/4/21	8	2	2	—	1	2	7	9	6	10	3	—	—	—	—	42
1/2/21 ...	9 and +	—	—	1	2	—	2	1	3	1	—	—	—	—	—	10
12/4/21	9 and +	1	—	1	1	1	8	3	1	3	—	1	—	—	—	20

TABLE III. (continued).

IRISH SAMPLES.—THIRD YEAR GROWTH.

CENTIMETRES.

Date	Winter Rings.	21	22	23	24	25	26	27	28	29	30	Total.
1/2/21 ...	3	—	—	—	—	—	3	4	2	3	—	12
17/2/21	3	—	—	—	—	—	—	—	3	5	2	10
12/4/21	3	—	—	—	—	2	1	3	2	—	—	8
1/2/21 ...	4	—	—	—	2	6	12	15	8	1	—	44
17/2/21	4	—	—	—	—	2	11	15	9	1	1	39
12/4/21	4	—	—	—	1	4	12	11	4	1	—	33
1/2/21 ...	5	1	—	1	2	3	6	10	2	1	—	26
17/2/21	5	—	—	1	1	7	2	5	5	2	1	24
12/4/21	5	—	—	—	—	3	2	5	—	—	—	10
1/2/21	6	—	—	1	—	4	4	3	—	—	—	12
17/2/21	6	—	1	1	1	2	5	9	5	2	—	26
12/4/21	6	—	1	1	—	2	3	3	—	—	—	10
1/2/21 ...	7	—	—	4	4	7	10	4	2	—	—	31
17/2/21	7	—	1	1	1	2	10	9	4	—	—	28
12/4/21	7	—	—	7	7	11	18	5	—	—	—	48
1/2/21 ...	8	1	—	3	4	6	2	1	1	—	—	18
17/2/21	8 and +	—	2	—	5	—	2	—	1	—	—	10
12/4/21	8	3	4	4	9	14	7	1	—	—	—	42
1/2/21 ...	9 and +	1	1	2	3	2	1	—	—	—	—	10
12/4/21	9 and +	2	2	5	4	5	1	1	—	—	—	20

TABLE III. (continued).

IRISH SAMPLES.—FOURTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	24	25	26	27	28	29	30	31	32	33	Total
1/2/21 ...	4	—	—	—	1	9	16	15	3	—	—	44
17/2/21	4	—	—	—	—	1	10	21	5	1	1	39
12/4/21	4	—	—	1	1	3	22	3	3	—	—	33
1/2/21 ...	5	—	—	1	1	10	9	4	1	—	—	26
17/2/21	5	—	—	—	2	7	7	6	2	—	—	24
12/4/21	5	—	—	—	2	2	5	1	—	—	—	10
1/2/21 ...	6	—	—	1	4	4	3	—	—	—	—	12
17/2/21	6	—	—	2	2	3	12	6	1	—	—	26
12/4/21	6	—	—	2	1	1	5	1	—	—	—	10
1/2/21 ...	7	—	—	3	11	10	4	2	1	—	—	31
17/2/21	7	—	—	1	2	7	12	6	—	—	—	28
12/4/21	7	—	—	8	15	19	6	—	—	—	—	48
1/2/21 ...	8	1	1	4	7	2	2	1	—	—	—	18
17/2/21	8 and +	—	—	3	2	3	1	1	—	—	—	10
12/4/21	8	3	3	8	20	8	—	—	—	—	—	42
1/2/21 ...	9 and +	1	2	1	6	—	—	—	—	—	—	10
12/4/21	9 and +	1	4	6	6	2	1	—	—	—	—	20

TABLE III (continued).

IRISH SAMPLES.—FIFTH YEAR GROWTH.

CENTIMETRES.

Date.	Winter Rings.	26	27	28	29	30	31	32	Total.
1/2/21 ...	5	—	—	1	6	10	8	1	26
17/2/21	5	—	—	—	1	9	11	3	24
12/4/21	5	—	—	1	3	3	3	—	10
1/2/21 ...	6	—	—	2	3	6	1	—	12
17/2/21	6	—	—	1	3	6	12	4	26
12/4/21	6	—	—	2	2	3	2	1	10
1/2/21 ...	7	—	1	5	14	7	3	1	31
17/2/21	7	—	—	1	5	13	9	—	28
12/4/21	7	—	2	14	18	14	—	—	48
1/2/21 ...	8	1	5	4	3	3	2	—	18
17/2/21	8 and +	—	1	1	5	1	2	—	10
12/4/21	8	1	6	17	15	3	—	—	42
1/2/21 ...	9 and +	2	2	6	—	—	—	—	10
12/4/21	9 and +	3	4	8	3	2	—	—	20

HERRING INVESTIGATIONS.

II.—SIZE.

BY DOROTHY COWAN

An analysis of the size of the herrings examined is given in Table I. The size is expressed to the nearest centimetre, 20·6 to 21·5 being taken as 21 cm.

It has not been considered necessary to publish a complete analysis of size for age for all the samples examined, as this would be a duplication of the data given in the Report of last year. Therefore six samples only have been dealt with in this way. Data as to the origin of these samples will be found in the list given by Mr. Storrow.

The first of these six samples was from Lerwick, 12th February, 1921. It was from a more south-easterly ground than any previous sample of winter herrings from that port, and is interesting when compared with a sample taken 21st February, 1920, 10 miles west of the Shetlands. As will be seen from the table below there was a great difference in size, the sample of this year being much smaller. The majority of the fish in the 1920 sample were at 31 and 32 cm., whilst the latter sample ranged principally from 28 to 31 cm.

		Centimetres.											
Port.	Date.	25	26	27	28	29	30	31	32	33	34	35	Total.
Lerwick	... 21/2/20	1	2	9	4	8	17	40	50	18	1	1	151
Do.	... 12/2/21	6	8	16	38	32	49	20	12	2	—	—	183

Herrings with four and five winter rings were more abundant in the sample of 1921, but this is not sufficient to account for the difference in size. From the data given below it will be obvious

that the winter herrings from the west side of the Shetlands are larger than those from the grounds to the east of the Shetlands.

CENTIMETRES.

Port.	Date.	Winter Rings	25	26	27	28	29	30	31	32	33	34	Total.
Lerwick ...	21/2/20	3	1	—	—	—	—	—	—	—	—	—	1
Do. ...	12/2/21	3	5	6	3	3	1	—	—	—	—	—	18
Do. ...	21/2/20	4	—	2	8	3	6	3	—	—	—	—	22
Do. ...	12/2/21	4	1	2	9	14	8	—	—	—	—	—	34
Do. ...	21/2/20	5	—	—	—	1	1	2	2	5	1	—	12
Do. ...	12/2/21	5	—	—	4	19	19	10	3	1	1	—	57
Do. ...	21/2/20	6	—	—	—	—	1	11	25	20	10	—	67
Do. ...	12/2/21	6	—	—	—	—	2	8	2	1	—	—	13
Do. ...	21/2/20	7	—	—	1	—	—	1	11	20	5	—	38
Do. ...	12/2/21	7	—	—	—	1	1	18	7	5	—	—	32

The Yarmouth samples were taken during November of 1920 and March of this year, the latter being a sample of spring herrings. As the data given in the Report last year referred to November samples only, the two samples are given in Table II. in detail for purposes of comparison. There was no difference in size, as in each sample the greater numbers are under 26 to 28 cm. While there is an apparent difference in age this is due to the fact that in the November sample the last winter ring counted was inside the edge of the scale, and in the March sample the last winter ring and the edge of the scale were taken as coinciding. This must be taken into consideration when examining the data given in Table II.

The three samples from Ireland have been analysed also, as this is the first year we have examined herrings from Irish waters. All these samples were composed of large fish, but the second sample differs from the first and third sample.

This sample, taken 17th February, 1921, 10 miles off the mouth of Lough Swilly, and from practically the same fishing ground as sample 1 but further out, was larger than the other samples.

In order to make the difference clear, the data have been arranged as below :—

CENTIMETRES

Sample.	Date.	Winter Rings.	26	27	28	29	30	31	32	33	34	Total.
1	1/2/21	3	3	4	2	3	—	—	—	—	—	12
2	17/2/21	3	—	—	3	5	2	—	—	—	—	10
3	12/4/21	3	—	3	2	—	—	—	—	—	—	8
1	1/2/21	4	—	1	9	16	15	3	—	—	—	44
2	17/2/21	4	—	—	2	9	21	5	1	1	—	39
3	12/4/21	4	1	1	3	22	3	3	—	—	—	33
1	1/2/21	5	—	—	1	6	10	8	1	—	—	26
2	17/2/21	5	—	—	—	1	9	11	3	—	—	24
3	12/4/21	5	—	—	1	2	4	3	—	—	—	10
1	1/2/21	6	—	—	—	1	4	6	1	—	—	12
2	17/2/21	6	—	—	—	1	3	7	12	3	—	26
3	12/4/21	6	—	—	—	2	2	3	3	—	—	10
1	1/2/21	7	—	—	—	2	3	15	9	1	1	31
2	17/2/21	7	—	—	—	1	—	6	15	6	—	28
3	12/4/21	7	—	—	—	4	13	24	7	—	—	48
1	1/2/21	8	—	—	—	1	6	4	5	2	—	18
2	17/2/21	8	—	—	—	1	2	1	2	2	—	8
3	12/4/21	8	—	—	—	6	12	19	5	—	—	42

It appears therefore that to the north-west of Ireland there are two shoals of herrings, one having a more rapid growth than the other.

Only one sample from the Firth of Forth was examined this year. It was taken 10th February, 1921, and is interesting when compared with the sample of 10th March, 1920.

The sample of 1921 contained a large number under 24 and 25 cm., and a smaller number under 28 and 29 cm.

The sample of 1920 had numbers under 23 and 24 cm, and still larger numbers under 26, 27 and 28 cm.

The particulars are given below :—

CENTIMETRES.

Sample.	Date.	21	22	23	24	25	26	27	29	29	30	31	Total.
Firth of Forth ...	10/3/20	2	11	20	27	17	20	32	30	15	2	1	177
Do. ...	10/2/21	—	14	33	65	50	19	7	18	18	4	1	229

This difference will be seen from the following table to be due to the large number of fish with four winter rings in the 1920 sample. Not only were fish of their age more numerous in the sample of 1920, but they had made a much larger growth than those of the same age in the sample of this year.

CENTIMETRES

Sample.	Date.	Winter Rings.	21	22	23	24	25	26	27	28	29	30	31	Total.
Firth of Forth ...	10/3/20	3	2	6	13	22	11	10	4	1	1	—	—	70
Do. ...	10/2/21	3	—	12	30	54	36	14	2	—	—	—	—	148
Do. ...	10/3/20	4	—	—	3	5	5	8	24	24	13	2	1	85
Do. ...	10/2/21	4	—	2	3	11	12	3	—	1	—	—	—	32
Do. ...	10/3/21	5	—	—	—	—	1	2	2	2	1	—	—	8
Do. ...	10/2/21	5	—	—	—	—	2	2	1	5	2	—	—	12

TABLE I.—SIZE.

CENTIMETRES.

Sample.		21	22	23	24	25	26	27	28	29	30	31	32	33	34
SY.—1	Nos.	—	—	—	9	15	19	41	45	36	14	7	4	—	—
	%	—	—	—	4·7	7·8	10·0	21·4	23·6	18·7	7·3	3·7	2·1	—	—
SY.—2	Nos.	—	—	—	1	19	42	58	27	18	15	7	7	1	—
	% ...	—	—	—	0·5	9·7	21·5	29·8	13·7	9·2	7·7	3·6	3·6	0·5	—
LK.—1	Nos.	—	—	—	—	5	4	19	38	35	37	25	15	2	—
	% ...	—	—	—	—	2·8	2·2	10·1	21·0	19·4	20·6	13·9	8·3	1·1	—
LK.—2	Nos.	—	1	—	—	3	5	12	33	69	50	20	3	—	—
	% ...	—	0·5	—	—	1·5	2·5	6·1	16·8	35·2	25·5	10·0	1·5	—	—
LK.—3	Nos.	—	—	—	—	6	8	16	38	32	49	20	12	2	—
	% ...	—	—	—	—	3·3	4·4	8·7	20·8	17·5	26·8	10·8	6·6	1·1	—
LK.—4	Nos.	—	—	—	—	8	31	57	47	21	5	—	—	—	—
	% ...	—	—	—	—	4·7	18·3	33·7	27·8	12·4	3·0	—	—	—	—
WK.—1	Nos.	—	—	1	9	17	33	59	26	25	17	2	—	—	—
	% ...	—	—	0·5	4·8	9·0	17·5	31·2	13·7	13·2	9·0	1·1	—	—	—
PD.—1	Nos.	2	4	10	34	46	26	17	16	21	16	7	1	—	—
	% ...	1·0	2·0	5·0	17·0	23·0	13·0	8·5	8·0	10·5	8·0	3·5	0·5	—	—
PD.—2	Nos.	—	—	—	—	1	13	17	14	12	14	24	42	14	3
	% ...	—	—	—	—	0·6	8·4	11·0	9 0	7·8	9·1	15·6	27·2	9·1	1·9
FF.—1	Nos.	—	14	33	65	50	19	7	18	18	4	1	—	—	—
	% ...	—	6·1	14·4	28·4	21·8	8·3	3·0	7·9	7·9	1·7	0·4	—	—	—
YH.—1	Nos.	1	2	4	5	31	60	74	42	6	—	—	—	—	—
	% ...	0·4	0·9	1·3	2·2	13·8	26·7	32·9	18·7	2·7	—	—	—	—	—
YH.—2	Nos.	—	—	1	5	20	43	58	33	10	1	—	—	—	—
	% ...	—	—	0·6	2·9	11·7	25·1	33·9	19·3	5·8	0·6	—	—	—	—
I.—1 ...	Nos.	—	—	—	—	—	3	5	13	30	41	40	17	3	1
	% ...	—	—	—	—	—	2·0	3·3	8·5	19·6	26·8	26·2	11·1	2·0	0·7
I.—2 ...	Nos.	—	—	—	—	—	—	—	2·9 ~~5·4~~	18 9	38	30	34	12	—
	% ...	—	—	—	—	—	—	—	~~8·7~~	13·1	27·8	21·8	24·8	8·8	—
I.—3 ...	Nos.	—	—	—	—	~~2~~	~~4·2~~	4	6	40·1	~~40~~ 39	55	22	—	—
	% ...	—	—	—	—	1·2	~~2·0~~ 1·2	2·3	2·9	~~28·4~~ 24·0	~~33·4~~ 22·8	32·2	12·9	—	—

TABLE II.—SIZE AND AGE.

CENTIMETRES.

Sample.	Winter Rings.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Total.
LK.—3	3	—	—	—	—	5	6	3	3	1	—	—	—	—	—	18
	4	—	—	—	—	1	2	9	14	8	—	—	—	—	—	34
	5	—	—	—	—	—	—	4	19	19	10	3	1	1	—	57
	6	—	—	—	—	—	—	—	—	2	8	2	1	—	—	13
	7	—	—	—	—	—	—	—	1	1	18	7	5	—	—	32
	8	—	—	—	—	—	—	—	1	1	12	7	4	1	—	26
	9	—	—	—	—	—	—	—	—	—	1	1	—	—	—	2
	10	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
		—	—	—	—	6	8	16	38	32	49	20	12	2	—	183
I.—1 ...	3	—	—	—	—	—	3	4	2	3	—	—	—	—	—	12
	4	—	—	—	—	—	—	1	9	16	15	3	—	—	—	44
	5	—	—	—	—	—	—	—	1	6	10	8	1	—	—	26
	6	—	—	—	—	—	—	—	—	1	4	6	1	—	—	12
	7	—	—	—	—	—	—	—	—	2	3	15	9	1	1	31
	8	—	—	—	—	—	—	—	—	1	6	4	5	2	—	18
	9	—	—	—	—	—	—	—	1	1	2	3	—	—	—	7
	10	—	—	—	—	—	—	—	—	—	—	1	1	—	—	2
	11	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
		—	—	—	—	—	3	5	13	30	41	40	17	3	1	153
I.—2 ...	3	—	—	—	—	—	—	—	3	5	2	—	—	—	—	10
	4	—	—	—	—	—	—	—	1	10	21	5	1	1	—	39
	5	—	—	—	—	—	—	—	—	1	9	11	3	—	—	24
	6	—	—	—	—	—	—	—	—	1	3	7	12	3	—	26
	7	—	—	—	—	—	—	—	—	1	—	6	15	6	—	28
	8	—	—	—	—	—	—	—	—	1	2	1	2	2	—	8
	9	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
	11	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
		—	—	—	—	—	—	—	[illegible]	18	38	30	34	12	—	137
I.—3 ...	3	—	—	—	—	2	1	3	2	—	—	—	—	—	—	8
	4	—	—	—	—	—	1	1	3	22	3	3	—	—	—	33
	5	—	—	—	—	—	—	—	1	3	3	3	—	—	—	10
	6	—	—	—	—	—	—	—	—	2	2	3	3	—	—	10
	7	—	—	—	—	—	—	—	—	4	13	24	7	—	—	48
	8	—	—	—	—	—	—	—	—	6	12	19	5	—	—	42
	9	—	—	—	—	—	—	—	—	2	4	2	3	—	—	11
	10	—	—	—	—	—	—	—	—	2	1	—	2	—	—	5
	11	—	—	—	—	—	—	—	—	—	1	—	2	—	—	3
	12	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
		—	—	—	—	[illegible]	[illegible]	4	6	40	40	55	22	—	—	171

TABLE II. (continued).

CENTIMETRES.

Sample.	Winter Rings.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Total.
YH.—1	2	1	2	3	—	—	—	—	—	—	—	—	—	—	—	6
	3	—	—	1	2	5	1	1	—	—	—	—	—	—	—	10
	4	—	—	—	3	21	36	16	3	—	—	—	—	—	—	79
	5	—	—	—	—	4	13	11	4	—	—	—	—	—	—	32
	6	—	—	—	—	—	6	28	14	—	—	—	—	—	—	48
	7	—	—	—	—	1	4	12	14	1	—	—	—	—	—	32
	8	—	—	—	—	—	—	6	7	4	—	—	—	—	—	17
	10	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
		1	2	4	5	31	60	74	42	6	—	—	—	—	—	225
YH —2	3	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
	4	—	—	—	4	1	—	—	—	—	—	—	—	—	—	5
	5	—	—	—	1	16	18	11	—	—	—	—	—	—	—	46
	6	—	—	—	—	2	10	12	—	2	—	—	—	—	—	26
	7	—	—	—	—	1	3	15	7	3	—	—	—	—	—	29
	8	—	—	—	—	—	9	14	16	2	—	—	—	—	—	41
	9	—	—	—	—	—	3	6	7	2	1	—	—	—	—	19
	10	—	—	—	—	—	—	—	3	1	—	—	—	—	—	4
		—	—	1	5	20	43	58	33	10	1	—	—	—	—	171

POLLUTION OF THE TYNE.

By A. MEEK.

This season (1921) has again been a bad one for the Tyne. Smolts were numerous, and large numbers have been killed in the Newcastle region by the pollution. This year it cannot be said that trade effluents caused the destruction, for owing to the miners' strike the by-products works and other works had ceased operations. The season has been an abnormally dry one, and during May and June the river was very low. This allowed of an accumulation of ordinary sewage in the tidal part of the river, and the effect could be seen and smelt.

Inspector John Crawford sent me on May 25th a sample of 25 smolts. Of these I identified 16 as trout, 6 as salmon and 3 were so intermediate in character as to leave me wondering whether on occasion pairing was absolutely specific. The smolts were not in very good condition, but the scales of those examined showed that they had been hatched in 1919.

Mr. Crawford also wrote to me on July 21st, 1921, stating that owing to the drought the smolts have been much later in getting to the sea. Some are very large, and have been hanging about the tideway during this month, and this is very late for smolts. Large numbers were destroyed from Lemington down to Newcastle, and at a time when the water from Lemington to Scotswood was not much polluted. Mr. Crawford also states that it is difficult to give an accurate estimate of the number destroyed, but he has no doubt there were several thousands.

FAUNISTIC NOTES.

Phocaena communis (F. Cuv.)—The porpoise has been common off the mouth of the Tyne during the present salmon season (1921). The fishermen complain strongly of their numbers and their effects on fishing operations, and urge that steps should be taken to destroy them. On June 10th a female, 5 feet 8 inches in length, was caught in the salmon nets of a Cullercoats boat. When it was hauled into the coble it was observed that a young one was in the vicinity, and persisted in accompanying the boat. It was captured and was found to be a male measuring 2 feet 9 inches in length and weighing 25 lbs 4 ozs., and from the distinct scar of the umbilical cord it was evidently born this season. The mother was larger than the females examined in 1917 (Jour. of Anat., v. 52, p. 187), and the generative organs bear evidence of the recent birth. It was observed that when landed from the coble, milk spurted from the mother's teats to a distance of about a yard and a half. The stomach was empty.

A. M.

Acipenser sturio, Linn.—A sturgeon was caught off the coast on February 2nd, 1921. It was a female weighing 240 lbs., and the eggs were nearly mature, measuring on the average 1·9 mm. Others were reported, but were not seen by us.

A. M.

Rhina squatina, (Linn.)—A male, 130 cm. in length, was landed 26th April of this year by the trawler "St. Lawrence," which had been fishing for six days in local waters, from the mouth of the Tyne to 60 miles E.N.E.

B. S.

Petromyzon marinus, Linn.—A large lamprey, 31 inches long, attached itself to a coble fishing off Tynemouth pier, 29th February,

1921. Messrs. Rayner and Boyle presented it to the Laboratory, and it lived in our tanks until 9th May. During the whole of this time it ate nothing.

B. S.

Echinus esculentus, Linn.—Sea urchins were plentiful on the local rocks during July of last year. Some brought into the Laboratory on the 19th yielded sperms later in the day, and on the following morning fertilised eggs were found at the bottom of the tanks.

B. S.