

REPORT OF THE NORWEGIAN - EEC JOINT SCIENTIFIC GROUP
ON MIGRATION AND AREA DISTRIBUTION OF MACKEREL
(WESTERN STOCK)
BERGEN, 11 - 13 NOVEMBER 1987

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1. INTRODUCTION

1.1 Terms of reference

This report was compiled by a Norwegian-EEC joint scientific group on migration and distribution of mackerel (western stock) which met from 11 to 13 November 1987 with the following terms of reference:

"The study group should collect and update the most relevant information on stock and catch distribution, in particular in the most recent years, specified on seasons and year classes. Relevant data for the North Sea stock should also be considered".

1.2 Participants

R.S.Bailey	Marine Laboratory, Aberdeen
E. Bakken (Chairman)	Institute of Marine Research, Bergen
W.A.Dawson	Fisheries Laboratory, Lowestoft
A. Eltink	Netherlands Institute for Fishery Investigations, IJmuiden
S.A.Iversen	Institute of Marine Research, Bergen
E. Kirkegaard	Danish Institute for Fisheries and Marine Research, Charlottenlund
A. Maucorps	IFREMER, Nantes
J. Molloy	Fisheries Research Centre, Dublin
S. Myklevoll	Institute of Marine Research, Bergen
A. Schumacher	Sea Fisheries Institute, Hamburg
T. Westgård	Institute of Marine Research, Bergen

1.3 Previous reports

The overall distribution of mackerel and the fishing areas during the 1960's and early 1970s are described in ICES Cooperative Research Report No 37 (Anon. 1974). The distribution (Fig 6 of that report) is, however, not given separately for the two stocks.

Distribution and migration for both the North Sea stock and the Western stock are given in ICES Cooperative Research Report No 74 (Anon. 1978). Illustrations (Fig 7,8,12 and 13) of main distribution areas, total distribution range, overwintering areas and spawning areas are presented.

The "Report of the Norwegian - EEC Joint Scientific Sub-group on Distribution of Shared Fish Stocks in the North Sea" (Anon. 1979) deals with the mackerel in the North Sea only.

The distribution and migration of the Western mackerel stock are described in various reports of the ICES Mackerel Working Group, notably in the 1981 and 1986 reports (Anon. 1981,1986). The Working Group reports constitute the main source of published data utilized by the present Norway - EEC Study Group.

A map of the ICES statistical area, with Sub-areas and Divisions, referred to in the text is given in Fig 1.1.

1.4 Stock definition

The ICES Mackerel Working Group in its 1986 report (Anon. 1986) discussed the basis for mackerel stock definition in detail. While there is evidence that mackerel of Western origin recruit to the North Sea spawning stock through the Channel and possibly also to the north of Scotland (Eltink et al. 1986), the Working Group was unable to quantify the extent to which this occurs, and retained the view that there are two principal stocks within the total area of distribution (ICES Divisions IIa, IIIa, IVa-c, Va,b, VIa,b, VIIa-k, VIIIa,b,d,e).

At the present meeting, the joint Norway-EEC Study Group accepted that there are two stocks; one spawning in the North Sea and one in the Western area.

2. SPAWNING AREAS

Investigations in the mackerel spawning area in the North Sea have been carried out every summer since 1968 except 1985. During the early years only the northern part of the spawning area was investigated. Since 1980 the total spawning area was covered several times each year during the spawning period in order to estimate total egg production and size of spawning stock. The spawning period in the North Sea falls between mid May and the end of July, with the main spawning during the second half of June.

The spawning area in the North Sea for the period 1977-1984 and 1986 is shown in Fig. 2.1. The figure is based on data given in: Iversen (1981,1982), Iversen and Eltink (1983), Iversen and Westgård (1984), and Iversen et al. (1985,1987). Spawning takes place within the delineated area every year, with the main spawning (>100 eggs/m² in at least 2 years) within the shaded area. The spawning area is well defined, and the size and location appear to be rather constant. The total spawning area seems, however, somewhat reduced since the early 1970's, when the spawning stock was much larger.

The spawning of the Western stock has been investigated every third year since 1977 for stock assessment purposes. The spawning area (determined as for the North Sea) for the years 1977, 1980, 1983 and 1986 combined is given in Fig. 2.1. This stock also seems to spawn in the same area every year. Only minor area changes have been observed over the years (Lockwood, Nichols and Dawson 1981, Lockwood et al. 1981, Thompson et al. 1984, and Anon. 1987a).

Western mackerel start to spawn in March with the main spawning in May-June. Spawning usually terminates by mid July. In 1986 and 1987 the area north of 54°N was investigated. (Fig 2.1). Although some spawning takes place in this area it only constitutes between 5 and 10 percent of the total Western stock egg production (Molloy and King 1987).

3. DISTRIBUTION OF LARVAE AND 0-GROUP

3.1 Larvae

Information was available about trends in the distribution, abundance and seasonal occurrence of larvae around the British Isles (Coombs and Mitchell 1981). In general, the main concentrations were found to be closely associated with the main spawning areas to the southwest of Ireland (see Fig 2.1). Smaller numbers of larvae were also located to the west of Ireland and Scotland.

In the North Sea there were some indications of a southerly shift in the distribution of larvae during the period 1948 - 1977. This shift in larvae distribution was also evident for larvae of other fish species and may have been caused by changing environmental conditions. It might also have been caused by decreases in the spawning stock in the northern part of the North Sea.

The larvae taken during the egg surveys conducted in recent years in both the North Sea and in the Western area are all closely associated with the main spawning areas (Fig 2.1). The dispersion and subsequent drift of the larvae away from the spawning grounds has not yet been investigated.

3.2 0-group

Mackerel spawn over a fairly long period from March to July. Growth during the first months is very rapid and 0-group mackerel may attain a length of 22 - 23 cm by the end of fourth quarter. They can therefore be exploited in commercial fisheries in their first year, and considerable numbers of 0-group mackerel were taken from 1976-1981, mainly in the fisheries conducted in Division VIIe,f (Anon. 1987b). Subsequent to this, catches of 0-group mackerel in this area decreased considerably but it was not possible to decide whether this was due to 1) the introduction of the protective box around Cornwall, 2) the very poor year classes of 1982 and 1983 or 3) the change in distribution of the juvenile fish or 4) a combination of some of these.

0-group fish are not present in catches taken in the North Sea.

The distribution of 0-group during 1984-1986 as indicated by research vessel surveys are shown in Figs 3.1,3.2 and 3.3. These figures are taken from the 1986 and 1987 ICES Mackerel Working Group reports, (Anon. 1986, Anon. 1987b) The surveys were carried out during the period October to March when fish were still less than 1 year old and changing from 0 to 1-group.

In 1984 0-group mackerel were present over a large area to the west and southwest of Ireland and the U.K. The distribution was considered unusual compared with that of previous years, particularly regarding the northward extent of the distribution along the continental shelf west of Scotland and the westward extent to the south of Ireland. 0-group appeared to be very scarce in the surveys carried out in the North Sea.

In 1985 0-group mackerel were abundant in a number of areas in Divisions VII d,e and VII g-k and in the southern part of Division VIa. They were, however

not as in 1984 present in catches taken in the remainder of Division VIa and were again very scarce throughout the North Sea.

In 1986 the research vessel surveys were severely hampered by bad weather and the areas covered were limited. Compared with previous years the areas of high abundance were very limited and confined to the south of Ireland. Some 0 - group were found west of Scotland. They were again poorly distributed in the North Sea.

Preliminary indications of the distribution of the 1987 year class based on available information from one research vessel survey and from by-catches in commercial fisheries indicate that 0-group may be widely distributed throughout the northern part of Division VII, throughout Division VIa and occurred also in Division IVa.

4. DISTRIBUTION OF JUVENILES

4.1 Catch data

Information on the distribution of juvenile mackerel, defined here as 1- and 2-group, is poor. This is largely because these age groups are incompletely recruited to the directed mackerel fisheries. In addition, there are regulations in some areas designed to protect juvenile mackerel, including a 30 cm minimum landing size in the North Sea, and since 1983, a closed area in parts of Sub-area VII. This means that the distribution of catches in the mackerel fisheries is an incomplete representation of the true distribution of these age groups.

With these reservations in mind, some positive indications of the distribution of concentrations of juvenile mackerel can be obtained from the estimated catches in numbers at age in each ICES Division. These are given in Tables 4.1 and 4.2 for the years 1980-1986. Up to and including 1985, it was assumed for assessment purposes that all 1- and 2-group mackerel caught in the North Sea area (Sub-area IV, Divisions IIa and IIIa) belonged to the North Sea stock, and that all those caught in other areas belonged to the Western stock. In 1986, it was recognized that a proportion of the juveniles caught in 1985 in the North Sea area may have originated from the Western stock.

Table 4.1 indicates that substantial quantities of 1-group Western stock are caught in the Western areas (Sub-areas VII and VIII up to 1983; and Division VIa from 1982-1985). In 1985 and 1986 1-group also constituted a significant percentage of the total catch in Divisions IIIa and IVc.

Table 4.2 indicates that the largest quantities of 2-group mackerel are caught in the Western areas, and particularly Divisions VIIId-k prior to the introduction of the closed area, and in some recent years also Division VIa. Relatively small quantities have been caught in the northern and eastern areas, although catches of 2-group in the North Sea are restricted to the latter half of the year (when most of this age group reach the 30 cm minimum landing size). An exception to the normal situation was in 1986 when 2-group mackerel of the 1984 yearclass were caught in almost all areas, including the North Sea.

4.2 Survey Data. 1-group

1st Quarter

Information on the abundance and distribution of 1-group mackerel in the first quarter in recent years were obtained mainly from English and Scottish bottom trawl surveys covering the Western area (Division VIa, Sub-areas VII and VIII) (Anon. 1986, 1987b). The International Young Fish Surveys carried out in February in Sub-area IV provide additional information on the abundance and distribution of 1-group mackerel in the North Sea (Anon. 1987b).

The main concentrations of 1-group mackerel during this time are found in the Celtic Sea (Divisions VIIg,h,j) and the Western Channel (Division VIIe). Lower concentrations can be found to the west of Scotland (Division VIa), with the exception of 1985 when the strong 1984 yearclass was more widely distributed than usual.

Low abundances of 1-group are present in the central North Sea (Division IVb). In 1987 1-group appeared off the coast of Norway in Division IVa.

2nd Quarter

There are no survey data available for this quarter.

3rd Quarter

There are no survey data available for the Western area during this time period in recent years. Information on the abundance and distribution of 1-group mackerel is available for the North Sea from both Scottish and English bottom trawl groundfish surveys. Danish acoustic surveys for 1985-1987 provide additional information about the distribution of 1-group mackerel in the North Sea and Skagerrak taken with pelagic trawl.

The groundfish survey data indicate 1-group mackerel to be present in the central and southern North Sea (Division IVb and IVc), and acoustic survey data demonstrate that 1-group mackerel were found in coastal waters in the eastern North Sea and in the Skagerrak, (Kirkegaard 1986, Kirkegaard et al. 1987).

4th Quarter

Recruitment surveys during this quarter have been carried out by the U.K. (England) in Sub-areas VII and VIII since 1979. In recent years, Scotland, the Netherlands and Ireland have also started similar surveys, and the area has been extended to cover Divisions VIIb and VIa. 1-group mackerel at this time have a similar distribution to those found in the first quarter with the main concentrations in the Celtic Sea (Division VII g,h and j) and the Western channel, (Sub-area VII) (Anon. 1986, 1987b). They are also present in lower concentrations off the coast of Scotland (Division VIa) and in 1987 were present close inshore off the coast of Ireland (Division VIIb).

In the North Sea they are present in low concentrations off the Dutch coast (Division IVb,c). Additional information from a Norwegian purse seine survey in 1985 covering the Shetland area, northern North Sea and the Skagerrak indicated scattered concentrations in the Norwegian coastal areas and the Skagerrak (ICES Mackerel Working Group doc, Iversen and Westgård, 1986).

The distribution of 1-group mackerel during the years 1985-1987 from both commercial data and survey data are illustrated in qualitative terms in Fig 4.1 for the first quarter and Fig 4.2 for the fourth quarter.

4.3 Survey data. 2-group

Information on the distribution of 2-group mackerel from research vessel surveys using bottom trawls is limited. The numbers of this age group caught in the International Young Fish Surveys in the North Sea in February are in most years negligible. A small concentration was recorded north of the Shetlands in 1986, however (Anon. 1987b).

Some additional information is available from acoustic surveys of small parts of the total distributional area. For example, in July 1985, and August 1986, 2-group mackerel were recorded in large quantities in the eastern half of the North Sea (Divisions IVa and IVb) (Kirkegaard 1986, Kirkegaard *et al.* 1987), but comparable information for other areas at this time is not available.

4.4 Changes in distribution

In general, the data available from the commercial catches indicate that the distribution of juvenile mackerel has changed in recent years. This is demonstrated in Table 4.3 taken from Walsh and Martin (1986). The table shows that up to and including 1981 juvenile mackerel (0 - 2-group combined) in no year formed a large component of the catches in Division VIa, while in Subareas VII and VIII they constituted up to half of the catch in numbers in some years. From 1982 onwards, juvenile mackerel have formed a higher proportion of the total catch in Division VIa. There was also a change in the proportion of the catch made up by juvenile mackerel in Subarea VII in 1984-1985, but this could have been due to the introduction of the closed area. The occurrence of considerable quantities of juveniles in the Channel in each of the last three winters, however, (Anon. 1987b), indicates that this area is still an important nursery area.

In the most recent years, there is also evidence from acoustic surveys of considerable quantities of juvenile mackerel in the eastern North Sea (Division IVa and IVb) in late summer. Since the relevant age groups do not appear to be present throughout the year, it may indicate that a high proportion of these are immigrants from the Western stock.

5. DISTRIBUTION OF ADULTS

5.1 Fishery data

Catches of mackerel in Sub-areas VI, VII and VIII reflected the catches of the Western mackerel stock until 1977 (Fig 5.1). During the subsequent years till 1981 mackerel taken in the Western area (Sub-areas VI, VII and VIII combined) included also mackerel of the North Sea stock. A part of the catch was therefore for assessment purposes allocated to the North Sea stock. A proportion of the mackerel caught in the North Sea area were similarly allocated to the Western stock. These allocations were based on Norwegian tagging data except for the 1986 catches (Anon.1987b). Fig 5.1 indicate that

during the period 1977 - 1981 relatively more mackerel caught in Western areas were allocated to the North Sea stock than vice versa.

Later during the period 1981 - 1986, relatively more mackerel caught in North Sea area were allocated to the Western Mackerel stock than vice versa. This trend might be caused by a northward shift in distribution of the Western mackerel outside the spawning season. (See also Section 6).

Shifts in seasonal distribution of Western mackerel have been analysed by the ICES Mackerel Working Group and by various authors by examining changes in the main mackerel fisheries.

A thorough examination of the changes is given in the 1985 Mackerel Working Group Report (Anon. 1985, p 5-9) and in a paper by Walsh and Martin (1986). The results are summarised in Fig 5.2 in the present report.

Throughout the 60's and 70's the main winter fisheries were concentrated to an area around the Cornish Peninsula (Division VIIe,f). During the 80's the fishery moved progressively to the west of the British Isles and further to the northwest and north of Scotland. Some fishing, however, continued in the Western English Channel.

There are also some evidence from the summer fishery indicating shifts in the distribution of the mackerel as indicated on Fig 5.2. There has been a progressive northeast shift from around Shetland towards the Norwegian Coast, with the exception of the period 1975-1978 when fish moved into the centre of Division IVa to feed. It should, however, be noted that the distribution of catches depends both on the distribution of fishing effort and on the distribution of the mackerel stock.

In order to map the area distribution of the mackerel catches by season for the most recent years, the Study Group compiled available catch data for 1984, 1985 and 1986 broken down to the smallest reported fishing areas by quarter of the year.

Figures 5.3 - 5.14 show catches in thousands of tonnes by Denmark, Federal Republic of Germany, England, Norway, Scotland and the Netherlands by quarter and by statistical rectangle for Divisions IIa, IIIa, IVa and Va, but only by Division or Sub-division for the rest of the areas. Danish catch data for 1984 were not available. These catches represent a major part of the total international landings.

The catches reflect where fishing occurred, but does not necessarily reflect the total distribution area of the mackerel. Some misreporting occurred in some quarters in the subdivision of Division VIa which is adjacent to Division IVa, and also in statistical rectangles in Division IIa adjacent to Division IVa. Catches reported in Division IVa are therefore underestimated.

Catches of mackerel 1978-1986 by year, quarter and area are listed in Table 5.1. The table shows the shift of the main fishery in the first and last quarter to the north and east. The shift is even more evident when catches are rearranged to take into account the seasonal nature of the fishery as shown in Table 5.2.

In the 1984/85 and 1985/86 winter seasons the fishery had shifted from Sub-area VII northwards to Division VIa. The increase in catches in Division IVa during the 1985/86 and 1986/87 season might indicate a further shift of the fishery towards the northern North Sea. In winter 1986, however, very high catches in Division IVa point to a further change in the distribution of the

fishery in that particular season. The reasons for this change are not known and it is not clear at present, whether this distribution pattern will be maintained.

5.2 Fishery independent data

The following fishery independent data on distribution of adult mackerel were available at the meeting:

Survey	Time of year	Period	Area	Reference
English groundfish	Aug	1977-87	IV	W.Dawson (pers.com.)
Scottish groundfish	Aug	1982-86	IVa,IVb	R. Bailey (pers.com.)
Scottish acoustic	Nov	1983,85,86	VIa,north	Heath (1984), Heath & Copland (1986, 1987)
Danish Acoustic	Aug	1985-87	IIIa, IVb east	Kirkegaard (1986) Kirkegaard et.al(1987)
IYFS	Feb	1967-87	IV	
North Sea Egg	May-Jul	1977-84,86	IV	See section 2
Western Area Egg	Mar-Jul	1977,80,83,86	VI,VI,VIII	See section 2
Norwegian Purse Seine	Oct	1985	IVa,IIIa, IVb east	Iversen and Westgård (1986)

North Sea and Western area egg survey

The egg surveys give a good picture of the distribution of adult mackerel during the spawning season (see Section 2).

Groundfish surveys

The surveys are carried out in August as bottom trawl surveys. At this time of the year, water masses in the North Sea, except for the most shallow parts, are stratified with a warm surface and a cold bottom layer. Mackerel are normally found in the warm surface layer, and this may influence catchability and make it doubtful to compare data from the different areas in the North Sea. Catches may also include an unknown proportion of North Sea mackerel. However, the data do not show any decrease in abundance as could be expected if the North Sea mackerel constitutes a major part of the catches.

The groundfish surveys show that adult mackerel are present over a large part of the North Sea during August. Over the period 1977-1987 the data also indicate an increase in the abundance of adult mackerel in Division IVc.

Danish acoustic survey

In 1985 and 1986 the survey only covered the most eastern part of Division IVb and the Skagerrak-Kattegat area. The concentration of adult mackerel was found to be very low.

Scottish acoustic survey

The target species in these surveys are herring and the catches of mackerel are very low. The only catches of adult mackerel were taken during the 1983 survey in the area northwest of Scotland.

The International Young Fish Survey (IYFS)

Catches of adult mackerel are very low, and it is not possible to draw any conclusions about the distribution or migration of adult mackerel from the data.

Norwegian purse seine survey

The concentration of adult mackerel was found to be very low in the Skagerrak area. In Division IVa adult mackerel were caught throughout the surveyed area, in highest concentration in the northwestern part of the Division.

Information on the distribution of adult mackerel from research vessel surveys is incomplete and it is therefore not possible to add significantly to what is obtained from commercial catch data. It should be noted, however, that the surveys indicate that the total distribution of mackerel may be more widespread than indicated by the fisheries and that the distribution of commercial catches may not in all instances reflect the precise distribution of the stock.

6. MIGRATIONS

6.1 Migration pattern

The Study Group reviewed and discussed published information on mackerel migrations, in particular the reports of the ICES Mackerel Working Group, and also assessed the fishery data (Section 5.1) as a means of determining migration patterns. In relation to this the shifts in distribution were given special consideration.

Adult Western stock mackerel migrate between areas of overwintering, spawning and feeding. The spawning area (Section 2) and the feeding area have, in general terms, remained the same during the last 10 years, while the overwintering area has shifted gradually northwards.

Figure 6.1, 6.2 and 6.3 give a schematic outline of the migration pattern. The figures are based on similar illustrations presented in the ICES Cooperative Research Reports No 37 and 74 (see Section 1.3), by the ICES Mackerel Working Group (Anon. 1981, 3.1-3.4 and Anon. 1986 Fig 4.1) and by Bakken and Westgård (1986), as well as charts of catch distribution by month for major fishing fleets available at the meeting.

The shift in overwintering area is reflected in the fishery as demonstrated in Table 5.2 which gives catches by season by area. Reported catches in the feeding area in Divisions VIa, IIa and IVa indicate that the extension of the area and the locations of the main concentration area varied during the period 1978-1986. During the late 1970's fishable concentrations of mackerel were mainly found northeast of Shetland in July-August. In the early 1980's fishing extended further north, even north to 65° N. In later years fishing indicate that the mackerel occurred further east in the southeastern part of Division IIa (Fig 6.2) and that the return migration westwards to the overwintering area took place via the northern part of Division IVa. Western stock mackerel are probably in late summer distributed over a wide area in Division IVa, but the fisheries indicate that a major part of the mackerel follows a migration route across the northern part of Division IVa, most likely north of 59°-60° N. It should, however, be noted that the distribution and migration of mackerel in the feeding area seem to vary substantially, probably in relation to the total size of the stock and to environmental factors, although the migration starts from a rather constant area of spawning.

6.2 Norwegian tagging experiments

Mackerel have been tagged by individually numbered steel tags every year since 1970, with two areas of release: one southwest of Ireland in May and one south of Norway in July-August (Hamre 1980, Bakken and Westgård 1986). The return of tags is influenced both by the fishery and by the efficiency of the system used to screen catches to recover tags. For the purpose of the Study Group, a limited data set was used to illustrate migration of Western mackerel. Only tags returned in the year of release, where the fishing position is known, are included. These are tags mainly from the Scottish and Norwegian fisheries. The geographic distribution of the returns will, however, reflect both the mackerel's migration pattern and the fishery.

Data on tag returns have been used by the ICES Mackerel Working Group to allocate catches to stocks in Divisions IIa, IVa and VIa for the years up to and including 1984. Details on the method are found in Mackerel Working Group reports.

Bakken and Westgård (1986) reviewed the Norwegian tag returns for the period 1971 to 1985. The main conclusions were:

Mackerel from the two spawning areas do not mix completely, and a possible hypothesis of one single mackerel stock must be rejected. Western mackerel and North Sea mackerel have a different distribution pattern, but the areas overlap. The intermixture in an area, measured as the relative proportion of mackerel present from each stock, decreases as the distance from the area of origin increases.

The analyses also confirmed that data on tag returns was adequate to use for allocation of catches to stocks for all years except the most recent ones.

In Fig 6.4 and 6.5 tag returns from releases southwest of Ireland (Western stock) are shown. Only tags recaptured in the year of release are included, and of these only tags for which recapture location given by Norwegian statistical rectangle are known. It was not possible during the meeting to evaluate the relative distribution of the Western Stock in different areas based on the tag returns and other data.

It is evident that fish tagged off southwest Ireland in May, migrate into to the Norwegian Sea (Division IIa), to the northern part of the North Sea

(Division IVa), and on occasions even into the central North Sea (Division IVb).

7. DISTRIBUTION OF THE NORTH SEA STOCK

The migration pattern of the North sea mackerel stock was investigated from tagging experiments and the distribution of the main fisheries between the mid 1960's and mid 1970's (Hamre 1978,1980). The text table below and Fig 7.1 (from Hamre 1978) summarizes the knowledge for that period, when the North Sea stock was considerably more abundant than at present.

Event	Time	Area
overwintering	Dec-Mar	northwest Norwegian Deep, west Shetland shelf
feeding	Apr-May	northeast North Sea
spawning	Jun	central North Sea - Skagerrak
dispersion	Jul-Aug	north and east Shetland (major component along Norwegian coast, southern Baltic)
dispersion	Sep-Oct	eastern North Sea
dispersion and overwintering	Nov-Dec	deeper waters, North of Norwegian Trench

It is pointed out that the main purse seine fisheries developed in the late 60's on very dense concentrations along the Norwegian Trench in the autumn before the mackerel descended to deeper water. Another major fishery occurred in summer around the north and east of the Shetlands and in winter west to North Rona where it exploited a mixture of mackerel of North Sea and Western origin.

At present the North Sea mackerel stock is very low and subject to restrictive management measures. Since Western mackerel mix with North Sea mackerel at certain times of the year, the seasonal distribution pattern of mackerel as reflected in the fishery in the North Sea could give a biased picture of the distribution and migratory pattern of the North Sea mackerel stock. The recent distribution and migration pattern of the North Sea mackerel stock outside the spawning season is therefore not at present known with any precision.

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Table 4.1 Catch in numbers of 1-group mackerel in millions. Figures in parentheses are catch of 1-group as percentage of all age groups. Catches less than 50 000 are given as a plus.

ICES Division	1980	1981	1982	1983	1984	1985	1986
IIa	-	-	-	-	-	┌	┌
	-	-	-	-	-	1.8	0.1
Vb	-	-	-	-	-	(1.3)	(0.04)
	-	-	-	-	-	┌	┌
IIIa	-	1.7	2.2	0.1	-	4.5	5.5
	-	(15.2)	(17.4)	(0.4)	-	(42.6)	(25.6)
IVa, N of 59°N	-	┌	┌	-	-	0.1	┌
	-	0.6	0.4	-	-	(0.8)	7.3
IVa, S of 59°N	-	(15.0)	(1.0)	-	-	0.4	(1.5)
	-	┌	┌	-	-	(0.8)	┌
IVb	┌	┌	+	-	-	0.4	+
	2.7	1.6	(0.3)	-	-	(3.0)	(0.2)
IVc	(16.3)	(2.3)	0.4	0.1	+	1.1	0.8
	┌	┌	(8.1)	(2.0)	(0.5)	(32.6)	(13.8)
VIa, N of 58°N, in winter	┌	0.1	21.0	3.0	5.0	129.8	┌
	3.0	(0.2)	(6.8)	(1.7)	(0.8)	(18.3)	6.4
VIa remainder	(0.7)	7.6	47.3	2.7	3.9	59.1	(2.1)
	┌	(1.4)	(9.1)	(0.4)	(3.8)	(23.5)	┌
VIIa-c	0.7	0.6	0.2	0.1	2.0	0.6	0.7
	(0.7)	(0.5)	(0.5)	(0.1)	(3.0)	(0.6)	(0.5)
VIIId-k	413.2	210.9	129.7	34.9	5.3	34.4	8.3
	(24.2)	(18.9)	(12.3)	(3.4)	(0.9)	(25.2)	(3.6)
VIIIa,b	67.6	46.8	4.7	3.0	0.6	2.0	+
	(55.5)	(37.2)	(9.7)	(3.4)	(0.9)	(25.3)	(3.7)
Source	Anon. 1981	Anon. 1984	Anon. 1984	Anon. 1984	Anon. 1985	Anon. 1986	Anon. 1987b
Tables	6.1	3.6	3.5	3.4	3.4	5.4	5.4
	6.2	4.5	4.4	4.3	4.3	6.3	6.3
	6.3						

Table 4.2 Catch in numbers of 2-group mackerel in millions. Figures in parentheses are catch of 2-group as percentage of all age groups. Catches less than 50 000 are given as a plus.

ICES Div	1980	1981	1982	1983	1984	1985	1986
IIa	0.1 (2.1)	-	2.1 (3.5)	2.5 (2.5)	0.4 (0.2)	┆ 0.4	┆ 29.5
Vb	-	-	-	-	+ (0.2)	(0.3) ┆	(15.4) ┆
IIIa	┆	0.4 (3.8)	6.2 (49.9)	6.1 (41.9)	0.6 (5.7)	0.2 (2.2)	11.3 (52.5)
IVa, N of 59°N	0.7 0.5	┆ 0.8	┆ 5.5	┆ 6.0	+ (0.2)	0.1 (0.3)	┆ 177.2
IVa, S of 59°N	┆	(19.6) ┆	(13.5) ┆	(14.3) ┆	1.1 (2.0)	0.2 (0.3)	(35.7) ┆
IVb	┆ 1.7	┆ 4.8	0.1 (0.8)	2.2 (14.2)	0.7 (7.4)	0.2 (1.9)	1.0 (11.8)
IVc	(10.2) ┆	(7.1) ┆	0.5 (9.8)	0.2 (7.8)	0.1 (4.6)	0.1 (4.3)	1.8 (30.1)
VIa, N of 58°N, in winter	┆ 26.0	0.3 (0.4)	84.9 (27.6)	88.5 (51.8)	13.0 (2.0)	12.7 (1.8)	┆ 138.1
VIa remainder	(5.7) ┆	40.5 (7.4)	59.5 (11.5)	115.2 (16.2)	2.6 (2.6)	1.7 (0.7)	(46.2) ┆
VIIa-c	11.3 (10.6)	20.0 (15.4)	1.7 (3.3)	17.7 (15.3)	0.5 (0.8)	+ (+)	25.4 (16.2)
VIIId-k	412.7 (24.2)	424.6 (38.0)	284.9 (26.9)	459.8 (44.6)	56.5 (9.5)	2.0 (1.5)	42.0 (18.1)
VIIIa,b	21.8 (17.9)	21.0 (16.7)	5.1 (10.4)	39.6 (44.9)	6.9 (9.5)	0.1 (1.2)	+ (18.2)
Source	Anon. 1981	Anon. 1984	Anon. 1984	Anon. 1984	Anon. 1985	Anon. 1986	Anon. 1987b
Tables	6.1 6.2	3.6 4.5	3.5 4.4	3.4 4.3	3.4 4.3	5.4 6.3	5.4 6.3

Table 4.3 Percentages of juvenile fish (0-2 groups combined) and total number landed (all age groups) in ICES Division VIa, VII and VIII from 1972 to 1985 inclusive.

Year	Percentage juveniles in catch (by number)		Total catch in nos x 10 ⁻⁶	
	VIa	VII + VIII	VIa	VII + VIII
1972	<0.5	7	30	395
1973	1	26	57	603
1974	2	16	73	712
1975	2	11	679	1301
1976	5	29	159	1670
1977	8	45	166	967
1978	1	37	309	1493
1979	1	26	434	1915
1980	6	49	436	1937
1981	8	56	604	1372
1982	26	37	805	1157
1983	24	45	860	1236
1984	4	9	692	735
1985	21	16	922	239

Table 5.1 Mackerel catches by year, quarter and area in thousands of tonnes. Catches in Division IIIa in parenthesis. Catches in Division IIIa and IVa-c not separated prior to 1982.

	1978	1979	1980	1981	1982	1983	1984	1985	1986
<u>Division</u>									
<u>IIa</u>									
Quarter	1	-	-	-	-	-	-	+	-
	2	-	-	-	+	-	+	+	-
	3	4	-	8	17	37	49	92	71
	4	-	-	-	+	+	1	1	2
<u>Division</u>									
<u>IIIa + IVa-c</u>									
Quarter	1	4	+	2	2	+	+	+	+
	2	8	6	5	6	5(1)	2(+)	2(1)	2(1)
	3	130	140	76	46	24(3)	31(5)	35(5)	40(3)
	4	8	8	5	2	2(+)	2(+)	2(+)	7(+)
<u>Division</u>									
<u>VIa</u>									
Quarter	1	2	26	19	24	36	25	39	92
	2	2	12	7	9	7	17	5	10
	3	78	60	57	95	54	55	5	17
	4	69	105	135	213	244	231	259	273
<u>Division</u>									
<u>VIIa-k</u>									
Quarter	1	124	185	197	119	150	115	111	51
	2	42	17	38	50	41	51	41	18
	3	14	20	33	25	16	10	4	2
	4	152	157	99	66	32	65	12	2
<u>Division</u>									
<u>VIIIa,b,d,e</u>									
Quarter	1	+	+	+	1	1	1	1	+
	2	1	1	1	1	1	1	1	+
	3	1	1	1	1	1	1	1	+
	4	1	1	1	1	1	1	1	2

Table 5.2 Catches (1000 tonnes) rearranged by season. (Catches in 3 and 4 quarter added to catch 1 quarter following year).

	Div. IIIa + IVa-c	Div. VIa	Div. VIIa-k
1978/79	138	173	351
1979/80	150	184	374
1980/81	83	216	251
1981/82	48	344	241
1982/83	23	323	163
1983/84	28	325	186
1984/85	34	356	67
1985/86	44	347	81
1986	230	42	7

ICES Fishing Areas

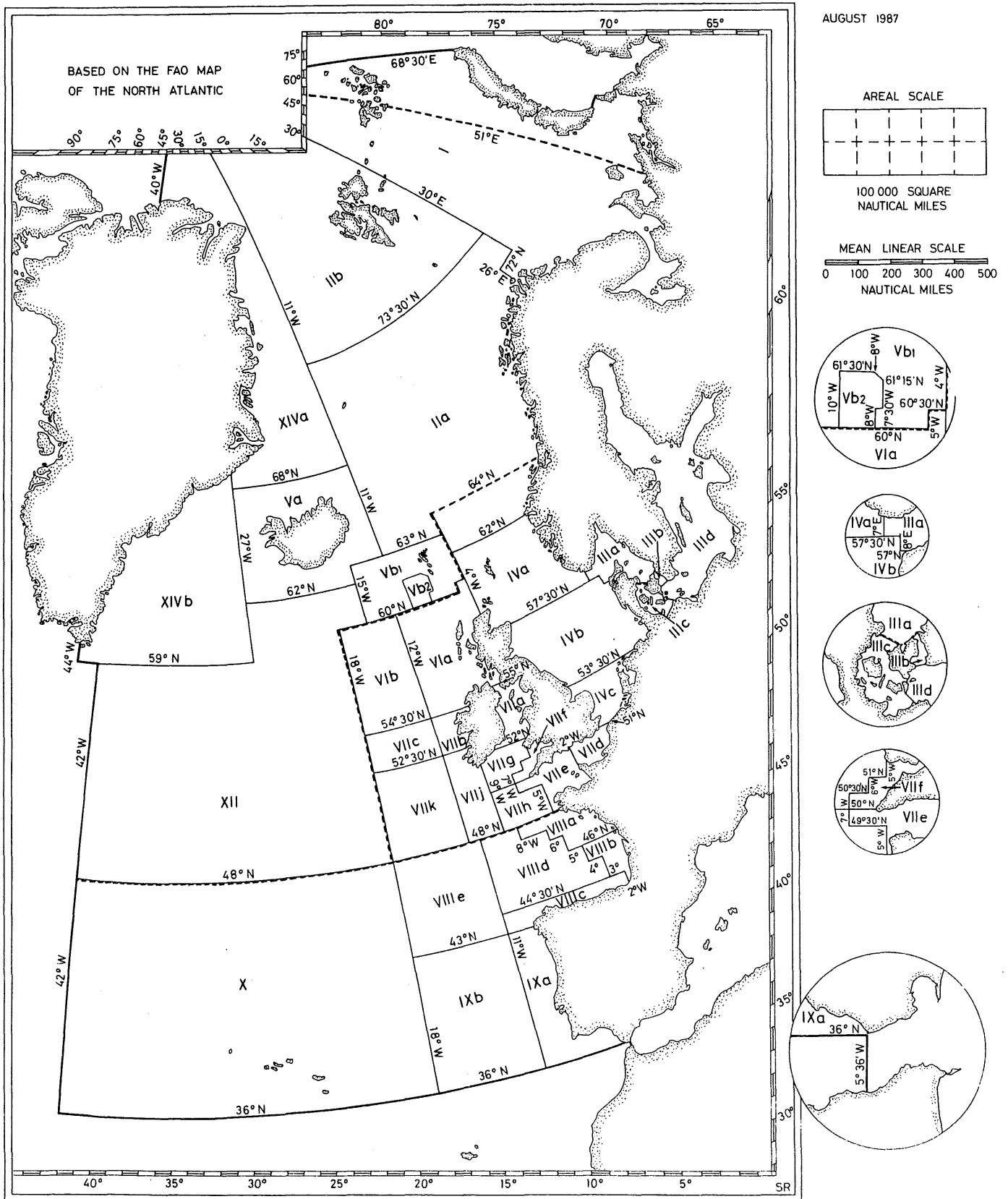


Figure 1.1 ICES statistical areas.

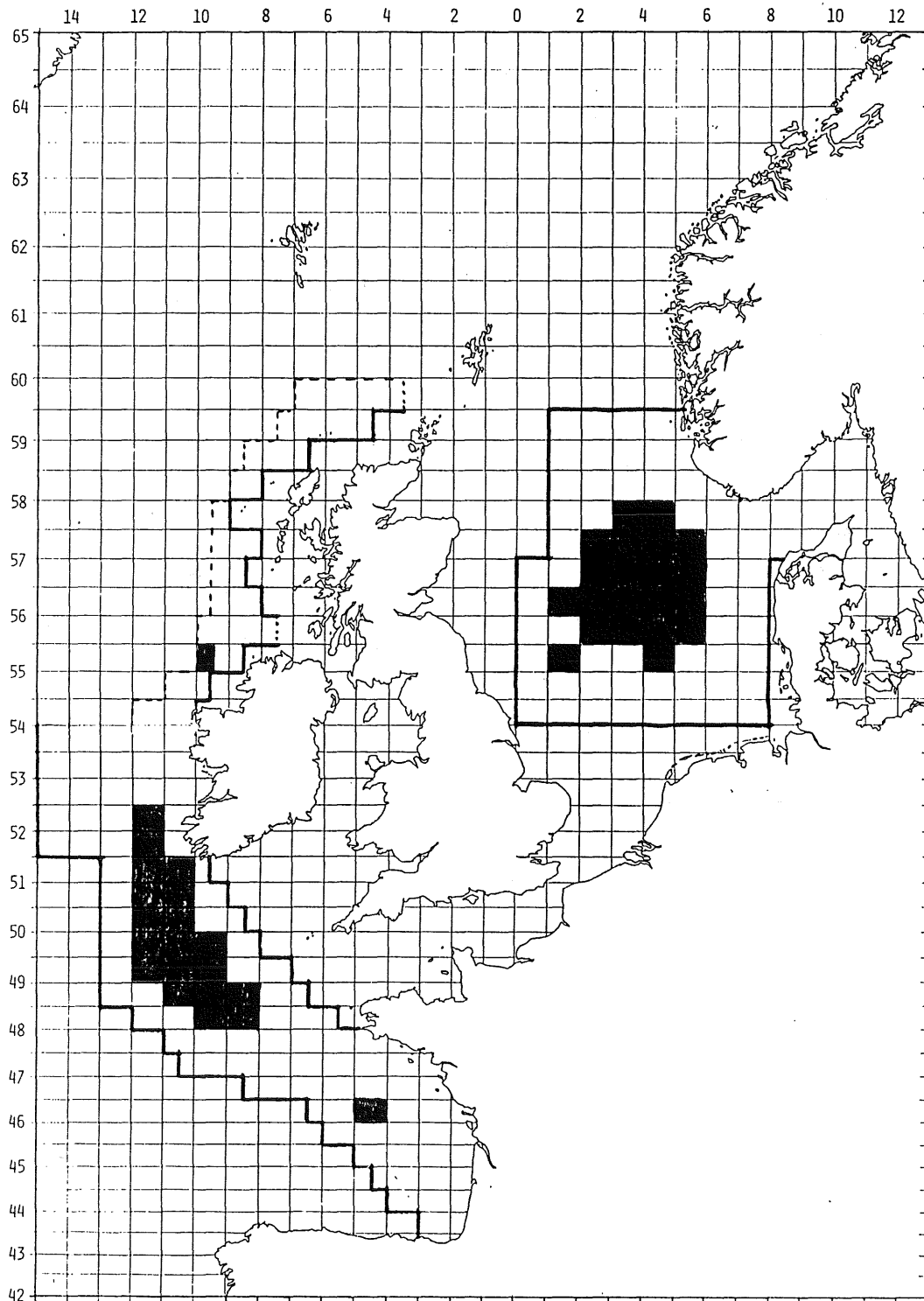


Figure 2.1 Mackerel spawning areas in the period 1977-1986. Shaded areas indicate > 100 eggs/m² in at least two of the years.

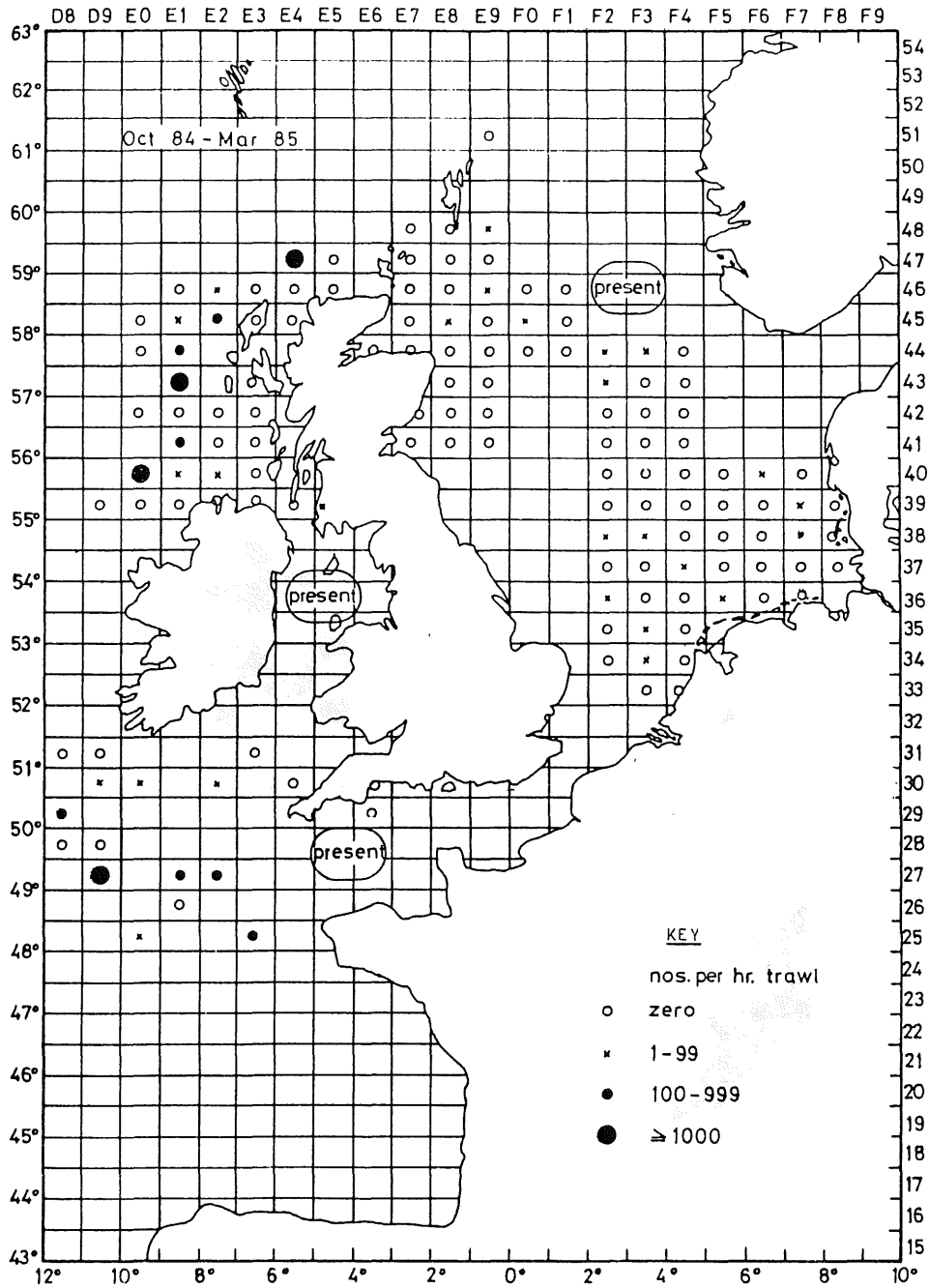


Figure 3.1 Distribution and abundance of the 1984 year class between October 1984 and March 1985 from Danish, Dutch, English, German (FRG), Norwegian and Scottish research vessel surveys. (From Anon.1987b).

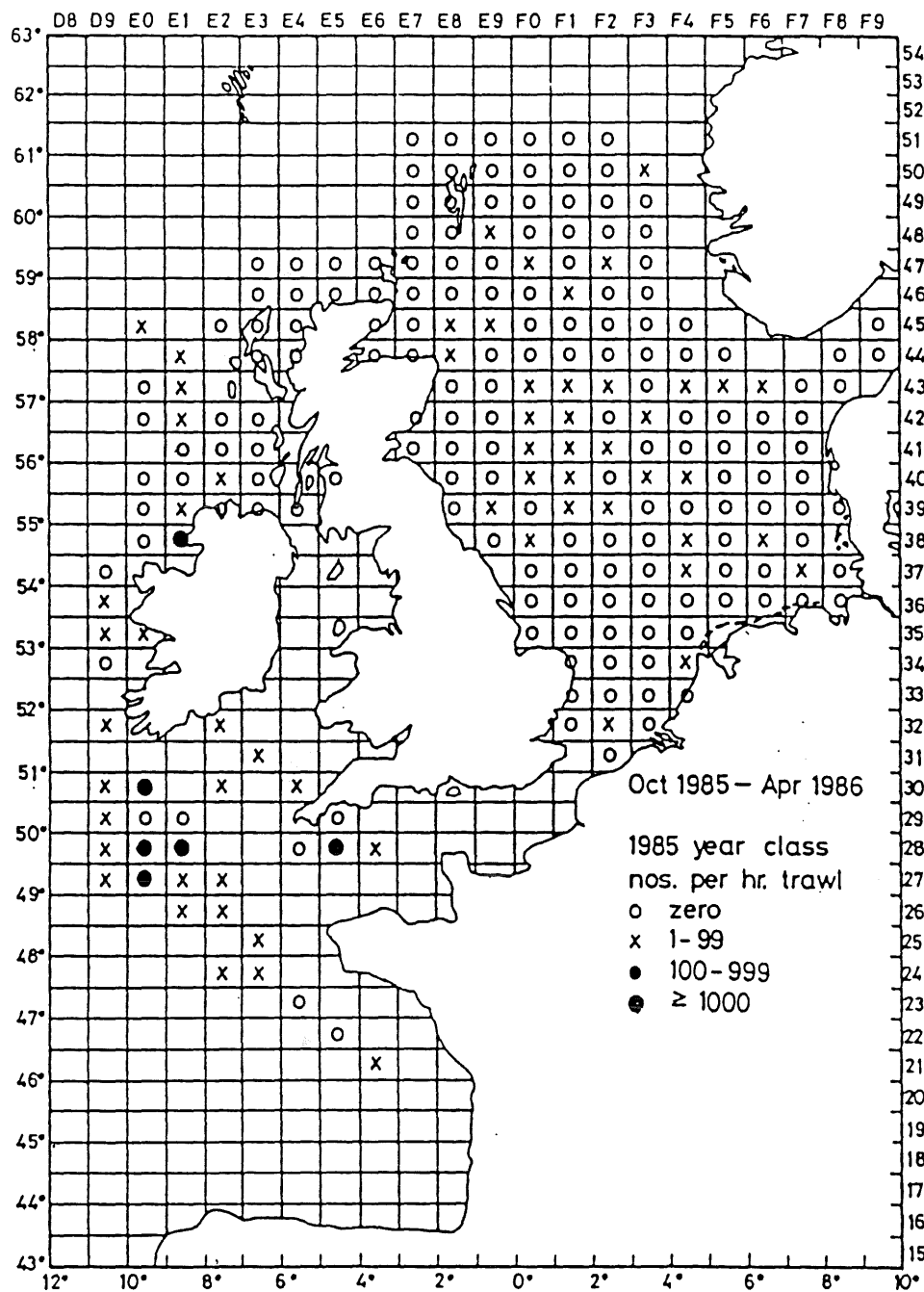


Figure 3.2 Distribution and abundance of the 1985 year class between October 1985 and March 1986 from Danish, Dutch, English, German (FRG), Irish, Norwegian and Scottish research vessel surveys. (From Anon.1987b).

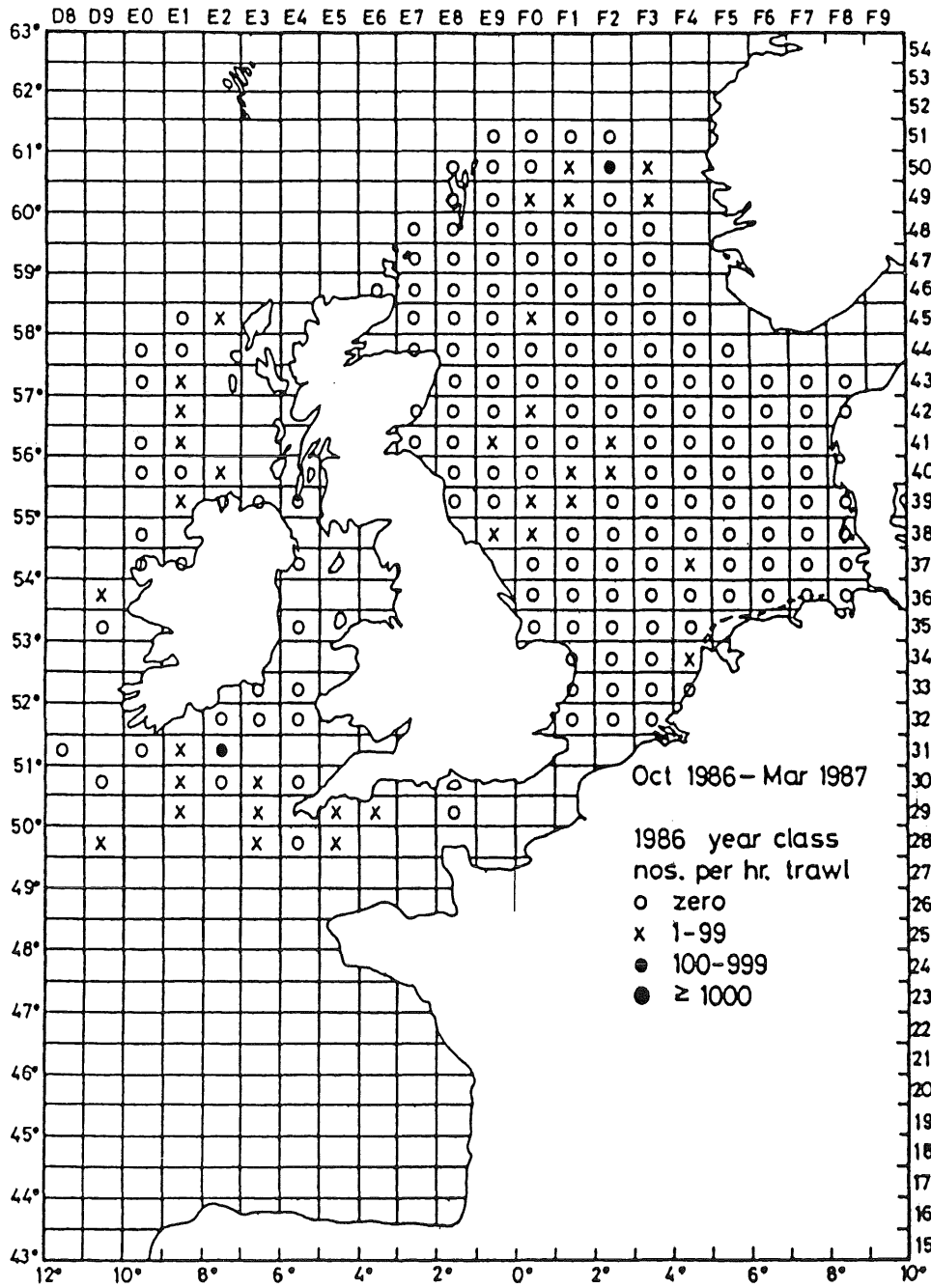


Figure 3.3 Distribution and abundance of the 1986 year class between October 1986 and March 1987 from Danish, Dutch, English, German (FRG), Irish, Norwegian and Scottish research vessel surveys. (From Anon.1987b).

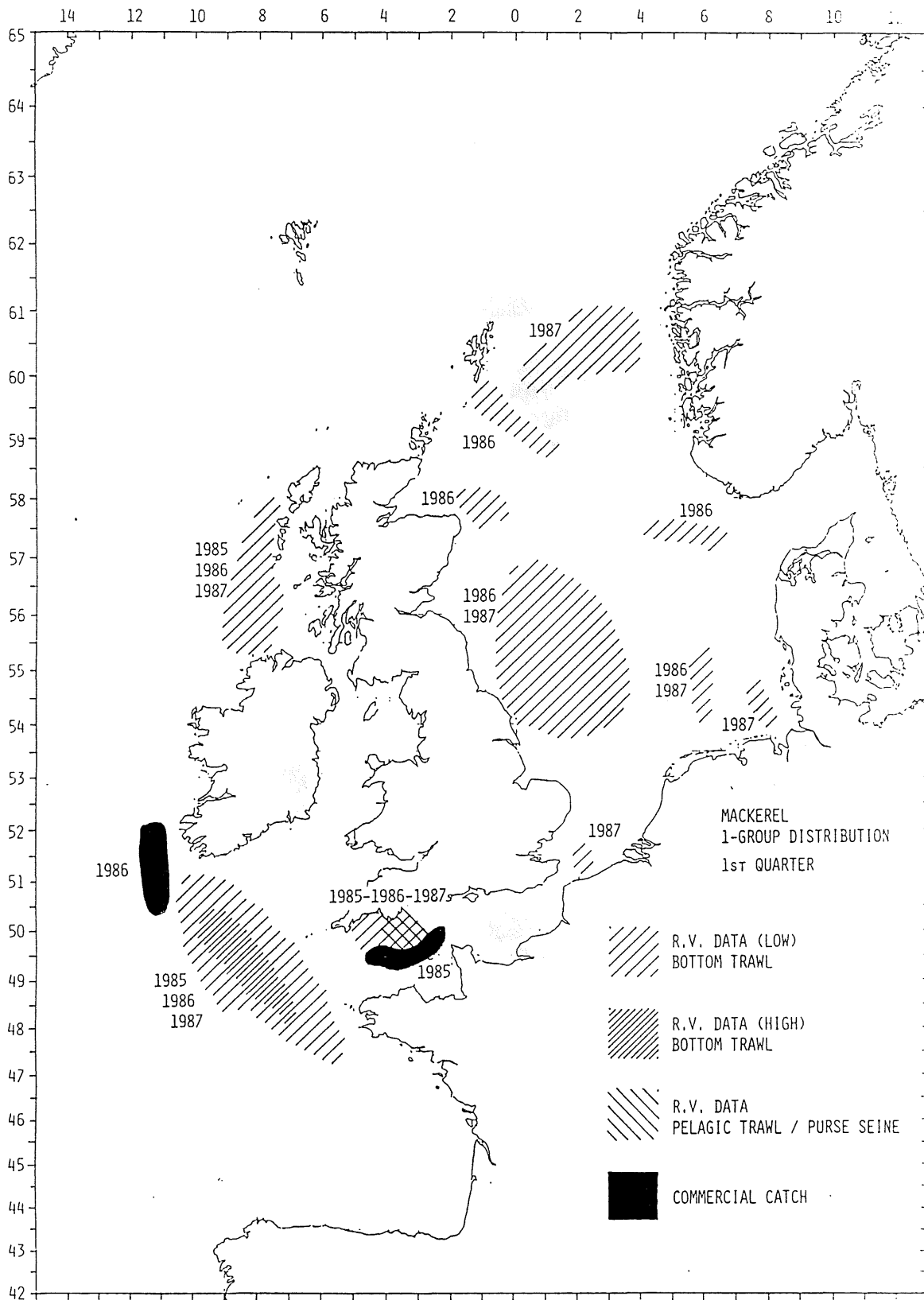


Figure 4.1 Distribution of 1-group mackerel first quarter.

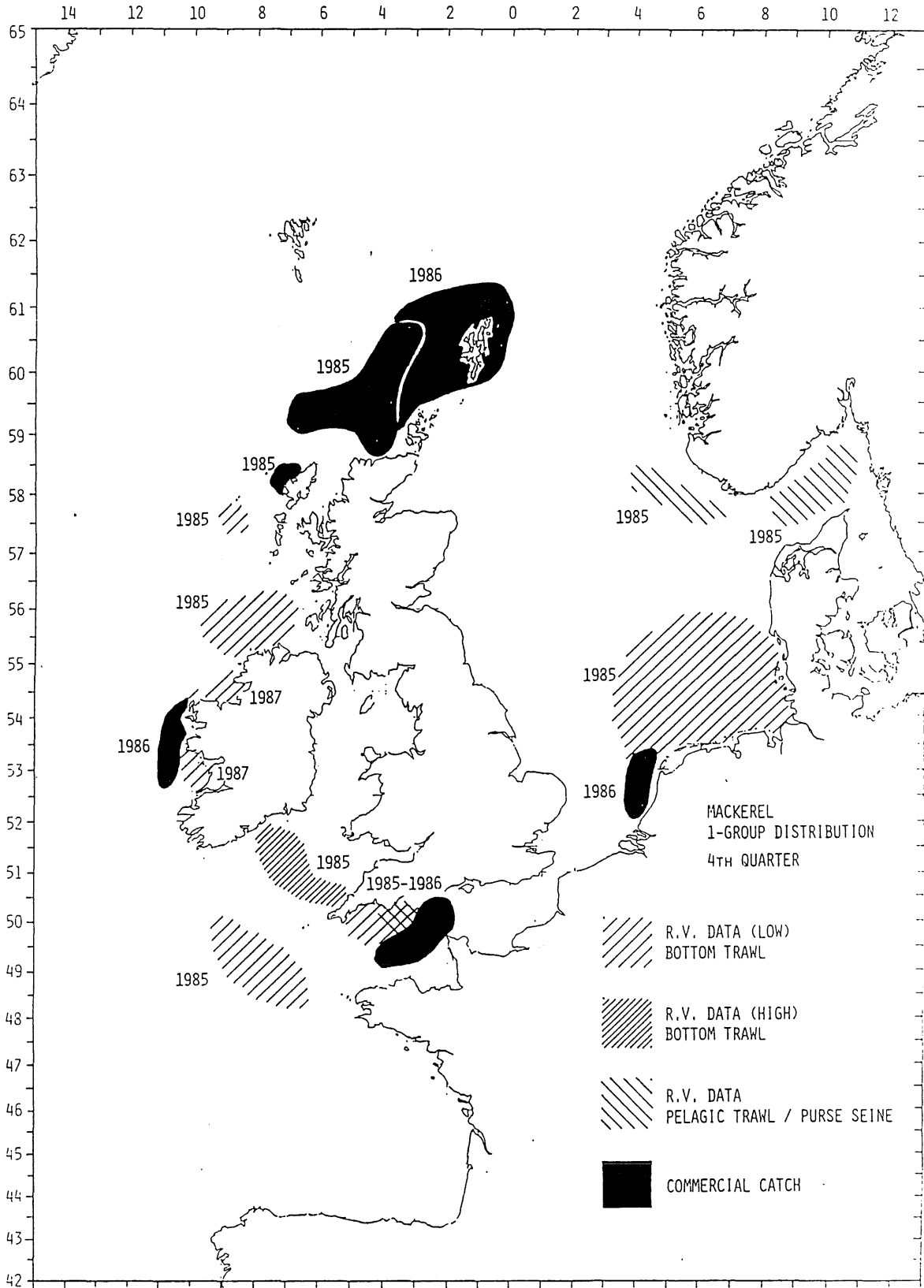


Figure 4.2 Distribution of 1-group mackerel fourth quarter.

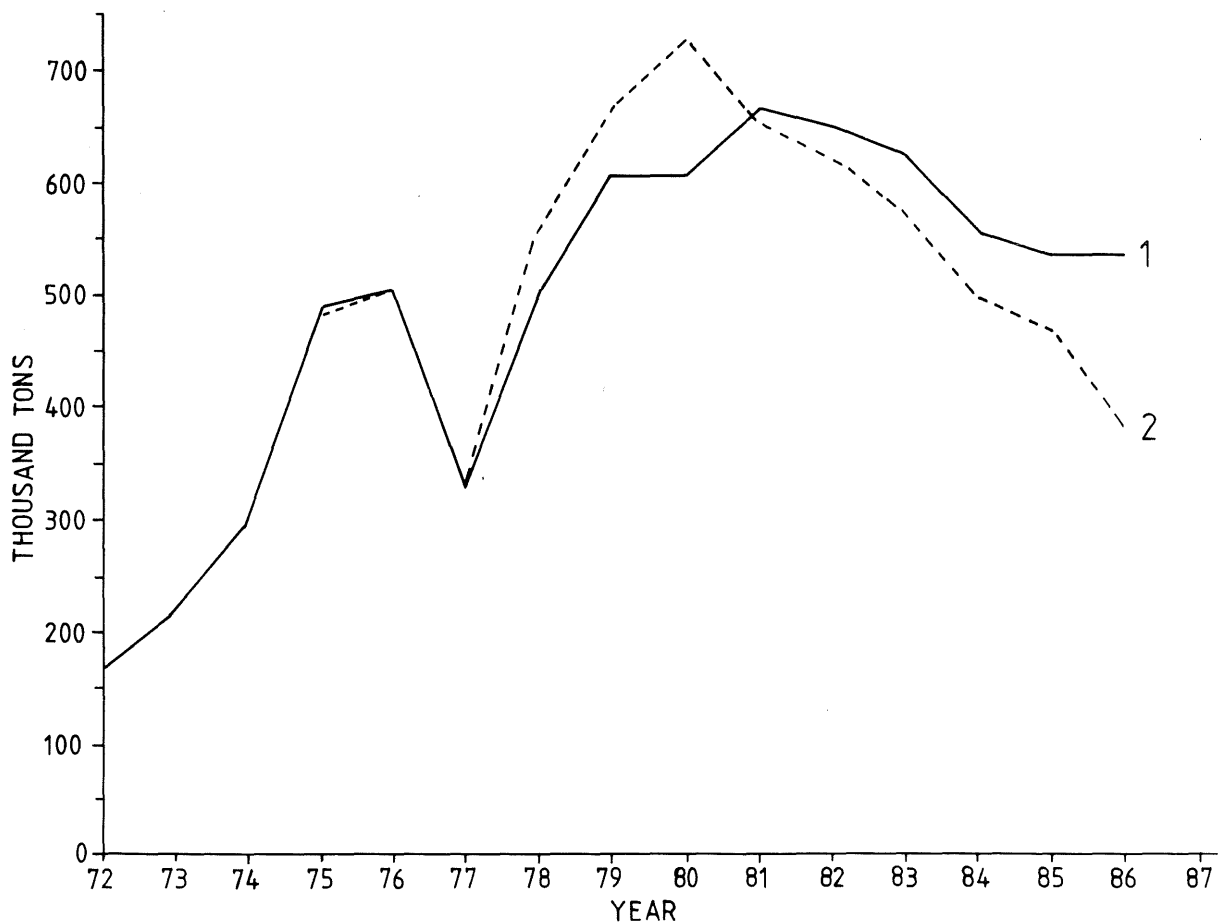


Figure 5.1 Catches in thousand tonnes of Western stock mackerel (1) compared to total mackerel catch in Sub-areas VI, VII and VIII (2).

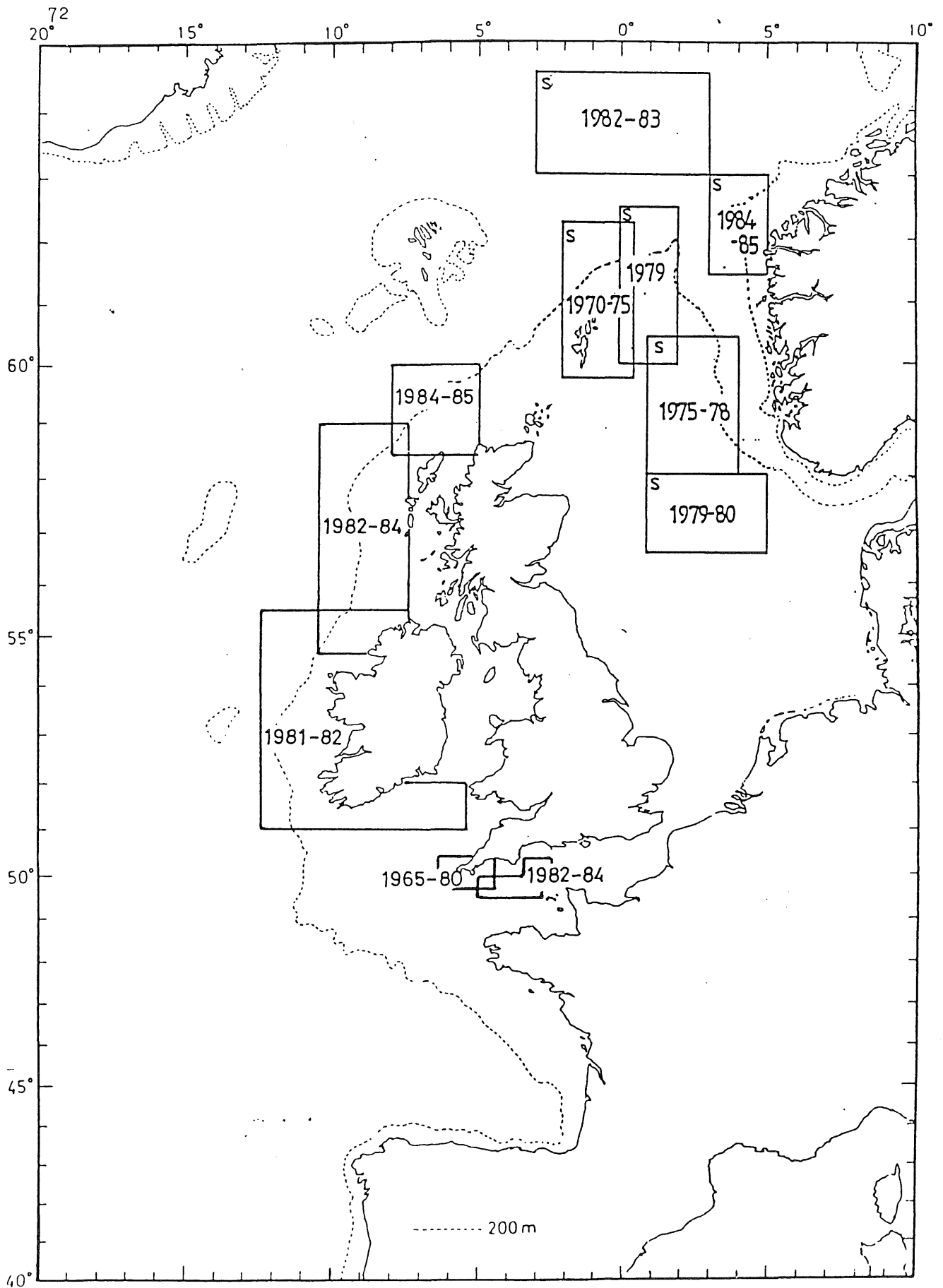


Figure 5.2 Shift in the position of the main Western stock fishery during summer north and east of Shetland and during winter south and west of the British Isles. Compiled from Anon.(1985) and Walsh and Martin (1986).

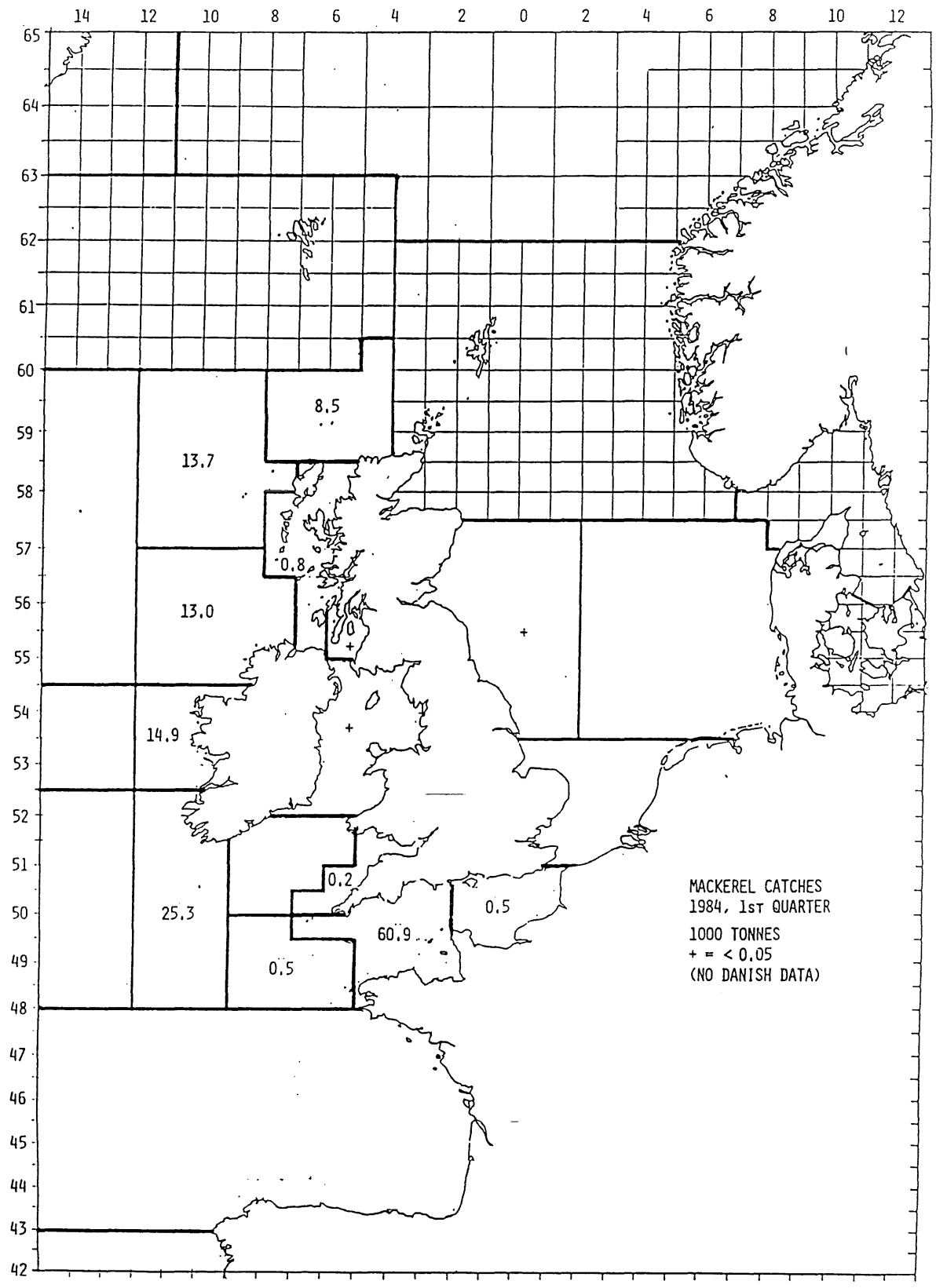


Figure 5.3 Mackerel. Catch by area. First Quarter 1984.

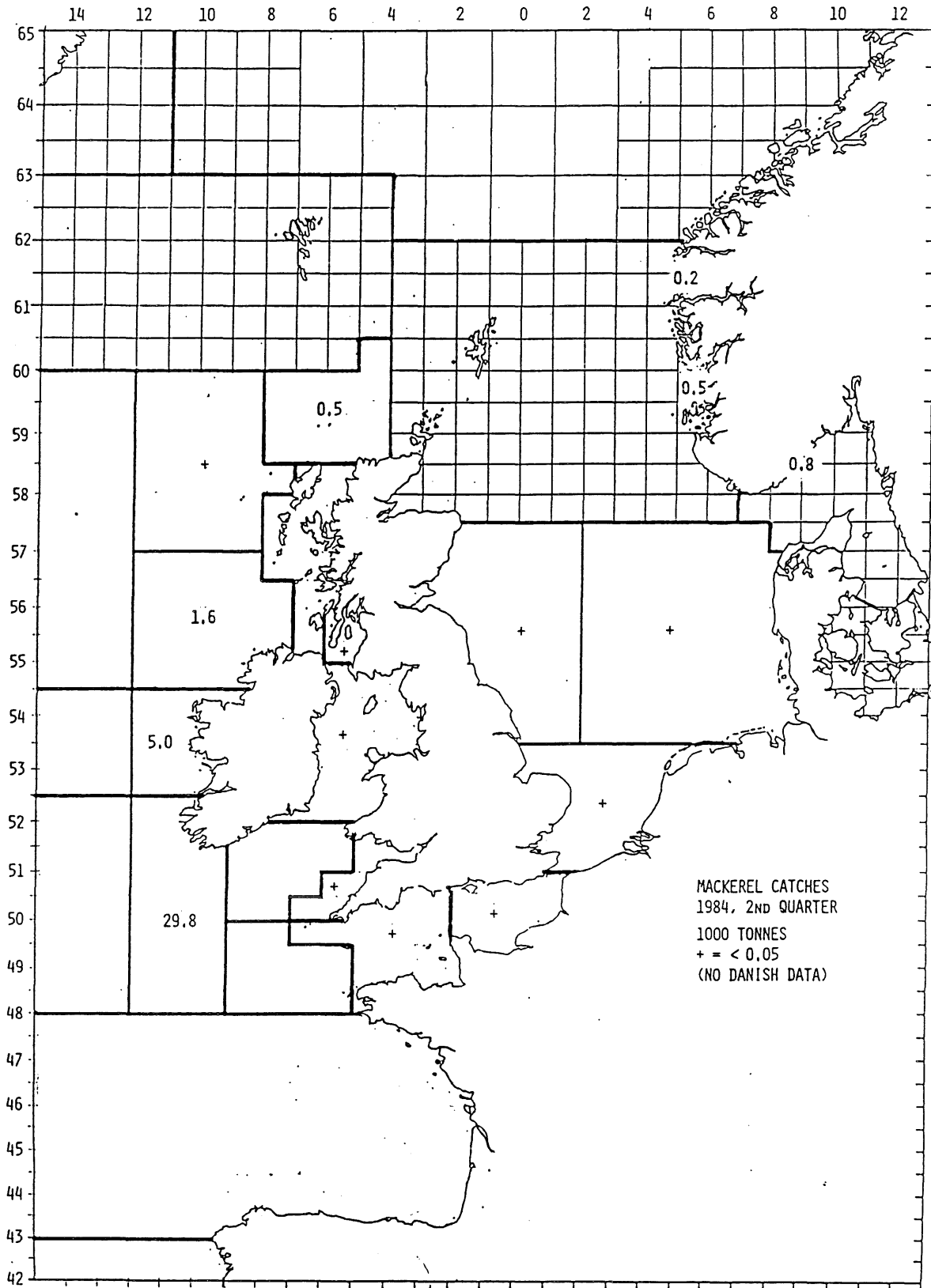


Figure 5.4 Mackerel. Catch by area. Second Quarter 1984.

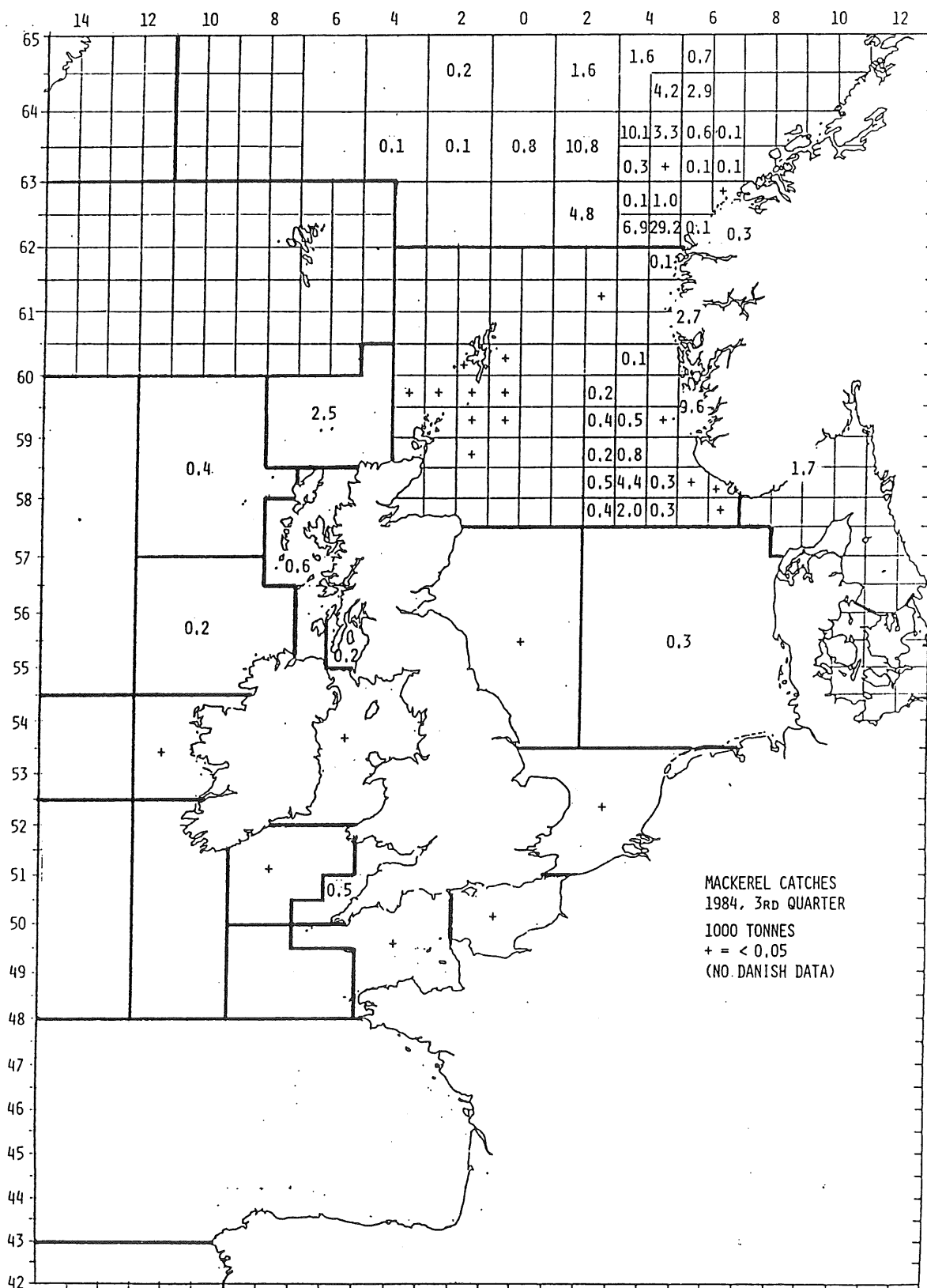


Figure 5.5 Mackerel. Catch by area. Third Quarter 1984.

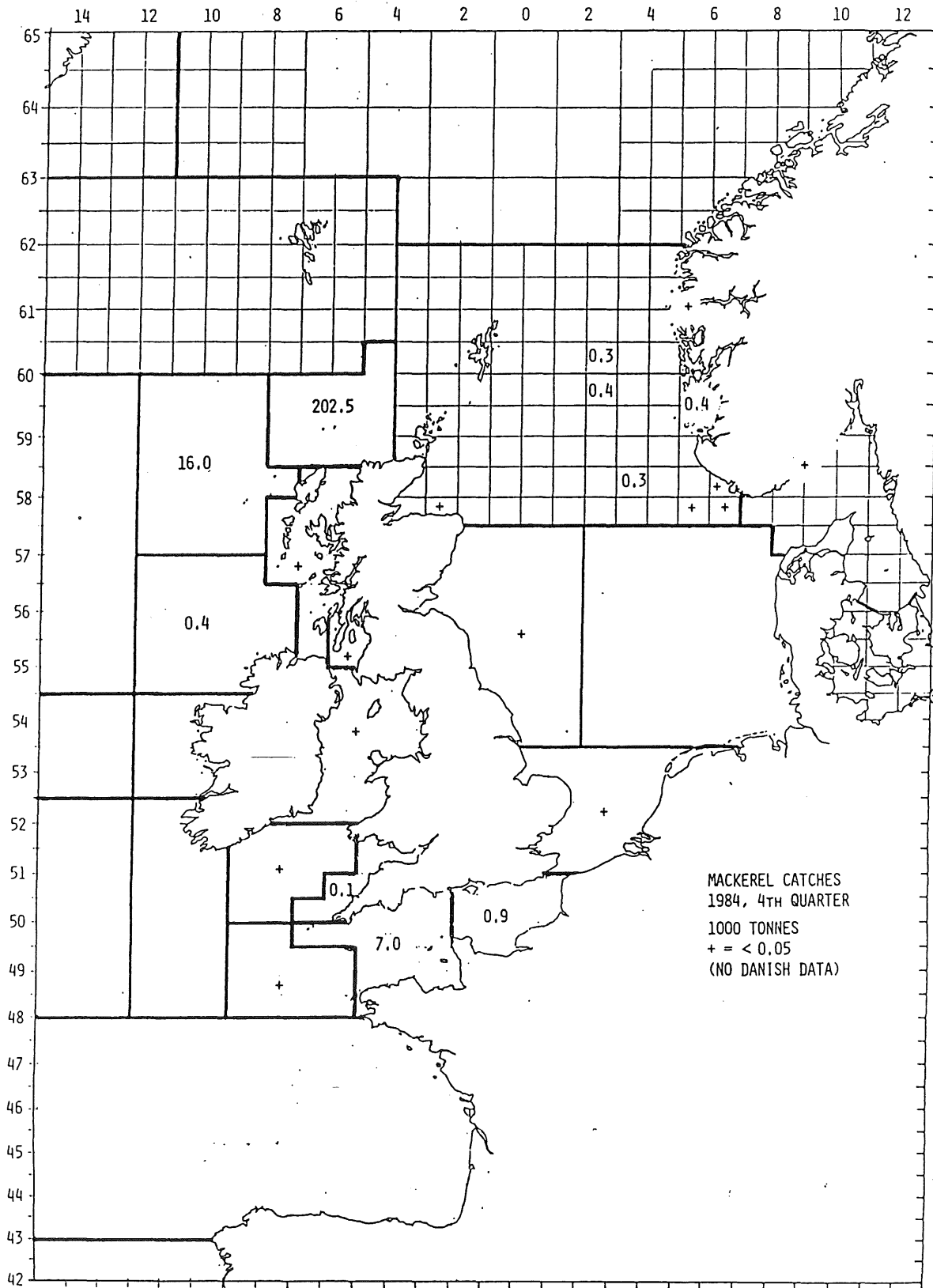


Figure 5.6 Mackerel. Catch by area. Fourth Quarter 1984.

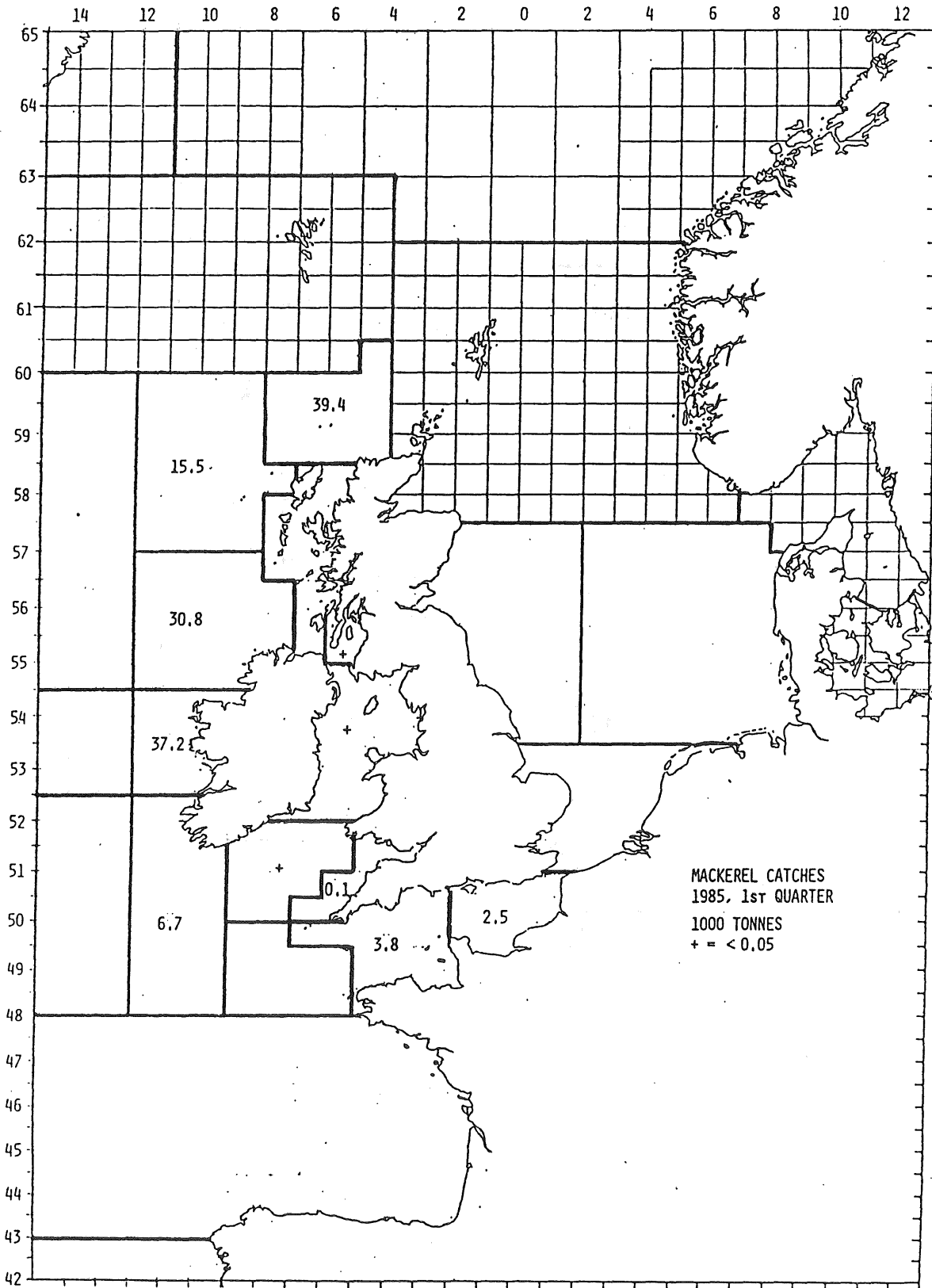


Figure 5.7 Mackerel. Catch by area. First Quarter 1985.

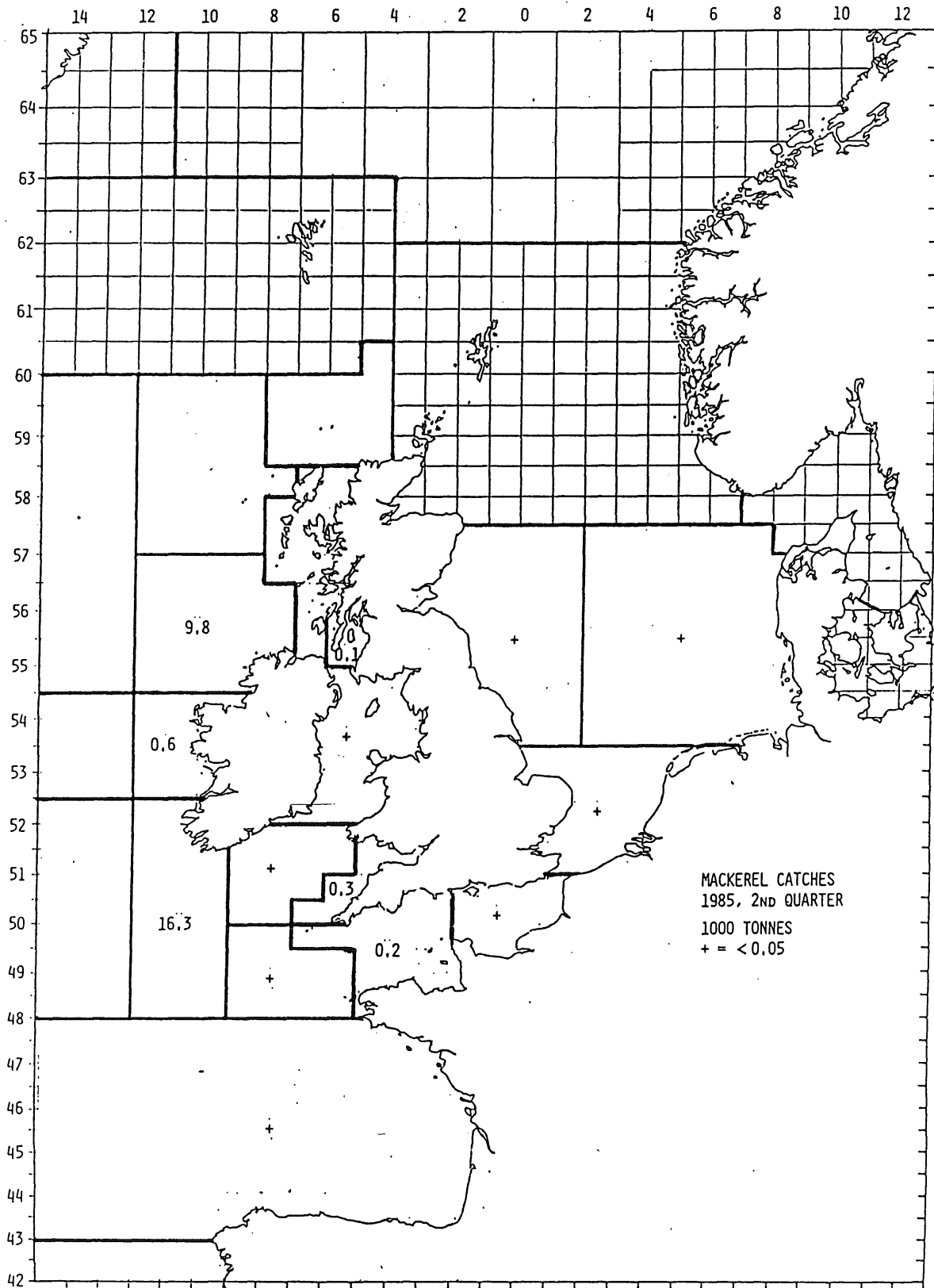


Figure 5.8 Mackerel. Catch by area. Second Quarter 1985.

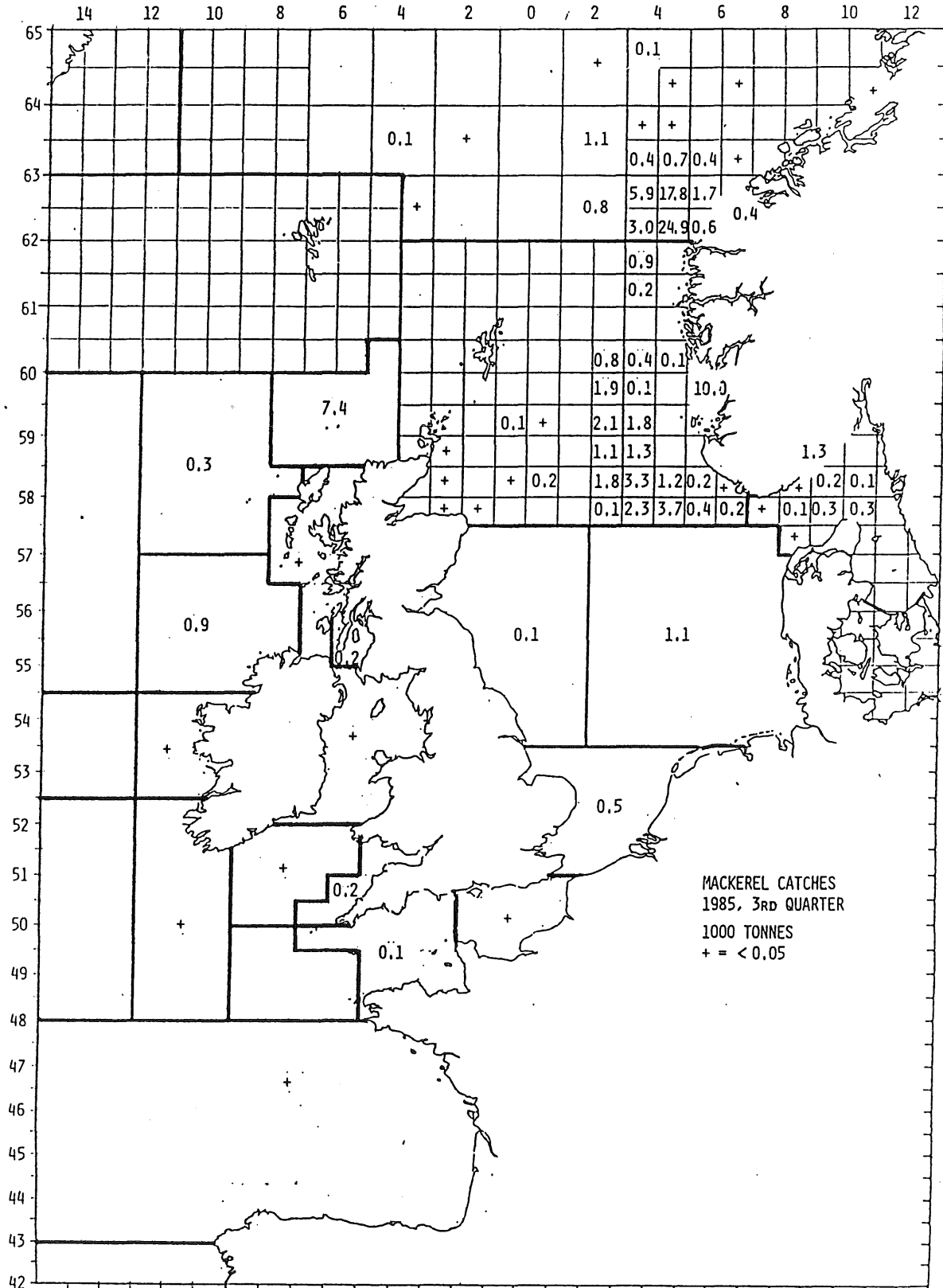


Figure 5.9 Mackerel. Catch by area. Third Quarter 1985.

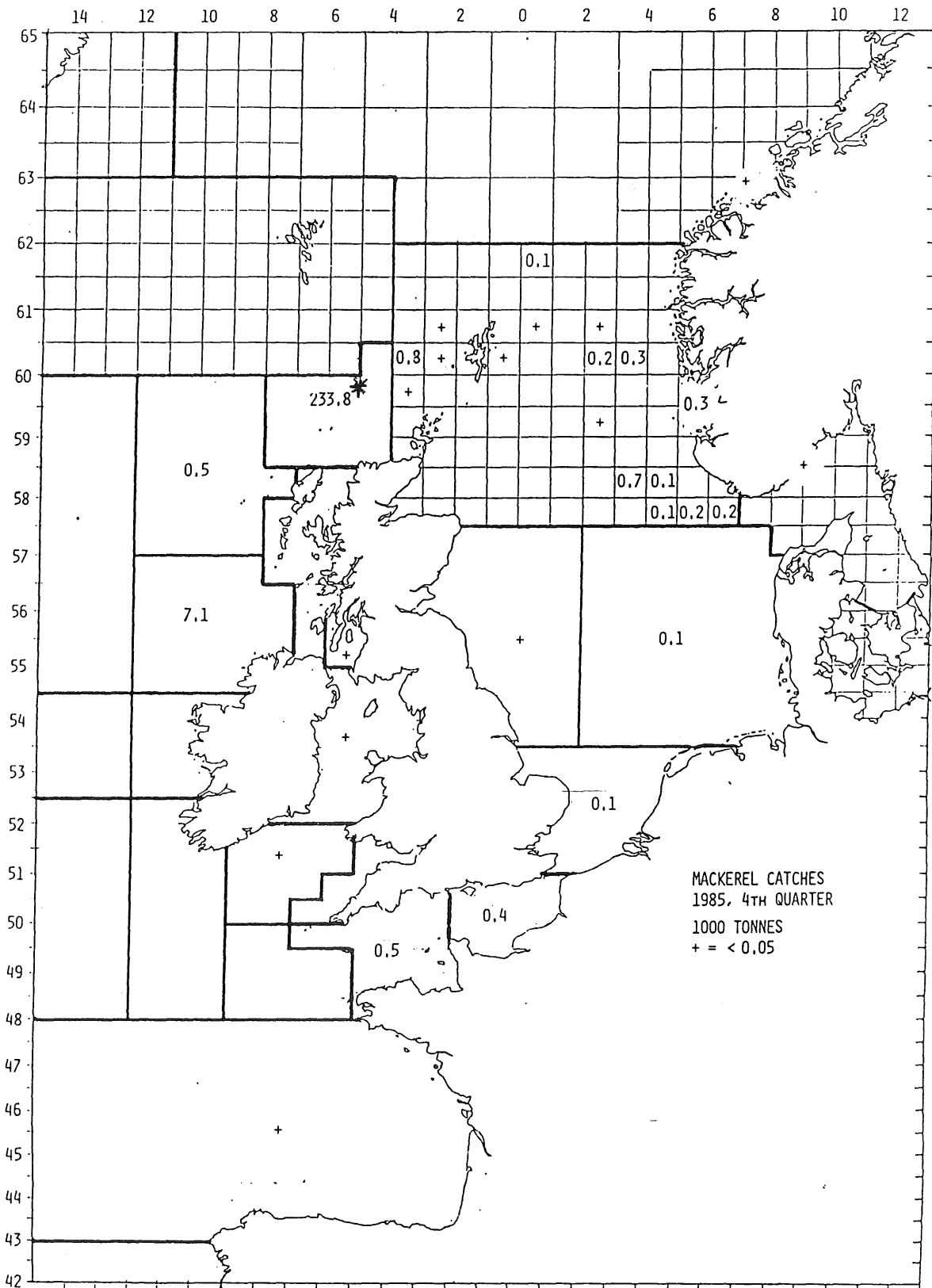


Figure 5.10 Mackerel. Catch by area. Fourth Quarter 1985.
* : Possibly includes catches misreported from the Western part of Division IVa.

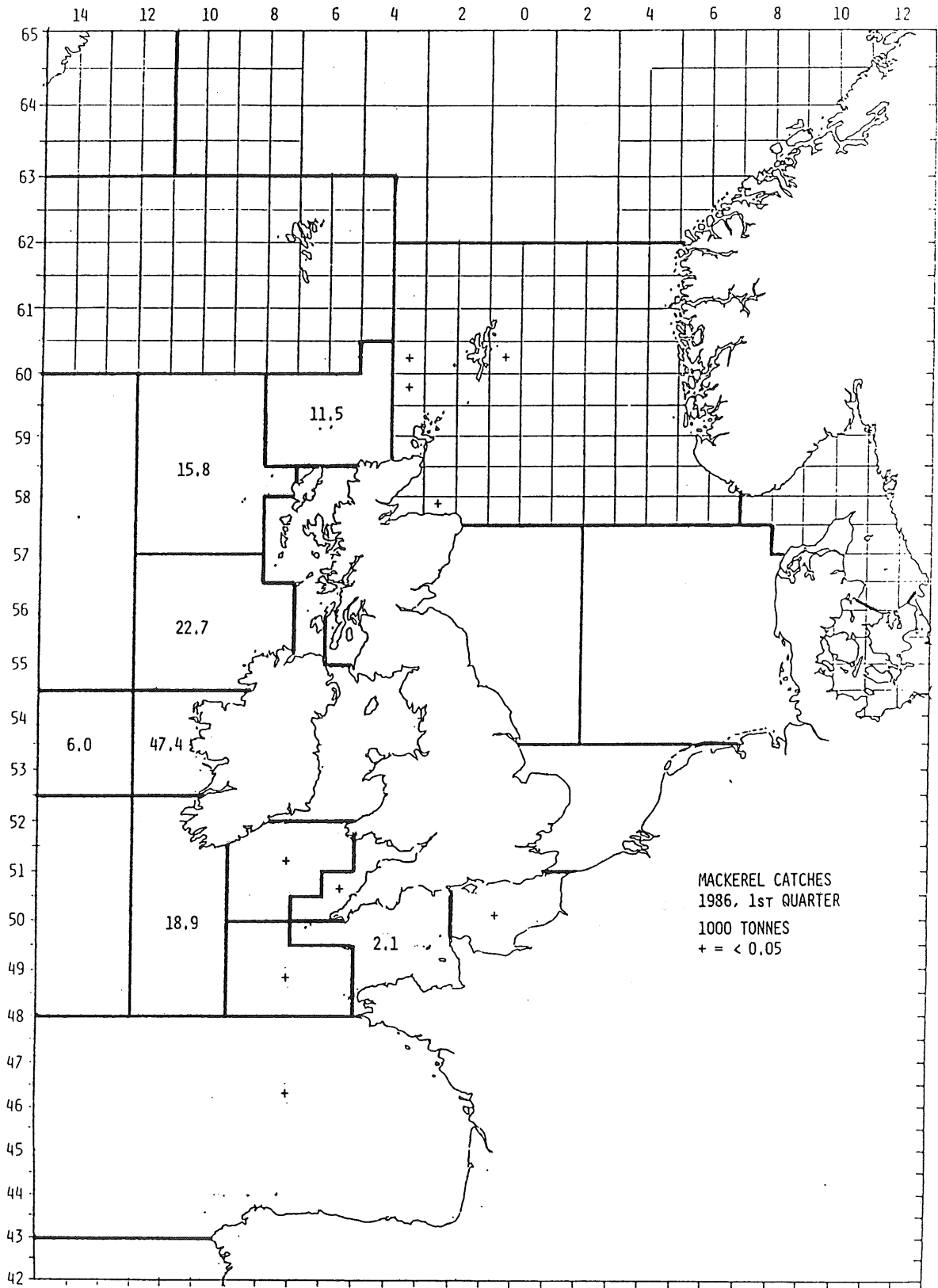


Figure 5.11 Mackerel. Catch by area. First Quarter 1986.

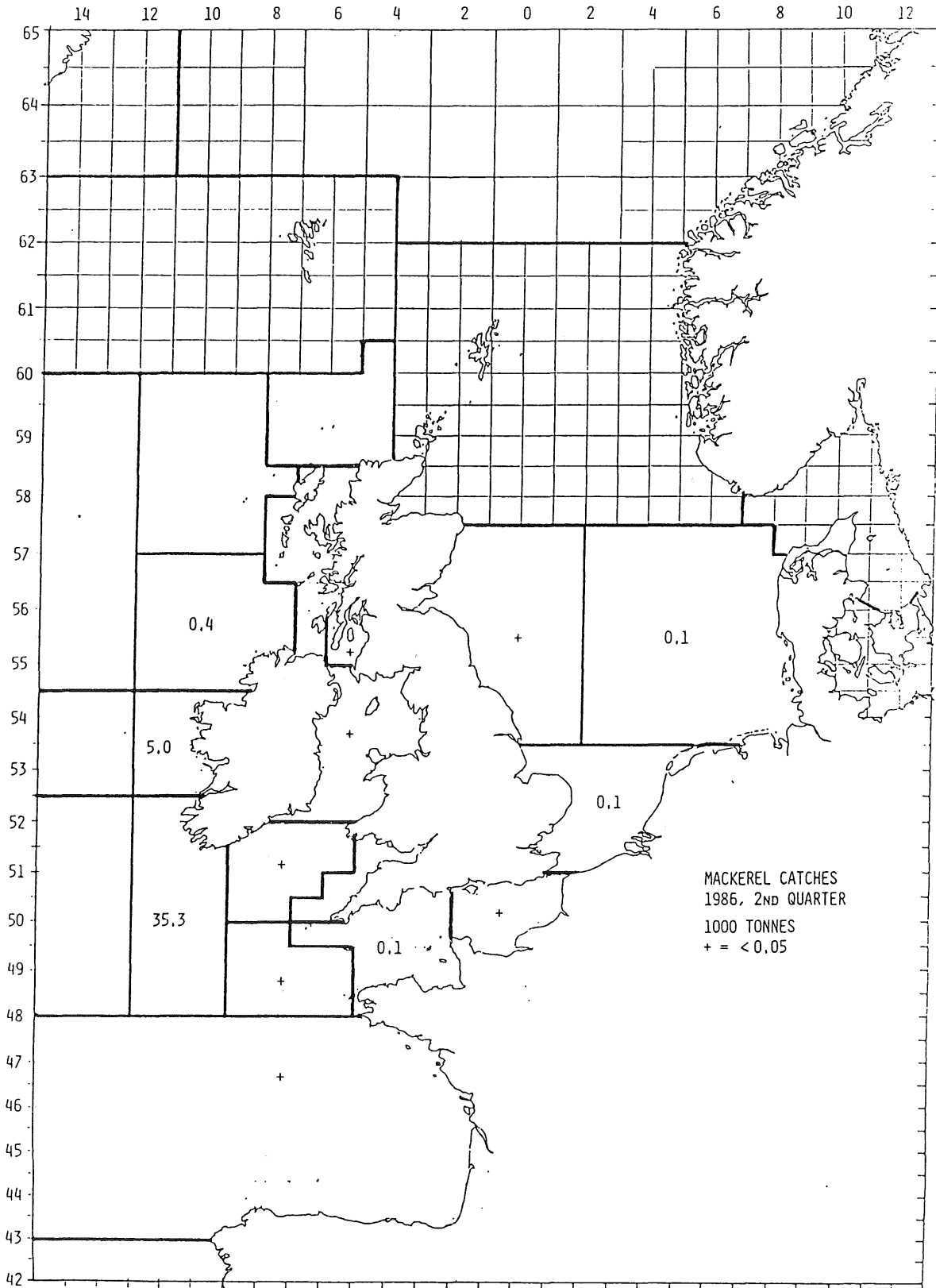


Figure 5.12 Mackerel. Catch by area. Second Quarter 1986.

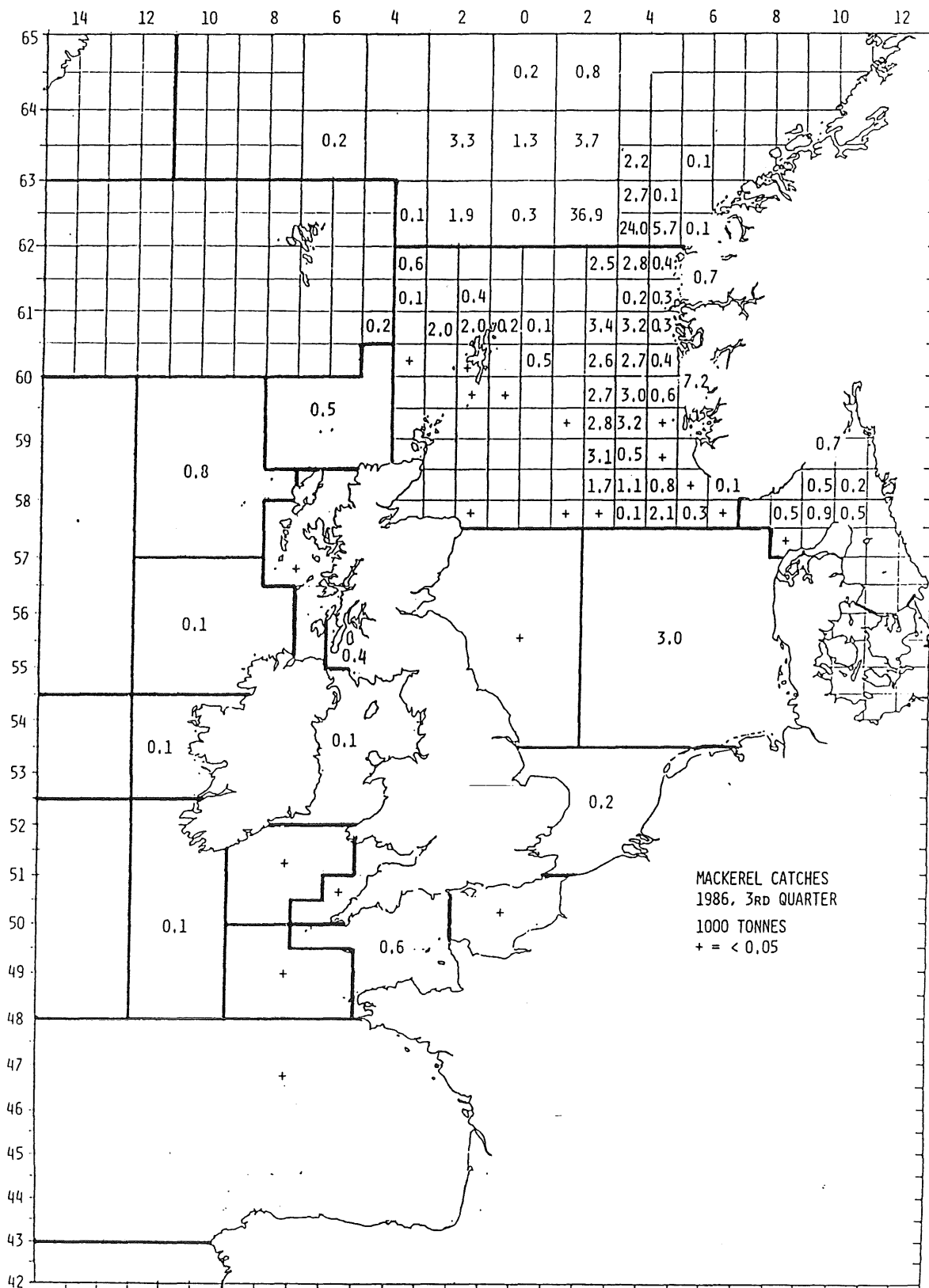


Figure 5.13 Mackerel. Catch by area. Third Quarter 1986.

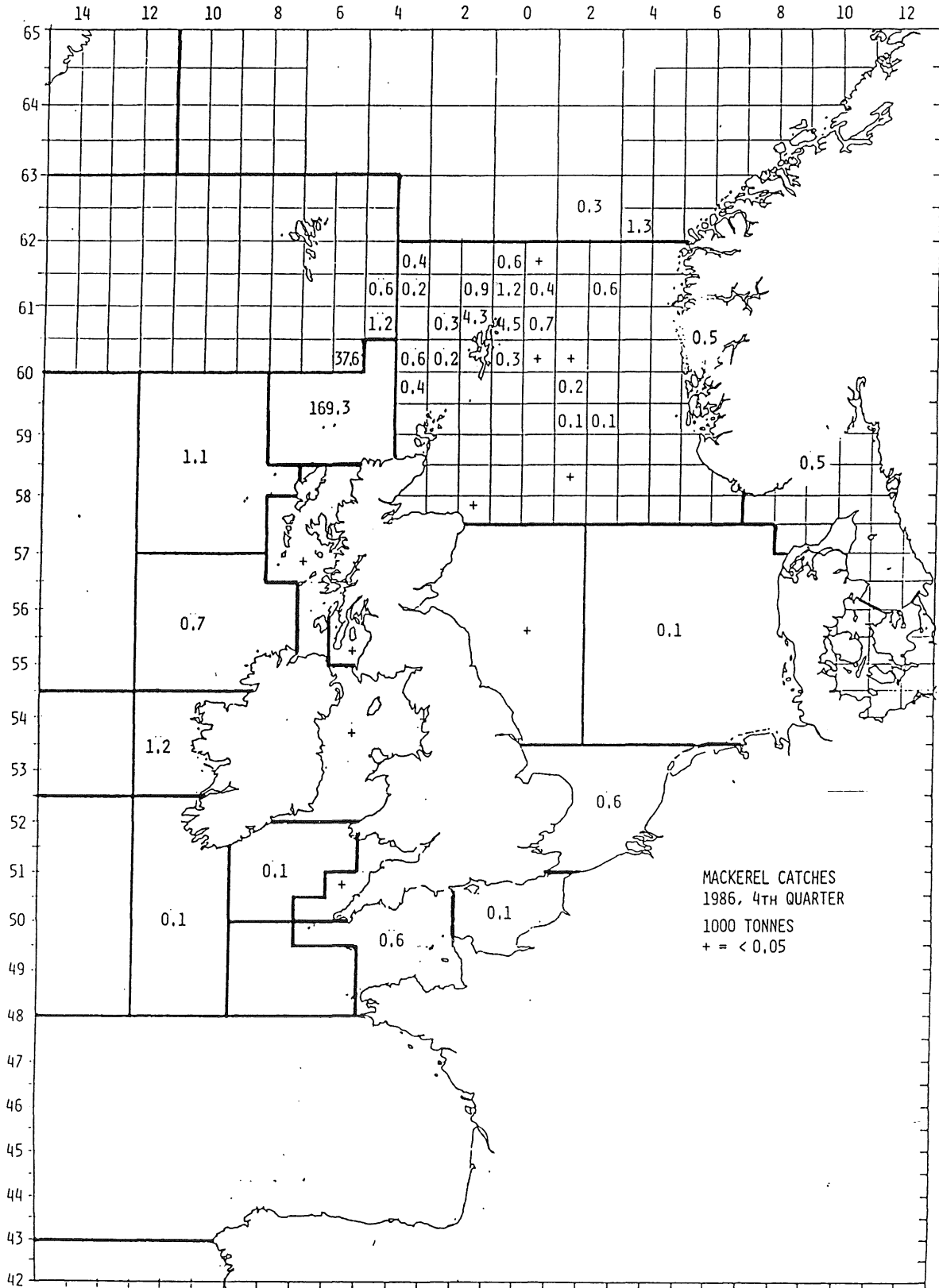


Figure 5.14 Mackerel. Catch by area. Fourth Quarter 1986.

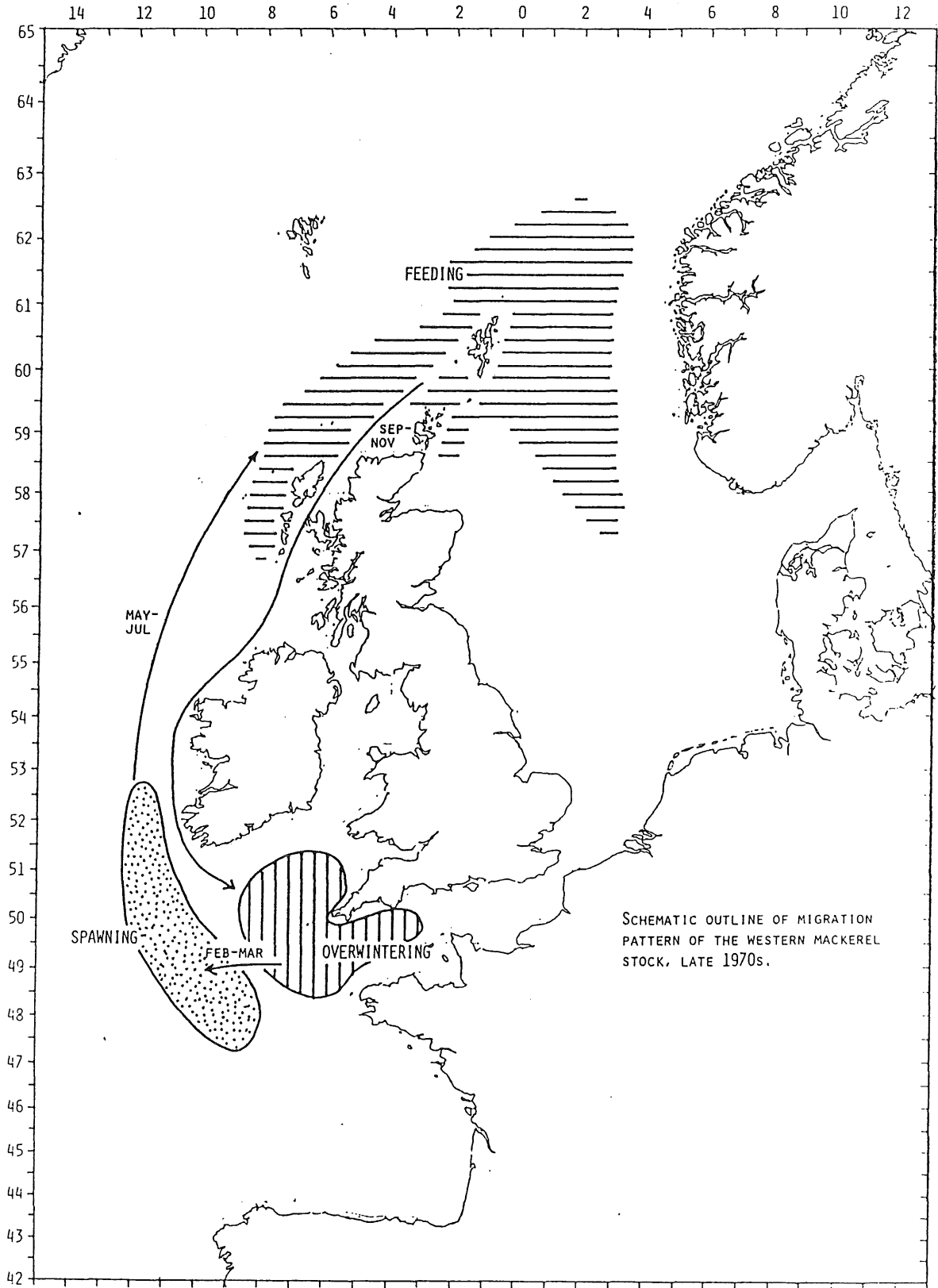


Figure 6.1 Schematic outline of the migration pattern of the Western mackerel stock, in the late 1970's.

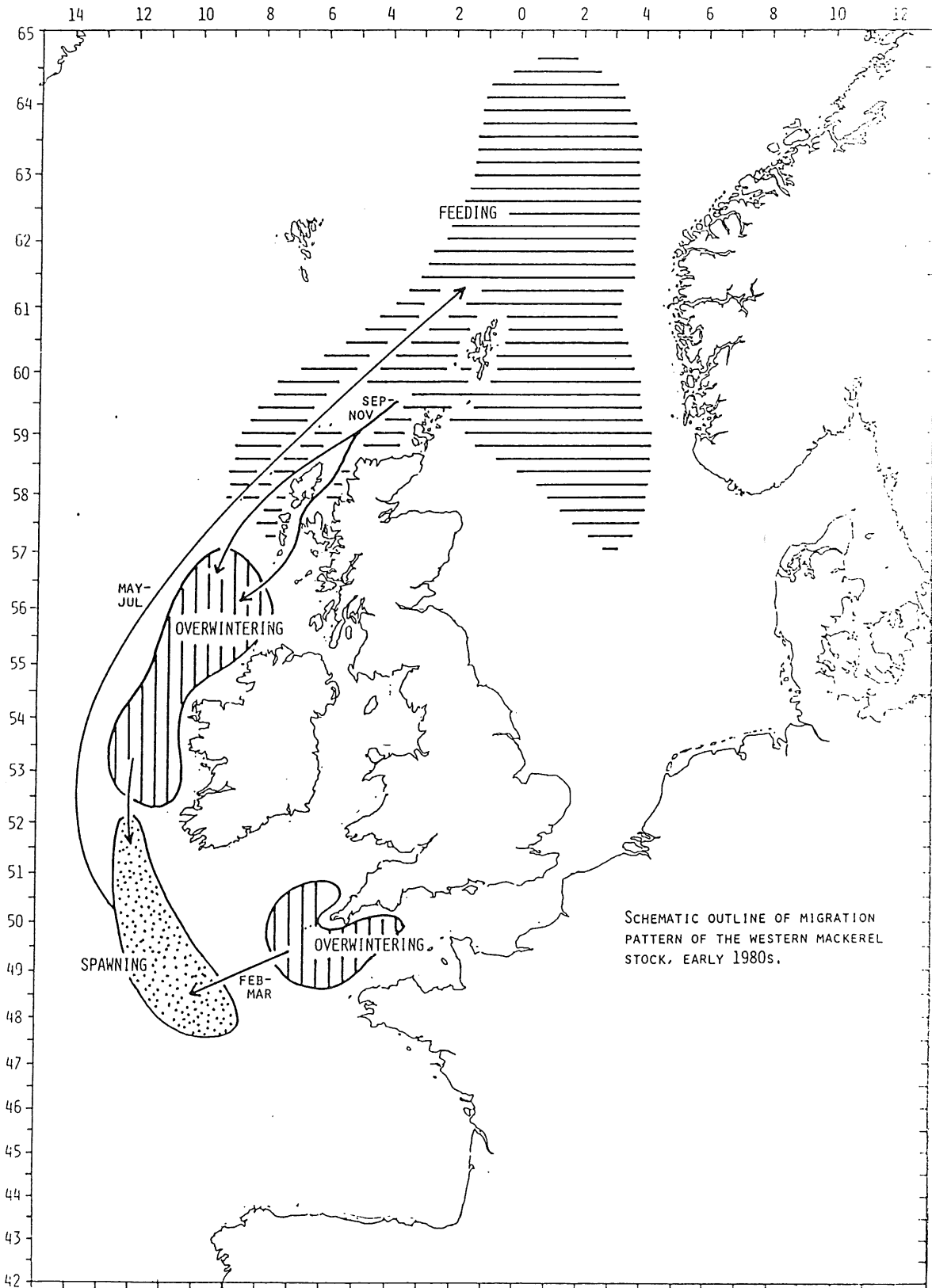


Figure 6.2 Schematic outline of the migration pattern of the Western mackerel stock, in the early 1980's.

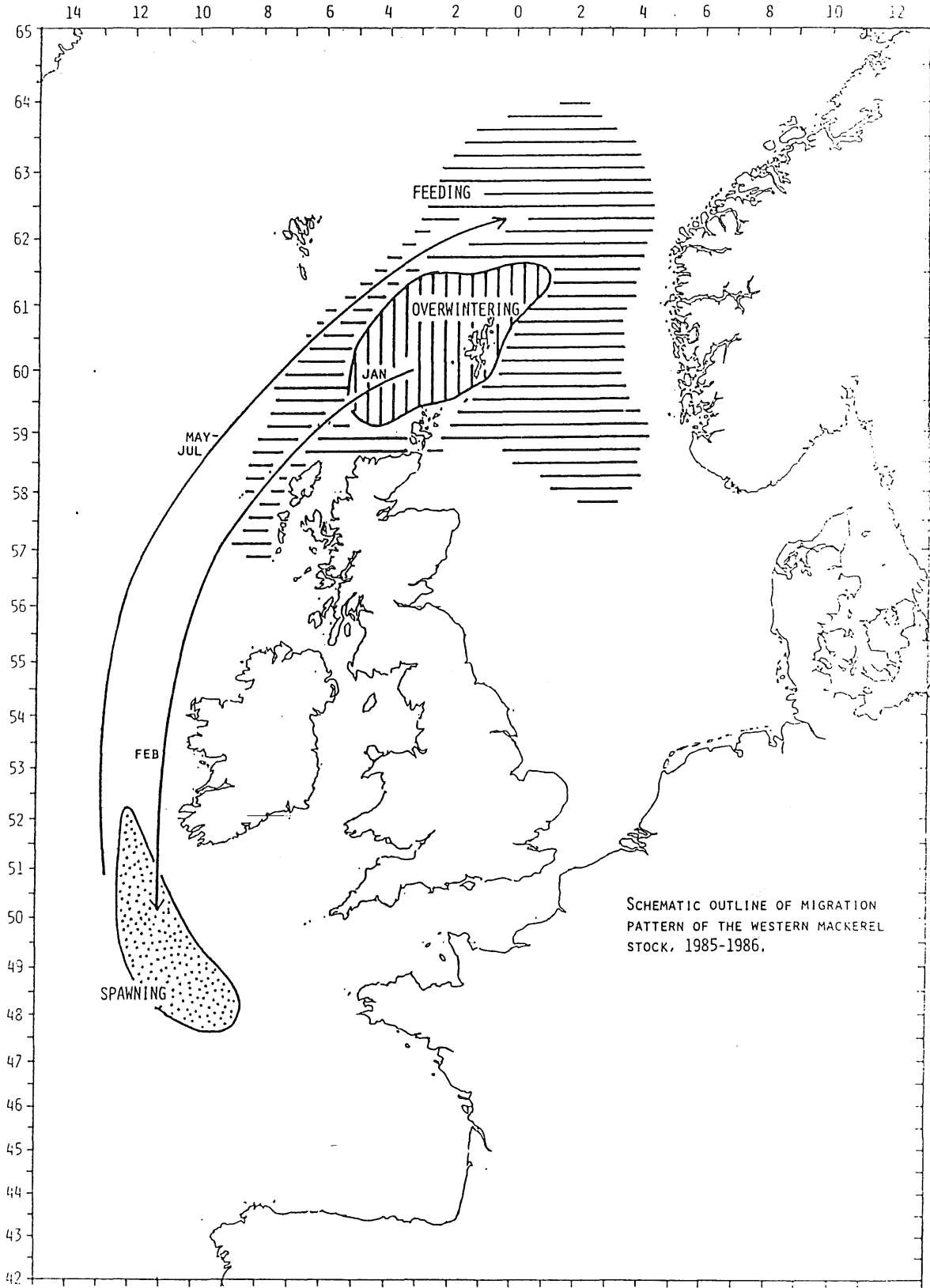


Figure 6.3 Schematic outline of the migration pattern of the Western mackerel stock, in 1985 and 1986.

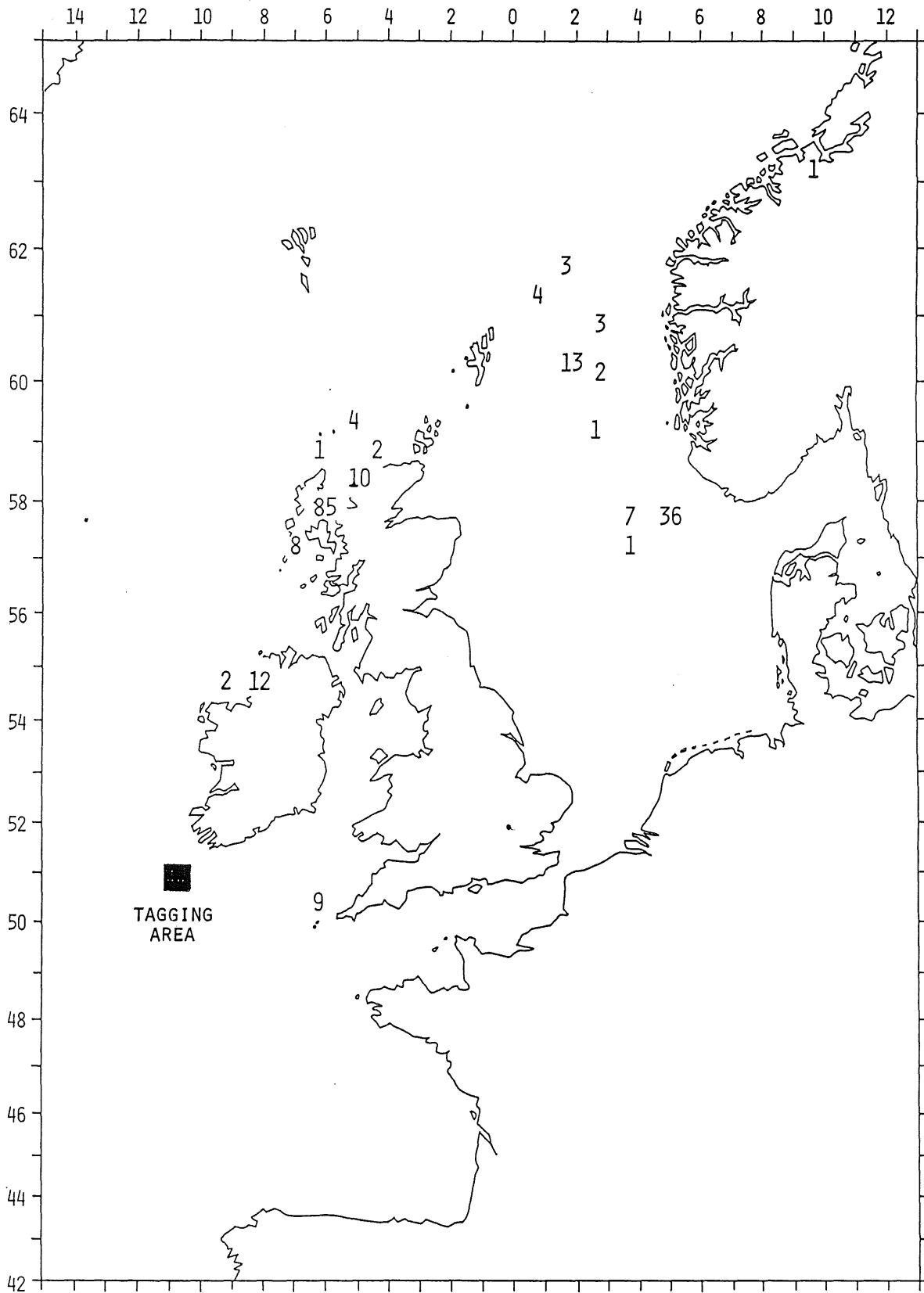


Figure 6.4 Number of tagged mackerel released in May and recaptured at known location later the same year, 1977 - 1981. Norwegian data.

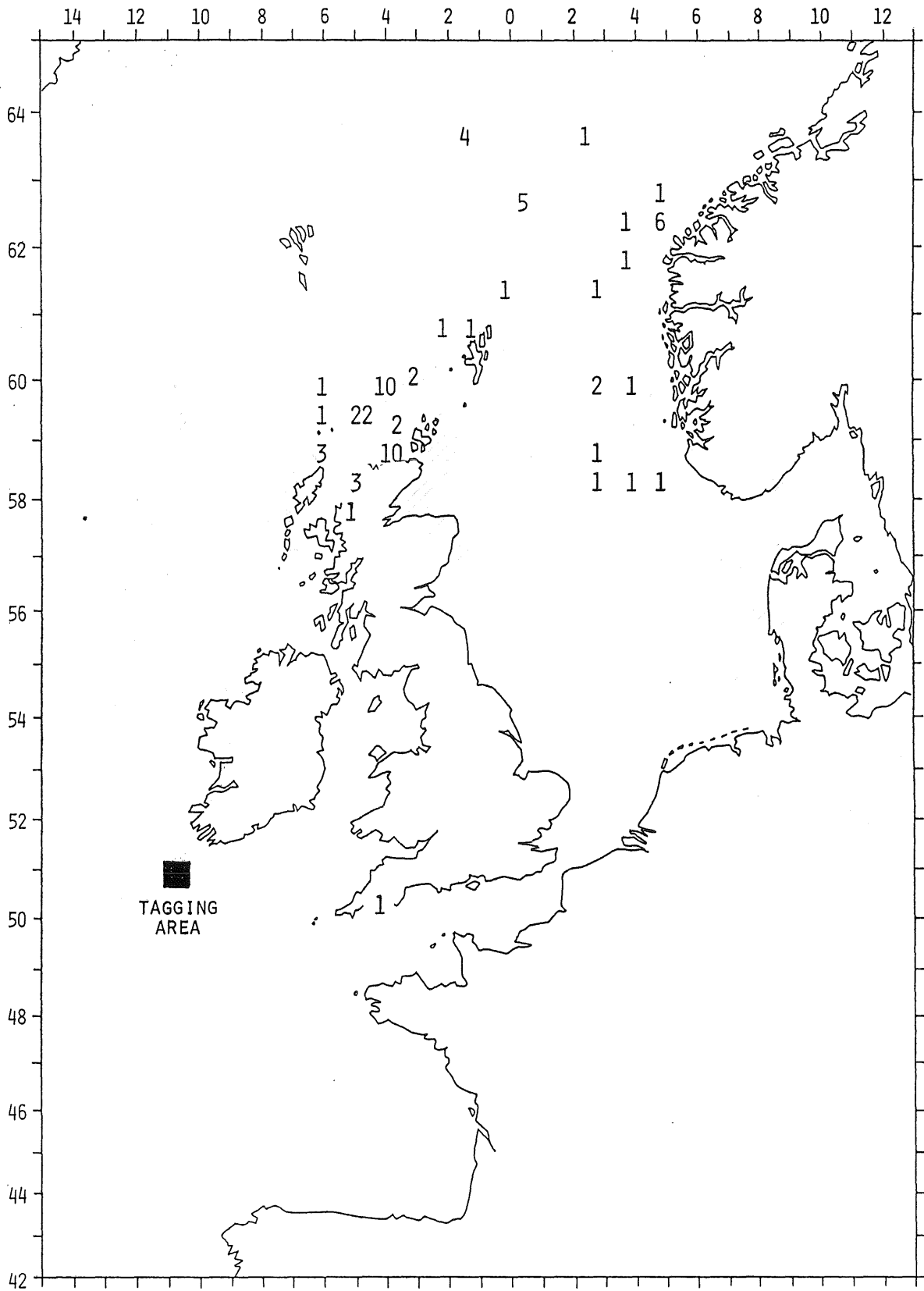


Figure 6.5 Number of tagged mackerel released in May and recaptured at known location later the same year, 1982 - 1986. Norwegian data.

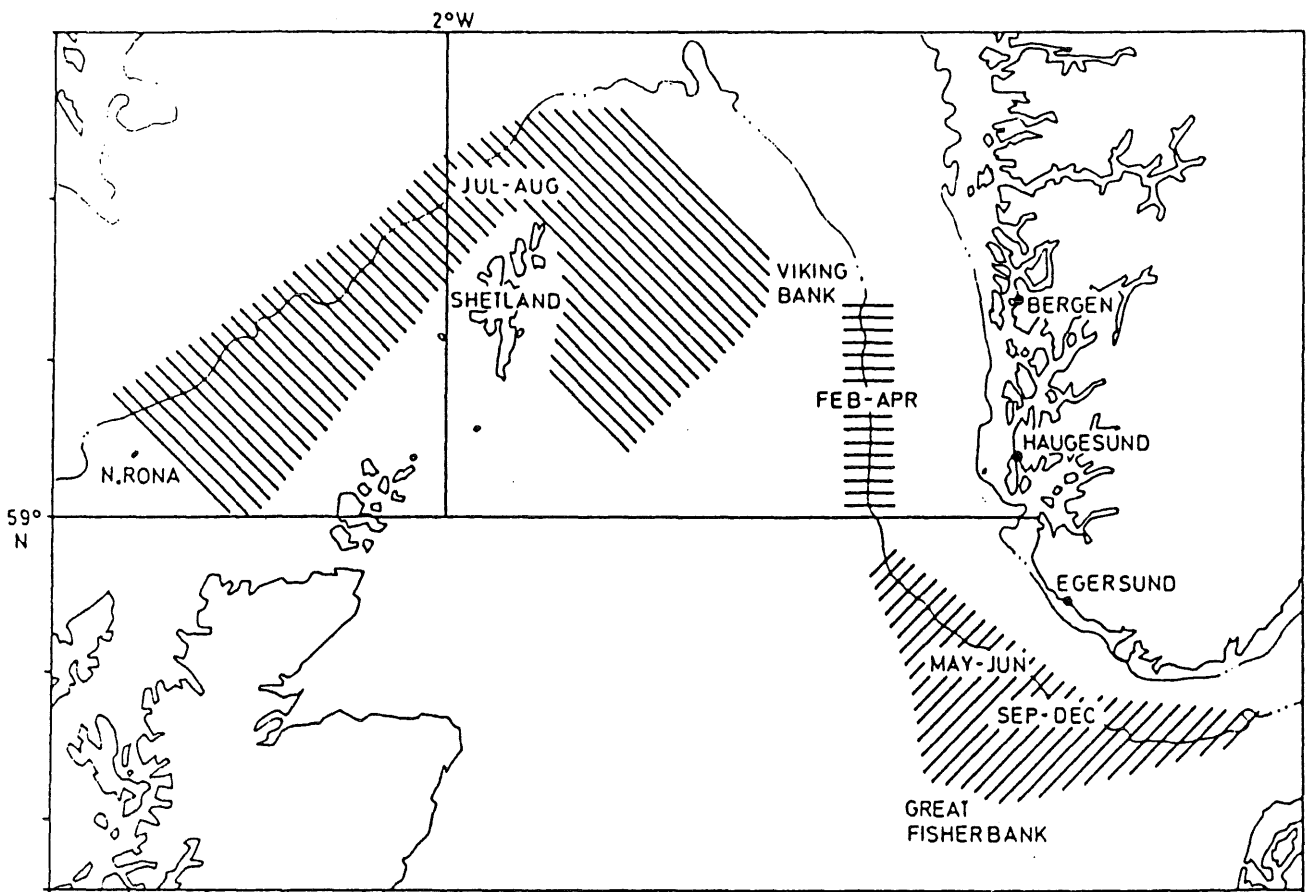


Figure 7.1 Main mackerel fishing grounds of Norwegian purse seiners by season, 1965-1975. (From Hamre 1980).