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International Council for the
Exploration of the Sea

C.M.1974/H:2
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REPORT OF THE MACKEREL WORKING GROUP

30 January - 1 February, 1974 Charlottenlund, Denmark

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General Secretary,
ICES,
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Denmark.

1. Introduction

At the 61st Statutory Meeting, the Council passed the following Resolution (C.Res.1973/2:5):

"It was decided that:

a Mackerel Working Group, with Mr J. Hamre as Convenor, should meet for 3 days (30 January - 1 February 1974) in Charlottenlund to:

- a) assess the value of the present minimum size of 30 cm for mackerel caught for industrial purposes in Division IIIa and Subarea IV, and
- b) assess the state of the stocks of mackerel in the North Sea and in waters west and south of the British Isles."

The terms of reference at a) above are treated in Section 2 of this Report, and those at b) above are treated in Sections 3 - 7.

The following Members participated:

Mr N.N. Argunov	U.S.S.R.
Mr G. Bolster	U.K. (England)
Dr J. Gueguen	France
Mr J. Hamre (Chairman)	Norway
Mr S. Munch-Petersen	Denmark
Mr K. Postuma	Netherlands
Mr E.S. Prosvirov	U.S.S.R.
Mr A. Saville	U.K. (Scotland)

Mr D. de G. Griffith, ICES Statistician, also attended the Meeting.

2. The Effect of a Minimum Size Regulation

The Working Group considered the effect of the present minimum landing size of 30 cm for mackerel caught for industrial purposes in Division IIIa and Subarea IV.

The results of a minimum landing size can be considered from two aspects:
a) the effect it has on the yield per recruit which can be taken from the stock over a range of values of fishing mortality and b) its effect on the size of the stock left in the sea and the implications of this for subsequent recruitment.

Yield per recruit curves, taken from Hamre (1970), for minimum landing sizes of 26, 30 and 33 cm are given in Figure 1. These show that with a minimum landing size of less than 30 cm there is no gain in yield at low values of fishing mortality (F) and a loss in yield per recruit

at values of F above 0.3. These curves also show that the yield per recruit over a wide range of F values is not significantly reduced by increasing the minimum landing size to 33 cm. The application of a minimum landing size does, however, have an appreciable effect on the quality of the yield from a mackerel fishery. Figure 2, taken from Postuma (1972), shows the effect of increasing the minimum age at first capture, equivalent to increasing the minimum landing size, on the mean weight of the fish in the catch. At a minimum size of 30 cm a 20% increase is obtained in the mean weight of the fish caught at an F of 0.4 compared with that obtained with a minimum size of 26 cm. The proportional increase in mean weight of the fish caught rises rapidly at higher values of F .

The effect of varying minimum sizes at first capture on the stock are illustrated in Figure 3, taken from Hamre and Ulltang (1972). This gives curves of stock per recruit with three alternative ages of first capture over a range of values of fishing mortality. This Figure shows that, except at very low values of fishing mortality, increasing the age of first capture (and hence the minimum landing size) has an appreciable effect on the size of the residual stock. At an F of 0.4 the spawning stock is increased by about 50% by increasing the age at first capture from 26 to 30 cm; at an F of 0.7 the stock is effectively doubled. Although a stock/recruitment relationship has not yet been demonstrated for North Sea mackerel, such an increase in stock, obtainable with no loss in yield by introducing a minimum landing size of 30 cm, has obvious advantages in providing a safeguard for future recruitment to the stock.

A 33 cm minimum landing size would give practically the same yield per recruit and would give a better condition of the stock than one of 30 cm. For practical reasons, however, 30 cm is preferable. Above a size of 30 cm, mackerel are shoaling with the adult component of the stock and a minimum size limit above 30 cm would be difficult to implement and enforce.

3. Development of the Mackerel Fisheries

3.1. North Sea, Skagerak and Kattegat (ICES Statistical Division IIIa and Subarea IV)

The total landings of mackerel from the North Sea, the Skagerak and the Kattegat increased from 20 000 tons to 115 000 tons in the period 1945 to 1964. After the introduction of the Norwegian purse-seine fishery in the northern and northeastern North Sea in 1964 the landings increased rapidly to 930 000 tons in 1967 (Revheim and Hamre, 1968). Since then, however, the landings have decreased steadily to 188 000 tons in 1972 and an estimated 394 000 tons in 1973 (Table 2). Postuma (1972) discussed the significant decline in the abundance of the mackerel stock in the years 1959 - 1969, and suggested that at least during the later part of this period (1966 - 1969) the severe drop in abundance was caused by failing recruitment as well as by a very intensive fishery. In 1969, Norway increased the minimum size limit for their industrial mackerel fishery from 20 cm to 30 cm. At the 11th Meeting of the Commission (1973), NEAFC

approved the following Recommendation:

- "1. In ICES statistical areas IIIa and IV [sic] it is prohibited to fish for industrial purposes mackerel of a size smaller than 30 cm measured from the tip of the snout to the end of the tail fin.
2. Notwithstanding the provision in 1 above, landings of mackerel for industrial purposes may consist of 20% by weight of undersized mackerel."

In 1970, Norway introduced a closed season and a catch quota for her industrial fishery.

3.2. The Western Fishery (ICES Statistical Subareas VI and VII)

The total landings from these areas to the west and south of Great Britain and Ireland have increased steadily from 27 000 tons in 1963 to 87 000 tons in 1971. The 1972 landings (134 000 tons) represented an increase of over 50% on the 1971 figure, and the total for 1973 is estimated to be in the region of 145 000 tons (Table 3). The area to the south of Ireland (VIIg-k) has always accounted for the greatest part of the total annual catch, although in 1972 it actually decreased from 62 000 tons to 52 000 tons (Table 5); the peak landings in that year resulted largely from heavy increases in the quantities taken from the Irish Sea and Bristol Channel (VIIa,f), the English Channel (VIId,e) and the west coast of Scotland (VIa). Throughout the western fishery the principal gear in use is the trawl, but English boats fishing out of the southwest port of Newlyn use the technique of "feathering", which has replaced the drift net as the main English method of fishing in that area. Bolster (1971) describes this fishery, in which the annual catches of feather-caught mackerel from the SW areas have increased from 587 tons in 1960 to 6 114 tons in 1972.

4. Distribution of Spawning Stocks

4.1. Southwest Area

The populations of mackerel fished off the south-west English Coast cannot be regarded as a single spawning stock. Bolster and Burd (1972) have shown that spent fish occurred in quantity in both the early part of the fishery and also later in the year, in August and September. It is considered that these are derived from different spawning stocks, namely the Celtic Sea stock which spawns in the spring (March - April), and others from a southern North Sea summer spawning stock (June - July).

The presence of these two spawning stocks of mackerel in the southwest has been shown also by the results of tagging experiments (Bolster 1969, and 1974, in press). From these data, the overwintering areas of the two groups are apparent: the Celtic Sea for the early spent fish, and the Eddystone area for the fish which are spent in the autumn.

Egg and larval surveys (Corbin 1947, Wallace and Pleasants 1972) confirm that eggs and larvae are present in the Celtic Sea/Western English Channel from April to June, and in the Eastern English Channel/Southern North Sea in July. Additional data are available from the results of the Continuous Plankton Recorder Survey 1948 - 1967 (Bainbridge, Cooper and Hart, in press). These not only confirm the times and places of the spawnings mentioned above, but suggest that other spawning areas exist off the west coast of Scotland in the spring, and in the central and northern North Sea in the summer.

4.2. North Sea

Norwegian investigations over the period 1968 - 1972 (Iversen, 1973) clearly indicate a major spawning centre in the northeastern and central North Sea (Figure 4).

5. National Sampling Programmes for Age and Length

The sampling programmes which are currently being carried out (or which have been carried out in the past) by the countries represented at the Working Group may be summarised as follows:

Scotland: Since 1970, there has been regular age and length sampling of commercial catches landed from all areas and by all methods of fishing.

Denmark: During the period 1967 - 1969 the catches for human consumption were sampled for age. There is no later material. The industrial fishery is known to contain a proportion of mackerel which is sometimes considerable and which may be largely 0-group and I-group fish. (Of 7 150 tons of mackerel caught in the North Sea and Skagerak in 1973, 5 963 tons - 83% - were industrial catches). The Working Group strongly recommends that a sampling programme on all catches (but especially on the industrial catches) be initiated.

France: No sampling takes place at present but a programme is to be commenced at Boulogne and in Brittany. Most of the French catches of mackerel are taken in the Celtic Sea; the catches in Biscay are mainly by-catches of boats fishing out of La Rochelle and Lorient. The catches in both areas are made by trawlers.

U.S.S.R.: Age composition data from the North Sea catches (which are trawler by-catches) are available from 1970. No sampling takes place on the catches made in the western area.

- Netherlands: North Sea catches have been sampled since 1959, and the catches in ICES statistical Subareas VI and VII since 1967 and 1969, respectively. Sample data are also available from the Irish Sea (Division VIIa) for 1963 and 1964.
- England: Age and length composition data from the southwest ports (which account for about 90% of the total English mackerel catch) are available from 1960.
- Norway: Regular sampling for age composition has been carried out since 1965 on the catches by all gears from all fishing areas. Since 1970, regular samples for length composition have been taken from the industrial purse-seine fishery, and age/length keys have been applied to these.

6. Stock Assessment

Information derived from egg surveys and tagging experiments suggest that in the ICES area there are two major stocks of mackerel - one with its centre in the North Sea and one in the Celtic Sea. There is a certain amount of mixing of the stocks, particularly in the Shetland area where Norwegian tagging experiments give estimates of the population components in that area in recent years being roughly 30% North Sea stock and 70% other stocks. For stock assessment purposes the Group has taken all the catch from the North Sea south of 59°N as being fish belonging to the North Sea stock and 30% of the catch from the Shetland area as belonging to the same stock. The residual 70% of the Shetland catch is ascribed to the western stock as are all the catches in Subareas VI and VII.

6.1. North Sea

6.1.1. Mortality Rates

In Table 6 two sets of total mortality rates for the North Sea stock over the period 1964 to 1972 are given, derived from independent sources. The first set has been estimated from the catch per unit effort of Dutch trawlers fishing in Division IVb in July to September, and the age compositions of their catch. The second set has been calculated from the results of Norwegian tagging experiments in Division VIa. The estimates from 1969 to 1973 are derived directly from tag returns; the mortality rates prior to 1969 in this set have been calculated by estimating the size of the stock in this area in 1969 from tagging results, and its age composition from that of Norwegian catches, and subsequently back-calculating the mortality rates in earlier years from the age composition of the catches in these years.

On average, the mortality rates calculated from the Dutch trawl data are about 0.2 higher than those from the Norwegian tagging experiments; however, both show a closely similar trend with the mortality rate rising sharply from 1966 to 1969 with the increase in Norwegian purse-seine catch, and subsequently declining sharply from 1969 to 1971 with the introduction of the regulation of the Norwegian purse-seine fishery in this area. The mortality rates estimated from tagging experiments would suggest that in 1971 and 1972 the total mortality rate was stabilised at a value of 0.35 - 0.39. With the natural mortality rate of 0.2 - 0.25 calculated from tagging experiments for mackerel, these total mortality rates would suggest that the exploitation rate was well in excess of that giving the maximum sustainable yield in the period 1968 - 1970 (Figure 1). The much lower mortality rates in 1971 and 1972 are below those giving the M.S.Y. and, if taken in conjunction with the better recruitment in these years, should have resulted in some recovery of the stock.

6.1.2. Stock Size

In Table 6 estimates are given of the weight of the stock of fish above 2 years of age calculated from the Norwegian tagging experiments over the period 1969 - 1973. These would suggest that the stock reached its lowest level of 700 000 - 750 000 tons in 1970, and has since increased by about 50% due to the reduction in exploitation rate and the addition of the relatively strong 1969 yearclass to the exploited stock. The stock size estimate for 1973 is based on tag recoveries from within-season releases, and may therefore be biased downwards due to incomplete mixing of the tagged fish.

6.2. The Western Area

Adequate data are not available to estimate mortality rates or stock sizes in the western area. The available information on the composition of the catches from this area, which contain a fairly high proportion of large, old fish, would point to the exploitation rate of this population being appreciably lower than that of the North Sea population in the period 1967 - 1970. However, the catches taken from this stock have been increasing rapidly in recent years and the Working Group would emphasise that a start should be made to collect adequate assessment data for this population immediately.

6.3. Egg Surveys as Indices of Spawning Populations

Egg survey data (Figures 4 and 5) are available from the main centre of mackerel spawning in the North Sea (Iversen, 1973), and from the Celtic Sea spawning area (Corbin, 1947). These data might permit a very rough estimate of the relative sizes of the two stocks. The Working Group did not have time available to undertake this work, but this should be done at any subsequent Meeting of the Group.

In both areas, however, the data available, because they are rather limited, either in time or space coverage, or both, are not adequate to allow a very accurate estimate of the sizes of the spawning stocks. The Working Group would recommend that countries with an interest in mackerel fisheries increase the resources available for mackerel egg surveys, so that adequate data can be collected in both the North Sea and the Celtic Sea spawning areas to give a measure of the stock sizes in the two areas, and to monitor their changes. This is likely to be of increasing importance in the future, as the current estimates of stock sizes obtained from tagging experiments will become less reliable if the quantity of mackerel used for industrial purposes decreases. Little is known about spawning areas for mackerel in the waters to the west of Ireland and the west of Scotland, and preliminary surveys in these areas, to investigate whether there are major spawning grounds in these waters, would be valuable.

7. Discussion

7.1. North Sea

For the North Sea population the data for assessment are reasonably satisfactory and the results of the assessment carried out would suggest that, with the implementation of the 30 cm minimum landing size and the current Norwegian regulations on catch limitation, this stock has now recovered to a more satisfactory state. In this area better data are required on the size and composition of the by-catch of mackerel landed by the Danish industrial fishery. In addition, surveys to provide measures of egg production as an alternative index of spawning stock size are required from the North Sea.

7.2. Western Area

For the western population the position is less satisfactory. The data available for assessment are highly inadequate, and although the age composition of the catches in this area would suggest that the population is not yet over-exploited, the catches taken are increasing rapidly. The Working Group would therefore recommend that egg surveys and tagging experiments for assessment purposes are intensified in this area. Better catch sampling is also required, since even the appropriate minimum landing size cannot be defined with any precision. A reliable assessment of the state of the western stocks can only be carried out when such data are available to the Working Group.

8. References

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Table 1. Mackerel Catches 1973 by ICES Fishing Areas - Preliminary Figures (See Notes on Page 10)

	IIIa	IIIb,c	III d	IVa	IVb	IVc	V Ia	V Ib	VIIa,f	VIIb,c	VII d-e	VIIg-k	Total
Denmark	733 ^{a)}	-	-	...	6 681 ^{b)}	...	-	-	-	-	-	-	7 414
France	-	-	-	2 888	3 040	132	600	10	2 943	-	8 439	14 517	32 569
Netherlands	-	-	-	765	393	1 460	1 810	-	...	-	-	17 656 ^{c)}	22 084
Norway	-	-	-	355 000	-	-	-	-	-	-	-	-	355 000
Sweden	11 ^{d)}	2 920 ^{e)}	-	-	-	-	-	-	2 931
U.K. (England and Wales)	-	-	-	7	20	4	7	-	3 059	-	7 542	9	10 648
U.K. (Scotland)	-	-	-	2 573	227	-	4 600 ^{f)}	...	-	-	-	-	7 400
U.S.S.R.	-	-	-	2 604	7 862	564	1 710	38	15 489	774	30 774	21 215	81 030
Total	733	-	11	366 757	18 223	2 160	8 727	48	21 491	774	46 755	53 397	519 076

a) Kattegat 264 tons; Skagerrak 469 tons.

b) Includes IVa and IVc.

c) Includes VII f.

d) Includes III b (Øresund).

e) Includes IIIa (Kattegat and Skagerrak), IVb and IVc.

f) Includes VI b.

NOTES: On next page.

Notes to Table 1.

France:

Preliminary data for January - September 1973, and total catch for 1972, compiled by Secrétariat Général de la Marine Marchande.

Total catch for 1973 calculated as $\frac{\text{Jan - Sep 1973}}{\text{Jan - Sep 1972}} \times \text{Total 1972 catch}$, and the quantity thus derived allocated to Divisions in proportion to 1972 distribution as published in ICES Bulletin Statistique.

Netherlands:

Data for January - September 1973, and 1972 (by quarters) supplied by Postuma.

Total 1973 catch calculated as $\frac{\text{Jan - Sep 1973}}{\text{Jan - Sep 1972}} \times \text{Total 1972 catch}$.

Norway:

Preliminary total catch; allocated to IVa by Hamre.

Sweden:

Preliminary statistics for January - November are based on reports from first-hand purchasers and include catches landed by Swedish fishermen abroad. The figures for December are added as an average for the last three years.

U.K. (England and Wales):

Preliminary data supplied by Fisheries Laboratory, Lowestoft,

calculated as $\frac{\text{Jan - Oct 1973}}{\text{Jan - Oct 1972}} \times \text{Total 1972 catch}$.

U.K. (Scotland):

Preliminary data supplied by Saville. North Sea figures are likely to be a considerable overestimate due to Horse mackerel landings.

U.S.S.R.

North Sea data for January - October supplied by Ministry of Fisheries taken as 1973 total, since no catches were made in the North Sea in November or December 1972. Total catch for Subareas VI and VII (70 000 tons) estimated by Prosvirov, and allocated to Divisions in proportion to 1972 distribution.

Table 2. Total Mackerel Catch by Countries, 1963 - 1973, in the North Sea (IVa, IVb, IVc), Skagerrak and Kattegat (IIIa). (Bulletin Statistique.)

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Belgium	118	125	138	67	201	77	139	19	85	129	78
Denmark	6 878	6 311	6 509	7 552	20 282	9 887	10 851	26 753	17 590	2 023	7 414
Faroe Islands	--	--	--	--	--	--	3 080	2 134	3 603	7 551	4 429
France	967	9 901	7 635	5 390	7 486	4 684	11 353	4 677	8 953	6 830	6 060
Germany (F.R.)	1 769	3 495	2 221	1 501	2 132	1 353	1 161	225	408	374	336
Iceland	--	--	--	--	105	352	612	1 492	649	676	939
Netherlands	11 846	17 085	16 977	12 247	10 801	5 986	4 928	2 956	4 945	4 436	2 618
Norway	23 350	51 383	156 605	484 428	866 548	779 084	683 045	278 631	200 635	160 141	355 000
Poland	3 110	7 617	3 695	2 294	2 261	1 629	12	205	130	244	193
Sweden	21 366	15 006	13 364	13 754	15 246	11 783	10 820	4 407	3 157	4 748	2 920
U.K. (England + Wales)	51	67	76	99	46	55	35	35	23	32	31
U.K. (Scotland)	1 923	854	1 019	618	742	583	231	148	616	395	2 800
U.S.S.R.	1 690	3 153	227	1 778	4 098	6 094	12 516	718	2 600	611	11 030
Total	73 068	114 997	208 466	529 728	929 948	821 567	738 783	322 400	243 400	188 190	393 848

Note: 1973 catches by France, Netherlands, U.K. (England + Wales), U.K. (Scotland), Sweden and U.S.S.R. are provisional estimates (see Table 1).

Catches for 1973 by other countries, except Denmark, are averages of the three years 1970 - 1972.

Table 3. Total Mackerel Catch by Countries, 1963 - 1973, in the Western Area (ICES Subareas VI and VII). (Bulletin Statistique).

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Belgium	--	3	3	5	7	2	11	8	2	---	3
France	23 304	21 591	14 651	38 309	28 655	29 751	27 290	35 593	24 538	29 904	26 733
Germany (F.R.)	374	187	1 959	302	333	613	428	783	258	98	380
Iceland	--	--	--	--	--	--	--	90	86	74	83
Ireland	759	1 334	1 860	1 507	2 245	2 164	1 615	1 055	3 107	4 592	2 918
Netherlands	638	1 218	1 411	2 831	3 859	2 597	4 441	3 828	3 837	6 166	19 466
Norway	--	--	--	--	--	--	--	--	1 611	---	---
Poland	353	330	212	3	520	1 518	2 149	6 054	10 832	13 129	10 005
U.K. (England + Wales)	1 812	1 794	1 583	1 884	2 634	2 585	2 692	3 374	4 791	6 923	10 617
U.K. (N. Ireland)	66	103	111	97	158	151	279	243	315	57	205
U.K. (Scotland)	422	567	426	670	490	537	402	803	805	1 412	4 600
U.S.S.R.	320	61	54	--	--	--	6 147	13 555	36 390	71 247	70 000
Total	27 048	27 188	22 270	45 608	38 901	39 918	45 454	65 390	86 572	133 692	145 010

Note: 1973 catches by France, Netherlands, U.K. (England + Wales) and U.K. (Scotland) are provisional estimates (see Table 1).

Catches for 1973 by other countries, except U.S.S.R., are averages of the three years 1970-1972.

Table 4. Total Mackerel Catch in the North Sea (IVa, IVb, IVc) Skagerrak and Kattegat (IIIa) Øresund and Belt Seas (IIIb,c) and the Baltic (IIId), 1963-1972. (Bulletin Statistique.)

Year	IVa	IVb	IVc	IIIa	IIIb,c	IIId	Total
1963	43 821	10 481	1 100	17 666	381	99	73 548
1964	67 626	11 579	185	35 607	332	104	115 433
1965	142 852	8 751	118	56 745	320	158	208 944
1966	496 873	8 014	247	24 594	243	64	530 035
1967	895 163	13 810	906	20 069	246	60	930 254
1968	796 660	10 483	1 557	12 867	90	32	821 684
1969	700 816	11 529	1 521	24 917	72	30	738 885
1970	257 328	26 674	5 988	32 410	78	31	322 509
1971	199 172	17 217	11 548	15 462	20	12	243 431
1972	174 324	5 596	2 309	5 961	19	4	188 213

Table 5. Total Mackerel Catch in the Western Area, by ICES Statistical Divisions 1963 - 1972

Year	VIa	VIb	VIIa+f	VIIb+c	VIIId,e	VIIg-k	Total
1963	2 466	22	2 582	1 232	4 776	15 970	27 048
1964	4 385	25	2 462	1 206	4 569	14 541	27 182
1965	5 694	9	1 617	1 497	3 177	10 271	22 270
1966	3 073	1 330	1 368	124	583	39 130	45 608
1967	4 858	525	10 403	1 576	4 697	16 842	38 901
1968	5 064	0	2 202	1 700	5 704	25 248	39 918
1969	4 759	1	2 439	5 286	6 780	26 189	45 454
1970	3 827	26	2 268	935	9 366	48 968	65 390
1971	8 685	14	2 954	1 439	11 944	61 536	86 572
1972	12 253	57	21 330	1 090	46 599	52 363	133 692

Table 6. Total Mortality Rates (Z) of North Sea Mackerel 1963 - 1972

Year	Dutch trawl data in IVb		Norwegian tagging experiments in IVa	Stock size (thousand tons)
	Observed	Smoothed ¹⁾		
1963	0.37			
1964	0.77	0.56		
1965	0.53	0.62		
1966	0.55	0.52	0.34	
1967	0.48	0.73	0.57	
1968	1.15	0.62	0.70	
1969	0.23	1.41	1.05	920
1970	2.86	0.99	0.76	720
1971	-0.13	0.52	0.36	920
1972	-1.17	-	0.39	1 290
1973	-	-	-	1 090

1) Running means of three estimates based upon annual catch per effort data derived from the Dutch trawl fishery.

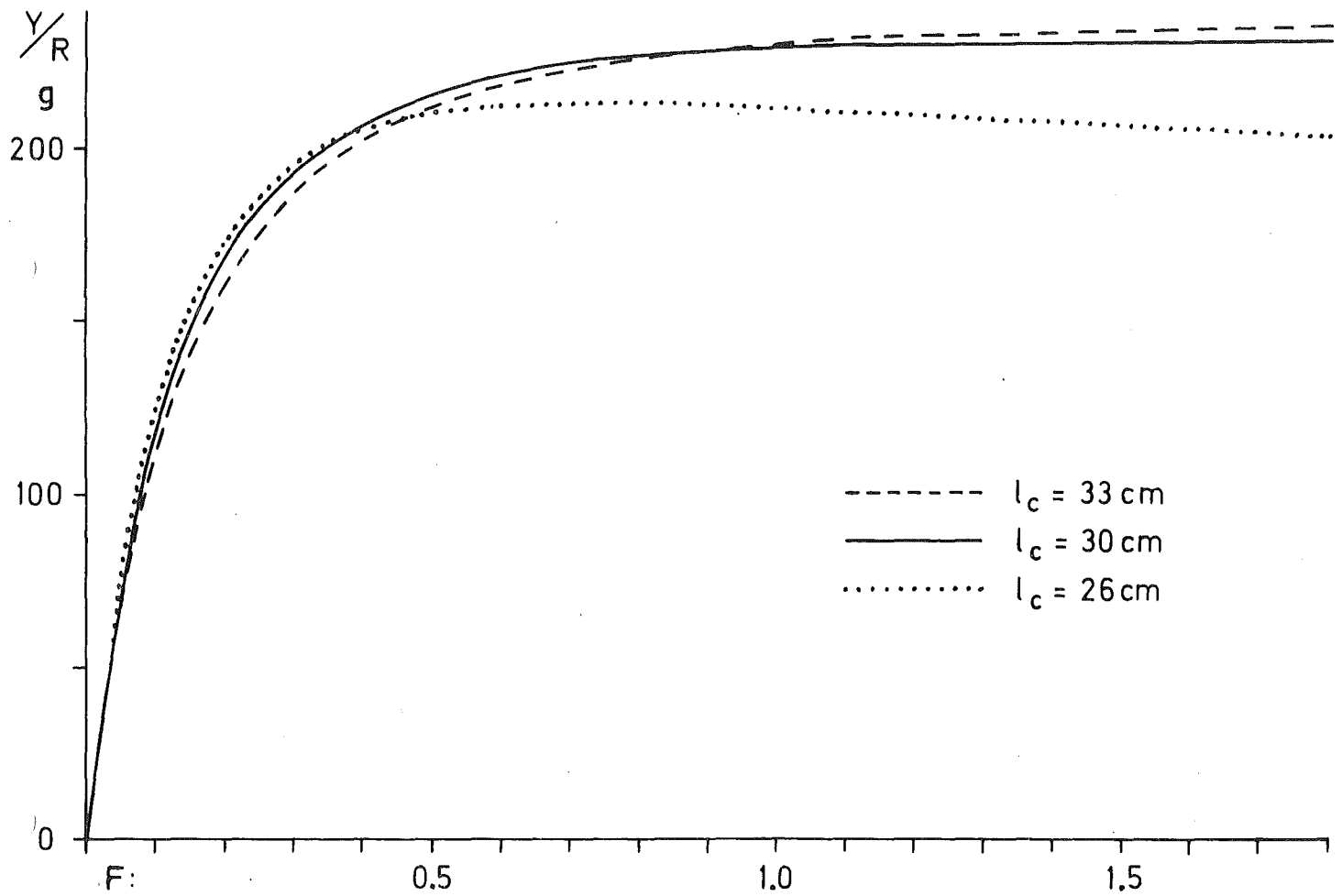


Figure 1. Yield per recruit (Y/R) by fishing mortality (F) and mean recruitment length at first capture (l_c). (Stock parameters: $L_\infty = 39$ cm corresponding to 550 gr., $K = 0.40$, $M = 0.20$).

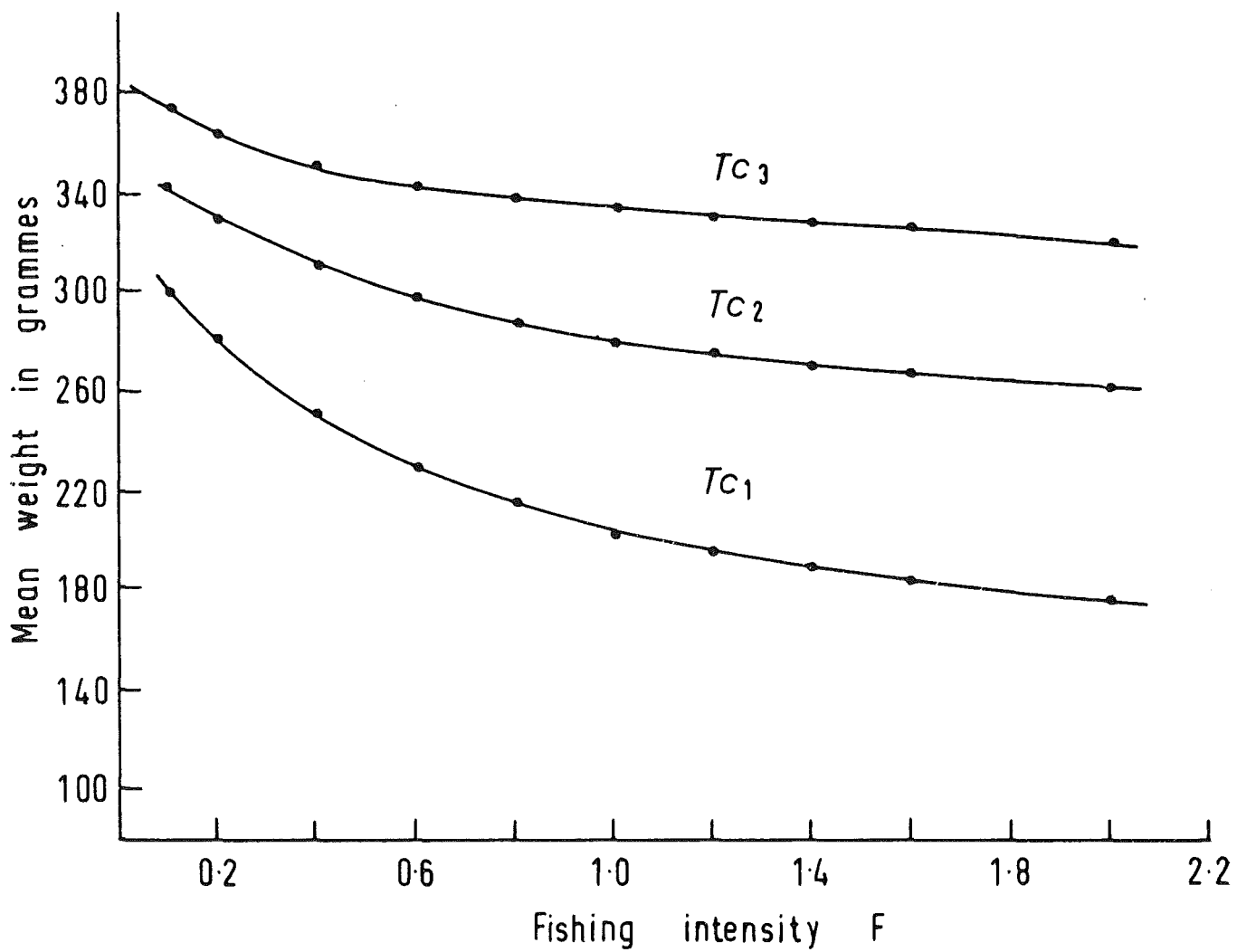


Figure 2. Mean weights of North Sea mackerel at different fishing intensities.

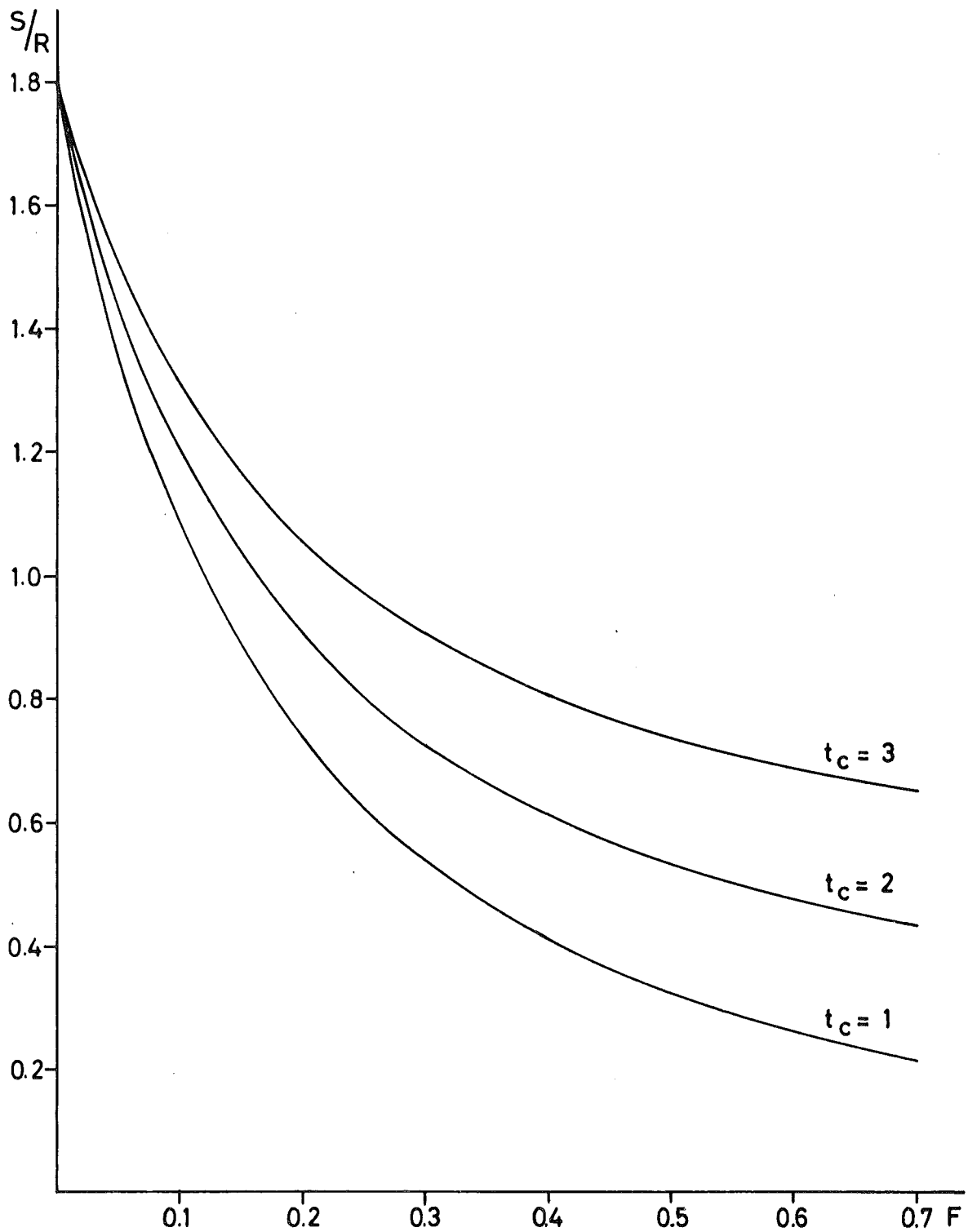


Figure 3. Spawning stock per recruit (S/R in kg) by fishing mortality (F) and age at first capture (t_c). ($t_c = 1, 2$ and 3 corresponding to 27 cm, 32 cm and 34 cm respectively, sampled in the autumn). The curves are derived from a computer model with input $M = 0.20$ and observed weight at age

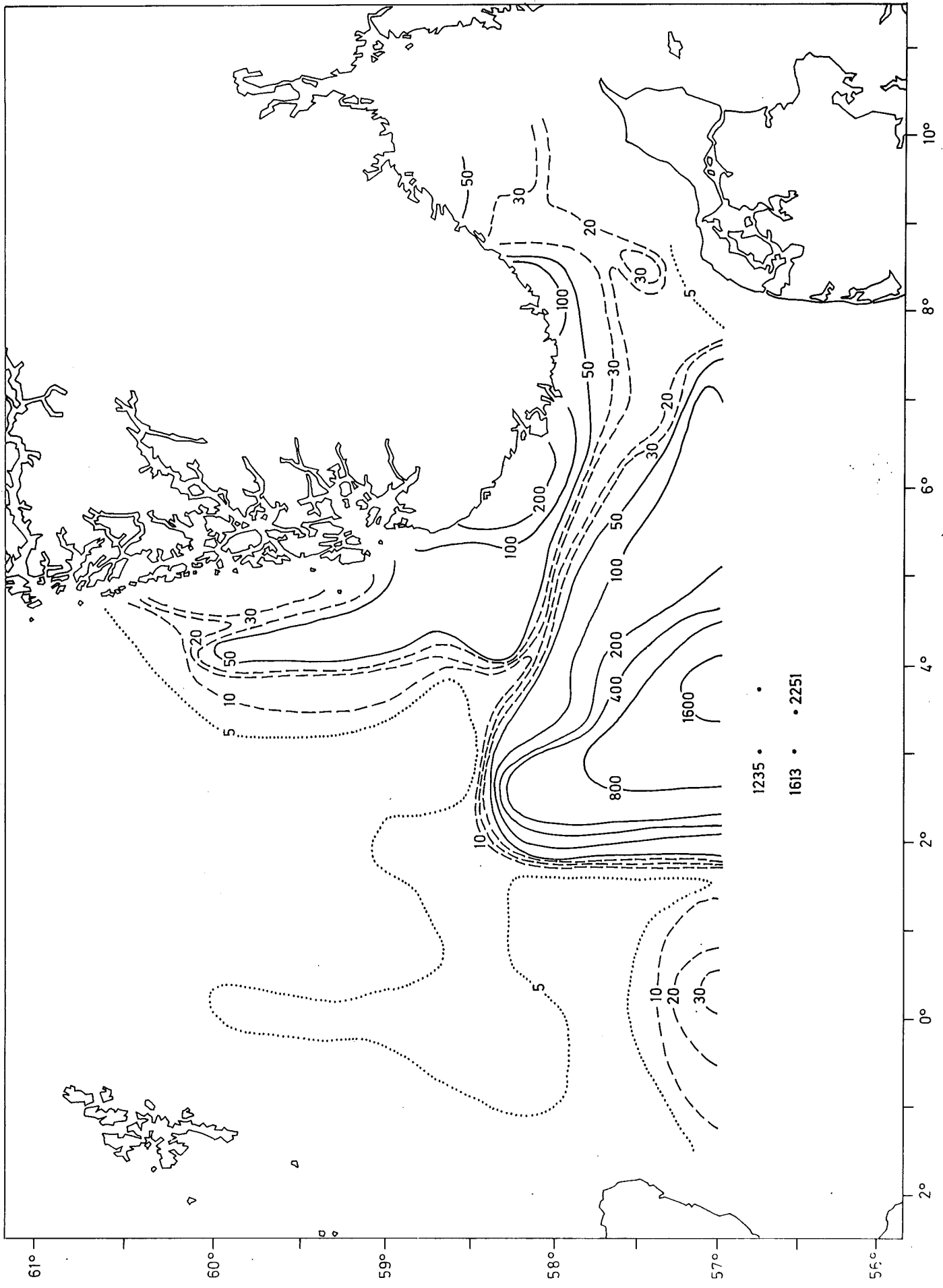


Figure 4. Egg distribution chart of wackerel, 22 June to 6 July 1972. Isolines show number of eggs per m² sea surface.

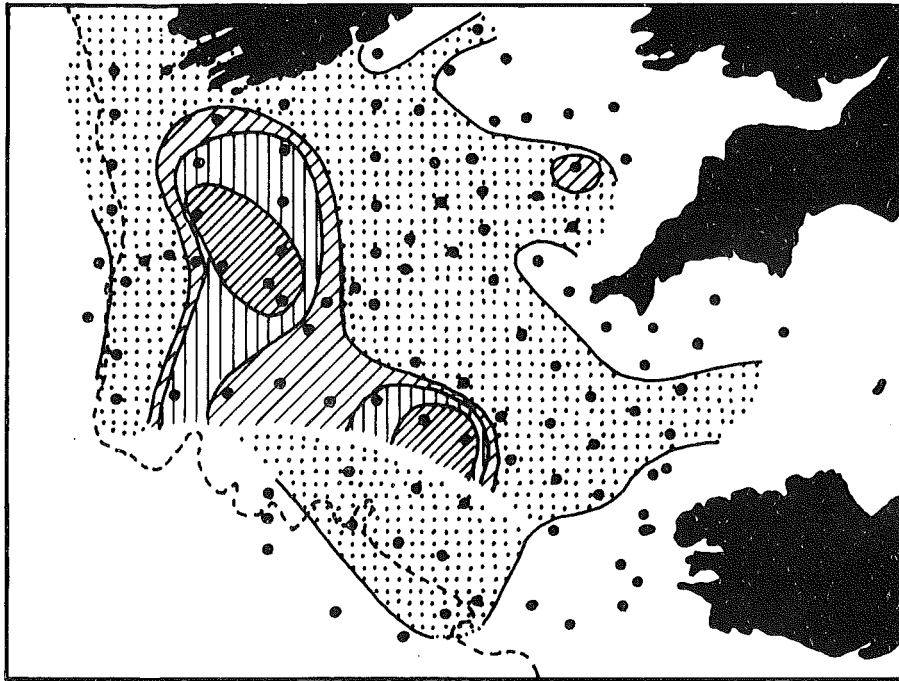


Figure 5. Distribution of mackerel eggs (contoured at 1, 1 000, 5 000 and 10 000 eggs per station) in the Celtic Sea, April.

Solid circles - survey stations.

Dashed line - 100 fathom contour.

(Based on Corbin, 1947).