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Exploration of the Sea

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REPORT ON THE NORTH SEA HERRING ASSESSMENT WORKING GROUP

Charlottenlund Slot, 13-22 June 1972

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CONTENTS

I. Terms of Reference and Participation

The International Council for the Exploration of the Sea, acting on a general concern expressed at the NEAFC Meeting in May 1968 about the North Sea herring fisheries, appointed a Working Group to review the state of the North Sea herring stocks and to discuss measures for the improvement of the fisheries exploiting them.

The Working Group held two Meetings in 1969, the results of which are published in Coop. Res. Rep., Ser. A, No. 26 (1971). The Working Group concluded that in order to increase the size of the adult stock it was advisable to stabilise the effort at a lower level than exerted then.

At its Ninth Meeting in May 1971, NEAFC passed the following resolution:

> "In view of the Commission's interest in the possibility of regulating the North Sea herring fishery by means of catch quotas, the ICES North Sea Herring Assessment Working Group is asked to review the present status of the North Sea herring stocks and to advise on the following questions:
>
> 1) What alternative schemes of total catch limits should be set in order to allow recovery of the stock to a satisfactory level within a reasonable period of time?
>
> 2) Are differential quotas by season, region and category necessary to achieve effective conservation; if so, what form might they take?
>
> 3) Is the 4°W Meridian the appropriate north-western boundary for the quota area?
>
> It is noted that all the catch, fishing effort and biological data for the period ending 31 December 1970 must be made available before the Group can carry out the above study, and that it is desirable that as many data for the year 1971 as possible, should also be made available".

Acting on the request of NEAFC, the Working Group met in June and September 1971 and in January and June 1972 with Mr K. Popp Madsen (Denmark) acting as Chairman.

All meetings were held at ICES Headquarters, Charlottenlund Slot, Charlottenlund, Denmark, and member countries were represented by the following scientists:

		1971		1972	
		14-19 Jun.	1-5 Sep.	24-28 Jan.	13-22 Jun.
Dr H. Ackefors	Sweden	x	x	x	
Dr Y.K. Benko	U.S.S.R.				x
Mr A.C. Burd	U.K.	x	x	x	x
Mr A. Corten	Netherlands				x
Dr H. Dornheim	Germany				x
Mr H. Lassen	Denmark		x	x	x
Mr A. Maucorps	France		x		
Mr K. Popp Madsen	Denmark	x	x	x	x
Mr K.H. Postuma	Netherlands	x	x	x	
Mr E.S. Prosvirov	U.S.S.R.				x
Mr A. Saville	U.K.	x	x	x	x
Dr A. Schumacher	Germany	x	x		
Mr Ø. Ulltang	Norway			x	x
Mr O.J. Østvedt	Norway	x	x	x	x

All meetings were attended by Mr J. Møller Christensen, in his capacities of Secretary to the Liaison Committee and of Statistician to ICES. It was noted with regret that representatives from nations with important fisheries in the North Sea were not attending the meetings.

II. Material and Agenda

The North Sea Herring Assessment Working Group at its 1969 sessions mainly considered the development in the stocks and fisheries in the period 1960-1968. Catch statistics and data on the biological composition were compiled for that period and a calculation of the number of herring caught per year by age and area was undertaken.

At the present meetings the Working Group has expanded this work to comprise the entire post-war period and to make additional assessment methods, such as the Virtual Population Analysis, applicable.

The main objective of the Working Group has been to establish prognoses on the future development in catch and biomass over a 4-5 year period at different levels of fishing mortalities. For this purpose the following data have been vital:

a) age compositions by areas and fisheries, together with data on numbers per kg;

b) abundance estimates from Young Herring Surveys and Young Herring Fisheries;

c) data on average weight by age and month;

d) data on catch and effort by gear and area.

As on earlier occasions, the Working Group had to spend a disproportionate amount of time on compiling the data in a suitable form. Major fisheries are still not covered by detailed catch statistics and are in some cases not even referable to the gross statistical areas used by ICES. Equally serious deficiencies characterise the biological data where such basic information as age distribution and numbers caught per unit of weight are lacking for entire areas or fisheries representing thousands of tons. The problem of inadequate data is most apparent in the case of Skagerrak, which for that reason had to be excluded from the analyses carried out.

The deficiences in the data available introduce an uncertainty in the conclusions drawn, which must necessarily affect the quota levels.

III. The Fisheries

a) Landings

The general decline in total catch from the North Sea and Skagerrak since the peak year of 1965 continued in 1969 and 1970 (Table 2). The total catch in 1971 of 574 000 tons was 32% below the average catch level in the period 1955-1964 prior to the heavy expansion of the fisheries, and 8% lower than the catch in 1970. The catch in 1971 is only slightly greater than the average catch in the period 1948-1950 when the main fisheries in the North Sea were the adult herring fisheries for human consumption and the effort was at least half the recent level.

In 1969 the herring fisheries showed a general decrease in catch in most sub-areas while the developments in 1970 and 1971 show a somewhat different pattern. In the latter years a continued decline took place in Skagerrak and the northeastern North Sea while a marked increase took place in the northwestern part (section VII). As shown in Table 2 the recorded catches in the northeastern North Sea went down by about 87% from 1969. It must be noted, however, that the allocations to North Sea sub-areas of Danish, Faroese, Icelandic and Swedish catches are based on a limited sampling of statistics in one Danish harbour. Though the actual figures are bound to be uncertain, the independent picture from the Norwegian catch distribution supports the general development as described above.

In the central North Sea after the increase in adult catch in 1970 over the previous two years, this fell in 1971 to the lowest level recorded. However, the closure of the herring fisheries in August/September 1971 will have contributed to this decline.

The catch levels in the south have remained constant, but at a somewhat higher level than in the 1966-1968 period. Nevertheless, the current levels are reduced by ten times from the fisheries in 1952-1954.

The highest catches on record were made in 1971 in the young herring fisheries in the central North Sea. This represents an increase of 2.2 times over the low 1970 catch and 1.4 times over the 1969 catch. The increase is associated with the entry of the strong 1969 year class into the fishery.

b) Catch composition

(i) Numbers caught per age group

Data are presented in Table 9 giving the total catches by area in number per age group for the period 1947-1971. The methods described in Coop. Res. Rep., No. 26, for obtaining the annual age compositions by which separate age compositions were used for fish taken by different gears, each being raised to the total catch by the respective gear, has been followed for the period 1955-1958 and 1969-1971. Any country's catches which could not be specified to gear were used to raise the total specified catch to the total area catch.

The age data used by areas and gear are summarised below:

Year	Area										
	IVa.W			IVa.E			IVb			IVc	
Gear	Drift	Trawl	Purse	Drift	Trawl	Purse	Drift	Trawl	Purse	Drift	Trawl
1955	S	G	-	S,G	G	-	E	G	-	E	H
1956	S	G	-	S	-	-	E	H	-	E	H
1957	S	G	-	S	B	-	E,S	H,G	-	E	H
1958	S	G	-	S	-	-	E	H,G	-	E	H,G
1959	S	G	-	S	G	-	E	H,G	-	E	H,G
1969	S	G,H	N,S	-	H,D	N	-	H,G	-	-	H,G
1970	S	G,D	N,S	-	H,D	N	S	G,H	-	-	H,P,G,F
1971	S	D,H	N,S,I	-	D	N,D/F	E,S	G,H	-	-	H

Key: B - Belgium
D - Denmark
D/F - Danish Faroese Landings
E - England
F - France
G - Germany
H - Netherlands
I - Iceland
N - Norway
P - Poland
S - Scotland

For the period 1947-1954 the age data for areas IVb and IVc are Belgian (Gilis, 1958). For trawl catches in IVa the same source has been used and Scottish drift net data have been applied to drift net catches (Parrish & Craig, 1963). Numbers per kg were derived from Gilis except for IVa drift net catches which were derived from Scottish data in Statistical News Letters.

The age data for the young herring fishery in IVb are all derived from the Danish trawl fishery.

The estimates of the total catches in numbers for each age group for the years 1960-1968, given in Table 9, differ from those given in Table 17 of Cooperative Research Report, No. 26. These differences have arisen from the application of better estimates of the number of fish per kg in the catches of the young herring fisheries in area IVb in these years, and thus affect predominantly the estimated numbers of 0-and 1-group herring caught.

During the June 1972 Meeting of the Working Group the catches in numbers per age group in the adult fisheries in 1965 were also recalculated. This estimate differed very markedly from the total catch in numbers per age group for the whole of the North Sea for 1965, given in Cooperative Research Report No. 26, largely because of big differences between the two estimates for areas IVa.W and IVa.E. This is hardly surprising, in view of the comments made in the previous Report of the Working Group on the inadequacies of the catch sampling of some of the major fisheries in these areas.

Because of the deficiencies in sampling, any estimate of catch in numbers per age group for these areas will contain a large measure of uncertainty. In view of this, it was decided that the labour involved in recalculating all of the data for the years 1960-1968 was unjustified. The data given in Table 9, originating from the adult fisheries, is therefore unchanged from those given in the previous Report.

(ii) Percentage of spring spawners in the North Sea catches

The percentages of spring spawning herring in the catches from the northwestern, northeastern, and Skagerrak areas are given in Table 10 according to the available national data. In the northwestern area the Norwegian and Scottish data are in close agreement for the period 1965-1968, but thereafter differ widely. This difference may be due to a methodological error in that after 1968 the Norwegian otoliths were read by a different operator than in the earlier period. It is also possible that this difference in the later years reflects a real difference in the proportion of spring spawners in the catches of the two countries. In these years an increasing proportion of the Norwegian catches was taken on the western boundary of the area, whilst an appreciable proportion of the Scottish catches came from the East of Shetland and within national fishing limits.

In the northeastern area, in all years, there are large differences between the percentages estimated by the different countries. This again may result from differences in the timing and location of the fisheries of the different countries.

In all areas there is some indication of a higher proportion of spring spawners in the catches after 1965. This might suggest that the spring spawning stock has not decreased to the same extent as the autumn spawning one did as a result of the major increase in fishing effort in 1964 and subsequent years.

(iii) Data on Skagerrak fisheries

In the previous Report, (Anon., 1971), an estimate of catch per age groups in number was given for the Skagerrak for the period 1963-1968 (loc. cit., Table 20, p. 47). Only limited data on age and weight composition of the catches were, however, available and most of these data came from the fisheries for human consumption. It also appears that the estimate of catch in number per age groups for 1968 was based on Norwegian research vessel samples which showed a predominance of 0-group fish while the Norwegian commercial fishery was mainly based on 1- and 2-ringers. Due to the inadequate sampling of the commercial catches any estimates of catch in numbers per age groups would be misleading.

Table 11 gives the Danish and Swedish herring catches landed in Denmark separated into catches for human consumption (C) and for industrial purposes (I), together with estimated mean number per kg for some years. For Norway, total catches only are given, but during the years 1964-1968 at least 90% of the catches were for industrial purposes. The catches for other countries are almost exclusively for human consumption.

The figures available on mean number per kg indicate that the Danish industrial landings mainly consisted of fish with 0 and 1 winter rings, while the Norwegian industrial landings in the years 1965-1968 exploited fish with 1 and 2 winter rings. It seems, therefore, that the total catch from Skagerrak during the years 1960-1971 consisted mainly of fish with less than 3 winter rings.

(iv) Catch per Unit Effort

For the period 1947-1971 catches per unit effort are given in Table 12 for trawl and drift net fisheries in the North Sea.

Apart from the extension in time some of these data differ slightly from those in Coop. Res. Rep., No. 26. In particular the Netherlands trawl data refer to herring in fresh weight while previously these were in landed weight.

In the central area the U.K. unit used is catch per landing. Since 1965, as some landings represent more than one night's fishing, these numbers should be reduced by a factor of about 0.8, to be comparable with the earlier data, but this correction has not been applied to Table 12. These data are derived from the summer fishery off the English northeast coast. In the early part of the season this fishery is directed at recruiting fishes, while later an increasing proportion of older fish are taken, when the drifters exploit the spawning grounds off the Yorkshire coast. The more stable nature of the drifter catches per effort compared with the trawler series, may be related to this greater dependence on recruit herring.

Both trawler and drifter units show declining catches per effort in the south and northeastern areas.

In the northwestern North Sea again the drifter data are more stable and do not show the marked decline seen in the Dutch trawl data. This difference in abundance indices between drifters and trawlers has been commented on before. Pope and Parrish (1964) considered that the differences between drifter and German trawl catches per effort from July 1947-1959 reflected real changes in abundance. They suggested that net selectivity could account for the difference. Zijlstra (1967) showed a consistent difference between the age compositions of trawl and drift net catches over the period 1930-1960. He concluded that the differences could be explained from the drifters selecting a younger component of the stock. Differences in area distribution of the two fleets might also have an effect.

(v) Effort

Estimates of effort for the period 1947-1971 are given in Table 13 for the northwestern, northeastern, central and southern North Sea and the Bløden area. These data are arrived at by dividing the total catch in an area by the catch per unit effort in that area. As discussed in Coop. Res. Rep., No.26, the method is only reliable when the catch per unit effort of an area is estimated from fisheries taking the major part of the total catch in that area. Difficulties in this respect were experienced in the areas of the northern North Sea, and the effort estimates of the northwestern and northeastern North Sea are, therefore, to be considered with reservations.

Using the U.K. drift net series and the Dutch trawl series, estimates of total effort in the adult fisheries in the North Sea have been computed. In the case of the drifter data for the central and northwest areas it has been assumed that each landing was a drifter shot. The effort for these areas, and area south, have been summed and raised by the difference between the total catches from these three areas and that for the total North Sea adult fisheries. Such a summation of the effort estimates for the individual areas is only valid on the assumption that they are measured in the same units and in this case they are derived from almost the same fleet of vessels.

In the case of the Dutch trawl data it has been assumed that the catches per unit effort for the northwest, northeast and central areas are all estimates of the total stock of herring in the North Sea. This is certainly not the case in the northeastern area where the major decline in catch per unit effort in the later years was partly due to a change in fishing area as the objective of this fishery changed, as the herring stock declined from predominantly herring to a greater emphasis on demersal fish. It is most unlikely that all of the stock is fully represented in any of these areas. This is particularly pertinent to the central area where few fish from the northwestern spawning stock are represented.

However, unless a reliable estimate of the proportion of the total stock fished in each area is available, the simplest assumption which can be made is that these estimates are equally valid measures of the total stock within that area. Because of availability differences between the areas, catches per unit efforts are not measured in the same units. To correct this, mean catches per unit effort were calculated per area using data from the period 1955-1967 for which catch per effort data are available for each area. The ratio of the mean catches per unit effort in the northwestern and northeastern areas to that of the central area were calculated, and the catches per unit effort for the first two areas were adjusted by this factor. Yearly means were then calculated for the three areas and this figure was raised to the total North Sea effort. Table 14 gives the estimated total North Sea efforts calculated by both methods.

The effort recorded in drifter landings is underestimated in 1969 and 1971, as there was no fishery in the southern area from which the catch per efforts were derived. The data suggest that after reaching a peak in 1961-1968, the total effort on adult herring has since declined somewhat.

The trawler effort also shows the increase in effort from 1961-1968, with, subsequently, an apparently slight decline.

Table 14 also gives catch per effort estimates in drifter and trawler units for the total North Sea catch. The drifter data originating from fisheries mainly on recruiting herring show little trend with time. However, those for the trawler index, being based mainly on the spawning stocks, show a large decrease with time.

Using the weighted mean fishing mortality for fish of 2 rings and older from the VPA analysis, apparent changes in fishing efficiency with time can be examined. The ratio $\overline{F}$/Cpe for each year describes the relative changes in $\overline{F}$ generated by one unit of catch per effort. The plots for drifter and trawler efficiencies appear in Figures 1 and 2. As the mean $\overline{F}$ values for 1968-1970 are not reliable from the VPA analysis because of the short periods involved, F has been set at 1.0, as has been used in other analyses, and which is of the order of the observed values of F from catch per effort data.

The drifter data indicate an increase in apparent efficiency (fishing intensity) of about two times by 1961 from the level of the earlier period. Accepting the values of F for 1968-1970, the increase was then three times.

The trawler data indicate a rather steady level of intensity from 1954-1964, subsequently jumping by a factor of about three.

In Figure 1 the relative change in fishing intensity for the Danish young herring trawlers is indicated. This has been calculated by using the catch per effort data of Table 12 and the index of fishing mortality for 1-ringed fish from the VPA analysis. The data suggest an increase in efficiency of the order of two times between 1958-1963 and 1964-1970.

IV. The Fish Stock

a) Natural mortality

Some impression can be gained from the use of the catch per effort data given in Table 14 of the relative size of M in relation to Z. For the Dutch trawler data the regression of annual 1/Cpe on total effort for the North Sea has been calculated (Figure 3). The statistic 1/Cpe is an approximation to the total fishing mortality. The intercept of 0.13 is not significantly different from the value M = 0.1. The intercept itself must be an overestimate, as the catches per effort in later years are not corrected for the fishing efficiency increase. This correction would tend to increase the slope and reduce the intercept. This would imply that for the adult part of the stock, the value of $M = 0.1$ is realistic.

Other estimates from catch per effort data of the natural mortality coefficient are available and summarised below:

Source	Stock	M
Postuma (1963)	Downs	0.08
Burd & Bracken (1965)	Dunmore, 1952-1959	0.13
Malloy (1969)	Dunmore, 1961-1968	0.15

In earlier assessments a value of natural mortality of 0.2 has been used when considering the effect of fishing on North Sea adult herring stocks. In the present Report the Virtual Population Analysis and the prognosis have been carried out using the value of $M = 0.1$. The same value of M was also applied to juvenile immature herring as 0- and 1-ringers included in the analyses as it was considered less objectionable to use the same value of M throughout the life span than trying to make changes in this value on hypothetical grounds.

b) Fishing mortality

Table 15 gives the values of F obtained from the Virtual Population Analysis on the total North Sea stock for $M = 0.1$. The effect of higher value of $M = 0.2$ is to decrease the fishing mortality. The correlation between $M = 0.1$ and $M = 0.2$ can be represented by the following equation:

$$F_{0.1} = 0.96\ F_{0.2} - 0.067$$

For the adult stock (2-ringers and older) the data show a relatively steady level in F up to 1964 followed by an increase in 1965-1967 to about 0.7-0.8 when the fishery in the northern North Sea expanded. Subsequent to 1967 the mortalities have remained at a high level of about $F = 1.0$, as indicated from catch per effort data.

The fishing mortalities for the 1-ringers show an increase in F from the early 50's up to about 0.5 in 1964 and have since stayed at about the same level. The increase in F corresponds in time with the commencement of the Bløden young herring fishery.

c) Stock size

(i) Estimates from virtual population analysis

Table 16 gives the estimated stock size in numbers by age and year for the total North Sea from the VPA using $M = 0.1$.

The stock sizes were also calculated for the total North Sea using $M = 0.2$. Using an M of 0.2 the stock sizes calculated are about 30% higher.

Over the years 1949-1965 the total stock sizes were remarkably stable, fluctuating around an average level of about 29.0×10^{-9}. After 1965 the stock sizes decreased to an average level of about 20.0×10^{-9}.

Considering the stock sizes for the different age groups, it appears that most of the reduction in stock sizes have taken place in the adult stock (2-ringers and older) which since 1966 has been reduced to about one third of the level in the early fifties. This decrease compares very well to the decrease in average trawl catch per effort (Table 14).

A reduction in the number of older fish greatly affects the spawning potential of the stock, and as is shown in Table 19, the estimated spawning potential has been reduced by about 3 times in the later years, as compared with the period 1947-1952.

(ii) Estimates from tagging experiments

From Norwegian tagging experiments in 1966 in the northeastern North Sea (June) and east of Shetland (July), the stock in the northeastern North Sea was estimated to be 0.54 million tons and in the Shetland area 0.57 million tons, totalling 1.11 million tons (Anon., 1971). These estimates were, however, based on returns during the first three months after tagging and most of the returns came from the areas of release (Haraldsvik, 1969). It seems evident, therefore, that the tagged fish were not randomly dispersed.

According to later reports from these experiments the returns during 1967 and 1968 show that 30-35% of the tagged fish from the experiment in the northeastern North Sea had migrated to Shetland, while 21-41% of the Shetland tagged fish were in the eastern area.

The autumn spawners in both experiments consisted of 2-ringers and older fish. About 10% of the tagged fish in the northeastern area and about 30% in the Shetland area were spring spawners.

Considering returns during 1967 and 1968, the estimates of the total stock of adult autumn spawners in numbers in 1966 in the northern North Sea range between 10 - 15 thousand million, or in weight (using an average number per kg of 5.2) from 1.9 - 2.9 million tons.

d) Larval abundance

Indices of larval abundance for the period 1946-1969 were presented in Coop. Res. Rep., No.26. In Table 17 of the present Report the results of the 1970 ICES Herring Larval Surveys have been added and some alterations made to the data for the southern North Sea.

The changes in the Downs estimates have resulted from restricting the larval abundances used to those obtained from sampling in comparable areas within the months December and January. The abundances are of all larval sizes, and as in earlier years (1946-1962) and in 1969 no separation by size was made. A simple mean has been taken of the abundance indices obtained from each survey within each spawning period for use as the annual index. In 1968 the Downs surveys were far apart in time (early December and late January) and the larval sizes were small in each case. As an exception, therefore, in this year the abundance taken is the sum of the two survey indices. In 1966 only two surveys were made up to 20 December when few larvae would have hatched out. No abundance index can be given for this year.

The abundance indices of larvae from the southern North Sea (Downs) show increases in number since the very low levels of the period 1963-1965. In the central North Sea larval abundances are still dependent on the spawning off the English northeast coast between the Longstone and Flamborough. In the northern region the major production originates from the Orkney/Shetland region, though in 1969 some production was recorded on the spawning grounds near the Aberdeen Bank.

Comparable data for 1971 were not available to the Working Group. Preliminary estimates suggest that in the south, larval abundance was low (1963-1965 level). In the central region abundances of the same order as 1970 were recorded, as was the case in the Orkney/Shetland area. In the northwestern area, however, increased production was evident on the Aberdeen-Turbent-Montrose Banks area.

e) Recruitment

(i) Recruitment estimates

Recruitment estimates are available as the number of 0, I or II group fish from the VPA, and as catch per unit effort of 3 year old herring in drift net and trawl fisheries. For the most recent year classes (1969, 1970) the only estimates available so far are from the International Young Herring Survey, the English 0-group survey, and the Danish industrial fishery.

Both the 1969 and 1970 year classes seem to be above average (Table 23). Over the whole period 1947-1970, there is no clear trend in the overall recruitment to the North Sea stock.

Recruitment estimates for Buchan, Bank and Downs stocks were available for the years 1951-1967 as the catch per unit effort of 3 year olds in the drift net and trawl fisheries in the areas (Table 18). In order to get an overall estimate for the recruitment to North Sea stocks, catches per unit effort for individual areas were expressed as standard measure $\left(\frac{x - \bar{x}}{\sigma}\right)$ and then added by years.

A comparison was made between these recruitment estimates and the figures for stock size at three years of age, calculated by VPA. For this purpose, VPA values were also expressed as standard measure (Figure 5).

A significant correlation ($r = 0.86$) was found between the two sets of recruitment estimates, indicating that recruitment levels calculated by VPA are of the same order as those estimated from the combined catch per unit effort of 3 year olds in the different areas.

(ii) Stock-recruitment relationship for total North Sea

Using estimates of each age group of the adult stock for the total North Sea (from VPA) the spawning potential of the stock was calculated from fecundity data on northern North Sea herring. The spawning potential is obtained by multiplying half the numbers of stock at each age by the mean fecundity for that age group. This gives the potential annual egg production or spawning potential.

Fecundity per age group (from Baxter, 1959)

Ringers	2	3	4	5	>5
No. of eggs x 10^{-3}	45	67	87	96	101

Spawning potential of the total North Sea stock is compared with recruitment estimates as 0-ringers from VPA in Table 19. There is no correlation between the two values for the period of observation. Instead, recruitment fluctuated around a rather constant level of about 8 x 10^9 (Figure 6).

The North Sea herring are regarded as consisting of three major stock units, Bank, Downs and Buchan. Stock recruitment relationships have been demonstrated for some of the individual stocks. By adding all stocks together in the present analyses, any underlying stock/recruitment relationships might well be masked.

(iii) Stock-recruitment relationship for Downs herring

Figure 7 shows a plot of Downs larval abundance (Table 17) against both the abundance of 0-group herring along the East Anglian coast and Thames estuary (Wood, 1970) and the abundance of low mean length herring (<15-16 cm) as measured during the International Young Herring Surveys. The 1968 year class has been excluded because larval production of the Downs stock was not properly measured in 1968/1969. For the remaining years (1964-1970) the relationship between number of larvae and abundance of young herring is quite apparent.

The plot of 0-group fish against low mean length I group in Figure 8 also includes the 1968 year class. This year class in the Downs stock was of about the same strength as the 1969 and 1970 year classes, while for the total North Sea the 1968 year class was only half as strong as the 1969 year class (Table 23).

f) Weight data

The monthly mean weights per age group are given in Table 20 for each area separately. These mean weights are based on data collected in the period 1966-1971 in area IVa.W on combined Netherlands and Scottish data, in area IVa.E on Netherlands data and in areas IVb and IVc on English and Netherlands data. Norwegian weight for age data for area IVa as a whole are tabulated separately. The rather few observations available for area IVa.E suggest that the weight per age in this area is very similar to that in IVa.W and the Scottish and Netherlands data for these two areas are very similar to those of Norway for the combined areas. Danish data of monthly weights for age in the juvenile fisheries are given in Table 21.

In all areas the data show a maximum weight per age in the adult fisheries in August-September and a fairly rapid decline thereafter to about 60-70% of this summer maximum in the early months of the following year. This would suggest that quite apart from any gain due to growth or reduction in fishing mortality, an appreciable increase in yield could be obtained by restricting fishing during the period November-April.

The mean number of herring per kg by month and area is shown in Table 22. In the northern North Sea the data refer to Scottish and Dutch catches, while those for the central and southern North Sea mainly derive from the latter. Additional figures for juvenile herring in the central area are obtained from the Danish young herring fishery. For the adult fisheries the number per kg is lowest in the period between the feeding and the spawning seasons.

Table 11 presents some information on numbers per kg in certain Skagerrak fisheries. These data, however, are hardly representative of the total catches.

V. Prognoses for Different Levels of Fishing Mortality

Essentially any fishery regulation is directed towards a control of the fishing mortality either in an entire fish stock or in components thereof (e.g. juveniles).

The main task of the Working Group was therefore to estimate the parameters of fishing mortality, natural mortality and stock size from earlier data and to establish a basis for prognoses of the future development of the herring stocks.

a) Parameters and assumptions

(i) Natural mortality

Natural mortality has been assumed to be 0.1 for all ages. The use of an alternative value of M = 0.2 was tested, but the effect on the prognosis was found to be negligible at current levels of fishing mortality.

(ii) Fishing mortality

From data of the 1968-1971 fisheries the following estimates of total mortality have been derived from catch per effort data:

Year	Total Mortality Z			
	IVa	IVb		IVc
	Scotland	England	Netherlands	Netherlands
1968/69	0.55	1.27	1.30	2.0
1969/70	1.34	1.30	0.79	1.0
1970/71	0.73	1.30	1.30	0.8

It would appear from these data that the total mortality in recent years has been high and a fishing mortality for adult herring (i.e. 2-ringers and older) of F = 1.0 was thought realistic.

Using the total North Sea catches, F values for the juvenile herring (i.e. 1-ringed herring) were calculated by Virtual Population Analysis using M = 0.1. From this an average value of F = 0.5 appears reasonable for 1 ringed herring.

Table 15 suggests that the fishing mortality of the 0-ringed herring is about 10% of the fishing mortality of the 1-group.

(iii) Initial age composition and recruitment

The stock composition as at 1 January 1972 was used as a starting point for the prognosis. This was derived from catch in number per age group in 1971, corrected to stock as at 1 January 1971 by applying an M = 0.1 for all age groups, an F = 1.0 to fish older than 1-ringers and F = 0.5 to 1-ringers. The catch figures given in Table 9 were used.

In order to simulate the likely changes in the stock under different levels of fishing mortality in the next five years, some estimates of the relative strengths of incoming year classes are required.

The strengths of the 1968, 1969 and 1970 year classes have been monitored in the English coastal surveys for 0-group herring, the ICES Young Herring Survey and the Danish Young Herring Fishery. Taking the 1969 year class as standard, the comparitive strengths of the others are shown for comparison in Table 23. All estimates for the 1968 year class are in close agreement.

The strength of the 1970 year class is believed to be underestimated in the northern part of the English coastal survey. The means used for the young herring survey differ from those quoted by Postuma and Kuiter (1972) in that abundance indices have been separately calculated for fish of low mean length and high mean lengths. The mean numbers of 1-ringed fish per rectangle for the two groups have been summed to give the overall abundance index. It seems that the relative year class strengths so obtained are close to the estimates derived from the Danish young herring fishery taking place at the time the survey was made. Using these data it was assumed that the 1970 year class is 50% greater than the 1962-1969 mean (7.9×10^{-9}) and that all subsequent year classes are of average strength.

The estimated age composition as at 1 January 1972 is shown below:

Age composition as at 1 January 1972

w.r.	0	1	2	3	4	5	6	7	8
Nos. 10^{-9}	7.9	10.7	5.4	1.16	.38	.13	.022	.017	.16

This gives a total biomass of 1.0×10^6

(iv) Mean weights per age group

In order to assess the effects of changes in juvenile and adult fishing mortalities on the stock and catch in weight, estimates of the mean weights of each age group, as caught, have been made. The mean weights of fish older than 2-ringers were calculated from the von Bertalanffy growth equation:

$$W_\infty = 271.09 \pm 2.0$$
$$K = 0.377$$
$$T_0 = -1.526$$

For the younger age groups estimates were obtained of their mean weight both in the annual catch and at 1 January.

The mean weights used in the computations appear below:

	Mean weights (g)	
Winter Rings	At 1 January	Annual catch
0	-	17
1	25	50
2	75	125
3	182	
4	207	
5	226	
6	240	
7	249	
8	256	
9	260	
10	264	
11	266	
12	268	

b) <u>Prognosis for different levels of fishing mortality</u>

Using the parameters indicated in the previous sections, computations were made of the expected catches in 1972 under different levels of juvenile and adult fishing mortalities. These are presented in Table 24 and in Figure 9 for all combinations of juvenile fishing mortality from F 0.0 - 0.8 and adult fishing mortalities from F 0.0 - 1.5. In addition is shown the expected percentage changes in the 1975 catch and biomass over that in 1972.

In Table 24 the first column indicates the expected changes, if there were no fishing on 1-ringed fish (F = 0.0). Thus at an adult F = 0.1, the expected catch in 1972 would be 92 000 tons, and if this pattern were continued to 1976, then the 1975 catch would be 298% greater and the biomass at 31 December 1975 would be 306% greater. At an adult F = 1.0, the expected catch for 1972 would be 613 000 tons and the catch in 1975 would be increased by 47% and the biomass by 26%.

The first row indicates the effects of stopping all adult fishing and exploiting 1-ringed fish only.

It has been assumed that the recruitment would be of average strength up to 1976. The annual 1972-1975 catches would then simply be a proportion of these recruits depending on the fishing rate. There would be no change in catch with time, as the 1-ringed fish after passing through the fishery would join the adult unfished stock. However, the biomass would increase by 365% over the 1972 level at F = 0.1 or 188% at F = 0.7.

The accuracy of the prognosis has been studied, assuming recruitment to be a pure random process. The forecast of both catch and biomass up to the end of 1975 has a mean error of 25%. This point must be kept in mind when using the table.

c) Comparison with former data

The prognosis technique was applied to the 1970 catch for forecasting the 1971 catch. With an adult F = 1.0 (2-ringers and older) and a juvenile F = 0.5 (1-ringers) for 1970, the predicted and observed values for the 1971 catch were as follows:

	Catch in '000 t	
	Predicted	Observed
Immature catch[x)]	238	212
Mature catch	321	298
Total	559	510

[x)] It is assumed that 25% of the catch of 2-ringers are immature.

It will be seen that the predicted catch is about 10% higher than that observed.

The value of F = 1.0 for adults is a mean fishing mortality for all ages older than 1-ringers. Estimating F for each age group, using the catch of 1970 and 1971, and assuming a juvenile F = 0.5 and an adult F = 1.0 for 1970, the following gives fishing mortalities for 1971 (M = 0.1):

W.r.	F
1	0.44
2	1.47
3	1.02
4	0.60
5	0.50

This shows that the assumption of an equal F for all adult age groups is disputable. The Working Group, however, had no model available for calculating the expected changes in distribution of F on age groups and had to adopt the assumption used. Inspection of the prognosis showed that the effect on the adult catch was not very serious, so that from an operational point of view the assumption of an adult F equal for all age groups can be applied.

VI. Conservation Measures

a) Overall catch quota

From Table 24 and Figure 9 the overall catch quotas can be derived once the decision has been made regarding the level of biomass and catch required in 1975. If a doubling of the biomass is considered desirable, the sets of fishing mortalities (0.0, 0.5), (0.2, 0.4) etc. can be read from the table giving the overall quota for 1972.

b) Differential measures

Differential quotas will in principle allow higher catches to be taken in a fishery than with an overall quota. The more detailed a catch quota system, the greater the possibility of directing the fishing effort towards those levels of fishing mortality which in different periods, life stages, or areas will allow the maximum catch to be taken.

Different conservation measures were discussed in the former Report by the Working Group (Anon., 1971). All these measures were aimed at increasing recruitment or reducing mortality in the adult stocks or a combination of both. Differentiation of catch quota by region, season and category will be discussed.

(i) By region

An overall quota in the North Sea could be divided between certain areas of the North Sea. The purpose of this measure would be the protection of specific components of the North Sea herring.

For the purposes of the assessment the North Sea catches have been reported in four major regions of the North Sea and separately the catches of juvenile fish in the central North Sea. However, no estimate could be made of the effects of changes in fishing mortality within these areas following the application of catch restrictions.

(ii) Closed seasons

To estimate the expected gain in yield by closed seasons, monthly mean weights for each age group were calculated (Table 21) by using weight data from the different areas (Table 20) and taking a weighted mean for each month according to catch distribution in 1969 and 1970. Yields per recruit were calculated (Ulltang, 1972) using monthly weights and coefficients expressing the distribution of the fishing intensity on the different months for the following alternatives:

a) No closed season
b) Closed seasons in May and September
c) Closed season from 1 April to 15 June
d) Closed season from 1 March to 15 June

The yield curves are shown in Figure 10. The monthly fishing mortality for 1-ringers was set to 50% of adult fishing mortality and at 10% of adult fishing mortality for 0-ringers in July-September. The yield curve for alternative b) is very close to alternative a). The expected gains in yield by closed seasons are shown in the table below:

Yield per Recruit. $F_{adult} = 1.0$

	M = 0.1	
	Y/R (g)	% Increase compared with alternative a)
a) No closed season	81.7	-
b) Closed seasons in May and Sep.	82.8	1.3
c) Closed season from 1 Apr. to 15 Jun.	85.2	4.3
d) Closed season from 1 Mar. to 15 Jun.	90.0	10.2

Using M = 0.2, the yield per recruit will be reduced by about 20 g (Figure 10). The relative increase in yield per recruit for the alternatives b, c and d will be almost unchanged.

(iii) Quota by categories

The only practicable differentiation of quotas by categories is that between juvenile (0-and 1-ringers) and adults (2-ringers and older). In Table 24 and Figure 9 predictions of catch and of stock are given for various levels of fishing mortalities on juvenile and adults, respectively.

The present effect of the juvenile fishery is best illustrated by following say the 700 000 t total catch curve on Figure 9 from the present level of the fishing mortality of 1-ringers $F_{juv} = 0.5$ to a total ban on the juvenile fishery $F_{juv} = 0.0$. In the case of $F_{juv} = 0.5$ the catch in 1975 will decrease by 7% of the 1972 catch and the total biomass will decrease by 2%. Taking the 700 000 t in 1972 as being exclusively adults (2-ringers and older), one would expect an increase in catch in 1975 of 25% and an increase in biomass of 6%. The optimal fishing mortality is about F = 0.4 on the yield per recruit criterion with a total ban on the juvenile fisheries. This indicates a catch quota for 1972 of 318 000 t with an increase in catch of 160% in 1975 (i.e. to 826 000 t) and an increase in biomass of 139%. A higher value of M than 0.1 will decrease the expected gain as illustrated by Figure 10.

VII. Northwestern Boundary of the Quota Area

The area to the west of Shetland has been fished by the Scottish fleet in the early part of the Shetland herring season for many years, but the proportion of the total Scottish catch taken in that area was, until 1965, comparatively small, averaging less than 10%. Since 1965 this proportion has increased considerably and in the 1968, 1969 and 1970 seasons other countries fishing in the northwestern North Sea have also taken an increasing proportion of their catches from west of Shetland. In 1970 and 1971 the fishery to the west of Shetland extended further west than in previous years and appreciable catches were taken west of 4°W - the western boundary of the ICES North Sea statistical area IVa. Table 25 gives the catches taken in area VIa and in area IVa.W annually in the period 1965-1971. The catches taken in area VIa have increased steadily during this period with particularly large increases in 1970 and 1971. The increased catches from this area in these years were largely due to the entry of Norwegian, Faroese and Icelandic purse-seine vessels fishing just west of the 4°W boundary in the vicinity of Rona.

a) Catch statistics

The catches taken by the Scottish and Norwegian fleets from the northwestern North Sea and that part of the Faroese, Icelandic and Swedish catches landed in Denmark from this area in 1970, are given in Table 26a by months. These have been sub-divided into three areas: west of 4°W, from 4°W to the west coasts of Shetland and Orkney, and to the east of Shetland and Orkney. In 1970 91% of the Norwegian catch from the Shetland area was taken from the grounds to the west of Shetland and 60% of the Scottish catch from this area. Of the Icelandic, Faroese and Swedish catches landed in Denmark, only about 20% of the northwestern North Sea catch came from these western grounds, but it is possible that this is an underestimate of the true proportion, in that catches from these western grounds were more likely to be landed in Faroese or Scottish ports than in Denmark.

The distribution of these landings by months in the three areas are of interest in showing that the fishery, and so presumably the fish, moved eastwards from these more westerly grounds as the season progressed. This was also the pattern of the Scottish fishery in the Shetland area in earlier years.

b) Age composition

The age composition of the catches of the Scottish and Norwegian purse-seine fleets in 1970 and 1971 in the three areas used for the catch statistics are given in Table 26b. In 1970 the age compositions for the three areas are in substantial agreement in showing that the catches were predominantly composed of 3 and 4 year old fish. The higher proportion of 3 year old fish in the East Shetland area in that year could be a reflection of the fact that most of the age sampling in that area was done in August when the proportion of younger fish in the Shetland catches is generally higher.

In 1971, however, although the age compositions of the catches from the two areas west of Shetland are in very close agreement, the east Shetland catches again showed much higher proportions of young fish and in that year sampling in the three areas was distributed over the same time period.

The scarcity of fish older than 5 years in the catches from all three areas makes it appear unlikely that an appreciable component of the population in any of them is derived from the Minch stock which still contains a higher proportion of older fish.

c) Meristic characters

The data available on the meristic characters of the herring populations in this area are given in Table 26c. The fish caught to the east and to the west of Shetland have very similar vertebral and keeled scale counts. However, Minch and east Shetland fish show identical values for these characters so that they are of no value in clarifying whether the fish caught west of Shetland belong to one or other of these stocks, or are a mixture of the two. The mean L-1 data given in Table 26c show that in this character there is no significant difference between the east and west Shetland herring, but that both have significantly higher values than fish from the Minch.

VIII. Discussions

In the previous Report, (Coop. Res. Rep., Ser. A, No.26), particular attention was drawn to the sequential nature of the changes of catch, catch per effort, larval production and mortality by fishing area in the North Sea. The reduction of the adult stock in the southern area was followed somewhat later in the central North Sea and finally in more recent years in the northern North Sea. It was noted that the decline in total catch since 1965 had not been as rapid as might have been expected from the reduction in catches of adult herring, and it was concluded that the real state of the North Sea stock was masked by the increased exploitation of herring before their first spawning and by the shift of the fishery to more northern areas.

These conclusions have been further strengthened by the evidence of the fisheries in 1969-1971. The North Sea catch was reduced to about 550 000 tons in 1969 and 1970, while a further reduction to about 510 000 tons took place in 1971. In these years there was a further expansion of the juvenile fisheries and an important part of the adult catches were taken in the northern North Sea west of Orkney and Shetland. This area was never exploited to that degree in previous years and the expansion of the fishery in this area has made the task of assessing the present state of the stock even more difficult than before.

The present assessment of the North Sea herring stock is based on data on catch in numbers per year and per age group The quality of this material is very uneven from area to area and from one fishery to another.

The most comprehensive set of data, available back to 1947, derives from the fisheries in the central and southern North Sea (area IVb and IVc). The reliability of age and catch data from the northern North Sea is rapidly deteriorating from west towards east. For the large fisheries in later years in Skagerrak, data are so poor that they had to be excluded from the analysis altogether.

It is not clear to what extent the exclusion of the Skagerrak area affects the analysis carried out. On the assumption that the herring in Skagerrak is partly or wholly also exploited in the fisheries in the North Sea proper, and that the age distributions in the two areas are similar, then the effect of the Skagerrak fisheries will be measured within the values of adult fishing mortalities obtained from the total North Sea data. The effect of excluding the Skagerrak catches of juvenile herring would be to underestimate the stock size of younger age groups, especially in the mid-sixties.

The reliability of the stock sizes and fishing mortality estimates derived from the VPA analysis are to some extent dependent on the initial values of F and M chosen. In the past the natural mortality M for North Sea herring has often been quoted at a value of about M = 0.2. There is, however, other evidence from mortality on effort studies which suggests a much lower value, less than 0.10 for adult herring. From the total North Sea adult catch per effort data presented here, a rather similar figure could also be derived. The effect of applying M = 0.2 instead of 0.1 will be to decrease fishing mortality estimates and to increase those of stock size.

It could be argued that it would be more realistic to use a higher M in the juvenile herring than the value of 0.1 in this analysis. This refinement has not been attempted, but its effect would be to increase recruitment levels and consequently subsequent stock levels.

The initial inputs of F for the oldest age group in each year class have been made by reference to estimates of total mortality from the catch per effort data. Attempts have been made to check the conclusions from the VPA with estimates derived from the more conventional types of analyses using catch per effort data. According to the VPA, fishing mortality on the adult stock has increased by about three times between 1949 and 1967. If the more recent catch per effort mortalities of the order of F = 1.0 are considered, the increase is greater than three times. This relative change in fishing mortality is also reflected in the reduction in catch per effort of the same order for the total North Sea using the Dutch trawl fishery data based on adult herring. The index based on drifter effort shows less reduction in catch per effort.

In the young herring fishery, mortalities increased as the fishery developed during the 1950's and early 1960's, but since 1964 they appear to have stabilised at about F = 0.5.

For all three indices of abundance from drifters/trawlers and Danish young herring trawlers there has been an apparent increase in fishing mortality generated per unit catch per effort of the order of 2-3 times over the periods for which data are available. In the case of the Danish vessels this may in part be interpreted as an increase in efficiency.

The apparent increase in efficiency for drifters and trawlers should not be interpreted as being solely due to improvements in their own technique. It reflects an increase in efficiency in any gear units within the total North Sea fleet.

The VPA analysis for the total North Sea shows a decline in adult stock ($>$1-ringers) of about three times since 1947. This is similar to the estimate from catch per effort. The total stock has remained fairly stable, being supported by a number of good year classes entering in recent years.

The level of recruitment in this analysis is determined largely by the young herring catches in area IVb. It has been shown that the estimates of North Sea recruitment as 1-ringed fish are closely correlated with estimates from catch per effort data from the adult fisheries.

The changes recorded in adult stock, fishing mortality and recruitment obtained from the VPA, have some support from other abundance indices. The techniques used, as for example in the estimate of total North Sea fishing effort, are crude and open to objection; the catches in numbers of fish per age group, used in the VPA, are in some cases derived from very poor material. However, independent evidence from adult herring tagging has supported the stock levels obtained in the VPA.

The predictions of catches and stocks under a range of fishing mortalities are dependent on the future level of recruitment. Attempts have been made to assess the strengths of these incoming year classes from a number of sources. These show that recent recruitment levels are higher than the long-term means.

As shown in Table 24, if the current estimated levels of fishing mortality are maintained in 1972, the total catch will be about 820 000 tons, this increase above the 1971 catch level reflecting the high recruitment levels from the 1969 and 1970 year classes. In practice it is difficult to predict what the total catch will be in 1972 because it is impossible to forecast the effect of the closure in force in that year on the mortality levels. The effect of this may be small as it has not so far been possible to show any significant effect of the 1971 closures on the mortality levels in that year. If mortality is maintained at the current level in 1972 and in subsequent years, the prognosis shows that by 1975 the catch and the stock will have declined by 18% and 15% respectively.

For the Downs herring, evidence has been presented that both 0- and 1-ringed herring abundances are correlated with larval abundances, these in turn reflecting the spawning stock size. The 1971/1972 Downs larval production was extremely low and comparable with the lowest periods of stock size in 1964-1965. Thus, the forecast of average recruitment for the total North Sea of the 1971 year class may not be valid and as a consequence the stock levels in 1975 may be overestimated.

From the yield per recruit curves it is clear that the maximum sustainable yield is obtained with F of about 0.3 - 0.4. This was the level of fishing mortality in the period 1949-1953 when the total adult catches were of the order of 600 000 tons. At the present catch levels of about 550 000 tons of both juvenile and adults, the fishing mortality was of the order of 1.0.

IX. Conclusions

a) Overall quota

The Working Group found that the maximum sustainable catch of North Sea autumn spawners is obtained at a level of fishing mortality of 0.3 - 0.4. From the data available the present level of F is about 0.8 - 1.0. Prognosis of future catch and biomass indicates that at this level of fishing mortality the point of balance between increase and decrease is reached. Considering the error on the estimates, it is likely that a further decline both in stock size and in catch could be the effect of a high sustained F. A reduction of F to that corresponding to the level of maximum sustainable yield would thus require a decrease in F of about 50% or a catch level in 1972 of about 400 000 tons. With no reduction in 1972, the required catch level in 1973 would be about 425 000 tons.

b) Differential conservation measures

The Working Group concluded that quotas by season and by category were practicable. The largest gains would be obtained from restricting fishing to the second half of the year combined with a quota for the fishing period. More severe restrictions on the fisheries for juveniles would lead to relatively higher gains for all combinations of these measures.

c) Western boundary of North Sea herring stocks

On the basis of the available data it is not possible to state categorically where the western boundary of the North Sea herring stocks should be drawn.

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Table 1a. Herring. Catch in '000 tons 1947-1959.
North Sea (Sub-area IV and Divisions VIId and e) by country,
Skagerrak and Kattegat (Division IIIa) total catch

Year / Country	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
Belgium	36	23	17	10	8	13	16	18	16	6	2	2	3
Denmark	9	7	5	8	34	33	50	58	66	83	88	134	145
England	101	114	71	75	73	66	71	61	39	36	32	22	21
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-	-	-
France	77	77	60	61	125	65	76	54	59	45	34	34	35
Germany Fed.R.	110	117	107	117	177	158	297	263	268	217	237	200	147
Iceland	-	-	-	-	-	-	-	-	-	-	-	-	-
Netherlands	155	163	131	133	149	158	186	174	148	136	129	127	118
Norway	4	6	3	4	1	2	2	3	5	5	8	8	17
Poland	-	-	-	-	-	-	-	-	39	46	49	56	71
Scotland	81	90	53	37	42	77	82	59	69	43	41	30	48
Sweden	25	26	25	27	31	37	37	39	47	38	49	50	57
U.S.S.R.	-	-	-	-	-	-	-	-	2	28	37	29	40
Total North Sea	598	623	472	472	640	609	817	729	758	683	706	692	702
Total Skagerrak and Kattegat	53	81	79	91	104	139	137	99	113	123	158	216	205
Grand Total	651	704	551	563	744	748	954	828	871	806	864	908	907

Table 1b. Herring. Catch in tons 1960-1971.
North Sea (Sub-area IV and Divisions VIId and e) by country
Skagerrak and Kattegat (Division IIIa) total catch

Year / Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Belgium	3 642	3 146	1 117	1 843	1 607	776	391	410	134	468	1 200	681
Denmark	119 400	138 800	126 000	117 600	141 600	158 700	105 900	135 000	163 100	180 260	133 331	185 393
England	16 354	17 849	11 994	22 821	16 533	11 494	10 716	8 215	5 128	6 666	9 702	4 113
Faroe Isl.	-	-	-	-	973	3 111	1 491	35 993	49 995	40 640	58 405	25 635
France	11 137	23 042	12 271	18 062	23 295	16 480	10 711	11 478	12 852	15 307	11 482	10 882
Germany, Fed.R.	148 388	100 944	89 056	93 815	86 586	77 032	54 157	32 312	21 216	12 798	7 150	3 810
Iceland	-	-	-	-	-	1 757	1 047	5 684	44 489	19 997	22 951	42 338
Netherlands	125 713	129 841	87 521	126 487	116 226	80 320	56 668	37 270	22 306	29 769	46 218	32 479
Norway	13 893	10 440	7 461	21 448	103 752	520 890	424 462	240 032	211 904	114 938	177 341	122 570
Poland	76 304	78 082	59 331	72 462	89 691	98 130	74 071	37 816	11 954	9 221	5 057	2 031
Scotland	29 006	23 038	22 416	34 571	21 125	20 569	17 557	18 138	16 477	22 053	21 885	25 073
Sweden	89 289	103 744	110 353	140 012	130 132	132 182	121 970	121 591	88 061	33 109	34 670	36 880
U.S.S.R.	63 105	67 722	100 265	75 965	139 637	47 322	16 442	11 660	70 029	61 549	18 078	18 000
Total	696 231	696 648	627 785	725 086	871 157	1168 763	895 583	695 599	717 645	546 775	547 470	509 885
Non-Member Countries	36 000	?	?	?	?	67 700	30 600	27 700	?	?	250	?
Skagerrak	75 820	85 291	104 246	163 228	309 804	256 742	144 655	279 744	280 036	113 279	70 527	64 179
Kattegat	31 000	41 100	51 600	64 200	79 300	81 400	75 300	72 000	108 900	59 300	74 300	90 200
Grand Total	839 051	823 039	783 631	952 514	1260 261	1574 605	1146 138	1075 043	1106 581	719 354	692 547	664 264

Table 2. Herring. Total catch in thousands of tons in the North Sea and Skagerrak

Year	Area							Total
	Northwest	Northeast	Central	South	Industrial Fishery	Total North Sea	Skagerrak	
1947	211.3	0.3	214.4	160.6	-	586.6	40.9*	627.5*
1948	169.4	1.9	168.0	162.5	0.3	502.1	54.9*	557.0*
1949	134.2	2.0	178.8	193.3	0.2	508.5	52.4*	560.9*
1950	125.1	1.6	181.3	178.3	5.4	491.7	51.3*	543.0*
1951	123.0	1.2	266.0	165.6	44.6	600.4	46.7*	647.1*
1952	168.4	6.6	203.1	236.1	50.2	664.4	61.1*	725.5*
1953	178.8	7.5	224.6	209.2	78.4	698.5	47.9*	746.4*
1954	168.0	4.3	218.4	276.9	95.3	762.9	99.1*	862.0*
1955	287.8	67.4	170.3	168.4	112.5	806.4	89.0	895.4
1956	194.5	79.1	163.9	134.0	103.7	675.2	82.0	757.2
1957	209.0	97.3	150.7	122.7	103.2	682.9	90.5	773.4
1958	164.7	98.2	156.1	92.6	158.9	670.5	131.0	801.5
1959	259.6	144.2	147.1	77.2	156.4	784.5	139.0	923.5
1960	101.1	264.0	166.3	64.9	99.9	696.2	75.8	772.0
1961	61.0	274.8	168.9	98.2	93.8	696.7	85.3	782.0
1962	37.6	291.8	143.3	54.7	100.4	627.8	104.2	732.0
1963	73.1	301.3	228.2	45.7	67.7	716.0	163.2	879.2
1964	66.1	444.0	187.9	56.6	116.6	871.2	309.8	1181.0
1965	298.3	580.8	132.9	21.8	135.0	1168.8	256.7	1425.5
1966	278.6	424.0	114.1	11.6	67.2	895.5	144.7	1040.2
1967	117.3	373.7	107.9	11.4	85.2	695.5	279.7	975.2
1968	286.7	256.8	57.8	9.6	106.9	717.8	280.0	997.8
1969	213.1	148.1	40.0	24.3	121.2	546.7	113.3	660.0
1970	312.6	21.3	111.7	27.1	74.8	547.5	70.5	618.0
1971	279.0	17.5	26.6	21.5	165.2	509.9	64.2	574.0

*) Data include some Kattegat catches.

Table 3. Herring. Total catch in tons.
Skagerrak (Division IIIa excl. Kattegat)

Year	Denmark	Faroe Islands	German Fed.R.	Iceland	Netherlands	Norway	Poland	Sweden	U.S.S.R.	Total
1960	43 200	-	42	-	-	2 578	-	30 000	-	75 820
1961	56 700	-	7	-	-	4 584	-	24 000	-	85 291
1962	70 600	-	3	-	-	5 049	594	28 000	-	104 246
1963	105 100	-	828	-	-	10 971	329	46 000	-	163 228
1964	129 500	-	6 064	-	-	85 916	4 324	84 000	-	309 804
1965	95 300	-	4 248	-	-	83 864	5 330	68 000	-	256 742
1966	75 200	-	432	-	74	30 438	511	38 000	-	144 655
1967	100 400	-	466	2 151	-	95 039	127	66 000	15 561	279 744
1968	143 600	-	2	695	36	71 865	42	45 000	18 796	280 036
1969	57 965	-	-	-	-	13 957	-	41 357	-	113 279
1970	30 107	-	-	6 453	-	7 037	-	26 930	-	70 527
1971	26 985	5 636	-	5 834	-	5 961	-	19 763	-	64 179

Table 4. Herring. Total catch in tons,
North Sea, Northeast (Division IVa east of 2°E)

Year	Belgium	Denmark	England	Faroe Islands	France	German Fed.R.	Iceland	Nether-lands	Norway	Poland	Scotland	Sweden	U.S.S.R.	Total
1960	-	41 800	-	-	-	29 455	-	15 442	9 005	15 749	1 598	87 825	63 105	263 979
1961	-	61 500	-	-	-	14 043	-	6 318	7 630	11 020	3 877	102 676	67 722	274 786
1962	-	49 600	3	-	-	8 913	-	6 990	5 793	5 036	4 899	110 287	100 265	291 786
1963	-	58 900	4	-	-	10 069	-	8 448	18 255	3 335	-	135 350	75 965	301 326
1964	-	53 100	-	-	-	9 972	-	9 313	91 006	12 949	627	127 425	139 637	444 029
1965	-	49 700	-	-	-	23 428	1 757	6 912	323 361	16 200	-	132 182	27 227	580 767
1966	-	51 400	6	-	-	12 329	1 047	4 555	205 239	11 690	186	121 141	16 442	424 035
1967	-	51 600	-	-	-	2 558	5 684	1 709	176 628	2 986	-	120 838	11 660	373 663
1968	-	57 100	-	-	-	2 487	9 355	1 022	66 046	1 880	-	88 061	30 799	256 750
1969	32	55 550	-	12 805	278	16	6 300	2 084	15 618	166	9 785	26 035	19 392	148 061
1970	50	1 800	-	5 898	48	10	1 220	281	3 331	123	1 929	5 560	1 012	21 262
1971	-	6 219	-	239	-	389	-	167	10 442	-	-	-	-	17 456

Table 5. Herring. Total catch in tons.
North Sea, Northwest (Division IVa west of 2°E)

Year	Belgium	Denmark	England	Faroe Islands	France	German Fed.R.	Iceland	Nether-lands	Norway	Poland	Scotland	Sweden	U.S.S.R.	Total
1960	122	-	163	-	1 151	45 746	-	19 863	3 343	7 000	22 292	1 464	-	101 144
1961	120	-	8	-	5 796	19 146	-	8 414	2 173	7 271	16 954	1 068	-	60 950
1962	125	-	11	-	3 757	7 125	-	4 659	837	3 807	17 191	66	-	37 578
1963	343	-	13	-	5 121	11 377	-	9 495	2 641	12 511	26 945	4 662	-	73 108
1964	155	-	8	973	6 405	7 319	-	11 420	4 350	15 962	16 753	2 707	-	66 052
1965	227	-	-	3 111	7 303	4 489	-	11 515	196 488	35 878	19 239	-	20 095	298 345
1966	178	-	34	1 491	2 628	7 069	-	3 414	219 223	27 199	16 548	829	-	278 613
1967	200	-	15	35 993	1 515	7 941	-	3 418	41 664	8 454	17 359	753	-	117 312
1968	23	-	-	49 995	1 349	7 150	35 134	3 072	131 598	2 806	16 324	-	39 230	286 681
1969	68	11 360	-	27 835	605	448	13 697	474	99 316	362	10 051	6 765	42 157	213 138
1970	750	61 423	-	40 884	818	177	20 587	177	146 397	2 069	17 767	4 470	17 066	312 585
1971	-	44 500	-	25 142	514	-	42 164	5 755	112 114	1 288	24 711	4 954	18 000	279 142

Table 6. Herring. Total catch in tons. North Sea, Central
(Division IVb)

Adult Herring Fisheries

Year	Belgium	Denmark	Faroe Islands	England	Iceland	France	German Fed.R.	Nether-lands	Norway	Poland	Scotland	Sweden	Total
1960	115	-	-	9 816	-	369	39 326	61 540	1 545	48 479	5 116	-	166 306
1961	121	-	-	8 579	-	2 535	35 402	70 336	637	49 064	2 207	-	168 881
1962	124	-	-	6 076	-	2 886	40 772	47 255	831	45 030	326	-	143 300
1963	558	-	-	14 465	-	8 296	60 818	81 524	552	54 370	7 626	-	228 209
1964	351	-	-	9 235	-	7 750	36 361	63 314	8 396	58 726	3 745	-	187 878
1965	47	-	-	8 524	-	7 037	22 520	47 551	1 041	44 815	1 330	-	132 865
1966	69	-	-	9 646	-	6 261	21 183	42 008	-	34 085	823	-	114 075
1967	5	-	-	6 809	-	6 540	18 917	26 769	21 740	26 370	779	-	107 929
1968	13	-	-	4 170	-	8 196	10 439	13 285	14 260	7 241	153	-	57 757
1969	-	-	-	5 964	-	3 362	3 528	16 542	4	8 077	2 217	309	40 003
1970	-	-	11 623	8 731	1 144	2 433	6 005	28 815	27 613	2 836	2 189	24 640	116 029
1971	8	2 488	254	4 113	179	5 918	421	10 172	14	743	362	1 926	26 598

Table 7. Herring. Total catch in tons. North Sea, Central (Division IVb).

Year	Young Herring Fisheries				Total young and adult fisheries (Tables 6 and 7)
	Denmark	German Fed.R.	Sweden	Total	
1960	77 600	22 322	-	99 922	266 228
1961	77 300	16 549	-	93 849	262 730
1962	76 400	23 975	-	100 375	243 675
1963	58 700	9 017	-	67 717	295 926
1964	88 500	28 126	-	116 626	304 504
1965	109 000	26 009	-	135 009	267 874
1966	54 500	12 737	-	67 237	181 312
1967	83 400	1 849	-	85 249	193 178
1968	106 000	847	-	106 847	164 604
1969	113 350	7 900	-	121 250	161 253
1970	70 108	400	-	70 508	186 537
1971	132 161	3 000	30 000	165 161	191 759

Table 8. Herring. Total catch in tons.
North Sea, South and English Channel, East and West
(Divisions IVc and VIId and e)

Year	Belgium	Denmark	England	France	German Fed.R.	Netherlands	Poland	Total
1960	3 405	-	6 375	9 617	11 539	28 868	5 076	64 880
1961	2 905	-	9 262	14 711	15 804	44 773	10 727	98 182
1962	868	-	5 904	5 628	8 271	28 617	5 458	54 746
1963	942	-	8 339	4 645	2 534	27 020	2 246	45 726
1964	1 101	-	7 290	9 140	4 808	32 179	2 054	56 572
1965	502	-	2 970	2 140	586	14 342	1 237	21 777
1966	144	-	1 030	1 822	839	6 691	1 097	11 623
1967	205	-	1 391	3 423	1 047	5 374	6	11 446
1968	98	-	958	3 307	293	4 927	27	9 610
1969	367	-	702	11 062	906	10 669	616	24 322
1970	400	-	971	8 183	558	16 945	29	27 086
1971	673	25	-	4 450	-	16 385	-	21 583

Explanatory Notes to Tables 1 - 8

Table 1a.

Data from Belgium, Denmark, France, Poland and Sweden according to Coop. Res. Rep., Series B, 1965, Annex II, Table 9. Data from England, Netherlands, Norway and Scotland submitted by Working Group Members. Data from Germany according to Statistical News Letters, No. 11B, 1961.

Table 1b.

Data derived as listed below under each country. The Kattegat catches are according to Danish national statistics and information from the Swedish laboratory at Lysekil.

Table 2.

1947-1954. Catches for northwest and northeast are derived from Statistical News Letters 11A and 11B. The national distributions of catch by area in some cases refer to all catches and in others to a large sub-sample of the catches.

Catches for central and south are taken from Cushing and Bridges 1966, Appendix 4. The catches for the south refer to the seasonal winter fishery and not the calendar year.

Catches for the industrial fishery are derived from Coop. Res. Rep. Ser. B, 1965, Annex II, Table 12.

The catches for the Skagerrak for some countries also include Kattegat catches, (Bull. Stat.). Taking the catches ascribed to areas for the North Sea, their total covers an average of 98% of the annual catches given in Table 1 for the period 1947-1954.

1955-1959. Catches for the northwest, northeast and central are based on data in Cushing and Bridges (1966). The Swedish catch from region IVa (Bull. Stat.) was regarded as taken in the northeastern area.

Catches for the south and the industrial fisheries are derived from Coop. Res. Rep. Ser. B, 1965, Annex II, Tables 11 and 12.

1960-1968. Data from Coop. Res. Rep. Ser. A, 26.

Skagerrak: 1955-1971 data from Danish national statistics and from the Fisheries Laboratory at Lysekil.

Industrial Fishing: These data refer only to the juvenile herring catches in area IVb by Denmark and Germany.

Belgium

All data derived from "Bulletin Statistique". Catches from division IVa for 1960-1968 are ascribed to IVa west of 2°E.

Denmark

All data used in the tables are based upon Danish national statistics (Popp Madsen). Catches from division IVa are ascribed to IVa east of 2°E for 1960-1968. Catches from division IVb (Young Herring Fishery) have been reduced for content of other species (1960 to spring 1965 by 5%, autumn 1965-1971 by estimates from individual years; Popp Madsen).

England

All data derived from "Bulletin Statistique". Separation of catches in division IVa east and west of 2°E according to national statistics.

Faroe Islands

Catches only from division IVa according to "Bulletin Statistique". Ascribed to IVa west for 1960-1968. From 1969-1971 the distribution of catches to fishing areas are based on landings in Danish ports.

France

The data given have been supplied by the "Institut des Pêches", Boulogne s/Mer.

German Fed.R.

All data are according to German national statistics (Schumacher). They are compiled by "Bundesforschungsanstalt für Fischerei", Hamburg, according to log books.

Iceland

All data derived from "Bulletin Statistique". Separation of catches in division IVa east and west of 2°E are according to Icelandic statistics for 1960-1969 and according to landings in Danish ports for 1970-1971.

Netherlands

All data derived from "Bulletin Statistique". Separation of catches in division IVa east and west of 2°E are according to Dutch national statistics.

Norway

The data are according to Norwegian official statistics. The separation of catches is based upon the statistics of the fishermen's organisations. Catches in inshore waters are not included.

Poland

All data according to "Bulletin Statistique". Separation of catches in division IVa east and west of 2°E is according to Polish national statistics.

Scotland

All data are according to "Bulletin Statistique". Separation of catches in division IVa east and west of 2°E is according to Scottish national statistics. Catches from the Moray Firth are not included.

Sweden

Data according to Swedish national statistics (Ackefors). Division IIIa: Data obtained from proportion of Skagerrak catches in Swedish landings in Danish ports applied to total Swedish landings. Separation of catches in division IVa east and west of 2°E. According to Swedish national statistics, but is supposed to be rather unreliable. A greater part of the landings presumably comes from division IVa, west of 2°E.

U.S.S.R.

All data according to "Bulletin Statistique". Separation of catches in division IIIa Skagerrak, IVa east and IVa west of 2°E are according to Soviet national statistics.

Table 9. North Sea Catch in Millions of Fish by Age

Year	Area	AGE IN WINTER RINGS 0	1	2	3	4	5	6	7	8	> 8	Total
1947	IVaW of 2°E	-	-	233.9	182.7	216.7	175.1	217.8	121.2	112.8	107.3	1367.5
	IVaE of 2°E	-	-	0.1	0.1	0.1	0.2	0.3	0.2	0.2	0.2	1.4
	IVb	-	-	80.1	94.4	190.9	234.4	431.0	259.3	273.3	244.9	1808.3
	IVbYH	-	-	-	-	-	-	-	-	-	-	-
	IVc + VIId,e	-	-	179.9	138.3	229.9	116.4	106.7	50.4	240.3	331.7	1393.6
	Total NS	-	-	494.0	415.5	637.6	526.1	755.8	431.1	626.6	684.1	4570.8
1948	IVaW of 2°E	-	-	93.2	256.4	126.1	202.6	131.2	104.6	72.5	93.6	1080.2
	IVaE of 2°E	-	-	0.0	1.7	1.1	1.8	1.3	1.3	1.0	1.3	9.5
	IVb	-	-	27.0	229.1	104.4	155.7	182.4	148.7	87.4	186.3	1121.0
	IVbYH	-	-	-	-	-	-	-	-	-	-	-
	IVc + VIId,e	-	3.4	126.5	184.9	96.3	240.9	172.0	145.8	90.7	383.7	1444.2
	Total NS	-	3.4	246.7	672.1	327.9	601.0	486.9	400.4	251.6	664.9	3654.9
1949	IVaW of 2°E	-	-	120.5	97.6	98.1	89.2	121.3	123.8	111.9	74.8	837.2
	IVaE of 2°E	-	-	0.1	0.3	1.1	1.2	1.8	2.0	1.9	1.3	9.7
	IVb	-	-	77.8	149.0	165.5	106.1	256.7	112.7	169.0	162.9	1199.7
	IVbYH	-	-	-	-	-	-	-	-	-	-	-
	IVc + VIId,e	-	-	280.0	397.0	131.3	90.2	272.0	223.1	131.2	384.3	1909.1
	Total NS	-	-	478.4	643.9	396.0	286.7	651.8	461.6	414.0	623.3	3955.7
1950	IVaW of 2°E	-	-	121.8	301.4	96.8	63.3	60.9	100.1	51.8	49.9	846.0
	IVaE of 2°E	-	-	1.4	2.9	0.7	0.6	0.7	1.3	0.6	0.6	8.8
	IVb	-	-	138.2	370.7	222.0	90.7	82.5	63.9	51.4	166.3	1185.7
	IVbYH	-	-	-	-	-	-	-	-	-	-	-
	IVc + VIId,e	-	-	273.6	363.5	297.1	135.4	109.5	165.3	91.2	184.9	1620.5
	Total NS	-	-	535.0	1038.5	616.6	290.0	253.6	330.6	195.0	401.7	3661.0
1951	IVaW of 2°E	-	-	43.8	131.6	217.7	124.6	78.7	50.0	42.7	79.6	768.7
	IVaE of 2°E	-	-	0.2	0.7	1.4	1.0	0.6	0.4	0.3	0.7	5.3
	IVb	-	-	73.3	362.9	685.7	280.6	79.5	49.2	108.2	132.3	1771.7
	IVbYH	-	452.8	240.6	49.5	-	-	-	-	-	-	742.9
	IVc + VIId,e	-	8.8	302.4	413.8	350.2	223.8	103.3	42.5	54.4	26.8	1526.0
	Total NS	-	461.6	660.3	958.5	1255.0	630.0	262.1	142.1	205.6	239.4	4814.6

Table 9 (Continued)

Year	Area	AGE IN WINTER RINGS										
		0	1	2	3	4	5	6	7	8	>8	Total
1952	IVaW of 2°E	-	-	189.3	125.1	118.0	157.5	90.4	78.2	55.5	149.3	963.3
	IVaE of 2°E	-	-	0.6	1.7	1.5	4.4	3.2	3.6	2.7	7.8	25.5
	IVb	-	-	212.8	188.2	191.5	248.3	178.7	61.2	58.5	122.9	1262.1
	IVbYH	-	699.3	189.7	12.5	-	-	-	-	-	-	901.5
	IVc + VIId,e	-	22.5	753.3	248.8	299.1	241.7	191.8	93.2	48.8	108.3	2007.5
	Total NS	-	721.8	1345.7	576.3	610.1	651.9	464.1	236.2	165.5	388.3	5159.9
1953	IVaW of 2°E	-	-	262.3	255.6	109.4	95.1	100.8	44.7	50.3	88.5	1006.7
	IVaE of 2°E	-	-	5.3	7.1	3.6	3.3	3.7	1.6	2.2	4.0	30.8
	IVb	-	9.4	307.2	311.3	160.5	109.0	183.6	97.1	30.0	127.2	1335.3
	IVbYH	150.0	1008.7	236.2	38.3	-	-	-	-	-	-	1433.2
	IVc + VIId,e	-	5.1	511.4	391.0	200.2	178.6	184.6	134.5	35.3	54.9	1695.6
	Total NS	150.0	1023.2	1322.4	1003.3	473.7	386.0	472.7	277.9	117.8	274.6	5501.6
1954	IVaW of 2°E	-	26.5	415.5	230.2	111.6	52.8	62.2	52.7	33.6	37.6	1030.7
	IVaE of 2°E	-	0.9	4.7	5.3	2.6	1.3	1.7	1.5	1.0	1.0	20.0
	IVb	-	20.2	185.9	344.7	223.2	119.5	91.9	130.2	51.8	172.9	1340.3
	IVbYH	218.5	1387.8	180.9	23.9	-	-	-	-	-	-	1811.1
	IVc + VIId,e	-	15.3	706.3	499.1	253.7	187.5	173.7	194.1	108.0	105.4	2243.1
	Total NS	218.5	1450.7	1493.3	1111.2	591.1	361.1	329.5	378.5	194.4	316.9	6445.2
1955	IVaW of 2°E	-	4.2	697.6	385.8	144.9	149.0	138.6	28.1	42.4	41.1	1631.7
	IVaE of 2°E	0.1	20.2	125.3	82.4	54.6	20.1	16.0	23.2	12.6	14.2	368.7
	IVb	-	87.1	610.8	216.5	108.8	84.7	39.9	30.2	16.9	10.9	1205.8
	IVbYH	164.2	1960.6	162.2	25.5	-	-	-	-	-	-	2312.5
	IVc	-	-	335.3	321.5	170.8	82.8	37.1	38.2	37.1	39.3	1062.1
	Total NS	164.3	2072.1	1931.2	1031.7	479.1	336.6	231.6	119.7	109.0	105.5	6580.8
1956	IVaW of 2°E	-	0.6	248.7	543.5	214.2	89.9	62.8	42.3	30.6	41.0	1273.6
	IVaE of 2°E	-	-	15.6	148.9	98.7	45.2	55.1	11.9	8.6	27.6	411.6
	IVb	-	22.5	607.9	341.7	92.7	33.1	39.7	29.1	49.0	106.0	1321.7
	IVbYH	95.9	1667.7	432.5	33.4	-	-	-	-	-	-	2229.5
	IVc	-	6.0	555.3	153.7	110.1	80.3	36.7	20.8	15.9	12.9	991.7
	Total NS	95.9	1696.8	1860.0	1221.2	515.7	248.5	194.3	104.1	104.1	187.5	6228.1

Table 9 (Continued)

Year	Area	AGE IN WINTER RINGS										
		0	1	2	3	4	5	6	7	8	>8	Total
1957	IVaW of 2°E	-	-	216.5	287.5	261.4	195.7	84.4	43.8	39.0	69.6	1197.9
	IVaE of 2°E	-	-	19.6	37.4	124.8	51.0	70.8	63.8	37.5	24.8	429.7
	IVb	-	14.1	421.9	143.3	219.0	70.7	37.3	30.3	20.2	53.5	921.3
	IVbYH	278.7	1461.1	400.6	37.0	-	-	-	-	-	-	2177.4
	IVc + VIId,e	-	7.4	585.3	231.0	38.7	26.7	14.7	9.2	2.8	5.5	1010.3
	Total NS	278.7	1482.6	1643.9	736.2	643.9	344.1	207.2	147.1	99.5	153.4	5736.6
1958	IVaW of 2°E	-	29.9	41.8	326.8	139.7	233.3	81.4	41.9	27.1	19.3	941.2
	IVaE of 2°E	-	-	43.5	247.8	64.3	85.5	28.5	17.1	9.3	22.9	518.9
	IVb	-	218.5	413.0	207.6	59.0	125.6	25.1	7.6	7.6	28.4	1092.4
	IVbYH	97.1	4028.7	265.0	26.5	-	-	-	-	-	-	4417.3
	IVc + VIId,e	-	1.7	266.1	190.6	58.9	16.7	11.7	6.7	1.7	1.7	555.8
	Total NS	97.1	4278.8	1029.4	999.3	321.9	461.1	146.7	73.3	45.7	72.3	7525.6
1959	IVaW of 2°E	-	13.5	1488.9	128.1	173.6	74.8	99.8	46.5	23.0	26.0	2074.2
	IVaE of 2°E	-	-	182.5	78.7	210.0	115.9	111.2	60.5	52.1	163.1	974.0
	IVb	-	85.1	929.5	140.1	60.2	24.9	34.0	9.2	5.2	24.9	1313.1
	IVbYH	-	1500.2	1847.9	61.4	-	-	-	-	-	-	3409.5
	IVc + VIId,e	-	10.6	485.1	79.2	53.5	17.8	4.0	3.3	2.0	4.6	660.1
	Total NS	-	1609.4	4933.9	487.5	497.3	233.4	249.0	119.5	82.3	218.6	8430.9
1960	IVaW of 2°E	-	-	174.3	339.3	17.6	35.4	22.5	18.0	8.5	6.8	622.4
	IVaE of 2°E	-	78.8	179.9	854.1	84.9	91.5	77.4	76.7	110.1	131.1	1684.5
	IVb	-	25.1	238.8	604.1	47.1	35.2	12.1	31.1	10.0	4.1	1007.6
	IVbYH	194.6	2275.3	260.2	27.8	-	-	-	-	-	-	2757.9
	IVc + VIId,e	-	13.5	289.1	141.4	16.3	5.6	0.9	-	-	-	466.8
	Total NS	194.6	2392.7	1142.3	1966.7	165.9	167.7	112.9	125.8	128.6	142.0	6539.2
1961	IVaW of 2°E	-	2.0	21.8	66.0	188.0	12.4	18.8	5.9	11.5	5.7	332.1
	IVaE of 2°E	1.2	68.6	96.3	227.6	942.2	97.8	139.1	55.5	44.5	81.8	1754.6
	IVb	-	29.4	560.0	96.1	807.4	8.8	-	-	-	-	981.7
	IVbYH	1268.0	235.3	625.6	10.8	-	-	-	-	-	-	2139.7
	IVc + VIId,e	-	0.7	585.7	79.4	38.3	5.0	-	-	-	-	709.1
	Total NS	1269.2	336.0	1889.4	479.9	1455.9	124.0	157.9	61.4	86.0	87.5	5917.2

Table 9 (Continued)

Year	Area	AGE IN WINTER RINGS										
		0	1	2	3	4	5	6	7	8	>8	Total
1962	IVaW of 2°E	-	0.6	22.3	14.9	29.5	114.2	6.8	15.6	7.2	10.1	221.2
	IVaE of 2°E	-	127.9	136.8	171.8	208.3	802.8	105.7	124.2	74.9	74.6	1827.0
	IVb	-	48.9	66.6	358.4	68.8	151.9	13.7	5.0	4.2	2.1	719.6
	IVbYH	141.8	1958.2	2.8	15.1	-	-	-	-	-	-	2117.9
	IVc + VIId,e	-	11.3	41.1	237.2	28.5	12.9	0.7	0.3	-	-	332.0
	Total NS	141.8	2146.9	269.6	797.4	335.1	1081.8	126.9	145.1	86.3	86.8	5217.7
1963	IVaW of 2°E	-	0.6	135.7	3.0	4.5	3.7	17.1	0.9	4.2	2.2	171.9
	IVaE of 2°E	-	69.0	1414.6	101.1	75.9	74.4	212.3	21.5	37.8	48.8	2055.4
	IVb	-	36.3	1080.5	62.5	55.0	-	-	-	-	-	1234.3
	IVbYH	442.8	1154.1	55.4	-	-	-	-	-	-	-	1652.3
	IVc + VIId,e	-	2.2	275.0	10.6	22.9	2.5	0.3	-	-	-	313.5
	Total NS	442.8	1262.2	2961.2	177.2	158.3	80.6	229.7	22.4	42.0	51.0	5427.4
1964	IVaW of 2°E	-	0.8	107.7	182.2	6.7	6.9	7.2	40.1	2.5	6.6	360.7
	IVaE of 2°E	4.6	28.6	830.3	1581.5	128.4	109.0	79.6	190.0	23.8	51.1	3026.9
	IVb	-	42.6	395.0	395.0	12.6	27.2	8.2	26.2	-	-	906.8
	IVbYH	492.3	2878.4	192.2	5.9	-	-	-	-	-	-	3568.8
	IVc + VIId,e		21.3	22.3	78.5	0.7	5.9	-	-	-	-	128.7
	Total NS	496.9	2971.7	1547.5	2243.1	148.4	149.0	95.0	256.3	26.3	57.7	7991.9
1965	IVaW of 2°E	-	52.9	613.2	367.2	571.7	21.9	23.2	28.6	108.2	24.9	1811.8
	IVaE of 2°E	2.6	456.4	542.9	771.9	1336.8	112.5	118.4	84.9	277.5	34.1	3738.0
	IVb	-	55.3	432.2	84.9	98.3	8.6	7.9	3.6	27.3	18.1	736.2
	IVbYH	154.5	2644.3	603.8	40.1	-	-	-	-	-	-	3442.7
	IVc + VIId,e	-	0.4	25.5	60.5	32.6	2.1	2.4	0.5	-	1.3	125.3
	Total NS	157.1	3209.3	2217.6	1324.6	2039.4	145.1	151.9	117.6	413.0	78.4	9854.0
1966	IVaW of 2°E	-	12.2	693.5	249.2	156.8	328.5	8.7	9.1	32.2	93.2	1583.4
	IVaE of 2°E	2.7	357.1	1102.9	383.7	276.2	534.7	36.6	54.4	60.6	141.8	2950.7
	IVb	-	1.3	539.4	91.6	15.9	23.5	-	1.3	2.7	1.3	677.0
	IVbYH	371.8	1008.9	179.1	6.8	-	-	-	-	-	-	1566.6
	IVc + VIId,e	-	3.6	54.8	9.9	1.2	3.1	-	-	-	-	72.6
	Total NS	374.5	1383.1	2569.7	741.2	450.1	889.8	45.3	64.8	95.5	236.3	6850.3

Table 9. (continued)

Year	Area	AGE IN WINTER RINGS										
		0	1	2	3	4	5	6	7	8	>8	Total
1967	IVaW of 2°E	-	12.2	119.1	315.6	67.7	51.5	71.4	4.7	4.1	33.8	680.1
	IVaE of 2°E	0.7	402.6	444.6	741.0	245.8	237.3	307.5	63.2	77.5	139.0	2659.2
	IVb	-	24.3	209.4	257.4	53.1	6.8	14.1	-	-	-	565.1
	IVbYH	644.7	1231.6	356.0	35.3	-	-	-	-	-	-	2267.6
	IVc + VIId,e	-	3.6	42.4	15.4	4.9	2.2	0.1	-	-	-	68.6
	Total NS	645.4	1674.3	1171.5	1364.7	371.5	297.8	393.1	67.9	81.6	172.8	6240.6
1968	IVaW of 2°E	-	83.1	577.7	231.5	372.1	83.5	86.8	89.8	10.6	63.5	1598.6
	IVaE of 2°E	-	579.7	781.7	1201.0	179.7	59.5	51.6	67.6	3.1	28.3	2952.2
	IVb	-	9.0	166.8	40.6	59.9	12.6	3.6	5.4	-	-	297.9
	IVbYH	839.3	1747.2	246.1	1.3	-	-	-	-	-	-	2833.9
	IVc + VIId,e	-	6.0	22.9	19.9	9.7	1.5	3.0	0.6	-	-	63.6
	Total NS	839.3	2425.0	1795.2	1494.3	621.4	157.1	145.0	163.4	13.7	91.8	7746.2
1969	IVaW of 2°E	-	101.1	736.2	109.4	52.4	103.9	17.2	14.7	10.3	4.5	1149.7
	IVaE of 2°E	-	128.2	559.3	136.0	61.9	66.9	29.3	27.4	16.9	20.4	1046.3
	IVb	-	44.8	154.6	29.1	13.5	18.1	3.0	0.2	0.2	-	263.5
	IVbYH	112.0	2223.7	271.1	13.0	-	-	-	-	-	-	2619.8
	IVc + VIId,e	-	5.5	161.8	8.8	5.3	1.9	0.4	0.4	-	0.2	184.3
	Total NS	112.0	2503.3	1883.0	296.3	133.1	190.8	49.9	42.7	27.4	25.1	5263.6
1970	IVaW of 2°E	-	13.0	930.9	695.3	98.7	39.4	49.3	5.7	10.0	4.0	1846.3
	IVaE of 2°E	-	32.6	68.7	23.5	9.6	5.4	4.1	1.2	1.2	8.1	154.4
	IVb	-	27.7	203.5	63.4	9.3	3.3	6.6	0.9	0.4	-	315.1
	IVbYH	898.1	1118.7	718.1	17.6	2.2	0.6	-	-	-	-	2755.3
	IVc + VIId,e	-	4.2	81.6	83.8	5.4	1.6	1.0	0.1	0.4	0.1	178.2
	Total NS	898.1	1196.2	2002.8	883.6	125.2	50.3	61.0	7.9	12.0	12.2	5249.3
1971	IVaW of 2°E	136.7	818.3	516.9	488.3	154.2	24.1	28.8	25.1	-	9.8	2202.3
	IVaE of 2°E	14.0	95.4	54.5	38.5	10.4	2.1	1.4	1.1	-	0.2	217.5
	IVb	-	2.1	140.3	54.4	12.6	-	-	-	-	2.1	211.5
	IVbYH	340.5	2748.5	1174.7	53.0	-	-	-	-	-	-	4316.7
	IVc + VIId,e	0.3	21.8	130.8	41.7	31.1	0.7	0.3	0.6	-	0.3	227.4
	Total NS	491.5	3686.1	2017.2	675.9	208.3	26.9	30.5	26.8	-	12.4	7175.4

Table 10. Percentage of Spring-Spawned Herring in the Northwestern North Sea, Northeastern North Sea and the Skagerrak

Year	Northwestern North Sea		Northeastern North Sea			Skagerrak
	Norwegian	Scottish	Norwegian	Danish	Scottish	Norwegian
1960	-	4.9	-	-	6.9	-
1961	-	4.0	-	22.1	3.0	-
1962	-	26.6	-	8.5	34.2	-
1963	-	25.8	-	-	23.6	-
1964	-	10.5	14.8	14.4	33.6	5.6
1965	16.5	12.3	8.4	15.6	35.6	5.8
1966	26.4	21.7	9.1	28.4	3.0	7.4
1967	20.1	23.5	21.3	21.7	13.0	10.4
1968	24.2	28.1	18.4	-	19.0	6.1
1969	10.7	43.9	13.3	-	-	6.9
1970	30.7	9.0	32.5	-	-	16.6
1971	12.9	23.4	-	-	-	-

Table 11. Skagerrak. Catch in 1 000 tons

Year	Total Catch	% of Total Catch North Sea + Skagerrak	Denmark		Swedish Catch Landed in Denmark		Norway	Other Countries
			C	I	C	I	C+I	C
1960	75.8	9.8	15.4	27.8(49)	7.4	0.8	2.6	21.8
1961	85.2	10.9	11.8	44.9(53)	7.2	1.2	4.6	15.6
1962	104.2	14.2	7.8	62.8(54)	13.0	3.3	5.0	12.3
1963	163.2	18.4	15.9(6.3)	89.2(43)	21.1	6.3	11.0	19.7(6.5)
1964	309.8	26.4	17.2(6.1)	112.3(59)	24.4	32.6	85.9	37.4(6.6)
1965	256.7	18.0	15.0(8.4)	80.3	24.9	21.5	83.9(7.6)	31.1(8.0)
1966	144.7	13.9	6.5	68.7	15.6	10.6	30.4(9.5)	12.9(6.9)
1967	279.7	28.7	16.1	84.7	28.4	15.9	95.0(10.2)	39.6(9.0)
1968	280.0	28.1	8.5	135.1	18.0	22.0	71.9(10.5)	24.5(8.9)
1969	113.3	17.2	10.2	47.7(39)	19.0	6.6	14.0	15.8
1970	70.5	11.4	1.6	28.5(38)	-	-	7.0	-
1971	64.2	11.1	2.5	24.9	-	-	6.0	-

Figures in brackets: mean number per kg

C: Herring for human consumption
I: Industrial catches

Table 12. Catch Per Unit Effort in Drift-Net and Trawl Fisheries in the Southern, Central, Northeastern and Northwestern North Sea

Years	Northwest		Northeast			Central			South		Bløden
	Drift 1)	Trawl 2)	Drift 3)	Trawl 4)	Trawl 5)	Drift 6)	Drift 7)	Trawl 8)	Drift 9)	Trawl 10)	Trawl 11)
1947	2.8	130.4	-	-	-	4.7	2.3	153.3	7.0	-	-
1948	3.1	68.8	-	-	-	3.7	1.9	110.0	6.9	-	-
1949	2.3	65.8	-	-	-	2.5	1.5	70.2	6.9	-	-
1950	2.6	43.1	-	-	-	2.8	2.2	92.4	6.7	-	-
1951	2.3	53.9	-	-	-	2.8	2.3	95.9	6.4	197.7	-
1952	4.1	70.4	-	-	-	3.3	2.9	111.2	6.3	167.3	-
1953	3.9	47.2	-	-	5.9	3.2	2.6	104.1	5.9	203.6	-
1954	3.9	43.9	-	-	1.6	2.9	3.3	76.1	7.2	156.8	-
1955	5.2	51.4	-	11.5	1.5	2.8	3.8	65.5	3.4	121.7	-
1956	3.9	27.7	-	16.3	3.6	3.5	4.1	53.8	4.3	103.0	-
1957	3.6	55.7	4.8	8.2	3.3	3.5	3.3	93.6	3.6	91.3	-
1958	4.1	31.7	3.1	15.6	4.3	3.0	3.0	31.6	2.7	94.8	1.94
1959	4.0	61.9	2.8	7.5	2.9	3.1	4.3	78.0	2.2	175.5	1.74
1960	3.2	34.6	3.4	15.2	2.7	2.4	3.1	29.4	3.4	132.2	1.22
1961	4.2	28.0	3.3	7.8	1.8	2.1	1.8	49.1	3.2	197.7	1.22
1962	3.7	22.0	1.8	4.8	2.0	2.0	1.5	29.0	2.7	65.5	1.94
1963	3.9	25.4	1.2	8.4	3.6	5.6	3.4	49.5	2.2	58.5	1.16
1964	3.4	29.7	2.5	11.1	3.4	2.6	3.1	44.8	3.8	67.9	1.78
1965	3.4	23.3	3.0	6.0	2.5	2.7	3.2	35.9	1.8	69.8	1.46
1966	4.3	17.2	2.8	3.4	1.6	2.8	4.8	43.9	1.4	-	0.98
1967	4.7	9.8	1.8	1.1	1.0	2.9	4.0	30.2	1.4	-	1.35
1968	3.8	(1.2)*	1.6	1.7	1.0	-	2.4	21.9	0.3	50.2	1.64
1969	4.8	(3.7)*	-	2.9	-	-	4.4	24.7	-	100.9	1.22
1970	3.4	(2.6)*	-	(0.2)*	-	-	5.1	26.6	0.9	57.2	1.07
1971	5.2	19.1	-	(0.2)*	-	-	4.1	20.7	-	44.2	1.34

*Based on catches less than 100 tons

/Continued

Footnotes to Table 12.

Catch Per Unit Effort in Drift-Net and Trawl Fisheries in the Southern, Central, Northeastern and Northwestern North Sea

1. United Kingdom catch per arrival in May-September (tons).
2. Netherlands catch per 100 hours' fishing by a standard (500 BHP) trawler in July-September (tons fresh weight).
3. Polish catch per shot in April-July (tons).
4. Netherlands catch per 100 hours' fishing by a standard trawler in January-April (tons fresh weight).
5. German lugger trawl, catch per day (only catches with over 60% herring) (tons).
6. Netherlands catch per shot (tons) (May-September).
7. United Kingdom tons per landing for central North Sea drift-net fisheries (May-September).
8. Netherlands catch per 100 hours' fishing by a standard trawler (tons fresh weight) (August-October).
9. United Kingdom catch per shot (tons) (October-December).
10. Netherlands catch per 100 hours' fishing by a standard trawler (tons fresh weight) (November-December).
11. Danish catch per hour (tons) in the immature herring fishery in the Bløden area.

Table 13. Effort Estimates for each Area from Catch per Effort Data of Table 12

Year	Northwest		Northeast			Central			South		Bløden
	UK Drift Landings x 10^{-3}	Dutch Trawl Fishing Hours x 10^{-5}	Polish Drift Shots x 10^{-3}	Dutch Trawl Fishing Hours x 10^{-5}	German Trawl Days Fishing x 10^{-3}	Dutch Drift Shots x 10^{-3}	UK Drift Landings x 10^{-3}	Dutch Trawl Fishing Hours x 10^{-5}	UK Drift Shots x 10^{-3}	Dutch Trawl Fishing Hours x 10^{-5}	Danish Trawl Fishing Hours x 10^{-3}
1947	75.5	1.6	-	-	-	45.6	93.2	1.4	22.9	-	-
1948	54.6	2.5	-	-	-	45.4	88.4	1.5	23.6	-	-
1949	58.3	2.0	-	-	-	71.5	119.2	2.5	28.0	-	-
1950	48.1	2.9	-	-	-	64.8	82.4	2.0	26.6	-	-
1951	53.5	2.3	-	-	-	95.0	115.7	2.8	25.9	0.8	-
1952	41.1	2.4	-	-	-	61.5	70.0	1.8	37.5	1.4	-
1953	45.8	3.8	-	-	1.3	70.2	86.4	2.2	35.5	1.0	-
1954	43.1	3.8	-	-	2.7	75.3	66.2	2.9	38.5	1.8	-
1955	55.3	5.6	-	5.9	44.9	60.8	44.8	2.6	49.5	1.4	-
1956	49.9	7.0	-	4.9	22.0	46.8	40.0	3.0	31.2	1.3	-
1957	58.1	3.8	-	11.9	29.5	43.1	45.7	1.6	34.1	1.3	-
1958	40.2	5.2	-	6.3	22.8	52.0	52.0	4.9	34.3	1.0	-
1959	64.9	4.2	-	19.2	49.7	47.5	34.2	1.9	35.1	0.4	-
1960	31.6	2.9	78.0	17.4	97.8	69.3	53.6	5.7	19.1	0.5	81.9
1961	14.5	2.2	83.0	35.2	152.7	80.4	93.8	3.4	29.8	0.5	76.9
1962	10.2	1.7	162.0	60.8	145.9	71.7	95.5	4.9	20.3	0.8	51.8
1963	18.7	2.9	251.0	35.9	83.7	40.8	67.1	4.6	20.8	0.8	58.4
1964	19.4	2.2	178.0	40.0	130.6	72.3	60.6	4.2	15.3	0.8	65.5
1965	87.7	12.8	194.0	96.8	232.3	49.2	41.5	3.7	12.1	0.3	92.5
1966	64.8	16.2	151.0	124.7	265.0	40.8	23.8	2.6	8.3	-	68.6
1967	25.0	12.0	205.0	339.7	373.7	37.2	27.0	3.6	8.1	-	63.1
1968	75.4	-	161.0	151.1	256.8	-	24.1	2.6	32.0	0.2	65.2
1969	44.4	-	-	51.1	-	-	9.1	1.6	-	0.2	99.3
1970	91.9	-	-	-	-	-	21.9	4.2	30.1	0.5	69.9
1971	53.7	14.6	-	-	-	-	6.5	1.3	-	0.5	123.3

Table 14. Estimates of Total North Sea Effort on Adult Herring and Relative Changes in Efficiency

Year	$\bar{F}_{VPA}$	Drifter			Trawl		
		Landings x 10^{-3}	Cpe	Efficiency $\bar{F}$/Cpe	Hours Fishing x 10^{-5}	Cpe	Efficiency $\bar{F}$/Cpe
1947	-	191.6	3.06		3.39	175.8	
1948	-	166.6	3.00		4.68	107.3	
1949	.08	205.5	2.46	.0325	5.97	85.1	.0009
1950	.19	157.1	3.09	.0615	6.16	79.0	.0024
1951	.34	195.1	2.84	.1197	6.25	88.9	.0038
1952	.33	150.1	4.09	.0807	5.63	109.1	.0030
1953	.38	169.4	3.65	.1041	7.05	87.9	.0043
1954	.45	149.3	4.49	.1002	9.35	71.4	.0063
1955	.42	166.1	4.19	.1002	10.10	68.7	.0061
1956	.48	140.5	4.07	.1179	9.29	61.5	.0078
1957	.46	165.5	3.50	.1314	7.80	74.3	.0062
1958	.48	156.9	3.27	.1468	9.34	54.8	.0088
1959	.50	174.5	3.61	.1385	8.86	70.9	.0071
1960	.38	186.7	3.19	.1191	10.88	54.8	.0069
1961	.48	254.1	2.38	.2017	13.49	44.7	.0107
1962	.50	282.2	1.87	.2674	17.88	29.5	.0169
1963	.31	199.3	3.26	.0951	14.54	44.6	.0019
1964	.40	231.6	3.26	.1227	15.06	50.1	.0079
1965	.77	322.2	3.21	.2399	29.88	34.6	.0222
1966	.67	198.6	4.17	.1607	28.08	29.5	.0227
1967	.70	155.1	3.94	.1777	35.90	17.0	.0412
1968	1.0	227.5	2.69	.3717	39.16	15.6	.0641
1969	1.0	(>81.9)	(>5.19)		21.06	20.2	.0495
1970	1.0	151.1	3.14	.3184	17.77	26.6	.0375
1971	1.0	(>63.2)	(>5.50)		13.99	24.9	.0401

Table 15. Calculated Fishing Mortalities by Age and Year. (M = 0.1)

Winter Rings	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
0	0	0	0	0	0	0	0.02	0.03	0.02	0.02	0.01	0.02	0	0.11	0.08	0.02	0.06	0.05	0.03	0.08	0.09	0.12	0.02	0.08
1	0	0	0	0	0.08	0.14	0.18	0.21	0.39	0.31	0.45	0.27	0.39	0.45	0.24	0.18	0.24	0.54	0.44	0.34	0.50	0.52	0.54	0.29
2	0.13	0.06	0.08	0.14	0.23	0.34	0.36	0.39	0.43	0.63	0.48	0.57	0.51	0.46	0.68	0.28	0.35	0.45	0.88	0.67	0.47	1.46	0.86	0.99
3	0.17	0.24	0.19	0.23	0.35	0.29	0.40	0.51	0.46	0.46	0.49	0.54	0.51	0.34	0.32	0.60	0.27	0.43	0.76	0.74	0.83	1.86	0.94	1.23
4	0.19	0.18	0.20	0.25	0.43	0.35	0.36	0.38	0.38	0.39	0.42	0.37	0.50	0.29	0.41	0.35	0.20	0.34	0.77	0.56	0.92	1.03	0.77	1.30
5	0.25	0.25	0.21	0.20	0.39	0.36	0.35	0.45	0.35	0.31	0.44	0.54	0.44	0.28	0.32	0.54	0.12	0.26	0.57	0.83	0.79	1.21	0.96	0.67
6	0.38	0.35	0.41	0.27	0.24	0.49	0.43	0.50	0.52	0.31	0.41	0.30	0.55	0.35	0.41	0.56	0.18	0.18	0.41	0.30	0.99	1.04	1.74	0.83
7	0.30	0.32	0.58	0.34	0.21	0.32	0.55	0.65	0.30	0.41	0.36	0.22	0.37	0.53	0.29	0.72	0.16	0.29	0.30	0.27	0.89	1.51	0.90	1.70
8	-	0.25	0.55	0.46	0.32	0.36	0.23	0.84	0.35	0.41	0.76	0.16	0.36	0.77	0.42	0.73	0.42	0.25	0.89	0.38	0.57	0.39	1.07	0.61
9	-	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.40	0.70	0.70	0.40	0.50	0.60	0.20	0.30	0.80	0.70	0.85	1.00	1.00	1.00
Mean F2w.r. and older	-	-	0.22	0.23	0.33	0.33	0.38	0.45	0.42	0.48	0.46	0.48	0.50	0.38	0.48	0.50	0.30	0.40	0.77	0.67	0.70	1.47	0.89	1.05
Mean F3w.r. and older	-	-	0.30	0.25	0.36	0.33	0.39	0.48	0.41	0.40	0.45	0.45	0.49	0.35	0.38	0.54	0.20	0.38	0.73	0.67	0.85	1.48	0.95	1.17

Table 16. Calculated Stock Size in Numbers ($\times 10^{-9}$) by Age and Year (M = 0.1)

Winter Rings	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
0	7.74	5.26	4.12	6.58	6.46	7.04	8.95	7.68	7.61	4.86	21.08	5.89	7.66
1	5.02	7.00	4.76	3.73	5.96	5.84	6.37	7.96	6.74	6.73	4.31	18.81	5.24
2	4.11	4.54	6.33	4.30	3.37	4.95	4.60	4.80	5.83	4.14	4.48	2.49	12.96
3	2.72	3.25	3.88	5.28	3.39	2.43	3.20	2.91	2.92	3.44	1.98	2.50	1.28
4	3.84	2.06	2.30	2.90	3.79	2.16	1.65	1.95	1.58	1.67	1.96	1.10	1.31
5	2.46	2.87	1.56	1.71	2.04	2.24	1.13	1.04	1.20	0.98	1.02	1.16	0.69
6	2.51	1.72	2.03	1.14	1.27	1.24	1.41	0.86	0.60	0.77	0.65	0.60	0.61
7	1.76	1.55	1.10	1.22	0.79	0.90	0.69	0.83	0.48	0.32	0.51	0.39	0.40
8	-	1.18	1.03	0.56	0.79	0.58	0.59	0.36	0.39	0.32	0.20	0.32	0.28
9	-	-	0.83	0.54	0.32	0.52	0.37	0.42	0.14	0.25	0.19	0.08	0.25
Total	-	-	27.94	27.96	28.18	27.90	28.96	28.81	27.49	23.48	36.38	33.34	30.68

Winter Rings	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
0	2.00	16.67	7.10	8.73	10.94	5.74	5.29	7.63	7.83	5.57	11.77	11.80*)
1	6.94	1.63	13.88	6.29	7.48	9.42	5.04	4.43	6.30	6.28	4.93	9.80
2	3.22	4.02	1.15	10.52	4.49	3.96	5.49	3.25	2.42	3.40	3.32	3.33
3	7.06	1.83	1.85	0.79	6.71	2.60	1.49	2.53	1.83	0.51	1.30	1.11
4	0.70	4.52	1.20	0.92	0.54	3.95	1.10	0.64	1.00	0.26	0.18	0.34
5	0.72	0.47	2.71	0.77	0.68	0.35	1.65	0.57	0.23	0.32	0.11	0.04
6	0.40	0.49	0.31	1.43	0.62	0.47	0.18	0.65	0.23	0.06	0.11	0.05
7	0.32	0.26	0.29	0.16	1.07	0.47	0.29	0.12	0.22	0.07	0.01	0.04
8	0.25	0.17	0.17	0.13	0.13	0.73	0.31	0.20	0.04	0.04	0.03	+
9	0.18	0.10	0.10	0.08	0.08	0.09	0.27	0.19	0.10	0.03	0.01	0.01
Total	21.79	30.16	28.76	29.82	32.74	27.78	21.11	20.21	20.20	16.54	21.77	26.52

*) Year class 1970 put equal to year class 1969.

Table 17. Larval abundance in the North Sea (- = no observations) (Numbers x 10^{-9}).

Year	Southern[1] North Sea	Central North Sea Dogger[2]	Central North Sea Total[3]	Northwestern North Sea[4] Buchan	Northwestern North Sea[4] Orkney-Shetland	Northwestern North Sea[4] Total
1946	537	-	-	-		
1947	596	-	-	-		
1948	-	-	-	-		
1949	-	-	-	-		
1950	288	-	-	-		
1951	255	-	-	900	420	1 320
1952	-	-	-	890	100	990
1953	-	-	-	2 110	940	3 050
1954	-	-	-	870	700	1 570
1955	99	-	-	20x)	700	720
1956	56	-	-	-	-	-
1957	16	232	-	300	-	-
1958	58	252	-	220	2 800	3 020
1959	11	97	-	300	860	1 160
1960	33	138	-	440	640	1 080
1961	44	86	-	380	4 940	5 320
1962	>30	66	-	400	720	1 120
1963	22	-	-	440	580	1 020
1964	9	52	63x)	920	880	1 800
1965	13	275	490x)	70	2 220	2 290
1966	+	3	142x)	10	680	690
1967	26	0	275	+	440	440
1968	15-18	0	28	0	162	162
1969	108	0	11	3	212	215
1970	126	0	273	0	273	273

1) Larval abundance in Downs area in December-January.

2) Abundance of larvae <11 mm in October on the Western and Southern slopes of Dogger Bank (Zijlstra).

3) Abundance of larvae <10 mm in September-October in the central part of the North Sea.

4) Abundance of larvae <10 mm in the Northwestern North Sea, apart from the Southern area (Buchan), the Northern area (Orkney-Shetland) and the total Northwestern North Sea (Saville).

x) Incomplete data.

+) Small numbers.

Table 18. Recruitment Indices to North Sea Stocks

Year Class	Buchan (1/10 th cran per arrival)	Bank (hundreds per day fishery)	Downs (hundreds per shot)
1951	42	77	218
1952	71	235	109
1953	50	43	321
1954	73	63	243
1955	17	148	95
1956	194	373	180
1957	42	20	80
1958	22	126	366
1959	14	7	30
1960	170	256	180
1961	70	74	168
1962	52	87	30
1963	180	259	100
1964	51	27	68
1965	61	38	10
1966	97	65	330
1967	114	70	55
1968	-	-	-
1969	-	-	-

Table 19. Year Class Size Compared with Spawning Potential Parent Stock

Year Class	VPA Number of 0-group $x\ 10^{-9}$	Spawning Potential Parent Stock Eggs $x\ 10^{-12}$
1947	5.26	633
1948	4.12	738
1949	6.58	703
1950	6.46	670
1951	7.04	590
1952	8.95	528
1953	7.68	475
1954	7.61	452
1955	4.86	437
1956	21.08	412
1957	5.89	380
1958	7.66	314
1959	2.00	502
1960	16.67	432
1961	7.10	422
1962	8.73	314
1963	10.94	431
1964	5.74	478
1965	5.29	454
1966	7.63	354
1967	7.83	272
1968	5.57	200
1969	11.77	130

Table 20. Average Weight by Age and Month

Month	Area	AGE IN WINTER RINGS						
		2	3	4	5	6	7	8+
Jan.	IVaW	-	-	-	-	-	-	-
Feb.		-	-	-	-	-	-	-
Mar.		97.3(21)	122.5(7)	175.4(7)	157.5(4)	190.0(4)	210.4(4)	-
Apr.		-	-	-	-	-	-	-
May		-	-	-	-	-	-	-
Jun.		152.4	175.9	171.8	-	251.2	287.0	269.0
Jul.		165.0	248.0	259.0	287.0	303.0	-	321.5
Aug.		180.8	222.0	247.0	324.5	273.5	-	349.5
Sep.		150.0	206.5	237.0	317.0	262.0	303.0	-
Oct.		150.4(64)	183.2(44)	210.3(9)	225.9(9)	262.5(6)	268.8(4)	265.0
Nov.		139.5(146)	168.4(86)	179.6(12)	212.5(2)	222.5(1)	202.5(2)	-
Dec.		139.7(85)	165.9(34)	192.5(3)	222.5(1)	262.5(1)	-	-
Jan.	IVaE	-	-	-	-	-	-	-
Feb.		97.6(52)	120.8(6)	175.8(3)	187.5(4)	-	-	227.5(2)
Mar.		-	-	-	-	-	-	-
Apr.		111.0(26)	149.6(7)	170.8(6)	-	209.2(3)	222.5(2)	242.5(2)
May		-	-	-	-	-	-	-
Jun.		-	-	-	-	-	-	-
Jul.		-	-	-	-	-	-	-
Aug.		186.3(45)	243.2(16)	258.5(15)	291.6(11)	292.5(1)	312.5(2)	322.5(4)
Sep.		-	-	-	-	-	-	-
Oct.		-	-	-	-	-	-	-
Nov.		137.5(2)	175.8(3)	-	242.5(1)	-	-	-
Dec.		153.9(7)	192.5(1)	-	222.5(1)	-	-	-

Continued/

Table 20. (Continued)

Month	Area	AGE IN WINTER RINGS								
		2	3	4	5	6	7	8	9	10
Jan.	Norwegian Data Area IVa	92(784)	141(159)	161(50)	191(50)	212(57)	195(3)	242(7)	226(7)	230(12)
Feb.		82(470)	123(154)	141(65)	161(22)	177(41)	162(17)	250(4)	257(4)	250(9)
Mar.		92(456)	136(132)	167(170)	184(129)	191(90)	214(89)	225(14)	222(28)	212(19)
Apr.		99(270)	134(48)	166(26)	185(29)	214(6)	216(10)	215(3)	198(6)	-
May		108(293)	143(190)	180(99)	189(29)	209(31)	207(13)	238(9)	-	225(2)
Jun.		148(522)	183(353)	221(139)	218(127)	224(151)	261(32)	254(28)	250(21)	243(38)
Jul.		177(757)	238(328)	265(171)	273(293)	292(50)	325(43)	291(50)	312(90)	470(1)
Aug.		184(672)	222(348)	257(146)	277(39)	283(35)	328(20)	325(33)	292(3)	372(2)
Sep.		152(52)	192(47)	214(65)	224(26)	243(8)	236(5)	225(12)	245(11)	240(1)
Oct.		158(81)	199(23)	219(33)	220(43)	243(5)	239(7)	248(6)	238(14)	-
Nov.		149(232)	177(83)	207(67)	228(56)	249(19)	242(16)	239(18)	245(9)	255(1)
Dec.		133(19)	203(2)	-	210(1)	220(1)	-	-	-	-

/Continued

Table 20. (Continued)

Month	Area	AGE IN WINTER RINGS						
		2	3	4	5	6	7	8+
Jan.	IVb	-	-	-	-	-	-	-
Feb.	IVb	-	-	-	-	-	-	-
Mar.	IVb	-	-	-	-	-	-	-
Apr.	IVb	93.5(29)	107.5(14)	-	-	147.5(1)	-	-
May	IVb	118.3(271)	138.6(114)	168.9(44)	172.0(10)	187.0(3)	208.0(1)	-
Jun.	IVb	136.2(1510)	168.7(470)	189.8(154)	200.0(52)	226.3(14)	229.1(9)	282.5(1)
Jul.	IVb	144.8(2464)	177.0(1154)	193.2(456)	200.3(85)	229.7(38)	248.3(6)	200.7(3)
Aug.	IVb	156.1(3538)	186.4(2132)	200.4(1332)	225.4(320)	245.4(136)	278.5(34)	326.7(9)
Sep.	IVb	160.2(3638)	192.7(1449)	218.8(882)	231.4(381)	280.1(193)	309.8(74)	321.4(13)
Oct.	IVb	159.1(1281)	191.2(592)	216.0(282)	229.6(99)	263.8(46)	274.6(9)	280.6(5)
Nov.	IVb	129.3(3)	-	-	-	-	-	-
Dec.	IVb	-	-	-	-	-	-	-
Jan.	IVc	102.7(11)	116.3(226)	149.2(9)	204.7(9)	-	172.5(1)	-
Feb.	IVc	52.5(2)	87.5(2)	-	-	-	-	-
Mar.	IVc	87.8(148)	113.3(42)	137.0(2)	172.5(1)	-	-	-
Apr.	IVc	-	-	-	-	-	-	-
May	IVc	-	-	-	-	-	-	-
Jun.	IVc	-	-	-	-	-	-	-
Jul.	IVc	-	-	-	-	-	-	-
Aug.	IVc	-	-	-	-	-	-	-
Sep.	IVc	153.7(180)	193.1(76)	195.0(2)	-	-	-	-
Oct.	IVc	151.3(>1000)	191.5(860)	214.1(250)	236.2(73)	246.9(25)	267.5(10)	252.5(1)
Nov.	IVc	143.6(>1000)	171.5(900)	192.7(170)	215.7(47)	237.4(57)	239.9(15)	302.5(1)
Dec.	IVc	128.7(>1000)	158.9(470)	191.0(47)	208.4(12)	241.4(9)	225.8(3)	254.8(9)

Table 21. Mean Weights (g) by Month and Age for Total North Sea

Month	AGE IN WINTER RINGS								
	0	1	2	3	4	5	6	7	8+
Jan.	-	29	84	131	159	195	207	222	232
Feb.	-	29	82	112	142	161	177	181	202
Mar.	-	30	94	121	144	174	195	210	222
Apr.	-	34	106	134	157	177	192	207	219
May	-	40	112	146	169	190	205	219	231
Jun.	-	47	147	175	197	218	233	247	258
Jul.	5	56	184	216	242	264	284	300	314
Aug.	7	64	170	205	230	252	273	291	304
Sep.	15	70	157	191	216	242	264	284	303
Oct.	22	75	157	185	212	234	255	272	289
Nov.	27	77	144	166	194	215	232	248	260
Dec.	28	78	133	160	187	207	224	239	253

Table 22. Mean number per kg by month and area

Period	Area	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1961-65	IVa.W	-	-	-	6.9	6.2	5.7	5.2	5.1	7.8	5.9	9.0	-
	IVa.E	4.4	-	5.9	6.7	7.0	6.5	5.6	5.1	6.0	5.9	-	-
	IVb	-	-	-	6.4	-	7.2	6.1	5.3	6.5	6.0	7.7	-
	IVc	-	18.7	20.0	-	-	-	-	-	5.7	5.3	6.3	6.4
1966-70	IVa.W	-	-	7.2	6.4	6.1	5.9	5.4	5.4	6.2	5.6	8.1	8.4
	IVa.E	-	9.1	4.1	5.9	5.6	6.2	4.7	4.5	4.7	-	8.4	9.6
	IVb	-	-	-	8.6	8.4	6.8	6.5	6.0	5.7	6.4	11.5	-
	IVd[x])	23.2	28.0	31.7	27.4	26.3	24.7	35.0	23.2	16.2	18.3	25.4	21.4
	IVc	9.7	37.7	-	10.8	-	-	-	-	-	5.9	6.8	7.3

[x]) Danish data for juvenile herring 1967-1971

Table 23. Estimates of Relative Strengths of Latest Year Classes

Source		1968	1969	1970
English 0/grp. Surveys		0.44	1.00	0.54*
ICES Young Herring Survey Feb/Mar.		0.38	1.00	1.31
Danish Young	0/grp. Autumn	-	1.00	0.96
Herring	1/grp. Spring	0.38	1.00	1.37
Fishery	1/grp. Autumn	0.45	1.00	-
	2/grp. Spring	0.48	1.00	-

* English coastal abundance underestimated compared with 1968 and 1969.

Table 24. Initial catch levels (1972) and percentage increase in catch and biomass 1972-75.

Juvenile mortalities (1- ringers)

Adult mortalities (2- ringers and older) F	.0	.1	.2	.3	.4	.5	.6	.7	.8
.0	0 - 403	50 -33 365	95 -34 331	136 -34 300	173 -35 272	207 -35 248	238 -36 226	266 -36 206	292 -37 188
.1	92 298 306	141 161 275	187 100 246	228 66 221	265 43 198	299 28 177	330 16 158	358 8 142	384 1 127
.2	175 241 234	224 159 207	270 110 183	311 79 162	348 56 143	382 39 125	413 27 110	441 16 95	467 8 83
.3	250 196 180	300 137 157	345 99 137	386 71 118	423 51 102	457 35 87	488 23 74	516 13 62	542 5 51
.4	318 160 139	368 114 119	413 82 101	454 59 86	491 41 71	525 27 58	556 16 47	584 6 37	610 -1 27
.5	380 131 107	430 93 90	475 66 75	516 46 61	553 30 48	587 17 37	618 7 27	646 -1 18	671 -8 10
.6	436 107 83	486 75 67	531 52 54	572 34 42	609 20 31	643 8 21	674 -1 12	702 -9 4	728 -15 -3
.7	487 87 63	537 60 50	582 40 38	623 23 27	660 11 17	694 0 8	725 -8 0	753 -16 -7	779 -22 -13
.8	533 71 48	583 47 36	628 29 25	669 14 15	706 3 6	740 -7 -2	771 -15 -9	799 -21 -15	825 -27 -21
.9	575 58 36	625 36 25	670 20 15	710 7 6	748 -4 -2	782 -13 -9	813 -20 -16	841 -26 -22	867 -32 -27
1.0	613 47 26	662 27 16	708 12 7	749 0 -1	786 -10 -9	820 -18 -15	851 -25 -21	879 -31 -27	905 -36 -32
1.1	647 38 18	697 20 9	742 6 0	783 -5 -7	821 -15 -14	855 -22 -20	885 -29 -26	914 -34 -31	939 -39 -35
1.2	678 30 11	728 13 3	773 0 -5	814 -10 -12	852 -19 -19	886 -26 -24	917 -32 -30	945 -37 -34	970 -42 -38
1.3	707 23 6	757 8 -2	802 -4 -10	843 -14 -16	880 -22 -22	914 -29 -28	945 -35 -33	973 -39 -37	999 -44 -41
1.4	732 18 1	782 3 -7	828 -8 -14	869 -18 -20	906 -25 -25	940 -32 -31	971 -37 -35	999 -42 -39	1024 -46 -43
1.5	756 13 -3	806 -1 -10	851 -12 -17	892 -21 -23	929 -28 -28	963 -34 -33	994 -40 -37	1022 -44 -41	1045 -48 -44

Upper figure : Catch in 1972 (1000 tons)

Middle figure: Increase in catch in 1975 (%)

Lower figure : Increase in biomass as at the beginning of 1976 (% in weight)

Table 25. Annual Catches from IVa.W and VIa, 1965-1971

	1965		1966		1967		1968		1969		1970		1971	
	IVa.W	VIa	IVa.W	VIa	IVa.W	VIa	IVa.W	VIa	IVa.W	VIa	IVa.W	VIa	IVa.W	VIa
Faroese	3 111		1 491	-	35 993	-	49 995	-	27 835	-	40 884	18 400	25 142	34 000
France	7 303	610	2 628	1	1 515	379	1 349	1 124	605	966	818	1 553	1 396	2 296
Germany	4 489	5 066	7 069	14 634	7 941	17 318	7 150	14 874	418	15 805	177	16 543	-	7 538
Iceland	-	-	-	-	-	-	35 134	-	13 697	-	20 587	5 595	42 164	5 416
Ireland	-	6 440	-	7 759	-	12 290	-	13 390	-	11 895	-	11 716	-	12 161
Netherlands	11 515	330	3 414	251	3 418	4 576	3 072	2 957	474	1 514	177	1 102	5 755	1 850
Norway	196 488	-	219 223	-	41 664	-	131 598	-	99 316	-	146 397	27 462	112 114	76 720
Poland	35 878	-	27 199	-	8 454	727	2 806	2 791	362	3 188	2 069	3 709	1 288	1 955
Scotland.	19 239	53 909	16 548	69 3 3	17 359	67 404	16 324	65 180	10 051	90 222	17 767	103 530	24 711	104 922
Total	298 345	66 383	278 613	92 032	117 312	102 694	286 681	100 323	213 138	123 593	312 585	189 610	280 024	246 858
VIa in % of Total		18.2		24.8		46.7		25.9		36.7		37.8		46.9

Catches by countries are specified only for those countries which fish in both areas. The totals given are those for all countries fishing in these cases and so exceed the summation of the catches listed.

Table 26a. Distribution of Catches in the Shetland Area in 1970 by Scotland, Norway, Iceland, Faroese and Sweden

Month	West of 4°W	Between 4°W-West of Orkney and Shetland	East of Orkney and Shetland
Apr.	-	340	911
May	-	4 211	3 872
Jun.	8 017	72 712	650
Jul.	14 565	59 915	9 177
Aug.	5 523	8 957	4 370
Sep.	-	801	7 073
Oct.	-	131	7 138
Nov.	-	-	6 431
Dec.	-	-	332
Total	28 105	147 067	39 954

Table 26b. Percentage Age Compositions (Norwegian and Scottish Data) in Three Areas of Shetland Fishery in April-August 1970 - 1971

Year	Area	WINTER RINGS									
		1	2	3	4	5	6	7	8	>8	n
1970	West of 4°W	-	41.2	43.3	4.3	3.5	6.0	0.6	1.0	0.2	840
	4°W-West of Orkney and Shetland	-	54.5	31.2	5.0	1.1	3.4	0.7	0.8	0.7	564
	East of Orkney and Shetland	-	79.9	15.5	2.0	0.4	1.0	0.5	0.4	0.5	2 017
1971	West of 4°W	0.2	14.6	52.5	21.8	3.0	4.9	1.1	0.9	1.1	467
	4°W-West of Orkney and Shetland	-	12.1	52.7	19.4	4.2	6.1	3.6	1.8	-	199
	East of Orkney and Shetland	10.4	36.1	41.0	10.2	0.7	0.2	0.8	0.3	0.3	1 709

Table 26c. Mean VS, K_2 and L-1, Characters of Herring Samples from West Shetland, East Shetland and Minch Grounds

West Shetland			East Shetland			Minch		
VS	K_2	L-1	VS	K_2	L-1	VS	K_2	L-1
56.53	14.14	15.11	56.51	14.19	14.93	56.51	14.19	13.86

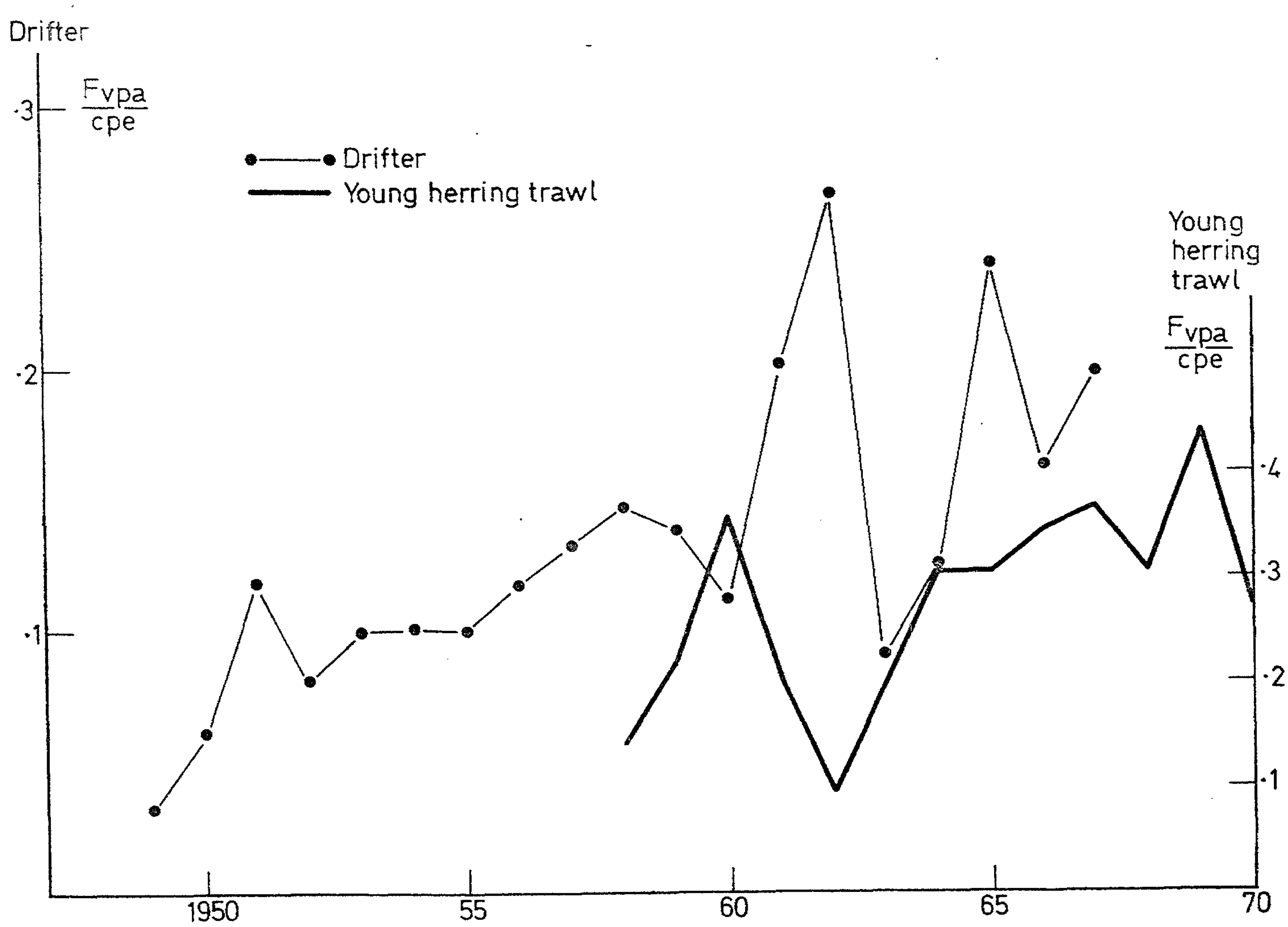

Figure 1. The development in efficiency as measured by F/cpe for drifters and young herring trawls (F derived from VPA).

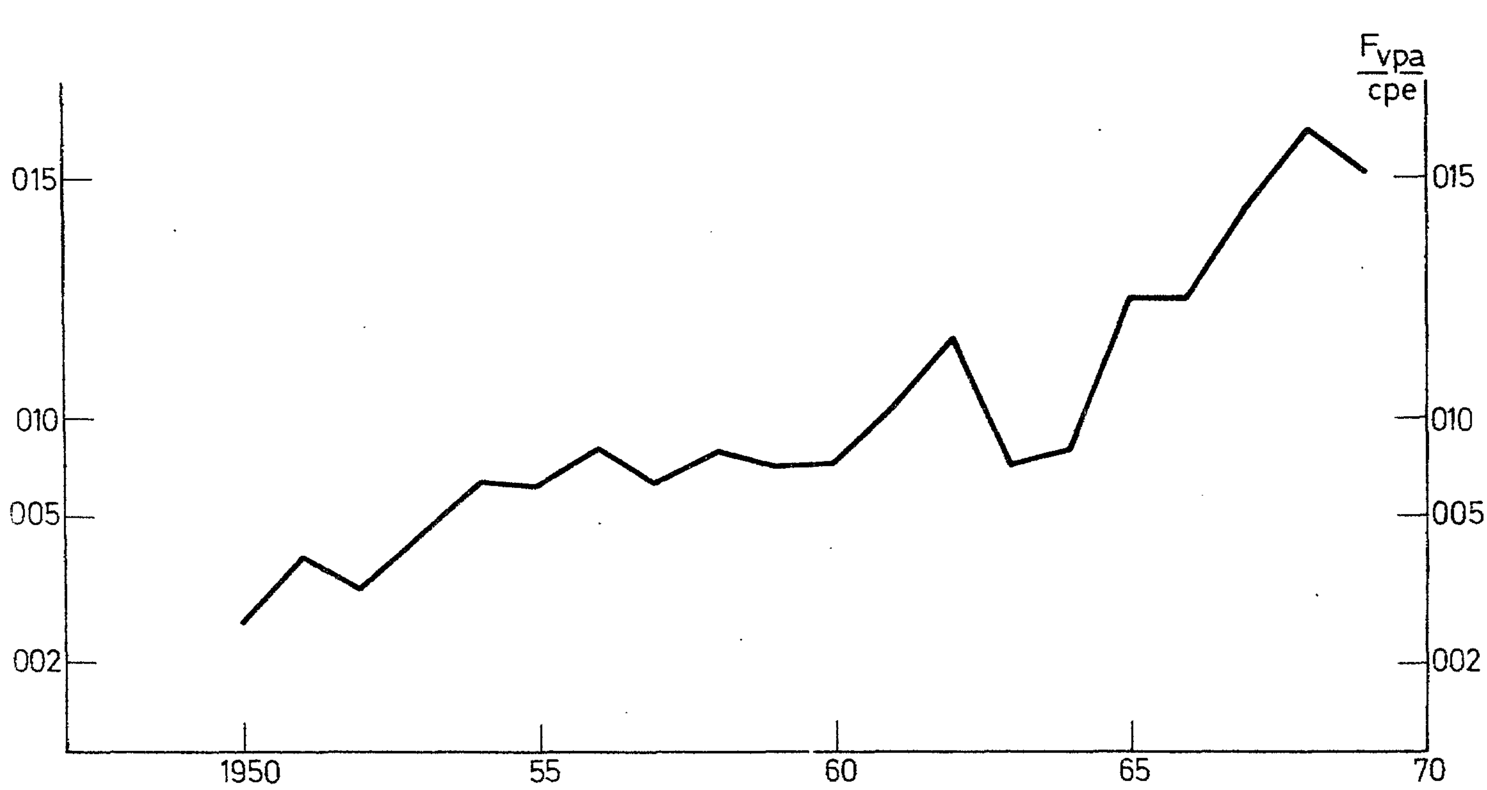

Figure 2. The development in efficiency as measured by F/cpe for Dutch trawlers (F derived from VPA).

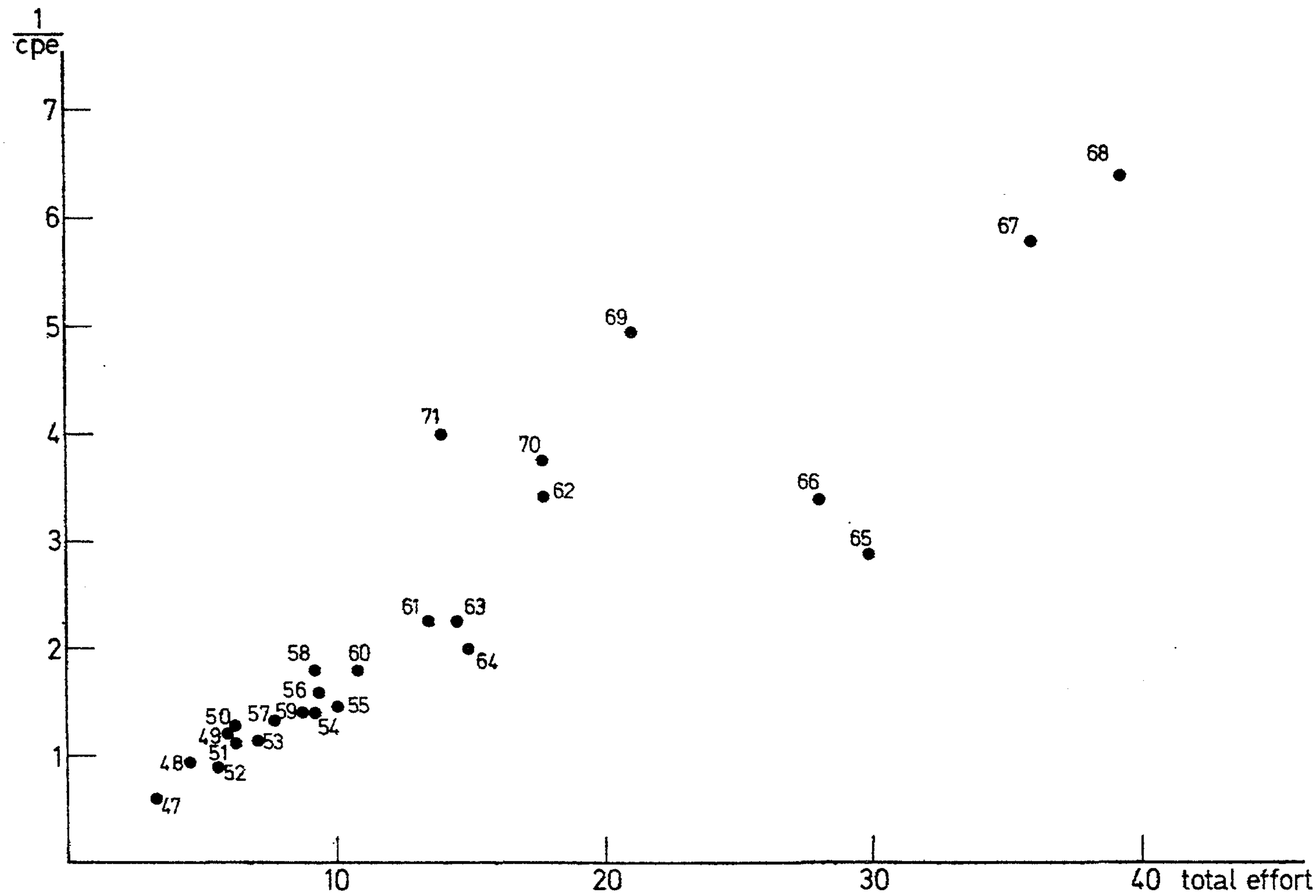

Figure 3. Total mortality, approximated by 1/cpe, on total effort (Dutch trawl).

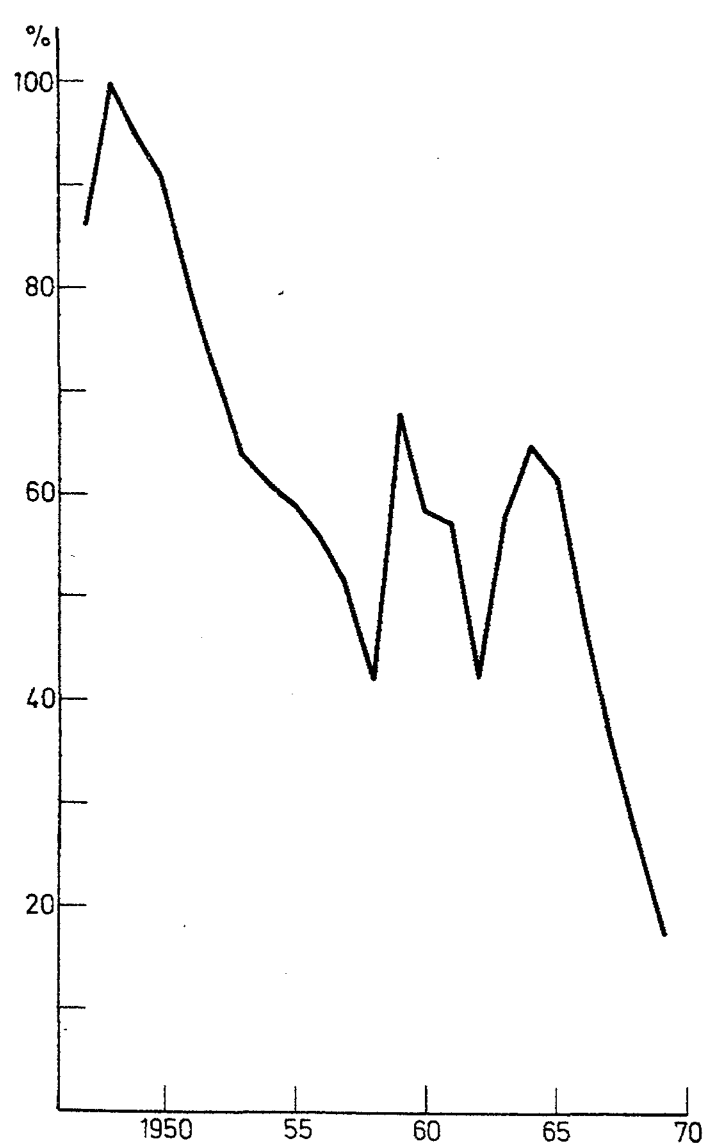

Figure 4. Spawning potential of North Sea herring stocks 1947 - 1969 in per cent of spawning potential in 1948.

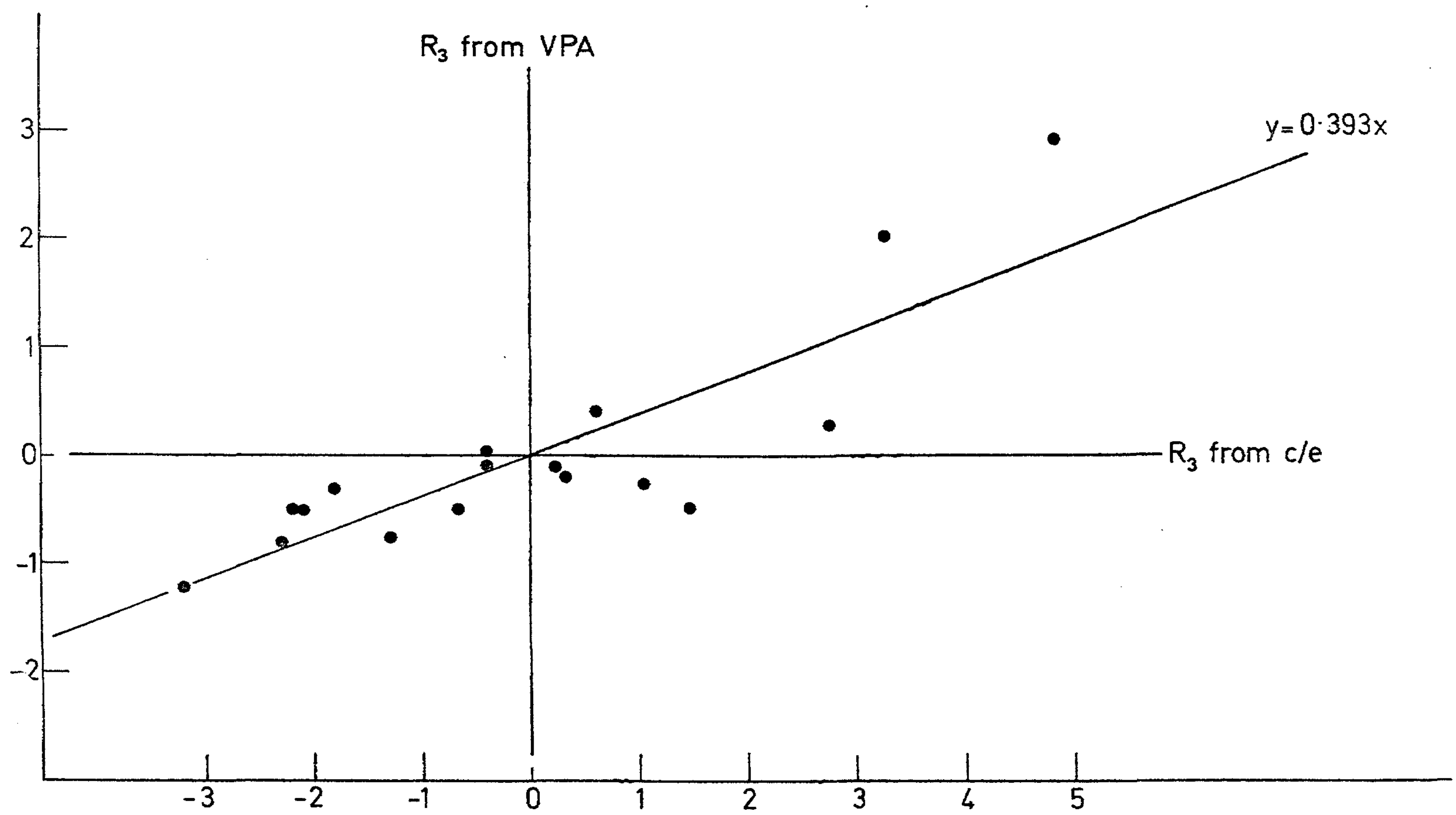

Figure 5. Regression of recruitment at 3 years of age estimated from VPA on estimates from catch-effort data.

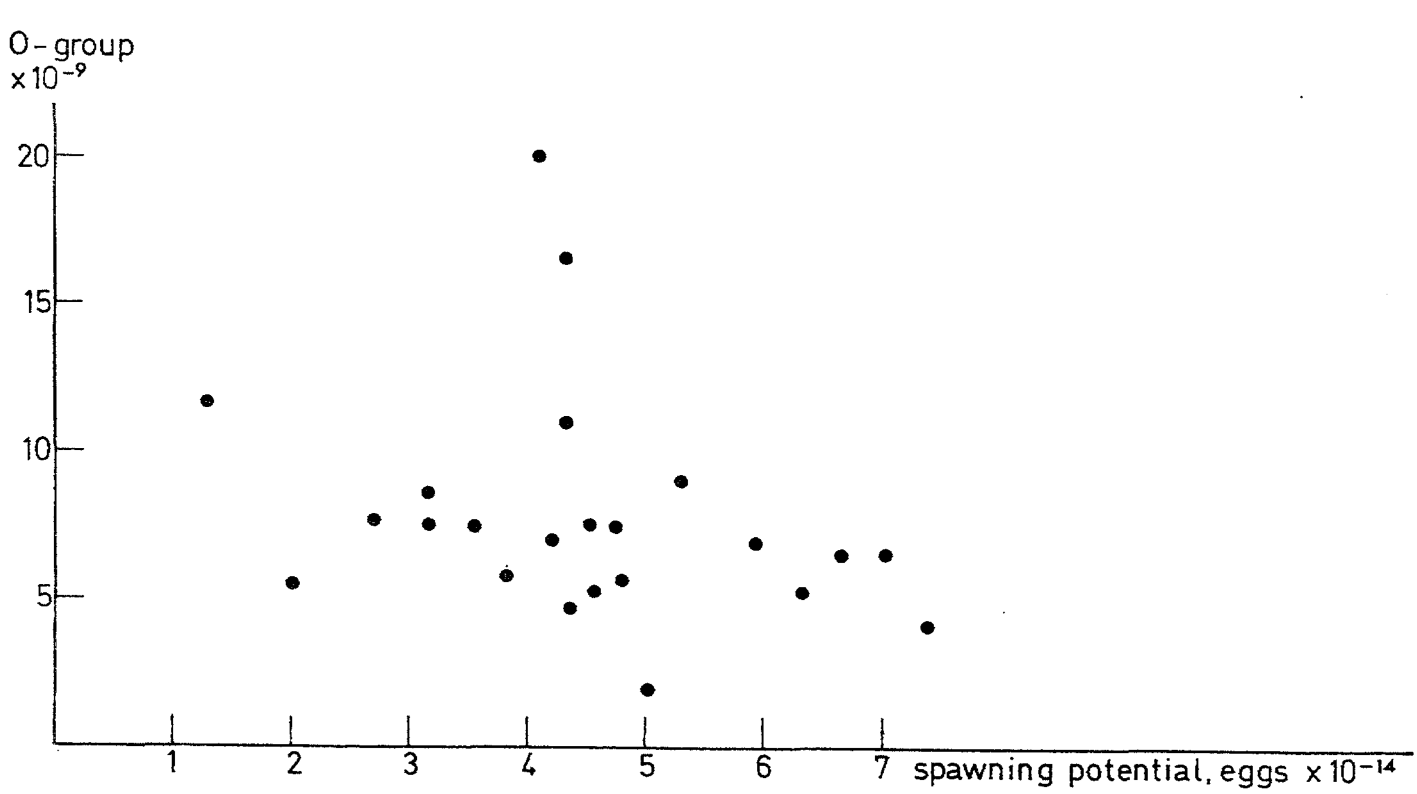

Figure 6. 0-group recruitment (derived from VPA) on spawning potential.

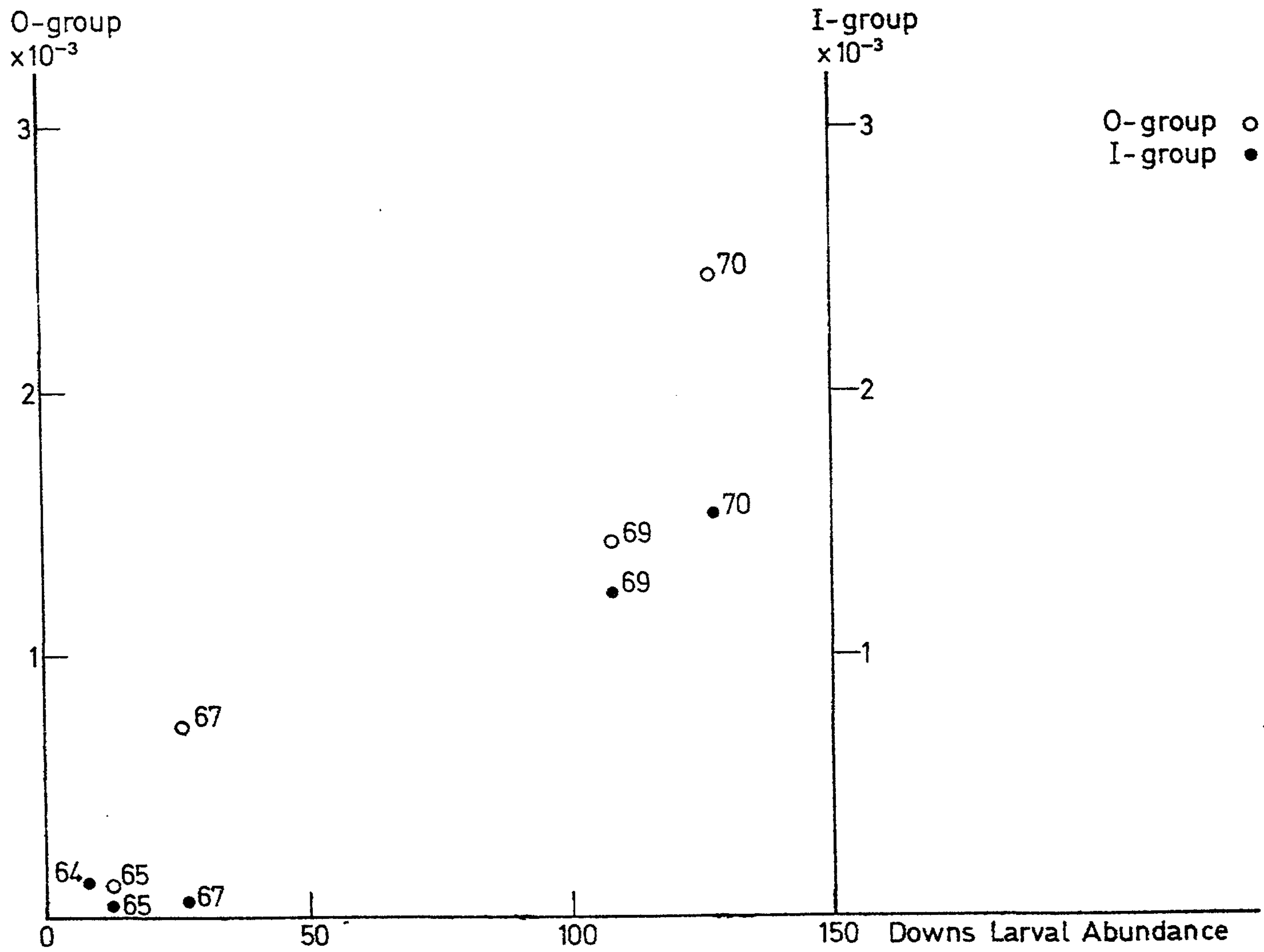

Figure 7. Abundance of O-group herring along the East Anglian coast and the abundance of low mean length I-group herring from the International Young Herring Surveys plotted on Downs larval abundance.

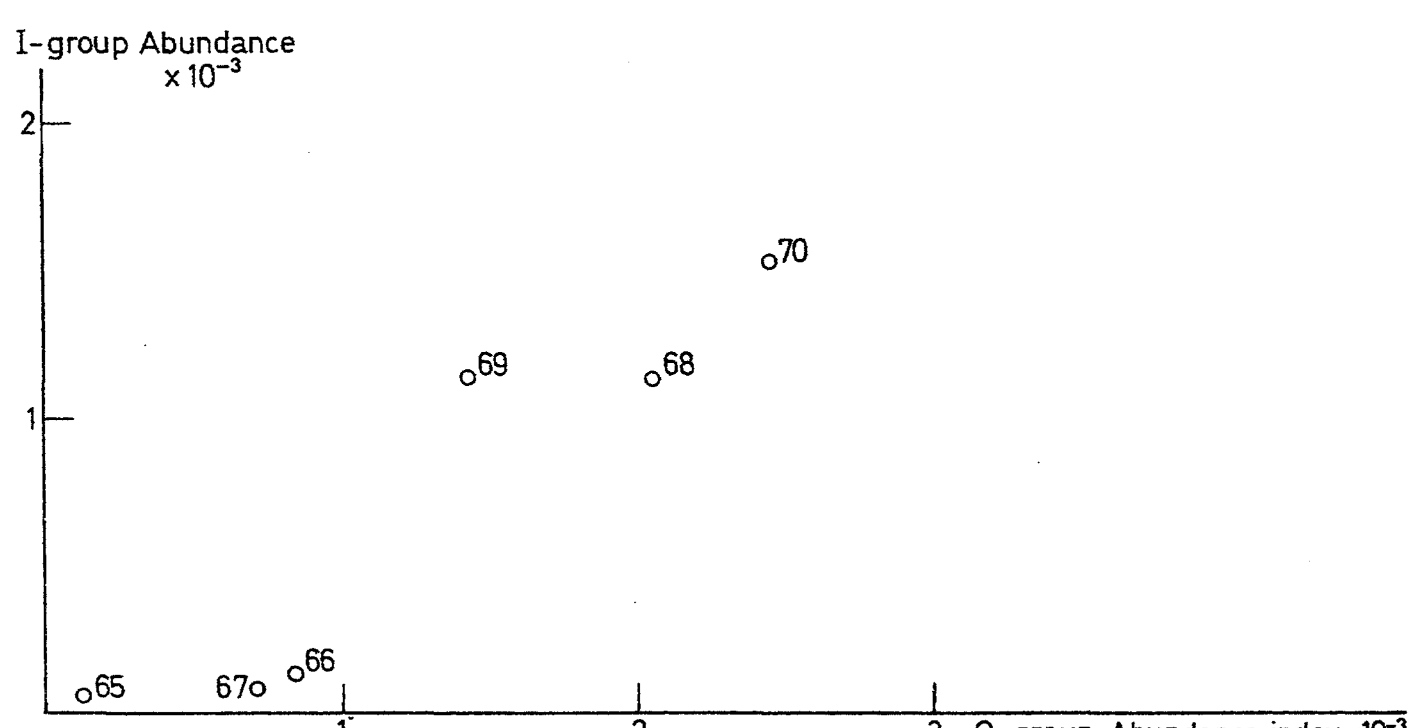

Figure 8. Abundance of low mean length I-group herring plotted against abundance of East Anglian O-group herring.

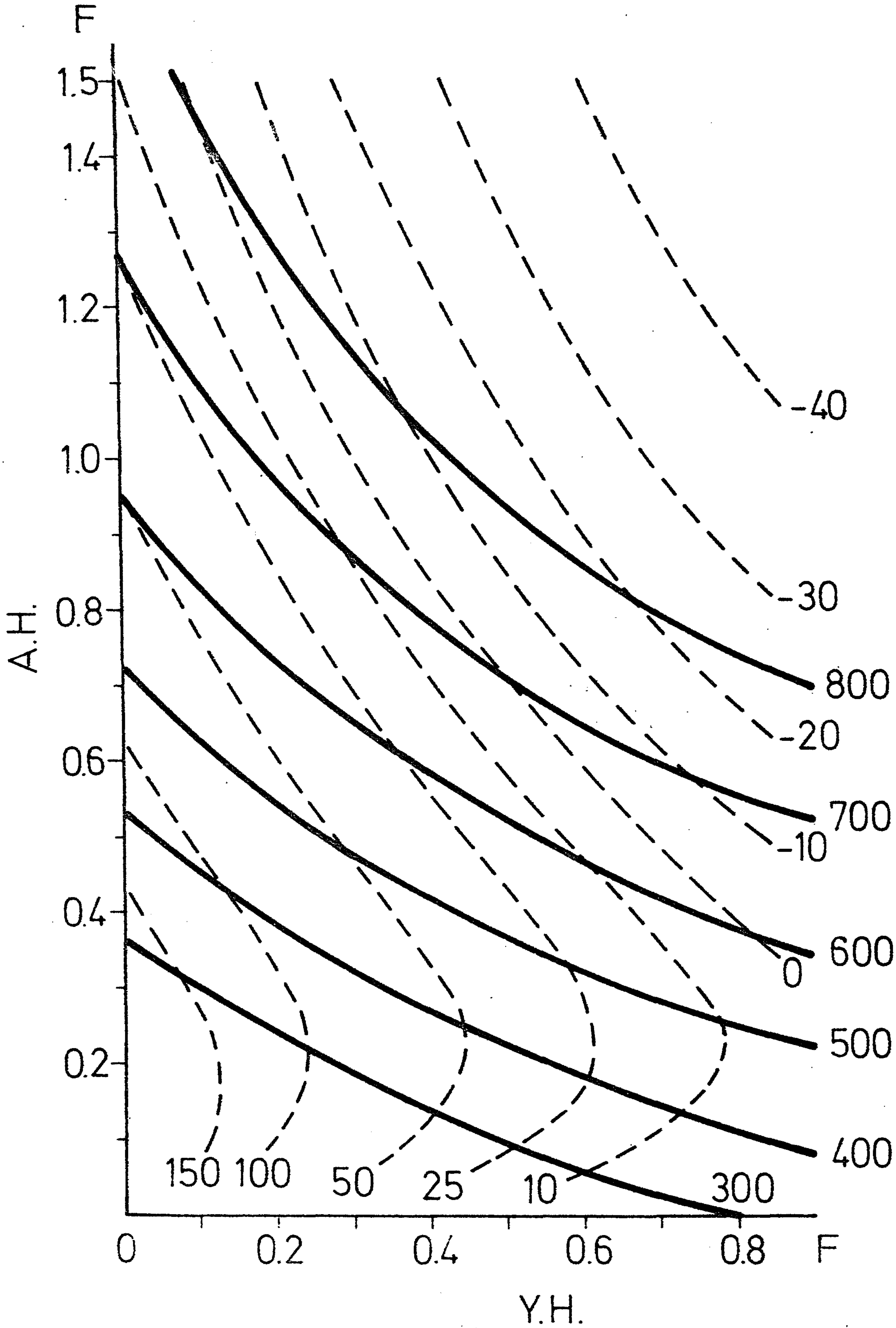

Figure 9. Total catch levels in 1972 in thousands of tons (full drawn lines) and percentage increase in total catch from 1972 - 1975 (broken lines) at various combinations of adult and juvenile fishing mortalities.

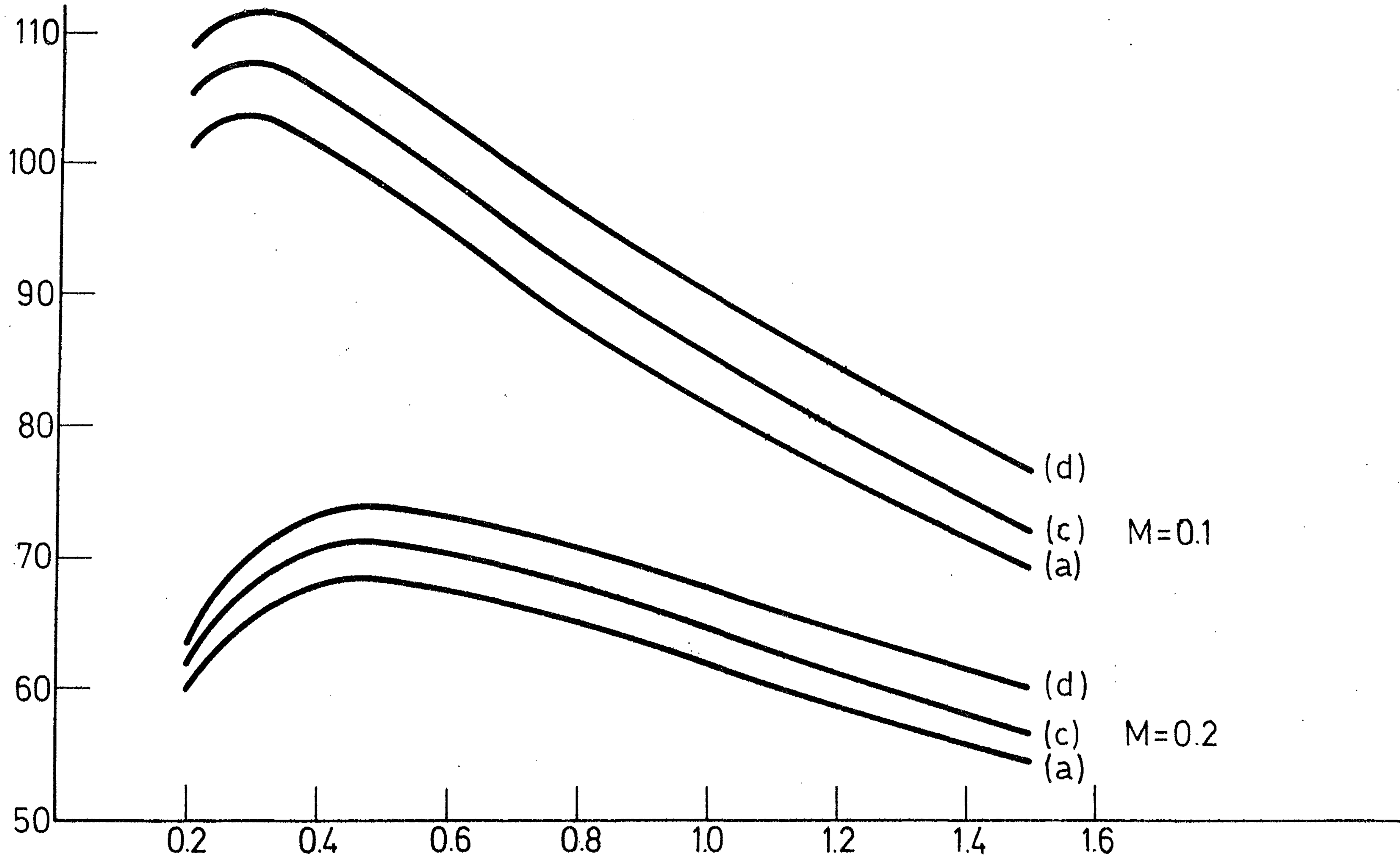

Figure 10. Yield per recruit curves for three seasonal distributions of the fishing intensity.
(a): No closed season. (c): Closed season 1 April - 15 June.
(d): Closed season 1 February - 15 June.

APPENDIX I

Notes on the Virtual Population Analysis and the Cohort Analysis

by

Hans Lassen

The Virtual Population Analysis (VPA) (Gulland, 1965) and the Cohort Analysis (CA) (Pope, 1971) estimate for an exploited year class the fishing mortality F_i and the stock N_i at age i, provided that the natural mortality M and that the fishing mortality F_n for the oldest age group is known.

A brief review of the methods are given in this appendix together with some recent evaluations of the errors inherrent in the methods.

Let the catch in numbers of a year class at age i be C_i; then according to Beverton and Holt (1957):

$$C_i = N_i \frac{F_i}{F_i + M} \left(1 - \exp(-F_i - M) \right) \qquad [1]$$

Defining

$$V_i \stackrel{D}{=} \sum_{j=i}^{\infty} C_i \qquad [2]$$

and

$$E_i \stackrel{D}{=} \frac{V_i}{N_i} \qquad [3]$$

it follows that:

$$\frac{V_i + 1}{E_i + 1\, C_i} = \frac{(F_i + M) \exp(-F_i - M)}{F_i \left(1 - \exp(-F_i - M)\right)} \qquad [4]$$

If C_j, j=i, i+1, n, E_{i+1} and M are known, F_i can be found from equation [4]. The Newton-Raphson iteration is a sufficient and effective solution- method for this problem. Continuation of the analysis requires E_i as defined by [1]. It can be found using [2] and [3]

$$V_i = N_i E_i = C_i + V_{i+1} = C_i + N_i e^{-Z_i} E_{i+1}$$

and by [1] one finally gets

$$E_i = \frac{F_i}{F_i + M} \left(1 - \exp(-F_i - M) \right) + E_{i+1} \exp(-F_i - M)$$

The stock in number N_i is then found by [3]

Pope (1971) has developed a modification (the Cohort Analysis) of the VPA based on the approximation

$$\frac{\sinh F/2}{\sinh (F+M)/2} \simeq \frac{F}{F+M}$$

which, according to Pope, is usable up to values of $M = .3$ and $F = 1.2$. He derived simple expressions for calculating the fishing mortality coefficient F_i and stock size N_i:

$$F_i = \ln (N_i/N_{i+1}) - M$$

and

$$N_i = C_i e^{M/2} + N_{i+1} e^{M}$$

The advantage of using the VPA is that F in a fishery where F_i is changing with time may be estimated for a given age group in a given year without the use of effort data.

The main disadvantage is that unknown and often considerable errors may be introduced due to uncertainties of M and F_n.

Pope (1971) has discussed errors in F_i and N_i arising from incorrect choice of F_n and from sampling errors of C_i. Agger, Boëtius and Lassen (1972) have discussed errors in F_i due to inaccurate guesses of M.

The results can be summarised as follows:

a The relative error from incorrect choice of F_n:

$$\frac{\sigma(F_i)}{F_i} = \frac{\sigma(N_i)}{N_i} \quad \frac{1 - \exp(-\hat{F}_i)}{\hat{F}_i}$$

where F_i is the estimated value from CA and $\hat{F}_i$ is the true value both of fishing mortality.

b the relative error from sampling errors in C_i:

$$\frac{\sigma(C_i)}{C_i} \simeq \frac{\sigma(F_i)}{F_i}$$

c the relative error from inaccuracy in M is found to bias the F_i's with 25% provided M is known $\pm$ 0.1 and F's $\approx$ 0.7. The effect is increasing for smaller F's.

References

Agger, P., Boëtius, I. and Lassen, H. J. du Cons. (In press).
Beverton, R.H.J. and Holt, S. "On the Dynamics of Exploited Fish Populations". Fish. Res. Ser. II, XIX. Her Majestic Stationery Office, 1957.
Gulland, J.A. "Estimation of Mortality Rates". Annex to Arctic Fisheries Working Group Report. ICES C.M.1965 No.3 Gadoid Fish.
Pope, J.G. "An Investigation of the Accuracy of the Virtual Population Analysis". ICNAF, Res. Doc., 1971.

APPENDIX II

Nominal catches of Herring in metric tons for 1971. North Sea and Skagerrak

	(Foot-notes)	Skagerrak IIIa	North Sea North East IVa.E	North Sea North West IVa.W	North Sea Central IVb	South + English Channel IVc + VIId.e	Total
Belgium	2	-	-	-	8	673	681
Denmark	1	26 985	6 219	44 500	134 649	25	212 378
Faroe Islands	3	5 636	239	25 142	254	-	31 271
France	1,4	-	...	1 514	5 918	4 450	10 882
Germany F.R.	1	-	389	-	3 421	-	3 810
Iceland	1,5	5 834	-	42 164	179	-	48 172
Netherlands	1	-	167	5 755	10 172	16 385	32 479
Norway	1	5 961	10 442	112 114	14	-	128 531
Poland	2	-	...	1 288	743	-	2 031
Sweden	1,6	19 763	-	4 954	31 926	-	56 643
U.K. (England)	1,7	-	-	-	4 113	-	4 113
U.K. (Scotland)	1,8	-	-	24 711	362	-	25 073
USSR	1	-	-	18 000	-	-	18 000
Total		64 179	17 456	279 142	191 759	21 533	574 069

Nominal catch of Herring for industrial purposes in metric tons for 1971.
North Sea and Skagerrak

	Denmark	Sweden	Norway	Germany F.R.	Total
Skagerrak IIIa	24 490	8 500	5 257		38 247
North Sea North West IVa.W	41 224		100 290		141 514
North Sea North East IVa.E	5 704		8 160		13 864
North Sea Central IVb	132 161	30 000	7	3 000	165 168
North Sea South + English Channel IVc + VIId.e.	25				25
Total	203 604	38 500	113 714	3 000	358 818

Footnotes to Apendix II

1. Submitted by Members of the Working Group.

2. From data submitted on STATLANT form 27A.

3. Faroese catches reported to be 30 800 tons. Landings in Danish ports 31 271 tons used in the table.

4. French landings at Boulogne-sur-Mer data submitted by A. Maucorps were raised by 1.25 to include the total French catches.

5. Icelandic total catches, excluding Skagerrak, were 47 938 tons. Of this, 5 600 tons were caught West of 4°W. The remaining 42 338 tons were distributed according to landings in Danish ports from Division IVa.W and IVb. The Skagerrak catch was taken as the landings in Danish ports.

6. Swedish North Sea landings of herring for consumption, 6 880 tons, distributed according to Swedish landings in Danish ports:

   IVa.W 72% = 4 954 tons
   IVb 28% = 1 926 tons

   Swedish landings for consumption from the Skagerrak: 11 263 tons

   Total Swedish landings for industrial purposes: 38 500 tons according to Ackefors , were distributed as follows:

   North Sea IVb 30 000 tons
   Skagerrak 8 500 tons

7. English catches do not include coastal stocks.

8. Scottish data do not include catches from the Moray Firth.