

Plaice Marking Experiments

in

Shetland Waters

1923—1931 (inclusive).

By

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If species with pelagic eggs and larvae are to maintain their position within a region it is obvious that the older fish must undertake at some time active and compensatory movements in the direction opposite to that in which the pelagic stages are carried passively from the spawning grounds by the prevailing currents.

The question of the exact relationship between the directions of movement of adolescent and adult fish and the strength and direction of the prevailing current systems has been the object of numerous investigations in Scottish waters. Much information regarding the movements of fish may be obtained from marking experiments and as early as 1893 Fulton (1) began such investigations with plaice (*Pleuronectes platessa*) — a hardy species admirably suited for this method of experiment.

In Fulton's early and subsequent plaice marking experiments the majority of the liberations were effected at various positions on the East Coast of Scotland within the 50 fathom contour line of depth in the area lying between Fair Isle in the north and the Firth of Forth in the south. In his latest report Fulton (2) summarised his analysis of the movements of "spawning fish" as follows: —

"The experiments show that the great majority of spawning plaice move northward and westward against the prevailing current. It is evident, however, that this habit, in the case of the plaice, is not without exception for a few of the spawning plaice were found to the south of the locality where they were liberated. A striking feature of the experiments is the large number of adult plaice which pass from the Firth of Forth area northwards into the Moray Firth and there spawn. In several cases the fish which were marked in the Firth of Forth or off the Isle of May in the late months of the year

were recaptured in a spawning or ripe condition in the Moray Firth, having in the interval made a rapid journey between the two firths. On the other hand there are some instances which show that adult plaice may remain a long time in the locality in which they were liberated and spawn there; this seems to be true more particularly of the very large fish. It is evident, therefore, that while there is a general migration for spawning purposes of the plaice in the contrary direction to the current, it cannot be said that this habit is a rigid one."

In these earlier experiments no liberations of marked plaice were effected in Shetland waters and it is the purpose of the present communication to amplify these earlier results by the analysis of the records of movements of adult plaice as ascertained from a series of post-war liberation experiments in the latter area.

The physical conditions surrounding the Shetland Islands play an important part in the biology of the plaice population in that area. Round the coast the sea floor shelves very rapidly seawards; depths of 20 and 30 fathoms occur close to the shore line and at many parts of the coast depths of more than fifty fathoms occur within the territorial zone. The fifty-fathom contour line of depth extends further seaward in the neighbourhood of Balta, of St. Magnus Bay, and of Foula. A narrow ridge of only a few miles in breadth at the broadest part where depths of over 40 but under 50 fathoms occur connects the Shetland plateau with the north of Orkney and consequently with the mainland.

Plaice are rarely found in depths of more than fifty fathoms although in areas such as Shetland where the gradient of the sea floor is steep a few large individuals may sometimes be caught in slightly deeper water. The rapidly shelving nature of the sea floor all around Shetland provides at all seasons of the year bathymetric conditions suitable for all sizes of plaice within a narrow zone surrounding the islands. Since the adolescent plaice are restricted in their distribution to comparatively shallow depths the deep water which encircles the islands is an effective barrier to their passage to and from the area. There is no exchange of adolescent stocks between Shetland and the mainland. The depth of water on the narrow ridge between the south of Shetland and the north of Orkney is, however, no barrier to the passage of larger (and older) fish.

The prevailing water movements are clockwise round the islands and during the spawning and hatching season pelagic organisms such as plaice eggs and larvae tend to be carried northwards along the west coast and southwards along the east coast. When the young plaice first take to a bottom habitat conditions such as are found on the shallow sandy margins of the shore are essential for further development and growth. Most of the Shetland coast is rocky and precipitous and shallow sandy grounds are few and of comparatively small extent. Even when hydrographic conditions are favourable to the survival of the larvae through the

pelagic phase a very large proportion of the fry when they are ready to assume the demersal habit will find themselves in unfavourable positions for further development and growth owing to the inhospitable nature of the greater part of the Shetland coast. The recruitment of the demersal population of plaice in Shetland waters is at all times precarious and even in the most favourable years must be small. While the extent of ground on the Shetland plateau on which it is possible to operate a trawl or seine net without risk of very considerable damage to gear is limited, the experiments carried out in postwar years at various localities round the coast provide sufficiently representative material for an analysis of the conditions. For the present purpose it is unnecessary to enter into a detailed description and examination of individual experiments.

Every opportunity has been taken during the periodic visits of the research vessel "Explorer" to liberate marked individuals at various localities round the islands. During the period 1923—1931 (incl.) a total of 2457 marked plaice has been liberated. The great majority (2067 or 84 %) were, however, immature individuals taken from the East Coast of Scotland and liberated in approximately the same depths in Shetland waters as those in which they were originally caught. The remainder were fish caught within the area and liberated as marked fish at the positions of capture. The latter were practically all adult fish at liberation.

The transplanted fish found conditions in the shallow water to which they had been transferred particularly favourable for growth. They settled down readily and grew much faster than the marked fish which were left in St. Andrews Bay as a "control" experiment. The most important feature of these transplantation experiments is that the transplanted fish, once they had settled down in their new environment, acquired the growth rate of the "indigenous" population. None was caught beyond the liberation centres before they had attained maturing or adult sizes. They behaved as stationary fish during their periods of immaturity. Objection to the use of these transplanted fish for the study of the migratory movements of the maturing and adult fish of the indigenous population cannot therefore be sustained.

Five hundred and fifty-six fish, or approximately 23 % of the total number liberated, have been recaptured up to 31st December 1932 and of these 450 may be assigned to the category "non-migrant", while 99 were migrants. The positions of recapture of the remainder are not known or doubtful and these have therefore been omitted.

For convenience of description of the movements of the marked fish the experiments may be grouped round eight centres of liberation. These are indicated by the letters A to H on the accompanying chart. The positions are representative of the conditions all round the islands.

Records of positions of recapture of marked specimens are to be regarded as the closest approximations possible under the conditions

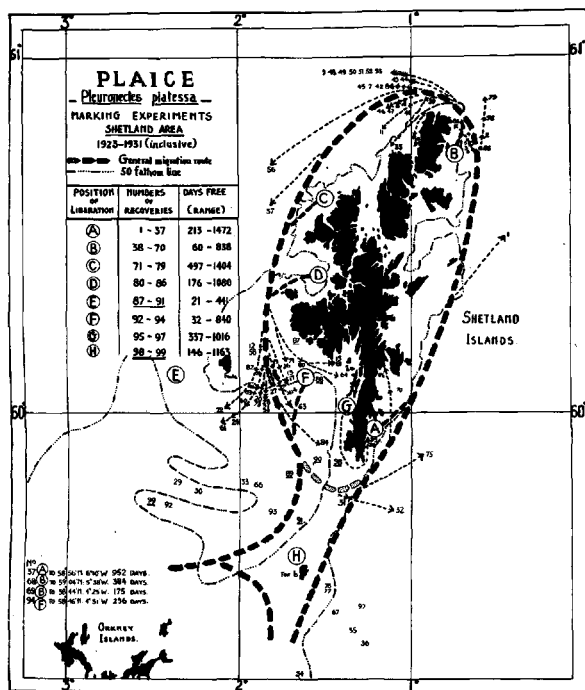
of the experiment. Having regard to the nature of the data the very high percentage (approximately eighty per cent.) of the recoveries, many after extended periods of freedom, at or near the place of liberation, is proof that the information received from the fishermen as to the places of recapture, is very reliable. The following arbitrary standard of classification is adopted for simplification of treatment of the data. Fish which have been recaptured within comparatively short distances of the places of liberation are regarded as stationary or non-migrant individuals. Whether any of these immigrated into the areas of liberation prior to the dates of the experiments cannot, of course, be definitely ascertained. No doubt some were taken near to the *loci* of liberations simply because their periods of freedom were too short to enable them to move far. It may be presumed, however, that, even in the case of a species undertaking no extended migrations, individuals liberated together will tend to scatter over a wider area, especially if conditions are more or less uniform. There are also seasonal offshore and inshore movements. The adoption of a comparatively wide limit will tend to exclude many of these from the migrant group. On the other hand many of the so-called stationary individuals were free for long periods, and as these included adult fish it may be presumed that conditions obtaining within the areas of liberation during the periods of freedom were more or less congenial both for feeding and spawning.

The non-migrants, or those fish which were recaptured within short range of the localities of liberation showing no signs of "directional" movement may be dismissed briefly. The majority were liberated as immature fish and were still in that condition on recapture. The remainder were liberated either as immature or adult fish and were recaptured later either in a spawning or spent condition in the vicinity of the localities in which they were liberated. Each centre of liberation contributes a quota to this group and the positions of recapture and the periods of freedom indicate that many of the adult stock all round the coast find conditions congenial for spawning in the vicinities in which they had passed their adolescent life.

There are ninety-nine cases of individuals which were recaptured at considerable distances from their centres of liberation. Their positions of recapture with reference to the centres of liberation are indicated by the appropriate numbers on the accompanying chart.

Consideration of the position of liberation and recapture of these migrants shows that the movement is a "directional" one. The fact that twelve of the migrants from centre A and eighteen from B were recaptured to the north of these liberation positions (at Balta and Flugga) definitely establishes the direction of migration on the east coast of Shetland as a northerly one. It is therefore not unreasonable to assume that the twenty-four individuals from these two liberation centres recaptured on the west coast (Foula grounds) traversed the same route as far as Flugga (the most northerly point of Shetland) and rounding the islands, turned southwards along the west coast.

The recapture of two migrants (Nos. 56, 57) from B in the vicinity of C and the recovery of four migrants (Nos. 71, 72, 73, 74) from the latter station and of five (Nos. 80, 81, 82, 83, 84) from D in the area between the island of Foula and the mainland of Shetland are



further links in the chain of evidence. Additional evidence as to the direction of migration is furnished by consideration of the periods of freedom of the recaptures from the various liberation centres, the periods of freedom being longer in general the greater the distances travelled by the migrants along this route.

The main migratory path of adult fish is therefore northwards along the east coast and southwards along the west coast, fish coming to the west from the east coast via the north of Shetland. The movement is counter-clockwise round the islands or in the direction contrary to that of the prevailing movement of the water masses in

the area. Migratory fish may or may not accomplish the encircling movement in one migratory season.

Adult fish in the Foula Bank area may remain in the vicinity to spawn or they may continue their contranant movements. The captures of seven migrants (Nos. 29, 30, 33, 66, 92, 93 and 99) some distance in a south-westerly direction and of four migrants (Nos. 37, 38, 69, 94) on the plateau north of Scotland (at North Rona, Whiten Head, and Cape Wrath respectively) much further afield in the same direction are in conformity with a contranant migration. The actual route or routes taken by these migrants is not ascertainable, but on the assumption that even the adult plaice prefer depths of less than fifty fathoms some may have entered the Fair Isle grounds before taking their departure.

In the Fair Isle area the current systems are of a complex nature and hydrographic conditions are subject to considerable and rapid variations. The subsequent movements of adult fish reaching the "debatable" ground appear to be conditioned by the current systems prevailing there at the time of their entry. Some migrants moving southwards along the west coast (Nos. 34, 35, 36, 67, 76, 77, 91, 93) to this area remain to spawn, being joined by "contranant" spawners from the East Orkney and Moray Firth grounds. Others entering the area may continue their contranant movement. Normally they have a choice of two directions. They may come within the influence of the south-coming stream from the east of Shetland (Nos. 31, 32, 65, 70, 75, 85, 86, 95, 96) and join in the encircling movement of the islands or they may enter that branch of the stream moving north-eastwards across the north of Scotland plateau which penetrates the North Sea between Orkney and Fair Isle. Earlier marking experiments have shown that adult plaice may leave the North Sea for the north of Scotland grounds by this gateway.

Pre-war marking experiments have indicated that maturing plaice from the Fair Isle grounds may occasionally seek the Moray Firth area at spawning time. This feature would suggest, at first sight, that the contranant habit of movement of maturing plaice is not without exception, but recent drift bottle experiments ⁽³⁾ have demonstrated that in some years under certain conditions a narrow stream releasing the congested waters of the inner reaches of the Moray Firth runs in a north-easterly direction along and off the eastern shores of Caithness and Orkney, its influence reaching to the Fair Isle grounds and even sometimes to Shetland. In the particular years when this current system is in operation plaice reaching the Fair Isle grounds from the west side of Shetland may continue their "contranant" migrations as far as the spawning grounds of the Moray Firth. In the present series of experiments no migrating plaice are included in this category.

A study of the periods of freedom of the migrants shows that the migratory impulse is most intensive just prior to and during the early part of the spawning season. The majority of those which had

travelled considerable distances in short periods of freedom was liberated as adults in the autumn months and recaptured in a spawning or spent condition. The movement is one preparatory to spawning, the urge coming from the developing reproductive organs.

While adult plaice may find conditions congenial for spawning all round Shetland in the vicinities in which they had passed adolescent life the route of those adults which migrate considerable distances preparatory to spawning is one encircling the islands so that the majority of the home-reared plaice remain in the area to spawn.

References.

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 3. Tait, J. B.: The Surface Water Drift in the Northern and Middle Areas of the North Sea and in the Faroe-Shetland Channel. *Fisheries, Scotland, Sci. Invest., 1930, No. IV.*
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