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REPORT OF THE ASSESSMENT GROUP ON HERRING
AND HERRING FISHERIES IN THE NORTH-EASTERN ATLANTIC

<u>Contents</u>	Pages
A. Introduction	1-2
B. General Considerations:-	
(a) On Population Dynamics in Herring	2-3
(b) On Regulatory Measures in Herring Fisheries	3
C. The Atlanto-Scandian Herring:-	
(a) Biology of the Atlanto-Scandian Herring and its Recent Trends	3-4
(b) Development of the Fisheries based on Atlanto- Scandian Herring	4-6
(c) Discussion	6
(d) Conclusions	6
D. The North Sea Herring:-	
(a) Biology of the North Sea Herring and its Recent Trends	7
(b) The Development of the Herring Fisheries in the North Sea	7-9
(c) Discussion	9
(d) Conclusions	9-10
Appendix I "List of Reports on Herring"	11/12
Tables 1-13	13-26
Figures 1-14	27-40

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A. INTRODUCTION

The North-East Atlantic Fisheries Commission (NEAFC), at its meeting in The Hague in May 1964 adopted the following resolution:-

"The Commission wishing to consider further at its third meeting what use if any should be made of the powers under the Convention for the conservation of the herring stocks invites the International Council for the Exploration of the Sea to continue through the Liaison Committee its study of the state of the stocks of herring in the Convention area".

Following this resolution the Liaison Committee of ICES appointed a group of experts to prepare a report on the present state and the exploitation of the herring stocks in the North-Eastern Atlantic. The Group consisted of:-

Dr. G. Hempel, CHAIRMAN
Mr. J. A. Gulland, Secretary of the Liaison Committee
Dr. D. H. Cushing
Dr. S. S. Fedorov
Dr. H. Höglund
Mr. J. Jakobsson
Mr. Cl. Nédélec
Mr. B. B. Parrish
Dr. J. Popiel
Mr. K. Popp Madsen
Mr. O. J. Østvedt
Mr. J. J. Zijlstra.

At a meeting of the Group during the Annual Meeting of ICES 1964 it was agreed that MM. Jakobsson and Østvedt, and MM. Popp Madsen and Zijlstra should prepare drafts for the special parts on Atlanto-Scandian herring and on North Sea herring respectively for further consideration by the entire Group which should prepare the final report during its meeting to be held at the first week of January 1965 in the "Bundesforschungsanstalt für Fischerei" in Hamburg. The Liaison Committee appointed Dr. Popiel as co-ordinator for the two small drafting groups. It was decided to focus the report on the main stocks of North Sea and Atlanto-Scandian herring and not to discuss also stocks of less economic importance.

International studies of the stocks of herring in the North-East Atlantic have been continuing for several years, and have been reviewed by two Working Groups of the Herring Committee of ICES, i.e. the North Sea Herring Working Group and the Atlanto-Scandian Herring Working Group. The Liaison Committee set up a Herring Assessment Group on the North Sea Herring and its Exploitation, which met early in 1964 and presented a report which was submitted to the NEAFC at its second meeting at The Hague in May 1964 (see List of Documents, Appendix I).

The present Group was set up to consider the reports of the previous Working Groups mentioned, present new information, and include samples of the possible effects of various regulation measures.

The following report falls into three main parts. The first offers some general considerations concerning the effect of fishing on stocks of herring, and on the total catch and catch per unit effort. The second and third parts deal with the main Atlanto-Scandian and North Sea stocks, respectively. These parts will consist of four sections as follows:-

- (a) the biological features of the stocks and recent trends in distribution, year-class strength, growth, and total mortality.
- (b) the trends of catch and catch per unit effort in the fisheries.
- (c) the extent to which the changes described in (a) are due directly or indirectly to fishing.
- (d) the effect of possible regulations on total catch and catch per unit effort.

Conclusions on the questions (a) and (b) have been reached through national and international research. It has, however, proved more difficult to reach conclusions regarding question (c). The main uncertainties concern:-

- (i) the difficulty of dividing the total loss ("total mortality") into that due to fishing (fishing mortality) and that due to other causes (including natural mortality and movement out of the reach of the fishery), and
- (ii) whether recruitment (year-class strength) is significantly affected by changes in the size and composition of the spawning stock.

B. GENERAL CONSIDERATIONS

a. On Population Dynamics in Herring

Many demersal fish (e.g. cod, plaice) increase in weight by 20-30 times during their exploited adult life-spans. In those stocks heavy fishing results in a decrease in total landings. In contrast, adult herring rarely increase in weight by more than twice, so that there is little or no decrease in total catch at high rates of fishing. This difference is illustrated in Figure 1 (page 27), which shows the relations between equilibrium catch per recruit and fishing intensity for plaice and herring. For stocks having a flat-topped curve (Figure 1 b), when the fishing effort is very high a moderate reduction of fishing effort will have little effect on total catch. Catch per unit effort, however, will be increased, and catch will be taken at reduced cost.

However, the flat-topped shape of the curve shown in Figure 1 b and the conclusions drawn above only apply if recruitment is independent of the size of the spawning stock over the range of stock sizes encountered in practice. If recruitment decreases with decrease in spawning stock size, the curve will have a maximum at some intermediate level of fishing effort. Doubts have been expressed whether recruitment is independent of stock size in some herring stocks.

Of practical importance is the variation in the catch due to variations in year-class strength. As the fishing effort increases fewer age-groups are represented in the exploited stock, until the fishery is based virtually on a single year-class. A high fishing effort will therefore produce less steady catches than low fishing effort.

The age when gain by growth becomes less than the loss by natural mortality is very early in herring. Thus regulations to increase the size at first capture, e.g. mesh regulation, which are used in demersal fisheries, are not applicable to adult herring fisheries.

Fisheries for immature herring can be considered in two ways. So far as the adult fisheries are concerned it is best considered as reducing the adult recruitment, and this reduction will presumably be equal to the percentage of the immature stock removed by fishing. The effect on the total catch (immature + adults) depends on the fishing mortality in the adult fishery, and on the difference in size of fish in the juvenile and adult fisheries and on the natural mortality which occurs in the time interval between these two phases. Heavier fishing on the adults, a larger difference in size between adults and juveniles and lower natural mortality tend to make the loss in weight to the adult fishery greater than the weight caught in the juvenile fishery.

The yield of herring fisheries is not influenced by the fishery alone, but also by natural changes in the stocks. In Atlanto-Scandian herring recent changes in place and time of spawning and in migratory routes were very striking and influenced the fishery considerably. In the northern North Sea recruitment was much higher in the middle and late fifties than before. In Downs herring, growth rate in the early fifties and in most recent years was higher than before the War and in the late fifties. The fish recruited also at a younger age. High growth rate and early recruitment were favourable to the fisheries.

b. On Regulatory Measures in Herring Fisheries

At meetings of the Permanent Commission and North-East Atlantic Fisheries Commission, various delegations have mentioned as possible regulation measures the closure of spawning areas, the protection of young herring, and the limitation or reduction of the total fishing effort.

In general, regulatory measures in a fishery can be of two types (1) those which increase the minimum age (and size) of fish when entering the fishery and (2) those which reduce the fishing mortality in the adult stock. Measures of the first type, such as minimum landing size or minimum mesh size in the fisheries on adult herring can be disregarded because of the small growth in adult herring. The introduction of those measures would result in losses in catch and would also be impracticable in many cases.

On the other hand, in the industrial fisheries on juvenile herring, some of the fish may be smaller than the optimum size of capture; therefore, for those fisheries closed areas, closed seasons, mesh regulations or size limits have been mentioned as possible regulatory measures.

A reduction in fishing mortality can be achieved by various measures:-

- (1) Reduction of fishing effort by limiting the number of boats or the number of days each boat is allowed to fish.
- (2) Catch quotas.
- (3) Closed areas.
- (4) Closed seasons.

The wide range of distribution and migration of herring, the seasonal mixing of the stocks and possible irregularities in the migratory pattern make measures which intend to reduce fishing effort for one stock only difficult to implement. However, since the Downs stock is segregated from other stocks in the Southern Bight in autumn and winter, some selective reduction of fishing effort on it could be achieved at this time.

c. THE ATLANTO-SCANDIAN HERRING

(a) Biology of the Atlanto-Scandian Herring and its Recent Trends

The Atlanto-Scandian herring group is composed of both spring and summer spawners. The centres of spring spawning are off the west coast of Norway, along the south coast of Iceland, on the Faroe plateau and along the eastern and northern edges of the North Sea shelf and to the north and west of Scotland. Norwegian spring spawners are the most important stock followed by the Icelandic spring and summer spawners.

The main centre of summer spawning is along the south and west coasts of Iceland in the same general localities as the spring spawning, but some summer spawning also takes place around the Faroes.

Adults of the main group mix on the fishing grounds north and east of Iceland. They segregate, however, on the spawning grounds and to a large extent on the overwintering grounds.

In the first years of life the Norwegian spring spawners are distributed along the Norwegian coast and in the Norwegian and Barents Seas. Recent detailed investigations have shown that the extent of their oceanic distribution, relative to the coastal concentrations, appears to be larger for rich year-classes than for poor ones. The adolescent Icelandic spring and summer spawners probably remain in Icelandic coastal waters.

A number of biological features of these stocks have recently shown definite trends of which the following are probably the most important:-

1. During the forties and fifties a gradual increase in the relative importance of the Norwegian spawning grounds north of Cape Stad took place. This coincided with a delay of approximately one month in spawning time. In the last two years the entire spawning fishery was confined to the region from Kristiansund to the Lofoten islands.
2. The recruitment of the very rich year-class of 1950 to the adult stock of the Norwegian spring spawners in the middle of the fifties was followed by a series of 8 poor year-classes. This resulted in a decline of the adult stock and an increase in its average age until 1963 and 1964 when the strong 1959 and 1960 year-classes began recruiting to the adult stock.
3. Total mortality rates of Norwegian spring spawners calculated from tagging and age-composition data increased in the late fifties.
4. The average length at age in Norwegian spring spawners showed a general increase since the forties.
5. In the Icelandic summer fishery, which is exploiting mainly Norwegian and Icelandic spring spawners, the relative importance of the Icelandic spring spawners increased during the period 1956-1962, but in 1963 and 1964 this proportion decreased again to less than 1/3 of the total catch.
6. The main fishing on the Icelandic feeding grounds has recently shifted from the north to the east coast of Iceland.

(b) Development of the Fisheries Based on Atlanto-Scandian Herring

Until the early fifties the Atlanto-Scandian herring stocks were mainly exploited in coastal waters by Norwegian and Icelandic land-seines, purse-seiners and drifters. From 1950 onwards the Soviet herring drifters have carried out an extensive all-year-round fishery in the open ocean; during the same period the Norwegian and Icelandic purse-seine and drift-net fisheries have also extended into the open ocean. Since 1961 there has taken place a rapid development of Icelandic powerblock purse-seining which resulted also in an increasing exploitation of the herring off the south-west coast of Iceland.

(i) The landings

The landings of the Norwegian spring spawners are given in Figure 2 (page 28) and Table 1 (page 13). The adult Norwegian spring spawners are mainly exploited by three fisheries:-

the Norwegian fishery on the spawning grounds along the Norwegian west coast. This fishery gave maximum annual yields of about one million tons during the period 1954-1956. It dropped to about 60.000 metric tons in 1963 but showed a recovery to 270.000 tons in 1964, due to partial recruitment by the strong 1959 year-class.

the summer fisheries off North and East Iceland. This improved in 1961-1963 after a long post-war period of poor catches (about 50.000 tons annually) to 242.000 tons per season.

the U.S.S.R. drift-net fishery. This has since 1950 exploited the Norwegian spring-spawning herring on the feeding grounds in the Norwegian Sea, in the overwintering area east of Iceland, and during the spawning migration. The annual yields increased steadily until 1960 (465.000 tons), were lower in 1961-1962 (240.000 tons), but in 1963 (330.000 tons) they improved due to the new strong year-classes.

The total annual landings of adult Norwegian spring spawners increased after the War from 400.000 tons in 1945 to 1.400.000 tons in 1956. They exceeded 1.000.000 tons during the four-year period 1954-1957 but declined rapidly afterwards. In 1963 they were less than half of the landing in 1956. During the most recent years, the quantities landed have not exceeded the catches in the years 1935-39 in spite of increased effort.

The landings from the north and east and from the south and west coasts of Icelandic spring spawners caught by purse-seine during the period 1949-1963 are given in Table 2 (page 14). The data show that following a period of very low yields of Icelandic spring spawners during the period of 1949-1954 there was a considerable increase after 1955 and especially in the period 1959-1962 when a peak level of 170.400 tons was reached. This was followed by a sharp decline in 1963 and 1964.

The landings of Icelandic summer spawners by Icelandic purse-seiners are shown in Table 3 (page 14). Comparison of Tables 2 and 3 show that the summer spawners have not contributed any major part to the north and east coast summer fishery on the main feeding grounds but on the other hand they have become increasingly dominant in the recent (1961-1963) more or less all-year-round purse-seine fishery off the south and west coast of Iceland. This fishery has of course resulted in greatly increased total landings of the stock since 1961.

Figure 3 (page 29) and Table 4 (page 15) show the landings of the small and fat herring fisheries in 1930-1963, which are based on immature Norwegian spring spawners. The catch of the small and fat herring generally stayed at a high level also during the period of poor year-classes from 1951-1958.

(ii) Catch per unit effort

The available data of catches per unit effort are shown in Figure 4 and Table 5 (pp. 30, 16). In the Norwegian winter fishery both in the purse-seine and the drift-net fisheries showed a decline in catch per unit effort since 1956-1957. The Soviet catch per haul during the pre-spawning fishery in February declined only after 1958-1959. There are signs of an improvement in the catch per unit effort in these fisheries after 1962.

Throughout the period 1946-1960 the Icelandic purse-seine catch per vessel remained very low, but during 1961-1963 they increased dramatically. Since this purse-seine fishery is based on migratory feeding shoals it has been subject to great variations in availability as well as large-scale improvements in the fishing power of the boats.

(iii) Estimates of absolute stock abundance

Estimates of the absolute abundance of the adult stock of Norwegian spring spawners made from the data on total catch and tag returns over the years 1953-1959 show a large decrease in stock size after 1956 from about 13 million tons in 1956 to 5 million tons in 1959 (last year of observation). Soviet estimates of stock size from echo-surveys and underwater photography over the pre-spawning, winter concentrations show a further decline between 1958 and 1962, followed most recently by an increase. These two sets of estimates are given in Table 6 (page 17).

Both these independent sets of data gave rather similar estimates for total abundance in the one year for which both are available (1958).

In 1957-1962 the absolute abundance of Icelandic spring spawners on the north and east coast feeding grounds exceeded that of the Norwegian spring spawners feeding there at the same time. Both groups together were estimated (from tagging data) at about 4 million tons in 1959-1960, whereas in the early fifties - due to the low abundance of Icelandic spring spawners - the corresponding estimate was 2-3 million tons. No estimates of the total abundance of the Icelandic summer spawners are available but in 1963 the total abundance of both the Icelandic herring stocks present on the south-west coast winter fishing ground was estimated from tagging data as only about 0.6 million tons in which the summer spawners predominated.

(iv) Mortality

In adult Norwegian spring spawners, estimates of total mortality (based on age-composition data) ranging from 25-40% and of fishing mortality (based on catch/absolute stock-size data) suggest that during the last decade natural and fishing mortality were of similar importance but fishing mortality was increasing somewhat during the last 5 years.

Recent tagging data on Icelandic spring and summer spawners from the south-west coast show on the other hand that there the fishing mortality is probably considerably higher than the natural mortality.

(c) Discussion

A number of independent data show that there was a sharp decline in abundance of the adult stock of Norwegian spring-spawning herring during the period 1957-1962. It is clear that the main cause of the decrease was due to a succession of 7-8 years of poor recruitment. This led to a gradual increase in the average age of the stock up to 10-12 years. In the same period a considerable shrinkage of the overwintering area was observed. Estimates of fishing mortality of the fully recruited age-groups remained approximately the same during the early years of the decline of abundance (up to 1958), but thereafter tended to increase.

The fishing for juvenile Atlanto-Scandian herring is mainly confined to Norwegian coastal waters (Norwegian "små-sild" and "feit-sild" fishery). As the distribution of juvenile herring of Norwegian spring-spawning stock seems to be related to the strength of the year-classes the juvenile coastal fishery may have a greater effect on small year-classes than on large year-classes. Information on the relative size of the exploited inshore and the unexploited offshore parts of the juvenile population and on the natural mortality in early years of life is insufficient. It is therefore at present impossible to determine whether the loss in weight to the adult fishery is less or greater than the catch in weight by the fishery on juvenile herring. It should be noted that recently the Governments of Norway and the U.S.S.R. introduced some restrictions in order to limit the catches of "små-sild".

The recent high fishing mortality and the drastic decline in the catches of Icelandic spring and summer spawners cannot be explained because the knowledge of the variable migration pattern of these stocks is very limited.

(d) Conclusion

The exploitation of the adult Norwegian spring spawners is probably still at a level where any reduction of effort exerted on the adult stock would tend to reduce the total catch (see pages 1 and 2 and Figure 1 b). The decrease in catch from 1957 to 1963 was due to the sequence of poor year-classes from 1951 to 1958. The primary cause of the failure of any of these year-classes to provide good recruitment has been natural.

The magnitude of the reduction of recruitment due to the "små-sild" fishery is not yet known. Any effect of a small herring fishery will be obscured by the very strong fluctuations in recruitment which are due to the high variation in year-class strength in Atlanto-Scandian herring.

In very recent years the rate of exploitation on Icelandic spring and summer spawners was probably higher than that of Norwegian spring spawners. Thus a further increase in effort on these stocks would under present conditions theoretically not result in a corresponding increase in total landings.

D. THE NORTH SEA HERRING

(a) Biology of the North Sea Herring and its Recent Trends

When dealing with the Near Northern Seas area, the Herring Assessment Group has for practical reasons limited its work to the North Sea autumn-spawning herring. These herring make up by far the dominant part of the herring catch in the North Sea, which has the largest share (c. 80%) of the total herring catch in the Near Northern Seas area (Figure 5, page 31).

The North Sea herring may be divided into three main groups - the Buchan, the Dogger, and the Downs herring - showing differences in spawning time and ground, in migration, year-class fluctuations, growth and other characters etc. The main spawning and feeding grounds, migratory routes, overwintering areas and nursery grounds are shown in Figures 6 and 7 (pages 32 and 33).

Adults of the three groups mix on the feeding grounds in the northern North Sea and to some degree on the pre-spawning run down the British east coast. They segregate to the spawning grounds and to some extent in the overwintering areas.

Hence the different fisheries are either carried out in areas where mixing of the different groups occurs, as for instance the summer and early autumn fisheries for feeding and pre-spawning herring, or they are exploiting one group, as for example the late autumn fisheries in the southern North Sea which are mainly based on the Downs herring.

Young immature fish from all the three groups are found together on the main nursery grounds in the central North Sea, whereas smaller concentrations can be found all over the North Sea, but especially in coastal waters.

During the fifties a number of biological features have shown very definite trends. Some of the more important of these are:-

1. A decrease in average age (Figures 8 and 9, pages 34 and 35). This feature is common to all three groups but is especially marked in the Downs herring.
2. An increase in growth rate (Figure 10, page 36). Though this seems to be a long-term development there was a sudden increase in the early fifties and again in the early sixties.
3. An increase in total mortality (Tables 7 and 8, pages 18 and 19). The values are fluctuating from year to year but the main trend of increase during the fifties is evident in all groups. The largest increase is found in the Downs herring, where the present figures indicate an annual death rate of about 76%.
4. Changes in recruitment (Figure 11, p.37). Estimates of recruitment suggest an increase in the Buchan, no trend in the Dogger and probably a decline in recruitment to the Downs stock.

To sum up, the recent herring fisheries have been based on younger, faster growing fish with a shorter life-span than in the pre-war and immediate post-war periods.

(b) The Development of the Herring Fisheries in the North Sea

Up to the First World War the method of capture was almost exclusively by drift-net. United Kingdom and Holland conducted the fishery which only took place in two seasons and areas - off Scotland and Shetland in summer and off East Anglia in autumn. In the interwar period trawling was taken up and the importance of the drift-net diminished somewhat. More countries and especially Germany engaged in the fisheries which were extended to the Fladen, the Dogger and the English Channel. The season lasted from June to January. After the Second World War the decrease in the drift-net fleets continued. Some more countries took part in the fishery which now extends over most of the North Sea and is conducted throughout the year. Especially in the latter period a rapid development of gear and auxiliary equipment for fish detection, communication etc. took place.

(i) The Landings

Tables 9, 10 and 11 (pp. 19-21) and Figure 12 (p.38) show the landings by country, area and gear. Attention is especially drawn to the following features:-

1. In the period 1900-1913 the total landings of adult herring from the North Sea ranged between 400.000-700.000 metric tons. The tables show that in the interwar period and in the present post-war period landings fluctuated between 300.000-700.000 and 400.000-800.000 metric tons respectively. So, in spite of the development in the fisheries outlined above, the maximum levels of total catch of adult herring are not very different in the three periods.
2. In the northern North Sea landings have been sustained at the rather high level reached before 1954. In contrast landings from the southern North Sea have dropped to less than half of the average for the period from 1946-1954.
3. Since 1950 Denmark and Germany have developed a fishery for young, immature herring in the eastern North Sea. If these catches are added to the landings of adult herring the total output of the North Sea herring fisheries shows a higher level than in any preceding period (Table 12, p.23). The immature fisheries reached a maximum in 1958-59 and have shown a general decline thereafter.
4. In the last two years a very important winter fishery for spent North Sea herring has re-developed in the north-eastern North Sea and Skagerak. Due to this fishery the total landings from the North Sea and Skagerak reached a new record in 1964 (judging from preliminary figures).

(ii) The catch per unit effort

Catch per unit effort for the trawl and drift-net fisheries in the northern, central and southern areas during post-war years are given in Tables 13 a, b, and c (pp.24-26) and Figure 13 (p.39). They show:-

1. In the northern area, the catch per unit effort of the trawl fisheries declined during the post-war period. It declined sharply between 1945-48, and thereafter fluctuated without trend until 1955, when a further decline took place. In the drift-net fisheries, no marked downward trend is evident during this period, except for 1945-1950. In fact, the catch per unit effort in these fisheries increased after 1950.
2. In the central area, the catch per unit effort of the trawl fisheries remained reasonably steady up to 1954, but thereafter declined. Again, as in the northern area, the data for the drift-net fisheries show no clear decreasing tendency.
3. In the southern area (IV c and VII d), the catch per unit effort of both the trawl and drift-net fisheries fell in the middle of the fifties.

(iii) The effort

Estimates of the total fishing effort in the northern, central and southern North Sea fisheries during post-war years were derived by the division of total catch by catch per unit effort. These data are illustrated in Figure 14 (p.40) and show that in the southern North Sea fishing effort increased somewhat between 1945-55 and thereafter decreased. If, however, a possible increase in efficiency of the southern drift-net fishery is taken into consideration, the later decrease is of a small order only.

In the northern and central areas effort remained comparatively steady between 1948 and 1955 and thereafter increased. According to the preliminary data an acceleration took place in 1963 and 1964 when the fishery in the north-eastern North Sea and Skagerak re-déveloped.

(c) Discussion

A central feature in the post-war changes of the North Sea herring stocks is the decrease in the average age of the herring. The following factors are most likely responsible:-

1. An increase in total mortality rate (Z)

which reduced the abundance of the older age-groups. This is reflected in a decline in the catch per unit of effort of these age-groups in most fisheries. The total mortality rate consists of two components:

- a) mortality due to the fishery (F) and
- b) loss by natural causes (M) i.e. predation, disease, emigration, etc.

There is no complete agreement among scientists on the division of total mortality into these two components. However, it was considered that in the southern North Sea fishing mortality has increased to a level greater and possibly much greater than natural mortality. In the central and northern North Sea fishing mortality has perhaps reached at least as high a level as natural mortality.

2. The decrease in the age of recruitment.

Before 1950 recruitment took place mainly at four years of age, whereas in later years recruitment has been almost completed at age three, thereby reducing the average age by about one year. This change in age at recruitment seems to be connected with the increase in growth rate.

Besides the effect on the average age of the stock, changes in the annual number of recruits, as probably occurred in the Buchan and Downs stocks, has an immediate effect on the fishery. A decline in recruitment which has probably taken place in the Downs stock since 1955 could be a major cause of the rapid decline of the total landings and catch per unit effort in the Southern Bight. There is, at present, no certainty concerning the causes of this decline, but the decrease of stock size and the subsequent decrease of recruitment could be considered as cause and effect, the adult stock being no longer large enough to ensure sufficient recruitment.

The industrial fishery on juvenile herring has also to be considered as a cause of the reduction in recruitment to this stock. However, that this cannot be a major contributory cause of the recent reduction is shown by the results of tagging experiments in the juvenile herring fishing in 1957 and 1958, which gave estimates of a fishing mortality rate of 15-20%, compared with the probable decrease in recruitment to the Downs stock of 60-70%.

(d) Conclusions

While in the northern and central North Sea landings have remained at a fairly high level, those in the southern North Sea have declined greatly. The following conclusions therefore refer only to the fisheries in the southern North Sea, and how their catches could be improved by regulations.

The scientists are confronted with four facts:-

- (1) The catch in the southern North Sea and the English Channel decreased after 1955 by three times.
- (2) At the same time the fishing effort in the same area decreased by 30-40%.
- (3) Total mortality remained high.
- (4) Recruitment rate probably decreased.

There is still much uncertainty about the relative importance of different factors governing these changes, especially the relation between recruitment and the size of the adult stock. However, it is likely that, whatever the relation, a reduction in fishing effort on the Downs stock in the total area of its distribution (see Figure 6, p. 32) would lead in the long term to an increase in catch per unit effort and greater stability in the catches from this stock from year to year. Furthermore, if recruitment is dependent on stock size, a reduction in fishing effort would lead to an increase in recruitment to the stock and hence an increase in total catch as well as catch per unit effort.

The Downs stock is exploited not only in the southern North Sea and eastern English Channel in autumn and winter, but also in the northern and central North Sea in spring and summer, where it is mixed with other spawning groups. Therefore, a reduction in fishing effort on this stock can be approached in two ways:-

- (1) by a moderate reduction of fishing effort in the North Sea as a whole,
- (2) by a drastic reduction in the effort in the southern North Sea and eastern English Channel.

Although the effect of the first of these measures on each of the stocks cannot be predicted accurately, it would inevitably result in a reduction in fishing effort on the less heavily fished spawning groups other than the Downs herring, so that the possible gain in catch from the Downs stock might be offset by a greater loss in catch from the other stocks, thereby leading to a reduction in total catch from the North Sea as a whole. The second measure would confine the reduction in effort to the Downs stock, and would therefore seem the more practicable. However, it should be noted that the moderate reduction of effort in this area in the sixties has so far had no measurable effect on the catch per unit effort.

A reduction of the juvenile herring fishery would also increase recruitment and hence accelerate recovery of the catches of the Downs stock. The direct gain in catch to the adult fisheries would not exceed the loss in catch of juvenile herring. A reduction of bottom trawling on the spawning grounds may also lead to increased recruitment, because bottom trawling may destroy large amounts of herring eggs (although there is no evidence of this).

APPENDIX I

List of reports etc. from International Working Groups and Symposia on herring.

(a) Symposia

"Herring tagging techniques and results", Paris 1954. Rapp.Cons. Explor.Mer, 140(2), 1955.

"On the herring of the southern North Sea", Copenhagen 1956. Ibid., 143(1), 1957.

"On herring races", Copenhagen 1956. Ibid., 143(2), 1957.

"Herring", Copenhagen 1961. Ibid., 154, 1963.

(b) Working Groups

"ICES herring tagging experiments in 1957 and 1958". Rapp. Cons. Explor.Mer, 152, 1961.

"Progress report of the North Sea Herring Working Group". ICES, C.M. 1961, Doc. No.10.

"Report of the North Sea Herring Working Group meeting at IJmuiden, 28th - 29th March, 1963". ICES, C.M. 1963, No.71. (This report will appear in the Cooperative Research Reports of ICES).

"Report of the Herring Assessment Group on the North Sea herring and its Exploitation". ICES, C.M. 1964, Doc. No.3. (Substantially the same report appeared as Annex I to the Liaison Committee's report to the North-East Atlantic Fisheries Commission (NC 2/9)).

"Report of the meeting of the Atlanto-Scandian Herring Working Group", Bergen, 22nd - 26th April, 1963. ICES C.M. 1963, Doc. No.70.

"Report of the Atlanto-Scandian Herring Working Group". ICES, C.M. 1964, Doc. No.8. (A preliminary report, unnumbered, was issued from Copenhagen in April 1964).

Table 1. Total catch (000's m. tons) of adult and pre-recruit Norwegian spring spawners 1925 - 1964.

Year	Norwegian west coast fishery	Soviet summer*) and winter fishery	Icelandic and Norwegian**) summer fishery	T o t a l
1925	250	-	44	294
1926	255	-	26	281
1927	282	-	68	350
1928	301	-	67	368
1929	343	-	61	404
1930	475	-	75	550
1931	305	-	92	397
1932	365	-	72	437
1933	330	-	81	411
1934	111	-	85	196
1935	401	-	69	470
1936	483	-	144	627
1937	319	-	223	542
1938	496	-	145	641
1939	412	-	131	543
1940	409	-	192	601
1941	214	-	91	305
1942	253	-	142	395
1943	228	-	174	402
1944	300	-	205	505
1945	350	-	50	400
1946	368	-	131	489
1947	494	-	143	637
1948	820	-	81	901
1949	567	-	85	652
1950	771	14	39	824
1951	888	43	67	998
1952	820	70	30	920
1953	670	110	54	834
1954	1092	160	28	1280
1955	965	207	32	1204
1956	1146	235	56	1437
1957	796	300	24	1120
1958	345	388	34	767
1959	416	408	45	869
1960	300	465	45	810
1961	69	285	127	481
1962	83	209 (25%)	216	508
1963	60 (15-20%)	330 (50%)	242	573
1964	270 (60-70%)	-	-	-

*) Total catches of Soviet summer and winter fisheries for adult and pre-recruit herring in Norwegian Sea.

**) Estimated from total catch in Icelandic and Norwegian summer fisheries from analysis of the relative proportions of Norwegian and Icelandic scale types in the period 1949-63, otherwise the numbers refer to total catches.

Table 2. Total catch of Icelandic spring spawners by Icelandic purse-seiners (in 000's m.tons).

Years	North and East Coasts	South and West Coasts
1949	3.2	
1950	1.3	
1951	3.5	
1952	0.9	
1953	6.5	
1954	9.8	
1955	11.0	
1956	26.4	
1957	52.2	
1958	47.0	
1959	108.0	
1960	61.0	
1961	128.7	42.7
1962	170.4	58.8
1963	60.7	30.7
1964	50.6	27.1

Table 3. Total catch of Icelandic summer spawners by Icelandic purse-seiners (in 000's m tons).

Years	North and East Coasts	South and West Coasts
1949		
1950	0.6	
1951	0.1	
1952	0.8	
1953	3.4	
1954	0.9	
1955	0.6	
1956	3.3	
1957	19.1	
1958	11.7	
1959	17.4	
1960	21.8	
1961	2.4	64.9
1962	2.6	90.1
1963	7.6	97.4
1964	4.3	59.8

Table 4. Total catches of small and fat herring (in tons) taken by Norway and U.S.S.R.

Years	Small Herring			Fat Herring		
	Norway	U.S.S.R.	Total	Norway	U.S.S.R.	Total
1930	94.8	0.9	95.7	38.8	0.2	40.0
1931	99.9	21.7	121.6	11.9	1.2	13.1
1932	131.1	0.5	131.6	38.4	28.7	67.1
1933	186.2	16.9	203.1	166.0	52.5	218.5
1934	112.7	28.7	141.4	105.0	76.6	181.6
1935	126.5	18.5	145.0	36.4	79.7	116.1
1936	103.2	1.1	104.3	30.9	0.7	31.6
1937	113.3	1.4	114.7	18.5	0.4	18.9
1938	110.7	5.6	116.3	9.3	5.7	15.0
1939	112.2	5.0	117.2	25.7	10.3	36.0
1940	253.7	3.8	257.5	44.2	0.3	44.5
1941	198.4	2.0	200.4	74.1	4.5	78.6
1942	133.0		133.0	55.2		55.2
1943	97.3		97.3	53.6		53.6
1944	63.4	1.5	64.9	16.9	0.1	17.0
1945	113.6	0.4	114.0	35.2	0.8	36.0
1946	59.2	1.1	60.3	31.4	0.1	31.5
1947	43.1	1.7	44.8	23.2	0.5	23.7
1948	80.3	2.2	82.5	19.7	0.9	20.6
1949	92.4	7.4	99.8	23.9	2.9	26.8
1950	66.7	1.3	68.0	31.1	13.7	44.8
1951	190.7	10.5	201.2	80.5	2.5	83.0
1952	276.4	2.1	278.5	55.2	1.9	57.1
1953	147.0	3.8	150.8	84.7	5.2	89.9
1954	190.1	8.8	198.9	138.0	1.2	139.2
1955	94.3	3.0	97.3	36.0	9.0	45.0
1956	86.8	0.0	86.8	102.0	10.0	112.0
1957	118.5	3.8	122.3	46.4	1.5	47.9
1958	133.5	8.1	141.6	55.1	4.9	60.0
1959	164.5	7.2	171.7	46.8	9.5	56.3
1960	212.0	5.7	217.7	62.2	0.8	63.0
1961	222.7	0.9	223.6	108.5	0.1	108.6
1962	124.5	0.7	125.2	171.3	0.9	172.2
1963	157.9		157.9	143.8	12.0	155.8

Table 5. Catches-per-unit effort of Atlanto-Scandian herring.

Year	Soviet Fishery in the Norwegian Sea (Norwegian spring spawners)			Norwegian Winter Herring Fishery (Norwegian spring spawners)		Icelandic Summer Fishery (Norwegian spring spawners, Icelandic spring spawners and summer spawners)	
	Drift-nets			Purse-seine	Drift-nets	Purse-seine	
	Catch per haul Tons	Catch per net Kg	Febr.	Catch per vessel Tons	Catch per net Kg	Catch per vessel	Catch per vessel
	Average pr. year	Average pr. year	Febr.	January to April	January to April	Tons	Tons
1946	-	-	-	1310	-	536	536
1947	-	-	-	1894	179	478	478
1948	-	-	-	2627	239	242	242
1949	-	-	-	1621	177	303	303
1950	5.4	62	-	2003	170	132	132
1951	4.4	55	-	2046	153	293	293
1952	4.4	56	125	1731	141	54	54
1953	4.4	56	102	1390	145	233	233
1954	4.4	47	65	2220	182	132	132
1955	4.0	50	79	1758	137	210	210
1956	3.5	46	81	2043	137	366	366
1957	3.9	51	77	1328	150	380	380
1958	4.1	54	130	582	100	310	310
1959	4.9	72	133	738	105	669	669
1960	5.2	60	115	684	80	420	420
1961	3.8	45	76	271	?	982	982
1962	5.0	77	55	426	?	1440	1440
1963	5.6	62	87	?	?	1111	1111

Table 6. Estimates of absolute abundance of adult stock of Norwegian spring spawners 1953-64 (in 000's m.tons).

Years	From Tagging Data	From Echo-Surveys and Underwater Photography (the area east of Iceland in December)			
		Total	Year-class 1958 and older	Year-class 1959 and younger	Year-class 1959 only
1953	12.462				
1954	12.183				
1955	13.857				
1956	11.997				
1957	9.393				
1958	6.603	6.046	6.011	35	
1959	5.022				
1960					
1961		2.504	2.464	40	
1962		2.847	1.300	1547	1495
1963		3.256	655	2601	1847
1964		~5-5.5	?	?	?

Table 7. Instantaneous Total Mortality Rates (Z)

Buchan, Dogger and Downs spawners

1924 - 1963

Years \ Ages	Buchan Spawners 5-11	October Dogger 5-9	October Dogger 5-9	Dogger 5-7	East Anglia 5-7	Channel 5-7	Channel 3-9
1924/25					0.38		
1925/26					0.52		
1926/27					0.60		
1927/28					0.20		
1928/29					0.07		
1929/30					0.54		
1930/31	0.82				0.84		
1931/32	1.02				0.61		
1932/33	-0.50				0.45		
1933/34	-0.24				0.08		
1934/35	0.71				0.65		
1935/36	0.13				-0.12		
1936/37	0.75				0.63		
1937/38	0.63				0.83		
1938/39	1.14				0.65		
1946/47					0.40		
1947/48					-0.13		
1948/49					0.52		
1949/50	0.54	0.37	0.49		0.49		
1950/51	0.51	0.05	-0.02		0.55		
1951/52	-0.16	0.38	0.44		0.42		
1952/53	0.05	0.49	0.29		1.09		
1953/54	0.33	0.48	0.38		0.21		
1954/55	0.30	0.46	0.21		1.11		
1955/56	0.25	0.38	0.50	0.70	0.68	0.46	0.93
1956/57	1.24	0.89	0.39	-0.06	1.81	1.53	0.97
1957/58	1.02	0.44	1.44	0.30	0.95	0.65	0.64
1958/59	0.87	0.79	1.86	0.72	0.93	1.06	0.82
1959/60	0.51		0.56	0.73	2.85	1.50	1.60
1960/61	-0.21		1.44	0.70	0.81	0.38	0.52
1961/62	1.09		0.63	1.27	1.07	2.14	1.70
1962/63	0.82		1.02	0.93	2.47	1.92	2.06
Units	l/10 cran /shot	kg/100 hp /cv	*) see foot-note	n/shot	n/shot	n/n hrs fishing	n/n hrs fishing
Author	Parrish & Craig Parrish (p.c.)	Gilis	Burd (p.c.)	Zijlstra	Cushing	Zijlstra	Zijlstra

*) Until 1959/60 calculated as % Whitby and % Belgian Dogger averaged and raised by Whitby catch/shot. Later figures based on Whitby fishery alone.

Table 8. Mean Instantaneous Total Mortality Rates (Z) for the Spawning Groups and for the East Anglian Herring in Various Periods.

Years	Buchan	Dogger	Dogger	East Anglia	Channel
1924/25 -1929/30	-	-	-	0.39 (32.3)	-
1930/31 -1933/34	0.28 (24.4)	-	-	0.50 (39.4)	-
1934/35 -1938/39	0.67 (48.8)	-	-	0.53 (41.1)	-
1946/47 -1950/51	0.53 *) (41.1)	0.22 *) (19.8)	-	0.37 (30.9)	-
1951/52 -1954/55	0.13 (12.2)	0.39 (32.3)	-	0.71 (50.8)	-
1955/56 -1959/60	0.78 (54.2)	-	0.71 (50.8)	1.44 (76.3)	1.02 (63.9)
1960/61 -1962/63	0.57 (43.5)	-	1.00 (63.2)	1.45 (76.5)	1.45 (76.5)
	Parrish & Craig	Gillis Burd	Burd Zijlstra	Cushing	Zijlstra

*) 1949-51

Figures in brackets are equivalent annual percentage total mortality rates.

Table 9. North Sea and English Channel¹⁾ Landings of Herring by Countries 1920-1963 (000's m. tons)

Years	Belgium	Denmark ²⁾	England	France	Germany ³⁾	Holland	Norway	Poland	Scotland ⁴⁾	Sweden	U.S.S.R.	Total
1920	0.2	0.1	226.8	-	31.6	89.2	0.4	-	112.1	-	-	460.4
1921	-	0.1	133.7	-	38.3	45.7	0.3	-	94.3	-	-	312.4
1922	-	+	121.5	-	36.9	31.1	0.5	-	93.5	0.9	-	284.4
1923	-	0.1	143.2	-	50.2	49.1	0.1	-	125.9	0.2	-	368.8
1924	-	0.1	226.4	-	70.8	69.6	1.1	-	164.9	-	-	532.8
1925	-	0.1	182.5	32.0	49.0	43.2	0.1	-	100.8	-	-	407.7
1926	-	0.1	168.4	29.7	61.6	58.4	-	-	133.2	-	-	451.4
1927	-	0.1	163.1	44.1	60.0	67.1	-	-	121.7	0.3	-	456.4
1928	-	0.1	200.0	41.4	78.2	71.7	-	-	133.9	-	-	525.3
1929	12.4	0.1	211.0	63.8	102.7	75.2	0.2	-	157.6	+	-	628.0
1930	11.8	0.1	199.1	39.7	87.6	72.0	-	-	127.2	-	-	537.5
1931	18.9	0.1	164.0	51.1	110.3	75.1	-	1.4	62.6	-	-	483.5
1932	4.5	1.8	115.7	48.5	123.8	66.4	-	1.9	79.4	0.1	-	442.1
1933	2.0	1.7	118.6	61.4	157.4	69.4	0.1	6.3	68.2	0.2	-	485.2
1934	8.0	1.4	110.8	51.2	163.4	85.5	0.1	4.9	94.7	0.2	-	520.2
1935	13.2	1.0	126.8	36.2	182.0	67.9	0.4	4.2	118.0	0.1	-	549.8
1936	9.2	1.6	132.4	47.8	226.5	97.1	0.9	5.0	114.3	+	-	634.8
1937	5.8	0.8	159.9	48.9	251.8	117.6	2.6	6.9	89.7	0.2	-	684.2
1938	5.6	1.1	122.2	59.2	216.1	91.7	2.7	9.6	107.1	-	-	615.3
1946	37.1	5.9	87.5	-	87.8	101.4	0.7	-	80.5	18.6	-	419.4
1947	36.1	9.0	101.1	76.5	144.5	132.3	4.4	-	83.1	25.1	-	612.1
1948	22.5	6.5	114.1	76.5	119.1	139.3	5.6	-	91.0	25.9	-	601.5
1949	16.8	5.2	70.7	59.5	213.3	109.9	3.2	-	56.4	25.0	-	560.0
1950	10.4	7.8	75.4	60.6	199.1	111.9	3.6	-	40.0	27.4	-	536.2
1951	7.6	34.1	72.8	124.8	312.6	124.7	1.3	-	44.2	31.0	-	753.1
1952	12.9	33.2	66.5	65.1	281.2	135.3	2.1	-	86.7	37.1	-	720.1
1953	16.2	49.8	86.7	76.2	350.3	159.0	2.5	-	89.8	37.3	-	867.8
1954	17.6	58.3	61.4	53.9	362.8	149.0	3.3	-	68.1	38.9	-	813.3
1955	15.7	66.3	38.7	58.8	398.9	126.1	5.1	-	77.3	46.7	2.4	875.2
1956	6.1	82.6	42.3	44.8	274.4	116.0	5.3	39.2	53.2	37.7	27.9	736.0
1957	1.8	88.1	32.1	34.4	284.4	128.7	7.7	45.7	42.1	48.8	36.5	753.9
1958	1.5	133.9	23.8	34.0	249.1	124.9	8.2	55.9	31.0	50.2	28.8	741.3
1959	3.0	145.0	21.5	34.7	297.9	118.4	16.9	70.7	50.9	57.2	39.5	855.7
1960	3.6	123.6	20.0	34.0	241.5	125.7	16.5	76.3	29.9	94.0	63.1	828.2
1961	3.1	143.1	17.9	30.1	130.6	129.8	14.2	78.1	23.6	95.1	67.7	733.3
1962	1.4	126.1	11.9	21.9	101.3	84.4	12.4	59.3	24.2	93.2	100.3	636.4
1963	1.8	121.8	22.8	24.1	97.0	126.5	32.4	72.5	34.7	-	76.2	636.4

1) Landings by E.Germany not available in post-war years. 3) Including industrial fish catch.
 2) Danish landings include adult and industrial herring (data for post-war years supplied by Mr. K. Popp Madsen). 4) Including immature herring fisheries in Moray Firth and Firth of Forth.

Table 10. Landings of Adult and Industrial Herring Fisheries in the Northern and Central North Sea, by Countries and Gears 1946-63.

Year	Adult Fisheries																	Industrial Fisheries								
	1) Denmark		1) England		1) France		2) W. Germany		3) Netherlands		4) Norway		5) Poland		Scotland		Sweden		U.S.S.R.		T o t a l		Denmark	Germany	Total	
	Trawl	1)	Drift	1)	Trawl	1)	Drift	2)	Drift	3)	Trawl	4)	Drift	5)	Drift	Trawl	Drift	Trawl	Drift	Trawl	Drift	Trawl				All Gears
1946	10.9	5.9	20.8	13.0	23.9	105.6	53.0	12.9	0.7						78.8	1.7	16.2				176.5	166.9	343.4	-		
1947	17.5	9.0	31.9	25.1	25.7	113.5	70.0	29.6	4.4						75.8	7.3	19.4				203.4	225.8	429.2	-		
1948	13.1	6.2	26.2	9.6	29.4	115.6	60.6	30.7	5.6						82.3	8.7	16.6				198.5	206.1	404.6	0.3		0.3
1949	9.0	5.0	16.7	9.1	30.6	150.4	46.8	31.2	3.2						45.2	11.2	15.1				139.3	234.2	373.5	0.2		0.2
1950	7.4	2.4	14.0	12.7	34.7	143.5	38.1	31.7	3.6						37.7	2.3	16.4				124.5	220.0	344.5	5.4		5.4
1951	5.6	2.6	17.1	14.5	43.6	175.8	43.5	47.9	1.3						40.0	2.2	26.3				144.2	276.2	420.4	31.5	13.1	44.6
1952	6.0	1.2	18.6	21.5	42.8	145.2	42.1	45.9	2.1						77.3	3.6	31.3				180.8	256.8	437.6	32.0	18.2	50.2
1953	7.2	0.7	23.0	16.2	37.5	168.0	56.7	55.0	2.5				8.1		79.4	1.4	31.8				196.6	290.9	487.5	49.1	29.3	78.4
1954	2.3	2.5	15.4	41.3	35.8	150.7	46.0	44.4	3.3				10.2		58.9	0.2	30.9				156.1	285.8	441.9	55.8	39.5	95.3
1955	1.1	6.2	17.9	34.3	39.0	171.4	54.9	37.9	5.1				33.4		69.3	+	39.6			2.4	183.5	329.0	512.5	60.1	52.4	112.5
1956	0.6	3.4	15.0	25.7	35.4	132.8	52.0	34.1	5.3				41.2		42.1	+	39.3			27.9	172.4	282.4	454.8	79.2	24.5	103.7
1957	0.6	5.1	12.1	17.6	35.5	143.9	37.8	44.6	7.7				7.5		40.2	0.1	45.0			36.5	169.6	305.1	474.7	83.0	20.2	103.2
1958	0.1	5.5	12.0	14.3	40.4	110.8	45.1	38.4	8.2				10.0		29.2	0.1	57.3			28.8	165.5	277.3	442.8	128.4	30.5	158.9
1959	0.6	31.6	14.7	12.8	37.7	134.2	41.8	54.0	16.9				6.0		47.8	0.1	52.3			39.5	187.5	363.5	551.0	113.4	43.0	156.4
1960	0.2	43.1	10.0	3.0	29.4	75.6	31.8	56.8	16.5				6.8		28.3	+	79.7			61.3	167.6	340.2	507.8	80.5	35.1	115.6
1961	0.2	64.5	8.6	13.5	17.9	48.9	23.9	60.6	14.2				6.4		23.0	+	95.1			67.7	147.5	358.0	505.5	78.6	18.2	96.8
1962	0.2	46.8	6.1	11.2	13.4	45.1	9.6	46.1	12.4				2.7		22.4	+	93.2			100.3	154.5	306.2	460.7	79.3	34.7	114.0
1963	1.2	65.7	15.8	17.9	33.3	49.2	21.6	76.9	32.4				16.2		34.2	+	-			76.2	197.3	-	-	56.1	11.9	68.0

1) Data from Bulletin Statistique Divisions IVa and IVb.

2) Data for 1946-52 from Jahresberichte, with allowance for mixed trips; 1953-61 from Statistical News Letters (No. 11 B).

3) Data supplied by Dutch Laboratory.

4) Data supplied by Norwegian Laboratory, mainly trawl, some purse-seine included in 1963.

5) Data from Statistical News Letters (No. 11 B).

Table 11. Landings of Adult Herring Fisheries in Southern North Sea and English Channel by Countries and Gears 1946-1963.
(in 000's m.tons)

Years	1)	1)	1) 2)	3)		4)		5)		T o t a l		
	Belgium	England	France	W.Germany		Netherlands		Poland		Drift	Trawl	All Gears
	Trawl	Drift	Trawl	Drift	Trawl	Drift	Trawl	Drift/Trawl		Drift	Trawl	All Gears
1946	26.1	66.7	31.9	6.2	-	50.4	2.3	-		123.3	60.3	183.6
1947	18.5	69.2	51.4	6.7	-	42.5	9.1	-		118.4	79.0	197.4
1948	9.5	87.9	66.9	10.6	-	53.8	15.5	-		152.3	91.9	244.2
1949	7.8	54.1	50.3	9.6	0.3	38.9	11.7	-		102.6	70.1	172.7
1950	3.0	61.4	(48.0)	12.5	5.2	58.1	2.9	-		132.0	59.1	191.1
1951	2.0	55.7	(56.1)	16.6	39.9	53.2	2.2	-		125.5	100.2	225.7
1952	7.0	47.9	43.6	13.6	42.7	60.5	6.2	-		122.0	99.5	221.5
1953	9.0	47.6	60.0	17.7	65.4	56.5	19.1	2.4		121.8	155.9	277.7
1954	12.3	46.0	12.6	18.0	47.2	69.4	16.3	3.7		133.4	92.1	225.5
1955	14.6	20.8	24.5	13.2	34.2	36.0	19.3	5.8		70.0	98.4	168.4
1956	5.4	21.2	19.1	14.2	19.6	34.6	15.3	4.6		70.0	64.0	134.0
1957	1.2	20.1	16.8	16.6	20.9	27.9	14.8	4.4		64.6	58.1	122.7
1958	1.4	10.2	19.7	10.5	9.2	22.9	15.1	3.6		43.6	49.0	92.6
1959	2.5	6.6	22.0	4.2	14.9	7.6	14.7	4.7		18.4	58.8	77.2
1960	3.4	6.4	(22.8)	9.7	1.8	17.0	19.7	5.1		33.1	52.8	85.9
1961	2.9	8.9	16.6	10.8	3.8	17.8	25.5	1.3	9.5	38.8	58.3	97.1
1962	0.9	5.8	10.7	5.0	3.1	5.9	22.8	0.3	5.1	17.0	42.6	59.6
1963	0.9	7.0	6.1	2.5	0.1	7.2	19.1	0.1	2.2	16.8	28.4	45.2

- 1) Data from Bulletin Statistique (Divisions IV c and VII d and e).
- 2) Data supplied by the Boulogne Laboratory indicate that the figures given above are probably substantial overestimates of the French landings from this area, especially during the years 1946-1955.
- 3) Data from 1946-1952 from Jahresberichte; 1953-1961 from Statistical News Letters.
- 4) Data supplied by Dutch Laboratory.
- 5) Data for drift-net and trawl combined.

Table 12. Landings from Industrial and Adult Herring
Fisheries in the North Sea 1945-1963 (000's m.tons).
(Excluding E.German catches)

Years	Industrial Fisheries			Adult Fisheries	All Fisheries
	Denmark	Germany	T o t a l	All Countries	All Countries
1945	-	-	-		
1946	-	-	-	419.4	419.4
1947	-	-	-	612.1	612.1
1948	0.3	-	-	601.2	601.2
1949	0.2	-	0.2	559.8	560.0
1950	5.4	-	5.4	530.8	636.2
1951	31.5	13.1	44.6	708.5	753.1
1952	32.0	18.2	50.2	669.9	720.1
1953	49.1	29.3	78.4	789.4	867.8
1954	55.8	39.5	95.3	718.0	813.3
1955	60.1	52.4	112.5	762.7	875.2
1956	79.2	24.5	103.7	632.3	736.0
1957	83.0	20.2	103.2	650.7	753.9
1958	128.4	30.5	158.9	582.4	741.3
1959	113.4	43.0	156.4	699.3	855.7
1960	80.5	35.1	115.6	712.6	828.2
1961	78.6	18.2	96.8	636.5	733.3
1962	79.3	34.7	114.0	522.4	636.4
1963	56.1	11.9	68.0		

Table 13a. Estimates of Catch Per Unit Effort of Herring Fisheries in Northern North Sea (Division IV a) by Country 1945-63.

For explanatory notes see overleaf

Years	Trawl Fisheries					Drift-Net Fisheries					
	1) Belgium	Germany		4) Netherlands	5) Total	Germany		8) Netherlands	9) Poland	10) Scotland	11) Total
		A ²⁾	B ³⁾			A ⁶⁾	B ⁷⁾				
1945	-	6.5	8.2	-	8.2	-	-	-		4.0	4.0
1946	251.0	8.0	8.3	-	9.4	-	-	-		3.9	3.9
1947	90.4	7.1	7.7	130.4	8.1	-	-	3.6		2.8	3.7
1948	70.0	5.5	5.8	68.8	5.8	-	-	1.9		3.1	3.1
1949	96.3	4.6	5.6	65.8	5.8	-	-	1.2		2.2	2.2
1950	73.1	4.3	4.4	43.1	4.3	-	-	1.7		2.8	2.8
1951	73.1	6.0	6.1	53.9	5.8	-	-	2.0		2.7	2.8
1952	78.2	6.1	6.1	70.4	6.2	-	-	2.6		4.5	4.5
1953	75.5	5.6	5.8	47.2	5.6	3.9	3.7	2.9		4.3	4.4
1954	67.4	4.8	5.2	43.9	5.0	2.6	2.2	2.2		4.4	4.2
1955	55.0	5.7	6.2	51.4	6.0	5.3	5.8	4.1		5.8	6.2
1956	41.3	3.9	4.3	27.7	3.9	3.6	2.5	3.4		5.0	5.2
1957	50.6	4.5	5.2	55.6	5.2	4.3	3.7	2.3	4.8	4.4	4.2
1958	30.5	3.0	3.3	31.6	3.2	3.4	3.2	2.2	3.1	4.6	4.4
1959	28.4	3.5	5.0	61.9	5.2	4.4	4.7	2.5	3.0	4.8	4.6
1960	36.0	2.1	3.6	33.0	3.5	3.6	3.4	2.4	2.8	4.2	4.3
1961	-	2-3	3-3	27.3	3.0	3.0	2.3	2.9	3.7	5.3	5.2
1962	-	4.1	2.0	21.7	2.0	2.6	2.5	1.3	1.4	4.8	4.7
1963	-	2.8	2.5	24.2	2.4	3.9	5.4	2.7	2.3	4.7	4.7

<u>Rank Correlations</u>	<u>Trawl</u>	Belgium - Germany	0.70
		Belgium - Netherlands	0.68
		Germany - Netherlands	0.85
<u>Drift-net</u>	Germany - Netherlands	0.28	
	Germany - Scotland	0.33	
	Netherlands - Scotland	0.52	
	Trawl - Drift-net -	0.45	

Explanatory Notes to Table 13 a

Trawl Fishery

- 1) Belgium Catch (kg) per 100 hrs fishing per HP in Division IV a.
- 2) Germany Catch (tons) per days fishing by German steam trawlers (corrected for fishing power) in Division IV a.
- 3) Germany Catch (tons) per days fishing by German steam trawlers (corrected for fishing power) in July-September in Area "B" (Statistical News Letters, No. 11 B).
- 4) Netherlands Catch (tons) per 100 hrs fishing of standard trawler of 500 BHP in Area "B" (Stat. News Letter, No. 11 A). (July-September).
- 5) Total (All trawl fisheries). Values obtained by
 - (a) bringing all estimates to same level, by taking German data (B) as standard.
 - (b) averaging these estimates, weighted by total catch in each fishery.

Drift-Net Fishery

- 6) Germany Catch (tons) per days fishing in Division IV a.
- 7) Germany Catch (tons) per days fishing in Area "B" (Stat. News Letters, No. 11 B).
- 8) Netherlands Catch (tons) per days fishing in Division IV a.
- 9) Poland Catch (tons) per days fishing in Division IV a.
- 10) Scotland Catch (tons) per "arrival" in north-western North Sea (mostly in Area "B").
- 11) Total (Drift-net fisheries). Estimates obtained as for trawl, taking Scottish fishery as standard. (Scottish and Dutch data only).

Table 13 b. Estimates of Catch per Unit Effort of Herring Fisheries in Central North Sea (Division IV b) by Country 1945-63.

For explanatory notes see overleaf.

Years	Trawl Fisheries					Drift-Net Fisheries	
	Belgium		3) Germany	4) Netherlands	5) Total	6) Germany	7) Netherlands
	A1)	B2)					
1945	-	-	3.5	-	3.5		-
1946	124	170	7.6	-	7.5		-
1947	124	122	6.0	131	6.9		4.7
1948	132	137	4.5	94	5.1		3.7
1949	124	126	5.6	60	5.4		2.5
1950	171	223	4.6	79	5.0		2.8
1951	137	158	6.9	82	6.7		2.8
1952	134	140	6.5	95	6.6		3.3
1953	139	139	6.9	89	6.8	3.2	3.2
1954	108	110	6.0	65	5.8	4.2	2.9
1955	101	102	4.8	56	4.6	1.6	2.8
1956	125	-	3.7	46	3.6	4.0	3.5
1957	58	58	5.2	80	5.4	4.1	3.5
1958	75	75	3.7	46	3.6	4.0	3.0
1959	47	33	5.2	67	5.1	4.3	3.1
1960	39	31	4.0	31	3.1	4.3	2.4
1961	-	-	4.8	42	3.7	2.8	2.1
1962	-	-	3.4	25	2.3	2.8	2.0
1963	-	-	?	45	3.3*)		5.1

*) no information from Germany.

Rank Correlations

Germany - Netherlands (trawl) 0.69
 Germany - Belgium (trawl) 0.58
 Netherlands - Belgium (trawl) 0.52

Explanatory Notes to Table 13 b

Trawl Fishery

- 1) Belgium Catch (kg) per 100 hrs fishing per HP in Division IV b.
- 2) Belgium Catch (kg) per 100 hrs fishing per HP in Division IV b in September and October only.
- 3) Germany Catch (tons) per days fishing in Division IV b - August-November.
- 4) Netherlands Catch (tons) per 100 hrs fishing by standard trawler of 500 BHP in Division IV b in August-October.
- 5) Total See explanatory note 5) in Table 13 a.

Drift-Net Fishery

- 6) Germany Catch (tons) per days fishing in Division IV b.
- 7) Netherlands Catch (tons) per days fishing in Division IV b.

Table 13 c. Estimates of Catch per Unit Effort of Herring Fisheries in Southern Bight and Eastern English Channel (Divisions IV c and VII d+e) by Country 1945-63.

For explanatory notes see overleaf.

Years	Trawl Fisheries				Drift-Net Fisheries			
	1) Belgium	2) Germany	3) Netherlands	4) Total	5) England	6) Germany	7) Netherlands	8) Total
1945	-	-	-	-	-	-	-	-
1946	62	-	-	-	40.3	-	-	7.9
1947	98	-	-	-	39.3	-	6.8	7.4
1948	141	-	-	-	38.5	-	6.3	7.1
1949	59	1.6	-	-	38.5	-	6.0	6.9
1950	63	3.4	-	-	37.6	-	8.4	7.9
1951	59	7.6	169	7.5	34.8	-	6.1	6.5
1952	104	5.1	143	5.0	34.9	-	7.4	7.2
1953	183	8.3	174	8.5	32.1	4.5	5.8	6.0
1954	95	4.8	134	4.7	39.9	4.9	8.8	8.4
1955	202	4.7	104	4.3	19.6	3.3	4.2	4.1
1956	31	3.7	88	3.4	24.8	3.8	4.5	4.7
1957	-	2.7	78	2.7	22.1	3.9	4.4	4.4
1958	-	2.6	81	2.7	17.8	2.9	3.5	3.5
1959	-	3.6	150	4.3	15.0	1.9	2.0	2.5
1960	-	3.0	113	3.4	18.7	3.5	3.9	3.8
1961	-	5.0	169	5.6	18.2	5.9	7.0	5.9
1962	40	3.2	56	2.1	15.0	2.7	3.1	3.1
1963	65	-	50	2.0	12.2	1.9	3.4	2.9

Rank Correlations

<u>Trawl</u>	Germany - Netherlands	0.82
<u>Drift-Net</u>	Netherlands - England	0.82
	Trawl - Drift-Net	0.81

Explanatory Notes to Table 13 c.

Trawl Fishery

- 1) Belgium Catch (kg) per 100 hrs fishing per HP in bottom trawl spent herring fishery. (Fleet varies much in size over period).
- 2) Germany Catch (tons) per days fishing (corrected for fishing power) in spawning fishery.
- 3) Netherlands Catch (tons) per 100 hrs fishing by standard trawler of 500 BHP in spawning fishery.
- 4) Total See explanatory note 5) in Table 13 a. German and Dutch data only. German fishery taken as standard.

Drift-Net Fishery

- 5) England Catch (crans) per shot in East Anglian fishery.
- 6) Germany Catch (tons) per days fishing in Southern Bight.
- 7) Netherlands Catch (tons) per shot in Southern Bight.
- 8) Total See explanatory note 11) of Table 13 a. English and Dutch data only. Dutch fishery taken as standard.

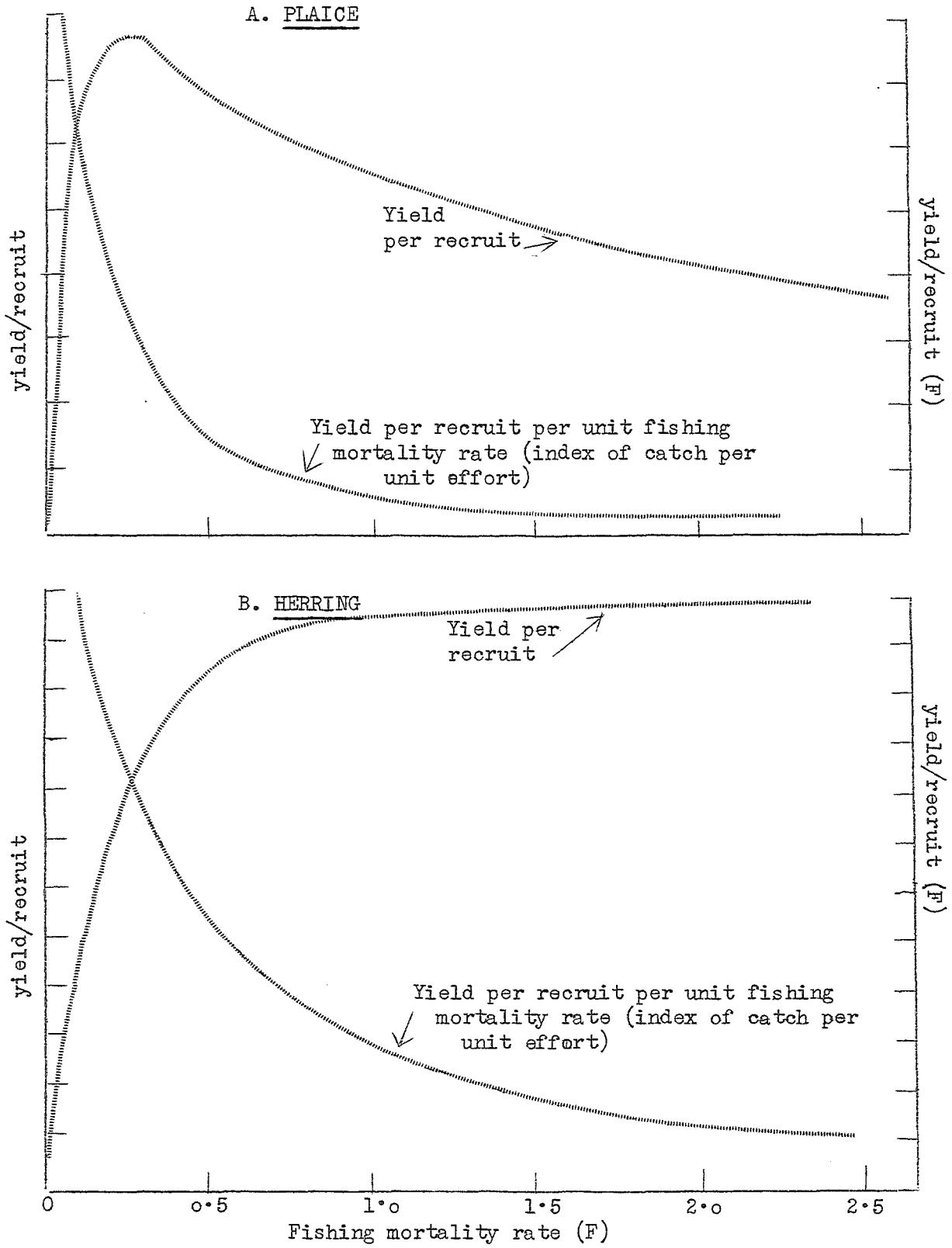


Figure 1 Theoretical curves showing changes in equilibrium yield (per recruit) and index of catch-per-unit-effort for North Sea plaice and herring for different values of fishing mortality rate.

Total catch (thousand metric tons) of adult and pre-recruit Norwegian spring spawners 1925-1963

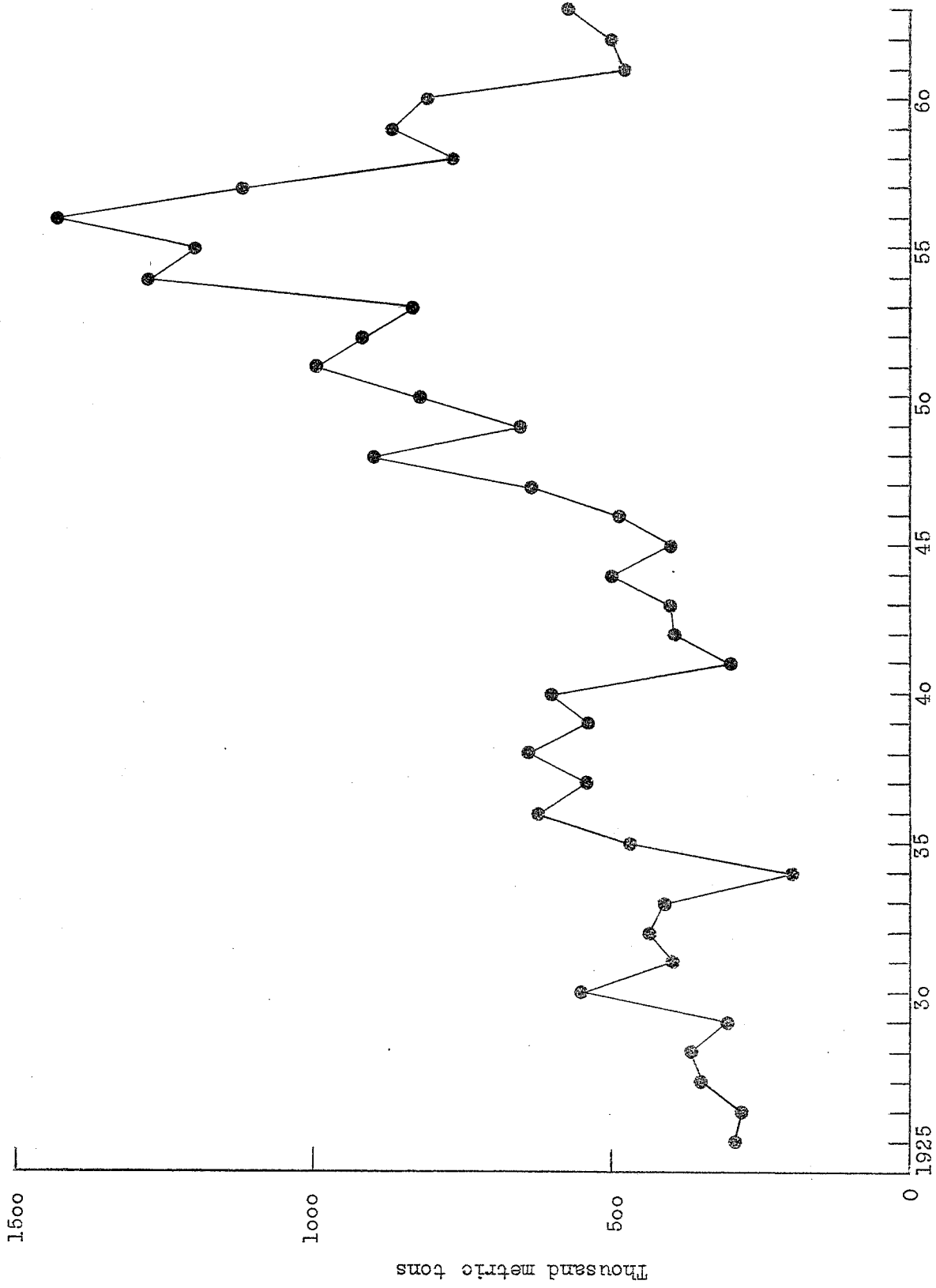


Figure 2. Catches of Norwegian spring spawners 1925-1963.

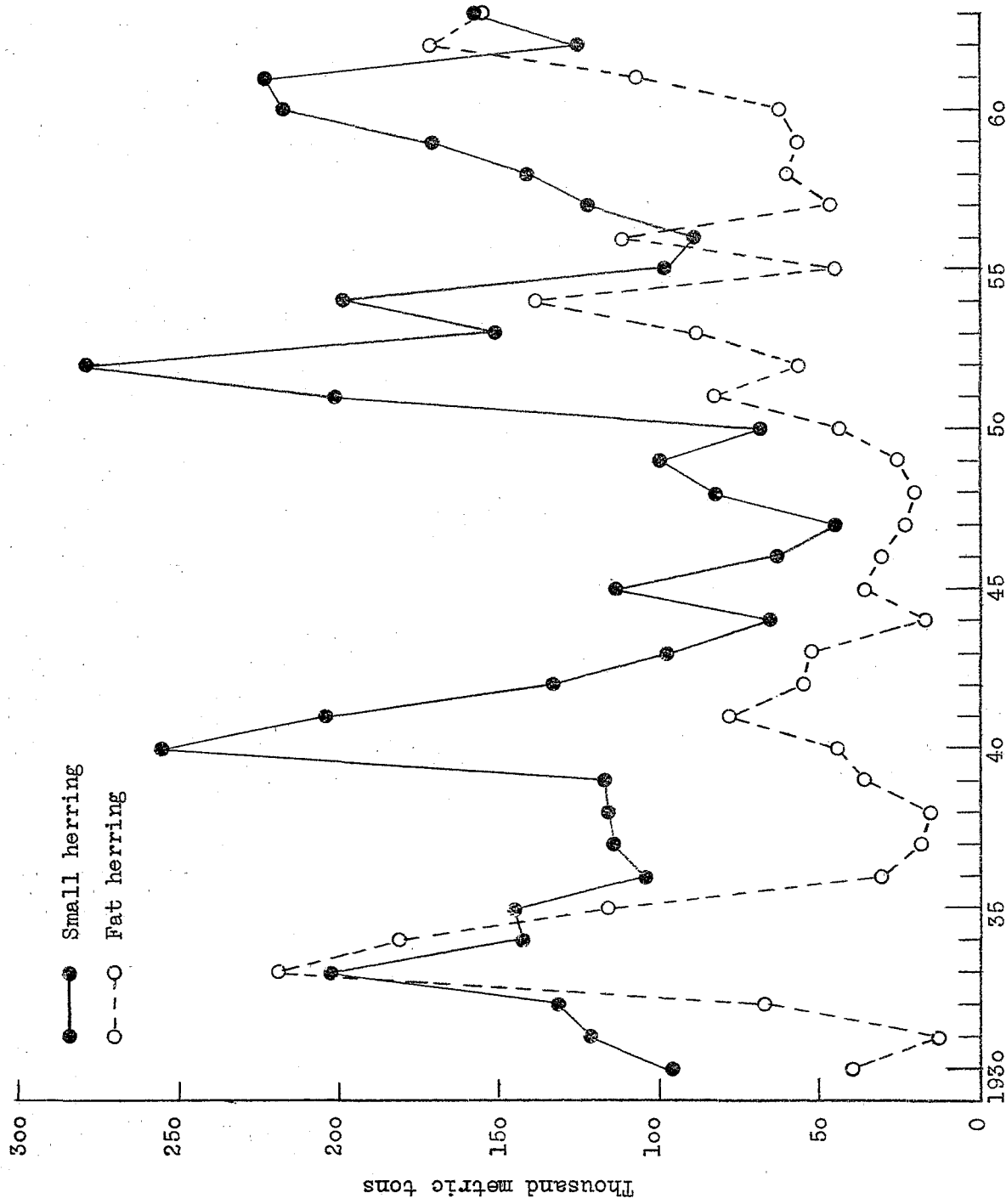


Figure 3. Total catches (thousand metric tons) of small and fat herring taken by Norway and U.S.S.R. 1930-1963.

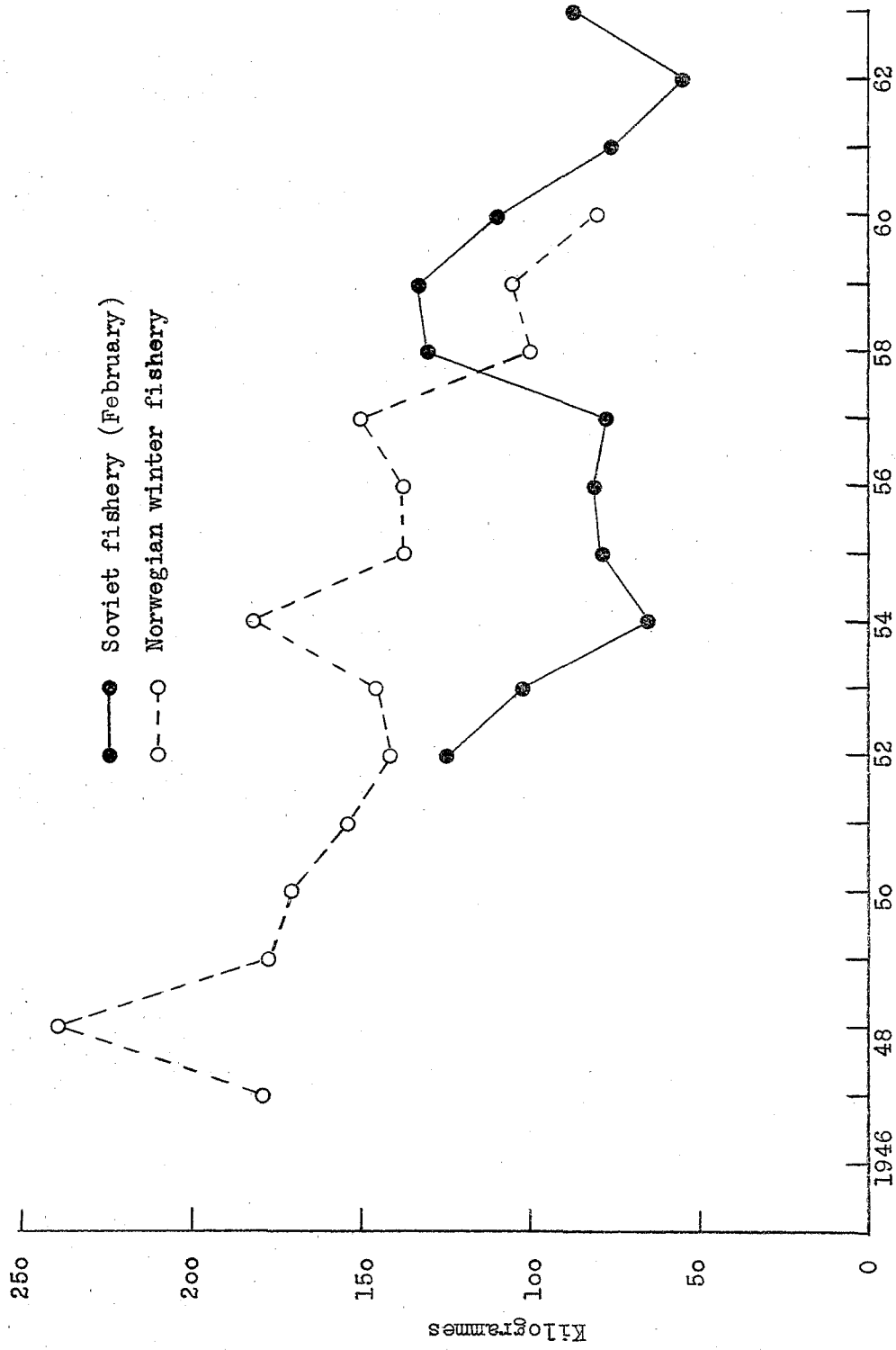


Figure 4. Catches per drift-net of Norwegian spring spawners by U.S.S.R. and Norwegian vessels.

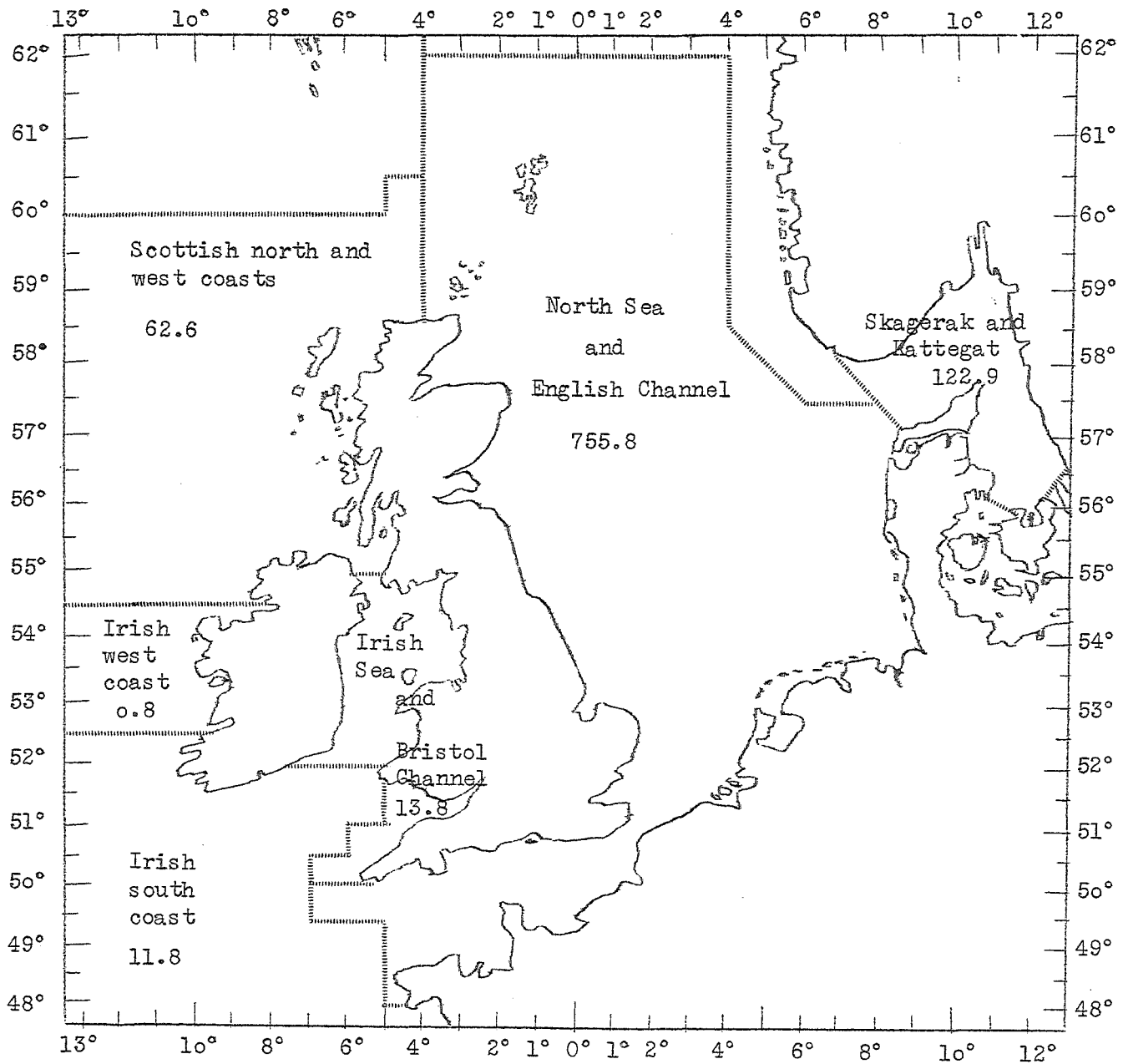


Figure 5. Distribution of herring fisheries in Near Northern Sea's area,

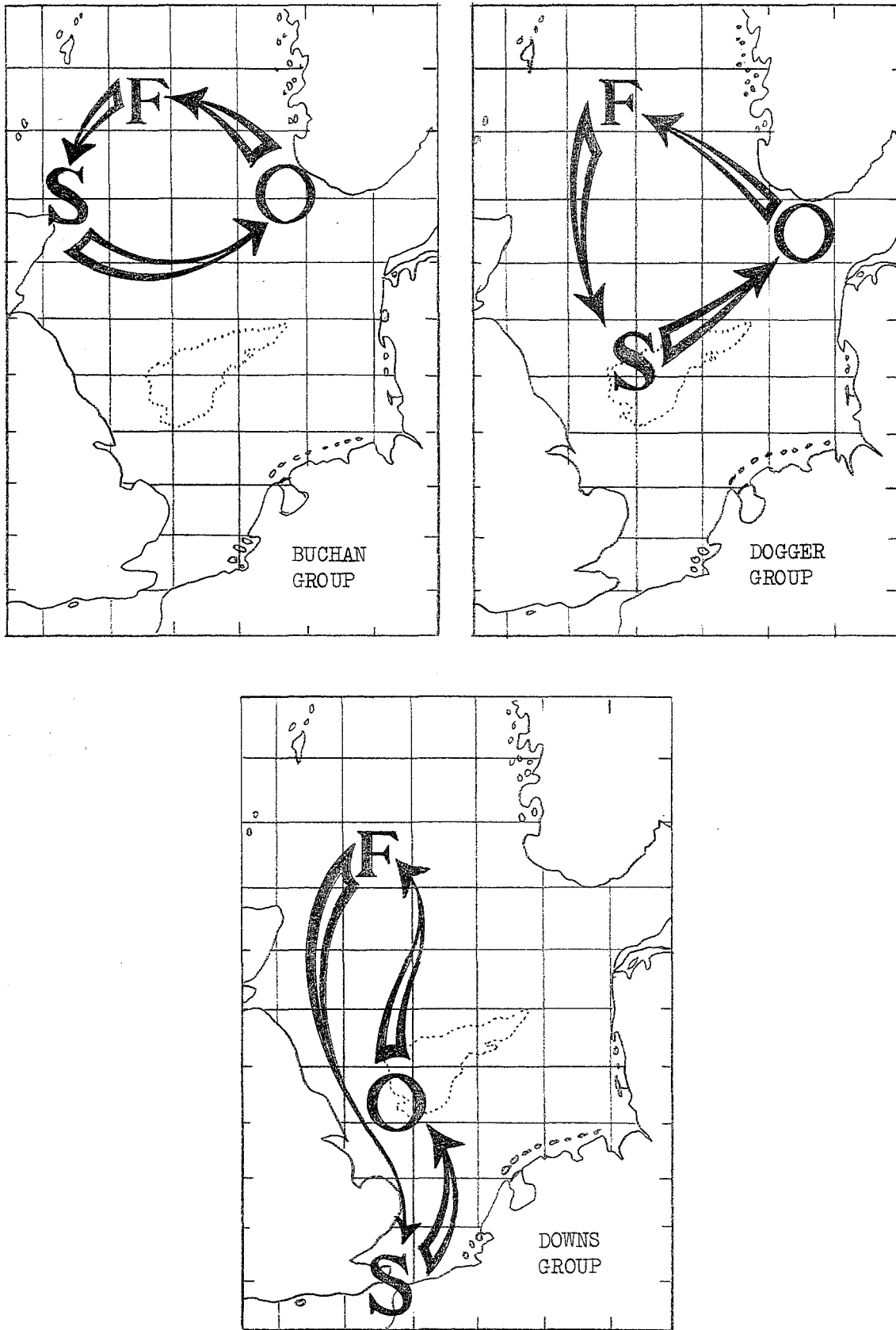


Figure 6. Spawning, overwintering and feeding grounds of North Sea herring.

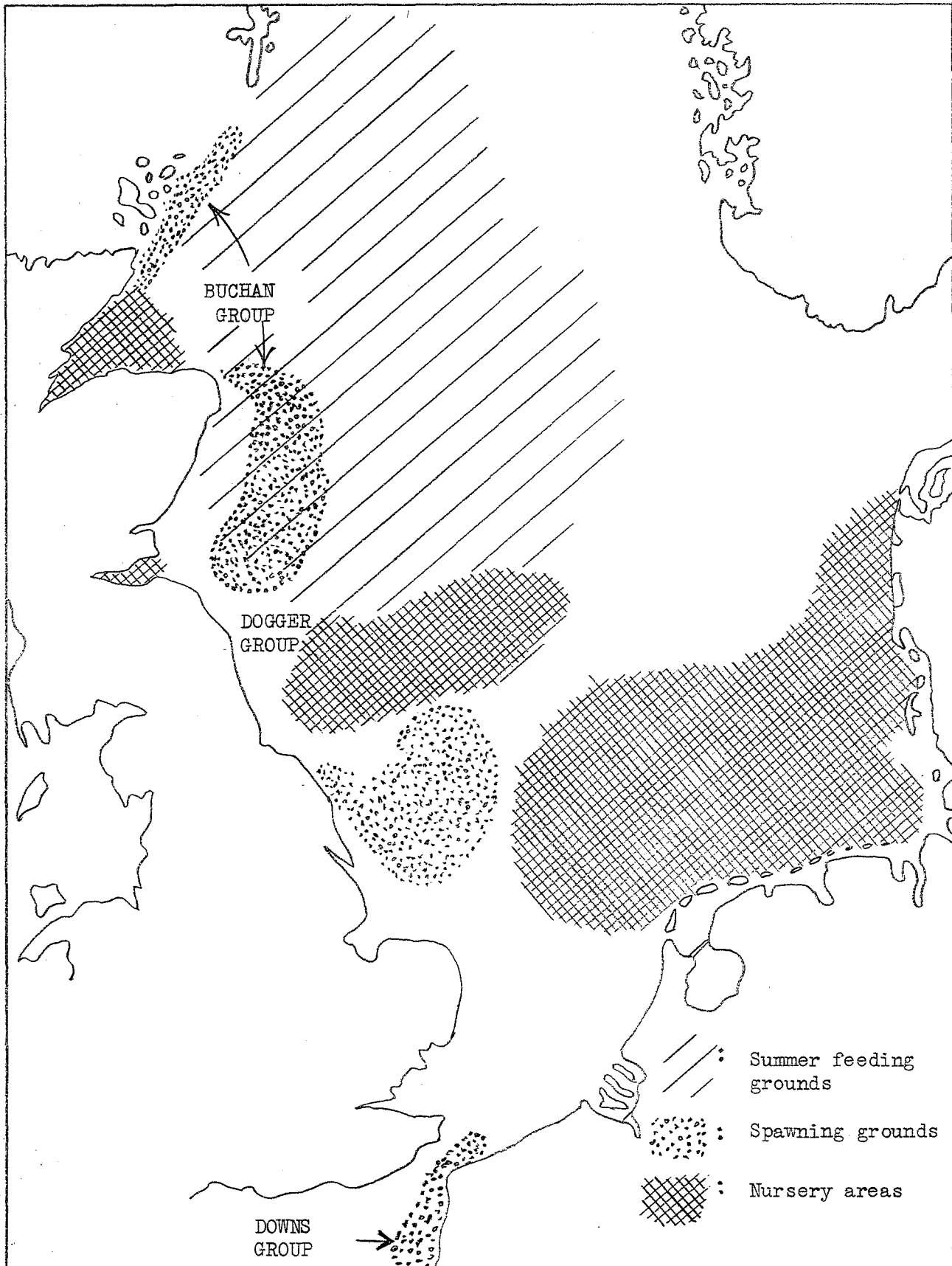


Figure 7. Location of nursery areas, feeding and spawning grounds of recruit herring in the North Sea.

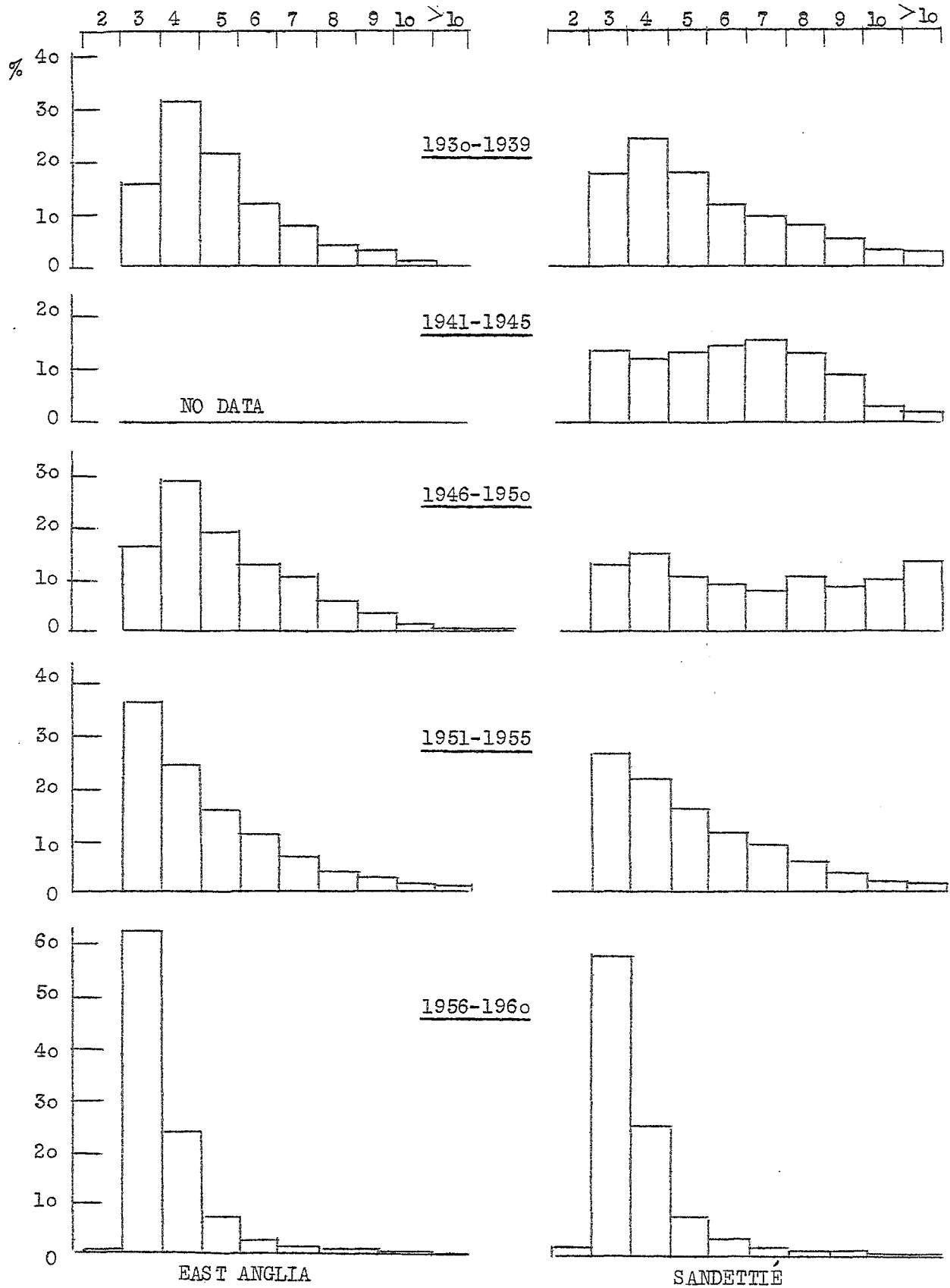


Figure 8. Average percentage age compositions: Southern North Sea (East Anglia - Drift-net), Sandettié (Trawl).

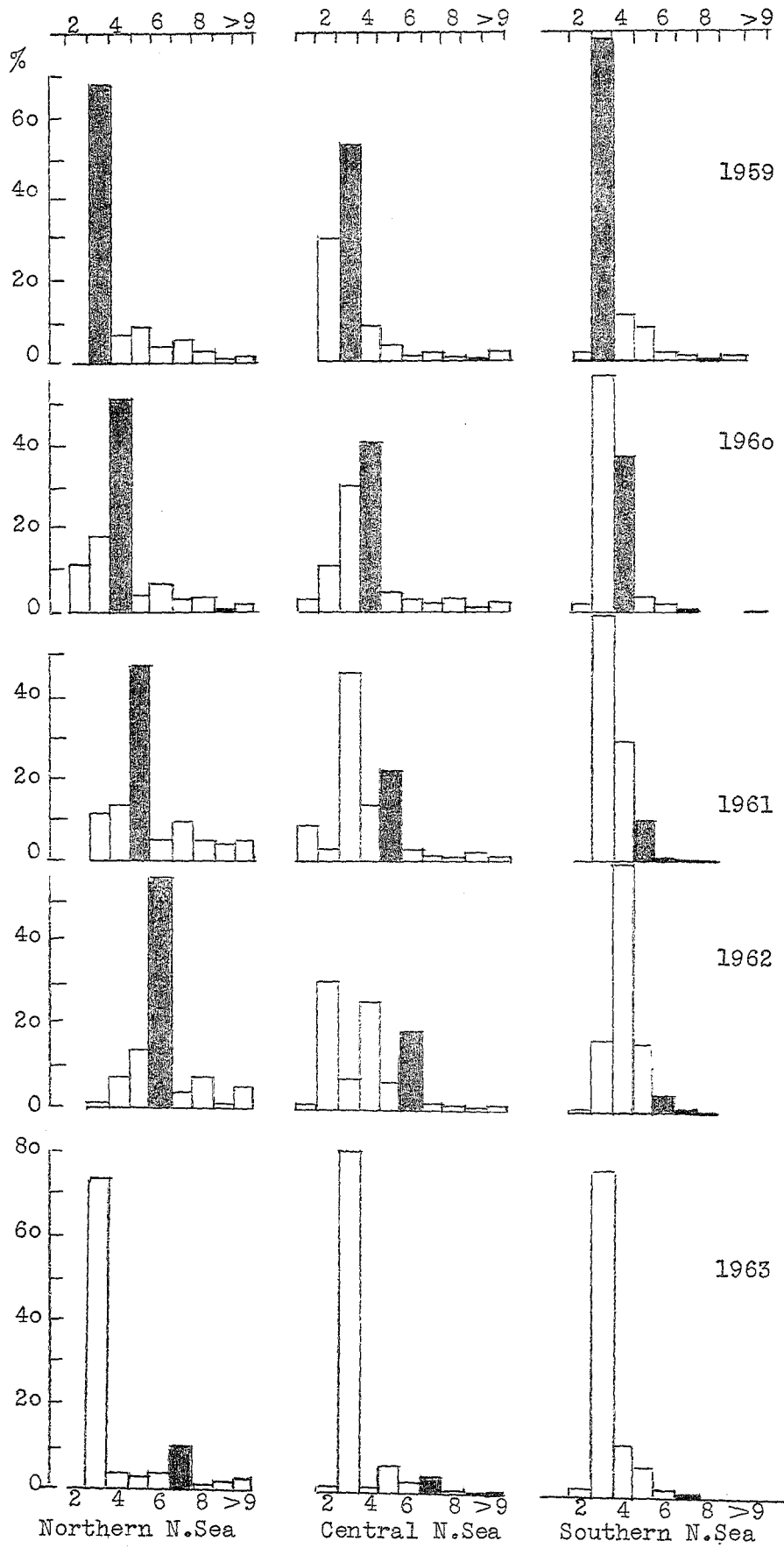


Figure 9. Average percentage composition of age of herring in different regions of the North Sea 1959-1963.

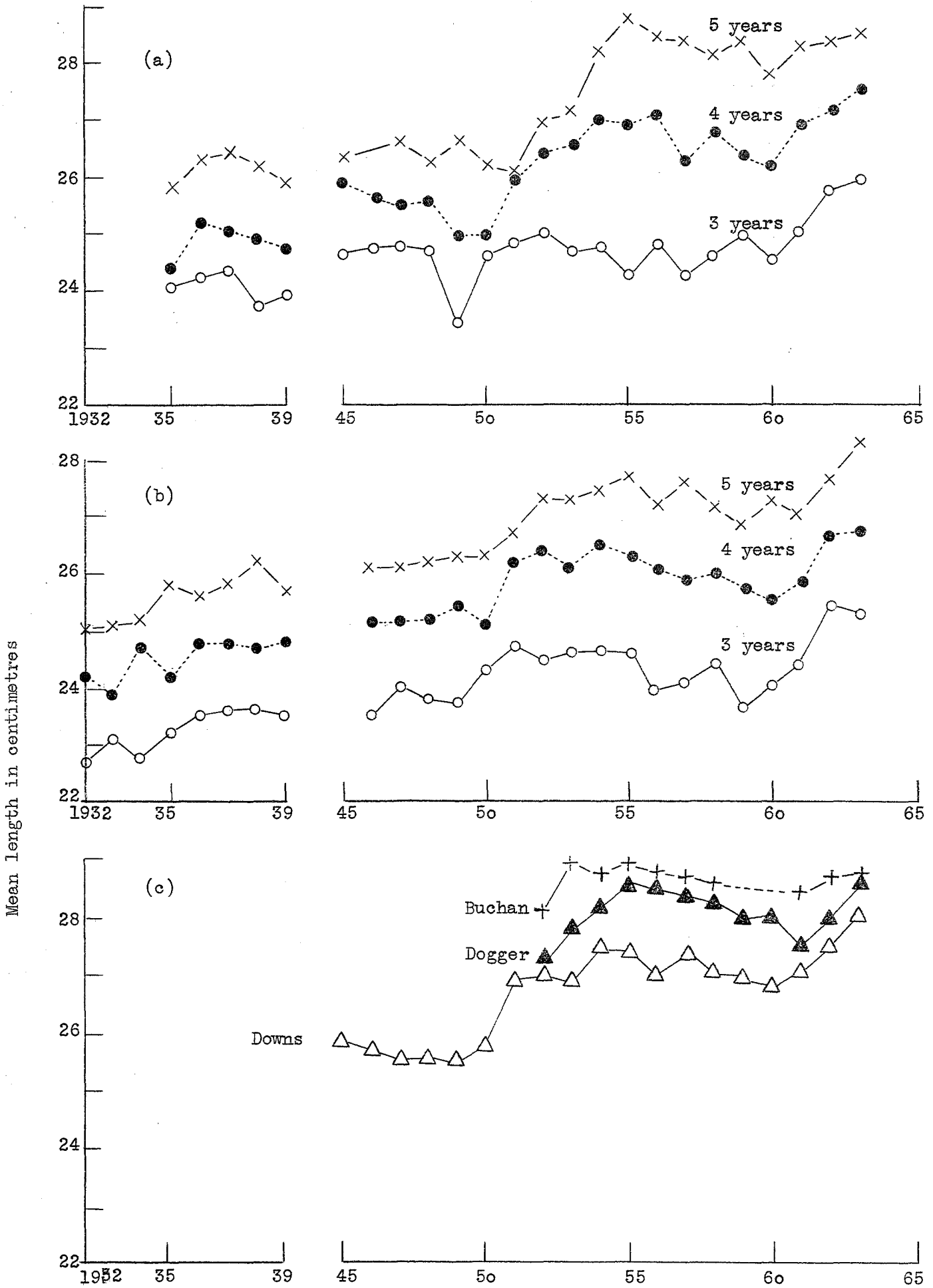


Figure 10. Average length of three to five year-old herring in Northern (a) and Southern (b) North Sea, and of five year-old Buchan, Dogger and Downs spawners (c).

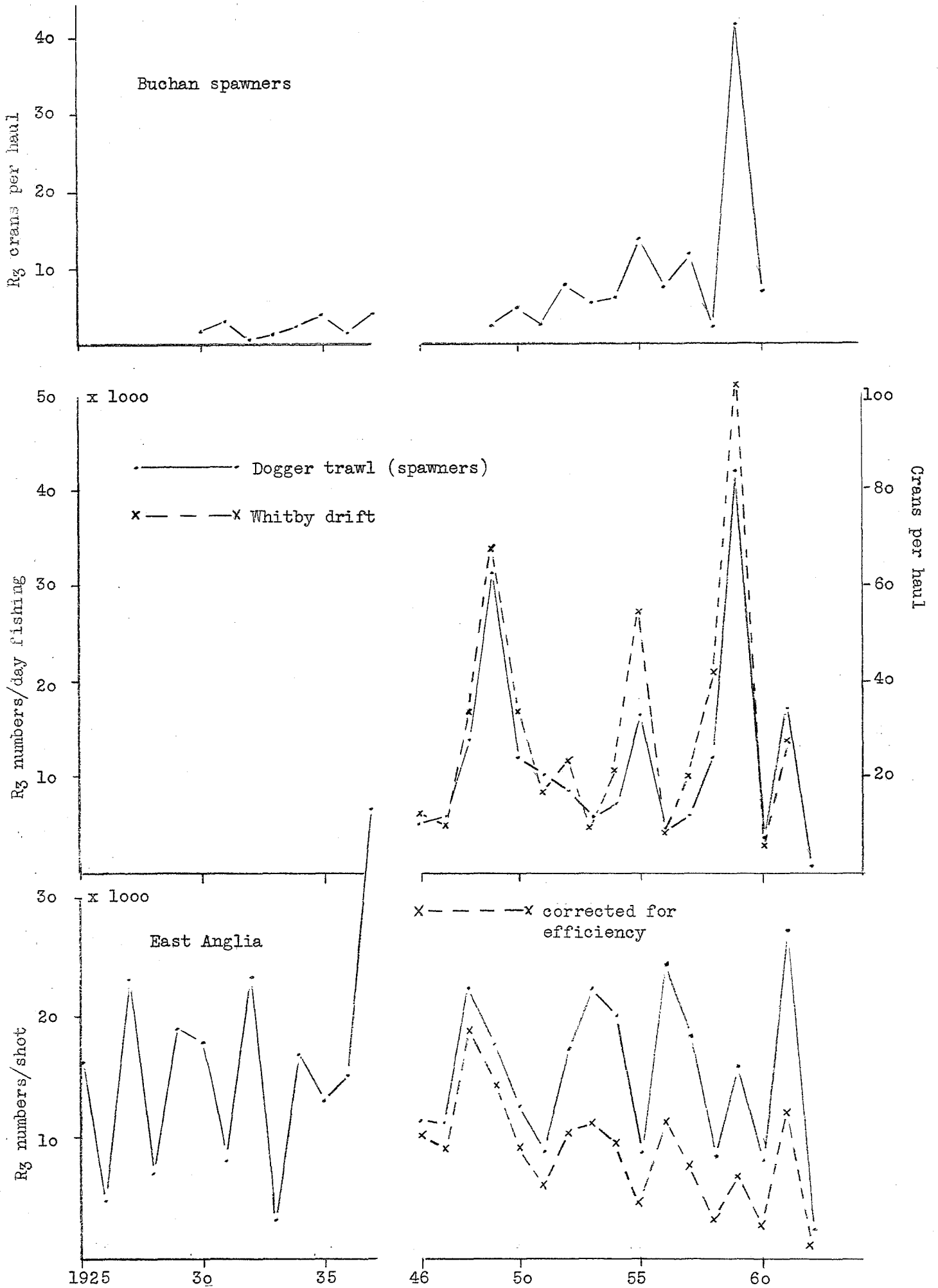


Figure 11. Indices of recruitment for Buchan, Dogger and Downs spawners.

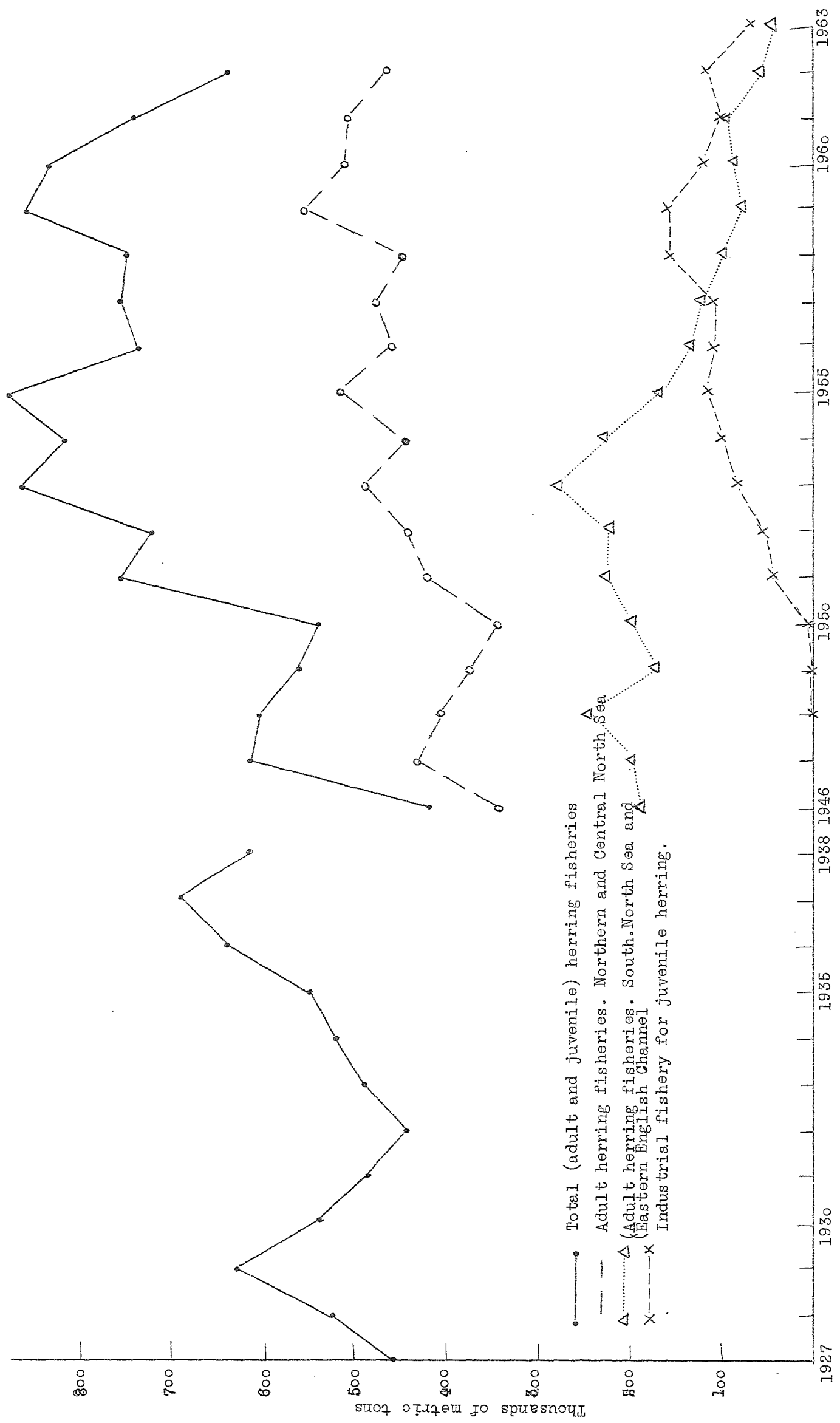


Figure 12. Landings of herring from the North Sea and Eastern English Channel

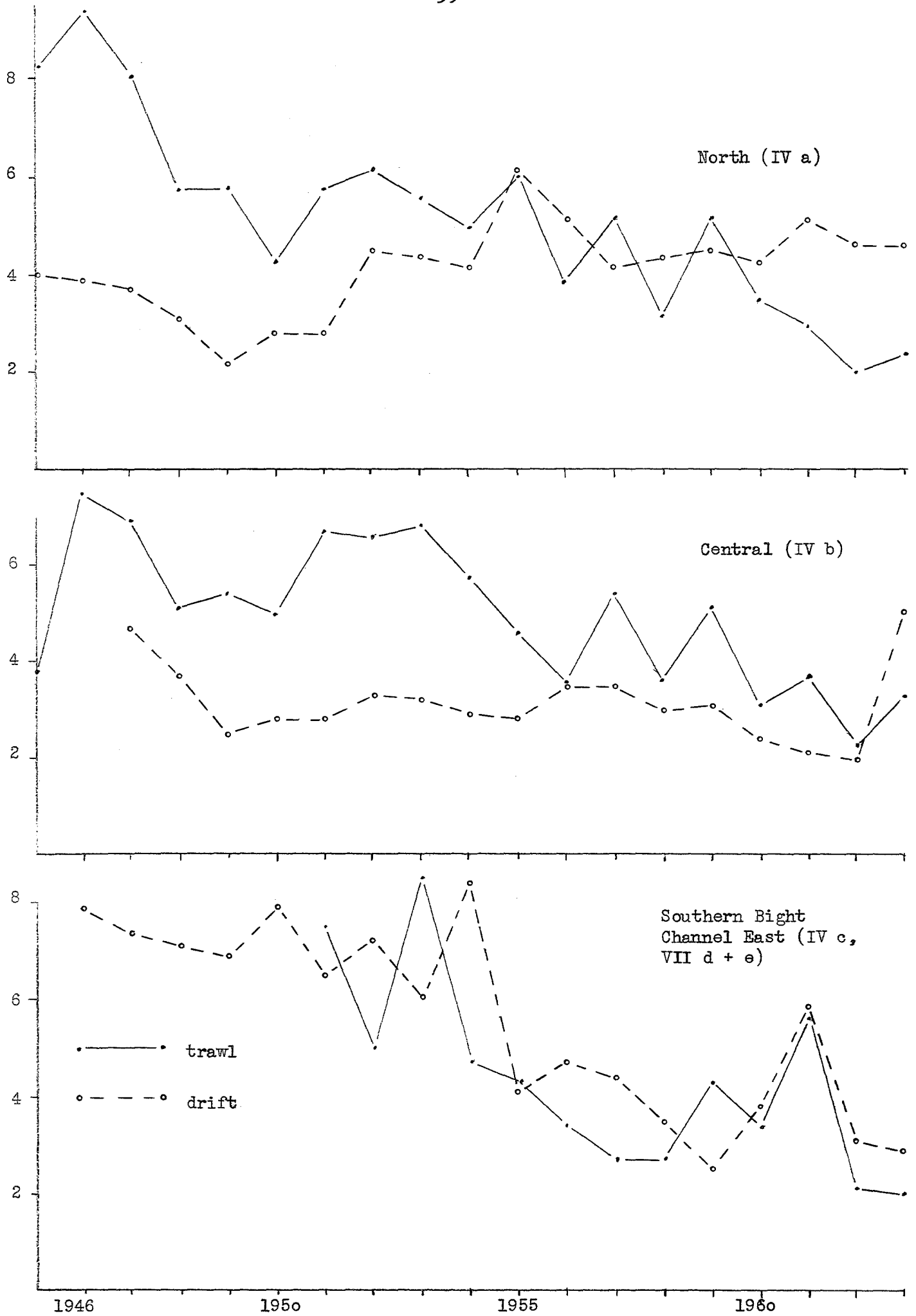


Figure 13. Catches per unit effort in North, Central and Southern North Sea.

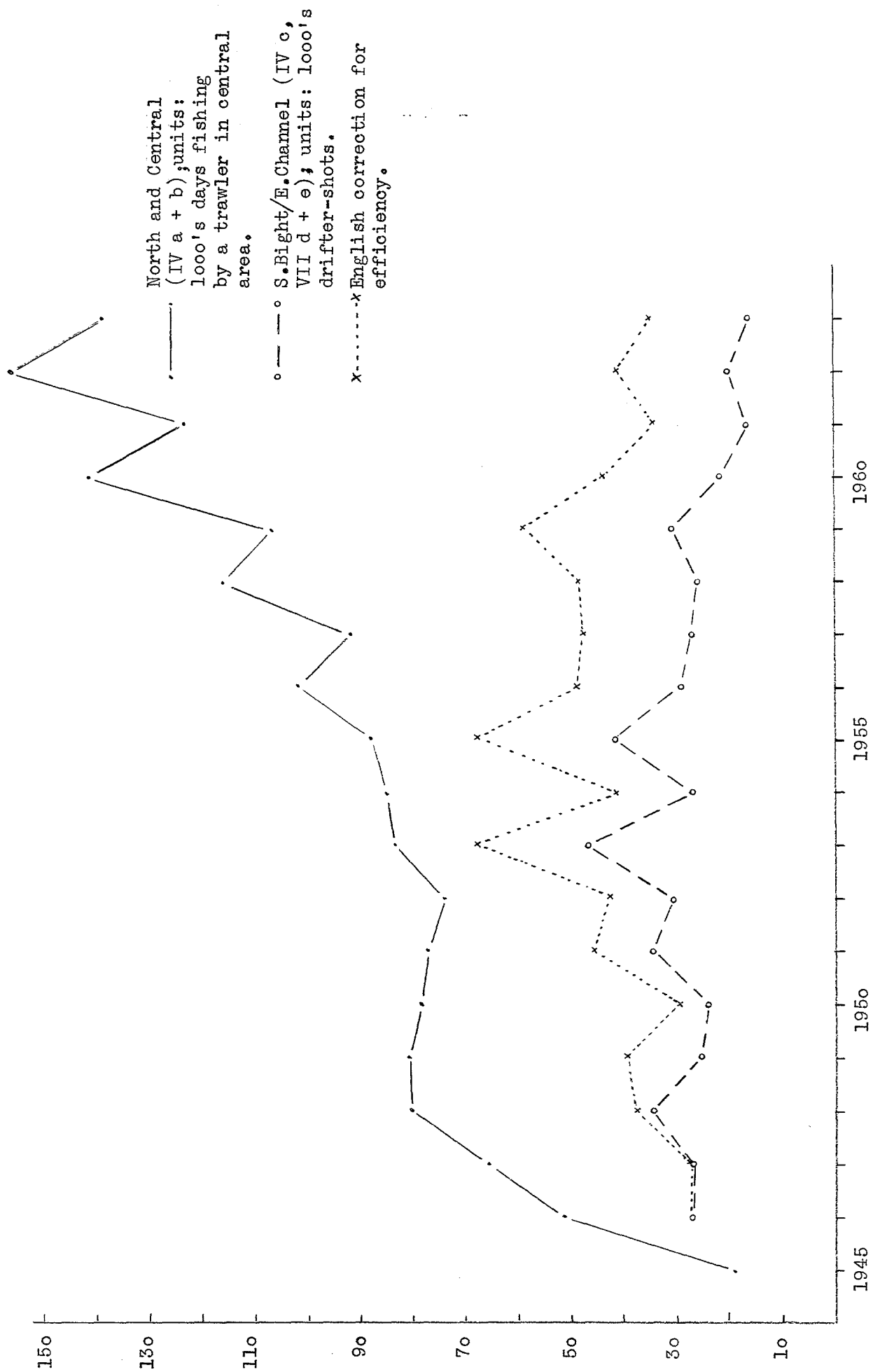


Figure 14. Estimates of total effort in different areas of the North Sea,