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Preliminary Investigations on Irish Sprat Stocks

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## Abstract

Landings of sprats have, in recent years, assumed considerable importance in Irish waters. The following paper describes the various biological characters to two Irish fisheries and makes preliminary estimates of population size and optimum sustainable yield.

## Introduction

Landings of sprat from around the coasts of Ireland have until recently tended to fluctuate very much and have depended greatly on market conditions. The method of fishing - which was small boats using drift nets in shallow bays and estuaries - also meant that if sprat failed to appear in any particular area no attempt was made to locate them anywhere else. In 1969, however, the establishment of a fish meal factory on the east coast at Mornington meant that there has since been a fairly continuous exploitation of sprat in that area, while in 1976 an inshore fishery for sprats for human consumption commenced off the south coast in the Celtic Sea. The estimated total catch from both these areas are shown in Table 1. Pair trawls (bottom and pelagic) are used in the east coast fishery but only pelagic trawls are used in the south coast fishery. Heaviest catches in both cases are made in the autumn and winter months.

## Scientific Investigations

Sampling of sprats along the east coast commenced in 1964 but was discontinued in 1966 because no fishery materialised. Sampling in that area was recommenced to a limited extent in 1969 with the opening of the fishmeal factory, and has continued since then. Sampling of the sprats from the south coast commenced in 1976 and continued for

the duration of the main fishery. However some information is available from earlier work on the traditional fisheries and from isolated surveys carried out by various bodies. This paper attempts to gather together this material so that the population or populations can be assessed.

### Recruitment

Although it is not yet possible to make any estimates about the size of recruitment the age distributions would suggest that along the east coast the 1970 and 1973 year classes were good. The 1973 year class was also well represented on the south coast. The monthly age and length distributions reveal that sprat are first captured along the east coast when they are 0-group and around 4 or 5 cm long. Fish of this size may be present in the catches in May until November indicating that recruitment takes place over a very long period. Some recruitment also takes place apparently when sprats are 1-group. It is difficult therefore to estimate what the average size at recruitment is because it will probably be governed by the time at which the major spawning takes place. However it would appear to coincide with the average size of the 0-group fish during the winter period which would be approximately 8.5 cm. The length distribution per month for the south coast during 1976/77 indicates that the smallest sprat captured were about 8 cm. long. These fish belonged to the 1975 year class and did not appear in the catches until February 1977. The main recruitment therefore will probably not take place until after this time. An estimate of the average age and length at recruitment would be 2.25 years and 11 cms, which is considerably later than in the Irish Sea.

### Age, length and weight.

Age data are available for landings made on the east coast for 1964, 1965 and 1966 and from 1971 to 1977. Data is available also for the

1977 catches off the south coast. In all cases the catches have been converted to numbers per age class and these are shown in Table 2. The data from the 1964-66 period on the east coast is from the summer fishery only and would therefore include more of the younger fish. However the east coast fishery does tend to exploit greater numbers of 0; I and II-group fish than the south coast fishery. Age was determined from otoliths, the birthday been taken as 1 January. The south coast fishery in 1977 was dominated by the 1973 year class. Length-weight data are also available for both areas and are shown in Table 3. Growth curves have been calculated for both areas and the parameters contained in the von Bertalanffy growth equation estimated. Mean lengths per age are shown below:-

W. Rings	East Coast		South Coast	
	Observed $\bar{l}$	Calculated $\bar{l}$	Observed $\bar{l}$	Calculated $\bar{l}$
0	8.5	8.3	-	6.6
1	11.8	11.4	10.1	9.8
2	13.6	13.3	11.7	12.1
3	14.8	14.7	14.0	13.7
4	16.0	15.6	15.0	14.8
5	-	-	15.6	15.6
6	-	-	16.1	16.2
7	-	-	16.5	16.6

The observed mean lengths are very similar to the calculated lengths in both cases, although the growth rate of east coast sprats is considerably faster than that off the south coast. The parameters obtained from the growth equation were as follows:-

	L <sub>oo</sub>	W <sub>oo</sub>	K	to
East Coast	17.0 cm	34.5 g	0.45	-1.479
South Coast	17.5 cm	37.2 g	0.35	-1.358

Sprats off the south coast appear to live longer and grow larger, both in length and weight, than those off the east coast. The L<sub>oo</sub> in both cases is considerably higher than the value of 13.4 cm obtained by Johnson (1970) for North Sea sprats.

#### Maturities and spawning time

Spawning in North Sea sprats is well known to take place over a period which may extend from January to July - eggs being released in successive batches. Some data are available which would suggest that a similar spawning pattern is observed in the Irish Sea. Fish examined in September were mainly virgin (stage I), while some recovering spents and some early maturing fish were also found. In November most fish were maturing, and they continued to mature during the winter and early spring. Peak spawning seems to have occurred in May and June. The majority of the fish examined off the south coast, however were either full or spawning during the period December to March. No recently spawned fish were found and it is possible that sprat leave the inshore waters immediately after spawning has been completed. Irish tin towner cruises carried out in the early sixties in this area in connection with Celtic Sea herring investigations found large numbers of sprat eggs and larvae in the January to March period. Surveys carried out in the late sixties and early seventies for pelagic eggs and larvae in a number of inshore areas along the south and southwest coasts again found sprat eggs and larvae in May and June (Kennedy and Fitzmaurice 1969). Plankton surveys carried out by the U.K. in 1967 and 68 found sprat eggs and larvae widely distributed over the Celtic Sea from early May to mid-July. (Wallace and

Pleasants, 1972). A sample of sprats examined from off the southwest coast in mid-June 1977 was also on the point of spawning. It would appear therefore that spawning takes place from January right through until the end of June and over a very large area. The 1967 U.K. survey was interesting in that the largest concentrations of eggs were found about 35-40 miles south of Dunmore East in about 45 fathoms, while the larvae were mainly distributed in shallow water along the Irish coast in approximately the same area as the traditional fisheries on small summer sprat and the 1976/77 winter fishery on adult sprat.

● Because of the prolonged spawning time it is difficult to estimate the average age or length of sprat at the time of their first spawning. In the Irish Sea there is evidence from the maturity data to suggest that it might be when they are about 10-11 cm long, i.e. when they are about 1.5 years old. In the Celtic Sea the absence of immature or juvenile fish would suggest that the first spawning would occur immediately after recruitment so that the average size and length at first spawning would be around 11 cms and 2.25 years.

#### Estimates of Mortality

● There is no series of catch per effort data for the Irish Sea fishery so that estimates of mortality using that method are not available. Estimates of total mortality co-efficient may however be obtained by an examination of the mean lengths and age in the catch using the expressions derived by Beverton and Holt (1957). The expressions were:-

$$Z = 1/\bar{t} - t_c$$

$$\text{and } Z = K (L_{\infty} - \bar{l}) / (\bar{l} - l_c)$$

where  $Z$  = total instantaneous mortality co-efficient,  $\bar{t}$  = average age of fish in the catch,  $t_c$  = average age at first capture,  $K$  = growth co-efficient,  $l_c$  = average length at first capture and  $\bar{l}$  = average length

of fish in catch. For both Irish Sea and Celtic Sea sprat the average size and length at first capture appears to be the same as that at recruitment because recruited fish are immediately liable to capture. Estimates of Z obtained using these two expressions were as follows:-

Values of Z

	$1/\bar{t}-t_c$	$K (L_{\infty} - l)/(\bar{l}-l_c)$
1964	1.59	1.56
1965	0.79	0.58
1966	0.86	0.61
1971	1.49	1.19
1972	0.89	0.71
1973	0.80	0.63
1974	0.57	0.40
1975	0.88	0.65
1976	0.86	0.36

The same expressions when applied to the data from the Celtic Sea give estimates of Z of 0.62 and 0.42. The value of M (natural mortality) for the North Sea sprat is assumed to be 0.80. If natural mortality for Irish Sea and Celtic Sea sprats is approximately the same as this, then the above values of Z would appear to be unrealistically low. However the value of K obtained by Johnson for North Sea sprat of 0.62 would imply a higher value of M for the North Sea. This together with the relatively unexploited state of the Irish fisheries could suggest that the value of Z obtained above are about the right order if M is assumed to be around 0.65. In the Irish Sea the mean value of Z obtained for the 1964-66 and 1971 to 1976 period were 1.00 and 0.76 respectively. The average catches in both these periods were 700 tonnes and 3900 tonnes

and it would thus appear that the increased catches in the later period has had little effect on the total mortality rate.

Catch per effort data is available for the Irish Sea for the 1975/76 and 1976/77 seasons, and estimates of total mortality have been made using this method. The values of  $Z$  obtained were as follows:-

$$0/1 = -.88, \quad 1/2 = 1.2, \quad 2/3 = 1.5 \quad \text{and} \quad 3/4 = 3.0$$

It would appear therefore that there is a considerable increase in the total mortality rate as the fish become older.

#### Estimation of biomass and yield per recruit

There is no information about whether mixing takes place between the population in the Celtic Sea and Irish Seas. Similarities in the growth rates, the dominance of the 1973 year class and the possibility that recruitment to the Celtic Sea stock may take place from the Irish Sea, would suggest that the two fisheries may exploit the same population. However until more information becomes available, estimates of population size have been made separately for both areas. In both cases the 1976 catch has been converted to numbers per age class ( $C_n$ ), and the numbers at the beginning of the year have then been calculated from the expression  $C_n \cdot Z/F(1-e^{-Z})$ . The value of  $F$  for the Irish Sea used was 0.22 which was the average of the last five years, and the value used for the Celtic Sea was 0.15. The latter was obtained by assuming that the 1976/77 fishery in the Celtic Sea was based on a hitherto unexploited stock and that the total mortality rate would therefore have been very near to the natural mortality rate. In estimating the numbers per age group at the beginning of each year different values of  $F$  were applied to each age group in the same ratio as the values obtained for the catch per unit effort data to allow for increasing  $F$  with age. The value of  $F_0$  was 0.20 for Irish Sea sprat and 0.01 for Celtic Sea sprat. Natural mortality was assumed to be 0.65. Calculations are shown in Table 4.



The total biomass ( $> 0$  w.ring) estimated for the Irish Sea sprat was approximately 23,000 tonnes, while the quantity estimated for the Celtic Sea ( $> 1$  w.ring) was approximately the same.

Yield per recruit curves were constructed for both sets of data, (Fig. 1) using the parameters  $E = F/F + M$ ,  $C = L_c/L_{\infty}$ , and  $M/K$ . Both curves were virtually flat topped but that for the Celtic Sea sprat showed that considerably higher yields could be obtained from similar levels of  $F$  than from the Irish Sea. This is probably because of the higher age and length at first capture. The value of  $F_{0.1}$  obtained for both sets of data corresponded to values of  $F = 0.5$  for the Irish Sea and  $F = 0.80$  for the Celtic Sea. Because of the preliminary nature of the data it would be better until the fisheries have developed further to restrain the fishing mortality to slightly below these levels. However taking these values ( $F = 0.50$  and  $0.80$ ) as being the level of  $F$  on the fully exploited age groups and applying the  $F$  at age array as shown in Table 4, the catches in 1977 were calculated to be 6,700 tonnes for  $> 0$  group sprat in the Irish Sea and 9,500 tonnes for  $> 1$  group sprat in the Celtic Sea.

#### REFERENCES

- Johnson, P.O. (1970) The Wash Sprat fishery. Fish Invest. Ser. II. Vol. 26, No. 4.
- Kennedy, M. and Fitzmaurice P. (1969) Pelagic eggs and young stages of fish taken on the south coast of Ireland in 1976. Irish Fish. Invest. Ser. B. No. 5.
- Wallace, P.D. and Pleasants, C.A. (1972) The distribution of eggs and larvae of some pelagic fish species in the English Channel and adjacent waters. ICES.CM 1972. J.8.
- Beverton, R.J.M. and Holt, S.J. (1957). On the dynamics of exploited fish populations. Fishery Invest., London Ser. 2.19.

Table 1.

Total Irish Catches of Sprat (Tonnes)

	Irish Sea	Celtic Sea
1960	-	5
1	-	1
2	0.8	0
3	-	76
4	712	154
5	744	77
6	684	169
7+	293	0
8+	126	1266
9	3171	0
1970	5540	0
1	4932	0
2	3553	119
3	3319	640
4	3509	192
5	2296	20
6	4918	38

+ The quantities for the Irish Sea are based on estimates from samples, except for 1967 and 1968 which are from official returns.

Table 2. Total catch in numbers per age class ( $10^{-3}$ )  
 I.S. = Irish Sea; C.S. = Celtic Sea

W. Rings

	0	1	2	3	4	5	6	7	E
1964 I.S.	31510	31920	4511	4238	-				68351
1965 I.S.	3772	36618	15959	1625	58				58032
1966 I.S.	438	45965	7332	985	-				54720
1971 I.S.	246639	381766	24926	2624	-				655955
1972 I.S.	51504	205335	75380	8868	-				341087
1973 I.S.	36914	150686	72450	13774	1653				275477
1974 I.S.	13924	66699	104428	38852	674				224577
1975 I.S.	11053	150358	21153	7242	762				190568
1976 I.S.	600	81899	196799	17100	3300				299998
1977 C.S.	-	1322	12581	44020	20784	2269	-	4	

Table 3. Length-weight data.

Length Group	Irish Sea (gm)		Celtic Sea (gm)
	1975/76	1976/77	1976/77
6.0	1.4	-	-
6.5	1.6	-	-
7.0	1.9	2.2	-
7.5	2.5	2.5	-
8.0	3.0	3.3	-
8.5	3.6	3.9	3.3
9.0	4.4	4.9	4.5
9.5	5.1	6.0	5.5
10.0	6.3	7.3	6.3
10.5	7.4	8.3	7.6
11.0	8.8	9.7	8.9
11.5	10.2	11.2	10.3
12.0	11.9	12.9	11.6
12.5	13.7	14.7	14.2
13.0	15.4	16.3	16.6
13.5	17.7	19.0	18.8
14.0	21.4	21.6	21.3
14.5	22.5	23.3	23.4
15.0	23.7	25.3	26.9
15.5	27.0	28.7	29.2
16.0	29.9	29.0	31.4
16.5	31.5	-	34.7
17.0	-	-	35.1
17.5	-	-	35.0

Table 4. Estimation of Stock sizes

IRISH SEA

W. Rings	Catch '76	F	Z	$e^{-Z}$	$\frac{F(1-e^{-Z})}{Z}$	Stock ( $10^{-3}$ )	$\bar{x}$ W	
0	600	.20	.85	.4274	.1347	4454	3.4	Adult stock 1-4 w. ring fish = 22653
1	81899	.20	.85	.4274	.1347	608010	10.4	
2	196799	.34	.99	.3716	.2158	911951	16.8	
3	17100	.99	1.64	.1940	.4865	35139	23.4	
4	3300	.99	1.64	.1940	.4865	6783	27.6	

CELTIC SEA

1	1322.1	0.01	0.66	.5169	.0032	413156	5.2	Adult stock 2-7 w. ring fish = 22603
2	12581.0	0.05	0.70	.4966	.00360	349472	11.5	
3	44401.0	0.10	0.75	.4724	.0703	631607	18.2	
4	20784.1	0.10	0.75	.4724	.0703	284714	23.5	
5	2266.8	0.15	0.80	.4493	.1651	13730	29.0	
6	-	-	-	-	-	-	31.0	
7	4.1	0.15	0.80	.4493	.1651	24.8	33.3	

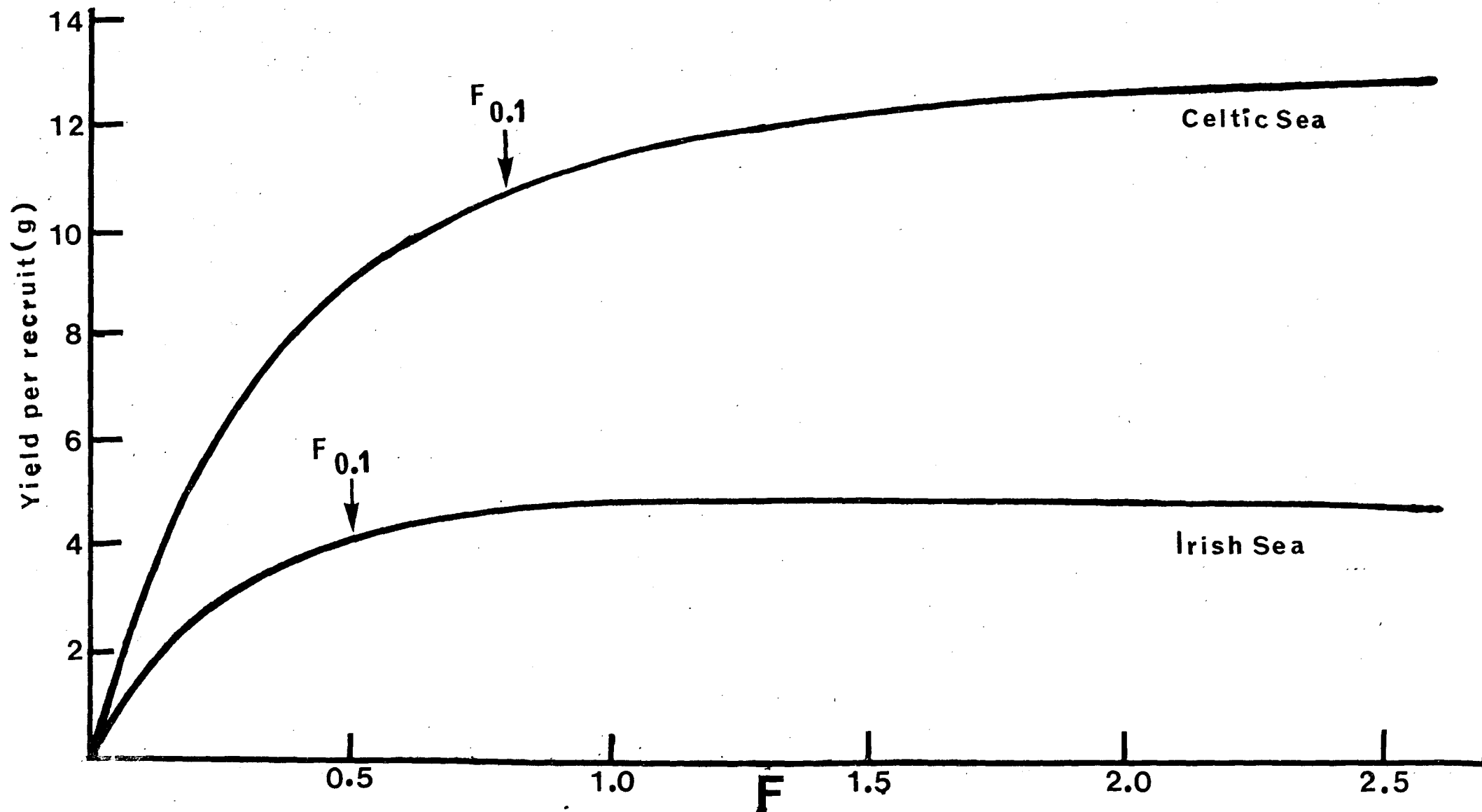


Fig.1. Yield per recruit curves for Irish Sea and Celtic Sea sprat