SCOTTISH HOME DEPARTMENT

MARINE RESEARCH
1955 No. 1

The Plankton of the Waters Approaching the British Isles in 1953

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EDINBURGH: HER MAJESTY'S STATIONERY OFFICE
1955

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ABSTRACT

The plankton communities of the incoming oceanic water masses off the coast of the British Isles are differentiated. The 1953 evidence indicates that the 'Lusitanian' fauna, partly of Mediterranean origin and containing a number of characteristic species was much more extensive than in previous years. Its course is traced off the south west of Ireland, west of Scotland both east and west of Rockall, and via the Faroe-Shetland Channel to the northern North Sea.

This fauna was associated with a scarcity of crustaceous plankton and may have contributed to the failure of the Shetland herring fishery and if prolonged it might affect the potential fish production of the northern North Sea.

INTRODUCTION

The main routes of inflow of oceanic water into the area round the British Isles have now been fairly well established. There are considerable annual and sub-annual variations in the strength of each of the several systems that contribute to the whole, so that the proportion of the water coming from each of the different regions of origin is very variable. This results in complex hydrographic conditions in the region of intermixing, which in turn affect the biology of the area. Indeed Tåning (1953) has emphasised most strongly the possible effects of hydrographic changes in the area west of the British Isles on the fisheries of the whole arctic region of the Atlantic Ocean. The main sources of oceanic inflow may be briefly summarised.

The most important source is the North Atlantic Drift Current, part of which flows north-east through the Faroe-Shetland Channel and along the Norwegian coast towards the Bear Island area. It is generally confined to about the upper 600 metres as it approaches the British Isles; and the volume of its water transport varies greatly within each year and also from year to year. A branch of this stream enters the North Sea round the north of Shetland and the strength of this branch also varies, not necessarily in accordance with the major variation through the Faroe Channel. In some years—e.g., 1935 (Tait 1936)—the main Atlantic stream embraces the entire group of the Faroe Islands: at other times an arctic influence mixes with a subsidiary oceanic stream to the west of Faroe or acts as a barrier across the Faroe-Shetland Channel to prevent or reduce the continuation of the flow of Atlantic water towards Norway (Tait 1949).

An outflow of subsurface water from the Mediterranean mixes with water in the Gulf of Gibraltar and, although the mixture gradually becomes diluted, it retains some of its original Mediterranean and Gulf characteristics as it continues northward towards the Celtic Sea and towards Rockall, underlying the Atlantic water from the west (Cooper 1952). It then apparently follows the edge of the Hebridean Continental Shelf, mixing on its western edge with open oceanic water, and upwells somewhat on the east side to overflow and mix with coastal water on the shelf. In some years this current may not reach Scotland or is too weak to be recognised, but on occasions it is sufficiently strong to continue into the South side of the Faroe Channel, though it only rarely penetrates beyond the north of Shetland. Frequently, however, it mixes with the coastal water on the shelf and the resulting mixture floods the area to the west of Orkney and often passes through the Fair Isle-Orkney Passage into the Moray Firth area (Fraser 1952).

The whole of this oceanic system to the north and west of Scotland overlies a south tending mass of arctic or boreal water. The main flow of this water mass is to the west of Faroe from whence it thrusts southwards in deep water (below about 1000 m.), but part also penetrates the Faroe Channel where it is checked by the Wyville Thomson Ridge. Although this water affects the inflowing system where it mixes at its interface it is not of such importance as are the more massive cold water currents on the other side of the Atlantic.

Each of the above water masses has a typical plankton fauna (see Russell 1939, and earlier works), which varies within certain limits, in the abundance and in the proportions of its constituent species

from year to year. As these organisms are transported further from their natural habitat they gradually die as their limit of tolerance is reached, and they are replaced by other species through mixing either with other oceanic streams or with coastal water. The fauna of an incoming water mass thus gradually changes along its length; for example, few of the oceanic species noted off Scotland normally reach north-western Norway (Wiborg 1954). The degree of survival of the original fauna gives a measure of the purity of the inflow, and the relative life of the species less tolerant to various factors may give an indication of the type of dilution or change involved. Plankton samples taken by the Scottish research vessels over a number of years have now been examined and reports referring to this theme have appeared annually in Annales Biologiques, and in several papers in which correlations with specific hydrographic conditions have been attempted (quoted in Fraser 1952).

CONDITIONS OFF THE SOUTH-WEST OF ENGLAND

Investigations off the Iberian peninsula by Fleury (1953b) and by the Continuous Recorder team of the Scottish Marine Biological Association at Edinburgh (e.g. Rae 1953 and earlier papers) have given much needed information about recent conditions in or near the areas of origin of the 'Lusitanian' fauna. 'Lusitanian fauna' is here defined as that fauna which, originating in the outflow from the Mediterranean, has become modified by admixture with fauna from the area between the Azores and Bay of Biscay. It thus corresponds to the fauna of the mixed Central and Gibraltar Water rather than to that of the capsized and cascaded water—see Cooper (1952) p. 504. It is used as a convenient term to distinguish it from the fauna of the North Atlantic Drift on the open Atlantic to the west of the British Isles—the North Atlantic Central water of Cooper (1952). A number of oceanic species are common to both, but although some are found only in the Lusitanian stream, there are few, if any, entirely confined to the North Atlantic Drift. Thus the distinguishing feature of the fauna of the latter is the presence of the cosmopolitan oceanic species, at times reinforced by an admixture of boreal forms, but without an appreciable representation of the Lusitanian species. A list of some of the more important species is given on Page 12, which is very far from exhaustive, especially in the Calanoid copepods, but which nevertheless contains sufficient information to distinguish the two communities. During 1953 the data have been augmented by the following collections made from H.M.S. *Challenger* off the entrance to the English Channel by Surgeon-lieut. Campbell, to whom I am greatly indebted:

1. 15-19 April — 12 stations, 49°39'N., 03°30'W. to 47°16'N., 17°52'W.
2. 25-28 May — 8 stations, 47°50'N., 17°40'W. to 49°28'N., 05°52'W.
3. 16-23 June — 14 stations, 50°08'N., 04°25'W. to 46°46'N., 19°37'W.
4. 30 July-1 Aug. — 5 stations, 48°15'N., 11°59'W. to Falmouth Bay.

These collections, together with the Scottish samples taken further north, have yielded some particularly interesting results which show that the Lusitanian component was particularly marked in 1953, and penetrated well into Scottish waters.

This was first noted in the April collections of the "Challenger" (see Fig. 1), which showed a very distinct change from typical coastal plankton in the Celtic sea to oceanic plankton over the deeper water. This oceanic plankton contained many species of general oceanic occurrence, such as *Salpa fusiformis, Dimophyes artica, Chelophyes appendiculata* and *Eucalanus elongatus,* but with a large proportion of Lusitanian forms, particularly the siphonophores *Bassia bassensis, Praya cymbiformis, Rosacea plicata, Eudoxoides spiralis* and *Hippopodius hippopus,* and also *Velella velella, Sagitta lyra, S. serratodentata var. tasmanica* (see Furnestin 1953) the polychaetes *Vanadis formosa, Callizona angelina, Sagitella kowalewskii,* and the medusae *Rhopalonema velatum* and young stages of *Pelagia noctiluca.* Of special interest is the record already published (Fraser 1954, 1955) of the occurrence of the salp *Ritteriella picteti* at 47°31'N., 14°21'W., which had never previously been reported from the north temperate Atlantic. This Lusitanian fauna was densest between 12° and 16°W. and was much reduced west of 16°30'W.

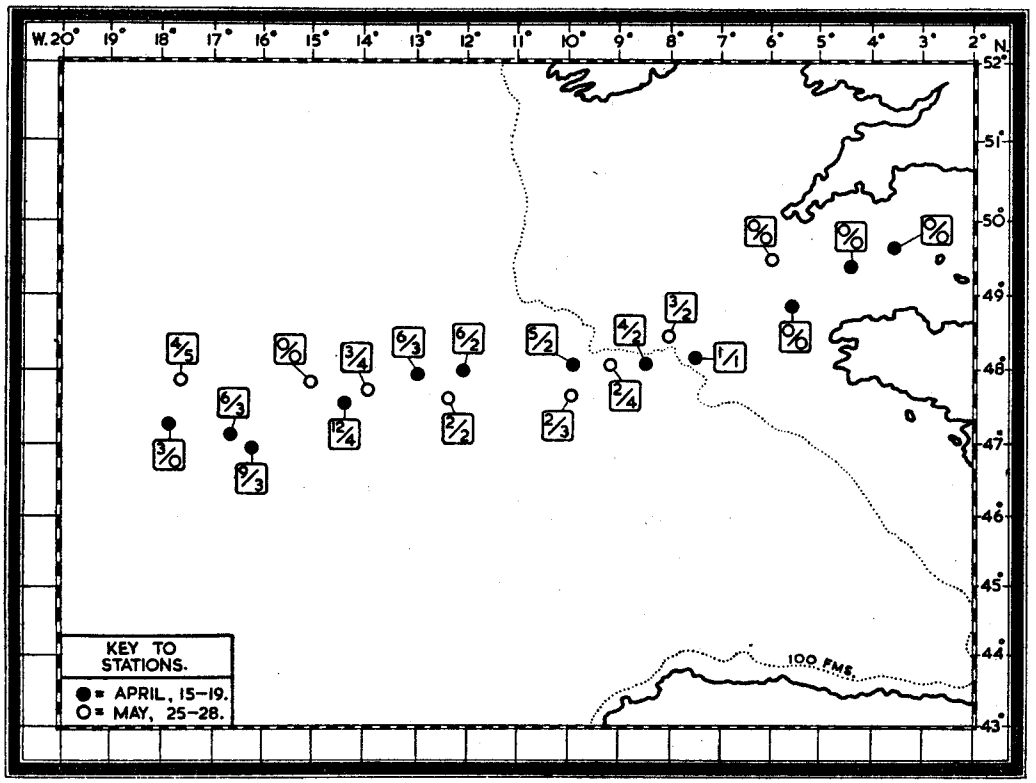

Fig. 1 The positions of the "Challenger" stations in April and May, 1953. The figures associated with the positions indicate the number of species named in the table; the upper figure represents species named in column 1, and the lower figure those in column 2, i.e., the higher the "fraction" the greater the proportion of Lusitanian forms.

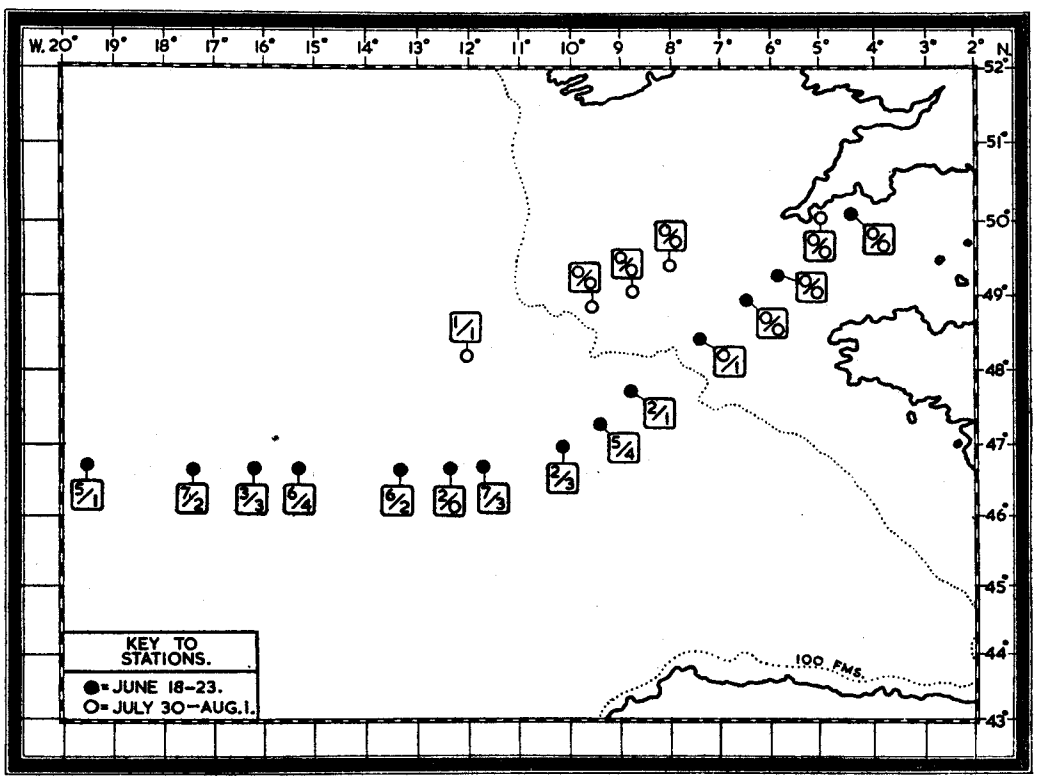

Fig. 2 The positions of the "Challenger" stations in June and July-August, 1953—See also legend to fig. 1.

By May (Fig. 1), this fauna, as sampled by the "Challenger", had changed considerably; *Salpa fusiformis* had become more generally distributed, and there were several species of *Sapphirina—S. angusta S. nigromaculata* and *S. ovatolanceolata,* as defined by Rose (1933)—though fewer siphonophores were present. At 47°40'N., 13°58'W. an excellent specimen of *Ethmodiscus gazellae* was found. This large diatom, 1.8 mm. in diameter, was probably of direct Mediterranean origin and has not previously been found in this area (Fraser 1954). Another complete but empty shell (i.e., both valves) and several broken bits of this diatom were taken again on June 21st at 46°45'N., 11°41'W. The line of stations in June (Fig. 2) indeed produced a most interesting series of collections. Starting near the Cornish coast of S.W. England, the Channel species *Sagitta setosa* was found at only the first station and no oceanic species were found until deep water was reached west of 8°W., but thereafter Lusitanian species were found at all stations. These included numerous *Doliolum nationalis,* often reported in this area but which have not yet been recorded from the Scottish plankton. At 47°22'N., 9°30' W. four specimens of *Doliolina mülleri* Krohn were taken and it is expected that these probably also originated in the Mediterranean. No *Salpa fusiformis* were taken but there were *Iasis zonaria* and numerous siphonophores (including *Bassia, Eudoxoides* and *Hippopodius*), *Eucalanus crassus, Pleuromamma gracilis, Phaenna spinifera* and several species of Sapphirina, including *S, scarlata, S. opalina* and *S. nigromaculata.* Other copepods also occurred in small numbers—*Calanus helgolandicus, Centropages bradyi, C. typicus, Aetidiopsis* with *Evadne* and numbers of Radiolaria, chiefly *Acanthochiasma* and *Collozoum.* The July series (Fig. 2) barely extended over the deep water and few Lusitanian species were found. At the edge of the shelf there was a dense patch of phytoplankton, particularly *Nitzschia delicatissima, Thalassiothrix longissima* and *Rhizosolenia alata,* whilst over the shelf were numreous small copepods, especially *Oithona similis, Microcalanus, Paracalanus,* and *Centropages typicus.* Off Falmouth was found a dense mass of ophioplutei. The only obvious "carry-over" of the oceanic species from June was the abundance of *Acanthochiasma,* here also accompanied by *Acanthometron.*

These results may be compared with those recorded off the Iberian coast in June, 1952, by Fleury (1953b), who also gives details of the copepods at the entrance to the Channel in May 1949 (1953a). There are a number of species in common between those found in 1953 by the "Challenger" and the Iberian species of Fleury in 1952, but in 1953 when oceanic species were dominant there was only a small copepod content, at least until July, although there were a number of species of Sapphirina which are associated with warm water. It is noteworthy that this genus is not included by Fleury in her 1949 list for the entrance to the Channel. These differences can all be associated with an increase in the transport of Lusitanian species northwards in 1953.

CONDITIONS OFF THE SCOTTISH COASTS

Scottish samples were first taken west of the Hebrides in 1953 in June, when many of the species taken by the "Challenger" were found. Here it must be remembered that although the Scottish samples were very much larger than those from the "Challenger", so that the chances of finding rarer species were much greater, the Lusitanian stream had carried the organisms some 700 miles to the north. Many of the less tolerant species would be lost during this passage, the degree of persistence depending on the volume and strength of water transport—i.e., the stability of the environment—and on the amount of its dilution by water of different origin. With the approach of summer conditions it is only to be expected that those forms sufficiently tolerant to thrive would reproduce in the new area, as distinct from those that would merely survive, so that the proportions of the various species is thus changed. Additional change is also caused by admixture of organisms from other water masses, and much of this fauna will also reproduce.

On the line of stations between Iceland, Rockall and the Butt of Lewis (Fig. 3), the Lusitanian fauna in 1953 was continuous between 16°W. and the edge of the Continental Shelf at about 9°W., i.e., on both sides of Rockall. The plankton here contained abundant Thaliacea—*Ihlea asymmetrica, Salpa fusiformis, Iasis zonaria, Dolioletta gegenbauri,* and the rare Mediterranean *Cyclosalpa virgula* of which three solitary and two aggregate specimens were taken. This is the first record of this species so far north. *Ihlea asymmetrica* was reproducing in quantity and consisted of excellent specimens, both solitary and aggregate forms, in contrast to most years when only the disintegrated remains are found in Irish (Farran

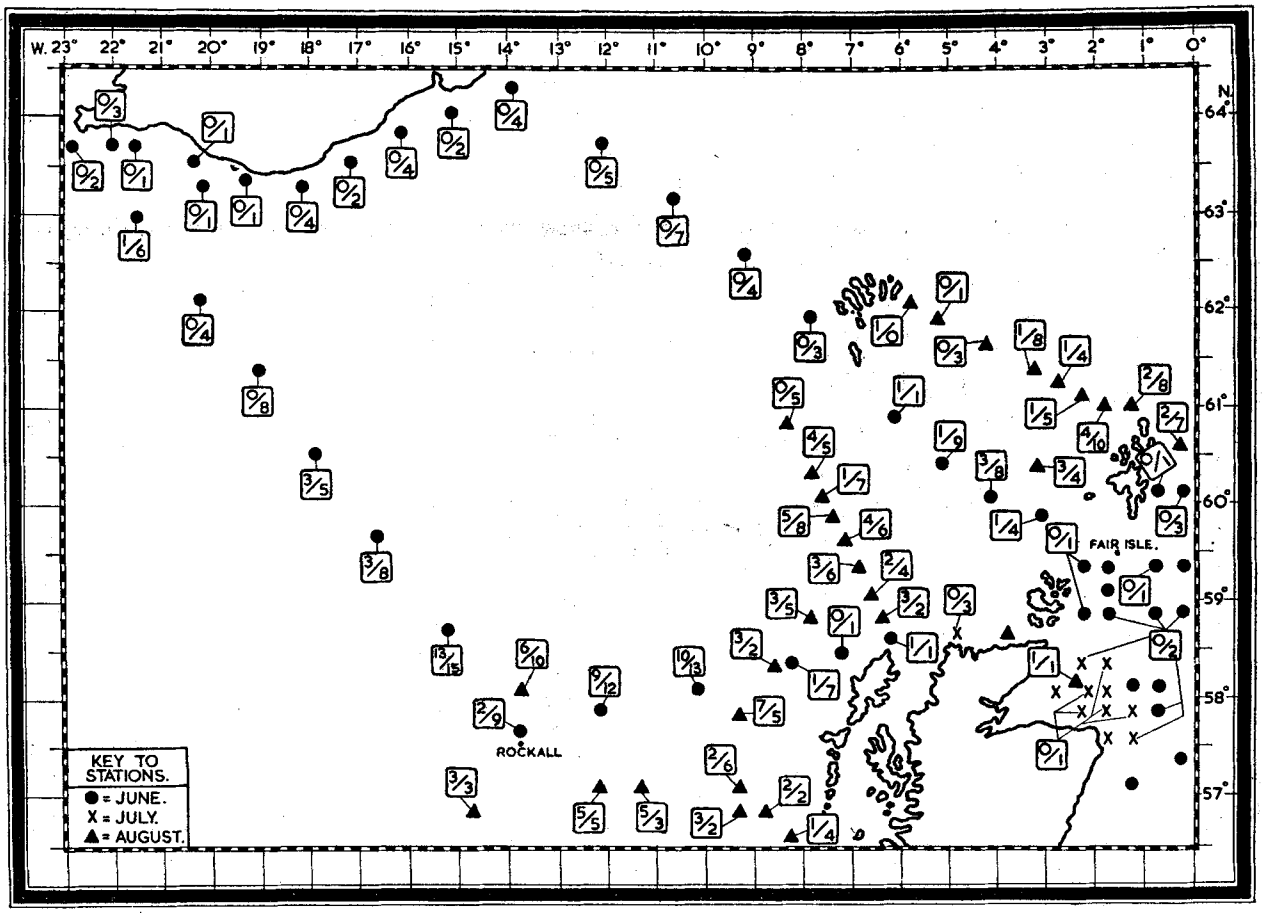

Fig. 3 The positions of Scottish plankton collections in June, July and August, 1953—See also legend to fig. 1 (The symbol $^{0}/_{0}$, for absence of either, is omitted in figs. 3, 4 and 5).

1909) or Scottish waters (Fraser 1949a). Other Lusitanian forms here were *Eudoxoides, Vogtia, Bassia, Rosacea, Hippopodius, Rhopalonema, Nausithoe, Pelagia, Travisiopsis, Sagitta serratodentata v. tasmanica, S. lyra, S. bipunctata, Vibilia pyripes* and the radiolarian *Thalassiocolla.* This is the second record of *S. bipunctata* from Scottish waters, as it was also found in 1949 (Fraser 1949b).

Although this rich Lusitanian fauna—the richest of the year—was not sampled west of the Hebrides until June, it is clear from other observations that these June collections did not represent their earliest arrival in this area. Plankton samples taken in the Faroe Channel in February, March, April, May and June (Fig. 4), showed that the Lusitanian species passed through in increasing numbers, starting in March when a few specimens of Hippopodius and Praya were found off the Butt of Lewis, and reached the immediate north-west of Shetland in April. The numbers both of individuals and of species in the Faroe Channel increased in May and reached a maximum in June. Species such as *Periphylla, Vogtia* and *Rosacea* first appeared in May but the Thalicea were not found until June. By August (Fig. 3), the numbers had become much reduced to the west of the Hebrides as the peak of the wave passing to the north and reaching the Faroe Shetland line in September (Fig. 5), produced a progressive increase in Shetland waters from June onwards, which culminated in a maximum in September-October. Few doliolids reached Shetland though the salps *S. fusiformis* and *I. asymmetrica* were very abundant, the latter by this time in a disintegrating condition. *Iasis zonaris* followed the edge of the shelf more closely and was last seen west of the Orkneys in September.

There had been little sign of oceanic influence in the northern North Sea until June. By then oceanic species that had lingered from the big inflow of the previous autumn had disappeared, but there-

after they became gradually renewed until they were dominant in September to the exclusion of many of the local elements in the plankton. *Salpa fusiformis* with *Galetta, Agalma, Pelagia, Eucalanus* and *Rhincalanus* were then plentiful north-east, east and south-east of Shetland, but not east of Orkney, nor in the Moray Firth, nor east of the Aberdeenshire coast. The progression had continued throughout October and November and although the Orkney and Moray Firth areas remained free until the end of the year, the oceanic species still flooded the Shetland area and extended as far south as 57°30'N., reaching 57°N.

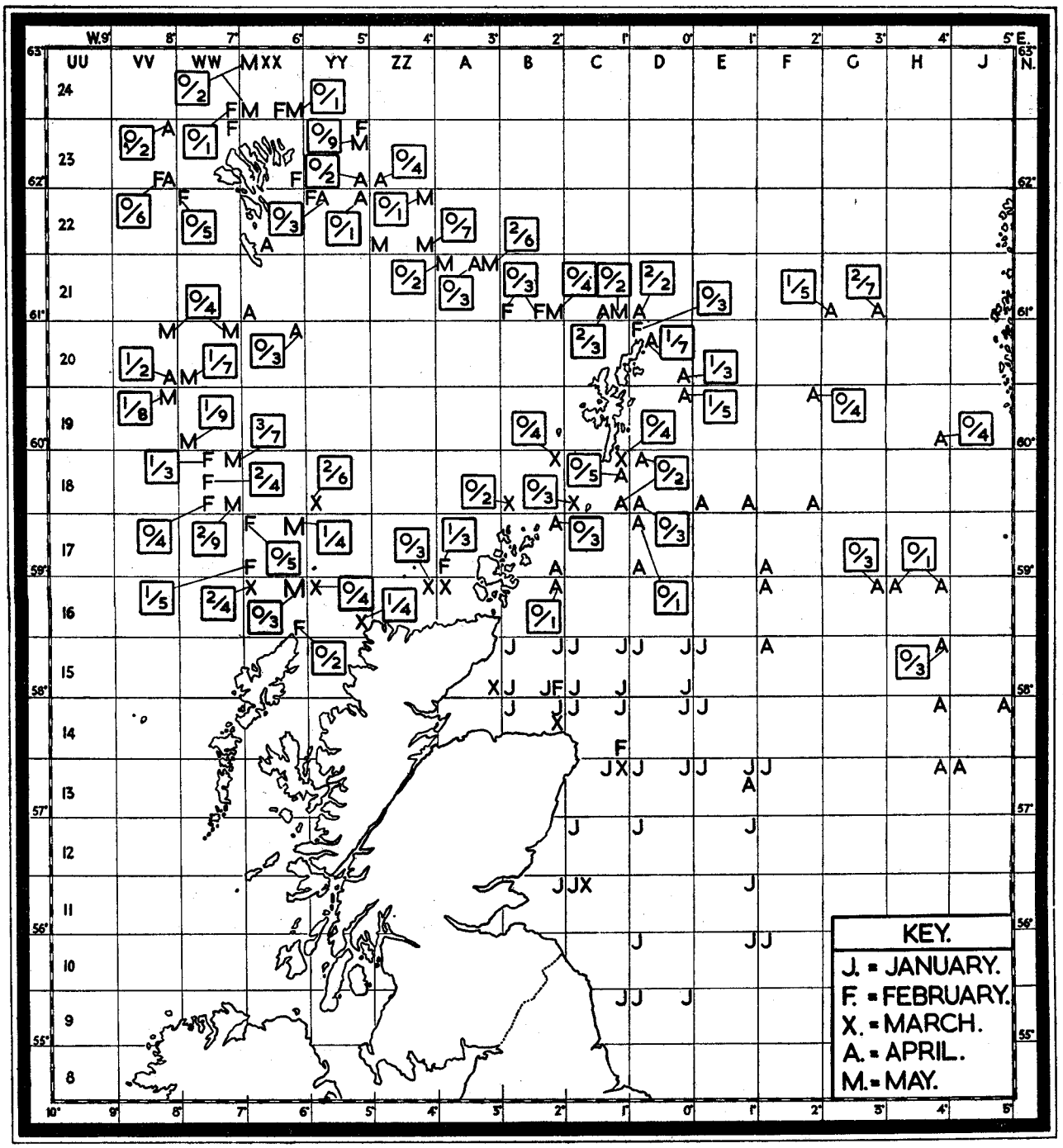

Fig. 4 The position of the spring collections, January-May, 1953. Positions are given only to the nearest sub-square—See also legend to fig. 1.

by December. Among the more interesting of the species penetrating into the northern North Sea were found an excellent specimen of *Phronima sedentaria*, in its case, east of Fair Isle in November, *Sagitta lyra* at 59°N. in December, and *Rhopalonema* as far south as 58°30′N. in November. *Fieraster* larvae occurred more abundantly in the North Sea in 1953 than in any year since 1904 and 1905, and five

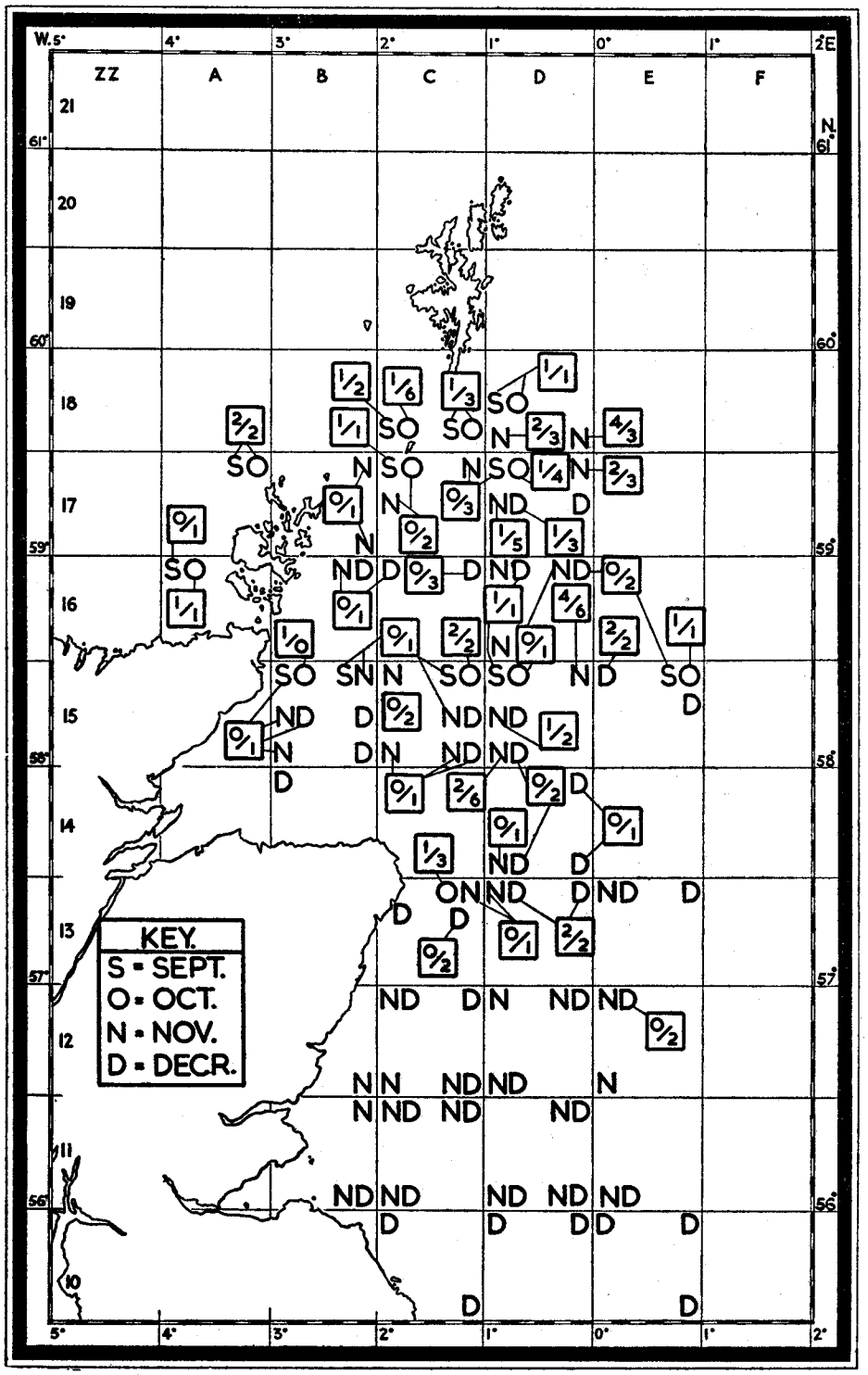

Fig. 5 The position of the autumn collections, September-December, 1953.—See also legends to figs. 1 and 4.

larvae were taken in a single haul in 59°40'N., 0°30'W. in October. They occurred fairly frequently, first found in June between Faroe and Orkney, and reached their greatest abundance east of Fair Isle in September, October and November, reaching as far south as 57°25'N., 0°20'W. and 57°25'N., 1°20'W. in December. *Pelagia noctiluca* increased in numbers from June onwards in this area, and by early November was abundant enough to interfere with fishing operations west of Shetland. It replaced the usual jellyfish, *Aurelia*, which however was still present in those areas not affected by the inflow, e.g., Moray Firth.

A most unusual siphonophore for this area, identified for me by Captain A. K. Totton as *Apolemia uvaria* (Lamarck), can also be regarded here as a Lusitanian species. Found first in August to the north-west of the Butt of Lewis, 58°51'N., 7°35'W., north-west of Orkney, 60°30'N., 3°09'W., and immediately east of Shetland, 60°12'N., 1°18'W., it was later found in October and November in five localities east of Fair Isle as far east as 0° and in the North Sea as far south as 58°25'N., 0°20'W. Like *Pelagia* and other Lusitanian indicators, it was not found in the Moray Firth.

The oceanic fauna not only contained the indicator species mentioned but included a large proportion of general oceanic species, with the consequent reduction of the rich mixed fauna usually associated with this area, and with fewer boreal species. *Calanus finmarchicus* had been fairly common in the northern North Sea prior to the inflow but was pushed southwards to be unusually abundant south of about 57°30'N. Round the edges of the oceanic area in the North Sea were large concentrations of young stages of euphausids, *Thysanoessa inermis* to the west, near the Scottish coast and *Nyctiphanes couchii* with some *T. raschii* and *T. longicaudata* to the south, east and north-west. Large numbers of *Pleurobrachia* were found near Orkney and in the Moray Firth in autumn, and off the east Scottish coast in November. *Limacina* was fairly widespread and reached dense concentrations particularly off the Firth of Forth in November. The paucity of crustaceous plankton in association with the oceanic inflow coincided with the failure of the herring fishery off Shetland. This fishery, which started in May with ordinary prospects, failed unexpectedly in June, i.e., about the period of the first arrival of the Lusitanian fauna, and did not recover. An explanation of this failure might be found here; either that the herring were directly repelled by these conditions which were sufficiently abnormal to prevent the indigenous species of plankton from following their usual development on admixture, or that the absence of the usual food value in the plankton made them seek food elsewhere. A prolonged scarcity of crustaceous plankton in this area would have serious effects on the potential fish production in the northern North Sea.

The paucity of *Calanus* and other organisms of rich food value in the oceanic area was not only recorded in the northern North Sea, but was abundantly evident in the whole Faroe-Shetland area after about May, and after March between Faroe Bank and the Butt of Lewis. *Calanus*, etc., was common enough between Faroe Bank and Faroe, and between Faroe and Iceland especially west of 10°W. There is some evidence of oceanic plankton penetrating northwards to the west of Faroe east of 10°W., and in this area *Calanus* was less abundant. A line of stations from south-west Iceland (Reykjanes) to Rockall in June did not meet with a high proportion of Lusitanian forms until east of 16°W., as stated earlier, but at all stations after leaving the Icelandic shelf oceanic species dominated the plankton. These included *Agalma, Arachnactis, Physophora, Chelophyes, Halicreas, Pantachogon, Clio pyramidata* etc., though it is significant that underlying the upper 250 metres there was a suspicion of Lusitanian admixture as far as 20°W. where some disintegrating *Ihlea asymmetrica* and *Hippopodius* were found. Interesting records are those of the medusa *Bythotiara murrayi* and the polychaetes *Lopadorhynchus unicinatus* and *Harmathoe benthophila*, all at 60°32'N., 17°55'W., below 250 m., and larval stages of the fish *Nansenia groenlandica* which were found both in this area and the Faroe Channel. This western Atlantic fauna continued eastwards, presumably north of Rosemary Knoll, to reach the north side of the Faroe Channel where it intermixed with and became lost in the dominant southern fauna.

Although the Lusitanian stream off the west of the British Isles is primarily a sub-surface inflow, its effects appear in the surface layers as shown by the I.C.E.S. surface temperature charts for the year. For example, the main inferences of this paper can be seen reflected in the positions of the 11° and 14° isotherms in the Rockall area in June and July 1953 compared with those of 1952, and in the position of the 11° isotherm in the Shetland area in September. It is probable that the very open winter conditions in the Scottish area during the last months of 1953 were associated with this inflow.

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