

hundred barrels have been secured. Often after the boat was loaded the fishermen had to call on their neighbors to come and empty the remainder of their nets so as not to lose them and the herring. But if the fish are spawning and weakly, so that they cannot raise the nets, then they sink to the bottom, and both nets and fish are lost. The result of this is, the herring remain in the nets until all the meat is eaten off their bones. These lying there all winter frighten the herring next season from coming to spawn. The bones in the nets appear like clouds of phosphorus. This causes the herring to leave the locality for years, as has been found to be the case at many places formerly frequented by herring shoals for spawning, and afterward deserted for many years at a time.

The fry of the winter herring, after feeding from April, leave the brackish water at Culross and Boness and go down the Firth of Forth. When captured in October they are 3 to 4 inches long, with a tough belly, and are called sprats or garvies. In November they are found at Queensferry, and are continually getting larger. If there is very rough weather they get mixed with the summer fry seeking to get up to Culross for the winter, and both are caught in the same net. Often, in December, they are found between Queensferry and Inchkeith. Then they are larger, and some caught measure 6 to 8 inches. In January they go down the Firth, and are found all the way down to the Island of May, then being immature herring. They meet their parents coming in from the sea, where they have been since March after spawning.

My fishermen, while fishing, have traced both the summer and winter herring, after spawning, 40 miles to sea, and found both kinds returning when fishing for them for bait for their large hooks. We have also traced and followed the fry from where they were spawned up the north shore of our Firth, all through the various bays, and up to Boness and Culross, and observed their rapid growth every month as they passed through our salmon nets and otherwise.

DENHAM GREEN, TRINITY,

Edinburgh, March 18, 1885.

55.—ON THE MIGRATION OF BIRDS IN THE SPRING AND AUTUMN OF 1884.

By J. A. HARVIE-BROWN, F. R. S., F. Z. S.

Regarding the unusually extensive migration of gulls to our coasts in 1884-'85, several suggestions as to the influencing causes are readily at hand, but the following appear to have the greatest weight and importance:

As we are informed in "Nature" of February 12, 1885, recent Norwegian explorations in the Spitzbergen seas show that the year 1884 was a very remarkable ice year. "The west side of Spitzbergen was

blocked by a belt of land-ice the whole summer through, while the east side, which is nearly always blocked with ice, was more open than it had been for many years. These conditions, there seems little doubt, depend on the prevailing direction of the winds."

Now, the temperature of water having been lowered by the accumulation of ice along the west coast of Spitzbergen, which is comparatively approximate to the farthest northeast influence of the Gulf Stream, it seems natural to suppose that a deflection of the branch of the Gulf Stream, caused by the colder arctic ice and current, the accumulation of which former was caused by the prevailing north and east winds in the arctic seas, would reach round past the south end of Spitzbergen to the east coast, and would cause the unusually open sea there. But the main channel of the Gulf Stream would still be towards the southwest, and would afford the natural outlet for all manner of ocean life which required certain temperatures, and which, such as Entomostraca, Copepoda, molluscan larvæ, &c., afford food to other higher organisms.

The great quantity of such food which in ordinary summers and autumns accumulates around the shores of Spitzbergen or the warm, shallow summer seas off the north coast of Europe, no doubt retire to deeper water on the approach of winter. In unusually cold seasons the retreat is continued, following the course of the milder Gulf Stream until more temperate seas are reached.

In the course of its retreat it is discovered by vast shoals of fish, which pursue these minute forms of life even to the uttermost limits of its possible extension, up certain firths and inlets of our east coast of Scotland. Naturally, also, the last link of the migratory chain is taken up by the enormous population of gulls and other species of sea-fowl, as we know has been the case in the winter of 1884-'85 in the Firth of Forth.

In the log of the steam whaler Eclipse, Capt. D. Gray (see Report, *ante*, p. —), in summer repeated mention is made of the unusual abundance of "whale food" in the Spitzbergen seas, and I am indebted also to Captain Gray, through Mr. Thomas Southwell, of Norwich, for a record of sea temperatures of the same seas.

Mr. Hugh R. Milne, of the marine station at Granton, sends me some temperatures taken from the Firth of Forth, extending over June, 1884, to January, 1885, taken at three points, namely, Isle of May, Queensferry, and near Alloa. These data, in connection with the vast swarms of sprats or garvies (*Clupea sprattus*) and the attendant thousands of gulls, are useful for future comparisons, and I append them here. It would be interesting to have similarly-taken temperatures of the Tay estuary, which was completely deserted this season by these migratory fish, and consequently by the birds also. If we had also means of knowing the temperature of the Firth of Forth in 1872-'73, when a similar vast migration of sprats and gulls was witnessed, such data would assuredly lead to most interesting, useful, and scientific results,

One great difference in the migration of gulls in 1884-'85 from that in 1872-'73 is that in 1884-'85 there were very few glaucous gulls (*Larus glaucus*) or Iceland gulls (*L. islandicus*), but in 1872-'73 both these species were in vast numbers, comparatively speaking. It seems to me possible that the 1872-'73 migration indicated by those arctic gulls was of even wider and more extensive influence than that of 1884 and 1885; but, of course, there is room here for further study.

Again, while the Tay usually is visited by sprats in great sprat seasons, equally or nearly so with the Forth, and was so visited in 1872-'73, though not to the extent that the Forth was, in 1884-'85 it appears to have been almost utterly deserted by fish and bird alike. The cause was, no doubt, comparative scarcity of entomostracan life, dependent, most likely, upon certain undefined conditions of sea temperature, affected, possibly from the river basin of Tay and its tributaries. If light can be thrown upon these not-difficult-to-be-ascertained data, in a few years, at most, much of our uncertainty as to the causes and effects of the migrations of Entomostraca, sea fish, and even salmon and migratory Salmonidæ, will be removed.

Temperature of the Firth of Forth, June, 1884, to January, 1885.

Month.	Isle of May.	Queens-ferry.	Near Alloa.
June (1884).....	51	53	58
July.....	52	58	[60]
August.....	54	[50]	[65]
September.....	[53]	54	58
October.....	53	52	51
November.....	49	47	45
December.....	44	44	[38]
January (1885).....	[43]	39	35
Range of surface temperature of the water.....	10°	20°	30°

The figures in brackets were not observed, but are entered hypothetically.

Mr. Milne, in writing to me, adds "I believe that in hot summer days the temperature at Alloa would be 70° or more * * * and during severe winter weather would certainly be down to 32°." My belief is that in October and April the temperature is uniform all over the Firth, and from April till October it is higher at Alloa than at the Isle of May, the difference attaining a maximum between July and August. From October to April it is lower at Alloa than at the May, the difference attaining a maximum about the end of the year. The maximum difference between the two places will be about 10° or 12°, giving a rate of change of 0° 2' per mile. Suspended matter taken in ten samples at Kincardine-on-Forth varied from 5 to 20 grains per gallon, averaging about 10 grains.*

I personally visited Kincardine several times, both in 1872-'73 and in 1884-'85, and witnessed the extraordinary congregation of gulls and the

* It was at Kincardine-on-Forth, the narrowest part of the Forth, between Alloa and Borrowstounness [=Bouess] that the greatest quantities of sprats were taken.

myriads of sprats. In 1884-'85 one smack, anchored off the pier at Kincardine, took 16 tons of garvies (or sprats) in one tide. There were in all some twenty smacks lying anchored at this narrow part of the Firth, but all of these were not fishing with the small meshed nets, some for herring only. Hundreds of tons were sold at from 14s. to, latterly, 8s. a ton, and were spread over the adjoining farm lands for manure. Hundreds of tons more were sold for making up a compost manure—being considered too rich in phosphates—to a firm in Alloa. Hundreds of tons more besprinkled the mud-flats at low tide, or hung by their gills in festoons along the tangle-covered timbers of the piers. The water itself was alive with them, and every wave that broke on the lower piers left the piers covered with glittering garvies. A man with a landing net could have caught an indefinite number.

Mr. J. T. Cunningham, of the Scottish Marine Zoological Station, Granton, in reply to inquiries, tells me that his notes dating November 28, show that copepods were very numerous and varied, as were also molluscan larvæ. The temperatures of the water, as will be seen by Mr. Milne's notes in December and January, 1885, were lower than at any other time of the year, being 38 and 35 near Alloa and Kincardine as compared with 41 and 39 at Queensferry, and 44 and 43 at the Isle of May. By the 17th of November, as it is recorded in our migration report, garvies were reported as very abundant around the Isle of May, at which time the temperature at that point was 49°, against 47° at Queensferry and 45° at Alloa. These shoals were accompanied by great numbers of gulls at the Isle of May.

As early as March, 1884, vast numbers of gulls were reported to have been fishing off North Unst, in Shetland, for many weeks together, such an assembly not having been before observed by the oldest inhabitant.

I feel convinced that a steady and carefully recorded journal of bird movements will result in very extensive additions to our knowledge of the natural laws which govern them.*

I may add that in the course of perhaps twelve months more we hope to be able to produce some certain data regarding this matter, namely, the relative conditions of temperatures of the Arctic Ocean in the Spitzbergen seas in 1884-'85, with the data already printed in our present report, from inquiries made by Mr. A. Buchan, of the Scottish Meteorological Society, and also the conditions of such data relating to the migrations of Entomostraca and "whale's food." Also we hope to have sufficient data to institute a comparison with the conditions of temperatures, &c., in other seasons.

DUNIPACE LARBERT, *April 7, 1885.*

* Mr. William Evans, a most careful and excellent field naturalist, sends me records of the occurrence of high arctic birds on the Firth of Forth in 1884. The gray plover, knot, and bar-tailed godwit, were seen on August 9th, which, however, was the first day Mr. Evans visited the shore. The sanderling was seen on August 14th, and the little stint on the 20th.