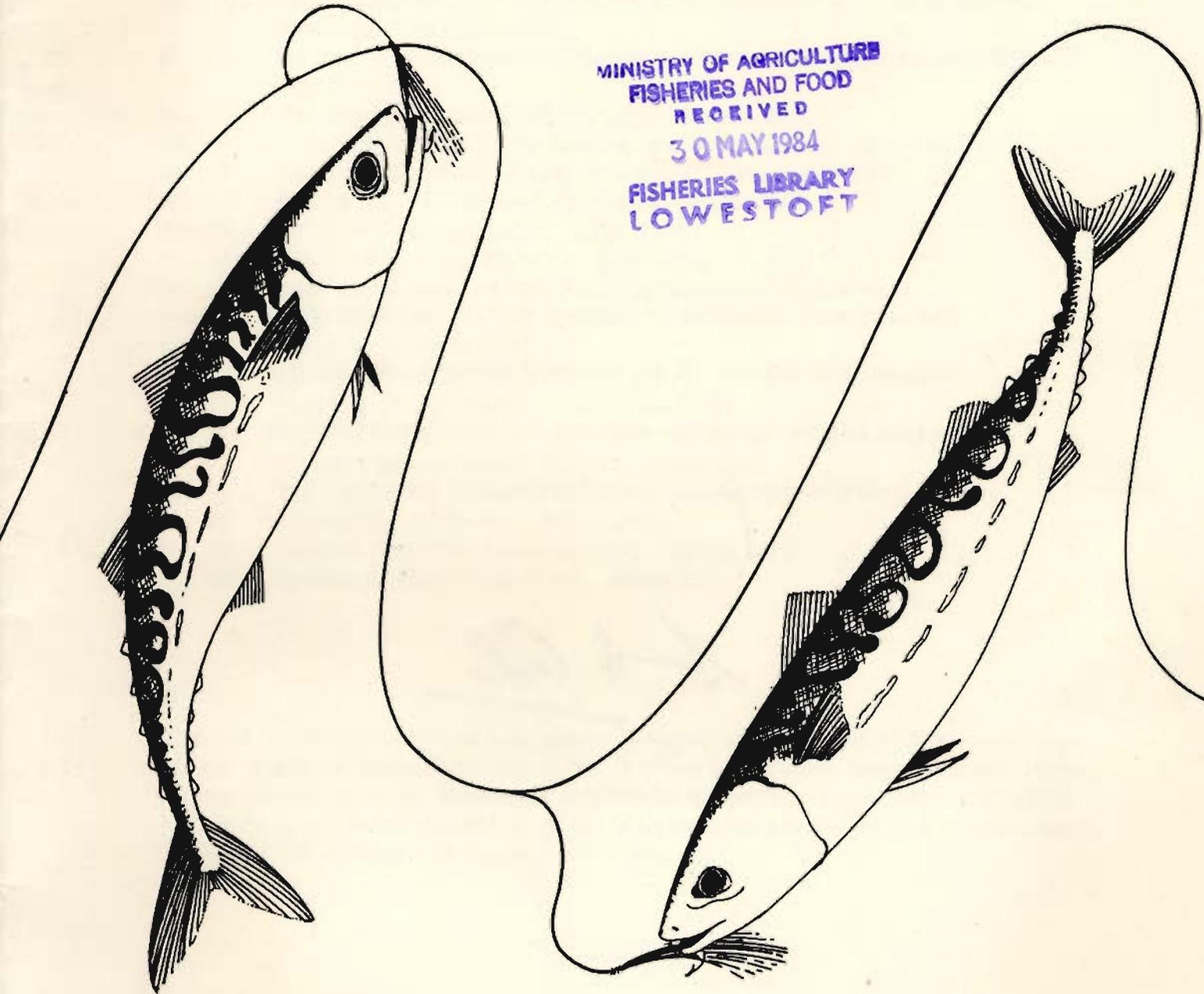


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MACKEREL OF THE SOUTH — WEST



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LABORATORY LEAFLET (NEW SERIES) No. 23

BY GEORGE C. BOLSTER

FISHERIES LABORATORY

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SUFFOLK

APRIL 1971

MACKEREL OF THE SOUTH - WEST

INTRODUCTION

The Atlantic mackerel, Scomber scombrus (Linnaeus), is a fast-swimming pelagic fish related to the tunnies and bonitos. On the eastern Atlantic seaboard its distribution ranges from Norway to Morocco and on the west from Labrador to North Carolina. It is present also in the Baltic, the Mediterranean, the Black Sea and the Sea of Marmora. Although mackerel are found off all coasts of Great Britain and Ireland, the most important of our commercial fisheries for them is off Cornwall and Devon.

In 1905 there were more than 200 drifters, mainly from Lowestoft and Great Yarmouth, working out of Newlyn. This was a deep-sea fishery which extended from the Isles of Scilly westwards out into the Celtic Sea south of Ireland as far as the edge of the continental shelf. Between 1905 and 1915, landings ranged from the peak catches of 19 000 tons and 12 800 tons in 1905 and 1907 respectively to 3 300 tons in 1913; they averaged 6 000 tons from 1919 until 1926 and then, until 1936, about 2 700 tons. This fishery declined after the last war; 650 tons were landed in 1950, 140 tons in 1960, and when it ended in 1966 two Lowestoft drifters accounted for only 20 tons. This decrease in the quantity of mackerel landed by drifters has been accompanied by an increase in the quantity taken by other means since 1960. Of the 2 683 tons landed by British vessels in England and Wales in 1969, 2 365 tons came from vessels of 40 feet and less (Table 1).

Table 1 The quantity and value of mackerel landed by British vessels from all regions, 1960-69

Year	Total landings (tons)	Landings (tons) by vessels of less than 40 ft	Total value (£)
1960	1 212	766	70 272
1961	1 668	988	88 534
1962	1 633	1 056	104 332
1963	1 836	1 490	113 297
1964	1 833	1 564	109 308
1965	1 634	1 340	97 111
1966	1 956	1 760	121 337
1967	2 640	2 522	158 105
1968	2 599	2 386	165 211
1969	2 683	2 365	160 558



Figure 1 Line fishing for mackerel with 'feathers'.

Drift netting has been replaced by 'feathering', and today it is by this hand-line fishing, in which up to a thousand fishermen are engaged either whole- or part-time, that most of the fish are caught. This is essentially a summer fishery (April-September), but in the last three years the period has been extended to February-October. A winter fishery lasting from October to March has been operated south of the Eddystone since 1967. A set of feathers consists of up to 24 hooks when fished by hand and as many as 32 when a 'Snella'-type reel is used. The hooks are dressed with hackle feathers from the necks of domestic poultry which have been dyed with bright colours; they look like crude, and somewhat over-size, salmon flies. Instead of the feather dressing some fishermen prefer to use coloured plastic tubing, which is fitted over the shank of the hook. The hooks are attached to a nylon line on short snoods set about a foot apart. One end of the 'set' is joined to a swivel on the handline, and a lead is attached to the other. When fishing, the lines are moved vertically up and down in the water between the surface and the bottom. It is not unusual, when the fish are plentiful and taking, to have one on every hook (Figure 1) and a day's taking of 150-200 stone, i. e. 3 750-5 000 fish, for a three-man boat is not unusual. Feathering was introduced to Cornwall and Devon in about 1945. At Newlyn, 100 tons of feather-caught mackerel were landed in 1960; in 1968 the catch at this one port alone was nearly 700 tons.

BIOLOGY

Because ripe and unripe eggs are found together in the ovaries it appears that the spawning of mackerel does not take place all at the one time, but that it may be a drawn-out process. The eggs are planktonic and, as such, after they are shed they are carried in the direction which tides and currents travel. In the Celtic Sea, spawning appears to be confined to the shallow waters of the continental shelf. It takes place from March until July with a peak in April. According to Corbin (1947) it begins on the western end of the shelf and, as the season progresses, spreads generally over the Celtic Sea and eastwards until, by July, there is virtually no spawning west of the Scillies. He observed, by towing plankton nets in this area, that at the peak in April there are two main spawning areas; these are to the south of Ireland and west of the mouth of the English Channel.

The distribution of the newly-hatched fish closely follows the shift in spawning during the season. Corbin found that the densest patches of larvae as well as eggs moved from west to east. Hauls with a modern high-speed plankton sampler from RV ERNEST HOLT, which were made in the spawning area north of the Little Sole Bank in the Celtic Sea in April 1966, showed that eggs and larvae were present. In order to track their movements from this area, Woodhead surface and seabed drifters were released at the time. Most of the surface drifters which were returned came from Cornwall, Devon and South Wales.

Not much is known about the dispersal of young mackerel. They are not often reported by trawlermen and, because of their small girth, they usually escape through the mesh of gill nets. They are seen occasionally in inshore waters during the summer months and, in some years, large numbers are taken in August and September in the beach seines on Chesil Bank in Dorset. Perhaps the most important single factor associated with the movements of the juveniles is the presence or absence of food, whereas the migrations of mature fish are associated primarily with spawning, and then, after spawning, food. Age governs the size of the food taken, and time and place the type. If a generalization is to be made, it is that mackerel feed mainly on planktonic organisms and that in the early part of the year - during the pre-spawning migration - these are mostly copepods or 'red feed'. In inshore waters, whitebait and sandeels, as well as copepods, are found among the gut contents. Sometimes feeding and non-feeding may be related to state of maturation, and though the stomachs of spawning fish are usually empty, ripe mackerel whose stomachs were crammed with krill - the euphausiid Meganyctiphanes norvegica - were caught on feathers from RV ERNEST HOLT on the Porcupine Bank in March 1968.

It is not surprising to find that in the past there has been a great deal of speculation about the migration of mackerel. The appearance of these fish in inshore waters in the summer months and their disappearance in the autumn is an obvious indication that they move from one place to another. Writing in 1866, the Yarmouth historian John Greaves Nall pointed out that "Wherever met with it is a restless, ever-wandering fish and its pursuit attended with extreme uncertainty". Until recently, nothing positive was known. The late Dr G. A. Steven of the Marine Biological Association at Plymouth considered that there were two annual phases in the life of the adult fish: the demersal phase - when they were overwintering near the bottom - and the pelagic phase - when they were swimming

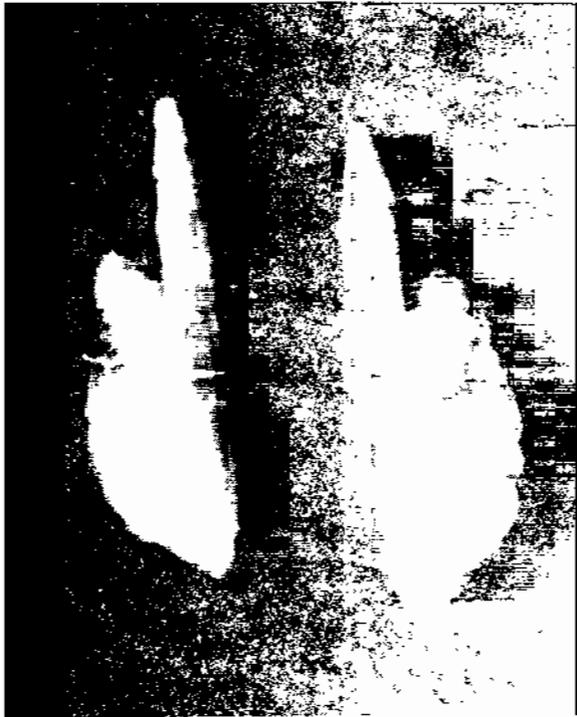
between the surface and the sea bed. During the latter, which lasts from spring until the autumn, the mackerel are migrating to their spawning area, spawning, and then moving inshore to feed. At the end of this phase "all, or nearly all, return to the sea floor in winter".

The differences of opinion about age and growth of mackerel were mainly over the amount of growth made in the first year. One school of thought considered that this did not exceed 10 cm (4 inches), the other that it was as much as 22.9 cm (9 inches). The matter was settled once and for all by the Norwegian biologist Dannevig (1948), who was able to make direct observations on their growth in the basins of his hatchery at Flødevigen in Norway. He found some young mackerel 8 cm (3 inches) long in with his lobsters on 6 August 1939. He isolated one of the young fish and managed to keep it alive for 25 days, during which time it grew 2.5 cm (1 inch). Later, on 14 September 1939, he found more young mackerel in with his oysters. These were 15 cm (6 inches) long. They could not have come through the pump as young fish and lived, and must, therefore, have entered as eggs when the water had been changed in the previous May or June. The growth had been 15 cm in 4 months. From this it follows that fish of less than 18 cm (7 inches) in length are usually in their first year. As a rough guide, 'small' fish of 23-28 cm (9-11 inches) are usually two-year-olds; 'medium' fish of 28-35 cm (11-14 inches) are from three- to six-year-olds, and fish of over 39 cm (15½ inches) are ten years old or more.

Age can be determined by counting the growth zones on either scales or otoliths (the earstones, which lie in the auditory capsules behind the brain). When readings of both are made from the same fish the degree of correlation is usually good. As the scales are shed very easily when the fish are caught, otoliths are preferred. These are cleaned and dried and then set in polyester resin mounted on glass slides. In this way it is possible to make direct readings up to the age of ten years and over. Photographs of otoliths showing three, seven and ten growth zones are given in Figure 2.

Samples of mackerel from both drift- and feather-caught landings have been examined at the laboratory each year since 1960. In all, 15 660 fish have been examined, out of which it was possible to read the otoliths from 14 560, or 93 per cent. When the yearly percentage age compositions were calculated for drift- and feather-caught mackerel it was seen that, firstly, the patterns were similar, and, secondly, the percentages of the different age-groups differed between one year and the next. This was shown very clearly by the high percentage of five-year-olds in 1960 and six-year-olds in 1961. These fish were spawned in 1955. The next good 'year-class' was the 1959 which came into the fishery as three-year-olds in 1962. By these means it becomes possible to assess - within reasonable limits - what year-class is going to be the mainstay of the fishery for the following two years or so.

Because the percentage age compositions for the drift- and feather-caught fish are similar, it might appear that the fish caught by these different means were from one and the same stock. When the average lengths for age of drift- and feather-caught fish are compared, again similarities are seen, in that both show rapid growth in the first three years and after this, when the fish are sexually mature (i. e. in their third year), the growth rate slows down.



3 zones



7 zones



10 zones

Figure 2 Photographs of mackerel otoliths showing 3, 7 and 10 growth zones.

The main difference is in the average lengths for age between drift- and feather-caught fish of one to three years of age: the feather-caught fish appear to have smaller average lengths. It is perfectly reasonable to explain these differences in size between mackerel caught by drift nets and those caught on feathers in terms of the smaller individuals escaping through the meshes of the drift net. This selection on size does not appear to occur with lines. Although the drift- and feather-caught fish of four years and over appear to have similar average lengths, that they were not in fact all from the same stock became evident:

- 1 when it was found that, in the feather-caught samples, the average length for age varied in some of the year-classes between fish of different stages of maturity;
- 2 by finding apparent negative increments of growth in some of the year-classes: this is nonsense - obviously fish do not grow smaller;
- 3 from the results of the tagging experiments: fish which were tagged in Mounts Bay did not all move away in one direction from the tagging area but travelled in different directions.

THE SEPARATION OF THE STOCK INTO TWO MAJOR GROUPS

The problem was to find a way of separating the fish into two or more different groups. This is one of the most intriguing problems met with in this kind of investigation and not always the most easily solved. In 1958, Claude Nédélec of the Boulogne laboratory distinguished three populations of mackerel; two of these - the Utsire (north-eastern) and the Dogger (central-southern) - occur in the North Sea, and the third in the Celtic Sea. He showed that there were differences between mackerel from these three areas in their average lengths for age, their body measurements and their spawning times. Although he thought that there was not very much movement between the two most widely separated populations (those of the Utsire and the Celtic Sea), more recent evidence from English and Dutch tagging experiments has shown that mackerel do migrate between the North Sea and the Celtic Sea. Nédélec suggested that there might be a relationship between salinity and the dispersal of the young, and between sea temperature and the abundance of mackerel in coastal waters in summer.

With this in mind, the abundance (expressed as average monthly catch per effort for the Newlyn feather-caught fishery) was plotted against the mean monthly sea temperatures at Newlyn for the years 1960-68. This showed that there are two periods of high abundance, one in April at about 9°C and one in August at around 15°C. Because it was possible that these two peaks might be indicative of two groups of mackerel, the data were split and treated separately. The early group consisted of samples taken each year between March and June/July, and the late group of samples taken between July and October.

The next step, after splitting the samples into these two arbitrary groups, was to examine the maturity data. Throughout the year, four main maturity stages are found in mackerel: these are of fish which are immature, maturing, ripe and spent. In most samples one finds that there are fish of different stages, and that the numbers of fish in each of these maturity stages differ from one month to the next. What is interesting is that having looked at the early and late

groups separately it was found that:

- 1 two groups of maturing fish were present in most of the years 1960-68, an early group between March and July, and a late one in August and September;
- 2 similarly, two groups of spent fish can be recognized in most years.

The interpretation of this must be that two groups of fish (designated as 'A' and 'B'), each of which has spawned a month or so previously, enter the fishery, one in April and the other in August. It is probable that the April fish spawned in the Celtic Sea in February/March, and the August fish in the southern North Sea in June/July. There is evidence to support this in the data relating to growth and mortality, as well as from the results of tagging experiments.

TAGGING

Tagging experiments were carried out between 1962 and 1967 in order to find out where mackerel went from inshore waters off Cornwall and south-west Ireland in the summer, and to see whether or not there was any similarity in the movements of mackerel from these two areas.

Most of the fish for tagging were caught on feathers. Only those which were hooked lightly and not bleeding freely were tagged. They were put into a tank containing sea water until required and, when the tag had been fitted, they were returned to the sea - by hand from the small commercial boats, and through a plastic chute from the research vessels. After different types of tag and methods of attachment had been tried it was found that, when working on one's own and often under unfavourable weather conditions in small vessels of less than 40 feet in length, tubular hydrostatic tags were the most satisfactory. These are fitted to the fish by means of a wire bridle, resembling a safety pin, which is passed through the muscles of the fish's back. Each tag bears a serial number and printed instructions to the finder, requesting that the fish, together with details relating to time, date, place and method of capture, be sent to the laboratory. The reward payable for the return of a tagged mackerel is 50p plus the value of the fish and a refund of postal expenses.

By March 1963 it was evident from the recaptures of mackerel which had been tagged in Mounts Bay during the previous year that fish moved away from the tagging area in three general directions - north, east and south-west. It was found subsequently that recaptures of mackerel which were tagged off Cape Clear, Co. Cork showed movements in the same three general directions. These are:

- 1 north, from Mounts Bay throughout the Irish Sea, west of Ireland and west of Scotland as far as the Shetland Islands and the Ling Bank, and from Cape Clear along the west coast of Ireland (Figures 3 and 4);
- 2 east, from Mounts Bay along the south coast of England and the north coast of France as far as Sandettié, and in the Bay of Biscay, and from Cape Clear along the south coast of Ireland, north Cornwall, south Devon and the north-west of France (Figures 5 and 6);
- 3 south-west from Mounts Bay, and south from Cape Clear into the Celtic Sea (Figures 7 and 8).

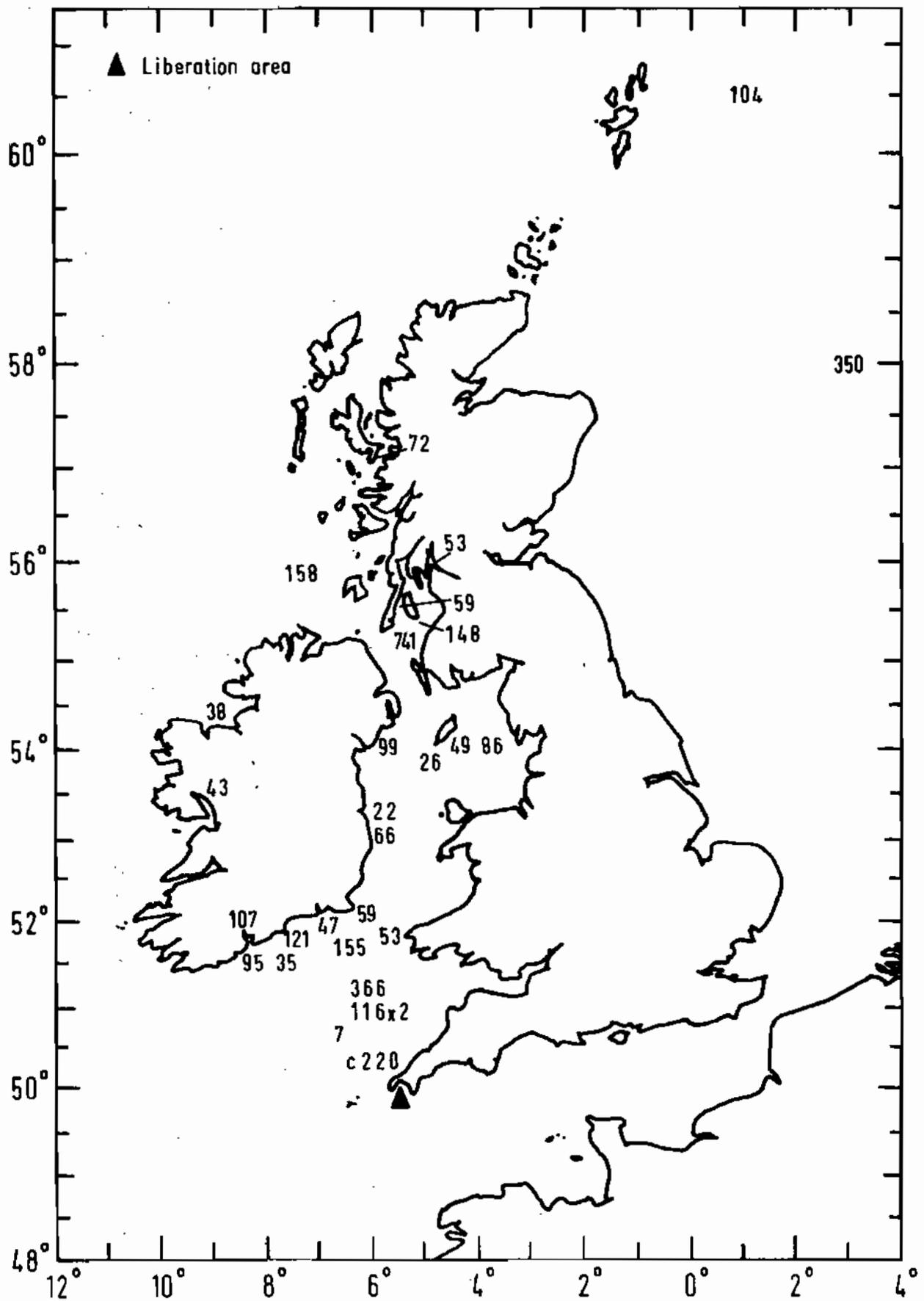


Figure 3 Recaptures of mackerel to the north of the area of liberation (Mounts Bay) from taggings in May, June, July, September and October, 1962-65. The numerals relate to number of days at liberty.

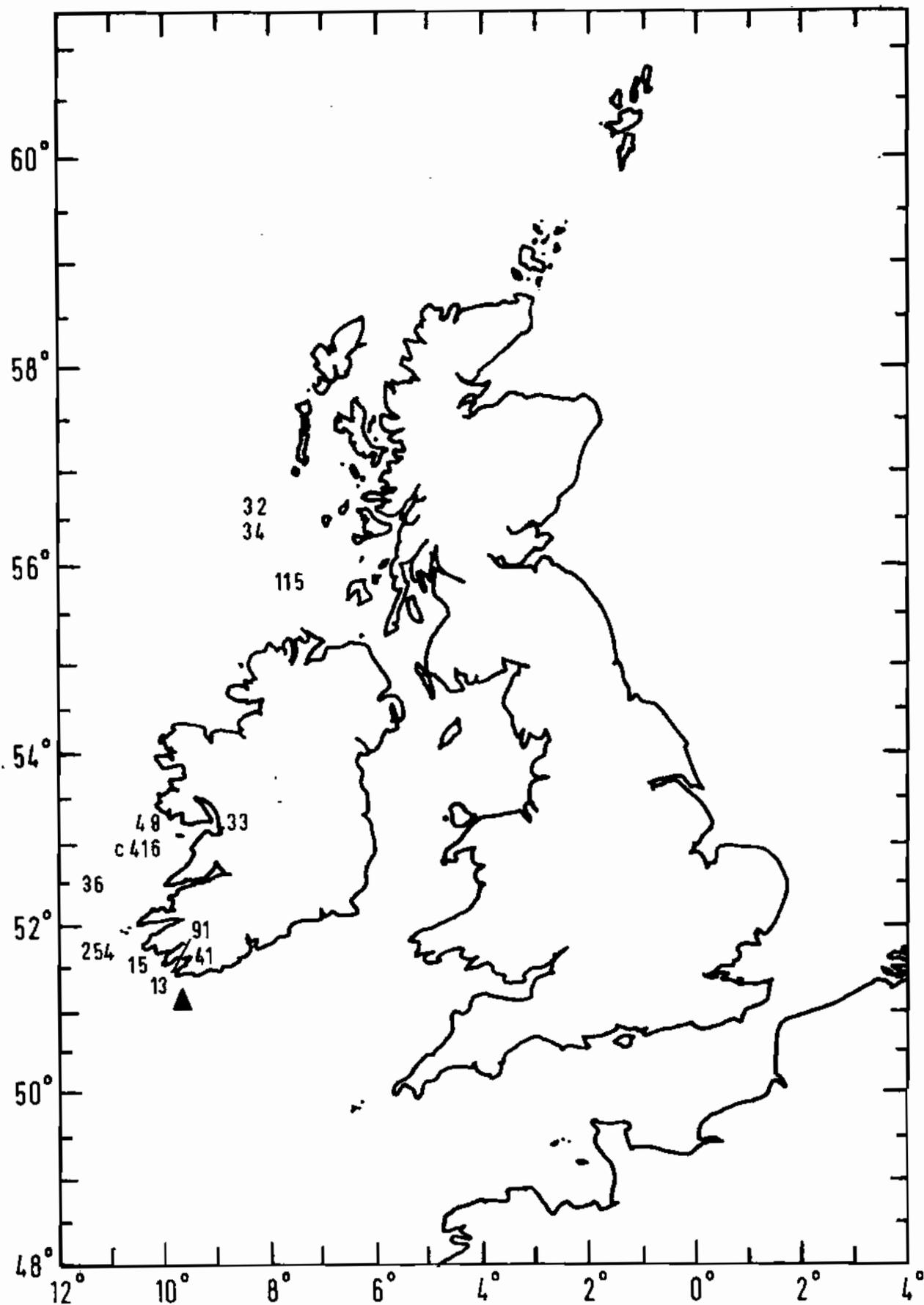


Figure 4 Recaptures of mackerel to the north of the area of liberation (Cape Clear) from taggings in July, August and September, 1964 and 1965.

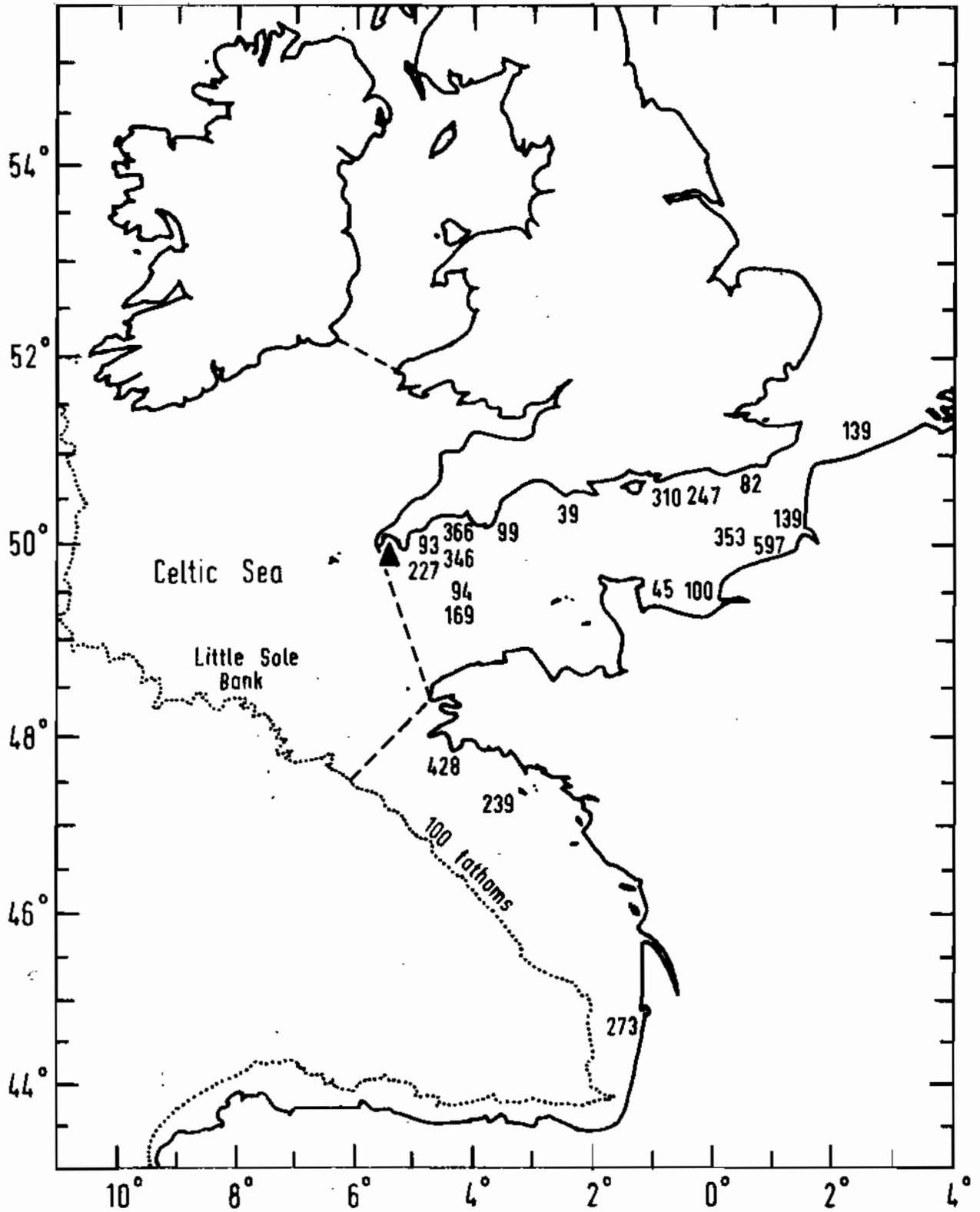


Figure 5 Recaptures of mackerel to the east of the area of liberation (Mounts Bay) from taggings in May, June, July, September and October, 1962-65.

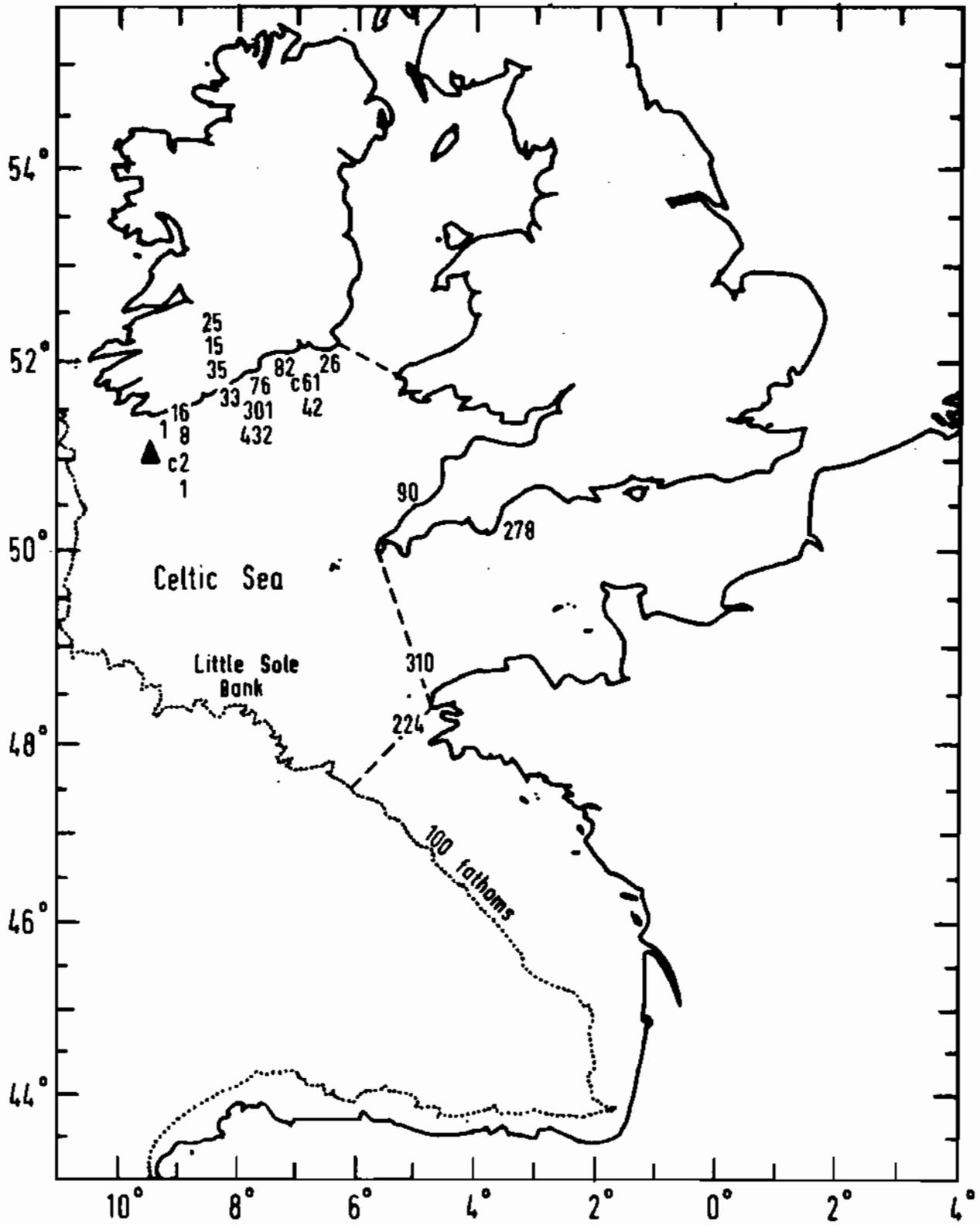


Figure 6 Recaptures of mackerel to the east of the area of liberation (Cape Clear) from taggings in July, August and September, 1964 and 1965.

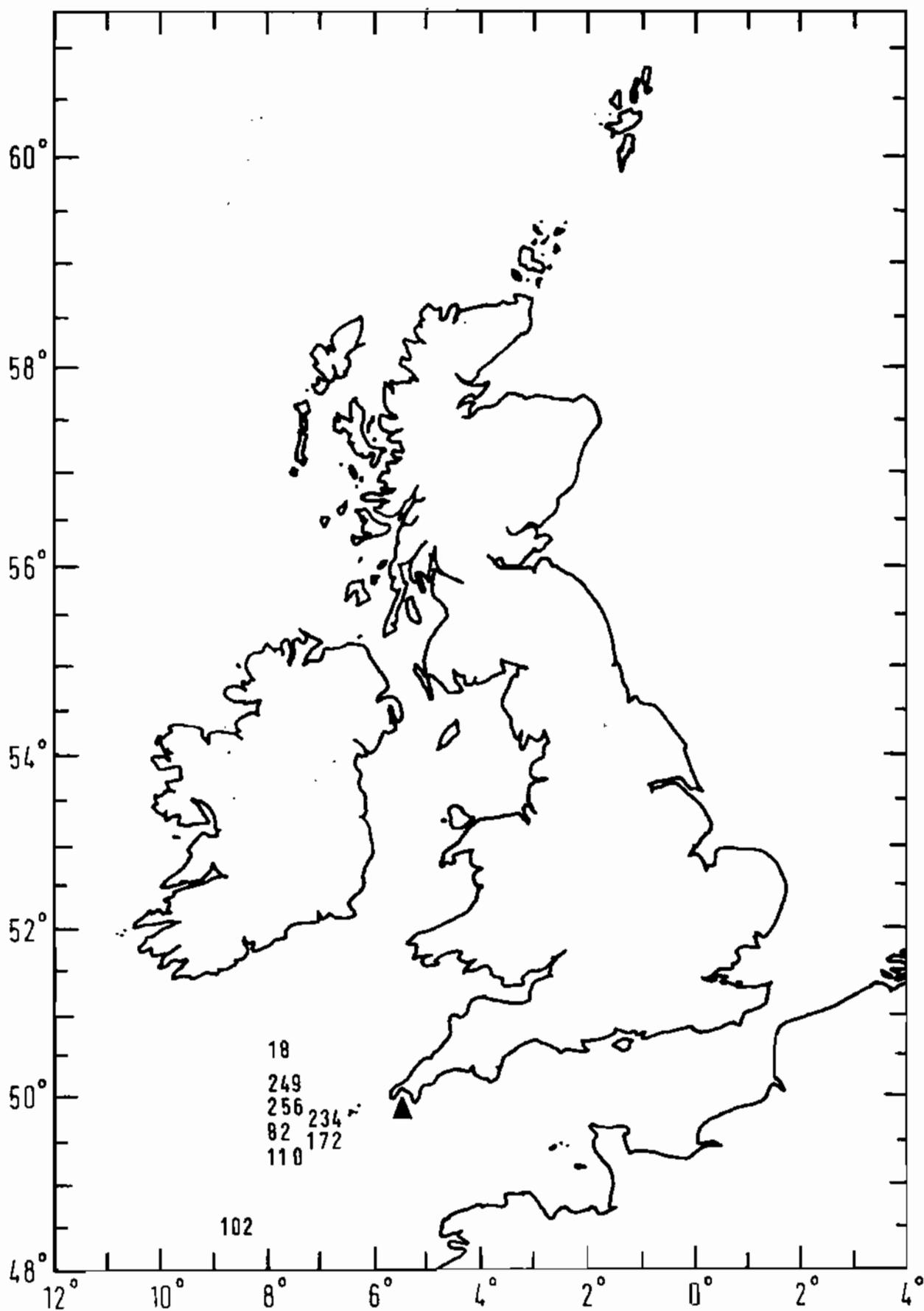


Figure 7 Recaptures of mackerel to the south-west of the area of liberation (Mounts Bay) from taggings in May, June, July, September and October, 1962-65.

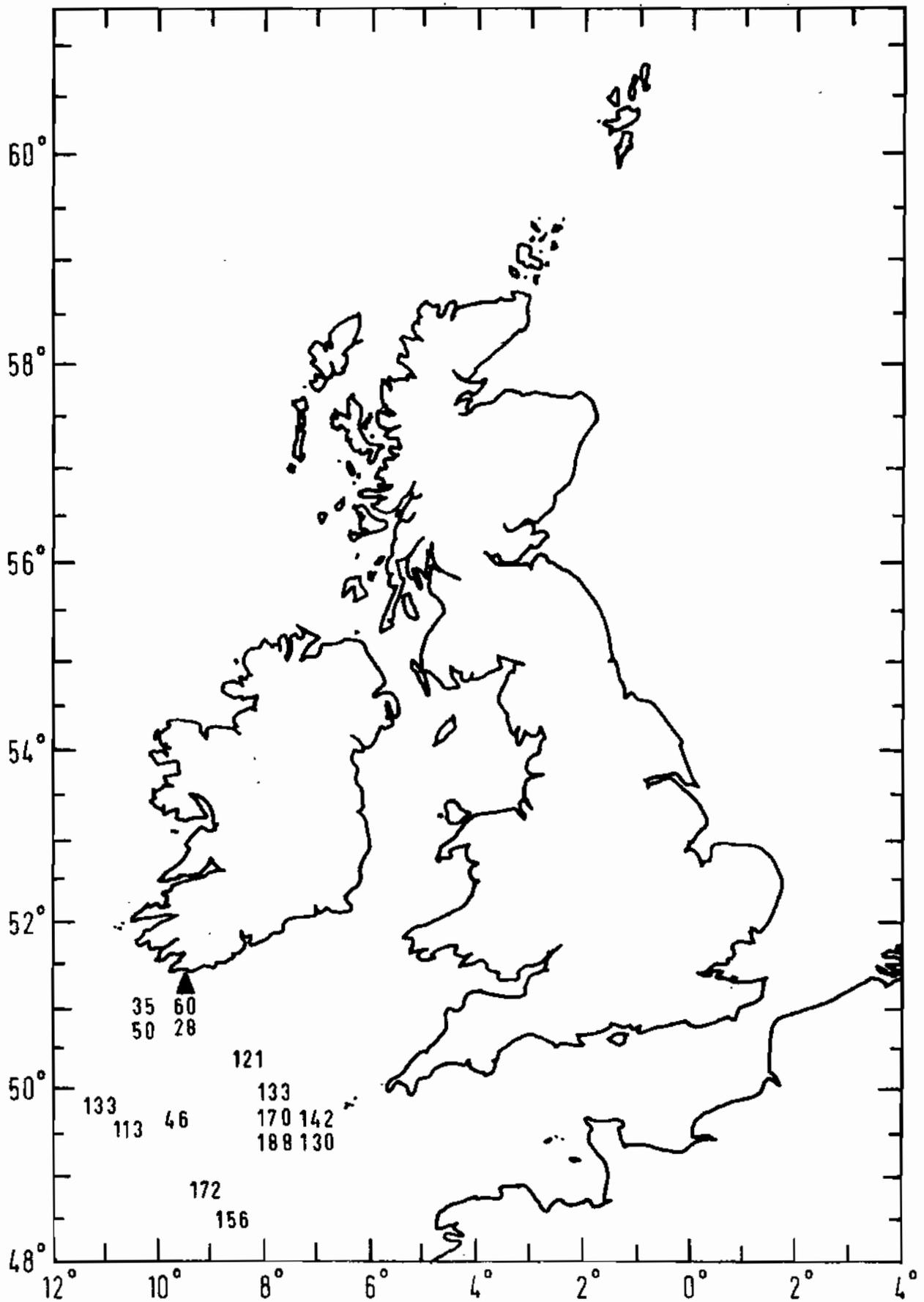


Figure 8 Recaptures of mackerel to the south-west of the area of liberation (Cape Clear) from taggings in July, August and September, 1964 and 1965.

One of the factors which governs the number of recaptures of tagged fish is the amount of fishing which takes place after they are liberated. It is necessary, therefore, if we are to determine whether or not the numbers of recaptures in each direction were due to chance, to know something about the amount of fishing which took place after the experiments were made. This is not easy to assess with accuracy in the case of mackerel, for although most recaptures were from trawlers (48 per cent), others were from rods and handlines (24 per cent), drift nets (7 per cent), and seine nets, salmon keddle nets and ring nets (7 per cent). The means of recapture of the remaining 14 per cent is not known. Fishing data are available, however, in the form of the catch in metric tons taken by all countries in the areas to the north, east and south-west of the tagging areas for the years in which the experiments took place.

The total catch of mackerel from the three areas related to the experiments from Mounts Bay is 95 310 metric tons, and the total number of recaptures, excluding the four local returns, is 57. The numbers of recaptures to be expected have been calculated on the assumption that they are proportional to the amount of fish landed in each area. They are, for Mounts Bay:

	Recapture area		
	North	East	South-west
Fish landed (metric tons)	24 321	15 801	55 188
Recaptures expected	14.5	9.4	33.1
Recaptures observed	29.0	20.0	8.0

The numbers of recaptures from mackerel tagged off Cape Clear are compared with the catch in metric tons made in the appropriate areas for 1964 and 1965, and can be separated into two groups, those going north, and those going east, south and south-west. The numbers of recaptures are almost proportional to the quantity of fish landed in each area. It follows from this that the number of recaptures to be expected is very close to the numbers observed. These are, for Cape Clear:

	Recapture area	
	North	East, south and south-west
Fish landed (metric tons)	12 787	32 558
Recaptures expected	13.2	33.7
Recaptures observed	12.0	35.0

These figures show that the numbers of recaptures from Cape Clear are proportional to the catches, and that in the experiments from Mounts Bay they are not so. The disproportionately large numbers of recaptures made to the north and east of Mounts Bay are strongly indicative of migrations taking place in these directions.

The details relating to the recapture of all mackerel tagged in Mounts Bay and off Cape Clear have been separated into north-, east- and south-west-going for the months in which they were released. When the numbers of recaptures which were made in each direction are expressed as percentages and examined for each month, a definite pattern emerges in that they vary for fish going in different directions during the period from May to October, both from Mounts Bay and Cape Clear.

Mounts Bay

- 1 The percentage number of recaptures of north-going fish is high for those tagged between May and September; there is a peak in June and a fall-off in October. This suggests that there is a north-going migration in summer.
- 2 The east-going fish show a high percentage number of recaptures for those tagged in May, low in June, July and August and high again in October. This indicates that there are two periods of east-going migration, one in the spring and one in the autumn.
- 3 The percentage number of recaptures for south-west-going fish tagged in June and July is low, but increases for those tagged in September and October. Most recaptures of mackerel in the Celtic Sea are of fish which were tagged in the autumn.

Cape Clear

- 1 The highest percentage recapture of north-going fish was from those tagged in July.
- 2 None of the fish tagged in July was recaptured to the east of Cape Clear, whereas many of those tagged in August and September were.
- 3 Fish liberated in July, August and September were recaptured in the Celtic Sea.

The results of a tagging experiment from RV ERNEST HOLT on the Little Sole Bank in April 1966 show a movement towards Cornwall and to the south coast of Ireland. One fish was recaptured south of the Dogger in the North Sea, a distance of 550 miles, 60 days later.

During 1966 and 1967, three tagging experiments were carried out from places on the south coast to the east of Mounts Bay; two of these took place off Newhaven, Sussex, one in June and one in September 1966, and the third, for which the fish were caught in a beach seine, from Chesil Bank, Dorset, in August 1967. The results, which are given in Figure 9, show that from each experiment fish were recaptured to the east and west.

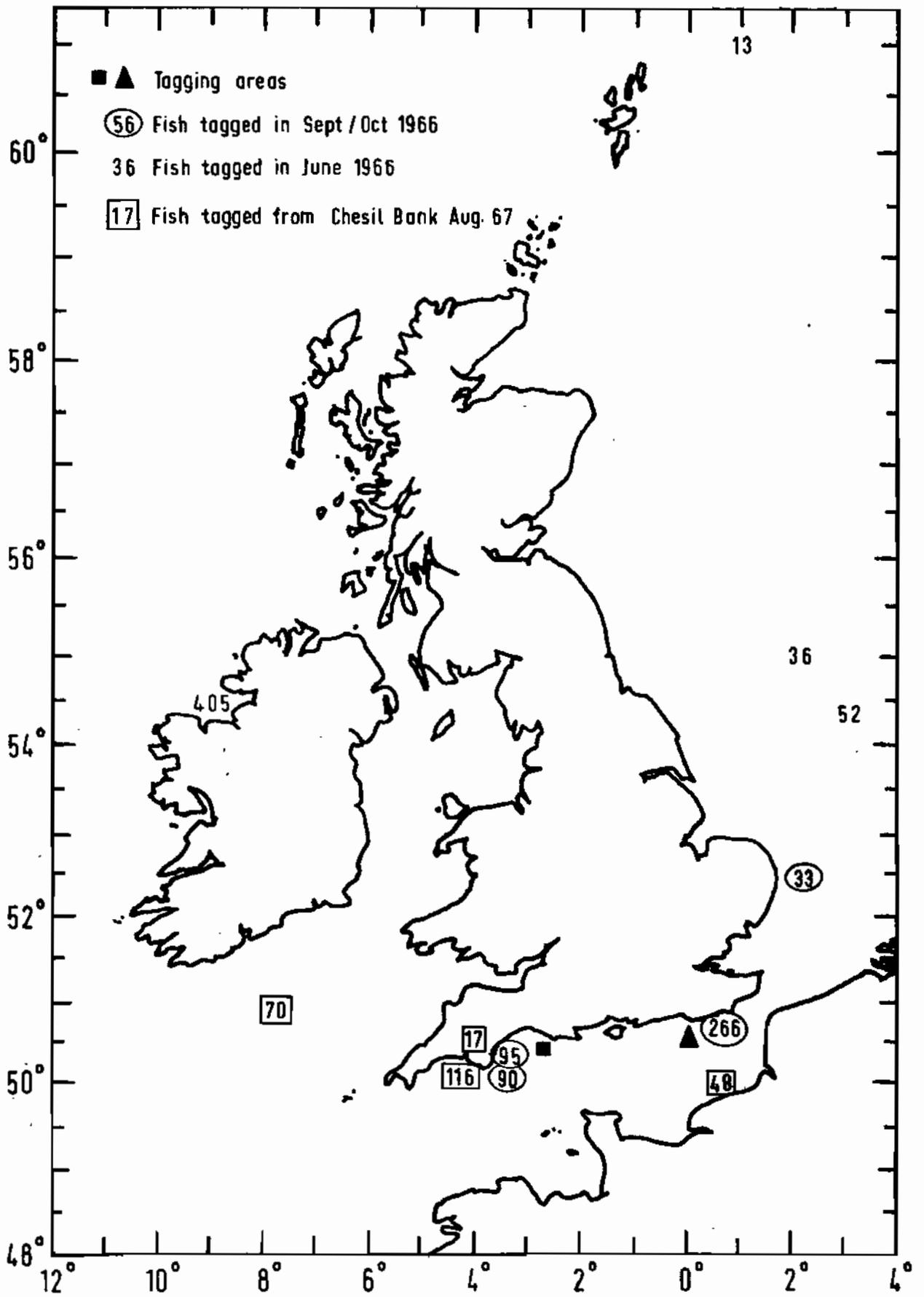


Figure 9 Recaptures of mackerel tagged off Newhaven, Sussex (▲) in 1966 and from Chesil Bank (■) in 1967.

DISCUSSION

It is evident from the data that the feather-caught fish sampled from Newlyn are not from a single stock. When they are separated - on the basis of growth characteristics, percentage age composition and maturation - into two groups, 'A', early and 'B', late, it is obvious that whereas similarities exist between the 'A' group and the drift-caught fish, the 'B' group appears to be unlike either of these. Evidence from the results of tagging experiments supports the interpretation of the 'A' group being Celtic Sea fish, and the 'B' group being fish which overwinter in the Eddystone area:

- 1 Fish tagged in the Celtic Sea were recaptured off the south coast of Ireland and towards Cornwall.
- 2 Fish tagged off Cornwall were recaptured to the north and east in summer and in the Celtic Sea in winter.
- 3 Whereas there does not appear to be a relationship between fast- and slow-moving fish and the month in which they were tagged for those that went northwards from Mounts Bay, the returns of east-going fish show that most of the fast-moving fish were tagged in May and the slow-moving fish in October. The fast-moving fish were recaptured to the east of Brighton and off the French coast - these are considered to be mostly 'A' group fish - and the slow-moving fish, which were recaptured off Falmouth, the Eddystone and Plymouth, are considered to be 'B' group fish.

Most of the fast-moving 'A' group in May appear to have come into the area of the fishery in Mounts Bay from westwards in the Celtic Sea. Their migrations in summer have been shown to extend not only northwards but also eastwards to the French coast and into the North Sea. From the evidence it may be adduced that among the slower-moving 'B' group are fish which overwinter off Devon from October until March. In the spring these fish move off along the south coast of England and enter the southern North Sea to spawn in the early summer. There is supporting evidence for this in that running-ripe mackerel were taken off Cherbourg, and spent off the ROYAL SOVEREIGN Lightship by RV CORELLA in July 1968. After spawning, these fish migrate westwards along the English Channel as far as Mounts Bay before returning to overwinter south of the Eddystone. It is significant that mackerel tagged by Dutch scientists off IJmuiden in August 1965 were recaptured off Devon in the following November and December, and that the fish tagged in Mounts Bay in September and October were recaptured off the Eddystone between the following January and March. If this interpretation of the data relating to the movements of the 'A' and 'B' groups of mackerel is correct, it follows that at certain times of the year different fish will be travelling in opposite directions along the south coast. This does happen - fish liberated off Newhaven in June and September 1966, and from Chesil Bank in August 1967 were recaptured, some to the east and others to the west.

The value of the results of tagging experiments lies not so much in the information they provide concerning the movements of individual fish as in the evidence they offer in support of the idea that this fishery of the south-west is dependent on the two groups of mackerel which have been identified and described in this leaflet.

ACKNOWLEDGEMENTS

I would like to thank all who, by their interest and cooperation in the tagging experiments and by their many kindnesses to me personally, made this work possible. They are many. All gave freely of their time and thought. Those from whose catches I tagged mackerel modified their way of working in order to accommodate me and the tagging equipment. I would like to mention particularly: in Cornwall, Messrs David Chapple of Penberth, Jack Worth of Mousehole, Tommy Farrell of St. Ives, John Arthur of Mevagissey, Jack Butters of Looe; in Dorset, Mr Huddy and his company on Chesil Bank; and in Sussex, at Newhaven, the late Mr Henry Boniface, MBE, Chief Fishery Officer of the Sussex Sea Fisheries Committee. In Ireland I had the pleasure of working with Mr Jimmy O'Reilly of Schull, Co. Cork, my friend and adviser on mackerel catching since my childhood. I acknowledge also the kindness and practical help given to me by HM District Inspectors of Fisheries - Mr W. H. Williams at Plymouth and Commander J. Quicke, RN (Retd), at Hastings. Mr Geoffrey Buchanan-Wollaston, HM Fishery Officer at Newlyn and my friend for many years, introduced me to men who know the ways of mackerel and so paved the way for me in Cornwall from the beginning.

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- No. 3 Yorkshire Crab Investigations 1962. May 1963.
- No. 4 Trawling Prospects off West Norway. September 1963.
- No. 5 Notes on Escallops, and Details of the Baird Sledge Dredge and its Handling. February 1965.
- No. 6 Studies with the Woodhead Sea-Bed Drifter in the Southern North Sea. February 1965.
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- No. 20 The Production of Clean Shellfish. September 1969.
- No. 21 Fishing for Sandeels. March 1970.
- No. 22 Cornish Crawfish Investigations. March 1971.
- No. 23 Mackerel of the South-West. April 1971.

NOTE

Although the complete list of Laboratory Leaflets is given to show the scope of the series, it will be appreciated that many of these leaflets are topical and therefore of interest chiefly at the time when they are written. For this reason most of the earlier ones are being allowed to go out of print when present stocks are exhausted; few copies are available of those prior to No. 13.