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Pelagic Fish (Northern) Committee

Report on the State of the Herring Stocks around Ireland and North-West of Scotland

December 1969

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Report on the State of the Herring Stocks around Ireland and North-West of Scotland

1. Introduction

Acting on a request of the Liaison Committee to assess the possible effect on other herring stocks of any regulatory measures applied to North Sea and Atlanto-Scandian herring, the Pelagic Fish (Northern) Committee of ICES decided that the Assessment Group on North Sea Herring at its meeting in December 1969 should consider the state of the herring stocks around Ireland and north-west of Scotland. It was considered that in case of a restriction of effort on the North Sea and Atlanto-Scandian herring effort could only be diverted to the areas west of the British Isles, in so far as the NEAFC-Convention area is concerned.

The Assessment Group on North Sea Herring met between 4th-13th December, 1969 at ICES headquarters in Charlottenlund, Denmark. Three days (4th-6th December) were devoted to the herring stocks to the west of the British Isles..

The membership of the Assessment Group was:-

Mr. J.J. Zijlstra, Chairman	Netherlands
Mr. K. Popp Madsen,	Denmark
Mr. A. Maucorps,	France
Dr. A. Schumacher,	Germany
Mr. J. Molloy,	Ireland
Mr. K.H. Postuma,	Netherlands
Mr. S. Haraldsvik,	Norway
Mr. H. Ackefors,	Sweden
Mr. A.C. Burd,	United Kingdom
Mr. A. Saville,	United Kingdom
Dr. S.S. Fedorov,	U.S.S.R.
Mr. A.S. Malkov,	U.S.S.R.

Mr. J. Møller Christensen, (Secretary of the Liaison Committee).

2. Areas and Stocks

For the purpose of assessing the state of the stocks around Ireland and north-west of Scotland a separation of the herring stocks was considered. On the basis of differences in such characters as age-composition, growth characteristics and meristic characters a separation into two areas was accepted. These were

a. the area south of Ireland, the Celtic Sea (Dunmore, Smalls, Labadie Bank)

and

b. the area north and north-west of Ireland and north-west of Scotland, including Donegal Bay, the Tory Island area, the Minch, Stanton Bank, the area around St. Kilda and the Butt of Lewis-Cape Wrath area. (Figure 1).

It is clearly indicated that the area south of Ireland is inhabited by a separate stock unit, characterised by relatively high vertebral and keelscale counts (see Table 1). These herring spawn in the period November-February at several places along the south Irish coast, close inshore. The nursery areas are mainly situated in Irish inshore waters. The mature herring is found outside the spawning season south and south-east of Ireland, on grounds like the Smalls, Labadie Bank and Jones Bank. The smaller fish tend to stay closer to the coast than the larger and older fish. Recruitment to the spawning stock occurs at an age of 3-4 years, as in the North Sea herring. The length-composition of the stock, too, is rather similar to that of North Sea herring.

North of Ireland and north-west of Scotland the stock situation is far less clear, largely because of the scarcity of data from areas outside the Minch. The herring population is composed of a mixture of autumn- and spring-spawners. It seems that at least since the early fifties the autumn-spawning component is dominant in the catches (ca. 80%). In the autumn spawners several characters such as lengths, l_1 and vertebral counts seem to be similar throughout the area (Table 1). There were some indications that the herring from the north coast of Ireland differ in respect of keelscale counts (Table 1) and possibly in age-composition from those in the rest of the area. In view of the inadequacy of the data for stock discrimination the Group decided to carry out an assessment for the area as a whole.

Autumn spawners spawn over a wide area from Donegal Bay to Cape Wrath, fairly close to the coast in August-October. Major spawning areas are located in Donegal Bay, near Tory Island, south of Barra Head and off the Butt of Lewis and Cape Wrath. Nursery areas are found in the Minches and even in the north-western part of the North Sea. There is a tendency for the younger adult herring to stay in the Minches more than the older adults. The age of recruitment and the length-composition again are similar to that of North Sea herring.

3. The Celtic Sea Herring Stock

3.1 The Fisheries

Over the period 1950-1968 the fisheries exploiting this stock have changed from mainly drift-net and ring-net in the earlier period to a mainly trawl fishery in the more recent period. Up to 1959 the major part of the fishery was conducted on and near the spawning areas off the Irish south coast in the period November to February. In 1959 a base-line system was introduced, followed by an area of exclusive fishing rights in 1965, which progressively inhibited fishing by non-Irish vessels on the productive spawning grounds. The introduction of a base-line system in 1959 resulted in a reduction of the numbers of visiting trawlers.

Southern Irish vessels began to convert to bottom and mid-water trawling from about 1960 and extended their areas of exploitation along the Irish coast. Since 1966 Dutch trawlers have increasingly exploited shoals offshore in the neighbourhood of the Labadie Bank and Smalls, because of poor catches in the North Sea.

3.2 The Catches

The annual catches by countries, from Divisions VII g-k which comprise the fisheries on the Celtic Sea stock, are given in Table 2. As the fishery has up to recently mainly taken place in November, December and January part of the seasonal catch is referred to one year and the rest to the next year. It is seen that the maximum catch of 25,809 metric tons reached in 1959 was followed by a big drop in total catch after the enforcement of the change in fishery limit.

With the decline in the North Sea catches in 1966 Dutch trawling effort was transferred to the Celtic Sea. This has resulted in a change in timing of the Dutch trawl fishery as is shown by the monthly catches given in Table 3.

3.3 Catch per Effort and Total Effort

Estimates of year-class abundance from catch per effort data have to be treated on a seasonal basis rather than by calendar years. Catches per effort were available from a number of sources for a number of different gears. In the case of the Irish data, changes in method of fishing and the high variability of the efficiency within each group of vessels using the same gear renders these data unusable over any major time period. German effort on the stock has varied greatly and does not provide any time series. Only the English drift-net data for the period up to 1962 and the Netherlands trawl catch data from 1958 to the present provide long-time series of catch per effort data in which gear changes are unlikely to effect the use of these data for abundance indices.

The Dutch trawler catches per effort for the period October-December had to be taken as the best index of abundance available. Although they may be biased in the later period, by changes of the national fishing limit. Using these data, estimates of total effort for recent years have been derived (Table 4).

Over the period 1957/58 to 1968/69 there has been an increase in effort during two periods. The first up to 1958/59, and after a period of lower effort, an increase again in recent years. In both cases these periods coincide with decreases in catch per effort.

3.4 Age-Composition and Recruitment

Age data are available for the Celtic Sea stock for all years since 1957. Burd and Bracken (1965) presented data up to 1962. Table 5 shows the abundance indices per age-group for the period 1961-1968. These data have been derived by taking means of the percentage age-compositions of the Dutch and Irish data. These percentage age-distributions have been raised by the estimates of numbers per 100 hours fishing by 500 h.p. Dutch trawlers given in Table 4.

The data of Table 5 have been used to calculate indices of recruitment as 3 years old herring. These new indices are shown with those of the earlier period in Table 6. During the most recent period there appears the same variability of recruitment as previously recorded. Though a direct comparison of the two abundance indices cannot be made, there would not appear to be any trend in recruitment. 4 strong year-classes have occurred namely, 1949/50, 1957/58, 1960/61 and 1962/63 while the 1955/56 has been notably poor.

3.5 Mortality Estimates

Estimates of total mortality for the period 1956-1968 are given in Table 7. The recent mortalities are now as high as during the period of maximum effort exerted earlier. For this earlier period Burd and Bracken (1965) showed that the total mortality rates were highly correlated with effort. Natural mortality was estimated to be 0.17.

Considering the recent values of total mortality and effort it is seen that the periods of higher effort have higher total mortalities. Mean total mortalities of 0.50 and 0.76 have been calculated for these two periods with an increase in effort of 1.92 times between the two periods. The expected increase in effort from a similar increase in total mortality has been calculated from the regression of Burd and Bracken as 1.79 times which would be within the confidence limits of the regression.

Molloy (1969), using a combination of Irish and Dutch catches per effort, obtained a significant correlation of total mortality in effort for the period 1961-1968. The natural mortality was estimated as 0.15. Burd (in press) has shown that this regression is not different from that obtained earlier using data from 1952-1963.

The changes in total mortality observed are related to changes in fishing effort. Compared with the North Sea a relatively small catch generates a rather high total mortality indicating a small stock.

3.6 Larval Surveys

In the years 1959 and 1960 larval surveys were carried out on and near the spawning areas of the Celtic Sea herring, along the south coast of Ireland. The larval surveys covered the period January-March in 1959 and February-March in 1960. Average numbers in the area were found to be 34×10^9 in 1959 and 13×10^9 in 1960, which gives an average of $23{,}5 \times 10^9$ in both years.

A rough estimate of the size of the spawning stock of the Celtic Sea herring can be made by comparing the larval numbers in the area with those in other areas, where spawning stock size can be assessed from catch data and mortality estimates. Comparisons were made with the Downs stock in the years 1946-1951 and the central northern North Sea stock in 1957-1960 and 1961-1964, as indicated below:-

Area	Period	Catch/t	Z	F	Stock-size * (tons)	Larval numbers
Downs	1946-51	210.000	0.50	0.30	700.000	420×10^9
Central/northern North Sea	1957-60	700.000	0.59	0.39	2.100.000	1974×10^9
"	1961-64	710.000	0.63	0.43	2.000.000	2877×10^9

In all cases an M = 0.2 was assumed. Fecundity in Celtic Sea herring and Downs herring is rather similar, but the central and northern North Sea stocks have a fecundity almost twice as high as the Celtic Sea herring. On the othern hand, larval numbers in the Celtic Sea herring and Downs herring include all sizes of larvae, whereas the central-northern North Sea estimates only refer to smaller larvae. Assuming, that in the comparison of larval estimates of the Celtic Sea and the central-northern North Sea the higher fecundity of the latter is more or less counterbalanced by the fact, that the estimates only include small larval,

the stock size of the Celtic Sea herring would be directly proportional to the larval numbers. Estimates of stock size for the Celtic Sea, thus obtained, range from approximately 17.000-26.000 tons as compared with the central-northern North Sea estimates and approximately 40.000 tons with the Downs herring. Thus, in the years 1959-1960, when the Celtic Sea stock was rather low, the spawning stock size was roughly indicated to be between 17.000-40.000 tons of herring, judging from larval abundances.

3.7 Discussion

Since 1952 the Celtic Sea spawning stock has twice experienced high levels of fishing effort. In both periods total mortality has rapidly increased. Decreasing catches per effort have been noted. The recent data may be considered in relation to the yield per recruit curve calculated by Burd and Bracken (1965). Little increase in sustained yield per recruit could be expected at fishing mortalities above 0.5 ($Z = 0.67$). During the period 1956-1960 the mean annual catch, at about this level of exploitation, was 18.400 tons. It was concluded that the average stock size would be of the order of 30.000 tons. This estimate is independantly supported by the abundances of herring larvae in this period. However, the stock then comprised the very poor 1955/56 year-class and the moderately poor 1952/53 year-class. The recent period of higher recruitment of high mortality has resulted in annual catches of 25.400 tons, which would suggest a stock of about 60.000 tons.

4. North-West of Ireland - North-West of Scotland

4.1 Fisheries and Total Catches

In Areas F and F_3 the total catch has shown short-term fluctuations, between 14-31.000 tons in the period 1950-1965. Since 1965 there has been a marked increase in the total catch, which in 1968 reached 55.000 tons. The total annual catch and the contributions by different countries are shown in Table 8. Throughout most of the period the Scottish catch has dominated in this area. Until the early 1960's this was largely a ring-net fishery. Since the mid-1960's there has been an increasing share of the Scottish catch taken by pair-trawl and purse-seine during the winter season, when the fishery is most productive. The catches of England, Germany, France and Holland were taken by bottom and pelagic trawl. The Irish catches in the 1950's were taken by ring-net and bottom trawl; in more recent years their catch has been caught by pair-trawl and bottom trawl.

In Area F_1 (Table 9) the total catch has shown short-term fluctuations within a range of 17-40 thousand tons. The catch in this area has been overwhelmingly taken by the Scottish fisheries in the north Minch. These in the 1950's and early 1960's were predominantly drift-net and ring-net fisheries. In recent years the importance of the drift-net has decreased markedly, and a rapid increase in the Scottish catch taken by pair-trawl and purse-seining occurred. Only since 1960 has there been a fishery in this area by other nationalities in offshore waters, but within the continental shelf. These are predominantly trawl fisheries pursued by France, Germany and Holland. The only noteworthy feature of the catches in the offshore fishery is the high German catch in 1964 and a continuing fairly high level of German catch in subsequent years.

4.2 Catch per Unit Effort and Total Effort

In Tables 10 and 11 the catch per unit effort indices have been calculated for the different fisheries in Areas F and F_1, and from these a total effort has been calculated by applying them to the total catch in each area.

In Area F the catch per effort indices for the German trawl fishery shows a sharply increasing trend over the period for which data are available, which is probably a function of the increase in size and efficiency of the fleet. In both indices derived from the Scottish fisheries the values of catch per unit effort have been high and have shown only minor fluctuations over the last five years.

The total effort derived from the two Scottish indices show a high level in the years 1950-52, a lower level from 1956-65 and an increase in effort again thereafter to about the same level as in the early 1950's.

In Area F_1 the longest series of catch per unit effort values are provided by the Scottish fisheries. In both these series there is a notable increase in catch per unit effort in recent years for the drift-net series starting in 1964 and for the ring-net series in 1962. For the catch per effort indices from the German trawl fishery the most notable feature is the high values in 1967 and 1968. This is perhaps partly accounted for by .....

increasing efficiency of the German effort in these years, but the impact of the very strong 1963 year-class must also have played a considerable part. The total effort in Area F_1 calculated from the two Scottish indices show high values in the years 1950-54 and thereafter rather lower values which fluctuate without trend; this is also true of the German values, all of which apply to the period after 1954.

4.3 Age-Composition and Recruitment

The percentage age-composition in the off-shore trawl fisheries is given in Table 12 a and in the Scottish drift- and ring-net fisheries in the Minch in Tables 12 b and 12 c. The age-composition of the inshore fisheries as catch per landing are given in Tables 13 a and 13 b for ring-net and drift-net. In the Minch fisheries, even during the winter season, the age-compositions are largely dominated by fish less than six years old. As shown in Table 12 a these older fish play a much larger part in the catches of the off-shore trawl fisheries.

There is in all three estimates of age-compositions evidence of strong year-classes being common to the fisheries considered. Thus in the off-shore fisheries the strong year-classes were those born in 1954, 1957, 1959 and 1963. In the Scottish drift- and ring-net fisheries in the Minch the estimated year-class strengths were in fairly close agreement. In these fisheries the year-classes 1951, 1954, 1956, 1957, 1959, 1960, 1961, 1963 were all strong to very strong. The 1963 year-class was a remarkably strong one and has dominated the catches in this area in all years since 1966 when it first recruited. It would appear that in the period under consideration strong year-classes occurred at least in the inshore fisheries at a frequency of about one every two years, without evidence of any trend in recruitment. This is much more frequent that in any of the North Sea fisheries.

4.4 Mortality Estimates

Estimates of total mortality (Z) over a longer period are only obtainable from the Scottish drift-net and ring-net fisheries in the Minch. These data are presented in Table 14. In the case of the drift-net fishery, Z-values are also shown for spring- and autumn-spawners separately. In all cases the year to year fluctuation is considerable but without any definite trend. There is a distinct difference in Z between spring- and autumn-spawners. It seems unlikely that this is due to different fishing or natural mortalities and it is most probably caused by differential emigration of older age-groups of the two components or by a bias in the stock discrimination.

Additional estimates for the last 2-3 years are presented by the Dutch trawl and Irish pair-trawl fisheries to the north-west of Ireland (Table 15).

A comparison is shown below:-

Fishery	Period	Z
Scottish drift-net	1966-67/1968-69	0.57
Dutch trawl	1966/67/1968	0.51
Irish pair-trawl	1967-68/1968-69	0.37
Scottish ring-net	1966-67/1968-69	0.13

Of the four estimates the most variable and the most susceptible to changes in availability is undoubtedly that obtained from the ring-net fishery. Moreover the mortality values from the Minch fisheries are probably over-estimates because of differential emigration of older fish from this area. Placing more reliance on the trawl and drift-net estimates the total mortality coefficient can be set at 0.4-0.5 with 0.2-0.3 being a reasonable estimate of the fishing mortality coefficient.

The mortality rates Table 14 have been compared with the total effort values Tables 10 and 11. There was no apparent relationship between these two parameters.

4.5 Larvae

The only reasonably adequate survey of herring larval distribution in the area is that carried out by England in October 1965. This survey showed three major centres of abundance of small larvae:-

(i) in Donegal Bay and off the NW Irish coast

(ii) between Barra Head and Tiree and

(iii) to the west and north of Lewis and Harris.

The total abundance of larvae in the area at the time of this survey was estimated as 1759×10^9. Taking into account fecundity and size differences between the spawning stocks in the two areas this would suggest that the size of the autumn-spawning stock af mature fish in Area F is of about the size as the Downs stock in the years 1946-1951 (Wood, 1968). According to section 3.6 this would mean roughly 700.000 tons of herring. Comparing the larval abundances in Area F with those in the central and northern North Sea in the two periods 1957-1960 and 1961-1964 (see section 3.6), a stock size of respectively 960.000 tons and 620.000 tons is indicated. These rough estimates were obtained by assuming fecundity to be approximately the same in the two areas and by taking into account that the Area F estimate includes all larvae, whereas the North Sea estimates only consider smaller larvae. For the purpose of this comparison it has been assumed that the "total larvae" estimate is twice the "smaller larvae" estimate.

The mean annual total catch of the fisheries on the west coast in 1964-1968 was about 67.000 tons and the estimated F-value was about 0.25. Thus the total mature stock of autumn spawners in this area would be about 300.000 tons. There is, therefore, a discrepancy between the stock sizes computed from larvae, which ranged from roughly 600.000-1.000.000 tons and from catch-fishing mortality. However, as the larval estimate is based on only one survey, perhaps not too much reliance should be placed on the estimates, derived by this method.

4.6 Discussion

From 1950 until 1965 the total catch from the area to the north and west of Ireland fluctuated without trend in the range 40-65.000 tons. In the three subsequent years for which catch statistics are available, the total catch from this area has been between 80-90.000 tons. This increase in the total catch has been largely taken in Area F, where it has been evident in the catches of all countries fishing the area. Much of this increased catch in these three years is probably due to the recruitment of the strong 1963 year-class; from the data available the increased catch would seem not to have affected the total mortality rates although from the effort measurements given in Tables 10 and 11 it would appear that there was some increase in effort in Area F in these years.

However, the total mortality rates derived from catch per unit of effort data given in Tables 14 and 15 for the stock in the area are in general low at average levels of 0.4-0.5. On the assumption that natural mortality on this stock is 0.2 - as is generally accepted for herring stocks in other areas - the exploitation rate in this area would seem to be rather low and an increase in yield from the stock would appear to be attainable. However, in the years under consideration this stock would have seemed to draw benefit from a high frequency of strong year-classes. If recruitment returns to a more normal level in future this could have an appreciable effect in lowering the sustainable yield. The size of the mature spawning stock as calculated from the only larval survey available is about 700.000 tons. This is much higher than the figure of 335.000 tons derived from the catch and mortality-rate data. Too much stress should not be laid on the high stock-size figure derived from the larval abundance data in view of the inadequacies of the data on which it is based.

5. Conclusion

The evidence available, which was quite considerable for the southern Irish area but less comprehensive for parts of the northern area, indicates a quite different situation in the two areas considered.

The area south of Ireland is inhabited by a small stock of winter-spawning herring, the size of which is estimated roughly as 30-60.000 tons of adult fish. The fishing rate increased on two occasions in recent years, first in the late fifties and then again in the years after 1965. Both increases are

probably related to failures of North Sea fisheries. The present mortality rate (Z = 0.7) must be considered as fairly high and a further increase in effort is unlikely to produce a sustained increase in yield. There is no trend in recruitment at present, but in case of a further increase of effort a collapse in recruitment and therefore in the fisheries is a possibility.

In the area north of Ireland and north-west of Scotland, the herring stock or stocks are far larger than in the southern area. At a rough estimate the adult stock could well be around 400.000 tons. The fishing effort, although probably increasing somewhat during the last few years as a result of poor fishing conditions in the North Sea, is still rather low as shown by the low total mortality (Z = 0.45). Recruitment fluctuates without any trend. It is probable that the stock could support some increase in fishing.

6. Recommendations

6.1 The Working Group, appreciating the use of larval abundance estimates for future stock assessments in the Celtic Sea and in the area north-west of Ireland and Scotland, recommends that regular sampling for herring larvae is considered for these areas.

6.2 To keep the development of recruitment to the Celtic Sea herring stock under observation, the Working Group recommends that attempts are made to develop a scheme for young herring surveys in the area.

6.3 The Working Group, with a view to the relative scarcity of sampling data, in particular from the offshore fisheries in the area north-west of Ireland and Scotland, recommends a more regular sampling in those fisheries.

6.4 With a view to future assessments of the herring situation around Ireland and north-west of Scotland the Working Group recommends, that an adequate collection of catch-effort statistics is maintained and where necessary, improved.

References

Burd, A.C. and Bracken, J.	1965	"Studies on the Dunmore Herring Stock. I.A. Population Assessment". J.Cons.perm.int. Explor.Mer, Vol. XXIX, No.3.
Molloy, J.P.	1969	"A Review of the Dunmore East Herring Fishery (1962-1968)". Irish Fish.Invest.Ser.B.(Mar), No.6.
Molloy, J.P.	1969	"Mortalities in the Dunmore East Herring Stock 1967/68 - 1968/69". ICES,C.M.1969/H:14.
Wood, R.J.	1968	"Autumn Spawning Grounds of Herring to the West of Scotland". ICES, Symp. on the Biology of Early Stages and Recruitment Mechanisms of Herring, No. 8.

Table 1. Comparison of mean length of three years old fish, l_1, VS and K_2 of autumn and winter spawning herring, year-classes 1960-1965 in areas south of Ireland (F_2), Donegal (north-west of Ireland), north of Ireland (F) and north-west of Scotland (F_1) (see Figure 1).

Character	Mean length of 3 years old fish					l_1					V.S.					K_2				
Area	F_2	"Donegal"	F + F_1	F	F_1	F_2	"Donegal"	F + F_1	F	F_1	F_2	"Donegal"	F + F_1	F	F_1	F_2	"Donegal"	F + F_1	F	F_1
year-class	cm	cm	cm	cm	cm	cm	cm	cm	cm	cm										
1960	24.7	26.3	25.6	25.7	25.6	?		13.7	13.0	14.2	56.97	56.67	56.48	56.48	56.48			14.17	14.16	14.19
1961	25.7		25.7	25.6	25.8	13.7	13.3	13.4	12.7	14.0	56.93	56.46	56.55	56.47	56.60	14.80	14.69	14.22	14.19	14.24
1962	26.4		25.7	25.5	25.8	13.4	13.2	12.7	12.3	13.1	56.82	56.47	56.56	56.53	56.56	14.75	14.44	14.23	14.23	14.23
1963	24.7		25.5	25.2	25.7	13.2	14.6	14.3	14.2	14.5	56.70	56.50	56.57	56.58	56.57	14.64	14.49	14.19	14.18	14.19
1964	26.4	25.6	25.6	25.8	25.4	14.6	14.4	13.8	14.2	13.2	56.91	56.78	56.67	56.60	56.70	14.78	14.75	14.30	14.24	14.38
1965	26.8	25.6	25.6	25.7	25.5	15.8	14.4	13.4	13.2	13.4	56.86	56.44	56.62	56.59	56.63	14.78	14.75	14.31	14.40	14.22

Table 2. Herring catches in ICES Division VII g-k, south coast Ireland according to Bulletin Statistique (metric tons).

Year	Country							Total
	Belgium	France	Germany	Ireland	Netherlands	Poland	England	
1951	534	1 001		600			888	3 023
1952	1 792	762		845			681	4 080
1953	502	1 697		693			883	3 775
1954	2 251	14		1 386			1 287	4 938
1955	4 230	21		1 619			1 789	7 659
1956	2 539	226		3 348			2 289	8 402
1957	1 256	397	949	6 116			881	9 599
1958	708	967	11 743	7 869		77	1 922	23 286
1959	98	1 717	9 248	10 132	3 720	124	770	25 809
1960		1 083	60	910	1 463		73	3 589
1961	128	1 575	757	494	3 449	96	2	6 501
1962	249	1 808	677	209	4 112	56		7 111
1963	7	2 528	46	761	10 018		340	13 700
1964		2 797		267	4 502		744	8 310
1965		1 579	631	207	7 039		1 054	10 510
1966		9 342[x)]	1 272	463	16 179	112	197	27 565
1967		1 599	709	11 133	12 964	300	398	27 103
1968		3 317	1 595	9 480	15 523	130	598	30 643

x) VIIa, f and VIIb, c included with VIIg-k according to Bulletin Statistique.

Table 3. Dutch catches in the Celtic Sea according to Dutch national statistics (in metric tons).

Seasons	Months											
	VII	VIII	IX	X	XI	XII	I	II	III	IV	V	VI
1960/61		135	130	200	26	4 660	510	-	-	4		
1961/62	-	67	224	649	633	861	846	-	-	-	-	-
1962/63	-	125	114	1 675	413	258	3 539	287	-	9	-	-
1963/64	-	-	-	1 971	833	1 745	1 680	-	-	-	-	-
1964/65	-	-	-	741	1 108	1 704	274	110	-	-	-	-
1965/66	-	-	-	2 375	1 665	1 760	2 965	1 927	4	-	-	-
1966/67	72	320	1 810	2 439	3 463	1 216	326	3	-	-	-	-
1967/68	2 445	711	1 400	2 745	1 620	1 284	-	-	-	-	-	70
1968/69	3 733	1 521	1 953	2 085	2 039	790	-	-	-	-	-	1 029
1969/70	1 651	451	1 938									

Table 4. The Celtic Sea Fisheries. Total seasonal catch, catch per effort and total effort.

Year	Total seasonal catch (1)		Catch/Effort			Total Effort	
	'000 tons	Millions of fish	English (2) tons/drifter landings	Dutch Oct.-Dec.		English (2) drifterslandings	Dutch 100 hours fishing
				Thousands of fish/ 100 hours	Tons/ 100 hours		
1957/58	25.8		15.0			1722.9	
1958/59	23.5	122	7.8			3006.9	
1959/60	14.1	81	7.5			1880.1	
1960/61	14.4	96	10.7	113	17.0	1342.0	851
1961/62	10.9	66	10.5	223	36.8	1041.8	296
1962/63	10.7	58	11.3	124	22.9	944.2	468
1963/64	13.6	76		185	33.1		410
1964/65	9.7	53		142	26.0		373
1965/66	13.6	71		177	34.0		401
1966/67	20.8	100		123	25.6		812
1967/68	24.7	124		87	17.3		1431
1968/69	30.6	155		62	12.2		2486

(1) Molloy (1968 and 1969)

(2) Burd and Bracken (1965)

Table 5. Celtic Sea Fisheries. Abundance indices (numbers) per age-group per 100 hours trawling.

Age (Years)	Seasons							
	61/62	62/63	63/64	64/65	65/66	66/67	67/68	68/69
2	7 128	744	370	10 651	354	4 435	10 655	2 805
3	51 454	22 942	97 036	22 722	100 875	21 557	23 043	22 317
4	100 458	23 066	26 666	45 302	17 874	47 795	11 262	15 958
5	16 929	49 852	10 370	11 929	21 945	9 731	23 043	4 675
6	6 237	7 565	33 703	12 497	5 663	13 550	6 844	9 725
7	14 924	2 728	6 481	27 550	6 017	5 297	4 678	2 119
8	8 019	8 557	1 296	3 266	15 928	3 572	1 473	2 057
9	4 455	3 596	4 815	3 976	2 124	12 195	1 733	623
10	8 019	2 480	1 296	2 556	885	2 340	2 339	1 434
>10	5 791	2 852	3 704	1 562	5 840	2 833	1 040	873
Total	223 414	124 382	185 727	142 011	177 505	123 305	86 110	62 586

Table 6. Estimates of recruitment as 3 years old herring.

Year-class	(1) tons/landing	(2) '000/100 hours
1949/50	6.23	
1952/53	2.51	
1954/55	4.38	
1955/56	0.77	
1956/57	3.91	17
1957/58	7.77	130
1958/59	3.01	48
1959/60		60
1960/61		82
1961/62		28
1962/63		160
1963/64		21

(1) Burd and Bracken (1965)

(2) Calculated from catch curve method.

Table 7. Total mortality rates of Celtic Sea herring.

Year	(1)	(2)
1956/57	0.67	
1957/58	0.67	
1958/59	1.04	
1959/60	0.71	
1960/61	0.56	
1961/62	0.47	0.77
1962/63	0.44	0.34
1963/64		0.54
1964/65		0.54
1965/66		0.60
1966/67		0.82
1967/68		0.70

(1) Burd and Bracken 1965.

(2) Calculated as $\frac{\sum n \ (>2)}{\sum n+1 \ (>3)}$

Table 8. Total catches of herring (in metric tons) from Areas F and F3. (According to National statistics).

Year	Scotland	Ireland	England	W. Germany	France	Netherlands	NW Ireland	Total
1950	11 781	1 354	17 506	-	-	-	-	30 641
1951	13 340	1 368	16 356	-	-	-	-	31 064
1952	10 746	939	14 401	-	-	-	-	26 086
1953	13 614	934	7 076	-	-	-	-	21 624
1954	16 309	753	3 624	-	-	-	-	20 686
1955	17 341	2 623	5 008	-	-	-	-	24 972
1956	15 990	3 866	5 293	-	-	-	10	25 159
1957	9 696	3 546	988	-	-	-	1	14 231
1958	12 902	4 052	1 944	-	-	-	6	18 904
1959	16 651	4 978	158	2 324	-	-	-	24 111
1960	18 096	3 711	245	4 072	-	-	-	26 124
1961	15 821	5 566	476	419	415	-	-	22 697
1962	22 079	3 950	508	3 295	337	253	-	30 422
1963	17 762	3 583	563	625	6	-	3	22 542
1964	22 011	4 480	264	854	-	-	1	27 610
1965	23 177	6 338	278	82	1 186	78	-	31 139
1966	29 419	7 559	7	2 456	426	494	-	40 361
1967	30 075	12 098	-	7 656	190	3 702	-	53 721
1968	30 916	13 185	34	7 403	825	2 432	-	54 795

Table 9. Total catches (in metric tons) in Area F_1 (north of St. Kilda). According to national statistics.

Year	France	Germany	Netherlands	Scotland	Total
1950	-	-	-	25 423	25 423
1951	-	-	-	23 007	23 007
1952	-	-	-	29 885	29 885
1953	-	-	-	36 455	36 455
1954	-	-	-	39 668	39 668
1955	-	-	-	18 149	18 149
1956	-	-	-	18 243	18 243
1957	-	-	-	24 305	24 305
1958	-	-	-	33 017	33 017
1959	-	-	-	33 847	33 847
1960	77	850	-	23 854	24 781
1961	415	1 276	-	15 354	17 036
1962	1 049	7 865	-	21 954	30 868
1963	1 561	3 827	-	19 478	24 866
1964	810	19 165	54	20 242	40 271
1965	443	4 242	231	15 787	20 703
1966	885	9 704	-	29 585	40 174
1967	403	7 608	28	29 102	37 141
1968	782	7 053	337	24 370	32 542
1969[1)]	1 340	No data	6	21 842	Incomplete

1) January-October.

Table 10. Catch per unit of effort and equivalent effort estimates in Area F.

Year	German Trawler		Scottish Ring-net		Scottish Drift-net		Dutch Bottom Trawl		Irish Pair Trawler	
	c/ef.	effort	c/ef.	effort	c/ef.	effort	c/ef.	effort	c/ef.	effort
1950	-	-	7.1	4 316	5.1	6 008	-	-	-	-
1951	-	-	7.5	4 142	5.4	5.752	-	-	-	-
1952	-	-	6.3	4 141	6.4	4 076	-	-	-	-
1953	-	-	10.7	2 021	6.5	3 327	-	-	-	-
1954	-	-	11.8	1 753	7.2	2 873	-	-	-	-
1955	-	-	11.4	2 191	7.9	3 161	-	-	-	-
1956	-	-	8.6	2 925	7.5	3 354	-	-	-	-
1957	-	-	7.2	1 976	7.4	1 923	-	-	-	-
1958	-	-	6.9	2 740	10.4	1 817	-	-	-	-
1959	8.1	2 977	10.5	2 296	12.4	1 944	-	-	-	-
1960	14.1	1 711	9.1	2 871	6.8	3 842	-	-	-	-
1961	6.9	3 289	7.5	3 026	7.0	3 242	-	-	-	-
1962	14.9	2 042	9.5	3 104	6.3	4 829	-	-	-	-
1963	17.9	1 259	7.4	3 046	7.7	2 927	-	-	-	-
1964	18.6	1 484	11.2	2 465	9.1	3 034	-	-	-	-
1965	11.7	2 662	11.4	2 731	9.4	3 313	13.4	2 324	-	-
1966	17.4	2 320	11.3	3 572	10.5	3 844	42.2	956	8.0	4 983
1967	26.8	2 005	11.3	4 754	10.6	5 068	24.1	2 229	10.4	5 165
1968	24.4	2 246	11.5	4 765	-	-	15.0	3 649	8.2	6 675

Table 11. Catch per unit effort (in metric tons) and equivalent effort (in fishing days) in Area F_1 (N. of St. Kilda).

Year \ F_1	C/F			Effort		
	Scottish[x]		German Trawl	Scottish[x]		German Trawl
	Drift	Ring		Drift	Ring	
1950	3.51	6.58		7243	3864	
1951	3.29	7.61		6993	3023	
1952	3.49	4.55		8563	6568	
1953	6.40	6.22		5696	5861	
1954	4.81	5.59		8247	7096	
1955	4.63	7.14		3920	2542	
1956	4.95	7.07		3722	2606	
1957	5.23	5.28		4647	4603	
1958	5.78	4.48		5712	7370	
1959	4.73	4.49		7156	7538	
1960	4.39	5.58	10.9	5645	4441	2273
1961	3.22	3.47	14.2	5291	4910	1200
1962	4.23	11.23	11.2	7297	2749	2756
1963	4.65	8.61	13.4	5348	2888	1856
1964	5.99	5.48	18.3	6723	7349	2201
1965	5.99	15.77	11.5	3456	1313	1800
1966	6.68	9.28	11.2	6014	4329	3587
1967	6.20	9.24	22.7	5990	4020	1636
1968[xx]	6.36	14.60	27.2	5117	2229	1196

x) Only winter fishery, November-February.

xx) Drift- and ring-net fishery, only November-December 1968.

Table 12a. Percentage age compositions. Areas F + F_1.
Derived from German and Dutch trawl catches.

Years	Area \ Age	2	3	4	5	6	7	8	9	>9
1958	F_1+F		2.2	26.2	15.3	20.3	14.4	7.1	4.1	10.4
1959	F_1+F	2.4	13.1	10.3	25.8	21.4	9.1	11.5	1.6	4.8
1961	F_1		9.7	43.9	24.5	5.0	10.9	2.6	1.7	1.7
1962	F_1	1.2	29.3	10.9	21.3	14.1	4.5	12.6	2.3	3.8
1963	F_1		9.6	25.7	8.7	27.1	12.7	7.5	5.7	3.0
1964	F_1+F	0.1	10.6	16.9	19.2	11.6	12.8	14.5	7.5	6.8
1965	F_1	4.1	10.6	23.0	15.5	6.4	4.1	16.2	9.5	10.6
1966	F_1+F		67.5	5.0	10.7	4.5	3.6	1.4	0.9	6.4
1967	F_1+F		5.1	68.2	6.9	9.8	3.6	0.9	1.7	3.8
1968	F_1+F	0.1	4.6	4.3	67.1	7.0	8.1	3.6	1.1	4.1

Table 12b. Percentage age compositions. The Minch.
November-February. Scottish drift-net fishery.

Years \ Age	2	3	4	5	6	7	8	9	>9
1958-59	2.29	11.97	58.42	9.25	6.37	6.60	2.59	1.56	0.71
1959-60	9.00	33.68	8.48	33.33	5.05	4.30	3.77	1.68	0.70
1960-61	1.11	29.98	49.55	6.76	7.52	1.92	1.51	1.26	0.30
1961-62	0.92	6.50	29.20	28.67	17.13	9.94	4.36	1.53	1.76
1962-63	18.61	40.75	6.42	17.11	10.80	2.14	2.89	0.32	0.96
1963-64	3.98	53.46	11.11	3.77	13.00	10.06	1.26	2.73	0.63
1964-65	1.03	36.16	34.81	6.30	2.07	7.54	8.26	1.34	2.48
1965-66	31.82	11.10	21.62	16.96	5.80	2.04	5.29	3.25	2.10
1966-67	0.77	63.47	7.74	11.15	7.12	1.86	1.08	3.56	3.25
1967-68	7.63	15.53	53.95	7.89	6.84	3.95	1.32	1.05	1.84
1968-69	16.56	26.99	14.11	29.45	4.91	3.68	1.84	0.61	1.84

Table 12c. Percentage age compositions. The Minch.
November-February. Scottish ring-net fishery.

Years \ Age	2	3	4	5	6	7	8	9	>9
1958-59	3.52	17.00	35.14	15.18	4.70	12.38	6.35	3.17	2.10
1959-60	5.81	25.69	12.35	26.33	13.70	4.78	6.17	3.08	2.05
1960-61	2.35	44.14	21.70	11.06	9.30	3.67	4.38	1.75	0.87
1961-62	6.04	15.18	29.23	17.94	12.54	9.15	4.10	4.29	1.55
1962-63	25.38	23.19	3.71	19.01	11.17	6.23	7.70	1.81	1.81
1963-64	22.46	28.80	8.99	3.68	13.41	10.28	4.15	5.79	2.45
1964-65	3.20	27.56	24.86	9.65	2.98	11.52	8.10	3.86	8.27
1965-66	40.71	3.14	16.47	12.24	6.90	1.88	6.82	5.65	6.20
1966-67	4.81	60.80	2.78	10.71	7.87	3.42	1.04	3.42	5.15
1967-68	17.77	10.86	48.95	3.72	9.08	4.50	1.78	0.78	2.56
1968-69	5.96	22.46	7.37	45.26	3.16	5.61	3.51	1.40	5.26

Table 13a. Age compositions. Crans/landing. Autumn spawners. The Minch. November-February. Scottish drift-net fisheries.

Years / Season	2	3	4	5	6	7	8	9	> 9
1954/55	0.333	6.924	6.729	4.048	0.732	0.555	0.240	0.119	0.433
1955/56	0.221	3.132	7.131	4.491	3.054	0.573	0.224	0.204	0.332
1956/57	0.119	5.456	4.240	4.268	1.963	1.722	0.619	0.210	0.332
1957/58	0.000	14.358	4.160	2.286	2.037	1.331	0.734	0.101	0.111
1958/59	0.114	2.545	19.331	2.659	2.205	2.152	0.904	0.545	0.248
1959/60	0.917	7.600	2.167	8.920	1.304	1.164	1.021	0.438	0.189
1960/61	0.202	5.658	11.407	1.800	1.902	0.449	0.405	0.338	0.080
1961/62	0.606	1.124	6.008	6.531	4.036	2.356	1.019	0.366	0.421
1962/63	1.858	8.509	1.450	3.639	2.408	0.496	0.703	0.078	0.194
1963/64	0.581	11.296	2.536	0.775	3.358	2.651	0.345	0.748	0.173
1964/65	0.351	10.735	9.698	2.077	0.574	2.362	2.866	0.429	0.825
1965/66	9.496	3.940	7.546	5.534	2.011	0.744	1.883	1.185	0.766
1966/67	0.232	13.812	2.797	3.673	2.390	0.700	0.407	1.340	1.224
1967/68	1.477	2.957	13.301	2.492	2.401	1.294	0.463	0.369	0.646
1968/69	4.409	6.742	1.207	8.065	1.681	1.260	0.630	0.209	0.630

1 cran = 178 kg

Table 13b. Age composition. Crans/landing. Autumn spawners.
The Minch. November-February. Scottish ring-net fisheries.

Years / Season	2	3	4	5	6	7	8	9	> 9
1954/55	2.342	20.183	12.628	5.646	493	2.368	937	493	493
1955/56	330	6.173	18.884	12.904	7.417	1.204	328	219	547
1956/57	0	11.978	3.647	6.679	4.578	2.551	89	449	1.090
1957/58	0	8.481	6.876	2.740	5.264	4.514	3.002	503	1.269
1958/59	423	4.937	12.211	4.458	1.577	4.168	2.294	1.145	725
1959/60	1.806	9.779	5.080	13.559	4.165	2.527	2.717	1.447	1.084
1960/61	485	15.281	9.035	4.839	3.910	1.543	1.938	0.789	392
1961/62	1.478	4.886	8.075	5.109	3.608	3.101	1.096	1.282	504
1962/63	12.669	15.020	1.480	10.862	7.119	3.958	5.163	1.245	1.103
1963/64	7.883	10.120	3.545	1.134	5.197	4.163	1.647	2.342	1.011
1964/65	1.674	13.886	11.897	5.384	1.656	6.130	4.476	2.205	4.668
1965/66	24.172	2.121	9.772	6.937	4.549	866	3.506	3.302	3.719
1966/67	1.555	30.906	1.576	5.712	4.087	1.996	506	1.894	2.972
1967/68	8.591	2.802	23.837	1.987	3.971	1.672	907	422	1.424

1 cran = 178 kg

Table 14. Total instantaneous mortality coefficient (Z) in the drift-net and ring-net fisheries in areas F and F_1 (3-ringers and older fish continued).

Season	Drift-net			Ring-net
	Spring spawners	Autumn spawners	Spring & Autumn spawners	Spring & Autumn spawners
1954-55/55-56	0.763	0.373	0.420	0.020
1955-56/56-57	2.289	0.563	0.799	0.874
1956-57/57-58	1.080	0.704	0.724	0.224
1957-58/58-59	1.539	0.210	0.399	0.548
1958-59/59-60	2.303	0.767	0.846	÷ 0.038
1959-60/60-61	0.544	1.112	1.071	0.951
1960-61/61-62	1.562	0.107	0.198	0.256
1961-62/62-63	0.567	1.015	0.979	÷ 0.115
1962-63/63-64	0.485	0.121	0.139	0.739
1963-64/64-65	0.612	0.148	0.183	÷ 0.231
1964-65/65-66	1.308	0.441	0.522	0.418
1965-66/66-67	0.354	0.704	0.679	0.721
1966-67/67-68	0.932	0.492	0.517	0.429
1967-68/68-69	1.090	0.518	0.621	÷ 0.172
Av.1954-55 to 1968-69	1.102	0.520	0.578	0.330

Table 15. Age composition and mortality (Z) in area F (Donegal).

Source	Years / Season	3	4	5	6	7	8	9	+9	Z
Dutch Kg/100 hours	1966	37,136	844	-	1,688	-	844	-	16	0.53
	1967	1,109	17,207	1,518	2,458	578	241	603	1,277	0.49
	1968	540	360	10,350	1,140	1,170	525	165	675	
Irish Crans/shot	1967/68	0.06	0.82	45.93	3.24	2.05	1.28	0.54	0.92	0.37
	1968/69	0.40	4.26	1.33	32.30	1.96	0.90	0.45	1.68	